Scheme of Evaluation

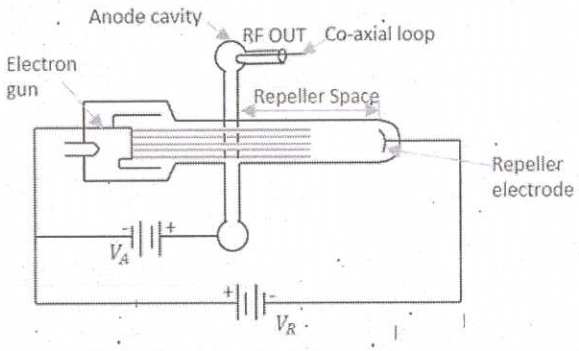
Revision: 2015

Course Title: Communication System — Course Code: 6042

Qst No:		Scoring Indicator	Split up Score	Sub Total	Total
		Part A			
I	1.	• Pyramid horn, Circular conical horn, Bi conical horn.	2	2	10
	2.	• A GIS is a particular form of Information System applied to geographical data. • A GIS is an organized collection of computer hardware, software, geographic data and personnel to efficiently capture, store, update, manipulate, analyze and display the geographically information.	2	2	
	3.	• Optical fibers are light in weight and smaller in size • Transmission is more secure and private • Data transmission rate is high • Greater Bandwidth (or any four)	$\frac{1}{2}$ *4=2	2	
	4.	• The transfer of a cellular phone transmission from one radio frequency within a cell to another radio frequency in an adjacent cell. • Handoffs occur when a cellular phone user passes out of the range that the cell can handle and into another cell range, and the signal is passed from one base station to the next	1*2=2	2	
	5.	• PIN diode • Avalanche photodiode	2	2	
		PART-B			

PART B

II	1.	• Large bandwidth • Very short wavelength • Low power consumption • Portable • Good stability • Longer working life • Small size	2(fig)+4	6	30
II	2.	This microwave generator, is a Klystron that works on reflections and oscillations in a single cavity, which has a variable frequency.Reflex Klystron consists of an electron gun, a cathode filament, an anode cavity, and an electrode at the cathode potential. It provides low power and has low efficiency. **Construction of Reflex Klystron** The electron gun emits the electron beam, which passes through the gap in the anode cavity. These electrons travel towards the Repeller electrode, which is at high negative potential. Due to the high negative field, the electrons repel back to the anode cavity. In their return journey, the electrons give more energy to the gap and these oscillations are sustained. The constructional details of this reflex klystron is as shown in the following figure.	2(fig)+4	6	



Constructional details of Reflex Klystron

It is assumed that oscillations already exist in the tube and they are sustained by its operation. The electrons while passing through the anode cavity, gain some velocity.

Operation of Reflex Klystron

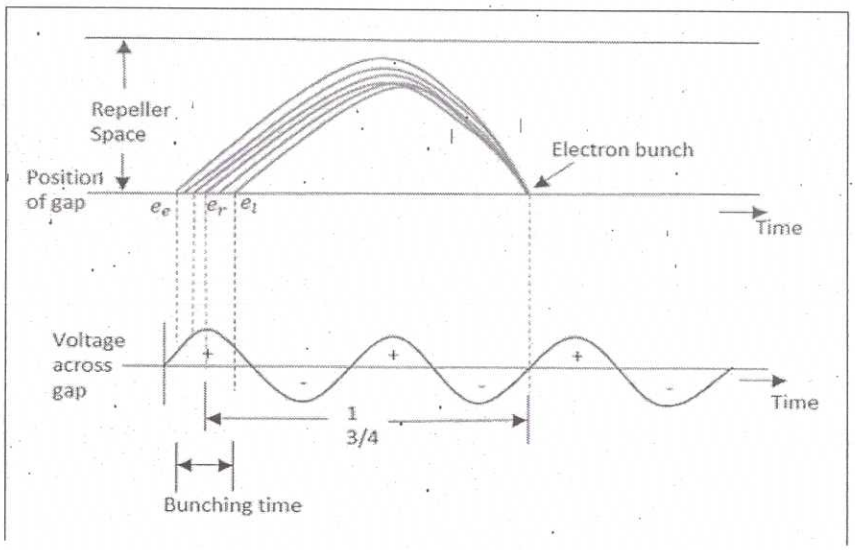
The operation of Reflex Klystron is understood by some assumptions. The electron beam is accelerated towards the anode cavity.

Let us assume that a reference electron $\mathbf{e_r}$ crosses the anode cavity but has no extra velocity and it repels back after reaching the Repeller electrode, with the same velocity. Another electron, let's say $\mathbf{e_e}$ which has started earlier than this reference electron, reaches the Repeller first, but returns slowly, reaching at the same time as the reference electron.

