Structure

1.1 Introduction to the TV transmitters
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1.8 Vertical, horizontal synchronization
1.9 Types of camera tubes
1.10 Construction and working of Image Orthicon tube

Learning Objectives

After studying this unit, the student will be able to

- Functioning of TV transmitters
- Working of TV system
• CCIR - B standards and specifications
• Scanning methods horizontal, vertical interlaced scanning
• Working of camera tubes
• Working of Image Orthicon tube

1.1 Introduction to the TV Transmitter

In electronics and telecommunications a transmitter or radio transmitter is an electronic device which, with the aid of an antenna, produces radio waves. The transmitter itself generates a radio frequency alternating current, which is applied to the antenna. When excited by this alternating current, the antenna radiates radio waves. In addition to their use in broadcasting, transmitters are necessary component parts of many electronic devices that communicate by radio, such as cell phones, wireless computer networks, Bluetooth enabled devices, garage door openers, two-way radios in aircraft, ships, and spacecraft, radar sets, and navigational beacons. The term transmitter is usually limited to equipment that generates radio waves for communication purposes; or radiolocation, such as radar and navigational transmitters. Generators of radio waves for heating or industrial purposes, such as microwave ovens or diathermy equipment, are not usually called transmitters even though they often have similar circuits.

1.2 Block diagram of basic TV system and its working of each block

Working of TV Transmitter

A transmitter is an electronic circuit which transforms electric power from a battery or electrical mains into a radio frequency alternating current, which reverses direction millions to billions of times per second. The energy in such a rapidly-reversing current can radiate off a conductor (the antenna) as electromagnetic waves (radio waves). The transmitter also "piggybacks" information, such as an audio or video signal, onto the radio frequency current to be carried by the radio waves. When they strike the antenna of a radio receiver, the waves excite similar (but less powerful) radio frequency currents in it. The radio receiver extracts the information from the received waves. A practical radio transmitter usually consists of these parts:

A power supply circuit to transform the input electrical power to the higher voltages needed to produce the required power output.

An electronic oscillator circuit to generate the radio frequency signal. This usually generates a sine wave of constant amplitude often called the carrier
wave. In most modern transmitters this is a crystal oscillator in which the frequency is precisely controlled by the vibrations of a quartz crystal.

Fig. 1.1 Block diagram of TV system

A modulator circuit to add the information to be transmitted to the carrier wave produced by the oscillator. This is done by varying some aspect of the carrier wave. The information is provided to the transmitter either in the form of an audio signal, which represents sound, a video signal, or for data in the form of a binary digital signal.

In an AM (amplitude modulation) transmitter the amplitude (strength) of the carrier wave is varied in proportion to the audio signal.

In an FM (frequency modulation) transmitter the frequency of the carrier is varied by the audio signal.

In an FSK (frequency-shift keying) transmitter, which transmits digital data, the frequency of the carrier is shifted between two frequencies which represent the two binary digits, 0 and 1.

Many other types of modulation are also used. In large transmitters the oscillator and modulator together are often referred to as the exciter.
An RF power amplifier to increase the power of the signal, to increase the range of the radio waves.

An impedance matching (antenna tuner) circuit to match the impedance of the transmitter to the impedance of the antenna (or the transmission line to the antenna), to transfer power efficiently to the antenna. If these impedances are not equal, it causes a condition called standing waves, in which the power is reflected back from the antenna toward the transmitter, wasting power and sometimes overheating the transmitter.

In higher frequency transmitters, in the UHF and microwave range, oscillators that operate stably at the output frequency cannot be built. In these transmitters the oscillator usually operates at a lower frequency, and is multiplied by frequency multipliers to get a signal at the desired frequency.

### 1.3 Formation of Picture

The picture is created by firstly all the odd lines (1, 3, 5, 7, 9 etc...625) being scanned from left to right and from top to bottom and followed by a scan of all the even lines (2, 4, 6, 8, 10 etc...624). The result is that a single scan creates only half an image. In a 50 Hz TV, one scan takes 1/50 second, so to make two half images it takes 1/25 second. In other words, every second 25 complete images are formed. As the process of scanning two half images takes place in only 1/25 second, to the human eye the two halves appear to be one. This process is called interlacing. Fifty half images are formed per second, making up 25 whole images. This interlacing technique means the picture will show less flicker than if the beam were to scan all lines at once. The frequency of scans is called the raster frequency which is 50 Hz (50 scans per second), whereas the line frequency is $25 \times 625 = 15,625$ Hz.

![Fig. 1.2 Picture formation](image)

#### 1.4 Need of horizontal and vertical scanning

**Scanning process**

Scanning is the process by which an electron beam spot is made to move across a rectangular area so as to cover it completely. This rectangular area may be the target surface in television camera or the screen of a picture.
tube in a television receiver. Former is the characteristic of transmitter scanning whereas the latter represents receiver scanning. The figure shows receiver scanning where the electron beam intensity modulated by the video signal scans the picture tube screen to reproduce the picture.

1. Horizontal Scanning:

The movement of electron beam spot from left to right and back so as to start a new line in the same direction is termed as horizontal scanning. Horizontal scanning frequency is defined as the number of lines scanned per second. Obviously in 625-line, 50 Hz system where 25 frames are transmitted per second, the horizontal scanning rate is 15625 lines per second. This is also termed as 15625 Hz because the signal that enables the spot scan horizontally at the rate of 15625 Hz, as one cycle makes the spot scan from left extreme to right extreme.

2. Vertical Scanning

Vertical scanning is the movement of the electron beam spot in the vertical direction. Vertical scanning frequency may be defined as the number of views.
also called fields transmitted per second. The frequency of the vertical, scanning signal is 50 Hz. One cycle takes the spot from top to bottom (during trace) and back from bottom to top (during retrace).

1.5 CCIR - B Standards and specifications of Monochrome TV Video Characteristics

- Number of lines per picture: 625
- Interlace ratio: 2:1
- Field frequency: 50 fields/sec
- Picture frequency: 25 picture/sec
- Line frequency: 15625 HZ
- Aspect ratio: 4:3
- Scanning sequence for lines: left to right
- Scanning sequences for field: top to bottom
- Video bandwidth: 5 MHZ
- Approximate gamma of picture signal: 0.5
Composite Video Signal characteristics

- Line period – 64microsecond
- Trace period - 52microsecond
- Retrace period – 12microsecond
- One vertical line period – 20msec
- Trace period – 18.72msec
- Retrace period – 1.27msec
- Pre equalizing pulse – 160 microseconds
- Post equalizing pulse – 160 microseconds
- Sync pulse – 4.7 microseconds
- Front porch – 1.5 microseconds
- Back porch – 5.8 microseconds

Radio Frequency Characteristics

- Channel bandwidth - 7MHZ
- Sound carrier relative to picture carrier – 5.5MHZ
- Sound carrier relative to the nearest edge of channel – 0.25MHZ
- Vestigial side band lower – 0.75MHZ
- Sync amplitude level – 100%
- Blanking level – 72 to 75%
- Peak white level – 10 to 12.5%

1.6 Interlaced Scanning

The lines that are scanned on the tube screen are produced by a narrow electron beam that is focused into a small 'spot' which is repeatedly moved across the screen, then progressively down it until the entire area has been covered (this is referred to as a 'raster'). The inside of the tube face is coated with a special phosphor that emits a bright light when bombarded with electrons. By varying the strength of the beam the luminance of the spot can be controlled, thereby reproducing the various levels of contrast in our images. Colour television operates on the same principle, except that there are three separate beams and three colour phosphors, one for each of the primary colours Red Blue Green.
This is a complication we do not need to be bothered with here, as all beams are scanned together and work in unison to provide the equivalent of the spot described above.

The spot is driven horizontally and vertically by two circuits called timebases. The Line Timebase moves the spot from left to right and the Field Timebase, from the top to the bottom. The video signal itself resets the timebases at the appropriate times to make the spot fly back from right to left and from the bottom to the top. This part of the raster scanning is called, appropriately, the flyback. The spot is turned off, or 'blanked' during flybacks. The Field Timebase scans very much slower than the Line Timebase.

The illustration below shows how the interlaced raster is created. At the beginning of a frame the two timebases are both reset so that the spot is at position (A). Both timebases then start scanning. The video signal triggers line flybacks at the appropriate time until the end of the first field (odd) is reached.

Half-way through the last line (B), the field timebase is reset. The spot then flies back to (C), and continues with the remainder of the line, then scans all the even lines in a similar manner. Because the field timebase was reset half way through a line, the even field naturally interlaces between the lines of the odd field.

Fig. 1.6 Interlaced Plan

When the spot reaches the end of the final line (D), both timebases are reset, and the spot flies back to (A), ready for the next frame.
This diagram gives the impression that the scan lines are at an angle. That is because so few lines are shown for clarity. In fact the angle is much less than 1 degree in reality, and is easily corrected by twisting the coils on the tube that deflect the electron beam.

The diagram also shows that the visible part of the screen is smaller than the area of the scanned raster. This is because it actually takes several line-scans for the frame timebase to fly back to the beginning (rather than the instantaneous paths shown for clarity on the diagram). The slight 'overscan' on the lines themselves also allows the spot time to stabilise before starting its active scan.

The PAL system comprises 625 lines, of which 574 are active. NTSC has 525 lines, of which 485 are active. During the time of inactive lines, it is customary to find non-image data stored in digital form. Examples of this are Teletext (Europe) and VITC timecode.

![Fig. 1.7 Formation of image in interlaced scanning](image)

Interlacing then, is a very effective way of reducing the flicker on the picture without increasing the amount (known as 'bandwidth') of transmitted information. The problem is, it can sometimes produce an undesirable vertical 'bounce' on images that have strong horizontal detail. Look at the illustration below, which shows a magnified capital F, as it may appear on the screen.

As you can see, the non-interlaced character is stationary, whilst the interlaced version (separated here into its two fields) will appear to bounce up and down at the frame rate.

This is not a great problem with domestic televisions, because the viewing distance is so great and the spot is relatively 'soft'. On a video monitor at close
quarters however, the effect is quite pronounced. That is why computer monitors are invariably non-interlaced.

Producers of TV graphics often attempt to minimise this effect by avoiding lots of horizontal detail and, where it is unavoidable, they use an odd number of lines for narrow horizontal features. This replaces the 'bounce' with a less obvious modulation in height.

1.7 Composit video signal (I.S.L. Standards)

A complete video image as seen on a TV monitor is called a frame, which consists of two interlaced vertical fields with 262.5 lines each. The TV image is scanned at a vertical frequency of 59.94 Hz such that the lines of field 2 are interlaced with the lines of field 1 to create the desired 525 lines frame at a repetition rate of 29.97 Hz. Historically, the 60-Hz vertical scan frequency was selected for monochrome TV sets to match the 60-Hz power line rate such that any power-related distortions would appear stationary. For color TV, both the horizontal and vertical scan frequencies have been slightly reduced from the monochrome display case to allow for the interference beat between the chrominance carrier and the aural carrier to be synchronized to the video signal. Figure 2.1 shows the modulated RF spectrum of an NTSC video signal based on AM-VSB format at an RF visual carrier frequency of 67.25 MHz (channel 4). The brightness portion of the video signal, which contains all the information of the picture details, is commonly called the luminance or visual carrier.
1.8 Need for Vertical / Horizontal Synchronization, blanking pulses, Front porch, Back porch and equilizing pulses

Synchronizing pulses added to the video signal at the end of every scan line and video frame ensure that the sweep oscillators in the receiver remain locked in step with the transmitted signal, so that the image can be reconstructed on the receiver screen.

A sync separator circuit detects the sync voltage levels and sorts the pulses into horizontal and vertical sync. (see section below – Other technical information, for extra detail.)

**Horizontal synchronization**

The horizontal synchronization pulse (horizontal sync HSYNC), separates the scan lines. The horizontal sync signal is a single short pulse which indicates the start of every line. The rest of the scan line follows, with the signal ranging from 0.3 V (black) to 1 V (white), until the next horizontal or vertical synchronization pulse.

The format of the horizontal sync pulse varies. In the 525-line NTSC system it is a 4.85 µs-long pulse at 0 V. In the 625-line PAL system the pulse is 4.7 µs synchronization pulse at 0 V. This is lower than the amplitude of any video signal (blacker than black) so it can be detected by the level-sensitive "sync stripper" circuit of the receiver.

**Vertical synchronization**

Vertical synchronization (Also vertical sync or VSYNC) separates the video fields. In PAL and NTSC, the vertical sync pulse occurs within the vertical blanking interval. The vertical sync pulses are made by prolonging the length of HSYNC pulses through almost the entire length of the scan line.

The vertical sync signal is a series of much longer pulses, indicating the start of a new field. The sync pulses occupy the whole of line interval of a number of lines at the beginning and end of a scan; no picture information is transmitted during vertical retrace. The pulse sequence is designed to allow horizontal sync to continue during vertical retrace; it also indicates whether each field represents even or odd lines in interlaced systems (depending on whether it begins at the start of a horizontal line, or mid-way through).

**Need for Blanking Pulse**

During scanning process of every horizontal line the electron beam is deflected from right to left for retrace. During retrace period no video signal is
applied to the cathode of the picture tube, but the electron beam from the cathode will strike the picture tube screen to produce a bright white horizontal line. Similarly at the end of the every field there is a vertical retrace.

During this period also electron beam can strike the screen to produce bright vertical line. So to avoid this retrace period, the retrace line should be made invisible. For this purpose we are sending blanking pulses along with the video signal, from the transmitter to the receiver.

**Front Porch and Back Porch**

The front porch is a brief (about 1.5 microsecond) period inserted between the end of each transmitted line of picture and the leading edge of the next line sync pulse. Its purpose was to allow voltage levels to stabilise in older television, preventing interference between picture lines. The front porch is the first component of the horizontal blanking interval which also contains the horizontal sync pulse and the back porch.

The back porch is the portion of each scan line between the end (rising edge) of the horizontal sync pulse and the start of active video. It is used to restore the black level (300 mV.) reference in analog video. In signal processing terms, it compensates for the fall time and settling time following the sync pulse.

**Equalizing Pulses**

Synchronization pulses of double frequency and of short period leading and following the vertical sync. Proper equalizing pulses are needed for picture stability on the screen, for proper vertical deflection, interlacing* and for PAL* switch generation. Missing or distorted equalizing pulses can cause misalignment of the video image on the screen, skewing* effect, color distortion and loss.

A narrow pulse superimposed on the vertical blanking pulse of a composite television signal before and after the vertical synchronizing pulse. Equalizing pulses are added to the synchronizing signal in interlaced scanning in order to eliminate the difference in the form of the odd and even vertical synchronizing pulses; the difference in form, which appears when the vertical synchronizing pulses are extracted from the synchronizing signal by means of an integrated filter, is due to the different location of the line synchronizing pulses. The duration of an equalizing pulse is approximately 2.5 microseconds, and the repetition frequency is twice the line frequency. The number of equalizing pulses depends on the identity requirements for the even and odd vertical synchronizing pulses and is usually five or six.
1.9 Different Types of Camera Tubes

An electron tube having a light-sensitive receptor that converts an optical image into an electrical television video signal. The tube is used in a television camera to generate a train of electrical pulses representing the light intensities present in an optical image focused on the tube. Each point of this image is interrogated in its proper turn by the tube, and an electrical impulse corresponding to the amount of light at that point of the optical image is generated by the tube. This signal represents the video or picture portion of a television signal. See also Television camera.

**Image orthicon**

The image orthicon made broadcast television practical. It was used for more than 20 years as the primary studio and field camera tube for black and white and color television programming because of its high sensitivity and its ability to handle a wide range of scene contrast and to operate at very low light levels. It is one of the most complicated camera tubes. The image orthicon is divided into an image section, a scanning section, and a multiplier section, within a single vacuum envelope. The image isocon is a further development of the image orthicon.

**Photoconductive tubes**

These types have a photoconductor as the light-sensitive portion. The name vidicon was applied to the first photoconductive camera tube developed by RCA. It is loosely applied to all photoconductive camera tubes, although some manufacturers adopt their own brand names. The vidicon tube is a small tube that was first developed as a closed-circuit or industrial surveillance television camera tube. The development of new photoconductors has improved its performance to the point where it is now utilized in one form or another in most television cameras. Its small size and simplicity of operation make it well suited for use in systems to be operated by relatively unskilled people.

The vidicon is a simply constructed storage type of camera tube (see illustration). The signal output is developed directly from the target of the tube and is generated by a low-velocity scanning beam from an electron gun. The target generally consists of a transparent signal electrode deposited on the faceplate of the tube and a thin layer of photoconductive material, which is deposited over the electrode. The photoconductive layer serves two purposes. It is the light-sensitive element, and it forms the storage surface for the electrical charge pattern that corresponds to the light image falling on the signal electrode.
Cross section of a vidicon tube and its associated deflection and focusing coils. Cross section of a vidicon tube and its associated deflection and focusing coils.

Photoconductor properties determine to a large extent the performance of the different types of vidicon tubes. The first and still most widely used photoconductor is porous antimony trisulfide. The latest photoconductors are the lead oxide, selenium-arsenic-tellurium, cadmium selenide, zinc-cadmium telluride, and silicon diode arrays.

**Silicon intensifier**

The silicon intensifier camera tube utilizes a silicon diode target, but bombards it with a focused image of high-velocity electrons. Each high-energy electron can free thousands of electron carriers in the silicon wafer (compared to one carrier per photon of light on a silicon diode vidicon). This high amplification allows the camera to operate at light levels below that of the dark-adapted eye. The silicon intensifier tube is utilized for nighttime surveillance and other extremely low-light-level television uses in industrial, scientific, and military applications.

**Solid-state imagers**

These are solid-state devices in which the optical image is projected onto a large-scale integrated-circuit device which detects the light image and develops a television picture signal. Typical of these is the charge-coupled-device imager. The term charge-coupled device (CCD) refers to the action of the device which detects, stores, and then reads out an accumulated electrical charge representing the light on each portion of the image. The device detects light by absorbing it in a photoconductive substrate, such as silicon. The charge carriers generated by the light are accumulated in isolated wells on the surface of the silicon that are formed by voltages applied to an array of electrodes on top of an oxide insulator formed on the surface of the silicon. A practical CCD imager consists of a structure that forms several hundred thousand individual wells or pixels, and transfers the charges accumulated in these pixel wells out to an output amplifier in the proper sequence. See also Charge-coupled devices.

**1.10 Construction and Working of Image Orthicon Tube**

The image orthicon, (sometimes abbreviated IO) was common in American broadcasting from 1946 until 1968. A combination of the image dissector and the orthicon technologies, it replaced the iconoscope and the orthicon, which required a great deal of light to work adequately.

The image orthicon tube was developed at RCA by Albert Rose, Paul K. Weimer, and Harold B. Law. It represented a considerable advance in the
television field, and after further development work, RCA created original models between 1939 and 1940. The National Defense Research Committee entered into a contract with RCA where the NDRC paid for its further development. Upon RCA's development of the more sensitive image orthicon tube in 1943, RCA entered into a production contract with the U.S. Navy, the first tubes being delivered in January 1944. RCA began production of image orthicons for civilian use in the second quarter of 1946.

While the iconoscope and the intermediate orthicon used capacitance between a multitude of small but discrete light sensitive collectors and an isolated signal plate for reading video information, the image orthicon employed direct charge readings from a continuous electronically charged collector. The resultant signal was immune to most extraneous signal "crosstalk" from other parts of the target, and could yield extremely detailed images. For instance, image orthicon cameras were used for capturing Apollo/Saturn rockets nearing orbit after the networks had phased them out, as only they could provide sufficient detail.

An image orthicon camera can take television pictures by candlelight because of the more ordered light-sensitive area and the presence of an electron multiplier at the base of the tube, which operated as a high-efficiency amplifier. It also has a logarithmic light sensitivity curve similar to the human eye. However, it tends to flare in bright light, causing a dark halo to be seen around the object; this anomaly is referred to as "blooming" in the broadcast industry when image orthicon tubes were in operation. Image orthicons were used extensively in the early color television cameras, where their increased sensitivity was essential to overcome their very inefficient optical system.

Operation

An image orthicon consists of three parts: a photocathode with an image store ("target"), a scanner that reads this image (an electron gun), and a multistage electron multiplier.

In the image store, light falls upon the photocathode which is a photosensitive plate at a very negative potential (approx. -600 V), and is converted into an electron image (a principle borrowed from the image dissector). This electron rain is then accelerated towards the target (a very thin glass plate acting as a semi-isolator) at ground potential (0 V), and passes through a very fine wire mesh (near 200 wires per cm), very near (a few hundredths of cm) and parallel to the target, acting as a screen grid at a slightly positive voltage (approx +2 V). Once the image electrons reach the target, they cause a "splash" of electrons by the effect of secondary emission. On average, each image electron ejects several "splash" electrons (thus adding amplification by secondary emission),
and these excess electrons are soaked up by the positive mesh effectively removing electrons from the target and causing a positive charge on it in relation to the incident light in the photocathode. The result is an image painted in positive charge, with the brightest portions having the largest positive charge.

A sharply focused beam of electrons (a cathode ray) is generated by the electron gun at ground potential and accelerated by the anode (the first dynode of the electron multiplier) around the gun at a high positive voltage.
(approx. +1500 V). Once it exits the electron gun, its inertia makes the beam move away from the dynode towards the back side of the target. At this point the electrons lose speed and get deflected by the horizontal and vertical deflection coils, effectively scanning the target. Thanks to the axial magnetic field of the focusing coil, this deflection is not in a straight line, thus when the electrons reach the target they do so perpendicularly avoiding a sideways component. The target is nearly at ground potential with a small positive charge, thus when the electrons reach the target at low speed they are absorbed without ejecting more electrons. This adds negative charge to the positive charge until the region being scanned reaches some threshold negative charge, at which point the scanning electrons are reflected by the negative potential rather than absorbed (in this process the target recovers the electrons needed for the next scan). These reflected electrons return down the cathode ray tube toward the first dynode of the electron multiplier surrounding the electron gun which is at high potential. The number of reflected electrons is a linear measure of the target's original positive charge, which, in turn, is a measure of brightness.

