19./20.

Q. 4. What is the frequency range of light signal. 19.

Ans. Ligh has frequency between 100 and 1000 THz.

Q. 5. What are the three commonly used fixed wavelengths in use in fiber optic communication system?

19.

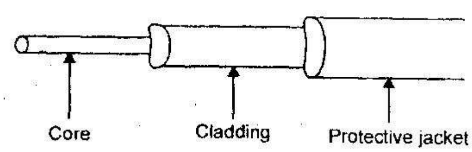
Ans. The commonly used wavelengths in today fiber optic communication system are 750 to 850 nm, 1310 nm and 1530 to 1560 nm.

Q. 6. What are the wavelengths ranges for optical bands S. C and L?

Ans. The wavelength ranges for optic band are: 19.

S is 750 nm to 850 nm
C is 1310 nm
L is 1530 nm 1560 nm.

Q. 7. What is an optical fiber? 19.



Ans. An optical fiber is a thin transparent flexible strand that consists of a core surrounded by cladding. It confines electromagnetic energy in the form of light to within its surfaces and guides the light in a direction parallel to its axis. The core is the portion of the fiber that carries the transmitted light. The cladding surrounds the core. It has a lower index of refraction to keep the light in the core. An optical fiber has an additional coating around the cladding called protective jacket. It protects the core and cladding from shocks that might affect their optical or physical properties. It has no optical properties affecting the propagation of light within the fiber.

Q. 8. What is Snell's law and laws of reflection? 19.

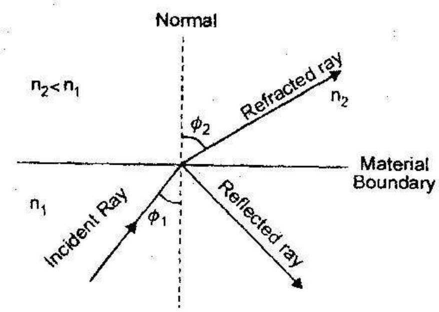
Ans. Snell's law gives a relationship at the interface of two mediums having different refractive indexes.

According to snell's law

$$n_1 \sin \phi_1 = n_2 \sin \phi_2$$

where, n_1 = Refractive index of material

n_2 = Refractive index of material 2



Laws of Reflection

According to laws of reflection.

1. The angle at which the incident ray strikes the interface is exactly equal to the angle the reflected ray makes with the same interface.
2. The incident ray, the normal to the interface and the reflected ray, all lie in the some plane which is perpendicular to the interface plane between the two materials.

Q. 9. What are the advantages of the cladding? 19

Ans. Advantages of the cladding are:

(a) It adds mechanical strength to the fiber and protects the fiber from absorbing surface contaminants with which it may come in contact.

(b) The cladding is capable of reducing the scattering loss of light resulting from dielectric discontinuities at the core surface.

Q. 10. Define the terms (a) Refractive Index (b) Total Internal Reflection. 19

Ans. Refractive Index: It is defined as the ratio of speed of light in vacuum to that in medium. It is given by

$$n = \frac{c}{v}$$

where, c = speed of light in vacuum = 3×10^8 m/s

v = speed of light in medium.

Total Internal Reflection: It is the mechanism by which light at a sufficiently shallow angle less than $90^\circ - \phi_c$ is considered to propagate down in an optical fiber with lovv loss.

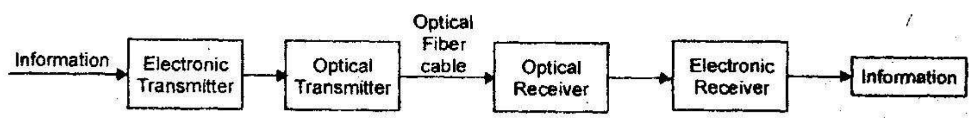
Total internal reflection occurs at the interface between two dielectrics of different refractive indices.

When a light ray travelling in one material hits a different material and reflects back into the original material without any loss of light, total internal reflection occurs. For total internal reflection to occur, the index of refraction ofthe core must be higher than that of the cladding.

Q. 11. Draw the block diagram of a fiber optic communications system and describe function of each component.

20

Ans.



