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Unit-1: WAVE PROPAGATION & ANTENNA

1.1 Effects of environments such as reflection, refraction, interference, diffraction, absorption and attenuation (Definition only)

1.2 Classification based on Modes of Propagation-Ground wave, Ionosphere ,Sky wave propagation, Space wave propagation

1.3 Definition – critical frequency, max. useable frequency, skip distance, fading, Duct propagation & Troposphere scatter propagation actual height and virtual height

1.4 Radiation mechanism of an antenna-Maxwell equation.

1.5 Definition - Antenna gains, Directive gain, Directivity, effective aperture, polarization, input impedance, efficiency, Radiator resistance, Bandwidth, Beam width, Radiation pattern

1.6 Antenna -types of antenna: Mono pole and dipole antenna and omni directional antenna

1.7 Operation of following antenna with advantage & applications.

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2.2 Equivalent circuit of transmission line & RF equivalent circuit

2.3 Characteristics impedance, methods of calculations & simple numerical.

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2.6 Quarter wave & half wavelength line

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Unit-3: TELEVISION ENGINEERING.

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3.5 Types of Televisions by Technology- cathode-ray tube TVs, Plasma Display Panels, Digital Light Processing (DLP),Liquid Crystal Display (LCD),Organic Light-Emitting Diode (OLED) Display, Quantum Light-Emitting Diode (QLED) – **only Comparison based on application**

3.6 Discuss the principle of operation - LCD display, Large Screen Display.

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3.8 Digital TV Technology-Digital TV Signals, Transmission of digital TV signals & Digital TV receiver Video programme processor unit.

Unit-4: MICROWAVE ENGINEERING.

4.1 Define Microwave Wave Guides.

4.2 Operation of rectangular wave gives and its advantage.

4.3 Propagation of EM wave through wave guide with TE & TM modes.

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4.5 Operational Cavity resonator.

4.6 Working of Directional coupler, Isolators & Circulator.

4.7 Microwave tubes-Principle of operational of two Cavity Klystron.

4.8 Principle of Operations of Travelling Wave Tubes

4.9 Principle of Operations of Cyclotron

4.10 Principle of Operations of Tunnel Diode & Gunn diode

Unit-5: Broadband communication

5.1 Broadband communication system-Fundamental of Components and Network architecture

5.2 Cable broadband data network- architecture, importance & future of broadband telecommunication internet based network.

5.3 SONET(Synchronous Optical Network)-Signal frame components topologies advantages applications, and disadvantages

5.4 ISDN - ISDN Devices interfaces, services, Architecture, applications,

5.5 BISDN -interfaces & Terminals, protocol architecture applications

Books Recommended:

1. Electronics Communication by G. Kennedy- MGH

2. Broadband Communication by Balaji Kumar (Reference)

COURSE OUTCOME:

After the completion of the course the students will be able to-

CO1-Analyze various methods of ratio wave propagation and explain different propagation terms such as critical frequency, maximum usable frequency virtual height, skip distance, fading & ducting.

CO2-Analyze different parameters of antenna for real time applications.

CO3- Characterize transmission line parameters using distributed model and solve simple SWR, reflection co-efficient, impedance matching using analytical method.

CO4-Recognize the limitation of existing vacuum tubes at microwave frequency and explain working of microwave components such as isolator, circulator, directional coupler, klystron, TWT & wave guide.

CO5-Sketch the block diagram of monochrome & color TV transmitter and receiver also identify the components of a monochrome &color TV and explain it.

Transmission Lines

A **transmission line** is a connector which transmits energy from one point to another. The study of transmission line theory is helpful in the effective usage of power and equipment.

There are basically four types of transmission lines:

- Two-wire parallel transmission lines
- Coaxial lines
- Strip type substrate transmission lines
- Waveguides

While transmitting or while receiving, the energy transfer has to be done effectively, without the wastage of power. To achieve this, there are certain important parameters which has to be considered.

Main Parameters of a Transmission Line

The important parameters of a transmission line are resistance, inductance, capacitance and conductance.

Resistance and inductance together are called as transmission line **impedance**.

Capacitance and conductance together are called as **admittance**.

Resistance

The resistance offered by the material out of which the transmission lines are made, will be of considerable amount, especially for shorter lines. As the line current increases, the ohmic loss $(I^2R\ loss)$ also increases.

The resistance **R** of a conductor of length "**l**" and cross-section "**a**" is represented as

$$R = \rho \frac{l}{a}$$

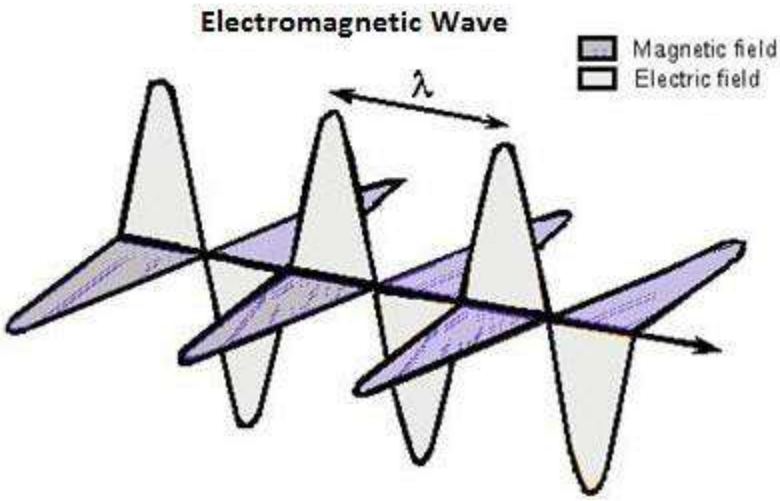
Where
ρ = resistivity of the conductor material, which is constant.

Temperature and the frequency of the current are the main factors that affect the resistance of a line. The resistance of a conductor varies linearly with the change in temperature. Whereas, if the frequency of the current increases, the current density towards the surface of the conductor also increases. Otherwise, the current density towards the center of the conductor increases.

This means, more the current flows towards the surface of the conductor, it flows less towards the center, which is known as the **Skin Effect**.

Inductance

In an AC transmission line, the current flows sinusoidally. This current induces a magnetic field perpendicular to the electric field, which also varies sinusoidally. This is well known as Faraday's law. The fields are depicted in the following figure.



This varying magnetic field induces some EMF into the conductor. Now this induced voltage or EMF flows in the opposite direction to the current flowing initially. This EMF flowing in the opposite direction is equivalently shown by a parameter known as **Inductance**, which is the property to oppose the shift in the current.

It is denoted by "**L**". The unit of measurement is "**Henry (H)**".

Conductance

There will be a leakage current between the transmission line and the ground, and also between the phase conductors. This small amount of leakage current generally flows through the surface of the insulator. Inverse of this leakage current is termed as **Conductance**. It is denoted by "**G"**.

The flow of line current is associated with inductance and the voltage difference between the two points is associated with capacitance. Inductance is associated with the magnetic field, while capacitance is associated with the electric field.

Capacitance

The voltage difference between the **Phase conductors** gives rise to an electric field between the conductors. The two conductors are just like parallel plates and the air in between them becomes dielectric. This pattern gives rise to the capacitance effect between the conductors.

Characteristic Impedance

If a uniform lossless transmission line is considered, for a wave travelling in one direction, the ratio of the amplitudes of voltage and current along that line, which has no reflections, is called as **Characteristic impedance**.

It is denoted by Z_0

$$Z_0 = \sqrt{\frac{voltage\ wave\ value}{current\ wave\ value}}$$

$$Z_0 = \sqrt{\frac{R + jwL}{G + jwC}}$$

For a lossless line, $R_0 = \sqrt{\frac{L}{C}}$

Where **L** & **C** are the inductance and capacitance per unit lengths.

Impedance Matching

To achieve maximum power transfer to the load, impedance matching has to be done. To achieve this impedance matching, the following conditions are to be met.

The resistance of the load should be equal to that of the source.

$$R_L = R_S$$

The reactance of the load should be equal to that of the source but opposite in sign.

$$X_L = -X_S$$

Which means, if the source is inductive, the load should be capacitive and vice versa.

Reflection Co-efficient

The parameter that expresses the amount of reflected energy due to impedance mismatch in a transmission line is called as **Reflection coefficient**. It is indicated by **ρ (rho)**.

It can be defined as "the ratio of reflected voltage to the incident voltage at the load terminals".

$$\rho = \frac{reflected\ voltage}{incident\ voltage} = \frac{V_r}{V_i}\ at\ load\ terminals$$

If the impedance between the device and the transmission line don't match with each other, then the energy gets reflected. The higher the energy gets reflected, the greater will be the value of **ρ** reflection coefficient.

Voltage Standing Wave Ratio (VSWR)

The standing wave is formed when the incident wave gets reflected. The standing wave which is formed, contains some voltage. The magnitude of standing waves can be measured in terms of standing wave ratios.

The ratio of maximum voltage to the minimum voltage in a standing wave can be defined as Voltage Standing Wave Ratio (VSWR). It is denoted by "**S**".

$$S = \frac{|V_{max}|}{|V_{min}|} \qquad 1 \leq S \leq \infty$$

VSWR describes the voltage standing wave pattern that is present in the transmission line due to phase addition and subtraction of the incident and reflected waves.

Hence, it can also be written as

$$S = \frac{1 + \rho}{1 - \rho}$$

The larger the impedance mismatch, the higher will be the amplitude of the standing wave. Therefore, if the impedance is matched perfectly,

$$V_{max} : V_{min} = 1:1$$

Hence, the value for VSWR is unity, which means the transmission is perfect.

Efficiency of Transmission Lines

The efficiency of transmission lines is defined as the ratio of the output power to the input power.

$$\%\, \boldsymbol{efficiency\ of\ transmission\ line\ \eta} = \frac{\boldsymbol{Power\ delievered\ at\ reception\ end}}{\boldsymbol{Power\ sent\ from\ the\ transmission\ end}} \times \mathbf{100}$$

Voltage Regulation

Voltage regulation is defined as the change in the magnitude of the voltage between the sending and receiving ends of the transmission line.

$$\%\boldsymbol{voltage\ \ regulation} = \frac{\boldsymbol{sending\ end\ voltage - receiving\ end\ voltage}}{\boldsymbol{sending\ end\ voltage}} \times \mathbf{100}$$

Losses due to Impedance Mismatch

The transmission line, if not terminated with a matched load, occurs in losses. These losses are many types such as attenuation loss, reflection loss, transmission loss, return loss, insertion loss, etc.

Attenuation Loss

The loss that occurs due to the absorption of the signal in the transmission line is termed as Attenuation loss, which is represented as

$$Attenuation\ loss\ (dB) = 10\ log_{10}\left[\frac{E_i - E_r}{E_t}\right]$$

Where

- E_i **=** the input energy
- E_r **=** the reflected energy from the load to the input
- E_t **=** the transmitted energy to the load

Reflection Loss

The loss that occurs due to the reflection of the signal due to impedance mismatch of the transmission line is termed as Reflection loss, which is represented as

$$Reflection\ loss\ (dB) = 10\log_{10}\left[\frac{E_i}{E_i - E_r}\right]$$

Where

- E_i **=** the input energy
- E_r **=** the reflected energy from the load

Transmission Loss

The loss that occurs while transmission through the transmission line is termed as Transmission loss, which is represented as

$$Transmission\ loss\ (dB) = 10\log_{10}\frac{E_i}{E_t}$$

Where

- E_i **=** the input energy
- E_t **=** the transmitted energy

Return Loss

The measure of the power reflected by the transmission line is termed as Return loss, which is represented as

$$Return\ loss\ (dB) = 10\log_{10}\frac{E_i}{E_r}$$

Where

- E_i **=** the input energy
- E_r **=** the reflected energy

Insertion Loss

The loss that occurs due to the energy transfer using a transmission line compared to energy transfer without a transmission line is termed as Insertion loss, which is represented as

$$Insertion\ loss\ (dB) = 10\log_{10}\frac{E_1}{E_2}$$

Where

- E_1 **=** the energy received by the load when directly connected to the source, without a transmission line.

- E_2 **=** the energy received by the load when the transmission line is connected between the load and the source.

Stub Matching

If the load impedance mismatches the source impedance, a method called "Stub Matching" is sometimes used to achieve matching.

The process of connecting the sections of open or short circuit lines called **stubs** in the shunt with the main line at some point or points, can be termed as **Stub Matching**.

At higher microwave frequencies, basically two stub matching techniques are employed.

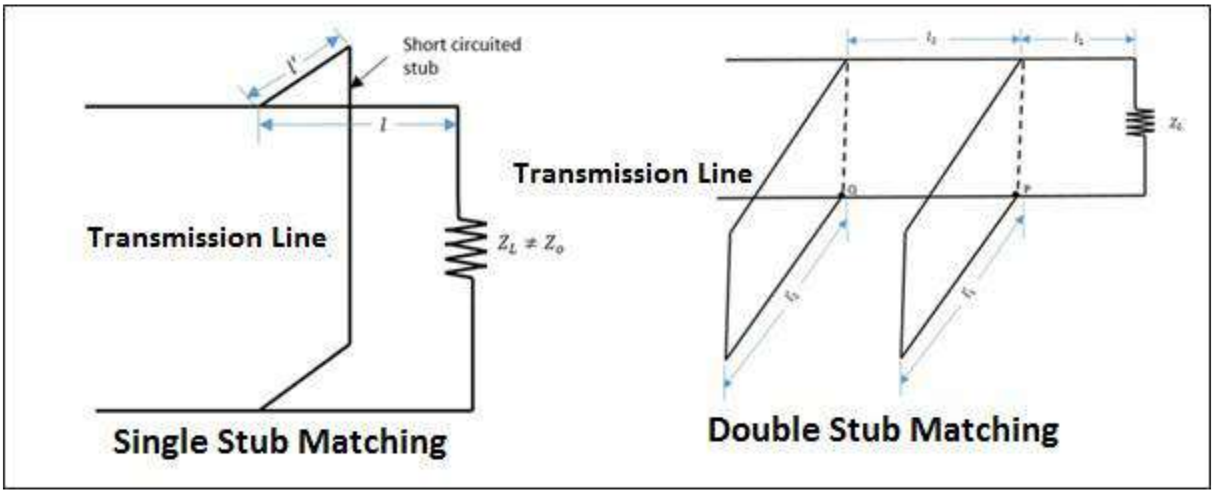
Single Stub Matching

In Single stub matching, a stub of certain fixed length is placed at some distance from the load. It is used only for a fixed frequency, because for any change in frequency, the location of the stub has to be changed, which is not done. This method is not suitable for coaxial lines.

Double Stub Matching

In double stud matching, two stubs of variable length are fixed at certain positions. As the load changes, only the lengths of the stubs are adjusted to achieve matching. This is widely used in laboratory practice as a single frequency matching device.

The following figures show how the stub matchings look.



The single stub matching and double stub matching, as shown in the above figures, are done in the transmission lines to achieve impedance matching.

UNIT-3

TELEVISION ENGINEERING

ASPECT RATIO:

The ratio between width to height of rectangle picture frame adopted in TV system is known as aspect ratio.

Aspect ratio = Width / height = 4/3 or 4: 3

Reasons for having this ratio is

1. Most of the objects are moving only in horizontal plane.
2. Our eye can see the movement of object comfortably only in horizontal plane than in vertical plane.
3. The frame size of motion picture already existing is having the aspect ratio of 4 : 3

FLICKER:

The sensation produced by incident light on the nerves of the eyes retina does not cease immediately. It persists for about 1/25th of a second (.062 Sec.) This storage characteristic is called as persistence of vision of eye.

Flicker means if the scanning rate of picture is low, the time taken to move one frame to another frame will be high. This results in alternate bright and dark picture in the screen. This is called “Flicker”.
To avoid flicker, the scanning rate of the picture should be increased i.e. 50 frames/Sec

HORIZONTAL AND VERTICAL RESOLUTION :

The ability of the image reproducing system to resolve the fine details of the picture distinctly in both horizontal and vertical direction is called as “resolution”.

• **VERTICAL RESOLUTION:** The ability to resolve and reproduce fine details of picture in vertical direction iscalled as Vertical resolution.

Vertical resolution (VR) = No. of active lines * Kell factor or resolution factor

• **HORIZONTAL RESOLUTION :**

__The ability of the system to resolve maximum number of picture elements along the scanning determines the horizontal resolution

Horizontal resolution = VR * Aspect ratio

VIDEO BANDWIDTH :

$$\text{Video Bandwidth signal} = \frac{\text{One horizontal line}}{\text{One horizontal line tracing}}$$

$$= \frac{267}{52 * 10^{-6}} = 5\text{ MHz}$$

$$\text{Video Bandwidth} = \frac{\text{Horizontal Resolution}}{2 * \text{One Horizontal line scan}} = \frac{534}{2*52*10^{-6}} = 5\text{ MHz}$$

SCANNING:

Scanning is the process used to convert the optical into electrical signal. Fastest movement of electron beam on the image is called scanning.