We have another electron, the late electron $\mathbf{e_l}$, which starts later than both $\mathbf{e_r}$ and $\mathbf{e_e}$, however, it moves with greater velocity while returning back, reaching at the same time as er and ee.

Now, these three electrons, namely $\mathbf{e_r}$, $\mathbf{e_e}$ and $\mathbf{e_l}$ reach the gap at the same time, forming an **electron bunch**. This travel time is called as **transit time**, which should have an optimum value. The

following figure illustrates this.



The anode cavity accelerates the electrons while going and gains their energy by retarding them during the return journey. When the gap voltage is at maximum positive, this lets the maximum negative electrons to retard.

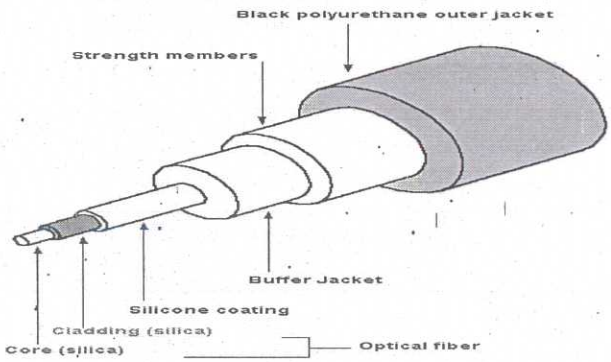
The optimum transit time is represented as

T=n+34where n is an integer

This transit time depends upon the Repeller and anode voltage

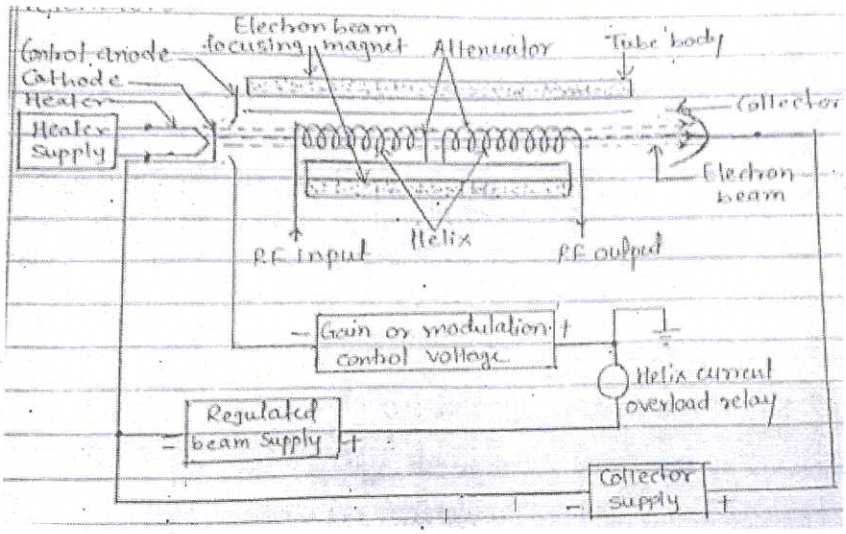
II	3.	A geostationary satellite is an earth-orbiting satellite, placed at an altitude of approximately 35,800 kilometers (22,300 miles) directly over the equator, that revolves in the same direction the earth rotates (west to east). At this altitude, one orbit takes 24 hours, the same length of time as the earth requires to rotate once on its axis. The term geostationary comes from the fact that such a satellite appears nearly stationary in the sky as seen by a ground-based observer. A single geostationary satellite is on a line of sight with about 40 percent of the earth's surface. Three such satellites, each separated by 120 degrees of longitude, can provide coverage of the entire planet,	6	6	

		with the exception of small circular regions centered at the north and south geographic poles. A geostationary satellite can be accessed using a directional antenna, usually a small dish, aimed at the spot in the sky where the satellite appears to hover. The principal advantage of this type of satellite is the fact that an earthbound directional antenna can be aimed and then left in position without further adjustment. Another advantage is the fact that because highly directional antennas can be used, interference from surface-based sources, and from other satellites, is minimized.			
11	4.	**Direct to home** technology refers to the satellite television broadcasting process which is actually intended for home reception. This technology is originally referred to as **direct broadcast satellite (DBS)** technology. The technology was developed for competing with the local cable TV distribution services by providing higher quality satellite signals with more number of channels. In short, DTH refers to the reception of satellite signals on a TV with a personal dish in an individual home. The satellites that are used for this purpose is geostationary satellites. The satellites compress the signals digitally, encrypt them and then are beamed from high powered geostationary satellites. They are received by dishes that are given to the DTH consumers by DTH providers. Though DBS and DTH present the same services to the consumers, there are some differences in the technical specifications. While DBS is used for transmitting signals from satellites at a particular frequency band [the band differs in each country], DTH is used for transmitting signals over a wide range of frequencies [normal frequencies including the KU and KA band]. The satellites used for the transmission of the DTH signals are not part of any international planned frequency band. DBS has changed its plans over the past few	6	6	