Additional amplification is also performed via secondary emission in the electron multiplier which consists of a stack of charged dynodes (pinwheel-like disks surrounding the electron gun) in progressively higher potentials. As the returning electron beam hits the first dynode, it ejects electrons similarly to the target; for each electron striking a dynode, many are emitted. These secondary electrons are then drawn toward the next dynode at a higher potential, where the splashing continues for a number of steps. Consider a single, highly energized electron hitting the first dynode, causing, say, four electrons to be emitted and drawn towards the next dynode. Each of these might then cause four each to be emitted. Thus, by the start of the third stage, you would have about 16 electrons to the original one. As many as 5 to 10 stages were not unusual, thus the achieved amplification is very important.

Overall, the amplification at the image front and at the electron multiplier, plus the wise use of secondary emission wherever possible make the Image Orthicon an excellent camera tube, with a typical illumination on photocathode for maximum signal output of 0.01 ft-c (0.1 lx). This makes it on the order of a thousand times more sensitive than the iconoscope.

Short Answer Type Questions

1. Write picture scanning frequencies.

2. Mention the types of scanning systems.

3. What is channel bandwidth.
4. Define interlaced scanning.
5. Draw the composite video signal.
6. Mention the signals in composite video signal.
7. Define Synchrononization.
8. Define Aspect ratio.
9. Write working principle of camera tube.
10. Mention the types of camera tube.

**Long Answer Type Questions**

1. Draw the block diagram of TV transmitter. Explain the working of each block.
2. Explain briefly the horizontal and vertical scan.
3. State the CCIR-B standards and specifications of monochrome TV.
4. Draw and explain the interlaced scan.
5. Explain the construction and working of image orthicon tube.
UNIT 2

Black and White TV Receiver

Structure

2.1 Block diagram of B/W TV receiver
2.2 Various stages of B/W TV receiver
2.3 Introduction to Colour TV receiver
2.4 Characteristics of human eye
2.5 Additive, subtractive mixing of colours
2.6 Definition of Sue, Saturation, Complimentary colours
2.7 Compatibility and Reverse compatibility
2.8 Specification of NTSC, PAL and SECAM
2.9 Block diagram of colour TV and working
2.10 Colour TV receivers- Operating and servicing controls
2.11 Colour picture tube features

Learning Objectives

After studying this unit, the student will be able to

• TV receivers, Monochrome and Colour TV receivers, Block diagram and working of each block is studied.

• Picture tubes, single gun and colour picture tube construction and working is studied.
**Introduction**

Television means "to see from a distance". The Television system extends the sight of the human eye throughout the world. Such television system includes both Transmission and Reception of T.V. signals. Transmission means sending of information through a network known as transmitter and reception means receiving of information through a circuit known as T.V. receiver.

T.V. Receiver is an electronic circuit which can reproduce the transmitted signal into corresponding light and sound either in mono chrome or in colour. Thus a Television receiver is the combination of AM receiver for picture and FM receiver for the associated sound reproduction.

**Type of T.V. Receivers :** T.V. Receivers are classified as follows

1. According to the devices and components used in the circuit.
2. According to the size of the screen (picture tube).

According to the components and devices used in the circuit T.V. Receivers are the following types.

1. **All tube receivers :** The receiver which uses tubes for the different functions in different stages of the circuit is known as all tube receivers. This type mainly applies to earlier Monochrome receiver. Now a day these are not in use.

2. **Hybrid Receivers :** These receivers uses both tubes and solid state devices like transistors and I.C’s. Present days these are also not in use.

3. **Solid State Receivers :** The receiver circuit which uses semiconductor devices for all its stages is known as solid state receivers. These can be further divided into the following types.
   1. Receivers which are using Transistors only.
   2. Receivers which are using Transistors and I.C’s.
   3. Receivers which are using IC’s only.
   4. Receivers which are using Microproserers

**Classification of T.V. Receivers according to screen size**

T.V. Receivers are also classified according to the size (diagonal length) of the screen of the T.V. receiver as follows.

These are

- 9" T.V.
- 14" T.V.
20" T.V.
29" T.V. etc.,

2.1 Block Diagram Black / White T.V. Receiver and Working of Each Block.

Fig 2.1 Block Diagram Black / White T.V. Receiver and Working of Each Block

The below fig. 2.1 shows the block diagram of a typical monochrome receiver with various input and output signal wave forms at different stages. The receiver has been divided into several main sections depending on their functions and each section is explained as follows.

Antenna: Antenna converts electromagnetic waves into corresponding electrical signals. Generally for VHF reception “Yaagi Uda Antenna. It consists of a dipole with one reflector and two or more directors are used. It is a compact high gain directional array often used in firing areas. In areas where signal strength is very low booster amplifiers with suitable matching networks are used.

A Transmission: line connects antenna to the front end of the T.V. Receiver i.e. R.F Tuner and its impedance is 300ohms. Twin lead is generally
used for this purpose. Its impedance is 300 ohms. Folded dipole also has an impedance close to 300 ohms. For maximum signal transfer the impedance of the antenna and the receiver’s end both should match. This is done with the help of a impedance balancing transformer known as ‘balun. Thus if the impedance is matched properly 500 micro volts to 1 mV signal strength is achieved. Thus using antenna all electromagnetic waves are converted into electrical signals and these are then coupled to turner through a transmission line.

**RF Section :** This section consists of RF amplifier mixer and local oscillator. This is normally mounted on a spate is called the front end or RF tuner. According to frequency of reception these are 1. VHF tuner, 2. UHF signals picked up by the antenna. Here the receiver uses the super heterodyning principle for conversion of the incoming signal into the common fixed carrier frequencies called Intermediate Frequencies. These are picture IF and sound IF. These values are 38.9 MHz for picture VIF and 33.4 MHz for sound SIF. Thus using RF section or channel selector or RF Tuner we can amplify the incoming composite video signal to the required level and then these are further converted into the VIF and SIF. Further these are fed the video IF amplifier.

**Thus the main function of the turner is as follows.**

1. To selected channel signal from the many signals up by the Antenna and reject others.
2. To amplify the received or selected signal.
3. To convert the incoming signal frequency to a common IF band.
4. To provide good S/N ratio.
5. It avoids adjacent channel frequency.
6. It provides image frequency rejection.
7. It acts as coupling device between antenna & receiver.
8. It prevents spurious picks ups from sources which operate in the IF band of receiver.
9. It has a fine control for accurate setting in the IF band.

**Video IF Amplifier**

Since the composite video signals is the envelope of the modulated pictures IF signal practically all the gain and selectivity of the receiver is provided by the IF section. Generally 3 or 4 IF transistors amplifier stages are used for this purpose. In integral circuits one IC contains all the IF amplifier stages.
The main functions of the IF sections

Black and White T.V. Receiver

1. To amplify the modulated IF signals over its entire bandwidths.
2. It also provides vestigial side band correction.
3. It provides again of above 800 to amplify the 0.5 mV input signal to about 4 v.
4. It also provides adjacent channel signal rejection.
5. It also provides good selectivity.

Video detectors: Modulated IF selections after due amplification in the IF selection are fed to the video detector. The detector is designed to receive the CVS and to transform the sound signal to another lower carrier frequency. This is done by rectifying the input signals and filtering out unwanted frequency components. Thus the video signal which is demodulated with correct polarity is fed to the cathode of picture tube after one stage of video amplification.

Video Amplifier: The picture tube needs video signal with peak amplitude of 80 to 100 V for producing picture with good contrast. This amplifier provides necessary gain to achieve necessary amplification to the video signal to drive the picture tube. Here gain control is also provides in the stage to adjust the contrast between black and white parts of the picture. That’s why this gain control is also known as contrast control. Thus the amplified video signals are fed to the cathode of the picture tube.

Sound Signal Separation: The picture and sound signals on their respective carrier are amplified together in the IF section. In video detector VIF of 38.9 MHz acts as carrier and beats with the sound carrier 33.4 MHz produce a difference of 5.5 MHz. This is called inter carrier signals. This retains all the FM modulated sound signals by providing a resonant tarp circuit in the video detector the sound signals is separated from the video detector.

Sound Section: The sound section consists sound IF amplifier, FM detector, Audio voltage amplifier, audio power amplifier and loud speaker. The inter carrier sound IF signal directly cannot drive the FM detector. So at least one stage of amplification is needed to drive the FM detector. This is achieved with the sound IF amplifier. After amplification the sound IF signals is fed to FM detectors. The FM detector is normally a ratio detector or discriminator proceeded by a limiter. Here in this stage sound is demodulated and De-emphasis restores the amplitudes of higher audio frequencies to their correct level. Thus
demodulated sound signal is further amplified using voltage amplifiers in order to drive power amplifier. The power amplifier is either single ended or a push pull amplifier employing Transistors. These stages provide volume and tone controls. Thus amplified signals are fed to loud speaker. Finally loud speaker converts electrical signal into corresponding sound signal.

**Picture Tube Circuitry and Control**: The output from the video amplifier may be fed to cathode. The cathode emits this video output by the application of the thermionic emission. This emitted electron from an electron beam. This electron beam moves with phosphor. Thus when electron beam. This electron beam moves towards screen and strikes the screen of the picture tube which is coated with phosphor. Thus when electron beam touches the phosphorous screen it emits light. If this electron beam is deflected horizontally and vertically by the application of deflection coils and circuits it produces raster on the screen. Thus using picture tube and its circuitry electrical signal can be converted into corresponding picture information.

**AGC**: AGC means automatic gain control. AGC circuit control gain of RF and IF stages to deliver almost constant signal voltage to the video detector, despite changes in the signal picked up by the Antenna. Generally the signal available from the antenna to the television receiver may vary from fraction of a m V to fraction of volt. It is clear that the television receivers gain will vary with these variations in the signal strength. The result variation in gain is that a strong signal will produces excessive contrast, if the signal is very strong it over loads the video IF stage. This results in clipping is sync pulse tips. As a result sync pulse will be lost and the picture will appear turnout and will roll vertically. Over loading of the video stage produces negative picture. In order to prevent the above we require a circuit that control the output of the video detector to produce a good picture is known as AGC. The main advantages of AGC are as

1. Intensity and contrast of the picture once set remains constant irrespective of changes in the input signal strength.
2. Contrast in the reproduced picture does not change when the receiver is switched from one situation to another.
3. Amplitude cross modulation distortion on strong signals is avoided.
4. Further due to passing aero planes and fading effects will be reduced.
5. The sound signal being the part of CVS also stays constants as it is also controlled by the AGC.
6. Separation of sync pulses becomes easy.
7. The gain on weak signals is improved using delayed AGC.

**Sync separator**: The horizontal and vertical sync pulses, that from the part of the composite video signal are separated in the sync separator. The CVS is either taken from the video detector output or after one stage of video amplification. A sync separator is clipper circuit that is suitably biased to produce output only during sync pulse amplitude of the video signal.

**Sync processing and AFC circuit**: The output obtained from the sync separators is fed simultaneously to a differentiator and integrator circuits. The differentiator provide sharp pulse for triggering the horizontal Oscillator. Thus using integrator and differentiator vertical sync pulses are separated from the sync separators.

As the differentiator is a high pass filter it also developed output in response to noise pulses in addition to the spiked horizontal sync pulses. These results in occasional wrong triggering to the horizontal oscillator, which results in diagonal tearing of the reproduced picture. This problem can be solved by using automatic frequency control circuit. The AFC circuit employs a discrimination arrangement which compares the incoming horizontal sync pulses and the voltage that develops across the output of the horizontal deflection amplifier.

Thus the AFC output is a dc control voltage that is free of noise pulses. This control voltage is used to synchronize the horizontal oscillator with the received horizontal sync pulses.

**Vertical deflection Circuit**: Blocking oscillator are normally used as vertical deflection oscillators. This oscillators produces necessary saw tooth voltages required for vertical deflection. A potentiometer frequency known as vertical hold is used in this section to reset the vertical oscillators frequency from its frequency drift. The output of the oscillators is fed to a power amplifier. After amplification the same output is coupled to vertical deflections coils to produce the vertical deflection of the beam on the picture tube screen.

**Horizontal deflection circuit**: The horizontal oscillators is similar to vertical oscillators. It is used develop sweep derive voltage at 15625 Hz. The frequency of this circuit. This oscillators is controlled by the control voltage developed by the AFC circuit. The oscillator output is wave shaped to produce linear rise of current in the horizontal deflection coils. Since the deflection coils need about one amp of current to sweep the entire raster, for this purpose the output of the oscillator is given one stage to power amplification and then fed to the horizontal deflection coils.
**High Voltage Supply (EHT)**: In black and white tubes, anode requires a voltage of 15KV for sufficient brightness. This is known as HV or EHT (extra high tension supply). This high voltage is produced during retrace intervals of horizontal scanning. A high voltage pulses of amplitude between 6 to 9 Kv are developed across the primary winding of the horizontal output transformer. Further these are stepped up by an auto transformer winding to about 10 to 15 KV and then fed to high voltage rectifier. The output of the rectifier is filtered to provide required DC voltage. This is fed to final anode of the picture tube.

**Low Voltage Power Supply**: The usual B+ or low voltage supply is obtained by rectifying and filtering the arc. mains supply. This given to various sections of the receivers. Thus a TV Receiver can convert CVS signals into corresponding picture and sound signal.

### 2.2 Various stages of B/W TV receiver

Here are a variety of possible connections on an AV receiver. Standard connectors include:

- Analog audio (RCA connector, or occasionally XLR connector)
- Digital audio (S/PDIF; TOSLINK or RCA terminated coaxial cable)
- Composite video (RCA connector)
- S-Video.
- SCART video (primarily used in Europe and very uncommon in many other parts of the world)
- Component video.
- HDMI.
- USB (usually involves special computer circuitry to read video formats from a file system)

Analog audio connections usually use RCA plugs in stereo pairs. Inputs and outputs are both common. Outputs are provided mainly for cassette tape decks.

Analog audio connections using XLR (Balanced) connectors are uncommon, and usually found on more expensive receivers.

Digital connections allow for the transmission of PCM, Dolby Digital or DTS audio. Common devices include CD players, DVD players, or satellite receivers.
Composite video connections use a single RCA plug on each end. Composite video is standard on all AV receivers allowing for the switching of video devices such as VHS players, cable boxes, and game consoles. DVD players may be connected via composite video connectors although a higher bandwidth connection is recommended.

S-Video connections offer better quality than composite video. It uses a DIN jack.

SCART connections generally offer the best quality video at standard-definition, due to the use of pure RGB signalling (although composite and S-Video may alternatively be offered over a SCART connector). SCART provides video and audio in one connection.

Component video has become the best connection for analog video as higher definitions such as 720p have become common. The YPbPr signalling provides a good compromise between resolution and colour definition.

HDMI is becoming common on AV receivers. It provides for the transmission of both audio and video. HDMI is relatively new technology and there are reported issues with devices not properly working with each other (referred to as hand-shake issues between devices), especially cable/satellite boxes connected to a display through an AV receiver. Different levels of support are provided by receivers with HDMI connections. Some will only switch video and not provide for audio processing. Some will not handle multi-channel LPCM. Multi-channel LPCM is a common way for Blu-ray Disc and HD DVD players to transmit the best possible audio.

2.3 Introduction to Color TV Receiver

As was the case with black-and-white television, an electronic means of scanning would be superior to the mechanical systems like Baird’s. The obvious solution on the broadcast end would be to use three conventional Iconoscopes with colored filters in front of them to produce an RGB signal. Using three separate tubes each looking at the same scene would produce slight differences in parallax between the frames, so in practice a single lens was used with a mirror or prism system to separate the colors for the separate tubes. Each tube captured a complete frame and the signal was converted into radio in a fashion essentially identical to the existing black-and-white systems.

The problem with this approach was there was no simple way to recombine them on the receiver end. If each image was sent at the same time on different frequencies, the images would have to be “stacked” somehow on the display, in real time. The simplest way to do this would be to reverse the system
used in the camera; arrange three separate black-and-white displays behind colored filters and then optically combine their images using mirrors or prisms onto a suitable screen, like frosted glass. RCA built just such a system in order to present the first electronically scanned color television demonstration on February 5, 1940, privately shown to members of the US Federal Communications Commission at the RCA plant in Camden, New Jersey.\[9\] This system, however, suffered from the twin problems of costing at least three times as much as a conventional black-and-white set, as well as having very dim images, the result of the fairly low illumination given off by tubes of the era. Projection systems of this sort would become common decades later, however, with improvements in technology.

Another solution would be to use a single screen, but break it up into a pattern of closely spaced colored phosphors instead of an even coating of white. Three receivers would be used, each sending its output to a separate electron gun, aimed at its colored phosphor. Although obvious, this solution was not practical. The electron guns used in monochrome televisions had limited resolution, and if one wanted to retain the resolution of existing monochrome displays, the guns would have to focus on individual dots three times smaller. This was beyond the state of the art at the time.

Instead, a number of hybrid solutions were developed that combined a conventional monochrome display with a colored disk or mirror. In these systems the three colored images were sent one after each other, in either complete frames in the “field-sequential color system”, or for each line in the “line-sequential” system. In both cases a colored filter was rotated in front of the display in sync with the broadcast. Since three separate images were being sent in sequence, if they used existing monochrome radio signaling standards they would have an effective refresh rate of only 20 fields, or 10 frames, a second, well into the region where flicker would become visible. In order to avoid this, these systems increased the frame rate considerably, making the signal incompatible with existing monochrome standards.

The first practical example of this sort of system was again pioneered by John Logie Baird. In 1940 he publicly demonstrated a color television combining a traditional black-and-white display with a rotating colored disk. This device was very “deep”, but was later improved with a mirror folding the light path into an entirely practical device resembling a large conventional console. However, Baird was not happy with the design, and as early as 1944 had commented to a British government committee that a fully electronic device would be better.
2.4 Main Characteristics of Human eye with regards to perception of color

The human eye senses this spectrum using a combination of rod and cone cells for vision. Rod cells are better for low-light vision, but can only sense the intensity of light, whereas while cone cells can also discern color, they function best in bright light.

Three types of cone cells exist in your eye, with each being more sensitive to either short (S), medium (M), or long (L) wavelength light. The set of signals possible at all three cone cells describes the range of colors we can see with our eyes. The diagram below illustrates the relative sensitivity of each type of cell for the entire visible spectrum. These curves are often also referred to as the “tristimulus functions.”

Select View: Cone Cells Luminosity

![Cone Cells Luminosity](image)

Note how each type of cell does not just sense one color, but instead has varying degrees of sensitivity across a broad range of wavelengths. Move your mouse over “luminosity” to see which colors contribute the most towards our perception of brightness. Also note how human color perception is most sensitive to light in the yellow-green region of the spectrum; this is utilized by the bayer array in modern digital cameras.

2.5 Additive, subtractive mixing of colours

Additive & Subtractive Color Mixing

Virtually all our visible colors can be produced by utilizing some combination of the three primary colors, either by additive or subtractive processes. Additive processes create color by adding light to a dark background, whereas subtractive processes use pigments or dyes to selectively block white
light. A proper understanding of each of these processes creates the basis for understanding color reproduction.

The color in the three outer circles are termed primary colors, and are different in each of the above diagrams. Devices which use these primary colors can produce the maximum range of color. Monitors release light to produce additive colors, whereas printers use pigments or dyes to absorb light and create subtractive colors. This is why nearly all monitors use a combination of red, green and blue (RGB) pixels, whereas most color printers use at least cyan, magenta and yellow (CMY) inks. Many printers also include black ink in addition to cyan, magenta and yellow (CMYK) because CMY alone cannot produce deep enough shadows.

<table>
<thead>
<tr>
<th>Additive Colour Mixing</th>
<th>Subtractive Colour Mixing</th>
</tr>
</thead>
<tbody>
<tr>
<td>( RGB Colour )</td>
<td>( CMYK Colour )</td>
</tr>
<tr>
<td>Red + Green</td>
<td>Yellow</td>
</tr>
<tr>
<td>Green + Blue</td>
<td>Cyan</td>
</tr>
<tr>
<td>Blue + Red</td>
<td>Magenta</td>
</tr>
<tr>
<td>Red + Green + Blue</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>Cyan + Magenta</td>
</tr>
<tr>
<td></td>
<td>Magen + Yellow</td>
</tr>
<tr>
<td></td>
<td>Yellow + Cyan</td>
</tr>
<tr>
<td></td>
<td>Cyan + Magenta +Yellow</td>
</tr>
</tbody>
</table>

Subtractive processes are more susceptible to changes in ambient light, because this light is what becomes selectively blocked to produce all their colors. This is why printed color processes require a specific type of ambient lighting in order to accurately depict colors.
2.6 Complimentary colors, Hue, Saturation, and Color circle

Color has two unique components that set it apart from achromatic light: hue and saturation. Visually describing a color based on each of these terms can be highly subjective, however each can be more objectively illustrated by inspecting the light’s color spectrum.

Naturally occurring colors are not just light at one wavelength, but actually contain a whole range of wavelengths. A color’s “hue” describes which wavelength appears to be most dominant. The object whose spectrum is shown below would likely be perceived as bluish, even though it contains wavelengths throughout the spectrum.

![Example Spectrum with a Bluish Hue](image)

Although this spectrum’s maximum happens to occur in the same region as the object’s hue, it is not a requirement. If this object instead had separate and pronounced peaks in just the red and green regions, then its hue would instead be yellow (see the additive color mixing table).

A color’s saturation is a measure of its purity. A highly saturated color will contain a very narrow set of wavelengths and appear much more pronounced than a similar, but less saturated color. The following example illustrates the spectrum for both a highly saturated and less saturated shade of blue.

Select Saturation Level: Low High
Color circle is an abstract illustrative organization of color hues around a circle that shows relationships between primary colors, secondary colors, complementary colors, etc.

Some sources use the terms color wheel and color circle interchangeably; however, one term or the other may be more prevalent in certain fields or certain versions as mentioned above. For instance, some reserve the term color wheel for mechanical rotating devices, such as color tops or filter wheels. Others classify various color wheels as color disc, color chart, and color scale varieties.