INTERLACED SCANNING:

To reduce flicker, the vertical scanning is done 50 times per second in TV system. However only 25 frames are scanned per sec.

In interlaced scanning the 625 lines are grouped into two fields. They are called as even field and odd field. Each field contains 312.5 lines. Even field contains even numbered lines and odd field contains odd numbered lines. During first scanning line numbers 1, 3, 5 are scanned. During next scan, line numbers 2, 4, 6.... are scanned. That is alternate lines are scanned every time. So to cover each frame, scanning is done two times. Here the vertical rate of scanning is increased twice. So it will reduce flicker.

Interlaced scanning is shown. Now the vertical frequency is 50 Hz. But there is no change in horizontal frequency.

Horizontal frequency = Number of lines in a Frame * Number of frames/sec

= 312.5 * 50 = 15,625 Hz

COMPOSITE VIDEO SIGNAL (CVS):

CVS consists of,

- Camera signal corresponding to the picture to be transmitted.
- Blanking pulses to made the retrace invisible.
- Sync pulse to synchronize the transmitter and receiver.

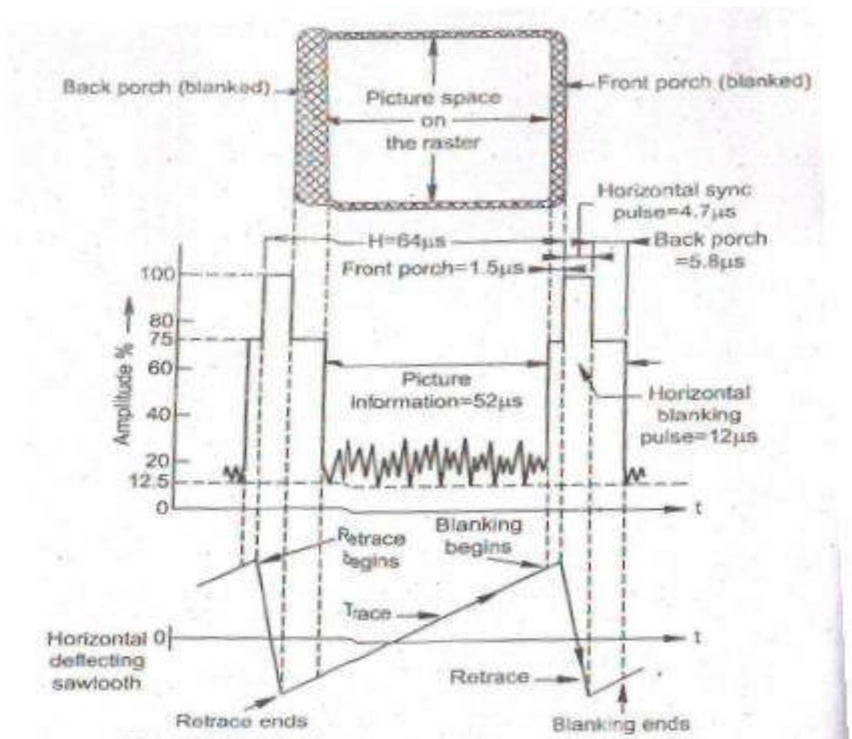
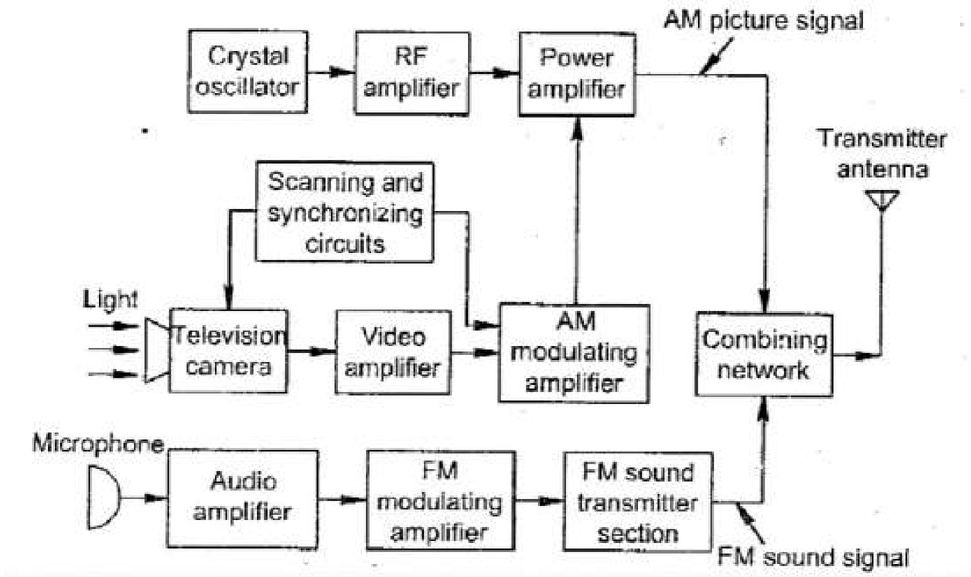


Fig.1.11 Composite video signal for one horizontal line

TV Transmitter – Block diagram & function of each block

Television means Tele + Vision, i.e., Television is used to see the picture telecast from long distance. In TV transmission both picture and sound are transmitted. For picture AM Modulation is used and for sound FM modulation is used.

The simplified block diagram of a Monochrome TV Transmitter is shown.



It consists of Television Camera, Video amplifier, AM Modulating amplifier, Audio amplifier, FM Modulating amplifier, FM sound transmitter, Crystal oscillator, RF amplifier, Power amplifier, Scanning and Synchronizing Circuits, Combining network, Transmitting antenna and Microphone

 TELEVISION CAMERA:
Its function is to convert optical image of television scene into electrical signal by the scanning process.
• **VIDEO AMPLIFIER:**
Video amplifier amplifies the video signal.
• **AM MODULATING AMPLIFIER**
The video signals are amplified by the modulating amplifier to get the modulated signal.
• **AUDIO AMPLIFIER**
Audio amplifier amplifies the electrical form of audio signal from the microphone.
• **FM MODULATING AMPLIFIER:**
Sound signal from audio amplifier is frequency modulated by FM Modulating amplifier.
 FM SOUND TRANSMITTER:
FM modulated amplified signal is transmitted through this FM sound transmitter to transmitting antenna through the combining network.
• **CRYSTAL OSCILLATOR:**
Crystal Oscillator generates the allotted picture carrier frequency.
• RF AMPLIFIER:
RF amplifier amplifies the picture carrier frequency generated by crystal oscillator to required level.
• **POWER AMPLIFIER:**
Power amplifier varies according to the modulating signal from AM modulating amplifier.
SCANNING AND SYNCHRONIZING CIRCUITS

Scanning is the process where picture elements are converted into corresponding varying electrical signal

COMBINING NETWORK

Combining network is used to isolate the AM picture and FM sound signal during transmission.

TRANSMITTING ANTENNA:

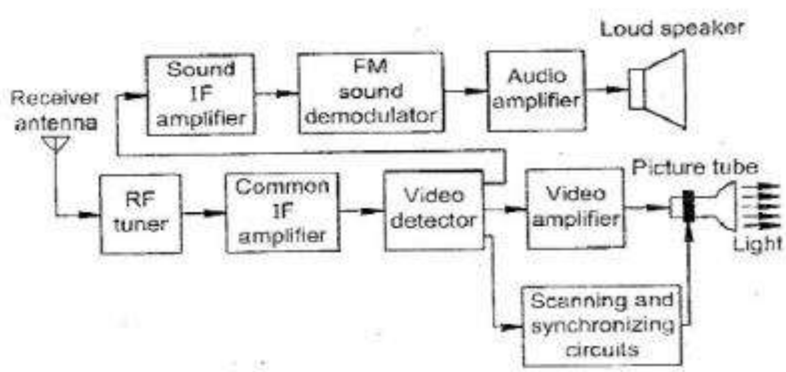
Transmitting antenna receives the AM picture signal and FM sound signal from combining network for radiation as electromagnetic waves.

MICROPHONE:

Converts sound associated with picture being televised into proportionate electrical signal

Monochrome TV Receiver -Block diagram & function of each block.

RECEPTION BASIC MONOCHROME TV



RECEIVER

Block diagram of a monochrome TV receiver is shown. It consists of RF Tuner, Receiver antenna, common IF amplifier, video detector, video amplifier, scanning and synchronizing circuits, sound IF amplifier, FM Sound demodulator, Audio amplifier, Loud Speaker, Picture tube.

RF TUNER:

RF Tuner selects the desired channel frequency band from the receiving antenna.

RECEIVER ANTENNA:

Receiver antenna intercepts the radiated RF signals and sends it to RF Tuner.

COMMON IF AMPLIFIER:

There are 2 or 3 stages of IF amplifiers.

VIDEO DETECTOR:

Used to detect video signals coming from last stage of IF amplifiers.

VIDEO AMPLIFIER:

It amplifies the detected video signal to the level required.

SCANNING AND SYNCHRONIZING CIRCUITS:

Scanning is the process where picture elements are converted into corresponding varying electrical signals.

SOUND IF AMPLIFIER:

Detected audio signal is separated and selected for its IF range and amplified.

FM SOUND DEMODULATOR:

FM Sound signal is demodulated in this stage.

AUDIO AMPLIFIER:

FM demodulated audio signal is amplified to the required level to feed into the loud speaker.

LOUD SPEAKER:

Loud Speaker converts FM demodulated amplifier signal associated with picture being televised into proportionate sound signal.

PICTURE TUBE:

In picture tube the amplified video signal is converted back into picture elements.

SCANNING:

Scanning is the process used to convert the optical into electrical signal. Fastest movement of electron beam on the image is called scanning

NEED FOR SYNCHRONIZATION:

At any time the same co-ordinate will be scanned by the electron beam in both the camera tube and picture tube. Otherwise distorted picture will be seen on the screen. So synchronization between the transmitter and receiver is needed. For that we are using Sync pulses.

At the receiver side these pulses are identified, separated and used for triggering the oscillator circuit.

Horizontal Sync pulse time period = 4.7 μSec.

Horizontal Sync pulse Frequency =15,625 Hz. Vertical Sync pulse time period = 160 μSec.

Vertical Sync pulse frequency = 50 Hz.

Color TV signals (Luminance Signal & Chrominance Signal) :

COLOUR TV FUNDAMENTALS:

In system we are sending only the luminance information. But in color system we have to send information about the colors also. All color TV system are based on the principle of our eye. Here wavelength unit is Arm strong. Visible spectrum – 4000 A^o to 7000 A^o.

1A^o = 10-10m 1nm = 10A^o

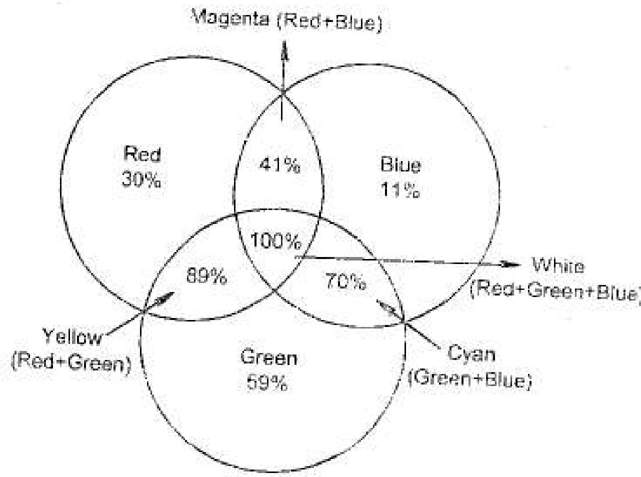
The three basic colors are called as primary colors. They are Red, Green and Blue. To get different color shading we have to mix primary colors. We have two types of mixing

1. Additive Mixing
2. Subtractive Mixing.

ADDITIVE MIXING:

In this method two or three primary colors are mixed together to form a new color. By mixing primary colors with different intensities we can obtain all types of colors.

Fig shows the method of additive mixing. By mixing 30% Red, 59% Green and 11% blue we can get white color



Y = 0% + 59%9+11%B

Red + Blue = Magenta (41%).

Blue + Green = Cyan (70%)

Red + Green = yellow (89%)

COMPLEMENTARY COLOUR:

Color obtained by mixing only two primary colors is called as complementary colors. Primary	Complementary
Red + Green	= Yellow
Red + Blue	= Magenta
Blue + Green	= Cyan

SUBTRACTIVE MIXING. :

In Subtractive mixing, the reflecting properties of color pigments are used. A color pigment can absorb all the color wavelength except its characteristic color wavelength. Its characteristic color frequency alone is reflected. If we are mixing two or three color pigments, then a color wavelength common to them only reflected. This method of mixing is generally used in color printing and color painting. By mixing primary colors, black color is got.

Different colors are obtained by subtracting primary and secondary colors from white. So this is called as subtractive mixing.

LUMINANCE, HUE AND SATURATION:

All the colors are having the following three characteristics. 1. Hue, 2. Saturation, 3.Luminance.

• **LUMINANCE**:

It is the amount of light intensity as perceived by the eye regardless of the color. It is also called as brightness signal, y signal, and white signal.

• **HUE (TINT)**

It is the predominant spectral color. For example, green leaf has a green hue and red apple has red hue.

• **SATURATION:**

It will indicate the spectral purify of color. i.e., it will indicate how much white mixed with a particular color.

CHROMINANCE:

Hue and Saturation together are called as chrominance or chroma signal.

FORMATION OF CHROMINANCE SIGNAL IN PAL SYSTEM WITH WEIGHTING FACTOR:

PAL system u or v signals.

U = .44 B - .29G .15 R

$V = .61R - .52G - .1B$

Es: Yellow color,

$y = R + G$

$U = -.29 + (-.15)$

$= -.44$

$V = .61 + (-.52) = .09$

Yellow color chrominace signal

$C = \sqrt{u^2 + v^2}$

$= \sqrt{(-.44)^2 + (.09)^2}$

$C = \pm .44$

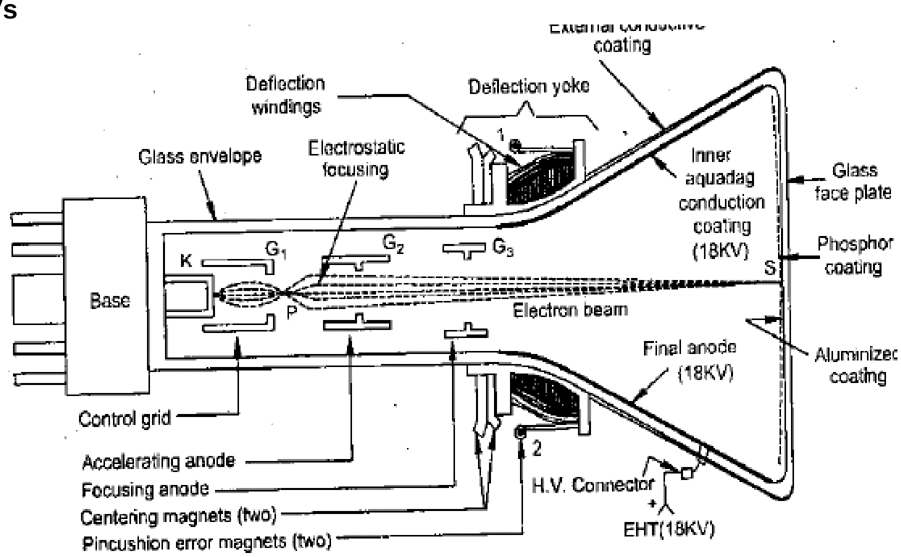
Yellow color y signal value,

$y = R + G$

$= .3 + .59 = .89$

Types of Televisions by Technology-

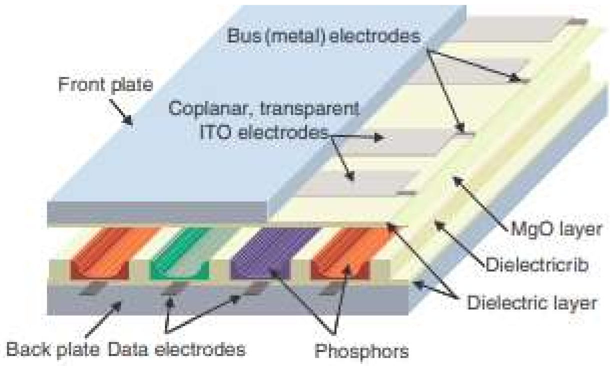
cathode-ray tube TVs



Mainparts :

- Electron gun
- Focusing anode
- Deflection Coils
- Final anode.
- Phosphor screen

Plasma Display Panels:



LIQUID CRYSTAL DISLAY:

What's Liquid Crystals (LC) Intermediary substance between a liquid and solid state of matter. e.g.

soapy water light passes through liquid crystal changes when it is stimulated by an electrical charge.