		years so as to include new countries and also modify their mode of transmission from analog to digital. But DTH is more famous for its services in both the analog and digital services which includes both audio and video signals. The dishes used for this service is also very small in size. When it comes to commercial use, DBS is known for its service providing a group of free channels that are allowed for its targeted country.			
11	5.	 Core and cladding are typically made of glass or plastic. Most important specification of the core is the index of refraction which is the value for light bending passing through the material and for the speed of that light could travel through material with. Cladding is having lower refractive index than the core. It allows light to stay inside the fiber and not escape into cladding, since it will be reflected. Coating is simply a protective layer that is protecting core and cladding from the fracture.	2(fig)+4	6	
11	6.	In wireless communications, fading is variation of the attenuation of a signal with various variables. These variables include time, geographical position, and radio frequency. Fading is often modeled as a random process. A fading channel is a communication channel that experiences fading. In wireless systems, fading may either be due to multipath propagation, referred to as multipath-induced	6	6	

		fading, weather (particularly rain), or shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading.The terms *slow* and *fast* fading refer to the rate at which the magnitude and phase change imposed by the channel on the signal changes. The coherence time is a measure of the minimum time required for the magnitude change or phase change of the channel to become uncorrelated from its previous value. • Slow fading arises when the coherence time of the channel is large relative to the delay requirement of the application.[2] In this regime, the amplitude and phase change imposed by the channel can be considered roughly constant over the period of use. Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver. The received power change caused by shadowing is often modeled using a log-normal distribution with a standard deviation according to the log-distance path loss model. • Fast fading occurs when the coherence time of the channel is small relative to the delay requirement of the application. In this case, the amplitude and phase change imposed by the channel varies considerably over the period of use.			
11	7.	WiMAX is a wireless broadband solution that offers a rich set of features with a lot of flexibility in terms of deployment options and potential service offerings. Some of the more salient features that deserve highlighting are as follows: 1. Two Types of Services:· WiMAX can provide two forms of wireless service: i. Non-line-of-sight: service is a Wi-Fi sort of service. Here a small antenna on your computer connects to	6	6	

		the WiMAX tower. In this mode, WiMAX uses a lower frequency range- 2 GHz to 11 GHz (similar to Wi-Fi). ii. Line-of-sight: service, where a fixed dish antenna points straight at the WiMAX tower from a rooftop or pole. The line-of-sight connection is stronger and more stable, so it's able to send a lot of data with fewer errors. Line-of-sight transmissions use higher frequencies, with ranges reaching a possible 66 GHz. 2. OFDM-based physical layer: The WiMAX physical layer (PHY) is based on orthogonal frequency division multiplexing, a scheme that offers good resistance to multipath, and allows WiMAX to operate in NLOS conditions. 3. Very high peak data rates: WiMAX is capable of supporting very high peak data rates. In fact, the peak PHY data rate can be as high as 74Mbps when operating using a 20MHz wide spectrum. More typically, using a 10MHz spectrum operating using TDD scheme with a 3:1 downlink-to-uplink ratio, the peak PHY data rate is about 25Mbps and 6.7Mbps for the downlink and the uplink, respectively. 4. Scalable bandwidth and data rate support: WiMAX has a scalable physical-layer architecture that allows for the data rate to scale easily with available channel bandwidth. For example, a WiMAX system may use 128, 512, or 1,048-bit FFTs (fast Fourier transforms) based on whether the channel bandwidth is 1.25MHz, 5MHz, or 10MHz, respectively. This scaling may be done dynamically to support user roaming across different networks that may have different bandwidth			

		allocations.			
		PART C			
III	a	Travelling wave tubes (TWTs) are widely used as broadband low and medium power microwave amplifier.. It is a device in which there exist a continuous interaction between electron beam and RF field. To prolong the interaction between electron beam and RF field, it is necessary to ensure that both are travelling in the same direction with nearly same velocity.  **Construction:** It consist of 1. Electron gun used to produce a narrow constant velocity electron beam; which is passed through the centre of a long axial helix. 2. Magnets are used to focus electron beam and prevent it from spreading due to space charge effect. 3. Helix is used as periodic slow wave structure, which is a loosely wound thin conducting helical wire. 4. A collector which is generally kept at a d.c. potential lower	4+4	8	15