As an illustrative model, artists typically use red, yellow, and blue primaries (RYB color model) arranged at three equally spaced points around their color wheel. Printers and others who use modern subtractive color methods and terminology use magenta, yellow, and cyan as subtractive primaries. Intermediate and interior points of color wheels and circles represent color mixtures. In a paint or subtractive color wheel, the “center of gravity” is usually (but not always) black, representing all colors of light being absorbed; in a color circle, on the other hand, the center is white or gray, indicating a mixture of different wavelengths of light (all wavelengths, or two complementary colors, for example).

The arrangement of colors around the color circle is often considered to be in correspondence with the wavelengths of light, as opposed to hues, in accord with the original color circle of Isaac Newton. Modern color circles include the purples, however, between red and violet. Color scientists and psychologists often use the additive primaries, red, green and blue; and often refer to their arrangement around a circle as a color circle as opposed to a color wheel.
2.7 Compatibility and Reverse Compatibility in TV System

Forward Compatibility or upward compatibility: (sometimes confused with extensibility) is a compatibility concept for systems design, as e.g. backward compatibility. Forward compatibility aims at the ability of a design to gracefully accept input intended for later versions of itself. The concept can be applied to entire systems, electrical interfaces, telecommunication signals, data communication protocols, file formats, and computer programming languages. A standard supports forward compatibility if older product versions can receive, read, view, play or execute the new standard.

The applicability of a forward compatible system with new versions requires not only the respecting of the older version by the designers of the newer version but additionally some agreement on future design features with the design freeze of current versions. The introduction of a forward compatible technology implies that old devices partly can understand data generated by new devices.\[1\]

Although the concepts of forward compatibility and extensibility are similar, they are not the same. A forward compatible design can accept data from a future version of itself and pick out the “known” part of the data. An example is a text-only word processor ignoring picture data from a future version. An extensible design is one that can be upgraded to fully handle the new data in the newer input format. An example is a text-only word processor that can be upgraded to handle picture data.

A forward compatible system is expected to “gracefully” handle input which is intended for a newer version, by ignoring the unknowns and selecting the known subset of the data that the system is capable of handling.

Forward compatibility is harder to achieve than backward compatibility because a system needs to cope gracefully with an unknown future data format or requests for unknown future features. Backward compatibility does not have this issue because it accepts a known data format.

Reverse Compatibility

In telecommunications and computing, a product or technology is backward or downward compatible if it can work with input generated by an older product or technology.\[1\] If products designed for the new standard can receive, read, view or play older standards or formats, then the product is said to be backward-compatible; examples of such a standard include data formats and communication protocols. Modifications to a system that do not allow backward compatibility are sometimes called “breaking changes.”
### 2.8 Specifications of NTSC, PAL and SECAM

**PAL signal details**

For PAL-B/G the signal has these characteristics.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel Clock frequency</td>
<td>13.5 MHz</td>
</tr>
<tr>
<td>(digital sources with 704 or 720 active Pixel/Line)</td>
<td></td>
</tr>
<tr>
<td>Bandwidth</td>
<td>5 MHz</td>
</tr>
<tr>
<td>Horizontal sync polarity</td>
<td>Negative</td>
</tr>
<tr>
<td>Total time for each line</td>
<td>60.000 µs</td>
</tr>
<tr>
<td>Front porch (A)</td>
<td>1.65 ± 0.4 µs</td>
</tr>
<tr>
<td>Sync Pulse length (B)</td>
<td>4.7 ± 0.20 µs</td>
</tr>
<tr>
<td>Back Porch (C)</td>
<td>5.7 ± 0.20 µs</td>
</tr>
<tr>
<td>Active Video (D)</td>
<td>51.95 ± 0.4 µs</td>
</tr>
</tbody>
</table>

The vertical timings are:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Lines</td>
<td>313 (625 total)</td>
</tr>
<tr>
<td>Vertical Lines visible</td>
<td>288 (576 total)</td>
</tr>
<tr>
<td>Vertical Sync polarity</td>
<td>Negative (burst)</td>
</tr>
<tr>
<td>Vertical frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Sync Pulse length</td>
<td>0.576 ms (burst)</td>
</tr>
<tr>
<td>Active Video</td>
<td>18.4 ms</td>
</tr>
</tbody>
</table>
AL broadcast systems

<table>
<thead>
<tr>
<th></th>
<th>PAL B</th>
<th>PAL G, H</th>
<th>PAL I</th>
<th>PAL D/K</th>
<th>PAL M</th>
<th>PAL N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission Band</td>
<td>VHF</td>
<td>UHF</td>
<td>VHF</td>
<td>VHF/UHF</td>
<td>VHF/UHF</td>
<td></td>
</tr>
<tr>
<td>Fields</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Lines</td>
<td>625</td>
<td>625</td>
<td>625</td>
<td>525</td>
<td>625</td>
<td>625</td>
</tr>
<tr>
<td>Active lines</td>
<td>576</td>
<td>576</td>
<td>582&quot;</td>
<td>576</td>
<td>480</td>
<td>576</td>
</tr>
<tr>
<td>Channel Bandwidth</td>
<td>7 MHz</td>
<td>8 MHz</td>
<td>8 MHz</td>
<td>8 MHz</td>
<td>6 MHz</td>
<td>6 MHz</td>
</tr>
<tr>
<td>Video Bandwidth</td>
<td>5.0 MHz</td>
<td>5.5 MHz</td>
<td>6.0 MHz</td>
<td>4.2 MHz</td>
<td>4.2 MHz</td>
<td></td>
</tr>
<tr>
<td>Colour Subcarrier</td>
<td>4.4336 MHz</td>
<td>4.4336 MHz</td>
<td>4.4336 MHz</td>
<td>4.4336 MHz</td>
<td>3.5756 MHz</td>
<td>3.5820 MHz</td>
</tr>
<tr>
<td>Sound Carrier</td>
<td>5.5 MHz</td>
<td>5.5 MHz</td>
<td>6.0 MHz</td>
<td>6.5 MHz</td>
<td>4.5 MHz</td>
<td>4.5 MHz</td>
</tr>
</tbody>
</table>

Fig 2.3 AL broadcast systems

2.9 Block Diagram of Color TV and Working

Fig. 2.4 Block Diagram of Color TV and Working
The R, G, and B signals also contain the basic brightness or luminance information. If the color signals are mixed in the correct proportion, the result is the standard B&W video or luminance Y signal. The Y signal is generated by scaling each color signal with a tapped voltage divider and adding the signals, as shown in Fig. 2.5. Note that the Y signal is made up of 30 percent red, 59 percent green, and 11 percent blue. The resulting Y signal is what a B&W TV set will see.

The color signals must also be transmitted along with the luminance information the same bandwidth allotted to the TV signal. This is done by a frequency-division multiplexing technique shown in Fig. 2.5. Instead of all three color signals being transmitted, they are combined into I and Q color signals. These signals are made up of different proportions of the R, G, and B signals according to the following specifications.

Fig. 2.5 Color mixing
Q_ 21 percent red, _52 percent green, 31 percent blue  
I_ 60 percent red, 28 percent green, _32 percent blue

The minus signs in the above expressions mean that the color signal has been phaseinverted before the mixing process.

The I and Q signals are referred to as the chrominance signals. To transmit them, they are phase-encoded; i.e., they are used to modulate a subcarrier which is in turn mixed with the luminance signal to form a complete, or composite, video signal.

These I and Q signals are fed to balanced modulators along with 3.58-MHz (actually 3.579545-MHz) subcarrier signals that are out of phase.

This type of modulation is referred to as a quadrature modulation, where quadrature means a 90° phase shift. The output of each balanced modulator is a double-sideband suppressed carrier AM signal. The resulting two signals are added to the Y signal to create the composite video signal. The combined signal modulates the picture carrier.

The resulting signal is called the NTSC composite video signal. This signal and its sidebands are within the 6-MHz TV signal bandwidth. The I and Q color signals are also called the R - Y and B - Y signals because the combination of the three color signals produces the effect of subtracting Y from the R or B signals.

The phase of these signals with respect to the original 3.58-MHz subcarrier signal determines the color to be seen. The color tint can be varied at the receiver so that the viewer sees the correct colors. In many TV sets, an extra phase shift of 57° is inserted to ensure that maximum color detail is seen. The resulting I and Q signals are shown as phasors.

There is still 90° between the I and Q signals, but their position is moved 57°. The reason for this extra phase shift is that the eye is more sensitive to the color orange. If the I signal is adjusted to the orange phase position.

The transmitted video and color signal spectrum better details will be seen. The I signal is transmitted with more bandwidth than the Q signal, as can be seen by the response of the low-pass filters at the outputs of the I and Q mixers.

The complete spectrum of the transmitted color signal. Note the color portion of the signal. Because of the frequency of the subcarrier, the sidebands produced during amplitude modulation occur in clusters that are interleaved between the other sidebands produced by the video modulation.
Remember that the 3.58-MHz subcarrier is suppressed by the balanced modulators and therefore is not transmitted. Only the filtered upper and lower sidebands of the color signals are transmitted. To demodul

Fig. 2.6 Color TV and Working

At these double-sided (DSB) AM signals, the carrier must be reinserted at the receiver. A 3.58-MHz oscillator in the receiver generates the subcarrier for the balanced modulator-demodulator circuits.

For the color signals to be accurately recovered, the subcarrier at the receiver must have a phase related to the subcarrier at the transmitter. To ensure the proper conditions at the receiver, a sample of the 3.58-MHz subcarrier signal developed at the transmitter is added to the composite video signal. This is done by gating 8 to 12 cycles of the 3.58-MHz subcarrier and adding it to the horizontal sync and blanking pulse as shown in Fig. 2.6. This is called the color burst, and it rides on what is called the back porch of the horizontal sync pulse.

The receiver uses this signal to phase-synchronize the internally generated subcarrier before it is used in the demodulation process.

A block diagram of a TV transmitter is shown. Note the sweep and sync circuits that create the scanning signals for the vidicons or CCDs as well as generate the sync pulses that are transmitted along with the video and color
signals. The sync signals, luminance Y, and color signals are added to form the final video signal that is used to modulate the carrier. Low-level AM is used.

The final AM signal is amplified by very high-power linear amplifiers and sent to the antenna via a diplexer, which is a set of sharp bandpass filters that pass the transmitter signal to the antenna but prevent signals from getting back into the sound transmitter.

At the same time, the voice or sound signals frequency-modulate a carrier that is amplified by class C amplifiers and fed to the same antenna by way of the diplexer. The resulting VHF or UHF TV signal travels by line-of-sight propagation to the antenna and receiver.

2.10 Different color TV Receivers, Operating and Servicing Controls

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**Onscreen Menus (Cont.)**

- Sound Settings
- Base
- Treble
- Balance
- MTS (Multi-channel Sound
- General Items
- On/Off Timer
- Closed Caption
- Front Panel Lock
- Auto Shut Off
- XDS ID
- V2 Component-In/
  V1 Component-In

**BUTTON FUNCTIONS**

- Menu
- Exit and PIP Off
- Display
- Video Status
- Sleep Timer
- Hyper Surround
- Muting
- 100+
- Return+
- Input
- VCR Button
- DVD Button
- TV/GATV Switch
- VCR/DVD Switch
- PIP (Picture-In-Picture)
  - Introduction
  - On/Move
  - Freeze
  - Swap
  - Channel +/−
  - Source
  - EZ-Surf

**APPENDICES**

- Troubleshooting
- Warranty
- Authorized Service Centers
- Search Codes
- Specifications
- Note
2.10.1 Servicing Controls

B+ Voltage Alignment:

Set and connected all the points.
Locate the RP551 alignment VR location.
Use digital multi-meter to measure the B+ voltage.
Switch on the TV chassis and connect by Philips pattern for alignment.
Align the Rp551 VR with the digital multi-meter to the required spec voltage 110 V olt +/- 0.5V (14”&21”) and 129.5V olt +/- 0.5V (25”/29”/34”).

Alignment finished, apply glue onto RP551 VR. After glue re-check the B+ voltage to ensure the B+ voltage is within spec of 110V(14”&21”) and 129.5Volt(25”/29”/34”).

Alignment Mode and Factory Setting:

Switch on the TV chassis and change to AV mode position.
Press “Factory mode” key to enter “ factory alignment mode”. Use “CH +/-” to select the alignment item, and use “V +/-” keys to do adjustment to you requirement.

IF Voltage Adjustment:

Setting-up – set-up the Philips 5418/5518 pattern generator, AV out frequency to 38MHz, signal level to 70dB +/- 2 dB.

IF set-up 38MHz signal connected with coaxial cable with 1 capacitor of “0.01uF” and connect to main chassis “IF” / ground points. Tuner must not insert with the antenna.

Switch on TV chassis, adjust the IF coil “T110” and check the Ch 2 brightness line for the range change from 0 to 5V. Reajust the voltage to meet Ch 1 position.

Note: LA76810A alignment only on VCO (T110) not others.

Vertical Line – Pin–Cushion Adjustment:-

Receive Channel 7 colour bar. Adjust the PR301 for vertical lines pin-cushion to 1 straight line, adjust the PR302 for horizontal phase to spec requirement.
**Vertical Line and Size Adjustment:**

Receive crosshatch pattern, use factory mode remote control to press “factory mode” key for adjustment.

Using CH +/- keys for V. Size and V. Line selection.

Use V +/- keys to adjust the picture line requirement and the size to spec.

**RF AGC Adjustment:**

Receive channel 13 of picture pattern. Adjust the AGC at 60 dB for no picture noise. 100 dB – picture should not be distorted and the VOS do not have unstable condition.

**Checking the Electrical Function:**

Connect the power cord and connect the signal to RF input.

Check the power supply whether OK or not. Switch on the TV set and the LED is on. Switch off the TV screen and should not have CRT spot within 3 sec.

Receive the channel 1 for monoscope pattern to check the picture focus and the round circle should not be distorted. The Centre position, and VOS line/size are within spec.

Check the brightness, contrast and colour condition.

Check the convergence, picture must be clear, focus OK and white balance are OK. Also check the complete screen picture quality. High voltage condition OK and the Screen picture must be OK.

Check all the functional keys must be working well.

Receive colour pattern signal and the system colour. (PAL/SECAM/NTSC) Check the power main on/off switch, brightness, volume, colour, contrast and tint.

The picture quality must not have colour noise, unbalance size and distorted condition. Check the sound quality standards, Volume up/down are OK to spec, and sound output. Ensure the sound output is not distorted and noisy. No interference for DK/BG/I/M. Use remote Control Unit for all types of function check and ensure OK.
Shock test and make sure the picture and sound are not distorted and shifted. Use strong and weak signal to check the colour picture condition. After adjust the signal level to 35-40 dB and the colour should not gone. The picture and sound must be OK. At 60 dB the picture should not have snow noise.

Ensure the factory mode setting are set. Set-off the factory mode function and last switch off the TV set. All the “NG” sets must send for repairing and recording for reference.

Check the AV input and output the picture and sound must be OK.

**Reliability Aging Test:**

1st lot of production sets. Sampling 20 sets for aging 7 days continues test with colour signal in. Normal production sets must be age for 1 day.

**Mechanical Inspection:**

Inspect all glue are firmly placed.
Check all screws are tightened, no missing and loose.
Check all the connectors are fully located onto the chassis base.
Check all the safety components are firmly located onto the chassis and no damage.
The TV internal side should not see any excess metal materials.
Check all the cable and wire are OK in-used.
Check the FBT and switching transformers not high mounting. The big capacitor are not slanting and high mounting.

**High Potential Testing:**

Set the mega-meter is set in position. (Insulation tester)
Set the meter to DC500V.
Use the meter probe onto the tuner body and the power cord on connector socket.
Switch on the button and test the insulation performance and the reading at 2/3 position.
Insulation spec must over 9.0 Mohm. if not reject.
Safety Check:-

High voltage checking. Use high pot tester and set the tester to 3100V, 10mA and ensure the AC/DC switch is in AC position. Set the tester to 10mA and timer to 5 sec.

Checking methods.

- connect the power cord into power socket.

- the high pot tester gun pointed at metal part of TV set body.

- switch on the switch to test the high electric power.

- connect with high voltage within 5 second and remove the tester gun point.

2.11 Construction features Color Picture Tubes

1. A stereoscopic color television image reproducing system, comprising a color television picture tube having a screen comprising a multiplicity of trios of picture elements comprising color dots or strips.

   Means for providing a color television signal with horizontal line interlace between successive fields, the video information in each field corresponding to a different one of two observation eyes than the video information in the immediately preceding and succeeding fields.

   Means for scanning said screen during each field so that alternate ones of said picture elements are excited during each horizontal line, with picture elements in vertical alignment being excited during successive lines of the same field, each field forming a vertical strip pattern of effective scan of said picture elements, adjacent fields corresponding to two different observation eyes exciting different picture elements to provide one vertical strip pattern corresponding to a left eye image and another intermeshed vertical strip.

   Pattern corresponding to a right eye image, with horizontal line interlace between successive fields; and a lenticular lens disposed in juxtaposition with said screen and comprising a plurality of vertical lenticules, each lenticule being disposed in alignment with one strip of said left eye image and one strip of said right eye image, to focus said images to stereoscopically reproduce said color television signal.

2. The system according to claim 1, wherein said lenticules are prismatic.

3. The system according to claim 1, wherein said color television signal providing means comprises a television camera with a signal or target plate,
Fig. 2.7 Construction of colour picture tube
right-hand side image focusing system, a left-hand side image focusing system, and an optical switching means disposed between said.

Television camera and said right-hand side and left-hand side image focusing systems in such a way that said optical switching means is switched between first position and second position in synchronism with the vertical scanning operation of the television camera whereby when said optical switching means is in said first position only the right-hand side image of a subject or a scene may be focused on said signal or target plate of the television camera during the scanning of the first field whereas when said optical switching means is in said second position only the left-hand side image may be focused through said left-hand side image focusing system on said signal or target plate of said television camera during the scanning of the second field.

4. The system as set forth in claim 3 wherein said optical switching means is a rotary or swinging reflecting mirror.

5. The system as set forth in claim 3 wherein said optical switching means are provided in both said right-hand side and left-hand side image focusing systems and each comprises shutter means which is opened and closed in synchronism with the vertical scanning operation of said television camera in such a way that the right-hand side image or the left-hand side image may be focused on said signal or target plate of said television camera only during the scanning time interval of the first or second field.

6. The system as set forth in claim 3 wherein said optical switching means comprises a right fixed polarizer incorporated in said right-hand side image focusing system, a left fixed polarizer incorporated in said left-hand side image focusing system and with a polarizing angle at right angles to that of said right-hand side polarizer, a half mirror disposed between the exists of said right-hand side and left-hand side image focusing systems and said color television camera, and a movable polarizer disposed between said half mirror and said color television system in such a way that said movable polarizer may be switched between first and second.

Optical positions in synchronism with the vertical scanning operation of said color television camera, whereby when said movable polarizer is in said first position the polarizing angle thereof may coincide with that of said right polarizer so as to focus the right-hand side image may be focused on the signal or target plate of the television camera only during the scanning time interval of the first field and when said movable polarizer is in said second optical position the polarizing angle thereof may coincide with that of said left polarizer so as to as to focus the left-hand side image on said signal or target plate of said television camera only during the scanning time interval of the second field.
7. The system as set forth in claim 6 wherein instead of said half mirror a dihedron full reflecting mirror is disposed.

**Short Answer Type Questions**

1. What are the different types of T.V Receiver?
2. What are the advantages of SMPS?
3. What is the need of SMPS?
4. What is meant by RF tuner?
5. What are the functions of RF Tuner?
6. Name different types of Tuner.
7. What are the advantages of AGC?
8. Name different types of picture tube used in Black and White Receiver.
9. What is meant by Yoke?
10. What are applications of centering and pincushion?
11. Which types of focusing is employed in T.V Receiver.
12. Which type of deflection system used in T.V. Receiver.
13. Name different I.C’s used in different sections of T.V receivers.
14. Write the values of EHT voltages used in different pictures tubes.
15. Write the differences between electromagnetic and electrostatic deflection system.
16. Write picture I.F and sound I.F Values?
17. What is the value of Sound inter carrier frequency?
18. What is the significance of the picture tube No 310C1P4?
19. What is meant by Balum Transformer and explain about it?

**Long Answer Type Questions**

1. Draw the block diagram of black and white T.V Receiver & explain the working of each block.
2. Explain the construction and working of picture tube with neat sketch.
3. Draw the block diagram of colour TV receiver. Explain working of each block.

4. Explain additive and subtractive mixing of colours.

5. Write colour transmission system standards.


7. Explain servicing and operating controls of a TV receiver.
UNIT 3

LCD / LED TV’S

Structure

3.0 Introduction
3.1 Understand the principles of LCD and LED Monitors
3.2 Block diagram of LCD / LED TV’s working
3.3 IC’s used in the LCD / LED TV’s
3.4 Advantages of LCD and LED TV’s
3.5 Common faults, servicing procedures

Learning Objective

On studying this unit, the student will be able to know about

• Working of liquid crystal display
• Working of Light Emitting diodes TV
• Different IC’s used in LCD / LED TV’s
• Different servicing procedures and rectification
3.0 Introduction

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

3.1 Understand the principles of LCD and LED Monitors

Basics of LCD Displays:

The liquid-crystal display has the distinct advantage of having a low power consumption than the LED. It is typically of the order of $\mu$ Watt for the display in comparison to the some order of $\mu$ Watt for LEDs. Low power consumption requirement has made it compatible with MOS integrated logic circuit.

Its advantages are

1. Low cost
2. Good Contrast

Disadvantages,

1. Light source
2. Limited temperature operation from (between 0 and 60° C)
3. Low reliability
4. Low life period
5. Poor visibility in low ambient lighting
6. Low speed and need air condition.

Basic structure of an LCD

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

**Types of LCD/Liquid Crystal Displays.**

Two types of display available are

1. Dynamic scattering display

2. Field effect display.

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

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

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

![Fig 3.1 working of LCD](image-url)
The main principle behind liquid crystal molecules is that when an electric current is applied to them, they tend to untwist. This causes a change in the light angle passing through them. This causes a change in the angle of the top polarizing filter with respect to it. So little light is allowed to pass through that particular area of LCD. Thus that area becomes darker comparing to others.