Introduction to Liquid Crystal Displays

Consists of an array of tiny segments (called pixels) that can be manipulated to present information.

Using polarization of lights to display objects.

Use only ambient light to illuminate the display.

CommonwristwatchandpocketcalculatortoanadvancedVGAcomputerscreen

Different types of LCDs

Passive Twisted Nematic Displays(TNLCD)

Super Twisted nematic LCD (STNLCD)

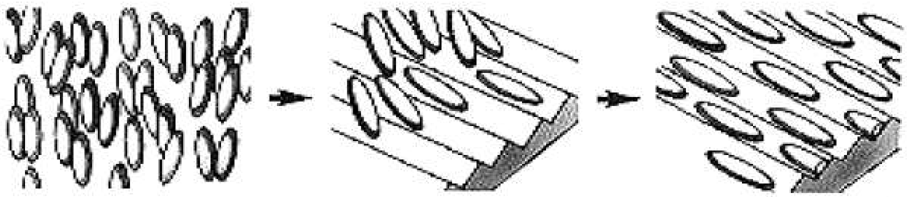
Thin Film Transistor LCD (TFT LCD)

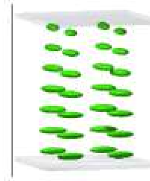
Reflective LCD

Rear Projection LCD

Operating Principle

- The parallel arrangement of liquid crystal molecules along grooves
- When coming into contact with grooved surface in a fixed direction, liquid crystal molecules line up parallel along the **grooves**.

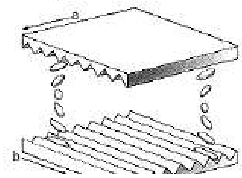




Molecules movement

Offline (no voltage is applied)

- Along the upper plate : Point in direction 'a'
- Along the lower plate : Point in direction 'b'
- Forcing the liquid crystals into a twisted structural arrangement. (Resultant force)

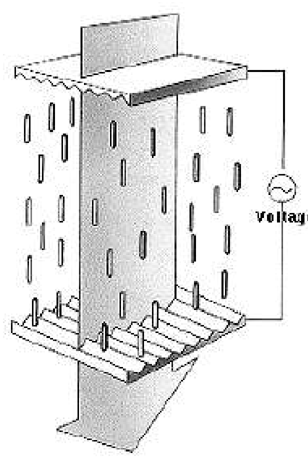


Operating Principle

Molecules movement

Online (voltage is applied)

- Liquid crystal molecules straighten out of their helix pattern
- Molecules rearrange themselves vertically (Along with the electric field)
- No twisting thoughout the movement
- Forcing the liquid crystals into a straight structural arrangement. (Electric force)



Organic Light-Emitting Diode (OLED) Display :

An organic light-emitting diode (OLED) is a light-emitting diode (LED), in which the emissive electroluminescent layer is a film of organic compound that emits light in response to an electric current. OLED's are used to create digital displays in devices such as television screens, computer, portable systems such as mobile phones, handheld game consoles and PDAs. A major area of research is the development of white OLED devices for use in solid-state lighting applications. OLED display devices use organic carbon-based films, sandwiched together between two charged electrodes. One is a metallic cathode and the other a transparent anode, which is usually glass. OLED displays can use either passive-matrix (PMOLED) or active matrix (AMOLED) addressing schemes. Active-matrix OLEDs (AMOLED) require a thin film transistor backplane to switch each individual pixel on or off, but allow for higher resolution and larger display sizes. An OLED display works without a backlight; thus, it can display deep black levels and can be thinner and lighter than a liquid crystal display (LCD). In low ambient light conditions (such as a dark room), an OLED screen can achieve a higher contrast ratio than an LCD, regardless of whether the LCD uses cold cathode fluorescent lamps or an LED backlight.

Construction : A typical OLED is composed of a layer of organic materials situated between two electrodes, the anode and cathode, all deposited on a substrate. The organic molecules are electrically conductive as a result of delocalization of pi electrons caused by conjugation over part or the entire molecule. These materials have conductivity levels ranging from insulators to conductors, and are therefore considered organic semiconductors. The highest occupied and lowest unoccupied molecular orbitals (HOMO and LUMO) of organic semiconductors are analogous to the valence and conduction bands of inorganic semiconductors.

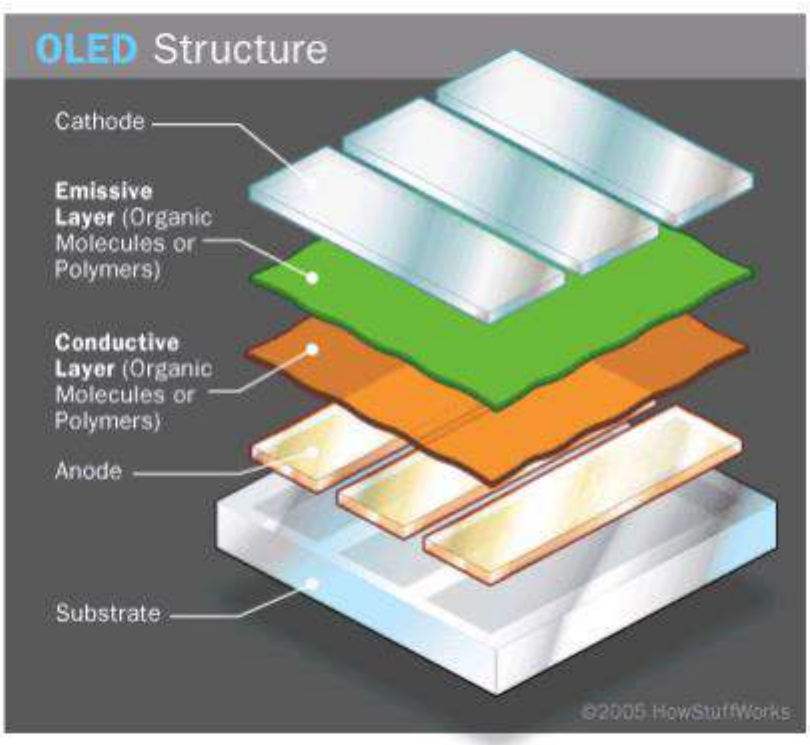
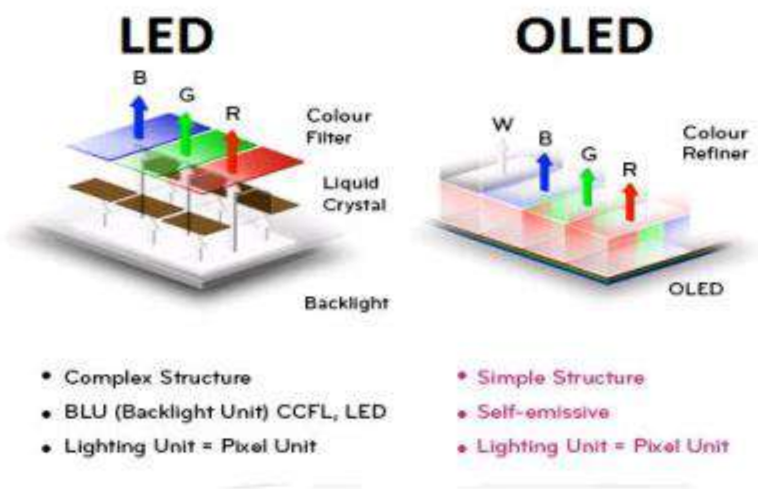


Figure 1: Basic OLED structure

Comparison Between LED and OLED: Although OLED name has been heard much more recently, it is not a new terminology in the technology world. In the beginning of 2000s, we used them in mobile phone screens. However LED took place much more in daily life afterwards. Technically, OLEDs emit light but LEDs diffuse or reflect and this seems the main difference between these two light sources. What is

LED? : Light-emitting diode is one of the widely used and known light sources these days. But its history is about a solid state device that makes light with the help of electrons through a semi-conductor. Also this type is smaller than some other sources such as compact fluorescent and incandescent light bulbs. However it provides higher brightness than its rivals. Although it has some advantages in this area, it is not enough to be used as a pixel of the television just because of its size. Therefore it became popular in lighting industry. What is OLED? : Organic light-emitting diode includes some organic compounds that light when electricity supplied. There is not much difference about architecture between LED and OLED but being thin, small and flexible are the main advantages of OLEDs. Also each pixel on OLED televisions works individually. As can be seen from the definitions of LED and OLED, they have some differences and these strongly affect the quality of the end product. For instance, backlight is used to illuminate their pixels in LED but pixels produce their own light in OLED. OLED's pixels called emissive. Therefore OLEDs provide the flexibility of brightness control through pixel by pixel changes. Tests of a LED display in dark conditions show that parts of an image are not perfectly black because backlight is showed through. The great advantage for LEDs looks about economy since its production costs are much cheaper. However after OLED market is developed, it is predicted that the difference will be made up. Production of an OLED is easier and it is possible to produce it in larger sizes. Its content plays the main role for this because plastic is a suitable material for this but it is harder to do it with liquid crystals.



Quantum Light-Emitting Diode (QLED):

Quantum dot light-emitting diode (QLED) attracted much attention for the next generation of display due to its advantages in high color saturation, tunable color emission, and high stability. Compared with traditional LED display, QLED display has advantages in flexible and robust application, which makes wearable and stretchable display possible in the future. In addition, QLED display is a self-emissive display, in which light is generated by individual sub pixel, each sub pixel can be individually controlled. Each sub pixel in LED display is constituted by liquid crystal and color filter, which make LED display have lower power efficiency and less enhanced functionality. This chapter introduces the QLED based on the QLED structure and light-emitting mechanism of QLED. Then, a novel method for fabricating QLEDs, which is based on the ZnO nano particles (NPs) incorporated into QD nano particles, will be introduced. The QLED device was fabricated by all-solution processes, which make the QLED fabrication process more flexible and more suitable for industrialization. What is more, as QLED devices were planned to integrate into a display, all-solution fabrication processes also make printing QLED display device possible in the near future.

Light emission mechanism of QLED The emission mechanism of QLED is discussed in this subsection. A QLED has a similar structure and behavior as an OLED. In the QLED, the emitter is a semiconductor nano particle, while in the OLED, the emitter is an organic material.

CATV systems & Types & networks :

Cable television is a technical system for distribution of television by cable (coaxial, twisted pair or fiber optic) with potential for largest bandwidth and integrated return channel for interactive services. With the introduction of new technology, the CATV networks will have more active components than at present. Access of an end-user to services in the CATV network is realised by the help of access network. Access network must be enhanced to carry various multimedia services. There are several options to introduce fiber in the access network, to the cabinet/curb FTTCa/C with a last copper drop based on very high rate DSL on one hand and fibre to the building/fibre to the home FTTB/H on the other. FTTCa/FFTC avoids the installation cost of fibre to the costumer premises, but introduces a high exploitation cost, since network operator personnel will have to travel to the cabinet or curb unit for every alteration or maintenance action. Moreover, the process by which the operator becomes entitled to site a cabinet or curb unit in suitable position is complex, and powering will require a large investment. Because of these reasons it is assumed here that network operators will make the strategic choice of introducing fibre directly to the costumer premises with FTTB/H. Residential broadband access network technology based on Asynchronous Transfer Mode (ATM) will soon reach commercial availability. The capabilities provided by ATM access network promise integrated services bandwidth available in excess of those provided by traditional networks. Other services such as desktop video teleconferencing and enhanced server-based application support can be added as part of future evolution of the network.

THE STRUCTURE OF THE INTERACTIVE NETWORK:

At present, the great importance of CATV is in the best transferring of information, mainly in association with satellite transmission of TV and R signals. It indicates that possibilities of CATV are much bigger and they reach to other spheres. Therefore, it is necessary to come nearer CATV from another point of view. This point of vie is the information approach, and new conception of CATV doesn't deal with system, which transfers the TV and R signals, but with the system transferring whatever information to arbitrary direction. By this new approach, primary sense of CATV fades and the network becomes the universal data network, where it is possible to create and realise almost arbitrary services. In interactive CATV, there are three levels, similarly as in distribution network. Tree structure is shown in figure 1:

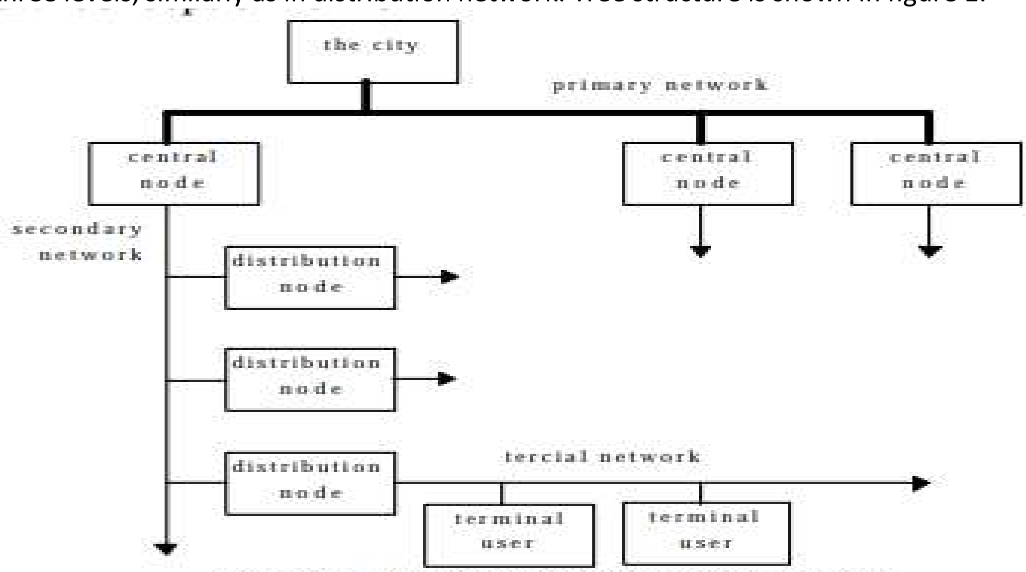


Figure 1 - Structure of interactive network

In a city or another larger region, there is a set of mutually connected central nodes, which create the primary network. Each of them serves respective part of the city e.g. and habitation, a street or likewise. Interactive CATVs can be independent networks, which exist simultaneously with other ones. But, it is economically better and efficiently when the primary network of CATV is an access network of certain great national network (WAN, MAN, B-ISDN etc...). Communication in the primary network must be enough wideband and of larger distance than in primary network of distribution CATV. Therefore, there is directly offered using of optical fibres with standard transfer rates here, e.g. 155Mb/s, 622Mb/s or much.

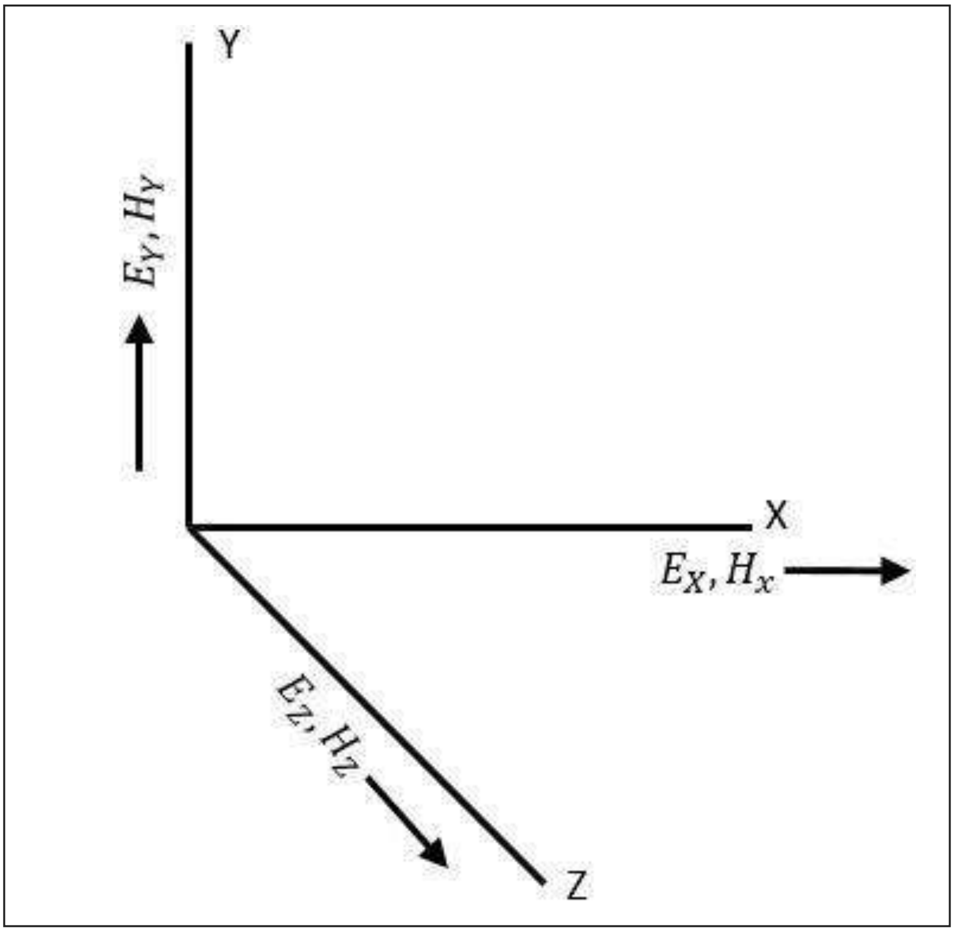
2. The central node is connected to set of distribution nodes and so it is created the secondary network in star form. Each of distribution nodes covers set of flats or offices in small area, e.g. in multi-storey building. Wideband connection through optical fibres uses standard transfer rates, e.g. 155Mb/s, 622Mb/s or much. Physical layer is the same as in primary network.