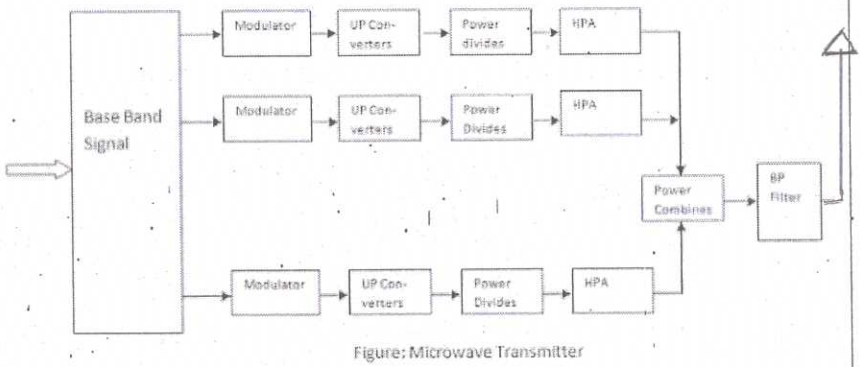
than that of the helix.

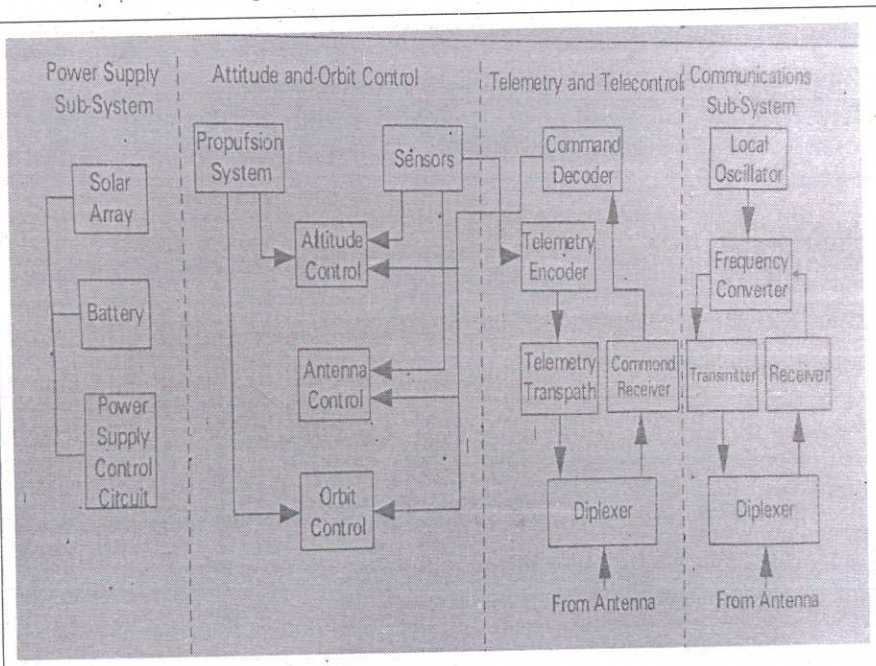
5. Input and output couplers.
6. The attenuator is used at the Centre of the circuit which absorb the reflecting wave fro-m mismatch at the output end. This preventing reflections reaching towards the input which causes oscillation.

Working:

1. When RF signal which is to be amplied is applied to the TWT, its initial velocity is nearly equal to the velocity of light but when the signal propagates around the turns of the helix, it produces electric field along the axis of the helix, which propagates along the axial direction with phase velocity which is small compared to the velocity of light by the slowing factor:
2. The axial electric field can now continuously interact with the electron beam. The electron entering the helix at zero field is not affected by the signal wave. Those electron entering the helix at accelerating field are accelerated and those are at the retarding field are decelerated thus velocity modulation takes place and this produces bunching of electron.
3. This bunch of electrons travel with the RF field and as consequence the field continuously acts to increase the bunching i.e velocity and density modulation occurs simultaneously in this region.
4. Since the dc electron velocity, its results into a situation in which more electrons face the retarding field than the accelerating field, energy is thus last by the electron beam and becomes more and more stronger and a longer amplification of the RF signal occurs at the end of the helix.