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

**Colour Liquid Crystal Display**

Colour LCDs are those that can display pictures in colours. For this to be possible there must be three sub-pixels with red, green and blue colour filters to create each colour pixel. For combining these sub-pixels these LCDs should be connected to a large number of transistors. If any problem occurs to these transistors, it will cause a bad pixel.

One of the main disadvantages of these types of LCDs is the size. Most manufacturers try to reduce the height than gain it. This is because more transistors and greater pixels will be needed to increase the length. This will increase the probability of bad pixels. It is very difficult or also impossible to repair a LCD with bad pixels. This will highly affect the sale of LCDs.

3.2 block diagram of LCD / LED Tv

**Design Considerations**

Digital television (DTV) receives digitally modulated information (standard-definition or high-definition format) which has been compressed for transmission. The compressed data is, in turn, decoded inside the television set or within a standard receiver with a set-top box. In contrast, traditional analog TVs make use of analog signals. In the US analog broadcasting is no longer in use so the digital video signals radiated from TV broadcasting stations must be converted over to analog if the end user still has a traditional TV set.
DTV’s rapid growth in popularity has been spurred by high-definition video quality as well as the availability of a variety of new features and services including video on demand (VoD), gaming, security, digital video recorder, interactive TV, merchandising and Web browser capabilities. LCD (Liquid Crystal Display) TVs in particular will continue their dominance in the market due to their affordability. Texas Instruments has a long history of providing expertise and superior products to the video market. TI’s comprehensive solutions cover everything from the initial capture of video content to the analog circuitry needed for the final viewing experience.

Fig 3.2 The block diagram of a typical digital LCD TV

3.3 IC’s used in the above with typical schematic circuit

Pin Definitions

LCD Connection Pins

LCD Enable Line (Pin 6): ..................................... LCD Enable line;
pin 6 on LCD screen module

**LCD RS Line (Pin 7):** ........................................... LCD Register Select line;

pin 4 on LCD screen module

**LCD RW Line (Pin 8):** ........................................... LCD Read/Write line;

pin 5 on LCD screen module

**D4 (Pin 10):** .................................................. LCD Data 4 line;

pin 11 on LCD screen module

**D5 (Pin 11):** .................................................. LCD Data 5 line;

pin 12 on LCD screen module

**D6 (Pin 12):** .................................................. LCD Data 6 line;

pin 13 on LCD screen module

**D7 (Pin 13):** .................................................. LCD Data 7 line;

pin 14 on LCD screen module

**Control & Data Pins**

**BAUD (Pin 1):** .............................................. Baud Rate Selection;

0 = 2400, 1 = 9600 Baud

**Polarity (Pin 2):** ............................................ Serial Data Polarity Control;

0 = Inverted, 1 = Standard

**RCV (Pin 17):** .............................................. Serial Data Input

**OUT (Pin 18):** .............................................. Digital Output (Need not be connected)

**Clock/ Power Pins**

**OSC1, OSC2 (Pin 16, Pin 15):** ....................... 4 MHz Resonator or Crystal Connection

**+5V Power (Pin 14, Pin 4):** ......................... Connect to +5V DC
Ground (Pin 5):................................................... Connect to 0 VDC (GND)

+5V or GND (Pin 3):........................................ * To maintain compatibility with EDE700 pinout, pin may be connected to either +5V or GND

PC Connection

The EDE702 can be used with most HD44780-based text LCD’s. The two most common types of connectors on these modules are the 1x14 and 2x7 pin arrangements (there may be two additional pins if the LCD is the backlit type). The pin numbers should be identified on the LCD module.

Refer to Figure One for connection of the LCD module to the EDE702. Notice that not all of the LCD module’s pins need to be connected because the EDE702 uses a 4-bit transfer mode.

Figure One also illustrates the hookup used for connection to a PC. A RS-232 voltage-level converter IC such as the MAX232 is not required; internal clamp diodes on the EDE702 convert the incoming RS-232 level voltages into TTL-level signals. Also, notice that the POLARITY input on the EDE702 is tied low; this causes the EDE702 to interpret the inverted RS-232 signals correctly (a voltage-converter IC such as the MAX232, inside the PC, inverts the signal for transmission).

3.4 Advantages of LCD and LED TV

Benefits of LCD Televisions

In the screen of an LCD monitor, each pixel is produced by a tiny cell which contains a thin layer of liquid crystals. These rod-shaped molecules bend light in response to an electric current. It’s the same display technology that resides in your digital watch but more sophisticated.

LCD televisions: tend to be clearer than CRTs which can suffer from convergence or focus difficulties. Their improved clarity means that even small LCD televisions can display higher resolutions than the corresponding sized CRT. They also make small text easier to read. Unlike CRTs, LCD televisions have only one optimal resolution. At lower resolutions, the screen is redrawn as a smaller area or all the pixels in the image are blown-up to fill the screen. The latter solution can make images look jagged and blocky so be sure the resolution of the LCD television is the resolution you want to use.
Resolution

A factor for both CRTs and LCD televisions is resolution. The number of pixels horizontally and vertically defines a monitor’s resolution in pixels or dots per inch (ppi or dpi). The greater the resolution, the more information or image you’ll be able to view at once. The average user will find a resolution of 1024x768 more than sufficient for everyday work. You can achieve this resolution on CRT monitors 17 inches and larger or LCDs 15 inches and larger. Keep in mind that CRTs can display multiple resolutions, but LCD televisions and displays are optimized at only one resolution.

Extras

LCD Monitors can come with a variety of extras. Some have built-in speakers or jacks for microphones and headphones. Other monitors have dual inputs so you can connect two computers to the same monitor. With the advent of USB (Universal Serial Bus), some monitors have USB hubs at the back, allowing you to connect more peripherals. You can also get accessories like anti-glare filters and specialized mounting stands that help minimize glare and provide a comfortable working position.

Power Conservation

To keep your utility bill down, you should look for a monitor that is Energy Star compliant. Energy Star is a program developed by the US Environmental Protection Agency (EPA) to make energy-saving office equipment like computers and monitors. An Energy Star monitor automatically goes to sleep or powers down after a period of inactivity. This feature can save 60-80% of power during idle times. All you have to do to wake up the monitor is touch the keyboard or mouse.

Emissions

The majority of monitors are certified as “low emission” since they meet standards like MPR II or TCO. These guidelines were developed in Sweden (the acronyms are Swedish too) by a number of organizations to set limits for electric and magnetic field emissions. The newer TCO standards are the strictest. So if you’re concerned about emissions look for MPR II or TCO certification, not just the words “low emission.”

LCD Television Features

Viewing Angle

One of the main disadvantages of LCD televisions when compared to CRTs is their limited viewing angle. When viewing a LCD straight on it looks
fine. But the screen will appear washed-out if you move your head over to the side and look at it from an extreme angle. Low-end LCDs can have viewing angles of only 100 degrees which won’t give everyone crowded round your desk a clear view. For a standard 15 inch LCD try to get a 140 degree viewing angle. Up that by 20-40 degrees when shopping for an 18 inch LCD.

Fig. 3.3 LCD Television

**Brightness**

The brightness of LCD television sets is another important factor. LCD monitors have several backlights that provide illumination. Brightness is measured in units called nits. The majority of LCDs produce 150-200 nits which is fine for most users. The backlights in a LCD television are good for 10 to 50 thousand hours of operation.

Since they’re fairly fragile and more likely to break, backlights usually come with only a one year warranty. This warranty is separate from the one for the screen so you might want to extend the backlight warranty to match the duration of your LCD television warranty.

**Positioning**

LCD televisions can provide a range of options for positioning a display. The common way to view a screen is landscape mode (longer than wide). Some LCDs let you pivot the screen 90 degrees so you can view it in portrait mode (taller than wide) which is great if you’re growing tired of scrolling so often. You should also check out whether the screen can both tilt and swivel. Easy adjustment is important if you’ll be doing presentations. You can even mount some LCDs on the wall like a picture.
3.5 Common Faults and Servicing Procedure

1. Unlike older cathode ray tube (CRT) displays that scan an electron beam over a phosphor screen to create light, LCD displays are composed of a fixed grid of tri-colour pixels that change transparency based on a range of voltage levels provided by the monitor’s controller. Without a voltage the pixel is opaque and blocks the screen’s backlight from transferring through it, and when a full voltage is applied then the pixel allows full transmittance of the backlight. When this is done over the entire pixel grid in patterns, then you see those patterns on the screen.

2. At a very basic level, the way pixels work is a voltage change alters the pixel to allow more or less light through. When there is no voltage, no light is let through (darker), and when the voltage is at its maximum level then 100 percent of the light is allowed to pass through (brighter). By supplying intermediate voltages the computer adjusts the pixel’s transmittance levels for its three colour components, to display various combined colours and intensities.

This pixel-based setup for LCD monitors provides many advantages over CRT displays, but does have potential drawbacks arising from the fact that the image is dependent on millions of independent electrical components as opposed to a single scanning beam, so if faults occur in these components then the display output can be affected. The resulting problems include stuck or dead pixels, as well as a residual image effect.

3. Fixing stuck pixels

One of the more common problems with LCD displays is the potential for stuck or broken pixels, where the pixel either does not receive a voltage and remains black, or does not respond to voltage changes and stays at a set luminance level. Sometimes this can happen for individual pixels, suggesting a problem with the pixel itself, or it can happen to groups of pixels, suggesting the possibility of problems with the display’s controller or a defect in a portion of the pixel grid.
A tool like LCD Repair will help you isolate and fix stuck pixels by presenting different colors and patterns onscreen.

When stuck or broken pixels occur, there are a couple of things you can try in order to fix the problem. One is to apply a small amount of pressure to the pixel when turning the display on or off, which can sometimes help stimulate the electronics to work properly. Unfortunately, Apple’s glass-covered glossy displays prevent this from working on modern Mac systems.

4. Fixing LCD residual images

LCD monitors can also be affected by another problem called “transient persistence” that is reminiscent of CRT burn-in. Classic burn-in would happen because the phosphor coating on the screen would get depleted by the persistent bombardment of electrons from the CRT, resulting in the inability of those sections of the display to convert the electron beam to visible light. This meant that if you kept a specific pattern showing on the screen then over time it could become a permanent residual image on the display that would show even when the display was turned off. This was a reason why screensavers were developed—to keep the wear on the screen’s phosphor coating as even as possible.

The physical burn-in of displays is no longer an issue now that LCD displays have taken over, but while transient image persistence is not a physical burn of the device, it is an alteration of the pixel response to voltage changes (usually temporary) that prevents pixels from getting as bright as others on the screen.

Similar to CRT burn-in, LCD image persistence generally happens after you have displayed a pattern of intense colors on screen; however, unlike CRT burn-in, LCD persistence can sometimes set in after only a few hours of displaying the image, as opposed to the weeks or even months that it can take for burn to set in on a CRT monitor. Additionally, unlike CRT burn-in, image persistence can often be reversed.

What happens with LCD monitors is the affected pixels have lost their ability to respond to the full range of voltages that the display gives them, resulting in a limited range of colors that can be output. This can happen if the pixel is acting like a capacitor and is retaining a residual charge, or if it is not able to reach the level of luminance that is desired when given a specific voltage. Either way, the pixel is not able to reach its full range of possible intensities.

Unlike stuck or dead pixels that may benefit from having the monitor turned on and off rapidly to produce rapid voltage changes, image persistence will benefit from a lengthy stretching of the pixel’s range. Therefore, instead of
using tools like JScreenFix to run random patterns over the affected screen area, you might instead place a pure white window (such as an empty TextEdit window, or what you get using the “White” option in the LCD Repair tool listed above) over the affected area for a few hours or even a few days if necessary. Doing this will force those pixels to be fully on, and over time their intensities may increase to be the same as the surrounding pixels.

5. Beyond pixels

But the system’s backlight can also suffer some common problems that include the backlight randomly blinking off, not turning on, or only illuminating part of the screen.

Shining a light through the Apple Logo on MacBook systems will show rendered text and graphics if the backlight, and only the backlight, is not working. Notice that reflected light on the right of the display reveals some graphical elements as well.

When the display fully cuts out and does not show any light, one possibility could be that your computer is not properly communicating with the display, or the display’s controllers or power supply are not working properly. If this occurs, try connecting the display to another system. But if power LEDs and other indicator lights turn off when the backlight goes out, then it may be your display’s power supply is failing.

If only the backlight is malfunctioning, then the LCD panel itself should still be working just fine and should be rendering the text and images of your computer’s output. To test for this, use a bright flashlight and shine it on your screen at an angle in an area where you expect images and text to be (such as
the Dock or menu bar). On Apple’s laptop systems, you can shine the flashlight through the Apple logo on the back to illuminate the screen on the front and better detect text and images that way.

If shining an alternative light source on the display causes graphical content to show up, then either the backlight or some component involved in controlling it (such as the power inverter for it) have failed and will likely need to be replaced, especially if you cannot rectify the problem by restarting the system, resetting PRAM and SMC, or otherwise toggling different hardware and software settings on your system.

6. How to Fix an LCD TV With Dead Pixels

![LCD TV with Dead Pixels](image)

Fig. 3.6 Dead pixels can harm your LCD screen.

Dead pixels can be an eyesore blotting your LCD television screen. Dead pixels are points on your screen that remain the same color no matter what the color is supposed to be. LCD (liquid crystal display) screens use a liquid in conjunction with backlighting to display images on your monitor. The amount of liquid varies, allowing different amounts of light through, which creates the different colors. Dead pixels are often pixels with uneven or no liquid behind them that get stuck in a certain position.

**Short Answer Type Questions**

1. Expand LCD and LED.

2. Write working principle of LCD.
3. Write working principle of LED.

4. Write any two differences between monitors and TV’s.

5. Mention the IC’s used in LCD, LED.

6. Write any two common faults in LCD / LED.

**Long Answer Type Questions.**

1. Explain working of LCD / LED monitors.

2. Draw the block diagram of LCD / LED TV and explain working of each block.

3. Write advantages of LCD / LED TV technology.

4. Explain servicing procedure of LCD / LED.
UNIT 4

Cable TV / DTH System

Structure

4.0 Introduction
4.1 Block diagram of Cable TV
4.2 Cable TV components
4.3 Necessity of Midband and Super band channels
4.4 Need of satellite for TV broadcasting
4.5 DTH reception working with block diagram
4.6 Deficiency of existing TV system
4.7 Improved existing TV system in HDTV

Learning Objective

After studying this unit, the student will be able to know about

• TV system, interconnections of cable network

• Components used such as amplifiers, BNC cables, connectors, and DTH system.
4.0 Introduction

Cable television, from its inception, developed in western countries into two separate systems called—Master Antenna Television (MATV) and Community Cable Television (CATV). The purpose of MATV was to deliver strong RF signals from one or more suitably located antennas to every TV receiver in complexes like hotels and apartment buildings, while that of CATV was to receive, combine and distribute signals of terrestrial (OFF-THE-AIR) television broadcasts through a network of cables to subscribers residing in remote towns and villages beyond the service area of local TV stations.

However, with the advent of Satellite Television (SAT-TV), reception of signals from a large number of TV stations located far-away became possible. With this, MATV lost its significance and CATV developed into a complex multi-channel system and expanded in a big way both in big cities and small towns. This large expansion became possible, because cable TV does not have the restriction of channel allocations as is necessary in terrestrial television and can thus offer a variety of programmes on a large number of channels.

4.1 Block diagram of Cable TV

![Fig 4.1 Block Diagram of Cable TV](image-url)
Modern Cable Systems carry and deliver signals of local and nearby TV stations that are available directly and of stations located far-away in and outside the country which are received through satellites. Besides, programmes earlier recorded on video tapes and discs are also distributed thereby offering a wide choice to CATV subscribers.

Cable systems meant for small towns, hotels and apartment buildings are less complex and offer six to eleven channels whereas CATV systems developed for large community areas and big hotels are quite complex and distribute television signals on 16 or 31 channels with provision to extend up to 50 or more channels.

From the technical point of view, a cable TV system can be divided into three main sections.

There are

1. Signal Reception (Outdoor Equipment)
2. Signal Processing (Indoor i.e. Control Room Equipment)
3. Signal Distribution (Cable Network).

As an introduction to cable television, each section is briefly described.
4.1.1 Signal Reception

The purpose of this section is to collect TV signals from different sources and on.

Composite Satellite and Cable Television

Conversion as necessary, deliver these through coaxial cables to corresponding signal processing units located in the control room. The reception of direct VHF and UHF broadcasts is done by installing conventional TV antennas and signals thus collected are sent directly through flat twin or coaxial cables to the signal processing section.

However, collection of signals coming from satellites is quite complex, because the arriving signal is extremely weak and its frequency is very high, being in the super UHF i.e. microwave spectrum. Therefore, a high gain antenna becomes necessary.

A horn type parabolic dish antenna of large diameter meets this requirement. This, when correctly oriented towards the satellite, collects signals arriving from it and reflects them to a common point called ‘focal point’ which is located in front and above the centre of antenna dish as shown in Fig. 1.1. A feed-horn is actually a small wave-guide section which is mounted at the focal point and its function is to receive signals reflected.

Fig. 4.1. A typical dish antenna assembly with feed-horn and LNBC mounted side-by-side at its focal point.

Elements of Cable Television

Towards it by the dish and deliver these to the close-by located low noise block converter (LNBC) as shown in the figure.

The down-link signals from most communication satellites are in C-band of frequency spectrum in the range of 3.7 to 4.2 Giga-Hertz (GHz) i.e. 3700 to 4200 MHz.

In order to minimise losses in coaxial cables that carry dish antenna signals to control room, the collected signals are first translated to a lower frequency range. This is done by a low-noise block converter (LNBC), the building blocks of which are shown in Fig. 4.2. The composite signal collected by the feed horn is fed to a low noise amplifier (LNA) which is specially designed to provide enough gain while maintaining maximum possible signal-to-noise ratio.

The LNA output is fed to a converter (mixer) which translates the incoming microwave signals to a lower frequency range of 950 to 1450 MHz.
This is achieved by fixing local oscillator (LO) frequency of the converter at 5150 MHz and selecting only the difference products from its output. The difference products will thus have the desired range of 950 MHz (5150 MHz - 4200 MHz) to 1450 MHz (5150 MHz - 3700 MHz). A band-pass filter (BPF) at the output of mixer separates the wanted.

IF signals from other signals. It is amplified by a multistage IF amplifier and then sent through a high grade coaxial cable to the CATV station. If necessary, a low noise amplifier (LNA) is provided in the middle of coaxial cable-run to make-up for any losses in it [see (Fig. 1.3)]. This LNA is often called ‘Bullet Amplifier’.

**Fig. 4.2.** Block diagram of an LNBC also called Front End Converter (FEC). The feed horn and LNBC unit is called Front-End-Converter (FEC) and also referred to as ‘Outdoor Equipment’ because it is located in the open and close to where the dish antenna is mounted. It is often necessary to install 2, 4, 6 or even 8 dish antenna units with associated feed horn and LNBCs to collect signals from different satellites.

Television programmes like movies, plays and songs recorded on video tapes and discs are also distributed on one or two channels of the CATV network. For this, video cassette recorders (VCRs) and C.D. players are provided in the control room.

### 4.1.2 Signal Processing

The signal processing unit, also called ‘Head-End Equipment’ consists of power dividers, satellite receivers, channel modulators, signal processors/amplifiers, VCRs, C.D. players and a combining network. Fig. 1.3 shows necessary details of processing different types of input signals which are briefly described.

**Signal processing blocks for different types of input signals.**

**LNBC Output:** The 500 MHz wide IF signal (950 MHz to 1450 MHz) is actually a multiplexed output of 12 separate transponder channels each having an effective bandwidth of 36 MHz (actual 40 MHz). In communication satellites, most of these channels carry television signals of different TV stations while the remaining cater to telephone and various data transmission services.

**Power Divider:** The IF signal from the LNBC is delivered to a signal splitter which is actually a multicoupler that divides the signal into independent paths. The signal splitter is commonly called a ‘Power Divider’ because it enables equal division of signal power at its output ports.
Satellite Receiver: The satellite receiver accepts inputs from one of the output ports on the power divider. It is designed to select manually or by remote control any one of the channels present in the 500 MHz IF signal. The receiver tuner can thus be set to select any desired channel out of many available. On selecting the wanted channel, the receiver functions like a TV receiver and demodulates the received frequency modulated (FM) signal of the selected channel to provide base-band signal. The term baseband signal is used to indicate the combined video (0-5 MHz) and SIF (FM) signal around 5.5 MHz. The sound IF (SIF) signal is further demodulated as in a TV receiver to obtain audio signal. It is either done in the satellite receiver or at the input of channel modulator.

Channel Modulator: A channel modulator functions as a mini TV transmitter to provide output in the same format as produced at any TV station. Each channel modulator receives video and audio signals from one satellite receiver and modulates these on carrier frequencies of the assigned cable channel. It then combines these outputs to form the composite output signal. The output of each channel modulator feeds into the combiner unit.

Terrestrial TV Signal: As explained earlier, signals of local or nearby TV stations are picked up by multichannel antennas installed at suitable locations. Each antenna output is fed to the combiner after necessary amplification. However, if it is to be shifted to another VHF channel, it is processed by a unit called ‘signal processor’ to obtain desired output before combining it with other modulator outputs.

As necessary, the signal processor demodulates video and audio signals and then modulates these on carrier frequencies of the assigned cable channel.

VCR/C.D. Player: All VCRs/C.D. players enable two types of outputs. One is in the form of video (V) and audio (A) signals and the other in the standard TV format either on VHF channel 3/4 or any UHF channel between 30 to 39. In Fig. 1.3, baseband signal has been chosen as the output and fed to a channel modulator for further processing.

The resulting output is then combined with other similar RF signals in the combiner (mixer) unit.

Combiner: This is a network with provision to accept outputs of different channel modulators and combine them to form a single wideband RF signal which is then distributed to subscribers over the cable network.
4.1.3 Signal Distribution

A representative signal distribution plan. The multiplexed output from the combiner is amplified before taking it to the distribution amplifier which is located at the geographical centre of the area to be served. From there, trunk lines carry the combined RF signal to distant locations. Trunk amplifiers are located on such trunk routes to compensate for signal loss in cables. Signal splitters also called direction couplers are used to distribute cable signal from trunk lines to branch routes as shown in the figure. Passive matching networks, usually called ‘TAP-OFFS’, are provided along branch cable runs from where individual cable runs take the signal to TV receiver locations.