3. Distribution node creates its own tercial network in star form, which connects user's terminal devices. The transfer medium is coax cable, therefore for this subnetwork is possible use the existing lines which were created for distribution CATVs. Tercial network is possible alternative to present LAN with transfer rate 10Mb/s. One connection in tercial network contain several Ethernet channels. So, the connection of terminal user is indeed wideband.

Modes of Propagation

A wave has both electric and magnetic fields. All transverse components of electric and magnetic fields are determined from the axial components of electric and magnetic field, in the **z** direction. This allows mode formations, such as TE, TM, TEM and Hybrid in microwaves. Let us have a look at the types of modes.

The direction of the electric and the magnetic field components along three mutually perpendicular directions x, y, and z are as shown in the following figure.



Types of Modes

The modes of propagation of microwaves are -

TEM (Transverse Electromagnetic Wave)

In this mode, both the electric and magnetic fields are purely transverse to the direction of propagation. There are no components in '**Z**' direction. $E_z = 0$ *and* $H_z = 0$

TE (Transverse Electric Wave)

In this mode, the electric field is purely transverse to the direction of propagation, whereas the magnetic field is not.

$$E_z = 0 \ \ and \ \ H_z \neq 0$$

TM (Transverse Magnetic Wave)

In this mode, the magnetic field is purely transverse to the direction of propagation, whereas the electric field is not.

$$E_z \neq 0 \ \ and \ \ H_z = 0$$

HE (Hybrid Wave)

In this mode, neither the electric nor the magnetic field is purely transverse to the direction of propagation.

$$E_z \neq 0 \ \ and \ \ H_z \neq 0$$

Multi conductor lines normally support TEM mode of propagation, as the theory of transmission lines is applicable to only those system of conductors that have a go and return path, i.e., those which can support a TEM wave.

Waveguides are single conductor lines that allow TE and TM modes but not TEM mode. Open conductor guides support Hybrid waves. The types of transmission lines are discussed in the next chapter.

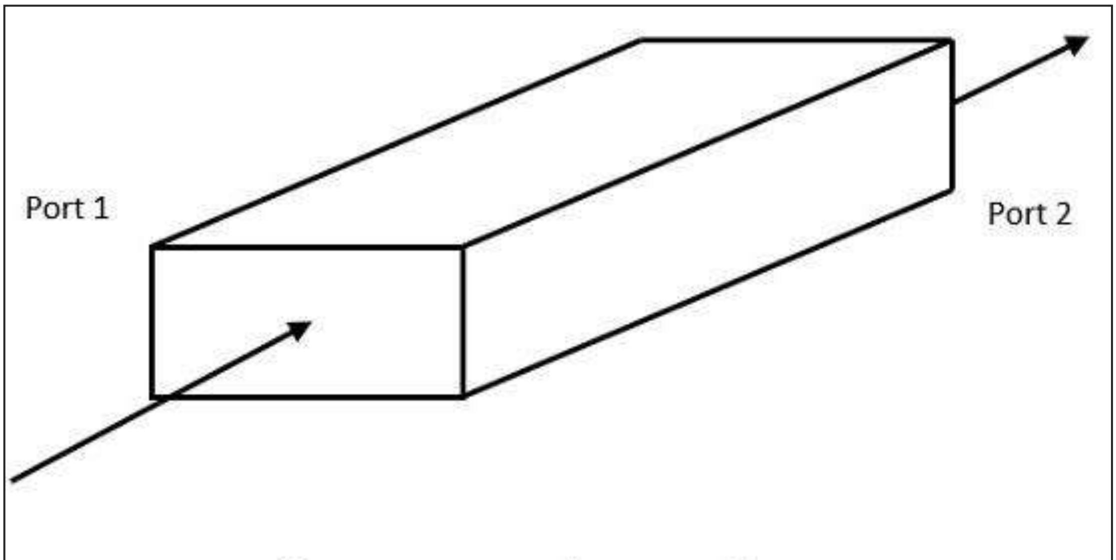
Microwaves – Waveguides

Generally, if the frequency of a signal or a particular band of signals is high, the bandwidth utilization is high as the signal provides more space for other signals to get accumulated. However, high frequency signals can't travel longer distances without getting attenuated. We have studied that transmission lines help the signals to travel longer distances.

Microwaves propagate through microwave circuits, components and devices, which act as a part of Microwave transmission lines, broadly called as Waveguides.

A hollow metallic tube of uniform cross-section for transmitting electromagnetic waves by successive reflections from the inner walls of the tube is called as a **Waveguide**.

The following figure shows an example of a waveguide.



A two-port rectangular waveguide

A waveguide is generally preferred in microwave communications. Waveguide is a special form of transmission line, which is a hollow metal tube. Unlike a transmission line, a waveguide has no center conductor.

The main characteristics of a Waveguide are -

- The tube wall provides distributed inductance.
- The empty space between the tube walls provide distributed capacitance.
- These are bulky and expensive.

Advantages of Waveguides

- Easy to manufacture
- They can handle very large power (in kilo watts).

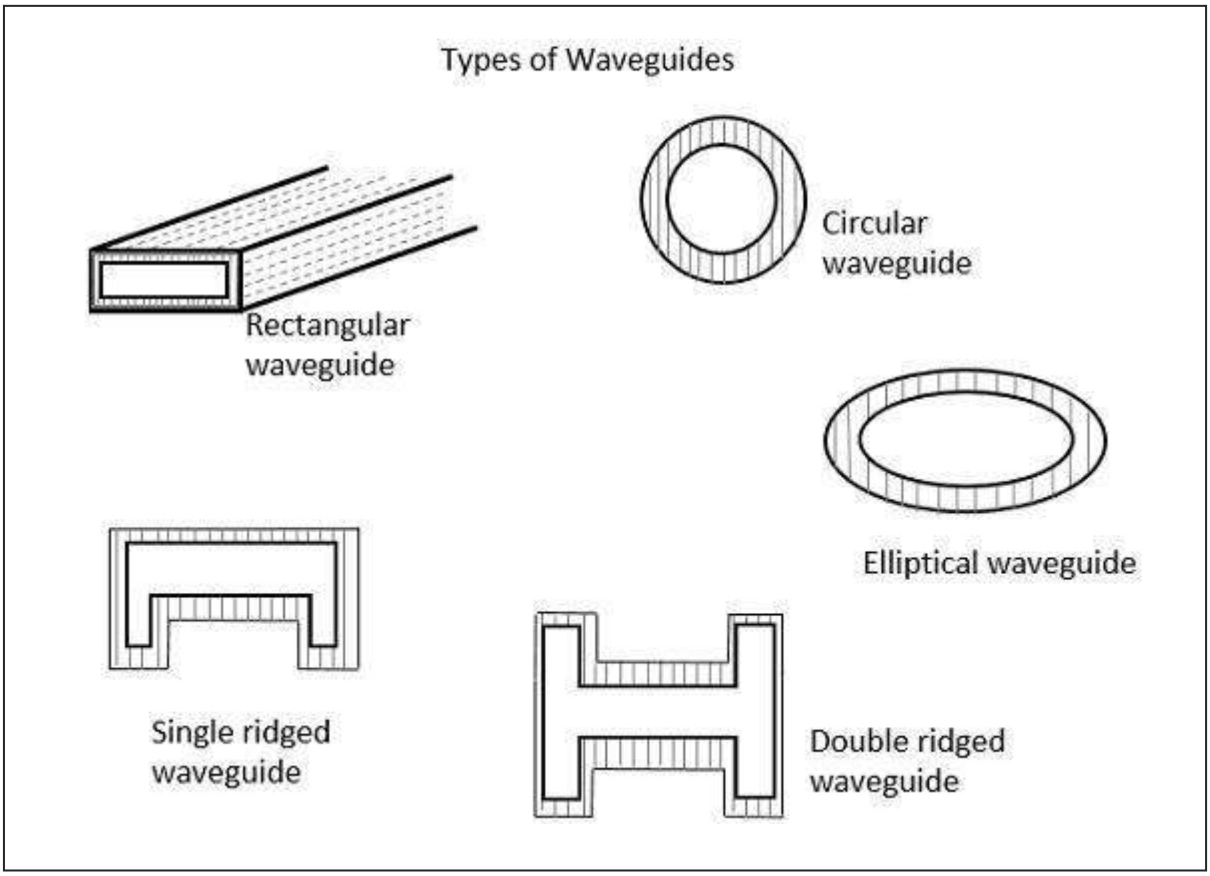
- Power loss is very negligible in waveguides.
- They offer very low loss (low value of alpha-attenuation).
- When microwave energy travels through waveguide, it experiences lower lossesthan a coaxial cable.

Types of Waveguides

There are five types of waveguides.

- Rectangular waveguide
- Circular waveguide
- Elliptical waveguide
- Single-ridged waveguide
- Double-ridged waveguide

The following figures show the types of waveguides.



The types of waveguides shown above are hollow in the center and made up of copper walls. These have a thin lining of Au or Ag on the inner surface.

Let us now compare the transmission lines and waveguides.

Transmission Lines Vs Waveguides

The main difference between a transmission line and a wave guide is -

A **two conductor structure** that can support a TEM wave is a transmission line.

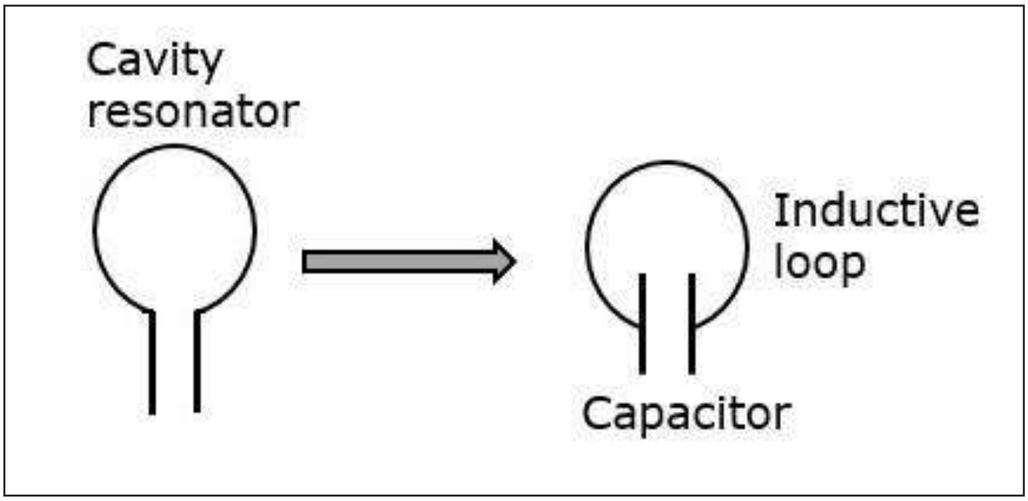
A **one conductor structure** that can support a TE wave or a TM wave but not aTEM wave is called as a waveguide.

The following table brings out the differences between transmission lines and waveguides.

Transmission Lines	**Waveguides**
Supports TEM wave	Cannot support TEM wave
All frequencies can pass through	Only the frequencies that are greater thancut-off frequency can pass through
One conductor transmission	Two conductor transmission
Reflections are less	Wave travels through reflections from thewalls of waveguide
It has characteristic impedance	It has wave impedance
Propagation of waves is according to"Circuit theory"	Propagation of waves is according to "Fieldtheory"
It has a return conductor to earth	Return conductor is not required as thebody of the waveguide acts as earth
Bandwidth is not limited	Bandwidth is limited
Waves do not disperse	Waves get dispersed

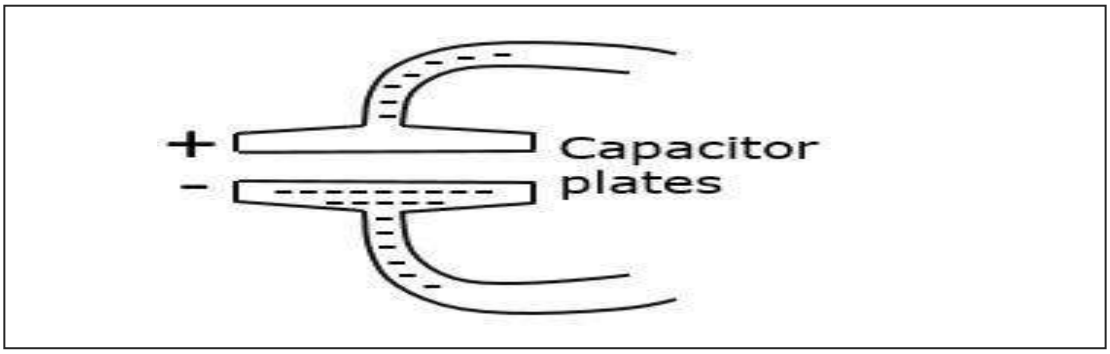
Cavity Resonator

Let us try to understand the constructional details and the working of a cavity resonator. The following figure indicates the cavity resonator.



A simple resonant circuit which consists of a capacitor and an inductive loop can be compared with this cavity resonator. A conductor has free electrons. If a charge is applied to the capacitor to get it charged to a voltage of this polarity, many electrons are removed from the upper plate and introduced into the lower plate.

The plate that has more electron deposition will be the cathode and the plate which has lesser number of electrons becomes the anode. The following figure shows the charge deposition on the capacitor.



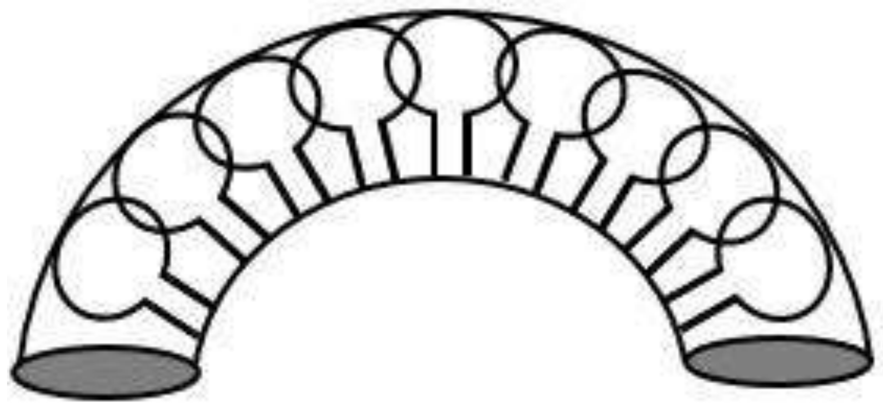
The electric field lines are directed from the positive charge towards the negative. If the capacitor is charged with reverse polarity, then the direction of the field is also reversed. The displacement of electrons in the tube, constitutes an alternating current. This alternating current gives rise to alternating magnetic field, which is out of phase with the electric field of the capacitor.

When the magnetic field is at its maximum strength, the electric field is zero and after a while, the electric field becomes maximum while the magnetic field is at zero. This exchange of strength happens for a cycle.

Closed Resonator

The smaller the value of the capacitor and the inductivity of the loop, the higher will be the oscillation or the resonant frequency. As the inductance of the loop is very small, high frequency can be obtained.

To produce higher frequency signal, the inductance can be further reduced by placing more inductive loops in parallel as shown in the following figure. This results in the formation of a closed resonator having very high frequencies.