III	b	A Tunnel Diode is also known as Eskari diode and it is a highly doped semiconductor which is capable of very fast operation. The Germanium material is basically used to make tunnel diodes. They can also be made from gallium arsenide and silicon materials. Actually, they are used in frequency detectors and converters. The Tunnel diode exhibits negative resistance in their operating range. Therefore, it can be used as an amplifier, oscillators and in any switching circuits. unnel Diode is the P-N junction device that exhibits negative resistance. When the voltage is increased then the current flowing through it decreases. It works on the principle of Tunneling effect. Metal-Insulator-Metal (MIM) diode is another type of Tunnel diode, but its present application appears to be limited to research environments due to inherit sensitivities, its applications considered to be very limited to research environments. There is one more diode called Metal-Insulator-Insulator-Metal (MIIM) diode which includes an additional insulator layer. The tunnel diode is a two terminal device with n-type semiconductor as cathode and p-type semiconductor as anode. The operation of the tunnel diode mainly includes two biasing methods such as forward and reverse Forward Bias Condition Under the forward bias condition, as voltage increases, then current decreases and thus become increasingly misaligned, known as negative resistance. An increase in voltage will lead to operate as a normal diode where the conduction of electrons travels across the P-N junction diode. The negative resistance region is the most important operating region for a Tunnel diode. The Tunnel diode and normal P-N junction diode characteristics are different from each other. Reverse Bias Condition	7	7	

		Under the reverse condition, the tunnel diode acts as a back diode or backward diode. With zero offset voltage it can act as a fast rectifier. In reverse bias condition, the empty states on the n-side aligned with the filled states on the p-side. In the reverse direction, the electrons will tunnel through a potential barrier. Because of its high doping concentrations, tunnel diode acts as an excellent conductor.			
IV	a	 Figure: Microwave Transmitter The signal to be transmitter must be at uplink frequency. The converter multiply the signal frequency to uplink frequency after it is encoded and modulated properly. After upconverting the frequency, it is applied to power dividers. The output of power divider goes to high power amplifier. Normally travelling wave tube amplifiers or multicavity klystron amplifiers are used. These tubes require good amount of cooling.Here the modulation is performed at 70 MHz intermediate frequency and is then upconverted to a uplink frequency of 6 GHz. The output of several high power amplifiers are combined in a power combining amplifier and the output then passes through band pass filter and circulators. Frequency stability and power control are necessary to avoid interferences. The manufacturing is high and it increases as transmitted power increases.	4+4	8	15
IV	b	• Waveguides are hollow metal tubes and used for transmission of very high frequency with as low attenuation as is possible. • At ultra high and microwave frequencies, waveguides provide	1*7	7	

		a practical alternative to transmission line for transmission of electrical energy. • Skin effect is not experienced in waveguide. • As the walls of a waveguide are perfect conductors ,there can be no tangential component of electric field at walls. • When travelling along a waveguide have a phase velocity and will be attenuated. • Waves reaches the end of the waveguide it is reflected unless the load impendence is adjusted carefully to absorb the wave. • The various possible modes are TE and TM modes.			
V	a	 Explain each block	4+4	8	15
V	b	• If the channel is not in use, it sits idle • Channel bandwidth is relatively narrow • Simple algorithmically, and from a hardware standpoint • Fairly efficient when the number of stations is amall and traffic is uniformly constant. • Capacity increases can be obtained by reducing the information bit rate and using efficient digital code. • No need for network timing • No restriction regarding the type of baseband or type of modulation	1*7	7	

VI	a	**FDMA** Frequency Division Multiple Access FDMA channel carries only one phone circuit at a time FDMA puts each call on separate frequency Complexity of FDMA system is lower Guard band is used Continues transmission Narrow bandwidth Low Overhead Can be used with both analog and digital Not sensitive to near far problem It requires high performing filters in receiver section.	**CDMA** Code Division Multiple Access Parallel communication without collision Whole bandwidth can be used Users are separated by code not by time slot and frequency Every channel uses the full available spectrum Individual conversations are encoded CDMA is the common platform in which 3G technologies are built Better signal quality Potentially larger capacity	8	8	15
VI	b	• It carries data rates of 64kbps to 120 Mbps • It provides the user with extended battery life and talktime • It is the most cost effective technology to convert an analog system to digital • TDMA technology separates users according to time, it ensures that there will e no interference • TDMA allows the operator to do services like fax, voice band data and sms , multimedia and video conferencing		1*7	7	
VII	a	The optical fiber consists of three main elements: Transmitter: An electric signal is applied to the optical transmitter.		4+4	8	15

The optical transmitter consists of driver circuit, light source and fiber flylead

- Driver circuit drives the light source.
- Light source converts electrical signal to optical signal.
- Fiber flylead is used to connect optical signal to optical fiber.
- Transmission channel: It consists of a cable that provides mechanical and environmental protection to the optical fibers contained inside.
- Optical splice is used to permanently join two individual optical fibers.
- Optical connector is for temporary non-fixed joints between two individual optical fibers.
- Optical coupler or splitter provides signal to other devices.

