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ENGINEERING PHYSICS II (SUBJECT CODE: 303192102)

CHAPTER 4

Laser and Fibre Optics

Applications

- **Optical Communications:**
- Traditionally, electronic communications were carried out by sending electrical signals through copper cables, coaxial cables or waveguides. In recent years optical fibers are being used, where light signals replace electrical signals.
- A basic communication system consists of a transmitter, a receiver and an information pathway. Normally the information must be converted to electrical signal by using a transducer. For example, a microphone converts sound waves into currents. A message signal is imposed on a carrier wave (high frequency wave), process is called modulation. This modulated signal is transmitted. The receiver demodulates the wave and separates out the message and feeds to a transducer such a loud speaker.
- The normal TV communication has a bandwidth of 250 MHz and therefore it can simultaneously transmit 20 TV programmes. Instead of microwaves if light waves are used as carrier wave, the bandwidth will be about 10^8 MHz and can therefore transmit about 10^6 TV programmes at a time. Thus the use of the light waves expands our communication capabilities tremendously.

Applications

- **Medical Applications:**
- The fiber optic endoscope is used to inspect internal organs for diagnostic purposes.
- A laser beam guided by optical fiber is used to reattach detached retina and to correct defective vision.
- The optical energy transmitted through a optical fiber is used to evaporate built-up plaque that is blocking an artery.
- In cancer treatment, special chemicals are injected that penetrates only the cancerous cells. Infra red energy transmitted via the fiber illuminates the affected area and is absorbed by the special chemical in the cancerous cells. The heat generated destroys the cancerous cells.
- **Military Applications:**
- An aircraft, a ship or a tank needs tons of copper wire for wiring of the communication requirement, control mechanism etc. Use of optical fiber in place of copper reduces weight.
- Fiber guided missiles are used in recent wars. Sensors mounted on the missile transmit video information through the optical fiber to a ground control van and receive commands from the van again. The control van continuously monitors the missiles position to ensure that the missile precisely hits the target.

Numerical

(3) Calculate the numerical aperture and acceptance angle of an optical fiber from the following data

n_1(core) = 1.55, n_2(cladding) = 1.50

Hint: $\mathrm{NA} = \sqrt{(n_1^2 - n_2^2)}$

$$\theta_0 = \sin^{-1}\left[\sqrt{(n_1^2 - n_2^2)}\right]$$

Solution: $\mathbf{NA} = \sqrt{(n_1^2 - n_2^2)} = \sqrt{(1.55^2 - 1.50^2)} = \sqrt{0.1525} = \mathbf{0.3905}$

$$\boldsymbol{\theta_0} = \sin^{-1}\left[\sqrt{(n_1^2 - n_2^2)}\right] = \sin^{-1}[0.3905] = \mathbf{22.98^0}$$

Numerical

(4) Optical Power of 1 mW is launched into an optical fiber of length 100 m. If the power emerging from the other end is 0.3 mW. Calculate the fiber attenuation.

Hint: $\alpha = \frac{10}{L} \log\left[\frac{P_i}{P_O}\right]$

Solution: $\boldsymbol{\alpha = \frac{10}{L} \log\left[\frac{P_i}{P_O}\right] = \frac{10}{0.1\ km} \log\left[\frac{1\ mV}{0.3\ mV}\right] = 52.28\ dB/km}$

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