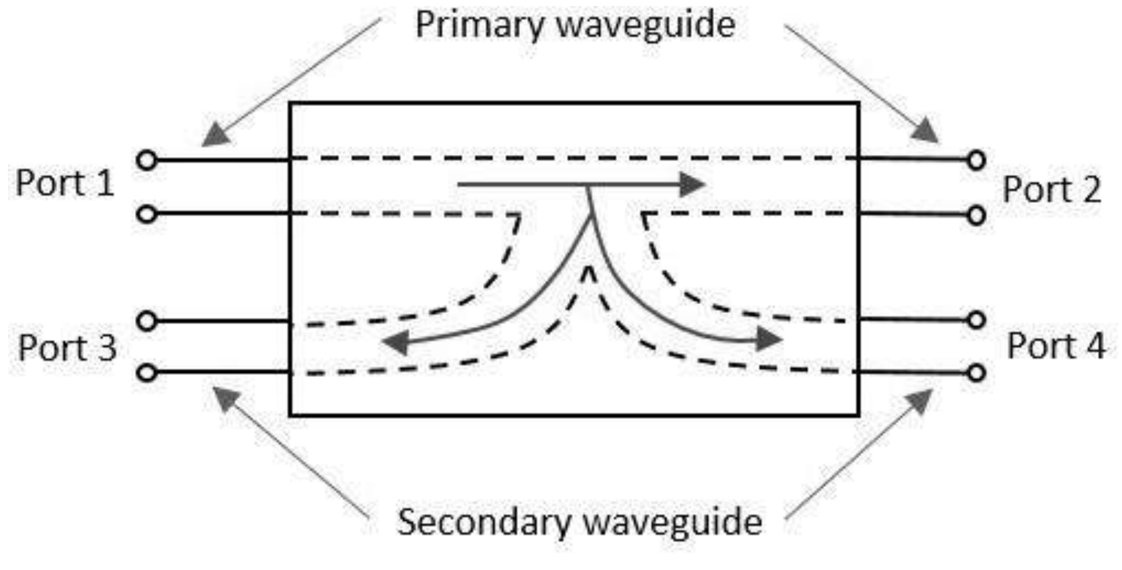
Cross-section of Cavity Resonator

In a closed resonator, the electric and magnetic fields are confined to the interior of the cavity. The first resonator of the cavity is excited by the external signal to be amplified. This signal must have a frequency at which the cavity can resonate. The current in this coaxial cable sets up a magnetic field, by which an electric field originates

Microwaves – Directional Couplers

A **Directional coupler** is a device that samples a small amount of Microwave power for measurement purposes. The power measurements include incident power, reflected power, VSWR values, etc.

Directional Coupler is a 4-port waveguide junction consisting of a primary main waveguide and a secondary auxiliary waveguide. The following figure shows the image of a directional coupler.



Directional Coupler

Directional coupler is used to couple the Microwave power which may be unidirectional or bi-directional.

Properties of Directional Couplers

The properties of an ideal directional coupler are as follows.

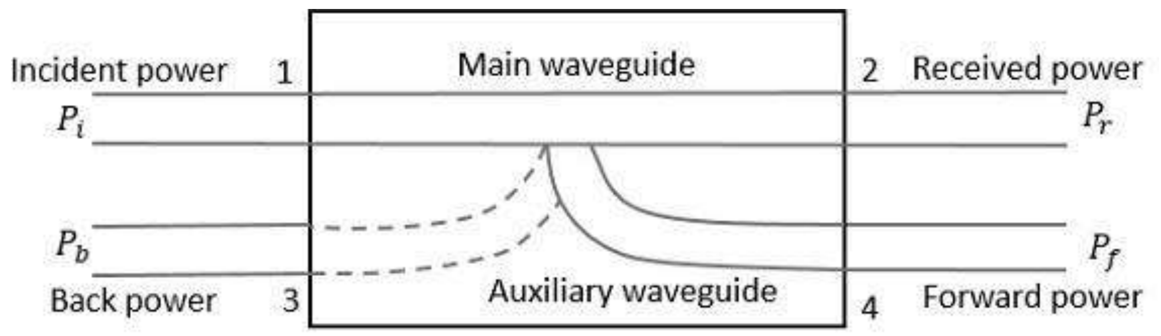
- All the terminations are matched to the ports.
- When the power travels from Port 1 to Port 2, some portion of it gets coupled to Port 4 but not to Port 3.
- As it is also a bi-directional coupler, when the power travels from Port 2 to Port 1, some portion of it gets coupled to Port 3 but not to Port 4.

- If the power is incident through Port 3, a portion of it is coupled to Port 2, but not to Port 1.

- If the power is incident through Port 4, a portion of it is coupled to Port 1, but not to Port 2.

- Port 1 and 3 are decoupled as are Port 2 and Port 4.

Ideally, the output of Port 3 should be zero. However, practically, a small amount of power called **back power** is observed at Port 3. The following figure indicates the power flow in a directional coupler.



Directional Coupler indicating powers

Where

- **P_i =** Incident power at Port 1
- **P_r =** Received power at Port 2
- **P_f =** Forward coupled power at Port 4
- **P_b =** Back power at Port 3

Following are the parameters used to define the performance of a directional coupler.

Coupling Factor (C)

The Coupling factor of a directional coupler is the ratio of incident power to the forward power, measured in dB.

$$C = 10 \log_{10} \frac{P_i}{P_f} \; dB$$

Directivity (D)

The Directivity of a directional coupler is the ratio of forward power to the back power, measured in dB.

$$D = 10 \log_{10} \frac{P_f}{P_b} \; dB$$

Isolation

It defines the directive properties of a directional coupler. It is the ratio of incident power to the back power, measured in dB.

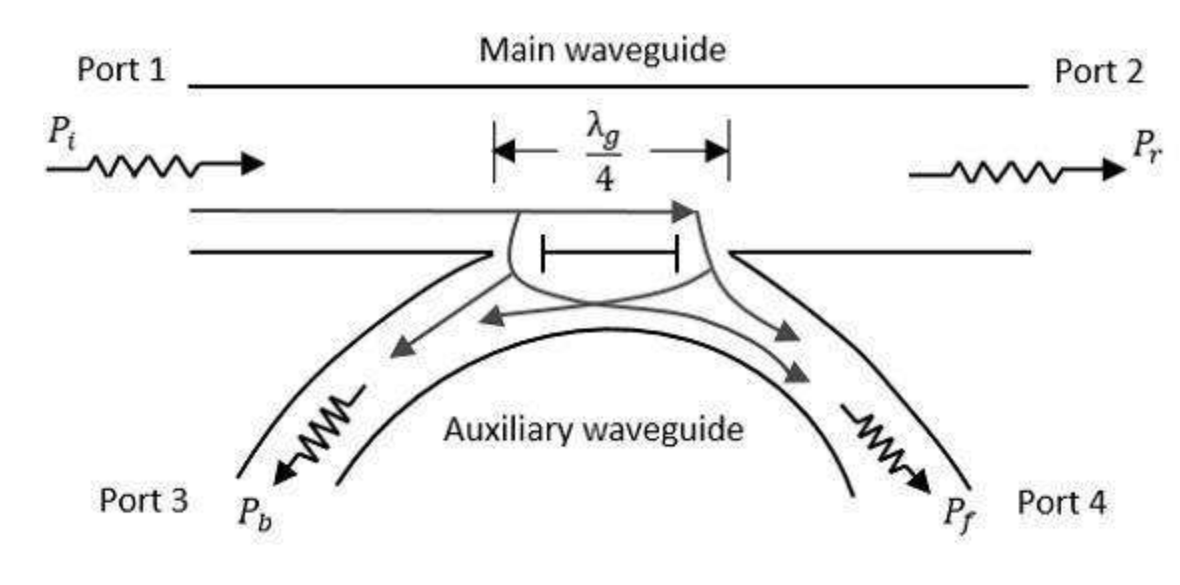
$$I = 10\log_{10}\frac{P_i}{P_b}\,dB$$

Isolation in dB = Coupling factor + Directivity

Isolation in dB = Coupling factor + Directivity

Two-Hole Directional Coupler

This is a directional coupler with same main and auxiliary waveguides, but with two small holes that are common between them. These holes are $\lambda_g/4$ distance apart where λg is the guide wavelength. The following figure shows the image of a two-hole directional coupler.



Two-hole directional coupler

A two-hole directional coupler is designed to meet the ideal requirement of directional coupler, which is to avoid back power. Some of the power while travelling between Port 1 and Port 2, escapes through the holes 1 and 2.

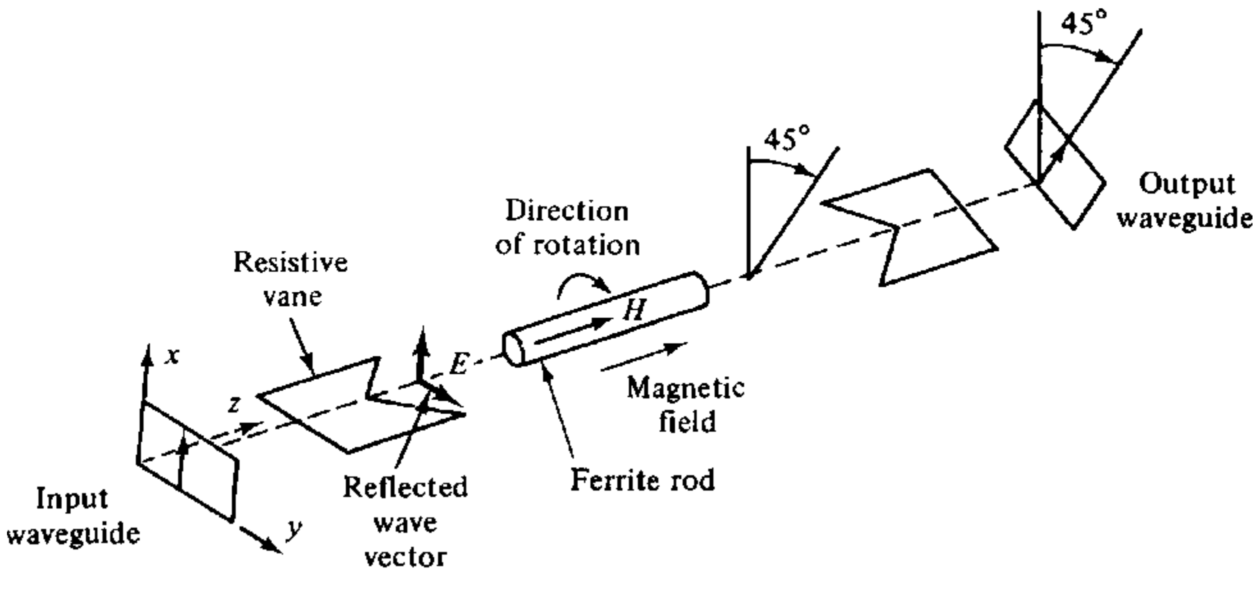
The magnitude of the power depends upon the dimensions of the holes. This leakage power at both the holes are in phase at hole 2, adding up the power contributing to the forward power $\mathbf{P_f}$. However, it is out of phase at hole 1, cancelling each other and preventing the back power to occur.

Hence, the directivity of a directional coupler improves.

MICROWAVE ISOLATORS:

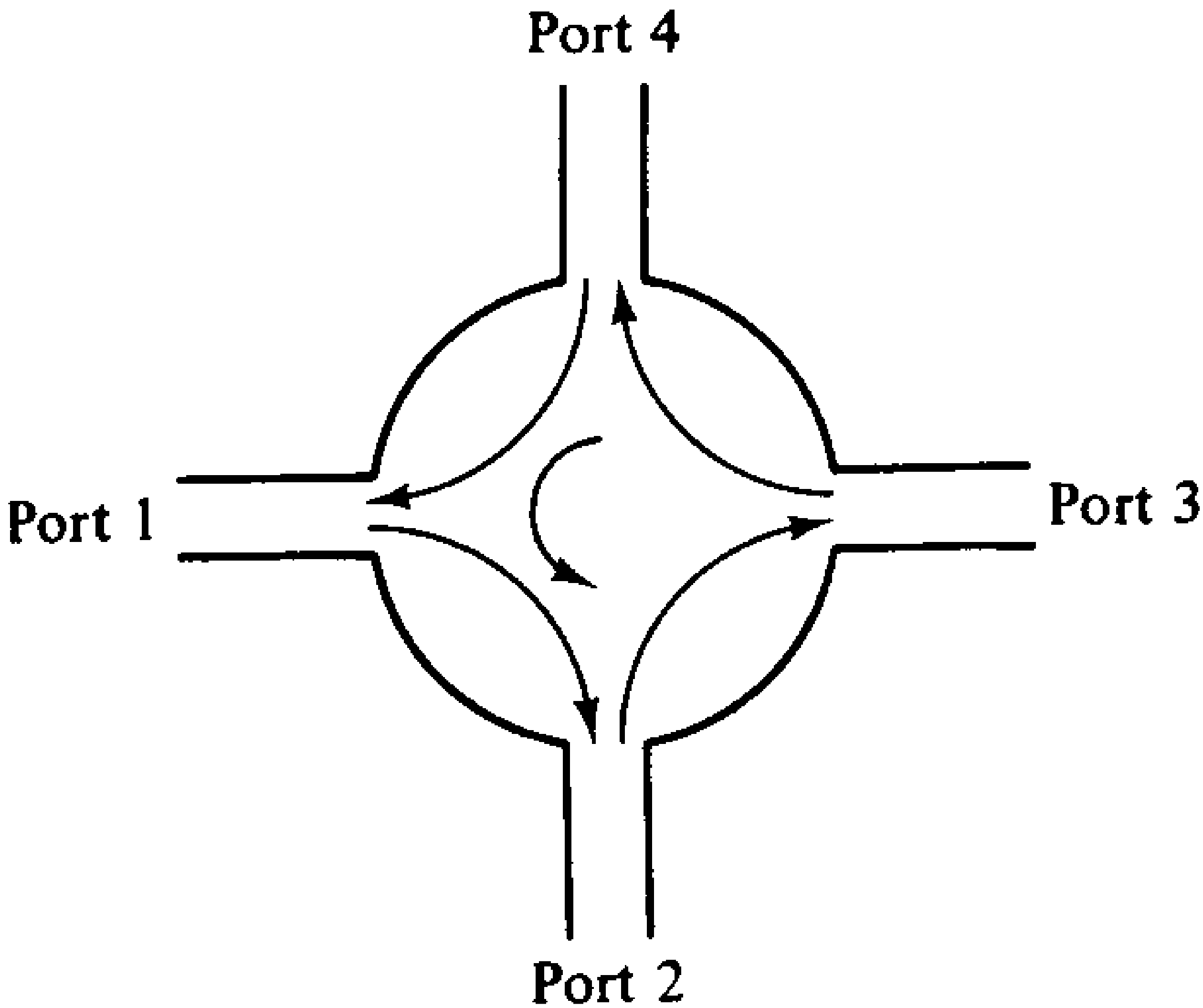
An *isolator* is a nonreciprocal transmission device that is used to isolate one component from reflections of other components in the transmission line. An ideal isolator completely absorbs the power for propagation in one direction and provides lossless transmission in the opposite direction. Thus the isolator is usually called *uniline.*

Isolators are generally used to improve the frequency stability of microwave generators, such as klystrons and magnetrons, in which the reflection from the load affects the generating frequency. In such cases, the isolator placed between the generator and load prevents the reflected power from the unmatched load from returning to the generator. As a result, the isolator maintains the frequency stability of the generator**.**



MICROWAVE CIRCULATORS:

A *microwave circulator* is a multiport waveguide junction in which the wave can flow only from the *nth* port to the *(n* + I)th port in one direction Although there is no restriction on the number of ports, the four-port microwave circulator is the most common. One type of four-port microwave circulator is a combination of two 3-dB side hole directional couplers and a rectangular waveguide with two non reciprocal phase shifters.

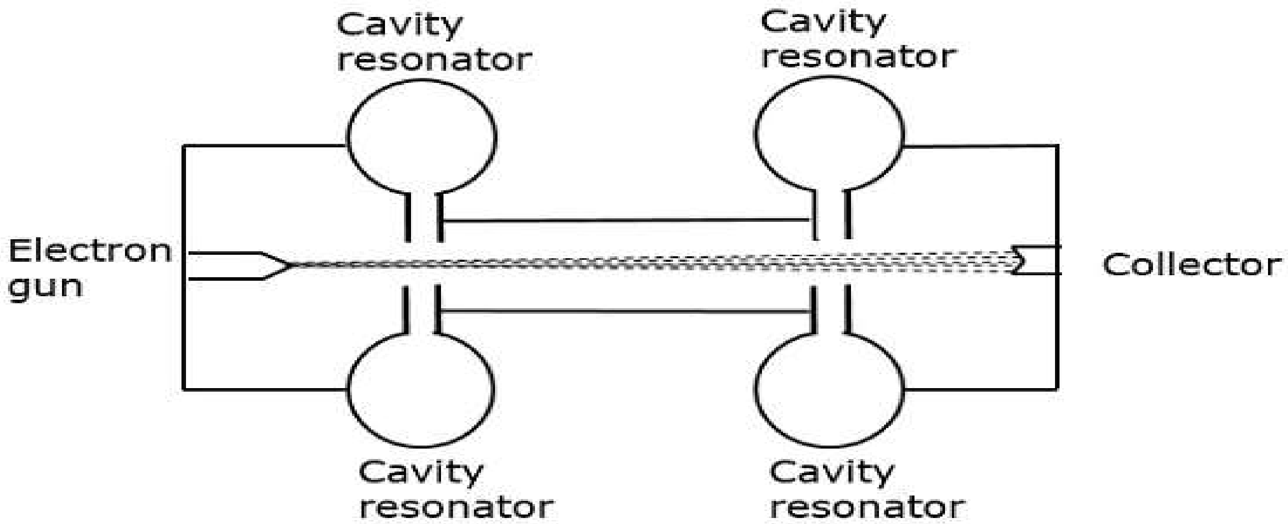


The symbol of a circulator.

