TUTORIAL -2 OPTICAL FIBERS

Review:

- Numerical aperture, NA = Sin $\theta_0 = \frac{1}{n_0}\sqrt{n_1^2 - n_2^2}$ where $\theta_0 \rightarrow$ angle of acceptance, $n_1 \rightarrow$ Core refractive index; $n_2 \rightarrow$ Cladding refractive index, $n_0 \rightarrow$ Refractive index of external medium
- $\Delta = \frac{\boldsymbol{n_1 - n_2}}{\boldsymbol{n_1}}$ $\Delta \rightarrow$ fractional change in refractive index.
- NA = $n_1\sqrt{2\Delta}$
- Critical angle, C = $\sin^{-1}(n_2/n_1)$
- $\mathbf{V} = \frac{\pi d}{\lambda}(\mathbf{NA}) = \frac{\pi d}{\lambda}\frac{\sqrt{n_1^2 - n_2^2}}{n_o}$ d $\rightarrow$ diameter of the fiber; $\lambda \rightarrow$ Operating wavelength
- Number of modes = $V^2/2$
- Attenuation coefficient, $\alpha = \frac{-10}{L}\ log_{10}\left[{}^{P_2}/{}_{P_1}\right]$ dB km^{-1}

  $P_2 \rightarrow$ output signal power; $P_1 \rightarrow$ input signal power; L $\rightarrow$ length of fiber in km.

NUMERICAL PROBLEMS

1. An optical fiber has a core of refractive index equal to 1.55 and a cladding of refractive index equal to 1.525. Calculate the following: (i) numerical aperture (ii) angle of acceptance (iii) fractional index change (iv) critical angle and (v) velocity of light in the core of the optical fiber. The fiber is placed in air.
2. An optical fiber has core R.I. =1.56 and fractional change in refractive index equal to 0.0005. The fiber is placed in water. Calculate (i) NA, (ii) cladding refractive index, (iii) critical angle and (iv) angle of acceptance.
3. An optical fiber has a numerical aperture of 0.35 and the relative refractive index change is 2.6%. Calculate the acceptance angle, critical angle and the refractive indices of core and cladding.
4. The relative refractive index of an optical fiber is 3% for a core refractive index of 1.58. The diameter of the fiber is 100μm. Calculate the number of modes for an operating wave length of 0.85 μm.
5. The number of modes in a step index fiber is 2500. The diameter of the core is 100μm and numerical

6. aperture is 0.5. Calculate the operating wavelength. If the same fiber is to be used for single mode operation what should be the operating wavelength?
7. An optical fiber has a core R.I. of 1.57 and cladding R.I. of 1.52. The core diameter is 45 μm. Calculate the fractional index change in R.I. and the number of modes propagating in the fiber for an operating wavelength of 0.9μm.
8. A fiber 1500 m long has an input power of 90 mW and an output power of 30 mW. Calculate the signal attenuation coefficient. What will be the output intensity if the fiber length is increased to 5 km?
9. The output is 50% when a signal travels 10 km in an optical fiber. Calculate the attenuation coefficient. If the input signal intensity is 10 mW, what is the output signal intensity after 5 km?
10. An optical fiber has a core Refractive index of 1.55 and fractional change in R.I. is 0.0075. What should be the diameter of the fiber to support 500 modes at an operating wavelength 80 μm?
11. The output is 60% of the input when the signal travels through 1 km. Calculate the output after 4km for an input signal intensity of 100 mW.
12. The core of a single mode fiber is 5 μm and the refractive indices of core and cladding are 1.51 and 1.48 respectively. Calculate the operating wavelength. If the core diameter is doubled, calculate the required refractive index of the cladding in order to maintain single mode transmission.
13. A step index fiber has normalized frequency 29 at 1350 nm wavelength. If core is 70 μm thick, calculate the acceptance angle of the fiber.
14. A 10 km fiber link uses fiber with a loss of 2.2 dB/km. The fiber is joined every kilometer with connectors which give an attenuation of 0.75 dB each. Determine the optical power which must be launched into the fiber to maintain an optical power level of 5μW at the detector.
15. Assume that a repeater is required in a fiber link whenever the intensity of the optical signal reduces to 60%. If the loss of the fiber is 3 dB/km, determine the distance between adjacent repeaters.