Repeater converts the optical signal into electrical signal using optical receiver and passes it to electronic circuit where it is reshaped and amplified as it gets attenuated and distorted with increasing distance because of scattering, absorption and dispersion in waveguides, and this signal is then again converted into optical signal by the optical transmitter.

Receiver: Optical signal is applied to the optical receiver. It consists of photo detector, amplifier and signal restorer.

- Photo detector converts the optical signal to electrical signal.
- Signal restorers and amplifiers are used to improve signal to noise ratio of the signal as there are chances of noise to be introduced in the signal due to the use of photo detectors.

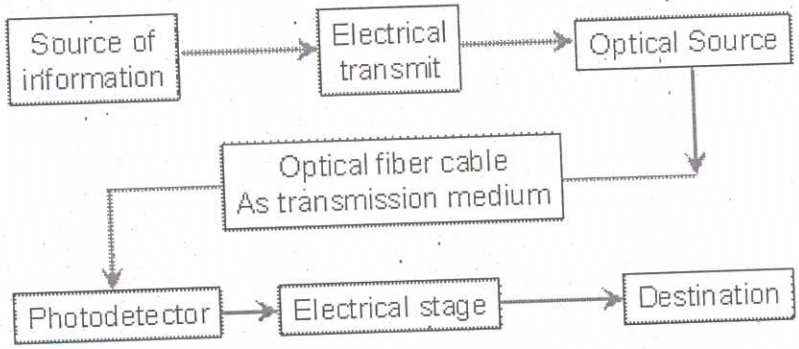
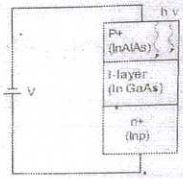


FIGURE 2

VII	b	**Single Mode Fibers**	**Multimode Fibers**	1*7	7	
		Lower Intermodal dispersion	Considerable dispersion due to different group velocities			
		Maximum bandwidth can be attained	Bandwidth is limited			
		Smaller core diameter	Larger core diameter			
		Uses coherent optical source	Uses incoherent optical source			
		NA is smaller	NA is larger			
		Low coupling efficiency	High coupling efficiency			
		Up gradation is possible	Up gradation is difficult			
VIII	a	• PIN photodiode		8	8	15

		.17 PIN PHOTODIODE As the name indicates, this diode consists of an undopped intrinsic layer between the two highly dropped regions. It gives improved performance as compared to conventional photodiodes. **Construction :** The construction of PIN photodiode is as shown in Fig. 3.11.  Fig. 3.11 PIN Photodiode It consists of an undopped intrinsic i layer as shown in Fig. 3.12. The width of this layer is more than that of dopped P+ and N+ layers. The resistivity of 'i' layer ranges from 10 ohms per centimetre to 100 KΩ per centimetre. While the resistivity of dopped P+ and N+ layer is less than 1 Ω/cm. This diode has much larger depletion area. **Working :** The PIN diode does not provide any gain. So the maximum internal quantum efficiency is 100%. Now since the resistance of 'i' layer is very high, all the reverse bias is applied across this layer. When the light is incident on this photodiode, the electron-hole pairs are generated in i layer. These charged carriers are attracted towards the respective battery terminal. Now this reverse biased P.N. junction will act as a capacitor. Here 'i' layer is the depletion region which acts as a dielectric material. For the optimum design the transit time should be equal to the RC time constant of such capacitor. $t_{tr} = \tau RC$ **Advantages :** 1. Very low reverse bias is necessary 2. It gives high quantum efficiency 3. A large bandwidths can be obtained 4. It gives lower noise performance **Disadvantages :** The only disadvantage is that the photodiodes doesn't give the amplification action. So in many cases an amplifier is required.			
VIII	b	**1.Linear scattering losses :** Through this mechanism a portion/total optical power within one propagating mode is transferred to another. Now when the transfer takes place to a leaky or radiation mode then the result is attenuation. It can be divided into two major categories namely **Mie scattering** and **Rayleigh scattering**. **Mie Scattering :** Non perfect cylindrical structure of the fiber and imperfections like irregularities in the core-cladding interface, diameter fluctuations, strains and bubbles may create linear scattering which is termed as Mie scattering.	7	7	

Rayleigh Scattering :

The dominant reason behind Rayleigh scattering is refractive index fluctuations due to density and compositional variation in the core. It is the major intrinsic loss mechanism in the low impedance window. Rayleigh scattering can be reduced to a large extent by using longest possible wavelength.