Microwave tubes-Principle of operational of two Cavity Klystron

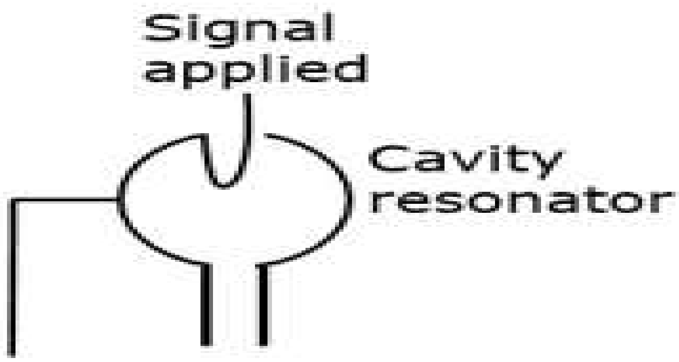
For the generation and amplification of Microwaves, there is a need of some special tubes called as **Microwave tubes**. Of them all, **Klystron** is an important one.

The essential elements of Klystron are electron beams and cavity resonators. Electron beams are produced from a source and the cavity klystrons are employed to amplify the signals. A collector is present at the end to collect the electrons. The whole set up is as shown in the following figure.



The electrons emitted by the cathode are accelerated towards the first resonator. The collector at the end is at the same potential as the resonator. Hence, usually the electrons have a constant speed in the gap between the cavity resonators.

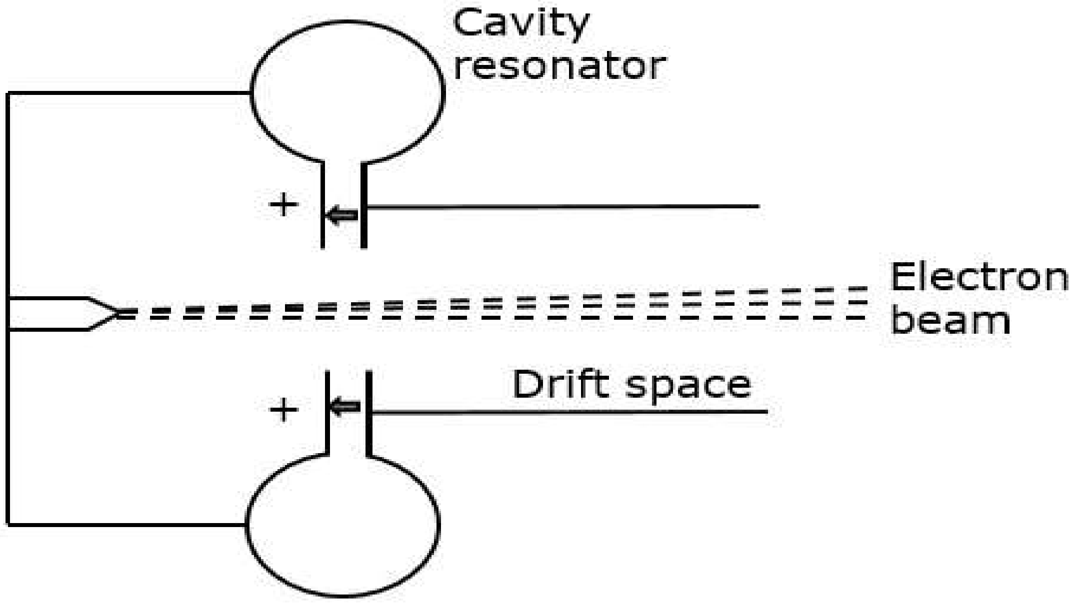
Initially, the first cavity resonator is supplied with a weak high frequency signal, which has to be amplified. The signal will initiate an electromagnetic field inside the cavity. This signal is passed through a coaxial cable as shown in the following figure



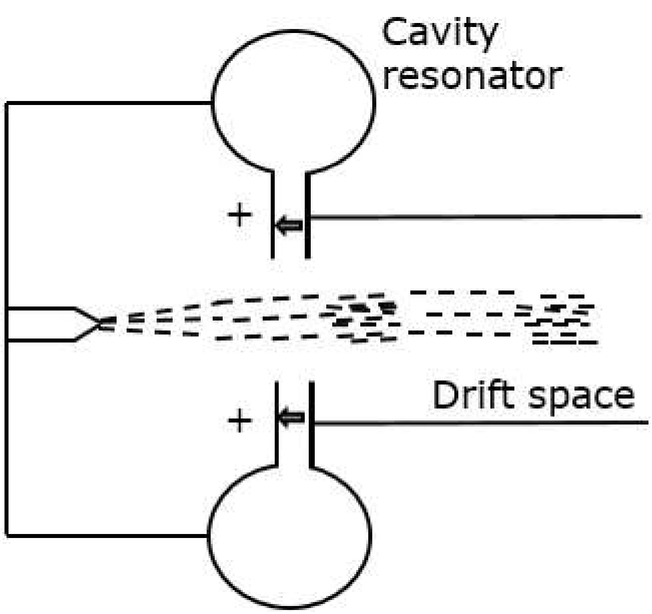
Working of Klystron

To understand the modulation of the electron beam, entering the first cavity, let's consider the electric field. The electric field on the resonator keeps on changing its direction of the induced field. Depending on this, the electrons coming out of the electron gun, get their pace controlled.

As the electrons are negatively charged, they are accelerated if moved opposite to the direction of the electric field. Also, if the electrons move in the same direction of the electric field, they get decelerated. This electric field keeps on changing, therefore the electrons are accelerated and decelerated depending upon the change of the field. The following figure indicates the electron flow when the field is in the opposite direction.

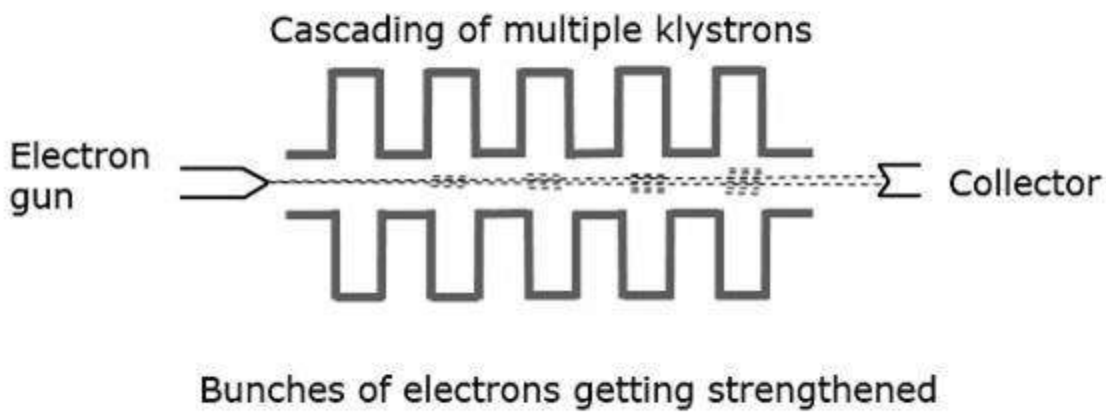


While moving, these electrons enter the field free space called as the **drift space** between the resonators with varying speeds, which create electron bunches. These bunches are created due to the variation in the speed of travel.
These bunches enter the second resonator, with a frequency corresponding to the frequency at which the first resonator oscillates. As all the cavity resonators are identical, the movement of electrons makes the second resonator to oscillate. The following figure shows the formation of electron bunches.



Formation of electron bunches

The induced magnetic field in the second resonator induces some current in the coaxial cable, initiating the output signal. The kinetic energy of the electrons in the second cavity is almost equal to the ones in the first cavity and so no energy is taken from the cavity.
The electrons while passing through the second cavity, few of them are accelerated while bunches of electrons are decelerated. Hence, all the kinetic energy is converted into electromagnetic energy to produce the output signal.
Amplification of such two-cavity Klystron is low and hence multi-cavity Klystrons are used.
The following figure depicts an example of multi-cavity Klystron amplifier.



With the signal applied in the first cavity, we get weak bunches in the second cavity. These will set up a field in the third cavity, which produces more concentrated bunches and so on. Hence, the amplification is larger

Traveling wave tube (TWT)
Travelling Wave Tube Amplifier:
_ High gain > 40 dB
_ Low NF < 10 dB
_ Wide Band > Octave
Frequency range:0.3 – 50 GHz

_ Contains electron gun, RF interaction circuit, electron beam focusing magnet, collector
_ Amplify a weak RF input signal many thousands of times

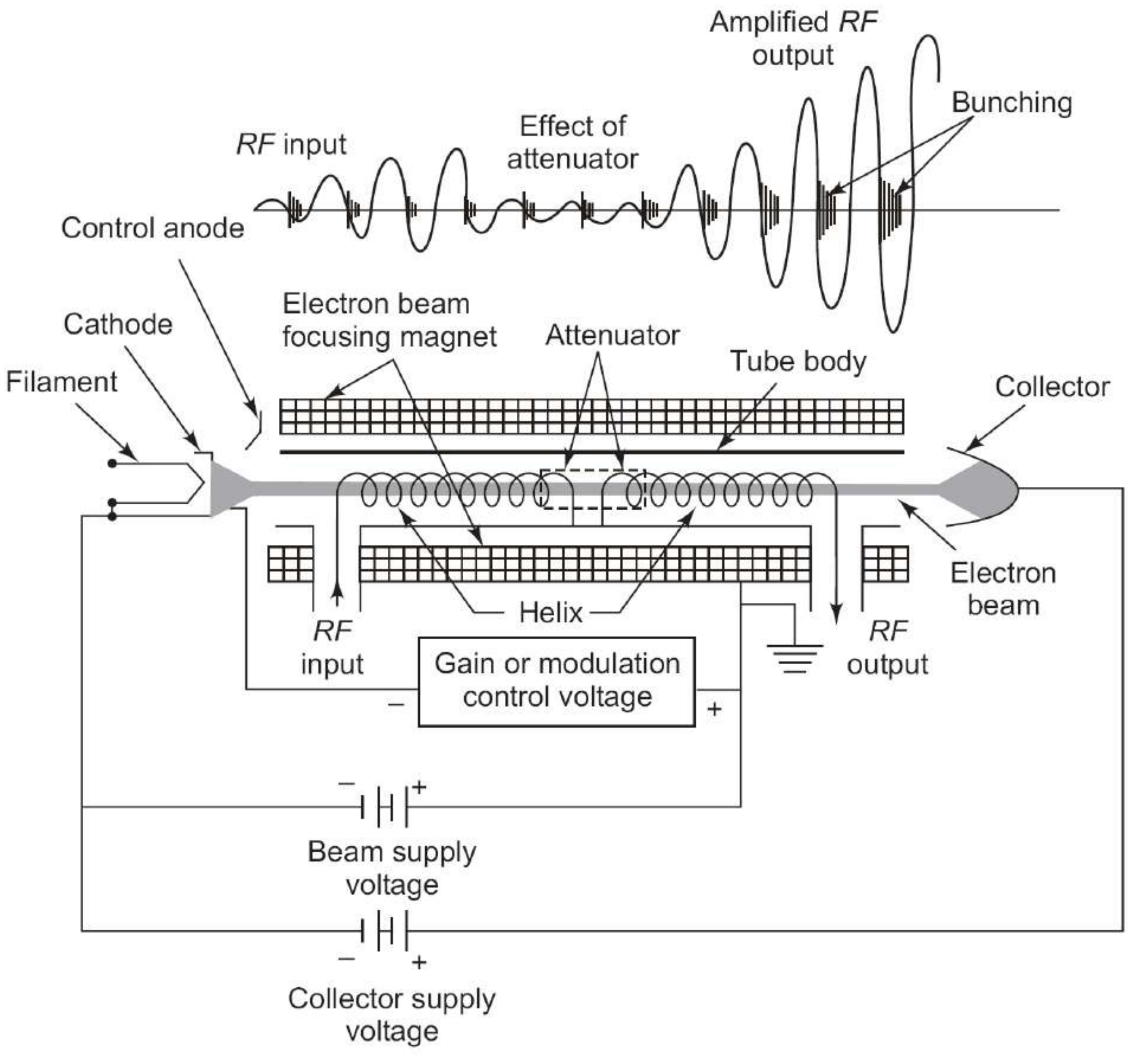


Fig. 9.18 *TWT amplifier tube and circuit*

a) Electron gun
_ To get as much electron current flowing into as small a region as possible without distortion or fuzzy edges

Sources of electrons for the beam- 6 elements:

- gun shells
- heater
- cathode
- control grid
- focus electrode
- anode

b) RF interaction circuit

_ Interaction structures : helix, ring bar, ringloop, coupled cavity
_ RF circuit – complex trade off analysis, based on many interlocking parameters
_ Low power level : helix
_ Medium power level : ring loop, ring bar
_ Power level & frequency increased: RF losses on the circuit become more appreciate able.

c) Electron beam focusing

_ A magnetic field – to hold the electron beam together as it travels through the interaction structure of the tube
_ The beam tends to disperse or spread out as a result of the natural repulsive forces between electrons.
_ Methods of magnetic focusing
_ Solenoid magnetic structure
_ Permanent magnet
_ Periodic permanent magnet (PPM)
_ Radial magnet PPM

d) The collector

_ To dissipate the electrons in the form of heat as they emerge from the slow wave structure
_ Accomplished by thermal conduction to a colder outside surface – the heat is absorbed by circulated air or a liquid

1. Gain compression

_ the amount of gain decrease from the small signal condition (normally 6dB)

2. Beam Voltage

_ the voltage between the cathode and the RF structure

3. Synchronous Voltage

_ the beam voltage necessary to obtain the greatest interaction between the electrons in the electron beam and the RF wave on the circuit

4. Gain

_ the ratio of RF output power to RF input power (dB)

5. Phase Characteristic

_ Phase shift – the phase of output signal relative to the input signal
_ Phase sensitivity – the rate of phase change with a specific operating parameter

Solid State Devices

The classification of solid state Microwave devices can be done –

☐ Depending upon their electrical behavior

- Non-linear resistance type. Example: Varistors (variable resistances)
- Non-Linear reactance type. Example: Varactors (variable reactors)
- Negative resistance type. Example: Tunnel diode, Impatt diode, Gunn diode
- Controllable impedance type. Example: PIN diode

Gunn Effect Devices

J B Gunn discovered periodic fluctuations of current passing through the **n-type GaAs** specimen when the applied voltage exceeded a certain critical value. In these diodes, there are two valleys, **L & U valleys** in conduction band and the electron transfer occurs between them, depending upon the applied electric field. This effect of population inversion from lower L-valley to upper U-valley is called **Transfer Electron Effect** and hence these are called as **Transfer Electron Devices** (TEDs).

Applications of Gunn Diodes

Gunn diodes are extensively used in the following devices:

- Radar transmitters
- Transponders in air traffic control
- Industrial telemetry systems
- Power oscillators
- Logic circuits
- Broadband linear amplifier

Gunn Diodes:

Single piece of GaAs or Inp and contains no junctions Exhibits negative differential resistance

Applications:

low-noise local oscillators for mixers (2 to 140 GHz). Low-power transmitters and wide band tunable sources

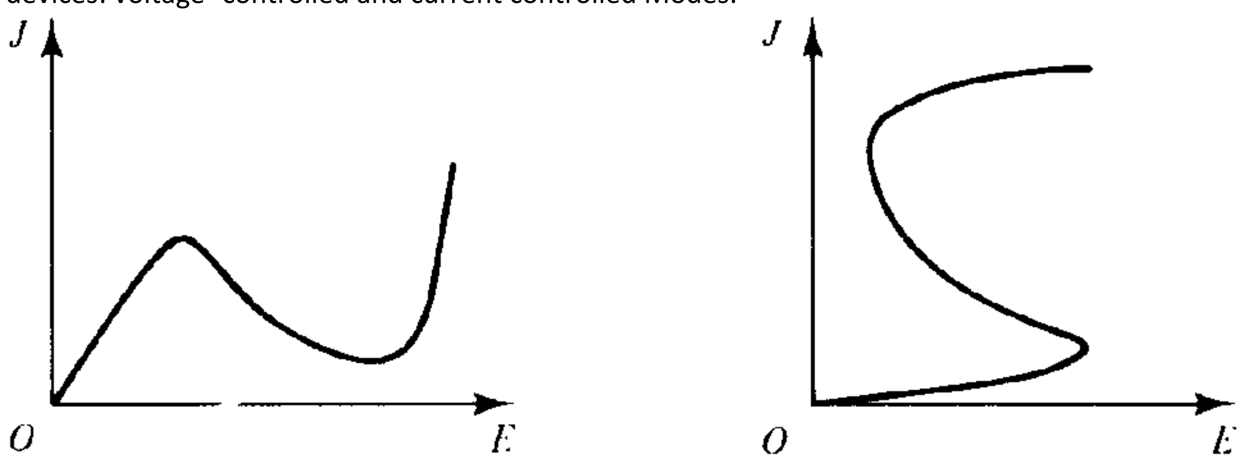
Continuous-wave (CW) power levels of up to several hundred mill watts can be obtained in the X-, Ku-, and Ka-bands. A power output of 30 mW can be achieved from commercially available devices at 94 GHz.