The basic blocks of fiber optic communication systems are transmitter, optical fiber cable and receiver. The transmitter consists of light source and its associated drive circuit, optical fiber cable offers mechanical and environment protection to optical fibers contained inside and receiver consists of photodetector, amplification and signal restoring circuit Information to be conveyed enters an electronic transmitter. In electronic transmitter it is converted into electrical form, modulated and multiplexed. The electrical signal then goes to optical transmitter where it is converted into optical form i.e. into light. The light signal is then transmitted over optical fiber. At the receiver end, light signal is received by optical detector which converts the light signal into an electrical signal. The electrical signal then enters into electronic receiver where electrical signal is processed to get the exact information.

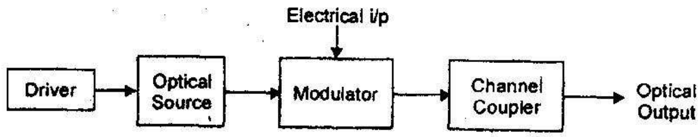
Transmitter: The heart of the transmitter is a light source. The main function of light source is to convert an information signal from its electrical form into light. LEDS and laser diodes are used as light sources.

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

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

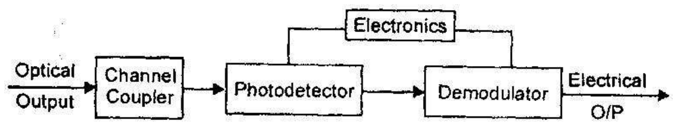
Q. 12. Draw the block diagram of optical transmitter and the optical receiver and explain function of each component.

Ans.



Block diagram of optical transmitter

The main function of an optical transmitter is to convert the electrical signal into optical signal and to launch the optical signal into the optical fiber. Optical transmitter consists of optical source, modulator and a channel coupler. Light emitting diodes (LEDS) and Laser diodes are used as optical sources. The input electrical signal modulates the intensity of light from the optical source. The optical carrier can be modulated internally or externally using an electro-optic modulator or acousto—optic modulator. Now a day's electro-optic modulators are widely used as external modulators which modulate the light by changing its refractive index through given input electrical signal. The function of a coupler is to couple the optical signal to optical fiber cable. The coupler is a micro lens that focuses the optical signal onto the entrance plane of an optical fiber with maximum efficiency.



Block diagram of an optical receiver

The main function of optical receiver is to convert the received optical signal back onto the original electrical signal. The optical receiver consists of a channel coupler, a pñoto detector and a demodulator. The coupler focuses the received optical signal onto if photo detector. The photo detector like avalanche photo diode (APD) or positivetrinsic-negative (PIN) diode converts the optical pulses into electrical pulses. The requirements for a photo detectors are similar to those of an optical source. It should have high sensitivity fast response, Low noise, low cost and high reliability. The demodulator, demodulates the received electrical signal back to original information. The design of demodulator depends on the modulation formate used by light wave system.

Q. 17. Find the critical angle at the core-cladding interface and numerical aperture for the fiber having core refractive index of 1.55 and a cladding refractive index of 1.50.

Ans. At the core cladding interface critical angle ϕ_c is given by

$$\sin\phi_c = \frac{n_2}{n_1}$$

$$\phi_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1.50}{1.55}\right) = 75.4^\circ$$

$$\text{Numerical aperture NA} = \sqrt{n_1^2 - n_2^2} = \sqrt{(1.55)^2 - (1.50)^2} = 0.39$$

Q. 18. An optical fiber has core refractive index of 1.50 and the cladding refractive index of 1.450. Calculate

(i) The critical angle for core-cladding interface. 20

(ii) The acceptance angle in air for the fiber.

(iii) The numerical aperture of the fiber.

(iv) The percentage of light collected by the fiber assuming that the diameters of the core of fiber is greater than the diameter of the light source.

Ans.

$$n_1 = 1.50$$
$$n_2 = 1.450$$

(*i*) Critical angle for core-cladding interface

$$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1.450}{1.50}\right)$$
$$= 75.16^\circ$$

(*ii*) Acceptance angle

$$\theta_a = \sin^{-1}\sqrt{n_1^2 - n_2^2} = \sin^{-1}\sqrt{(1.50)^2 - (1.45)^2}$$
$$= 22.3^\circ$$

(*iii*) Numerical Aperture

$$\text{NA} = \sqrt{n_1^2 - n_2^2} = \sqrt{(1.50)^2 - (1.45)^2}$$
$$= 0.38$$

(*iv*) Percentage of light collected by the fiber

$$n_c = \sin^2\theta_a$$
$$= (\text{NA})^2 = (0.38)^2$$
$$= 0.1444 = 14.4\%.$$