2.Non linear scattering losses :

Specially at high optical power levels scattering causes disproportionate attenuation, due to non linear behaviour. Because of this non linear scattering the optical power from one mode is transferred in either the forward or backward direction to the same, or other modes, at different frequencies. The two dominant types of non linear scattering are :

a) Stimulated Brillouin Scattering and

b) Stimulated Raman Scattering.

3.Material Absorption losses :

When there happens to be some defect in the material composition and the fabrication process of optical fiber, there is dissipation of optical power in the form of heat in the waveguide. Here also there are two types of absorption losses in the fiber such as **intrinsic absorption** and **extrinsic absorption.** When the absorption is caused by interaction with one or more components of glass it is termed as intrinsic absorption whereas if it is due to impurities within the glass like transition metal or water then it is called the extrinsic one.

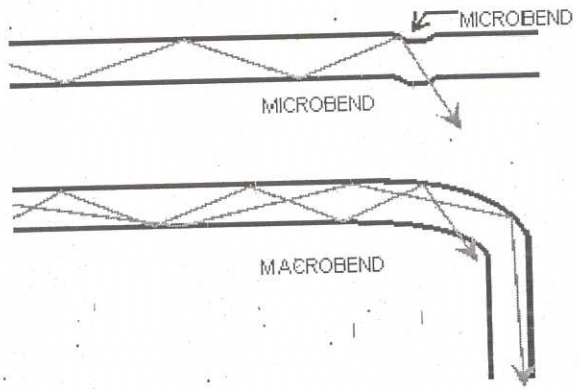
4.Dispersion :

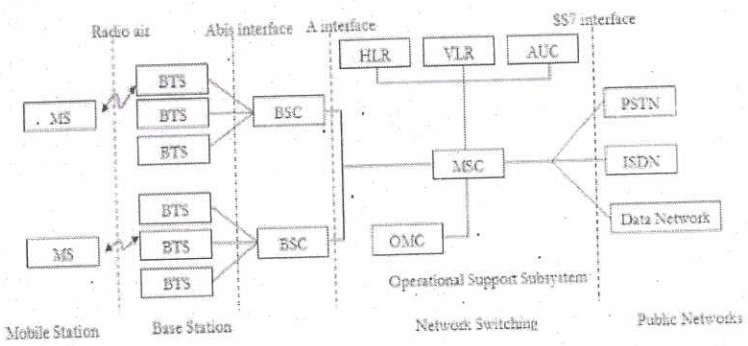
It is defined as the spreading of the light pulses as they travel down the fiber. Because of the spreading effect, pulse tend to overlap, making them unreadable by the receiver which is a critical problem to deal with. It creates distortion for both digital and analog transmission. Dispersion limits the maximum possible

bandwidth attainable within a particular fiber

5. **Fiber bending losses :**

Light energy gets radiated at the bends on their path through the fiber and eventually is lost. This is the mechanism known as fiber bend losses. There are two types bending causing this loss namely micro bending and macro bending. If the fiber is sharply bent so that the light traveling down the fiber can not make the turn and gets lost then it's macro bending .When small bends in the fiber created by crushing, contraction etc causes the loss then it is called micro bending .



IX	a	 Fig: GSM Architecture The GSM architecture consists of three major interconnected subsystems that interact with themselves and with users through certain network interface. The subsystems are Base Station	4(fig)+4	8	15

Subsystem (BSS), Network Switching Subsystem (NSS) and Operational Support Subsystem (OSS). Mobile Station (MS) is also a subsystem but it is considered as a part of BSS.

1. **Mobile Station (MS):** Mobile Station is made up of two entities.

   A. **Mobile equipment (ME):**

   - It is a portable, vehicle mounted, hand held device.
   - It is uniquely identified by an IMEI number.
   - It is used for voice and data transmission. It also monitors power and signal quality of surrounding cells foe optimum handover. 160 characters long SMS can also be sent using Mobile Equipment.

   B. Subscriber Identity module (SIM):

   - It is a smart card that contains the International Mobile Subscriber Identity (IMSI) number.
   - It allows users to send and receive calls and receive other subscriber services.
   - It is protected by password or PIN.
   - It contains encoded network identification details.

2. **Base Station Subsystem (BSS):** It is also known as radio subsystem, provides and manages radio transmission paths between the mobile station and the Mobile Switching Centre (MSC). BSS also manages interface between the mobile station and all other subsystems of GSM. It consists of two parts.

   A. Base Transceiver Station (BTS):

   - It encodes, encrypts, multiplexes, modulates and

feeds the RF signal to the antenna.

- It consists of transceiver units.

B. Base Station Controller (BSC):

- It manages radio resources for BTS. It assigns frequency and time slots for all mobile stations in its area.
- It handles call set up, transcoding and adaptation functionality handover for each MS radio power control.