Higher power can be achieved by combining several devices in a power combiner.

Gunn oscillators exhibit very low dc-to-RF efficiency of 1 to 4%.

Differential Negative Resistance:

The fundamental concept of the Ridley-Watkins-Hilsum (RWH) theory is the differential negative resistance developed in a bulk solid-state III-V compound when either a voltage (or electric field) or a current is applied to the terminals of the sample. There are two modes of negative-resistance devices: voltage- controlled and current controlled Modes.



(a) Voltage-controlled mode (b) Current-controlled mode

MODES OF OPERATION OF GUNN DIODE:

A gunn diode can operate in four modes:

1. Gunn oscillation mode
2. stable amplification mode
3. LSA oscillation mode
4. Bias circuit oscillation mode

Gunn oscillation mode: This mode is defined in the region where the product of frequency multiplied by length is about 107 cm/s and the product of doping multiplied by length is greater than 1012/cm2.In this region the device is unstable because of the cyclic formation of either the accumulation layer or the high field domain.

When the device is operated is a relatively high Q cavity and coupled properly to the load, the domain I quenched or delayed before nucleating.

***2.*stable amplification mode :**

This mode is defined in the region where the product of frequency times length is about 107 *cmls* and the product of doping times length is between l011and *1O12/cm2*

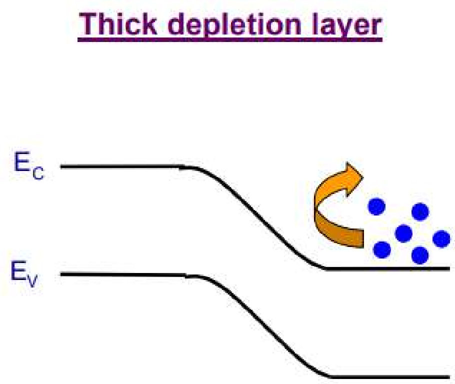
3. LSA oscillation mode: This mode is defined in the region where the product of frequency times length is above 107 *cmls* and the quotient of doping divided by frequency is between 2 x 104 and 2 x 105.

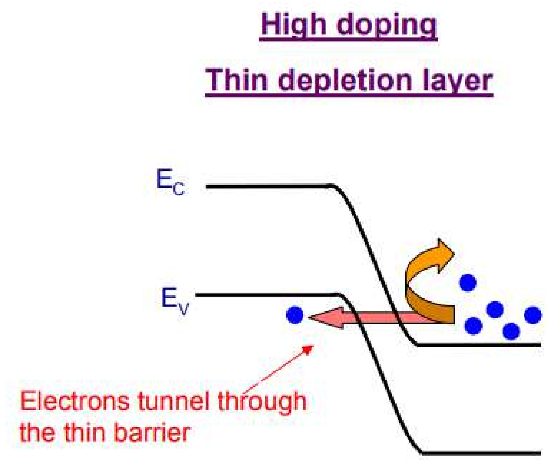
4. Bias-circuit oscillation mode: This mode occurs only when there is either Gunn or LSA oscillation. and it is usually at the region where the product of frequency times length is too small to appear in the figure. When a bulk diode is biased to threshold. the average current suddenly drops as Gunn oscillation begins.

Tunnel Diode:

When the p and n region are highly doped, the depletion region becomes very thin (~10nm).

- In such case, there is a finite probability that electrons can tunnel from the conduction band of n-region to the valence band of p-region
- During the tunneling the particle ENERGY DOES NOT CHANGE



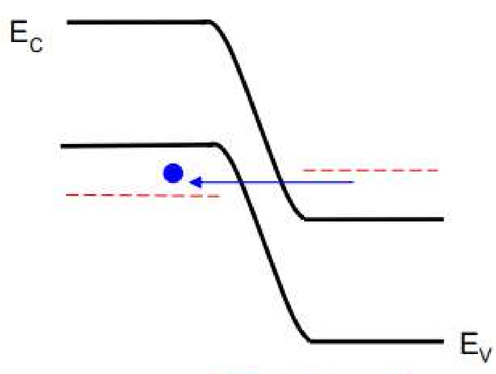


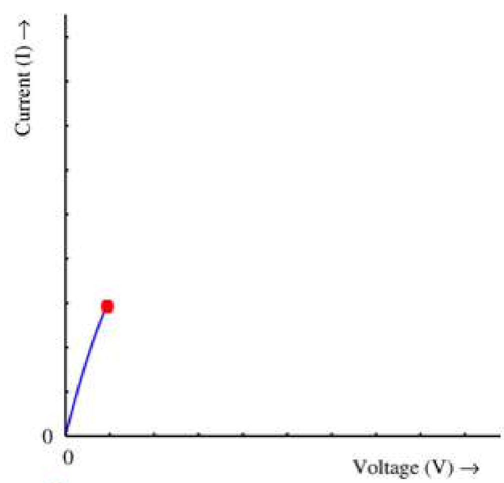
- When the semiconductor is very highly doped (the doping is greater than N o) the Fermi level goes above the conduction band for n-type and below valence band for ptype material. These are called degenerate materials.

Under Forward Bias

Step 1: At zero bias there is no current flow

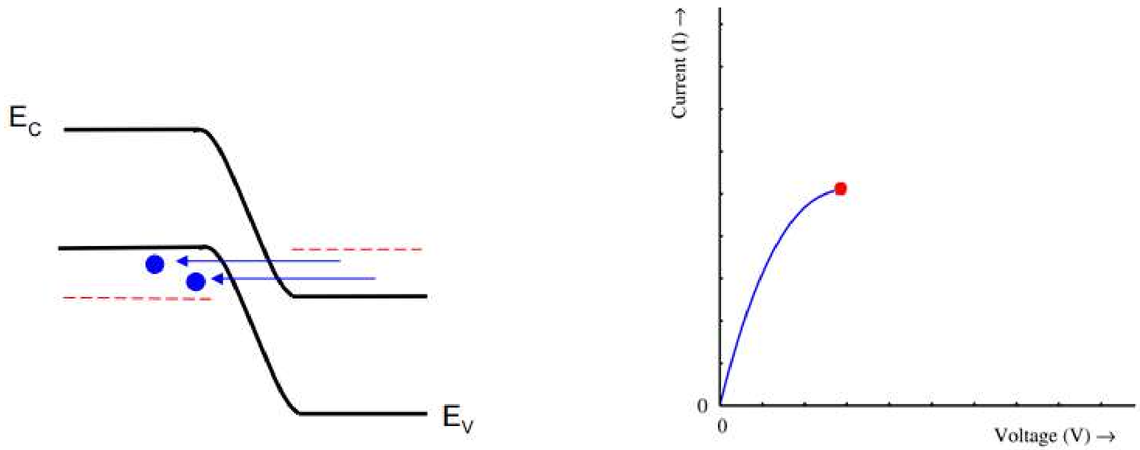
Step 2: A small forward bias is applied. Potential barrier is still very high – no noticeable injection and forward current through the junction. However, electrons in the conduction band of the n region will tunnel to the empty states of the valence band in p region. This will create a forward bias tunnel current





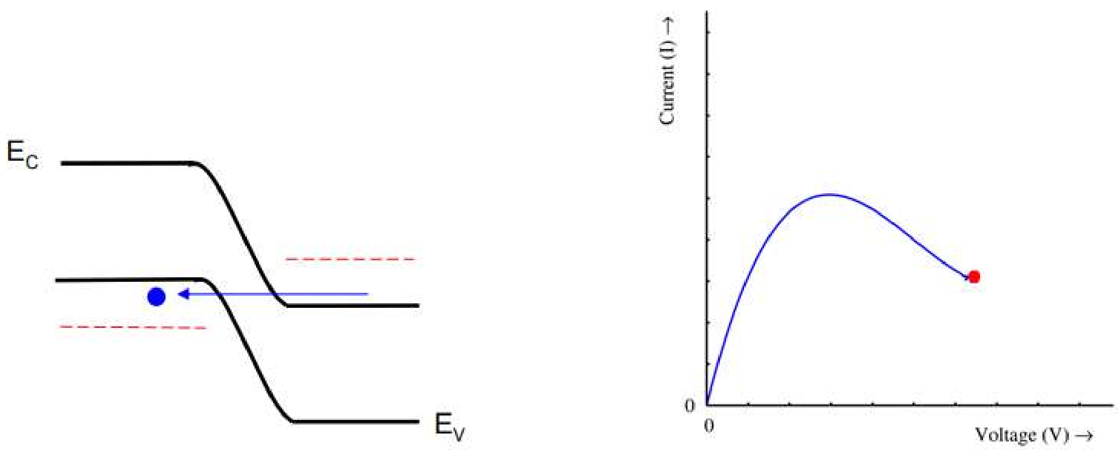
Direct tunneling current starts growing

Step 3: With a larger voltage the energy of the majority of electrons in the n-region is equal to that of the empty states (holes) in the valence band of p-region; this will produce maximum tunneling current



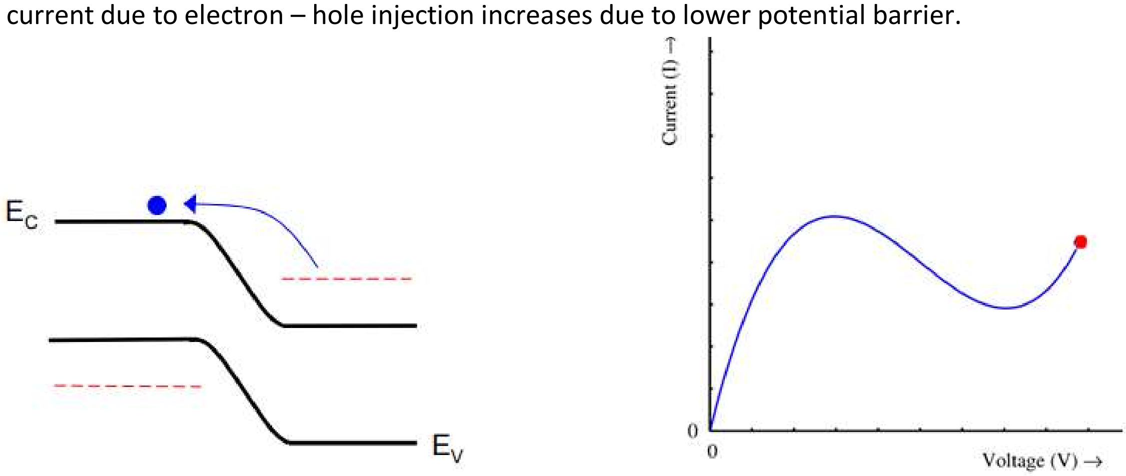
Maximum Direct tunneling current

Step 4: As the forward bias continues to increase, the number of electrons in the n side that are directly opposite to the empty states in the valence band (in terms of their energy) decrease. Therefore decrease in the tunneling current will start.



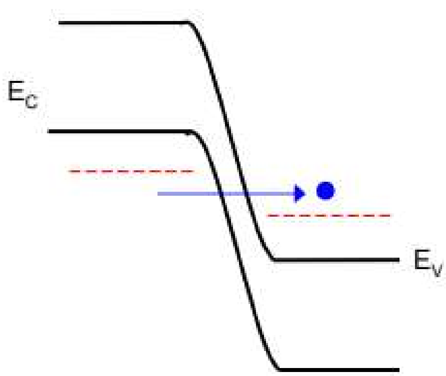
Direct tunneling current decreases

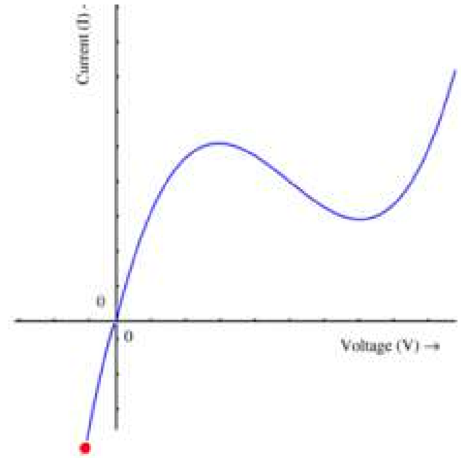
Step 5: As more forward voltage is applied, the tunneling current drops to zero. But the regular diode forward current due to electron – hole injection increases due to lower potential barrier.



No tunneling current; diffusion current starts growing

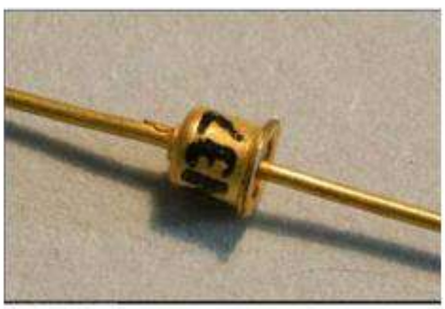
Under Reverse Bias In this case the, electrons in the valence band of the p side tunnel directly towards the empty states present in the conduction band of the n side creating large tunneling current which increases with the application of reverse voltage. The TD reverse I-V is similar to the Zener diode with nearly zero breakdown voltage.

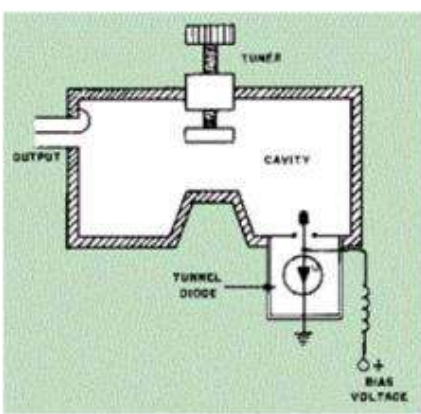


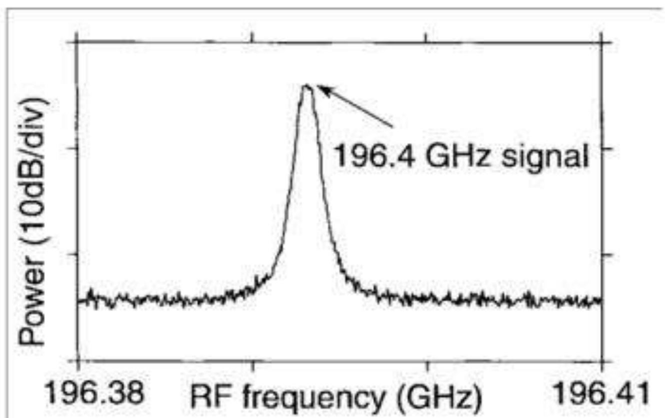


Applicatio:

Tunnel Diode microwave oscillators







After: M. Reddy et.al,

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~ 600 GHz oscillation frequencies has been achieved.

SONET(Synchronous Optical Network)-

Synchronous optical network (SONET) is a standard for optical telecommunications transport. It was formulated by the ECSA for ANSI, which sets industry standards in the United States for telecommunications and other industries. The comprehensive SONET/synchronous digital hierarchy (SDH) standard is expected to provide the transport infrastructure for worldwide telecommunications for at least the next two or three decades.

The increased configuration flexibility and bandwidth availability of SONET provides significant advantages over the older telecommunications system. These advantages include the following:

- reduction in equipment requirements and an increase in network reliability
- provision of overhead and payload bytes—the overhead bytes permit management of the payload bytes on an individual basis and facilitate centralized fault sectionalization
- definition of a synchronous multiplexing format for carrying lower level digital signals (such as DS–1, DS–3) and a synchronous structure that greatly simplifies the interface to digital switches, digital cross-connect switches, and add-drop multiplexers
- availability of a set of generic standards that enable products from different vendors to be connected
- definition of a flexible architecture capable of accommodating future applications, with a variety of transmission rates

In brief, SONET defines optical carrier (OC) levels and electrically equivalent synchronous transport signals (STSs) for the fiber-optic–based transmission hierarchy.

Basic SONET Signal

SONET defines a technology for carrying many signals of different capacities through a synchronous, flexible, optical hierarchy. This is accomplished by means of a byte-interleaved multiplexing scheme. Byte-interleaving simplifies multiplexing and offers end-to-end network management.

The first step in the SONET multiplexing process involves the generation of the lowest level or base signal. In SONET, this base signal is referred to as synchronous transport signal–level 1, or simply STS–1, which operates at 51.84 Mbps. Higher-level signals are integer multiples of STS–1, creating the family of STS–N signals in *Table 1*. An STS–N signal is composed of N byte-interleaved STS–1 signals. This table also includes the optical counterpart for each STS–N signal, designated optical carrier level N (OC–N).