The signal level at the input of each TV receiver should be of the order of 1.5 mV (P-P) which is enough to generate good quality pictures. Since improperly terminated lines develop standing waves i.e. signal reflections, which result in disturbance and signal loss, the end of each distribution cable is terminated in a resistance (usually 75 ohms) which is equal to the characteristic impedance of the line. Such a termination provides correct impedance match to the line and hence, reflections are prevented.

Set-Top Converter: Drops i.e. connections to subscriber TV receivers are made either directly or through a VCR if in use. If the number of channels is not more than.

A representative signal distribution plan of a Cable TV system.

A eleven, channel modulators are allotted the usual TV channels that lie in VHF I and III bands. Depending on the mode of connection, the corresponding tuner of the TV receiver or VCR, is used to select incoming programmes on various channels. However, if the number of cable channels is large, it becomes necessary to look for an alternative to accommodate additional channels. For this, recent models of TV receivers have modified tuners that extend selection in the mid band, super band and hyper band i.e. higher frequency range than available on earlier receivers. Such TV receivers are called ‘CABLE READY’ and can also receive ‘S’ band channels.

However, with earlier TV receivers which do not have additional band provision, it becomes necessary to use an external converter which translates all incoming cable channels to a common VHF channel which is either channel No. 3/4 or a UHF channel.

Such a converter is called ‘SET-TOP CONVERTER’ because it is usually put on top or along-side the television receiver.
The channel selection is done at the converter either manually or by remote control depending on its design. The cable coming from tap-off is connected at the input socket of the converter and its output goes to antenna input point of the TV receiver.

The receiver is tuned to the chosen common channel and left there to receive all the incoming cable channels.

4.2 Cable TV Component

Amplifier

This cable tv amplifier circuit is a rf-amplifier designed to be quickly installed between two coaxial cables. Both input and output impedances are compatible with 75 Ω cables. The main amplifier is T1 transistor, T2 is working as an emitter follower. The feedback bias is determined by R3 and R4.

The total gain of this tv cable amplifier is 22dB.

Because of the high frequency limit of transistors (≤ 2GHz) the tv amplifier works well up to 150 MHz. It must be housed in a metal case and the coaxial cables must be 75 Ω type. The total current consumption of this tv cable amplifier circuit is around 20mA.

Cable tv amplifier circuit schematic

![Cable tv amplifier circuit schematic](image)

Fig 4.3 TV Amplifier Active Components
• T1, T2 = 2SC4308 or 2SC1324

![Transistors Image]

**Fig. 4.4 Transistors**

**TV Cable Amplifier PCB**

![Amplifier PCB Image]

**Fig. 4.5 Amplifier PCB**

**Directional Couplers**

<table>
<thead>
<tr>
<th>Isolation</th>
<th>Insertion loss</th>
<th>Isolation</th>
</tr>
</thead>
</table>

![Directional Couplers Image]

**Top Loss**

Fig 4.6 Three Important Parameters of a Direction Coupler are Insertion loss Top loss & Isolation
Directional couplers, or Taps as they are sometimes called, are used to extract a small portion of the signal from the distribution cable to feed subscribers taps, while maintaining the proper characteristic impedance of the distribution cable. A directional coupler has three important parameters to check: insertion loss, isolation, and tap loss. These parameters are illustrated in Figure 4.6.

The most important parameter of a directional coupler is the tap loss. Tap loss is how much lower the signal level at the tap output is, compared to the signal level at the input. Common tap loss values range from 3 dB to 28 dB. Directional couplers are placed at various locations throughout a distribution system based upon the required tap loss and signal level needed. If, for example, the signal level on a line is 28 dBmV, a directional coupler having a tap loss of 28 dB would be used to provide the signal of 0dBmV needed for a subscriber tap.

Apply Signal of Known Level to input

![Diagram of directional coupler with labels: left output, middle output, right output, read level, terminated 75 ohms, read level]

Tap loss can be measured using the Frequency Selective Voltmeter by the following procedure illustrated in Figure 4.7. Apply a signal of known level to the input of the directional coupler. Terminate the output terminal of the directional coupler with a 75 ohm terminator. Then measure the signal level at the tap output with the Frequency Selective Voltmeter. The difference in level between the input signal and the signal at the tap output is the tap loss of the directional coupler.
The procedure for measuring the insertion loss of a directional coupler is illustrated in Figure 53. Apply a signal of known level to the input port of the directional coupler, while the tap output is terminated in 75 ohms. Then measure the signal at the output of the directional coupler using the Frequency Selective Voltmeter. The difference in signal level between the input and output is the insertion loss. The insertion loss of a directional coupler should be quite small, typically about 1.5 dB.

Isolation in a directional coupler is measured with a known signal applied to the output terminal with the input terminated, as shown in Figure 54. Between the applied signal level and the signal level measured at the tap output is the isolation of the directional coupler. The isolation of a directional coupler becomes greater as the tap loss increases, with a typical isolation of 20 dB for a 3 dB directional coupler.

**Convertors**

A cable converter box or television converter box is an electronic tuning device that transposes/converts any of the available channels from a cable television service to an analog RF signal on a single channel, usually VHF channel 3 or 4. The device allows a television set that is not “cable ready” to receive cable channels. While later televisions were “cable ready” with a standard converter built-in, the existence of premium television (aka pay per view) and the advent of digital cable have continued the need for various forms of these devices for cable television reception. While not an explicit part of signal conversion, many cable converter boxes include forms of descrambling to manage carrier-controlled access restriction to various channels.

Cable-ready televisions and other cable-aware A/V devices such as video recorders can similarly convert cable channels to a regular television set, but these do not include advanced capabilities such as descrambling or digital downconversion.

The task of a cable box is to convert a television channel from those transmitted over the CATV wire.

The basic converter box is passive and does not communicate back to the carrier. It simply tunes to one of the channels being transmitted together over the wire and re-transmits it to a television or other video device on a standard broadcast frequency (usually a customer-selected, locally unused frequency between VHF 2 and 4). Like other set-top boxes, converter boxes usually provide multiple options for the output channel (either 2/3 or 3/4) so that the same box can be used, with simple configuration, in multiple television markets. Despite not having a broadcast reception television antenna, a strong local
television station can cause interference with the TV’s reception of the cable converter’s signal, resulting in undesired static or ghosting.

Later cable boxes became addressable, allowing the carrier to independently identify one cable box from another. In early systems, this permitted the carrier to send instructions to the boxes by addressing them over the wire. This allowed customers to subscribe to premium television and pay-per-view. More recent cable boxes, particularly those for digital cable, engage in two-way communication with the carrier central office, allowing for more advanced and interactive features.

### 4.3 Necessity of Midband and Super band channels

<table>
<thead>
<tr>
<th>Band</th>
<th>Channels</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>V Band</td>
<td>T7 - T13</td>
<td>7 - 48 MHz</td>
</tr>
<tr>
<td>VHF Band</td>
<td>Ch. 2 - 13</td>
<td>54 - 216 MHz</td>
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<td>Low Band</td>
<td>VHF Ch. 2 - 6</td>
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<td>Mid Band</td>
<td>UHF Ch. 14 - 22</td>
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<td>Super Band</td>
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<td>Ultra Band</td>
<td>CATV Ch. 63 - 158</td>
<td>457 - 1002 MHz</td>
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<tr>
<td>UHF Band</td>
<td>Ch.14 - 83 - CATV Ch. 63 - 158</td>
<td>70 - 1002 MHz</td>
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</tbody>
</table>

Broadcast TV audio and video signals are transmitted as radio frequency (RF) information. These frequencies vary depending upon the selected channel. Normal TV broadcast signals are divided into three blocks of frequencies known as VHS low band, VHF high band and UHF.

Cable compatible TV receivers are intended for display for home entertainment and must be capable of receiving over-the-air ATSC and/or NTSC type signals on all very high frequency and ultra high frequency channels. As well, these type of receiving apparatus can be connected to a cable TV distribution undertaking using a coaxial cable. The TV receiver must then be capable of
receiving on all very high frequency channels, mid-band channels, super band channels and ultra high frequency channels.

**VHF Television Frequencies**

<table>
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<tr>
<th>BAND</th>
<th>CH #</th>
<th>FREQUENCY</th>
<th>BAND</th>
<th>CH #</th>
<th>FREQUENCY</th>
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**UHF Television Frequencies**

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<th>CH #</th>
<th>Frequency</th>
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27  548-554 MHz   51  692-698 MHz   75  836-842 MHz
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30  566-572 MHz   54  710-716 MHz   78  854-860 MHz
31  572-578 MHz   55  716-722 MHz   79  860-866 MHz
32  578-584 MHz   56  722-728 MHz   80  866-872 MHz
33  584-590 MHz   57  728-734 MHz   81  872-878 MHz
34  590-596 MHz   58  734-740 MHz   82  878-884 MHz
35  596-602 MHz   59  740-746 MHz   83  884-890 MHz
36  602-608 MHz   60  746-752 MHz
37  608-614 MHz   61  752-758 MHz

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### 4.4 Need for Satellite TV broadcasting

**Satellite television**: Television programming delivered by the means of communications satellite and received by an outdoor antenna, usually a parabolic reflector generally referred to as a satellite dish, and as far as household usage is concerned, a satellite receiver either in the form of an external set-top box or a satellite tuner module built into a TV set. Satellite TV tuners are also available as a card or a USB peripheral to be attached to a personal computer. In many areas of the world satellite television provides a wide range of channels and services, often to areas that are not serviced by terrestrial or cable providers.

![Fig. 4.8 TV transmission using satellite network](image)
Direct-broadcast satellite television comes to the general public in two distinct flavors - analog and digital. This necessitates either having an analog satellite receiver or a digital satellite receiver. Analog satellite television is being replaced by digital satellite television and the latter is becoming available in a better quality known as high-definition television.

Since the satellite antenna or dish is the place where your system starts to receive your programming, that’s where we’ll start too. There are about as many different satellite dishes available as there are channels! Dishes range from that simple single LNB dish that came with your basic system all the way up to mobile dish units that can locate and track the satellite automatically, even when you are driving down the road! All these dishes work on the same basic principle and do approximately the same job: they collect the weak signals from the satellite orbiting overhead and amplify them before sending them along to the receiver. Since the signal is so weak, the parabolic dish antenna must be pointed directly at the satellite with a fair degree of accuracy and must be tightly controlled to keep it pointed there. For most of us on a typical limited budget, a manual dish antenna of some sort is probably what we’ll have. That means we’ll be responsible for getting that antenna pointed in the right direction and keeping it there. For those of you with the money to afford an automatic antenna, this section really doesn’t apply to you unless you have a backup manual antenna. Many folks with automatic systems still carry a simple manual antenna. You may wind up in a parking situation where your automated wonder won’t be able to lock on and your only hope for TV is to set up that old manual antenna.

**All basic satellite antennas work about the same way**

- They all have a concave dish to collect the satellite signal and focus it on the LNB.

- The LNB collects the signals, amplifies them and sends them along a cable to the receiver located inside the home.

- The LNB can support one or more receivers, depending on design. Some systems use a multiple headed LNB to allow the system to “see” two satellites at once.

- The dish is mounted to an adjustable bracket that allows you to change the dish’s elevation (how high the dish tilts into the sky) and it’s azimuth (the compass heading in degrees that the dish points at).

- A cable, generally RG-6 coax, connects the LNB to the Receiver. Dual LNBs will use 2 separate cables to connect to two separate receivers.
Fig. 4.9 Block diagram of satellite

Well, assuming that we’ve come up with some method to mount our dish, let’s find someplace to mount the receiver! Ideally, it needs to be located somewhere near the TV to minimize the length of cable needed, but if that’s not convenient for you, you can put it just about anywhere. One thing to remember: there are two different types of remote controls. One type is Infrared... it uses an IR beam to communicate with the receiver. The other is Radio Frequency operated and uses RF energy to communicate to the receiver. Depending on which satellite system you purchased, you will have one or the other. Some systems have remotes that are selectable between the two communication methods.

The main reason that I’m bringing this up is that an IR remote must be able to “see” the front of the receiver in order to communicate with it. IR will not penetrate into cabinets or travel through walls. If your remote is an IR type, be sure that your receiver is installed somewhere that will allow it to see the beam from the remote. It often doesn’t have to be directly in front of the remote, as IR tends to reflect and bounce around a lot, but it does limit your mounting options. On the other hand, RF remotes communicate using radio frequencies and typically can reach the receiver no matter where you choose to mount it.

Many of the smaller receivers will fit in an existing cabinet or in your entertainment center, if you have one. Remember to follow any special recommendations that the manufacturer makes and also avoid blocking the cooling vents on the receiver. These vents need to be open to keep the receiver from overheating. It is usually not necessary to use the receiver’s front panel controls (if any) as all the functions are accessible from the remote. Use common sense: don’t mount the receiver where it can get wet or directly over a heating...
vent, etc., etc. Make sure that there is an AC outlet somewhere nearby... we
don’t want to have to run an extension cord to power the receiver. Think about
how you will route cables from the receiver.... at a minimum, we will need to run
one coax to the TV and one to the satellite dish. There’s bound to be a good
place somewhere.

Most satellite systems come with a self installation kit that will include a
length of RG-6 coax cable, usually 100 feet. This is probably all the cable you
will need. If you don’t have an installation kit, that’s OK. Cable and connectors
are available at many home centers, Radio Shack stores and appliance stores.
Although you can use RG-59 coax cable, the RG-6 is better. Here’s why:

These are basic specs for the two common types of cable used with TV
systems. Both are 75 ohm impedance.

RG-59BU, ~ 6.15 mm Ø, ~ 3.5 dB attenuation/100m @ 10 MHz.

RG-6/U, ~ 7 mm Ø, ~ 2.3 dB attenuation/100m @ 10 MHz.

RG-6 is slightly larger in diameter and offers a much lower attenuation
over distance than RG-59. If you are going only a short distance to your dish,
then RG-59 is acceptable, but once you start passing the 25 foot mark, it really
starts to affect your signal strength.

If you have the permanent type of antenna on the roof that requires
manual turning and raising, there are devices that will give you a read out in
degrees of the elevation of the antenna. All you have to do is elevate the antenna
to the correct degrees based on zip code and then turn it till you acquire the
signal. One such little gadget is the Winegard Digital Magic elevation meter. This
digital elevation sensing unit gives the exact elevation of the antenna on an LCD
readout inside the RV and is accurate to within one degree even when the RV
is not level! The sensing unit is attached to the elevating tube, and a wall plate
with LCD readout is installed inside the RV.

When you are attempting to set up a satellite dish in a heavily wooded
area or one with lots of man made obstructions, it helps to understand how the
dish really works. One common misconception is that the dish points ‘directly’
at the satellite. This isn’t the case for most dish designs. The apparent elevation
of the dish is 15 or more degrees lower than it’s actual receiving window. Have
I thoroughly confused you? Have a look at this diagram.... it’s easier to see it
than it is to explain it.

When you are trying to aim for that little gap in the trees, remembering
this will probably mean the difference between success and failure!
Fig. 4.10 Signal reception from satellite to dish antenna

Another great little tool to help you find that hole in the trees is this easy to make elevation gauge. All you need is one of those little bubble tilt gauges that are commonly attached to the front of RVs for leveling and a piece of paper towel tube! Put them together and you’ve got a handy aid to determine true elevation of an object or opening in the tree canopy. To use it, simply hold (or attach permanently) the level gauge against the bottom of the tube. Angle the tube upward while watching the gauge for the desired elevation. Once there, you can look through the tube to see what might be in the path of your satellite signal. Takes a little practice, but you’ll get the hang of it.

4.5 DTH Reception with block diagram

Working of DTH Transponder

In simple terms the service provider broadcasts the signal that is sent to the satellite that then transmits the signal back to earth which is picked up by your dish antenna and fed to your television set.

A DTH service provider has to lease Ku-band transponders from the satellite. The encoder converts the audio, video and data signals into the digital format and the multiplexer mixes these signals. At the user end, there will be a small dish antenna and set-top boxes to decode and view numerous channels. On the user’s end, receiving dishes can be as small as 45 cm in diameter.
DTH is an encrypted transmission that travels to the consumer directly through a satellite. DTH transmission is received directly by the consumer at his end through the small dish antenna. A set-top box, unlike the regular cable connection decodes the encrypted transmission.

![DTH Transponder](image)

**Fig 4.11 DTH Transponder**

**Working of DTH Receiver**

The end component in the entire satellite TV system is the *receiver*. The receiver has four essential jobs:-

1. **De-scrambling**: It de-scrambles the encrypted signal. In order to unlock the signal, the receiver needs the proper decoder chip for that programming package. The provider can communicate with the chip, via the satellite signal, to make necessary adjustments to its decoding programs. The provider may occasionally send signals that disrupt illegal de-scramblers, as an *electronic counter measure* (ECM) against illegal users.

2. **Conversion**: It takes the digital MPEG-2 signal and converts it into an analog format that a standard television can recognize. In the United States, receivers convert the digital signal to the analog NTSC format. Some dish and receiver setups can also output an HDTV signal.

3. **Channel Extraction**: It extracts the individual channels from the larger satellite signal. When you change the channel on the receiver, it sends just the signal for that channel to your TV. Since the receiver spits out only one channel at a time, you can’t tape one program and watch another. You also can’t watch two different programs on two TVs hooked up to the same receiver. In order to
do these things, which are standard on conventional cable, you need to buy an additional receiver.

![Fig 4.12 DTH Receiver](image)

It keeps track of pay-per-view programs and periodically phones a computer at the provider’s headquarters to communicate billing information. Receivers have a number of other features as well. They pick up a programming schedule signal from the provider and present this information in an onscreen programming guide. Many receivers have parental lock-out options, and some have built-in digital video recorders (DVRs), which let you pause live television or record it on a hard drive.

While digital broadcast satellite service is still lacking some of the basic features of conventional cable (the ability to easily split signals between different TVs and VCRs, for example), its high-quality picture, varied programming selection and extended service areas make it a good alternative for some. With the rise of digital cable, which also has improved picture quality and extended
channel selection, the TV war is really heating up. Just about anything could happen in the broadcasting arena where IPTV is another player in the field thus these television providers battle it out.

4.6 Deficiency of existing TV system

When there are issues related to customer service. You cable connection can go off at any moment and may not come for hours. When you call to complain, the cable operator simply does not pick up the phone. Plus, they also form cartels, so each locality is divided among different cable operators and they have a complete monopoly in that area. They don’t allow any other cable tv service in that area.

Now, with the digitization order will bring more changes in the cable service:

- You will have to buy a Set Top Box from your cable operator, which will be an additional cost.
- Your will require a Set Top Box for every TV in your home.
- Your monthly subscription rates might change and in many cases this will mean an increase in rates.
- In case your cable operator has been showing pirated movies and unlicensed TV channels, it will no longer be possible for him to do so.

4.7 Improved existing TV system in HDTV

Most simply, a high-definition television system is able to offer a clearer and more detailed picture than any existing broadcast system, because it contains more picture information. All television signals, whether analogue or digital, are made up of many dots or picture elements (pixels) that form the image you see, so by using more of these pixels in a high-definition (HD) transmission a better image can be produced.

Digital television (DTV) is a transmission method that will continue to be used to broadcast high-definition signals. In the same way that audio quality was improved moving from analogue music cassettes to Compact Discs, a similar change is happening to television.

The first stage of this has been to ‘digitise’ the existing analogue television system, that is to take the same picture information but broadcast it digitally rather than using analogue. The amount of picture information does not change, but digital transmission is more efficient than analogue resulting in a more consistent picture quality and an improved range of available channels.
How does high-definition compare to standard definition television systems.

An HD signal can contain up to around five times the picture information compared to standard definition (SD). Standard definition pictures are made up of approximately 500-600 horizontal lines of pixels depending on the local transmission system used, whereas high-definition transmissions use at least 700 to around 1000 lines as illustrated below.

High definition broadcasts also include better native support for multi-channel sound and windscreen formats which can improve the experience of sport and movies.

![Fig 4.13 Picture Resolutions](image)

What high-definition resolutions are available?

Two different picture resolutions are commonly used for high-definition television, they are named after the number of horizontal picture lines they use, either HD720 or HD1080 containing 720 and 1080 lines respectively.

The television which can be used as HDTV system are

- At least 720 lines of horizontal picture resolution in a widescreen aspect ratio and be able to display 720 and 1080 line content
• The necessary connection to interface with HD set-top boxes and next generation games consoles and DVD players. This is called an HDMI input which must also support the HDCP copy protection system.

### Short Answer Type Questions

1. What are the components in cable TV?
2. Write any four mid band frequencies.
3. Write any four super band frequencies.
4. What are the applications of satellites?
5. What is TV broadcasting?
6. Expand DTH.
7. Write any four deficiencies in existing TV system.
8. Expand HDTV.

### Long Answer Type Questions

1. Draw the block diagram of cable TV network. Explain working of each block.
2. Explain cable TV components and its working.
3. Explain use of satellite TV transmission over wide area.
4. Draw the block diagram of DTH. Explain its working.
5. Write improved version of HDTV compared to existing TV system.
UNIT 5

Optical Fiber Communication Fundamentals

Structure

5.1 Introduction to fiber optic communication
5.2 Total internal reflection phenomena using optical fiber
5.3 Definitions of numerical apperture, modes and dispersion
5.4 Various losses with interference to optical fiber
5.5 Advantages of optical fiber in communication
5.6 Types of Fiber optic cables
5.7 Different splices and connectors, optical couplers, relays
5.8 Operation of LED used in optical fiber communication
5.9 Operation of LASER, Diodes
5.10 Working of PIN diode used as detector
5.11 Operation of APD used as a detector

Learning Objectives

After studying this unit, the student will be able to know about

- Optical fiber cables, connectors, amplifiers, switches and relays working.
- Operation of LED, LASER diodes, PIN diodes and APD.
**Introduction**

Communication may be broadly defined as the transfer of information from one point to another. When the information is to be conveyed over any distance a communication system is usually required with in a communication system the information transfer is frequently achieved by superimposing or modulating the information on to electromagnetic wave which acts as carrier for the information signal.