3. **Network Switching Subsystem (NSS):** it manages the switching functions of the system and allows MSCs to communicate with other networks such as PSTN and ISDN. It consist of

A. Mobile switching Centre:

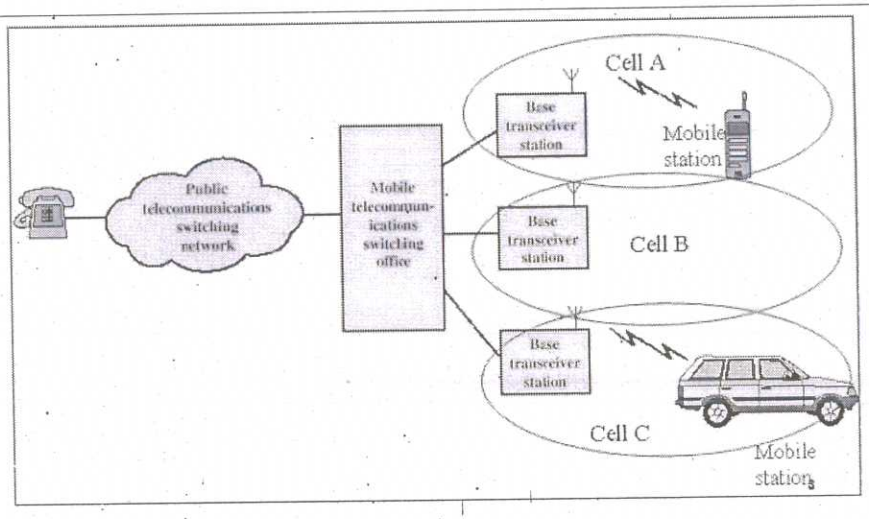
- It is a heart of the network. It manages communication between GSM and other networks.
- It manages call set up function, routing and basic switching.
- It performs mobility management including registration, location updating and inter BSS and inter MSC call handoff.

B. Home Location Registers (HLR):

- It is a permanent database about mobile subscriber in a large service area.
- Its database contains IMSI, IMSISDN, prepaid/post-paid, roaming restrictions, supplementary services.

		C. Visitor Location Registers (VLR): ○ It is a temporary database which updates whenever new MS enters its area by HLR database. ○ It controls mobiles roaming in its area. It reduces number of queries to HLR. ○ Its database contains IMSI, TMSI, IMSISDN, MSRN, location, area authentication key. **D. Authentication Centre:** ○ It provides protection against intruders in air interface. ○ It maintains authentication keys and algorithms and provides security triplets (RAND, SRES, Ki). **E. Equipment Identity Registry (EIR):** ○ It is a database that is used to track handset using the IMEI number. ○ It is made up of three sub classes- the white list, the black list and the gray list. • **Operational Support Subsystem (OSS):** It supports the operation and maintenance of GSM and allows system engineers to monitor, diagnose and troubleshoot all aspects of GSM system. To maintain all telecommunication hardware and network operations with a particular market. • To manage all charging and billing procedures			
IX	b	**ADVANTAGES**	7	7	

		• More bandwidth . • Security and reliability • Fixed and variable data rates • Asymmetric data rates • Always online devices, 3G will use IP connectivity • Rich multimedia services **DISADVANTAGES** • Cost is high • 3G handset is a complex product • Base stations need to be closer to each thus involving more cost • Content Provisioning to make services popular			
X	a	Basic Components of a Cellular Telephone System Cellular Mobile Phone Base Station: A Low Power Transmitter, other Radio Equipment [Transceivers] plus a small Tower Mobile Switching Center [MSC] /Mobile Telephone Switching Office[MTSO] : An Interface between Base Stations and the PSTN Controls all the Base Stations in the Region and Processes User ID and other Call Parameters A typical MSC can handle up to 100,000 Mobiles, and 5000 Simultaneous Calls Handles Handoff Requests, Call Initiation Requests, and all Billing & System Maintenance Functions	4+4	8	15



The Cellular Concept · RF spectrum is a valuable and scarce commodity.

RF signals attenuate over distance

Cellular network divides coverage area into cells, each served by its own base.station transceiver and antenna

Low (er) power transmitters used by BSs; transmission range determines cell boundary

RF spectrum divided into distinct groups of channels

X	b	Advantages 1. It creates adhoc connection and its connection is very quik. 2. It has low power consumption. 3. It can pass through walls. 4. It has range better than Infrared communication. 5. It is used for voice and data transfer. 6. It uses FHSS and hence data communication is more secure. 7. Bluetooth devices are available at cheap rates. 8. It has less interference	1*7	7	