Table 1. SONET Hierarchy

Signal	Bit Rate (Mbps)	Capacity
STS–1, OC–1	51.840	28 DS–1s or 1 DS–3
STS–3, OC–3	155.520	84 DS–1s or 3 DS–3s
STS–12, OC–12	622.080	336 DS–1s or 12 DS–3s
STS–48, OC–48	2,488.320	1,344 DS–1s or 48 DS–3s
STS–192, OC–192	9,953.280	5,376 DS–1s or 192 DS–3s

Note:
STS = synchronous transport signal
OC = optical carrier

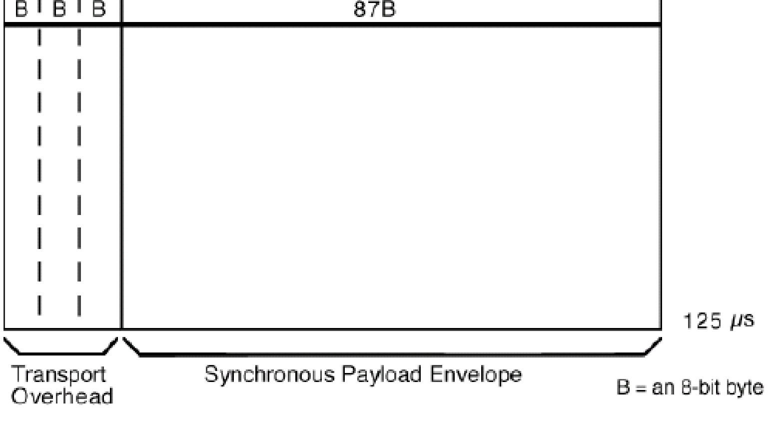
3. Frame Format Structure

SONET uses a basic transmission rate of STS–1 that is equivalent to 51.84 Mbps. Higher-level signals are integer multiples of the base rate. For example, STS–3 is three times the rate of STS–1 (3 x 51.84 = 155.52 Mbps). An STS–12 rate would be 12 x 51.84 = 622.08 Mbps.

STS–1 Building Block

The frame format of the STS–1 signal is shown in *Figure 1*. In general, the frame can be divided into two main areas: transport overhead and the synchronous payload envelope (SPE).

Figure 1. STS–1 Frame Format



9. What Are the Benefits of SONET?

The transport network using SONET provides much more powerful networking capabilities than existing asynchronous systems.

Pointers, MUX/DEMUX

As a result of SONET transmission, the network's clocks are referenced to a highly stable reference point. Therefore, the need to align the data streams or synchronize clocks is unnecessary. Therefore, a lower rate signal such as DS–1 is accessible, and demultiplexing is not needed to access the bitstreams. Also, the signals can be stacked together without bit stuffing.

For those situations in which reference frequencies may vary, SONET uses pointers to allow the streams to float within the payload envelope. Synchronous clocking is the key to pointers. It allows a very flexible allocation and alignment of the payload within the transmission envelope.

Reduced Back-to-Back Multiplexing

Separate M13 multiplexers (DS–1 to DS–3) and fiber-optic transmission system terminals are used to multiplex a DS–1 signal to a DS–2, DS–2 to DS–3, and then DS–3 to an optical line rate. The next stage is a mechanically integrated fiber/multiplex terminal.

Optical Interconnect

Because of different optical formats among vendors' asynchronous products, it is not possible to optically connect one vendor's fiber terminal to another. For example, one manufacturer may use 417–Mbps line rate, another 565–Mbps.

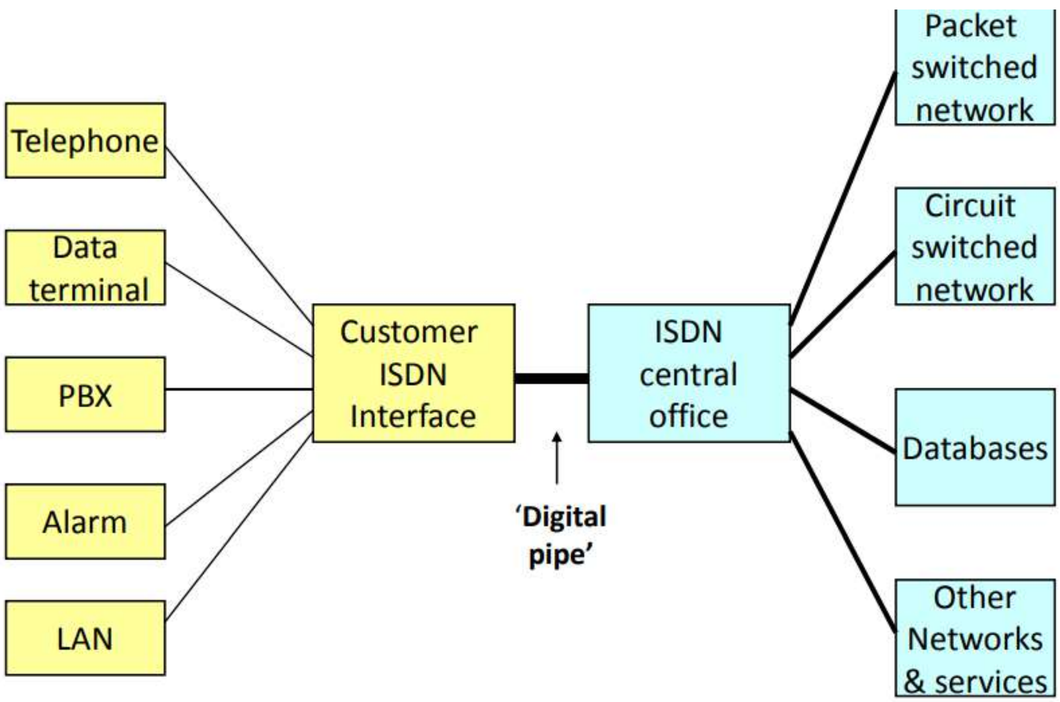
A major SONET value is that it allows midspan meet with multivendor compatibility. Today's SONET standards contain definitions for fiber-to-fiber interfaces at the physical level. They determine the optical line rate, wavelength, power levels, pulse shapes, and coding. Current standards also fully define the frame structure, overhead, and payload mappings. Enhancements are being developed to define the messages in the overhead channels to provide increased OAM&P functionality.

SONET allows optical interconnection between network providers regardless of who makes the equipment. The network provider can purchase one vendor's equipment and conveniently interface with other vendors' SONET equipment at either the different carrier locations or customer premises sites. Users may now obtain the OC–N equipment of their choice and meet with their network provider of choice at that OC–N level.

<u>ISDN</u> (INTEGRATED SERVICES DIGITAL NETWORK)

• Users have a variety of equipment to connect to public networks

–Telephones
– Private Branch Exchanges
–Computer Terminals or PCs
– Mainframe Computers
• A variety of physical interfaces and access procedures are required for connection
• The telephone network has evolved into a digital one with digital exchanges and links • The signaling system has become a digital message-oriented common channel signaling system (SS#7) • The term 'Integrated Digital Network' is used to describe these developments
• The Public Switched Telephone network is still analogue from the subscriber to the local exchange
• The need has arisen to extend the digital network out to subscribers and to provide a single standardized interface to all different users of public networks
• ISDN fulfils that need

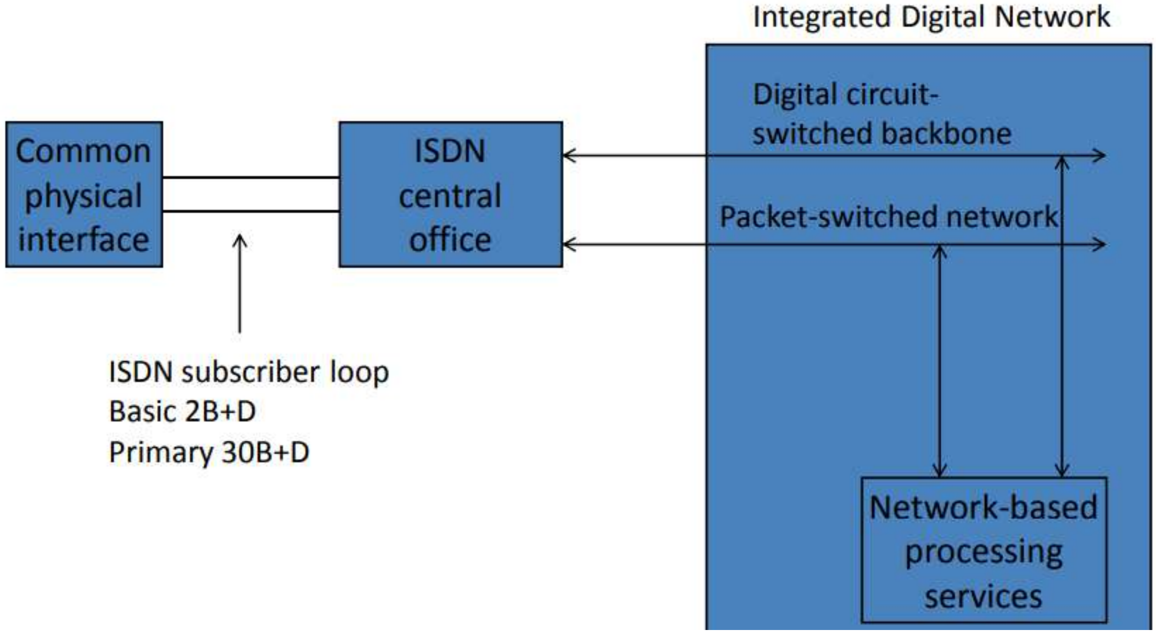


• In Practice there are multiple networks providing the service nationally
• The user however, sees a single network

Benefits to Subscribers

• Single access line for all services
• Ability to tailor service purchased to suit needs
• Competition among equipment vendors due to standards
• Availability of competitive service providers

Architecture



ISDN Channels

- The Digital pipe is made up of channels - one of three types
- B channel, D channel or H channel
- Channels are grouped and offered as a package to users

B Channel

- B channel-64 kbps
- B is basic user channel – can carry digital data or PCM-encoded voice – or mixture of lower rate traffic.
- Four kinds of connection possible
- Circuit-switched
- Packet-switched - X.25
- Frame mode - frame relay (LAPF)
- Semi permanent - equivalent to a leased line

D Channel

- D Channel - 16 or 64 kbps
- Carries signaling information to control circuit-switched calls on B channels
- Can also be used for packet switching or low speed telemetry

H Channel

- Carry user information at higher bit rates 384kbps or 1536kbps or 1920kbps
- Can be used as a high-speed trunk
- Can also be subdivided as per user’s own TDM scheme
- Uses include high speed data, fast facsimile, video, high-quality audio

<u>ISDN Basic Access</u>

- Intended for small business and residential use
- A single physical interface is provided

• Data rate is 144kbps plus 48kbps overhead bits totaling 192 kbps
• Most existing subscriber loops can support basic access

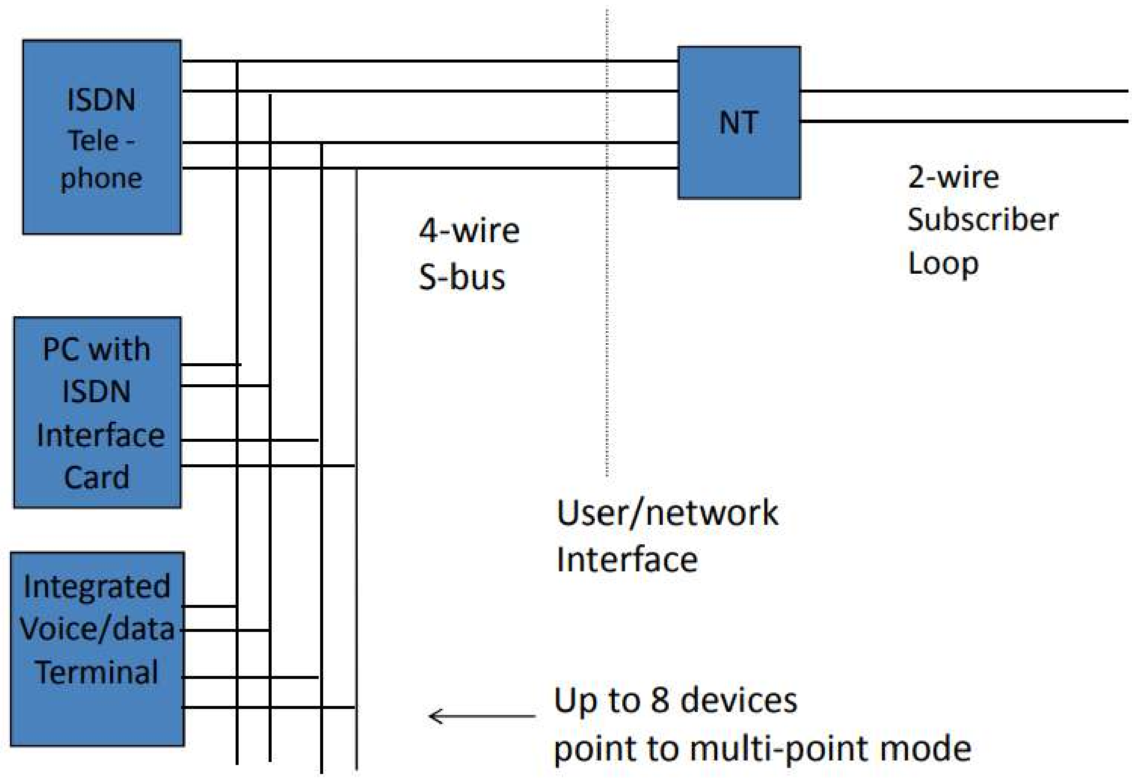
ISDN Primary Interface

• Multiple channels multiplexed on single medium
• Only point to point configuration is allowed
• Typically supports a digital PBX and provides a synchronous TDM facility

User Access

• Defined using two concepts
– Functional groupings of equipment
–Reference points to separate functional groupings

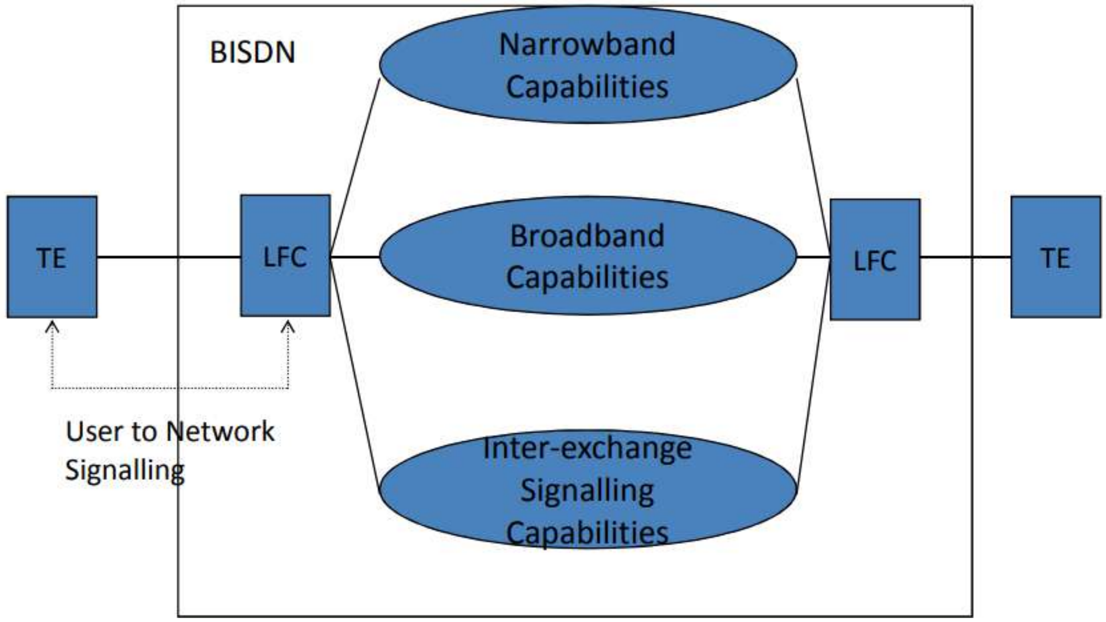
User access Layout:



Broadband ISDN (BISDN)

• Recommendations to support video services as well as normal ISDN services
• Provides user with additional data rates – 155.52 Mbps full-duplex – 155.52 Mbps / 622.08 Mbps – 622.08 Mbps full-duplex
• Exploits optical fiber transmission technology

B-ISDN Architecture



TE = Terminal equipment LFC = Local function capabilities

- ATM is specified for Information transfer across the user-network interface
- Fixed size 53 octet packet with a 5 octet header
- Implies that internal switching will be packet based

BISDN Protocol Structure