The modulated carrier is then transmitted to the required destination where it received and the original information signal is obtained by demodulation. Sophisticated have been developed of this process using electromagnetic carrier waves operating radio frequencies as well as microwaves and millimeter wave frequencies. However communication may also be achieved using an electromagnetic carrier which is selected from the optical range of frequencies.

Since optical frequencies are extremely large (~$10^{15}$ HZ) as compared to the conventional radio waves (~$10^{10}$ HZ), a light beam acting as carrier wave is capable for carrying more information than radio waves and microwaves. It is expected that in the not too distant future, the demand for flow of information traffic will be so high that only a light wave be able to cope with it.

Soon after the discovery of the laser some preliminary experiments on propagations of information carrying light waves carried out, but it was realized that because of the vagaries of the dependable communication system are would require a guiding medium in which information carrying light waves could be transmitted. This guiding medium is the optical fiber which is a hair thin structure and guides the light beam from one place to another.

Thus the communication system which utilizes optical fiber for transmission of information is called optical fiber communication.

Thus “The optical fibre is a thin thread like structure of pure glass which is capable for transmitting large volumes of data in the form of light waves”.

The basic optical fibre in its construction consists of a high refractive index material which consist of a high refractive index region called core and a low refractive index medium around this core called Claddies.

**Types of Fibers:** There are two types of optical fibre configuration.

These are 1. Step index fibre, 2. Multi mode step index fibre (or) graded index fibers.
**Mode of Propagation**: In fibre optics terminology the word mode simply means path. If there only one path for light trans down the cable it is called single mode if it is more than one path is called Multimode.

**Index profile**: The index profile of an optical fibre is a graphic is a graphical representation of the refractive index of the core. The refractive index is plotted on the horizontal axis and the radial distance from the core axis is plotted on the vertical axis. There are two basic types of index profile step and graded. In a step index fibre there is an abrupt change in the refractive index at the core/cladding interface. In a graded index fibre there is no cladding, and the refractive index of the core is non-uniform, it is highest at the centre and decrease gradually towards outer edge.

### 5.1 Introduction to Fiber optic communication

The data transmission through fibre optic cables is done by means of light waves. The principle involved in this information of light waves through fibre optic cables is the “total internal reflection” principle.

When the ray of light moves from a medium of higher refractive index into a medium of lower refractive, then it bends away from the normal. At a particular angle of incidence the refracted angles becomes 90°. Then incident angle is called critical angle (θc).

When the incident angle into the same as the “Total internal reflection” transmission of light or data through it.

Fig. 5.1 Fiber optic video transmission multipoint to point
Working

The theory of multipoint-to-point and point-to-point transmission form is basically same. But receivers of multipoint-to-point all use rack-mount, the receivers are card style and inserted into chassis. That is transmitters are stand-alone, receivers are rack-mount, must use in pairs, for example, 4-channel stand-alone transmitters must connect with 4-channel rack-mount receivers.

This transmission form advantage is to facilitate the back-end management, centralized power supply, and can be installed in standard 19-inch rack, also could choose network management system that could better monitor working state for convenient maintenance and management of fiber optic transmitters and receivers.

In the above case is the system separately composed of 1-channel, 2-channel, 4-channel and 8-channel fiber video optic transmitter and receiver.

In the front-end video signal collected by fixed or PTZ cameras, and then the video electronic signal is converted into optical signal by 1-channel, 2-channel, 4-channel and 8-channel transmitters, also transmit the optical signal to relevant card style receivers (insert into chassis) by means of single-mode or multi-mode optical cable. then receivers convert optical signal into video signal output to DVR or matrix etc.

Camera’s video images finally transmitted to indicator, meanwhile, users could control PTZ cameras by keyboard. In the whole transmission process fully use digital transmission, image lossless, uncompressed, No EMI or RFI, images collected by cameras could clearly transmit to indicator.

If light rays the fibre under preferred conditions, the rays will be propagated over length of the fibre. Ultimately they emerge from the other end of the fibre. Only small part if the light will be from the side walls of the fibre. So, much of the light entering the fibre in the preferred conditions will be guided through the fibre to the opposite end. This the reason why we call the fibre as light pipe or light guide.

1. The reason for the light rays to staying inside the fibre is that they are reflected inside the fibre. The light entering the fibre with a small angle to the axis of the fibre under goes multiple reflections. The light follows a zig path along the structure of the fibre. In order to have total internal reflection phenomenon in the fiber, the following two conditions are to be satisfied.

2. The refractive index of the core ‘n1’ must be a bit higher than the refractive ‘index of the cladding ‘n2’. the angle of incidence (0i) of the light must be greater than the critical angle (0c).
5.2 Total internal reflection phenomena using optical fiber

An optical fiber is a cylindrical dielectric waveguide (nonconducting waveguide) that transmits light along its axis, by the process of total internal reflection. The fiber consists of a core surrounded by a cladding layer, both of which are made of dielectric materials. To confine the optical signal in the core, the refractive index of the core must be greater than that of the cladding. The boundary between the core and cladding may either be abrupt, in step-index fiber, or gradual, in graded-index fiber.

Internal Reflection

When light traveling in an optically dense medium hits a boundary at a steep angle (larger than the critical angle for the boundary), the light will be completely reflected. This is called total internal reflection. This effect is used in optical fibers to confine light in the core. Light travels through the fiber core, bouncing back and forth off the boundary between the core and cladding. Because the light must strike the boundary with an angle greater than the critical angle, only light that enters the fiber within a certain range of angles can travel down the fiber without leaking out. This range of angles is called the acceptance cone of the fiber. The size of this acceptance cone is a function of the refractive index difference between the fiber’s core and cladding.

In simpler terms, there is a maximum angle from the fiber axis at which light may enter the fiber so that it will propagate, or travel, in the core of the fiber. The sine of this maximum angle is the numerical aperture (NA) of the fiber. Fiber with a larger NA requires less precision to splice and work with than fiber with a smaller NA. Single-mode fiber has a small NA.

5.3 Numerical aperture, modes and dispersion

Numerical Aperature

In optics, the numerical aperture (NA) of an optical system is a dimensionless number that characterizes the range of angles over which the system can accept or emit light. By incorporating index of refraction in its definition, NA has the property that it is constant for a beam as it goes from one material to another provided there is no optical power at the interface. The exact definition of the term varies slightly between different areas of optics. Numerical aperture is commonly used in microscopy to describe the acceptance cone of an objective (and hence its light-gathering ability and resolution), and in fiber optics, in which it describes the cone of light accepted into the fiber or exiting it.
Numerical aperture refers to the maximum angle at which the light incident on the fiber is totally internally reflected and it can be transmitted properly along the fiber.

![Fig. 5.2 Numerical aperture](image)

### Numerical Modes

Since the core has a higher index of refraction than the cladding, light will be confined to the core if the angular condition for total internal reflectance is met. The fiber geometry and composition determine the discrete set of electromagnetic fields, or fiber modes, which can propagate in the fiber.

There are two broad classifications of modes: radiation modes and guided modes. Radiation modes carry energy out of the core; the energy is quickly dissipated. Guided modes are confined to the core, and propagate energy along the fiber, transporting information and power. If the fiber core is large enough, it can support many simultaneous guided modes. Each guided mode has its own distinct velocity and can be further decomposed into orthogonal linearly polarized components. Any field distribution within the fiber can be expressed as a combination of the modes. The two lowest-order guided modes of a circularly symmetrical fiber — designated \( LP_{01} \) and \( LP_{11} \) — are illustrated in Figure 5.2.

When light is launched into a fiber, the modes are excited to varying degrees depending on the conditions of the launch — input cone angle, spot size, axial centration and the like. The distribution of energy among the modes
evolves with distance as energy is exchanged between them. In particular, energy can be coupled from guided to radiation modes by perturbations such as microbending and twisting of the fiber — increasing the attenuation.

Dispersion

Intermodal Dispersion

As its name implies, intermodal dispersion is a phenomenon between different modes in an optical fiber. Therefore this category of dispersion only applies to multimode fiber. Since all the different propagating modes have different group velocities, the time it takes each mode to travel a fixed distance is also different. Therefore as an optical pulse travels down a multimode fiber, the pulses begin to spread, until they eventually spread into one another. This effect limits both the bandwidth of multimode fiber as well as the distance it can transport data.

Intramodal Dispersion

Intramodal Dispersion, sometimes called material dispersion, is a result of material properties of optical fiber and applies to both single-mode and multimode fibers. There are two distinct types of intramodal dispersion: chromatic dispersion and polarization-mode dispersion.

The index of refraction varies depending upon wavelength. Therefore, different wavelengths will travel down an optical fiber at different velocities. This is known as Chromatic Dispersion.

This principle implies that a pulse with a wider FWHM will spread more than a pulse with a narrower FWHM. Dispersion limits both the bandwidth and the distance that information can be supported. This is why for long communications links it is desirable to use a laser with a very narrow line width. Distributed Feedback (DFB) lasers are popular for communications because they have a single longitudinal mode with a very narrow line width.

Polarization Mode Dispersion (PMD) is actually another form of material dispersion. Single-mode fiber supports a mode, which consists of two orthogonal polarization modes. Ideally, the core of an optical fiber is perfectly circular. However, the fact that in reality, the core is not perfectly circular, and mechanical stresses such as bending introduce birefringency in the fiber, causes one of the orthogonal polarization-modes to travel faster than the other, hence causing dispersion of the optical pulse.
5.4 Various losses with interference to optical fiber

The light pulses that propagate through a fibre suffer several dispersion effects. It causes spreading of output pulse in the time domain and changes its shape. Thus the optical signal becomes distorted as it propagates through an optical fibre. This distortion of the signal is due to the two types of dispersion

1. Intramodal dispersion

2. Intermodal dispersion

1. Intramodal Dispersion: The intramodal dispersion is also called chromatic dispersion. The intramodal dispersion is pulse spreading that occurs within a single mode. This dispersion is due to the fact that group velocity of guided mode is a function of the wavelength. (The group velocity is the speed at which energy in a particular mode travels along a fibre).

The intramodal dispersion depends upon the wavelength and therefore, its effect on signal distortion increases with the spectral width of the optical source. The spectral width of the optical source is defined as the band of wavelengths over which the optical source emits light. As shown in the fig. $\lambda_0$ is peak emission wavelength and $\Delta\lambda$ is the spectral width. The dispersion that occurs due to the core material as a function of a wavelength is called intramodal dispersion.

The spectral width is normally characterized by the root mean square spectral width denoted by $\alpha_2$. In case of light emitting Elioide as an-optical source the spectral width is approximately 5 percent of the central wavelength.

There are two main causes of intramodal dispersion.

(a) Material dispersion

(b) Wavelength dispersion.

(a) Material dispersion: The refractive index of the core material depend upon the wavelength of the guided mode. As the group velocity of the given mode depends upon the refractive index of the core material of fibre, therefore, group velocity of an given mode depends upon the wavelength. The above said effect is similar to the deviation of the different wavelengths by different angles by a given prism due to the different refractive index of the prism for different wavelengths.

(b) Waveguide dispersion: In a given single-mode optical fibre, 80% of the total optical power is being transmitted through the core. The remaining 20% signal is travelling through the cladding. As the refractive index of the cladding is less as compared to the refractive index of core, light signal propagating through
the cladding travels faster than light signal propagating through core. The
dispersion that arises is called waveguide dispersion. It is observed that in case
of a single mode operation near zero, dispersion wavelength \( \lambda_0 = 1300 \text{ nm} \),
the intermodal and material dispersion disappear and waveguide dispersion its
name. arises.

The propagation constant \( K \) is function of \( \frac{a}{\lambda} \), where ‘a’ is the radius of
core, and is the wavelength of the signal. Hence the amount Of waveguide
dispersion depends on the fibre dimension. This effect is only the result of the
guiding properties of the fibre and hence its name.

2. Intermodal Dispersion : The intermodal dispersion is a result of
the fact that each mode is having different value of the group velocity at a single
frequency. The intermodal dispersion gives rise to pulse spreading or pulse
dispersion. A dispersion in which the pulse spreading is due to the result of each
mode having different value of the group velocity at a single frequency is called
intermodal dispersion.

The disadvantages of optical fibres are

**Price** - Even though the raw material for making optical fibres, sand, is
abundant and cheap, optical fibres are still more expensive per metre than copper.
Although, one fibre can carry many more signals than a single copper cable and
the large transmission distances mean that fewer expensive repeaters are required.

**Fragility** - Optical fibres are more fragile than electrical wires.

**Affected by chemicals** - The glass can be affected by various chemicals
including hydrogen gas (a problem in underwater cables.)

**Opaqueness** - Despite extensive military use it is known that most
fibres become opaque when exposed to radiation.

**Requires special skills** - Optical fibres cannot be joined together as
easily as copper cable and requires additional training of personnel and expensive
precision splicing and measurement equipment.

### 5.5 Advantages of Fiber Optic Communication

The following are the advantages of fibre optic cables

1. These cables offer very low attenuation of the order of 0.01 db of
   one kilometer.

2. They offer very band width and hence higher data carrying capability.

3. They are more immune to electrical and magnetic interferences.
4. Fibre cables are very light in weight and are also more flexible.
5. They have large traffic carrying capability.
6. The security is more because tapping is not possible.
7. Electrical hazard problem does not occur because only 5 to 12 volts power supplies are sufficient.
8. They withstand to vibration.
9. No shielding requirement.
10. Very few repeaters will fill our requirement.
11. They are very small size.
12. There is no need to worry about ground loops.
13. Fibre to Fiber cross talk is very low.
14. Silica is the principle material of which optical fibre are made.

5.5.1 Application of Fibre Optics

The application of fibre optic technology in the various fields are given below. In general fibre optics are used in all communication links.

1. Air-Craft maintenance and manufacture.
2. Automatic industry.
3. Data processing purpose.
4. Telecommunications trucking.
5. Medicine.
8. Instrumentation.
10. Air planes, ships and computer networks.
11. Wave length multiplexing system.
12. Interfacing with synchronous signal.
15. Analog links for video, telemetry, IF and RF remoting.
17. System measurement.
18. In closed circuit TV system.
19. Ship board communications.
20. Manufacturing of metals.
22. College campus communications.

### 5.6 Types of Fibre Optic Cables

Understanding the characteristics of different fiber types aids in understanding the applications for which they are used. Operating a fiber optic system properly relies on knowing what type of fiber is being used and why. There are two basic types of fiber: multimode fiber optic cable and single-mode fiber optic cable. Multimode fiber is best designed for short transmission distances, and is suited for use in LAN systems and video surveillance. Single-mode fiber is best designed for longer transmission distances, making it suitable for long-distance telephony and multichannel television broadcast systems.

#### Multimode Fiber

![Total Internal Reflection in Multimode Step-index fiber](image)

Multimode fiber, the first to be manufactured and commercialized, simply refers to the fact that numerous modes or light rays are carried simultaneously through the waveguide. Modes result from the fact that light will only propagate in the fiber core at discrete angles within the cone of acceptance. This fiber type
has a much larger core diameter, compared to single-mode fiber, allowing for the larger number of modes, and multimode fiber is easier to couple than single-mode optical fiber.

Multimode fiber may be categorized as step-index or graded-index fiber. Multimode Step-index Fiber, fig. 5.3 shows how the principle of total internal reflection applies to multimode step-index fiber. Because the core’s index of refraction is higher than the cladding’s index of refraction, the light that enters at less than the critical angle is guided along the fiber.

Three different lightwaves travel down the fiber. One mode travels straight down the center of the core. A second mode travels at a steep angle and bounces back and forth by total internal reflection. The third mode exceeds the critical angle and refracts into the cladding. Intuitively, it can be seen that the second mode travels a longer distance than the first mode, causing the two modes to arrive at separate times. This disparity between arrival times of the different light rays is known as dispersion, and the result is a muddied signal at the receiving end. For a more detailed discussion of dispersion, see “Dispersion in Fiber Optic Systems” however, it is important to note that high dispersion is an unavoidable characteristic of multimode step-index fiber.

Multimode Graded-index Fiber Graded-index refers to the fact that the refractive index of the core gradually decreases farther from the center of the core. The increased refraction in the center of the core slows the speed of some light rays, allowing all the light rays to reach the receiving end at approximately the same time, reducing dispersion. Figure 5.4 shows the principle of multimode graded-index fiber. The core’s central refractive index, nA, is greater than that of the outer core’s refractive index, nB. As discussed earlier, the core’s refractive index is parabolic, being higher at the center.

![Fig. 5.4 Multimode Graded-index Fiber](image-url)
As Figure 5.4 shows, the light rays no longer follow straight lines; they follow a serpentine path being gradually bent back toward the center by the continuously declining refractive index. This reduces the arrival time disparity because all modes arrive at about the same time. The modes traveling in a straight line are in a higher refractive index, so they travel slower than the serpentine modes. These travel farther but move faster in the lower refractive index of the outer core region.

**Single-mode Fiber**

Single-mode fiber allows for a higher capacity to transmit information because it can retain the fidelity of each light pulse over longer distances, and it exhibits no dispersion caused by multiple modes. Single-mode fiber also enjoys lower fiber attenuation than multimode fiber. Thus, more information can be transmitted per unit of time. Like multimode fiber, early single-mode fiber was generally characterized as step-index fiber meaning the refractive index of the fiber core is a step above that of the cladding rather than graduated as it is in graded-index fiber. Modern single-mode fibers have evolved into more complex designs such as matched clad, depressed clad and other exotic structures.

![Fig. 5.5 Cladding Core](image)

Single-mode fiber has disadvantages. The smaller core diameter makes coupling light into the core more difficult. The tolerances for single-mode connectors and splices are also much more demanding. Single-mode fiber has gone through a continuing evolution for several decades now. As a result, there are three basic classes of single-mode fiber used in modern telecommunications systems. The oldest and most widely deployed type is non dispersion-shifted fiber (NDSF).

These fibers were initially intended for use near 1310 nm. Later, 1550 nm systems made NDSF fiber undesirable due to its very high dispersion at the 1550 nm wavelength. To address this shortcoming, fiber manufacturers developed, dispersion-shifted fiber (DSF), that moved the zero-dispersion point to the 1550 nm region. Years later, scientists would discover that while DSF worked extremely well with a single 1550 nm wavelength, it exhibits serious nonlinearities when multiple, closely-spaced wavelengths in the 1550 nm were
transmitted in DWDM systems. Recently, to address the problem of nonlinearities, a new class of fibers were introduced. These are classified as non zero-dispersion-shifted fibers (NZ-DSF). The fiber is available in both positive and negative dispersion varieties and is rapidly becoming the fiber of choice in new fiber deployment. For more information on this loss mechanism, see the article “Fiber Dispersion.”

Fig. 5.6 – Dispersion for Alternating 20 km Lengths of (+D) NZ-DSF and (-D) NZ-DSF Fiber

One additional important variety of single-mode fiber is polarization-maintaining (PM) fiber. All other single-mode fibers discussed so far have been capable of carrying randomly polarized light. PM fiber is designed to propagate only one polarization of the input light. This is important for components such as external modulators that require a polarized light input. Figure 7 shows the cross-section of a type of PM fiber. This fiber contains a feature not seen in other fiber types. Besides the core, there are two additional circles called stress rods.

Fig. 5.7
As their name implies, these stress rods create stress in the core of the fiber such that the transmission of only one polarization plane of light is favored. Single-mode fibers experience nonlinearities that can greatly affect system performance. For complete information, see “Fiber Nonlinearities.”

### 5.5 Different splice, connectors, optical, couplers, switches and relays

#### Splices

Splices normally are a permanent joint between two fibers. The two basic categories of splices are fusion and mechanical. Generally speaking, splices offer a lower return loss, lower attenuation, and greater physical strength than connectors. Also, splices are usually less expensive per splice (or per joint) than connectors, require less labor, constitute a smaller joint for inclusion into splice closures, offer a better hermetic seal, and allow either individual or mass splicing.

#### Fusion Splicing

Fusion splicing works on the principle of an electric arc ionizing the space between the prepared fibers to eliminate air and to heat the fibers to proper temperature (2,000°F). The fiber is then fed in as a semiliquid and melds into its mate. The previously removed plastic coating is replaced with a plastic sleeve or other protective device.

The perfect fusion splice results in a single fiber rather than two fibers having been joined. One drawback to fusion splicing is that it most generally must be performed in a controlled environment, that is, a splicing van or trailer, and should not be done in open spaces because of dust and other contamination.

![Fig. 5.8 Fusion Splicing](image-url)
Fusion splicing in manholes is prohibited because the electric arc generated during this process may cause explosions if gas is present. Due to the welding process, it is sometimes necessary to modify the fusion parameters to suit particular types of fibers, especially if it is necessary to fuse two different fibers (from two different manufacturers or fibers with different core/cladding structures).

Fusion splicers can be purchased rather plain, such as the fixed V-groove type, for as little as $10,000, or completely automated and capable of fusing 12 fibers in a ribbon simultaneously. To assure consistent low-loss splices, an automated splicer costing $25,000–40,000 can be acquired with features such as self-alignment and automatic loss testing.

**Mechanical Splicing**

Mechanical splicing, on the other hand, is quick and easy for restoration, its major use, and is also used for new construction, especially with multimode fiber. It does not require a controlled environment other than common sense dust control. The strength of a mechanical splice is better than most connectors; however, fusion remains the strongest method of splicing. Back reflection and loss vary dramatically from one type of splice to another. Equipment investment for specific splicing kits need not exceed $5,000.

Mechanical splices employ either a V-groove or tube-type design to obtain fiber alignment. The V-groove is probably the oldest and is still the most popular method, especially for multifiber splicing of ribbon cable. Examples of this type include the 3M Fibrlok, Siecor CamSplice, AMP CoreLink, and the Lucent CSL splice.

![Fig. 5.9 Mechanical fibers](image)
Mechanical Splicing

Tubular splices, on the other hand, require that the fibers be inserted into a small tube, which provides alignment. The splice is then glued or crimped to hold the fibers together. Examples of this type of splice include the Fastomer, Elastomeric, the AMP Optimate, and the Norland Optical Splice.

Splices originally were either glued (GTE Elastomeric) or polished (AT&T Rotary). However, splices using adhesives have been phased out of common use because of the reusability of the more modern “no-glue” type. Polished splices are very much like miniaturized connectors using ferrules and a polishing process.

Because of the extensive time required, polish type splices are also extinct. In nearly all of today’s splices, the fibers are crimped or locked to achieve fiber alignment and attachment. Most of them may be reopened for fine-tuning and possible reuse. These mechanical splices must all use some type of indexmatching gel inside to eliminate back reflection and reduce splice loss. This gel is subject to contamination, so care is required when handling the splice, particularly if it is going to be reused later.

To prepare for mechanical splicing, the fibers are first stripped of all primary coating material, cleaned with alcohol, and then cleaved as previously described. Completed splices, whether fusion or mechanical, are then placed into splicing trays designed to accommodate the particular type of splice in use. Splicing trays then fit into splice organizers and in turn into a splice closure.

Connectors

Remember that connectors are used as terminating fixtures for temporary nonfixed joints. As such, they are made to be plugged in and disconnected hundreds and possibly thousands of times. Since no one connector is ideal for every possible situation, a wide variety of connector styles and types have been developed over the short life of fiber communications. We can classify connectors by assigning them into five major categories

1. Resilient ferrule
2. Rigid ferrule
3. Grooved plate hybrids
4. Expanded beam
5. Rotary
Couplers

Optical Couplers: An optical fibre coupler is a device that distributes light from a main fibre into one or more branch fibres. Now-a-days, these couplers are used in LANS, telecommunication access networks etc.

Optical fibre couplers are passive devices in which the power transfer takes place by (a) the fibre cross-section by butt joining the fibres or by using some form of imaging optics between the fibres or (b) by through the fibres surface and normal to its axis by converting the guided core modes to both cladding and refracted modes which then enable the power sharing mechanism.

The multimode fibre couplers are sub-divided into the following main categories

(a) Three and four port couplers which are used for signal splitting, distribution and combining.

(b) Star couplers are generally used for distributing a single input signal to multiple outputs.

(c) Wave length division multiplexing, which is a specialized form of coupler designed to permit a no. of different peak wavelength optical signals to be transmitted in parallel on a single fibre. This device either combine the different optical wavelength optical signals or separate the different optical signals at the outputs.

Switches

Definition

An optical switch is used to alter outputs or complete a circuit in telecommunication systems. A switch is an electrical component used to interrupt, divert or break an electrical current.

Applications

Optical switches can be used to switch optical fibers and IOC (Integrated Optical Circuits) from one circuit to another. An optical fiber is a thin fiber that transmits light between the two sides of the fiber. Fiber optics are used to facilitate fiber-optic communications, which enable communication over long distances at high bandwidths. Integrated Optical Circuits, also known as silicon chips, are used to control the processors of devices such as computers and cellular phones.
Types

- Optical switch types include photonic and electro-optic. Photonic switches physically switch circuits using tiny mirrors that reflect input signals and direct them to different ports. Electro-optic optical switches connect optical fiber lines by internally converting photons to electrons on the input end, and converting the electrons back to photons on the output end.

Relays

To keep pace with advances in the electronics industry, test and measurement systems increasingly require advanced solid-state relays that combine low capacitance, low on-resistance, physical isolation and high linearity.

All these characteristics play an important role as data acquisition devices become faster and more precise. Here’s why

- Low capacitance Improves switching times and isolation characteristics for high frequency load signals.
- Low on-resistance Reduces power dissipation when switching high currents and increases switching speeds to improve the precision of measurement.
- When considering on-resistance values, pay close attention to the temperature range the relay must withstand. Rising temperatures decrease the mobility of electrons, driving up the on-resistance. Starting with a relay that has low on-resistance will minimize the effects of temperature drift.
- Physical isolation. Sometimes referred to as galvanic separation, physical isolation between the relay’s input and output or between different output channels enhances precision by minimizing noise. Optically-isolated relays offer a true physical separation of the input and output, and the best of these products exhibit isolation voltages as high as 5,000 volts AC.
- High linearity ensures accurate measurements.

With a variety of signals at work in a typical test system, it’s particularly important to find relays that offer the right combination of electrical characteristics. For example, many systems have both DC and AC switching needs and will require relays that combine low-on-resistance and low capacitance: The low on-resistance minimizes signal loss when switching DC signals, while low capacitance improves isolation when switching AC signals.
Types of Relays

<table>
<thead>
<tr>
<th>Relays</th>
<th>Package</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM1271</td>
<td>SOP-4</td>
<td>MOSFET Driver</td>
<td>4500.0</td>
</tr>
<tr>
<td>VO3120</td>
<td>DIP-8, SMD-8</td>
<td>MOSFET Driver</td>
<td>5300.0</td>
</tr>
</tbody>
</table>

5.8 Operation of Led used in Optical Fiber Communication

Light emitters are a key element in any fiber optic system. This component converts the electrical signal into a corresponding light signal that can be injected into the fiber. The light emitter is an important element because it is often the most costly element in the system, and its characteristics often strongly influence the final performance limits of a given link.

LEDs are complex semiconductors that convert an electrical current into light. The conversion process is fairly efficient in that it generates little heat compared to incandescent lights. LEDs are of interest for fiber optics because of five inherent characteristics: 1. They are small. 2. They possess high radiance (i.e., they emit lots of light in a small area). 3. The emitting area is small, comparable to the dimensions of optical fibers. 4. They have a very long life, offering high reliability. 5. They can be modulated (turned off and on) at high speeds. Table 1 offers a quick comparison of some of the characteristics for lasers and LEDs.

Light Emitter Performance Characteristics

Several key characteristics of LEDs determine their usefulness in a given application. These are Peak Wavelength:

**Wavelength**: This is the wavelength at which the source emits the most power. It should be matched to the wavelengths that are transmitted with the least attenuation through optical fiber. The most common peak wavelength are 780, 850, and 1310 nm.

**Spectral Width**: Ideally, all the light emitted from an LED would be at the peak wavelength, but in practice the light is emitted in a range of wavelengths centered at the peak wavelength. This range is called the spectral width of the source.

**Emission Pattern**: The pattern of emitted light affects the amount of light that can be coupled into the optical fiber. The size of the emitting region should be similar to the diameter of the fiber core.
**Power**: The best results are usually achieved by coupling as much of a source’s power into the fiber as possible. The key requirement is that the output power of the source be strong enough to provide sufficient power to the detector at the receiving end, considering fiber attenuation, coupling losses and other system constraints. In general, LEDs are less powerful than lasers.

**Speed**: A source should turn on and off fast enough to meet the bandwidth limits of the system. The speed is given according to a source’s Rise or fall time, the time required to go from 10% to 90% of peak power.

LEDs have slower rise and fall times than lasers. Linearity is another important characteristic for some applications. Linearity represents the degree to which the optical output is directly proportional to the electrical current input. Most light sources give little or no attention to linearity, making them usable only for digital applications. Analog applications require close attention to linearity. Nonlinearity in LEDs causes harmonic distortion in the analog signal that is transmitted over an analog fiber optic link.

LEDs are generally more reliable than lasers, but both sources will degrade over time. This degradation can be caused by heat generated by the source and uneven current densities. In addition, LEDs are easier to use than lasers. LEDs are found in a wide variety of consumer electronics products. LEDs are used as visible indicators in most electronics equipment, and laser diodes are most widely used in compact disk (CD) players. The LEDs used in fiber optics differ from the more common indicator.

(a) LED  (b) Laser

![Fig. 5.10 Emitter Characteristics](image)
LEDs in two ways: 1. The wavelength is generally in the near infrared (because the optical loss of fiber is lowest at these wavelengths). 2. The LED emitting area is generally much smaller in order to allow the highest possible modulation bandwidth and improve the coupling efficiency with small core optical fibers. LEDs and laser diodes are very similar devices. In fact, when operating below their threshold current, all laser diodes act as LEDs.

The plots show the relative amount of light output versus electrical drive current. The LED outputs light that is approximately linear with the drive current. Nearly all LEDs exhibit a “droop” in the curve as shown in Figure 2b. This nonlinearity in the LED limits its usefulness in analog applications.

The droop can be caused by a number of factors in the LED semiconductor physics but is often largely due to self-heating of the LED chip. All LEDs drop in efficiency as their operating temperature increases. Thus, as the LED is driven to higher currents, the LED chip gets hotter causing a drop in conversion efficiency and the droop apparent. LEDs are typically operated at currents to about 100 mA peak. Only specialized devices operate at higher current levels.

5.9 Operation of LASER diodes used in Optical fiber system

Light emitters are a key element in any fiber optic system. This component converts the electrical signal into a corresponding light signal that can be injected into the fiber. The light emitter is an important element because it is often the most costly element in the system, and its characteristics often strongly influence the final performance limits of a given link. Laser Diodes are complex semiconductors that convert an electrical current into light. The conversion process is fairly efficient in that it generates little heat compared to incandescent lights. Five inherent properties make lasers attractive for use in fiber optics.

1. They are small.

2. They possess high radiance (i.e., They emit lots of light in a small area).

3. The emitting area is small, comparable to the dimensions of optical fibers.

4. They have a very long life, offering high reliability.

5. They can be modulated (turned off and on) at high speeds.
Laser Diode Performance Characteristics

Several key characteristics lasers determine their usefulness in a given application.

There are

**Peak Wavelength** : This is the wavelength at which the source emits the most power. It should be matched to the wavelengths that are transmitted with the least attenuation through optical fiber. The most common peak wavelengths are 1310, 1550, and 1625 nm.

**Spectral Width** : Ideally, all the light emitted from a laser would be at the peak wavelength, but in practice the light is emitted in a range of wavelengths centered at the peak wavelength. This range is called the spectral width of the source.

**Emission Pattern** : The pattern of emitted light affects the amount of light that can be coupled into the optical fiber. The size of the emitting region should be similar to the diameter of the fiber core. Figure 2 illustrates the emission pattern of a laser.

**Power** : The best results are usually achieved by coupling as much of a source’s power into the fiber as possible. The key requirement is that the output power of the source be strong enough to provide sufficient power to the detector at the receiving end, considering fiber attenuation, coupling losses and other system constraints. In general, lasers are more powerful than LEDs.

Fig. 5.11 - Laser Emission Pattern
Speed: A source should turn on and off fast enough to meet the bandwidth limits of the system. The speed is given according to a source's rise or fall time, the time required to go from 10% to 90% of peak power. Lasers have faster rise and fall times than LEDs. Linearity is another important characteristic to light sources for some applications. Linearity represents the degree to which the optical output is directly proportional to the electrical current input. Most light sources give little or no attention to linearity, making them usable only for digital applications.

Analog applications require close attention to linearity. Nonlinearity in lasers causes harmonic distortion in the analog signal that is transmitted over an analog fiber optic link. Lasers are temperature sensitive; the lasing threshold will change with the temperature. Figure 3 shows the typical behavior of a laser diode. As operating temperature changes, several effects can occur. First, the threshold current changes. The threshold current is always lower at lower temperatures and vice versa. The second change that can be important is the slope efficiency.

The slope efficiency is the number of milliwatts or microwatts of light output per milliampere of increased drive current above threshold. Most lasers show a drop in slope efficiency as temperature increases. Thus, lasers require a method of stabilizing the threshold to achieve maximum performance. Often, a photodiode is used to monitor the light output on the rear facet of the laser. The current from the photodiode changes with variations in light output and provides feedback to adjust the laser drive current.

5.10 Working of PIN diode used as detector in optical fiber communication

Detectors perform the opposite function of light emitters. They convert optical signals back into electrical impulses that are used by the receiving end of the fiber optic data, video, or audio link. The most common detector is the semiconductor photodiode, which produces current in response to incident light. Detectors operate based on the principle of the p-n junction. An incident photon striking the diode gives an electron in the valence band sufficient energy to move to the conduction band, creating a free electron and a hole.

If the creation of these carriers occurs in a depleted region, the carriers will quickly separate and create a current. As they reach the edge of the depleted area, the electrical forces diminish and current ceases. While the p-n diodes are insufficient detectors for fiber optic systems, both PIN photodiodes and avalanche photodiode (APDs) are designed to compensate for the drawbacks of the p-n diode.
Important Detector Parameters

- **Responsivity**: Ratio of current output to light input. High responsivity equals high receiver sensitivity.

- **Quantum Efficiency**: Ratio of primary electron-hole pairs created by incident photons to the photons incident on the detector material.

  **Capacitance**: Dependent upon the active area of the device and the reverse voltage across the device. This relationship is illustrated.

  **Response Time**: Time needed for the photodiode to respond to optical inputs and produce an external current.

- **Response**: Time can be affected by dark current, noise, linearity, backreflection, and edge effect (see Figure 2). Edge effect results from the fact that detectors only provide fast response in their center region. The outer region of the detector has a higher responsivity than the center region, which can cause problems when aligning the fiber to the detector. The higher responsivity may fool one into thinking they have aligned the fiber to the center region. Because response is much slower at the edge, this misalignment will reduce the response time of the detector.

**PIN Photodiode**

A p-n diode’s deficiencies are related to the fact that the depletion area (active detection area) is small; many electron-hole pairs recombine before they can create a current in the external circuit. In the PIN photodiode, the depleted region is made as large as possible. A lightly doped intrinsic layer separates the more heavily doped p-types and n-types. The diode’s name comes from the
layering of these materials positive, intrinsic, negative — PIN. Figure 3 shows the cross-section and operation of a PIN photodiode.

![PIN Photodiode](image1)

**Fig. 5.13 — PIN Photodiode**

### 5.11 Working of APD used in detector in optical fiber communication

Avalanche Photodiode (APD)

![APD](image2)

**Fig. 5.14 — APD**
The avalanche photodiode (APD) operates as the primary carriers, the free electrons and holes created by absorbed photons, accelerate, gaining several electron Volts of kinetic energy. A collision of these fast carriers with neutral atoms causes the accelerated carriers to use some of their own energy to help the bound electrons break out of the valence shell. Free electron-hole pairs, called secondary carriers, appear.

Collision ionization is the name for the process that creates these secondary carriers. As primary carriers create secondary carriers, the secondary carriers themselves accelerate and create new carriers. Collectively, this process is known as photomultiplication. Typical multiplication ranges in the tens and hundreds. For example, a multiplication factor of eighty means that, on average, eighty external electrons flow for every photon of light absorbed. APDs require high-voltage power supplies for their operation.

The voltage can range from 30 or 70 Volts for InGaAs APDs to over 300 Volts for Si APDs. This adds circuit complexity. Also, APDs are very temperature sensitive, further complicating circuit requirements. In general, APDs are only useful for digital systems because they possess very poor linearity. Because of the added circuit complexity and the high voltages that the parts are subjected to, APDs are always less reliable than PIN detectors. This, added to the fact that at lower data rates, PIN detector-based receivers can almost match the performance of APD-based receivers, makes PIN detectors the first choice for most deployed low-speed systems. At multigigabit data rates, however, APDs rule supreme.

**Short Answer Type Questions**

1. What is Fibre Optic?
2. What are the types of Fibres?
3. List the advantages of Fibre Optics.
4. List any four applications of Fibre Optics.
5. Explain the basic principle of data transmission through Fibre optic cable.
6. Define numerical aperture
7. Define modes.
9. Define internal reflection in fiber optic cables.
10. Mention the types of fiber optic cables
11. Mention the optical fiber components.
12. Write application of LED’s.
13. Write application of LASER diodes.
14. Write application of APD.
15. Write working principles of PIN diode.

**Long Answer Type Questions**

1. Draw the block diagram of Fibre optic communications system and explain its working.
2. Draw the block diagram of optical fibre transmitter and explain about it briefly.
3. Draw the block diagrams of optical fibre receiver and explain about it briefly.
4. Explain total internal reflection phenomena used in optical fibers.
5. Explain advantages of optical fibers in communication.
6. Explain working of LED used in optical fiber communication.
7. Explain working of LASER diodes used in optical fiber communication.
8. Explain working of PIN diode in optical fiber communication.
9. Explain the working of APD in fiber optic communication.
UNIT 6

Fibre Communication Systems

Structure

6.1 Fiber optic communication system, block diagram, working
6.2 Repeaters and optical amplifiers working
6.3 Wave length division, multiplexing
6.4 Working principles of DWDM
6.5 Optical fiber in Local area network
6.6 Ethernet on fiber and Gigabit ethernet, working
6.7 Application of optical fibers
6.8 Application of optical fibers in local telephone and cable TV applications.
6.9 Various tools used for measurement of parameters of OFC’s.
6.10 OTDR application and servicing

Learning Objective

After studying this unit, the student will be able to know

• Block diagram of optical fiber system
• Working of repeaters and amplifiers and its applications
Introduction

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. The light forms an electromagnetic carrier wave that is modulated to carry information. First developed in the 1970s, fiber-optic communication systems have revolutionized the telecommunications industry and have played a major role in the advent of the Information Age. Because of its advantages over electrical transmission, optical fibers have largely replaced copper wire communications in core networks in the developed world.

The process of communicating using fiber-optics involves the following basic steps: Creating the optical signal involving the use of a transmitter, relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak, receiving the optical signal, and converting it into an electrical signal.

6.1 Fiber optic communication system, block diagram, working

The basic blocks: Fiber optic communication systems are transmitter, optical fiber cable and receiver. The transmitter consists of light source and its associated drive circuit, optical fiber cable offers mechanical and environment protection to optical fibers contained inside and receiver consists of photodetector, amplification and signal restoring circuit Information to be conveyed enters an electronic transmitter. In electronic transmitter it is converted into electrical form, modulated and multiplexed. The electrical signal then goes to optical transmitter where it is converted into optical form i.e. into light.

The Light Signal: Then transmitted over optical fiber. At the receiver end, light signal is received by optical detector which converts the light signal into an electrical signal. The electrical signal then enters into electronic receiver where electrical signal is processed to get the exact information.

Transmitter: The heart of the transmitter is a light source. The main function of light source is to convert an information signal from its electrical form into light. LEDs and laser diodes are used as light sources.

Optical Fiber: The transmission medium in fiber optic communication systems is an optical fiber. The optical fiber is the transparent and flexible filament that guides light from a transmitter to a receiver. The optical fiber provides the connection between a transmitter and a receiver. The optical fiber basically consists of two concentric layers, the light carrying core and the cladding.
The cladding acts as a refractive index medium which allows the light to be transmitted through the core and to the other end with very little distortion or attenuation.

**Receiver:** The heart of an optical receiver is the photo detector. The major task of a photo detector is to convert an optical information signal back into an electrical signal.

![Block Diagram Optical Fibre Communication](image-url)
6.2 Working of Repeater and Optical Amplifiers

Optical Amplifier

Most optical amplifiers amplify incident light through stimulated emission, the same mechanism that is used by lasers. Indeed, an optical amplifier is nothing but a laser without feedback. Its main ingredient is the optical gain realized when the amplifier is pumped (optically or electrically) to achieve population inversion.

The optical gain, in general, depends not only on the frequency (or wavelength) of the incident signal, but also on the local beam intensity at any point inside the amplifier. Details of the frequency and intensity dependence of the optical gain depend on the amplifier medium. To illustrate the general concepts, let us consider the case in which the gain medium is modeled as a homogeneously broadened two-level system.

An optical amplifier is a device that amplifies an optical signal directly, without the need to first convert it to an electrical signal. An optical amplifier may be thought of as a laser without an optical cavity, or one in which feedback from the cavity is suppressed. Optical amplifiers are important in optical communication and laser physics.

There are several different physical mechanisms that can be used to amplify a light signal, which correspond to the major types of optical amplifiers. In doped fiber amplifiers and bulk lasers, stimulated emission in the amplifier’s gain medium causes amplification of incoming light. In semiconductor optical amplifiers (SOAs), electron-hole recombination occurs. In Raman amplifiers, Raman scattering of incoming light with phonons in the lattice of the gain medium produces photons coherent with the incoming photons. Parametric amplifiers use parametric amplification.

![Fig. 6.2 Optical Amplifier](image)
Repeater

An optical communications repeater is used in a fiber-optic communications system to regenerate an optical signal by converting it to an electrical signal, processing that electrical signal and then retransmitting an optical signal. Such repeaters are used to extend the reach of optical communications links by overcoming loss due to attenuation of the optical fibre and distortion of the optical signal. Such repeaters are known as optical-electrical-optical (OEO) due to the conversion of the signal. Repeaters are also called regenerators for the same reason.

Fiber optical repeater (FOR) is different from wireless repeater with the way of transmission. When wireless booster receives the mobile phone signal through the airspace, it can regenerate and amplify it to expand the signal coverage of the cellular base station. Fiber optical repeater transmits signal through fiber line. Using a fiber-optic repeater every 28-43 miles (45-70 km), the data signal can be transmitted for great distances. It consists of the Master Block (called Donor unit, near or in the Base station), fiber-optic networks, Slave Block (called Remote Unit) and antenna. Old analog signals used amplifiers to extend the distance of a signal.

![Fig. 6.3 Repeaters](image-url)
Amplifiers, however, had the unwanted effect of amplifying electrical noise as well as the original signal. Fiber-optic repeaters, on the other hand, remove noise that has entered a signal. This is because digital signals can be electronically separated from unwanted noise. Unlike analog signals, even a weak and distorted fiber signal can be cleaned up and sent further down the network line.

### 6.3 Wavelength division of multiplexing

In fiber-optic communications, **wavelength-division multiplexing** (WDM) is a technology which multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths (i.e. colours) of laser light. This technique enables bidirectional communications over one strand of fiber, as well as multiplication of capacity.

The term wavelength-division multiplexing is commonly applied to an optical carrier (which is typically described by its wavelength), whereas frequency-division multiplexing typically applies to a radio carrier (which is more often described by frequency). Since wavelength and frequency are tied together through a simple directly inverse relationship, the two terms actually describe the same concept.

**WDM systems**

![Fig 6.4 Nortel's WDM System](image)
A WDM system uses a multiplexer at the transmitter to join the signals together, and a demultiplexer at the receiver to split them apart. With the right type of fiber it is possible to have a device that does both simultaneously, and can function as an optical add-drop multiplexer. The optical filtering devices used have conventionally been etalons, stable solid-state single-frequency Fabry–Pérot interferometers in the form of thin-film-coated optical glass.

The concept was first published in 1970, and by 1978 WDM systems were being realized in the laboratory. The first WDM systems combined only two signals. Modern systems can handle up to 160 signals and can thus expand a basic 10 Gbit/s system over a single fiber pair to over 1.6 Tbit/s.

WDM systems are popular with telecommunications companies because they allow them to expand the capacity of the network without laying more fiber. By using WDM and optical amplifiers, they can accommodate several generations of technology development in their optical infrastructure without having to overhaul the backbone network. Capacity of a given link can be expanded simply by upgrades to the multiplexers and demultiplexers at each end.

This is often done by use of optical-to-electrical-to-optical (O/E/O) translation at the very edge of the transport network, thus permitting interoperation with existing equipment with optical interfaces.

Most WDM systems operate on single-mode fiber optical cables, which have a core diameter of 9 µm. Certain forms of WDM can also be used in multi-mode fiber cables (also known as premises cables) which have core diameters of 50 or 62.5 µm.

Early WDM systems were expensive and complicated to run. However, recent standardization and better understanding of the dynamics of WDM systems have made WDM less expensive to deploy.

Optical receivers, in contrast to laser sources, tend to be wideband devices. Therefore the demultiplexer must provide the wavelength selectivity of the receiver in the WDM system.

WDM systems are divided into different wavelength patterns, conventional/coarse (CWDM) and dense (DWDM). Conventional WDM systems provide up to 8 channels in the 3rd transmission window (C-Band) of silica fibers around 1550 nm. Dense wavelength division multiplexing (DWDM) uses the same transmission window but with denser channel spacing. Channel plans vary, but a typical system would use 40 channels at 100 GHz spacing or 80 channels with 50 GHz spacing. Some technologies are capable of 12.5 GHz
Spacing (sometimes called ultra dense WDM). Such spacings are today only achieved by free-space optics technology. New amplification options (Raman amplification) enable the extension of the usable wavelengths to the L-band, more or less doubling these numbers.

Coarse wavelength division multiplexing (CWDM) in contrast to conventional WDM and DWDM uses increased channel spacing to allow less sophisticated and thus cheaper transceiver designs. To provide 8 channels on a single fiber CWDM uses the entire frequency band between second and third transmission window (1310/1550 nm respectively) including both windows (minimum dispersion window and minimum attenuation window) but also the critical area where OH scattering may occur, recommending the use of OH-free silica fibers in case the wavelengths between second and third transmission window should also be used. Avoiding this region, the channels 47, 49, 51, 53, 55, 57, 59, 61 remain and these are the most commonly used.

WDM, DWDM and CWDM are based on the same concept of using multiple wavelengths of light on a single fiber, but differ in the spacing of the wavelengths, number of channels, and the ability to amplify the multiplexed signals in the optical space. EDFA provide an efficient wideband amplification for the C-band, Raman amplification adds a mechanism for amplification in the L-band. For CWDM wideband optical amplification is not available, limiting the optical spans to several tens of kilometres.

6.4 Principle of DWDM

The emergence of DWDM is one of the most recent and important phenomena in the development of fiber optic transmission technology. In the following discussion we briefly trace the stages of fiber optic technology and the place of DWDM in that development. We then examine the functions and components of a DWDM system, including the enabling technologies, and conclude with a high-level description of the operation of a DWDM system.

At its core, DWDM involves a small number of physical-layer functions. These are depicted in Figure 2-5, which shows a DWDM schematic for four channels. Each optical channel occupies its own wavelength.

Note: Wavelength is expressed (usually in nanometers) as an absolute point on the electromagnetic spectrum. The effective light at a given wavelength is confined narrowly around its central wavelength.
The system performs the following main functions

**Generating the signal**: The source, a solid-state laser, must provide stable light within a specific, narrow bandwidth that carries the digital data, modulated as an analog signal.

**Combining the signals**: Modern DWDM systems employ multiplexers to combine the signals. There is some inherent loss associated with multiplexing and demultiplexing. This loss is dependent upon the number of channels but can be mitigated with optical amplifiers, which boost all the wavelengths at once without electrical conversion.

**Transmitting the signals**: The effects of crosstalk and optical signal degradation or loss must be reckoned with in fiber optic transmission. These effects can be minimized by controlling variables such as channel spacings, wavelength tolerance, and laser power levels. Over a transmission link, the signal may need to be optically amplified.

**Separating the received signals**: At the receiving end, the multiplexed signals must be separated out. Although this task would appear to be simply the opposite of combining the signals, it is actually more technically difficult.
Receiving the signals: The demultiplexed signal is received by a photodetector.

In addition to these functions, a DWDM system must also be equipped with client-side interfaces to receive the input signal. This function is performed by transponders (see the “Interfaces to DWDM” section). On the DWDM side are interfaces to the optical fiber that links DWDM systems.

Enabling Technologies

Optical networking, unlike SONET/SDH, does not rely on electrical data processing. As such, its development is more closely tied to optics than to electronics. In its early form, as described previously, WDM was capable of carrying signals over two widely spaced wavelengths, and for a relatively short distance. To move beyond this initial state, WDM needed both improvements in existing technologies and invention of new technologies. Improvements in optical filters and narrowband lasers enabled DWDM to combine more than two signal wavelengths on a fiber. The invention of the flat-gain optical amplifier, coupled in line with the transmitting fiber to boost the optical signal, dramatically increased the viability of DWDM systems by greatly extending the transmission distance.

Other technologies that have been important in the development of DWDM include improved optical fiber with lower loss and better optical transmission characteristics, EDFAs, and devices such as fiber Bragg gratings used in optical add/drop multiplexers.

Components and Operation

DWDM is a core technology in an optical transport network. The essential components of DWDM can be classified by their place in the system as follows.

- On the transmit side, lasers with precise, stable wavelengths
- On the link, optical fiber that exhibits low loss and transmission performance in the relevant wavelength spectra, in addition to flat-gain optical amplifiers to boost the signal on longer spans
- On the receive side, photodetectors and optical demultiplexers using thin film filters or diffractive elements
- Optical add/drop multiplexers and optical cross-connect components

These and other components, along with their underlying technologies, are discussed in the following sections. While much of this information, particularly the pros and cons of various competing technologies, may be of more importance to a system designer than to an end user or network designer, it may also be of
interest to other readers. Note as well that this is summary information and is not intended to be complete or authoritative.

### 6.5 Optical Fiber in Local Area Network

Local Area Network (LAN) is a combined group of computers, or computer systems, connected to each other that allow shared program software or data bases. LAN systems are used by colleges, universities, office buildings, and industrial plants, for making use of optical fiber.

#### LAN in Colleges and Universities

With the technology of LAN and fiber optic applications, college students and professors can do their research from their rooms and offices without having to go to the library. It provides access to other campus colleges, enabling staff members to perform research with other college professors. It also enables students to take special courses from instructors at other colleges. College students in rural areas can now have quality-advanced curriculum without the high traveling expense.

Purchasing software programs for a network will save the college a tremendous amount of money and also allows for easier upgrading. Colleges can also have passwords on their programs for denying access to unauthorized users. Using passwords, they do not have to worry about programs being illegally copied.

Colleges or universities with a large number of students can add additional computers, scanners, and modems to the network for students to share.

LAN provides dollar savings for students by allowing them to e-mail their friends at home and on other campuses instead of having to pay for a long distance phone bill.

#### LAN and Office Buildings

More and more companies today are demanding that fiber optic applications be made available when considering an office building as a rental place for their businesses. Some companies will even pay more to rent a building or office with fiber optic applications because they feel it is very important for their business to have access to a fast communication network.

Companies that use fiber optic cables to set up their LAN do not have to worry with dangling and tangled cables, and their data is transmitted at an even higher quality and speed than with other network applications. With the fiber optic system, the company does not have to be concerned about a fire
hazard because no electricity runs through the cables. Many very large office buildings use fiber optic lighting for their offices or for outdoor advertisements.

**LAN and Industrial Plants**

High-speed and high-quality communication links are needed in industrial plants. To monitor their processes online, industrial plants can use a fiber optic application to connect their control systems to their computer networks. A plant can also collect valuable information from other machines and plants that might help their plant’s machines run more smoothly and efficiently.

Optical fibers have many physical properties that make them an excellent choice for the harsh environmental conditions found in industrial plants such as electromagnetic interference (EMI), extreme temperatures, and even lightning strikes. Fiber optic cables are rugged, have a very large bandwidth, have long cable lengths, and are immune to electromagnetic interference (EMI).

By combining both LAN and fiber optic applications, colleges, universities, and businesses can obtain an almost endless stream of information on a daily basis. Companies can also use both of these to increase productivity while providing a convenient, safe environment for their employees and customers.

### 6.6 Ethernet on Fibre and Gigabit Ethernet

One form of cabling supported by Ethernet is fibre optic cable. This type of cable is expensive to purchase and difficult to install. Its primary use is to interconnect buildings and to connect equipment which is too remote for connection using other types of cabling (e.g. 10B5, 10B2, or 10BT). (It is also used by other networking systems than Ethernet, and may operate at much higher speeds). The official name for this cable is 10 BasebandF (10BF), indicating that it is specified for baseband communications (i.e. not modulated) at 10 Mbps using fibre optic cabling.

Fibre optic cable is usually installed by a specialist cabling contractor and â€œterminatedâ€ at a wall-mounted connector. A flexible fibre optic â€œpatchâ€ cable is used to connect a fibre optic Ethernet transceiver to the glass fibre optic cable. Fibre optic cable is much more expensive to purchase and install than copper cable. However, it has advantages.

- It is immune to electromagnetic interference
- It can span longer distances without attenuation
- It eliminates grounding problems
- It is secure from unauthorised taps
Giga Bit Ethernet

In computer networking, Gigabit Ethernet (GbE or 1 GigE) is a term describing various technologies for transmitting Ethernet frames at a rate of a gigabit per second (1,000,000,000 bits per second), as defined by the IEEE 802.3-2008 standard. It came into use beginning in 1999, gradually supplanting Fast Ethernet in wired local networks where it performed considerably faster. The cables and equipment are very similar to previous standards, and by the year 2010, were very common and economical.
Half-duplex gigabit links connected through hubs are allowed by the specification, but full-duplex usage with switches is much more common.

### 6.7 Applications of Optical Fibre

The use and demand for optical fiber has grown tremendously and optical-fiber applications are numerous. Telecommunication applications are widespread, ranging from global networks to desktop computers. These involve the transmission of voice, data, or video over distances of less than a meter to hundreds of kilometers, using one of a few standard fiber designs in one of several cable designs.

Carriers use optical fiber to carry plain old telephone service (POTS) across their nationwide networks. Local exchange carriers (LECs) use fiber to carry this same service between central office switches at local levels, and sometimes as far as the neighborhood or individual home (fiber to the home [FTTH]).

Optical fiber is also used extensively for transmission of data. Multinational firms need secure, reliable systems to transfer data and financial information between buildings to the desktop terminals or computers and to transfer data around the world. Cable television companies also use fiber for delivery of digital video and data services. The high bandwidth provided by fiber makes it the perfect choice for transmitting broadband signals, such as high-definition television (HDTV) telecasts.

Intelligent transportation systems, such as smart highways with intelligent traffic lights, automated tollbooths, and changeable message signs, also use fiber-optic-based telemetry systems.

Another important application for optical fiber is the biomedical industry. Fiber-optic systems are used in most modern telemedicine devices for transmission of digital diagnostic images. Other applications for optical fiber include space, military, automotive, and the industrial sector.

### 6.8 Application of Optical Fibres in Telephone and TV

#### 6.8.1 Optical Fibres in Telephone

Telephone transmission method uses fibre-optic cables. Optical fibres transmit energy in the form of light pulses. The technology is similar to that of the coaxial cable, except that the optical fibres can handle tens of thousands of conversations simultaneously.
The transformation of copper wire to fiber optic in the telecommunications industry has opened up the new era of technology. Since then, optical fibers are used in various applications. Presently, it is relevant to say that telecommunications industry is the dominant user for the optical fiber technology because the demand is high. Why is the demand high? The main reason is speed. People like high speed because they can get their things done quickly. Through optical fiber, information can be transferred at much greater speeds due to the fact that information is transmitted through coded flashes and lights (which travel at approximately the speed of light \( c = 3.0 \times 10^8 \text{ms}^{-1} \)) are deciphered at the receiving end.

Optical fibers have extremely high bandwidth. High bandwidth means they have greater capacity to carry more information at a faster rate, and this is the ideal that the telecommunications industries are striving towards. Presently, optical fiber can carry about 300 television channels and 45,000 phone conversations at single instances in time.

The digital protocol is based upon a 160-bit frame structure and line coding exploiting scrambling techniques. The protocol is described in detail in the EVLA Memorandum #33- “Digital Transmission System Signaling Protocol”

This advantage has forced telecommunications industries particularly the communications and entertainment industries to change the old cable system to optical fiber.

Telephone, email, fax, and videoconferencing have become lifelines, to connect one individual with another across the globe. These service providers changing their medium of connection from copper wires to optical fiber cable in order to have a safer and more secure communication. This is very useful for people who want to transfer sensitive data.

Information can only be transmitted when there are magnetic radiations. Since no magnetic fields radiated around optical fiber, therefore, it is impossible to tap the signal transmission unless one cuts into the fiber. If this is done, safety protocols will go into play and ensure that the data is not leaked. Since optical fiber is made of non-metallic compounds, therefore, it is physically safer and if it breaks, there would be any danger or direct electric shock.

Besides safer and secure communications, the telephone; which previously was limited to sound only can now link with video images and speaker. As for videoconferencing, it would allow faster and clearer transmission of image and information, which replicates traditional face to face. Through optical fiber, a clear visual image of people involved in the conference and data charts shown would provide a better understanding for both parties when dealing with an important agreement.
Applications of Optical fibre in Television

Television production and broadcast engineers have always sought out the best technology for media events such as the Olympics. In the mid-1980s, fiber optic transmission was introduced into the television industry. Since that time there has been no looking back. Fiber optics are used in all aspects of production and distribution of video and audio signals. The state of the art for the transport of analog video is to use 10-Bit Digitally Encoded. The serial digital bit rate can vary from about 144 to 300 Mbps.

With the introduction of digital video in the 1990s, fiber optic transmission systems continued to enjoy growth in the broadcast industry. Digital video was encoded into data rates ranging from 144 to 360 Mbps. These high bit rate video signals could only travel over copper up to about 300 meters. Transmission distance beyond 300 meters required fiber.

The transition to 100% DTV/HDTV has created a need to transport signals with a bit rate as high as 3 Gbps. HDTV using an SDI interface (HD-SDI), in its native or uncompressed form, is 2.97 Gbps. HD-SDI can only reach about 150 meters over a coax. Once again, fiber is the only choice to reach distances beyond 150 meters.

Systems can be designed using many of the technologies described above. Analog and digital signal transmission can be mixed. Time-division and optical multiplexing can be combined. A broadcast television station may typically reside in a downtown metropolitan area. The television transmitter and satellite up and down links may be on a distant mountaintop outside the city. This situation is a perfect application for fiber transmission. The system may require both analog video and digital video since the station may be in the midst of their conversion from analog to digital broadcast. Signals in both directions will be required to support downlink satellite video.

Another typical application is that of back-haul feeds, where many channels of video and audio are trunked together over one fiber. Such a system can use TDM to combine groups of eight channels of video with audio into single wavelengths. The optical multiplexing or CWDM technology is used to combine the wavelengths with groups of eight videos onto one fiber. The combined technique of TDM and CWDM provides a fiber transport capacity of more than 144 video channels on one fiber.

Typical applications:

- Real-time studio monitoring for editing/demonstration
- General Broadcast (News/Sports/Events)
• Broadcast Remote DVB Drop Distribution
• Post Production (Point-to-Point)
• Station Networking
• Uncompressed Transport (Post-Editing and Pre-Compression/ Distribution)
• Multi-Channel Distribution

6.9 Various tools used for measurement of parameters of OFC’s

Fiber-optic tools are instruments used by technicians in the telecommunication industry to work on fiber-optic cables and equipment. Some of the fiber-optic tools are used for installation and others are used for repair projects. These fiber-optic tools range from fiber-optic testing equipment to splicing tools.

There are certain fiber-optic tools that are necessary for the installation of fiber-optic cables. When workers are preparing a site to put in fiber-optics, they will need the fiber-optic cable, buffer cables, optical connectors and splicing tools. Other tools used in the installation process consist of a pulling fixture to pull the cable, measuring tape and safety glasses. Technicians also use high-visibility warning signs to alert people not to dig near buried fiber-optic cable.

Fig. 6.8 Measurement of parameters in OFC’s
Technicians are never without fiber-optic testing equipment, which consists of tools such as a fiber-optic identifier and micropulse continuity tester. These tools use lasers and low beeper sounds to find breaks in fiber-optic cables and detect signals. By using non-invasive techniques to inspect fibers, there is little risk of damaging the ultra thin cables.

One crucial type of fiber-optic tools used by professionals in this business is a fiber-optic test and restoration kit. Technicians use the components in this kit to quickly diagnose and fix problems that can shut down fiber-optic networks. Most restoration kits include an inspection scope to magnify breaks in fibers, a light source with visual detectors and alcohol coated swabs to wipe down connectors.

There are all kinds of optic test equipment (visual fault locators, PON optical power meters, optical light source), tool kits (optic hand tool bags, FTTH quick termination kits anaerobic field termination kits), cable preparation tools (cable cutters, precision fiber cleavers), fiber cleaning solutions and fiber polishing equipment & consumables.

Fiber optic tools are various types used in the fiber optic installation and maintenance works. There are splicing fiber optic tools, test fiber optic tools and cleaning fiber optic tools.

Common used fiber optic test equipment includes fiber optic power meter, fiber optic light source, fiber multimeter, optical time domain reflectometer (OTDR) and fiber fault locator. Power meter is used for absolute optical fiber power measurement as well as fiber optic loss related measurement. Light source is used with power meter to test the fiber system loss. Multimeter is an integrated unit of power meter and light source. OTDR is classic fiber optic test equipment, it is most easy to use but it is also one of the most expensive, OTDR could give you an overview of the whole system you test and it could test the whole system fiber length, joint point and loss. Fault locator’s name already expresses its function, it could be regarded to be part of OTDR and fiber fault locator is cheap.

Measurement of Parameters of fibre optic cables

Calibrating fiber optic power measurement equipment requires setting up a reference standard traceable to a national standards lab like the National Institute of Standards and Technology in the US for comparison purposes while calibrating every power meter or other instrument.
Measurement Uncertainty

Two Types of Measurement Errors

Measuring a physical parameter always involves errors. Unfortunately, you never know the real value you are trying to measure to begin with, so all you can do is to estimate the error based on the possible sources of error in making the measurement. There are two types of errors, random and systematic.

Random errors are what you see when you make a measurement multiple times and get a slightly different value each time. Hook up your instrument and make the measurement, disconnect and try again. Each time, the result will be slightly different. Generally one should make several measurements, average them and use the data to calculate the random error, called standard deviation, to understand the uncertainty of the measurement.

Systematic errors are how the average measurement differs from the real value, which can be caused by some problem in setup or calibration. Unfortunately, it’s hard to determine the systematic error, but some possible ways exist sometimes. We’ll look at systematic errors first.

Systematic Errors in Fiber Optic Measurements

Why would all measurements be slightly different from the “real” value. Consider testing long lengths of singlemode fibers. The attenuation coefficient of the fiber is measured by the manufacturer at 1310 nm, but your test source may have a wavelength slightly different. If your source wavelength is shorter than 1310 (say 1290 nm, still within the limits of wavelength standards for laser sources,) all measurements of loss will be slightly higher than the manufacturer’s tests. It may only be 0.02-0.03 dB/km, but over 25 km, that makes a difference of 0.5-0.75 dB loss. Likewise a test source at longer wavelength (say 1330 nm) will measure lower loss.

In multimode fiber, LED test sources, which have wide spectral output, may have not only a different wavelength, but different spectral outputs. The measured loss will be an integration of all the wavelengths. Different LEDs will measure different losses, but the effect may not be large because most measurements are made on short cables. A bigger problem is the way the output of the LED fills the modes in the core of the multimode fiber, discussed below.

For all measurements, systematic errors can be caused by testing with launch cables that have bad connectors, especially fibers not centered in the ferrule or are made with fibers with different core sizes (62.5 micron fiber cores can vary from about 60 to 65 microns.) Test this yourself, using a a light
source and power meter and two cables of 50 and 62.5 micron cores. Test loss single-ended in one direction and then the other and note the enormous difference and how it is directional.

### 6.10 OTDR applications in servicing

An optical time-domain reflectometer (OTDR) is an optoelectronic instrument used to characterize an optical fiber. An OTDR injects a series of optical pulses into the fiber under test. It also extracts, from the same end of the fiber, light that is scattered (Rayleigh backscatter) or reflected back from points along the fiber. (This is equivalent to the way that an electronic time-domain reflectometer measures reflections caused by changes in the impedance of the cable under test.) The strength of the return pulses is measured and integrated as a function of time, and is plotted as a function of fiber length.

**Maintaining Fiber Infrastructure Performance**

OTDRs are also used for maintaining fiber plant performance. An OTDR allows you to see more details on cable installation, termination quality and provides advanced diagnostics to isolate a point of failure that may hinder network performance. An OTDR allows discovery of features along the length of a fiber that may affect fiber reliability. OTDRs characterize features such as attenuation uniformity and attenuation rate, segment length, location and insertion loss of connectors and splices, and other events such as sharp bends that may have been incurred during cable installation.

### Short Answer Type Questions

1. Mention applications of optical fiber communication system.
2. What is repeaters?
3. Write functions of optical amplifiers.
4. Define wavelength division multiplexing.
5. Define DWDM.
6. Expand LAN.
7. Write applications of optical fiber.
8. What are the tools used to measure OFC’s parameters.
9. Expand OTDR.
10. Write application of LAN.
Long Answer Type Questions

1. Explain fiber optic communication system with block diagram.
2. Explain repeaters and optical amplifiers.
3. Explain working of DWDM.
4. Explain the uses of optical fiber in LAN.
5. Explain the applications of optical fibers in local telephone and Cable TV’s.
6. Explain the servicing of OTDR.