Sample Problems for ECE 572 - 23.03.2012

(From Agrawal Ch. 2, pp. 72-73) (1)

1) A multimode step index fibre has a diameter 50 μm and intermodal dispersion of $\Delta T/L = 10$ ns/km. Find NA and B of this fibre. Take $L = 10$ km, $n_2 = 1.45$

Solution: $\frac{\Delta T}{L} = \frac{NA^2}{2nc}$ (ns/km)

$NA = (\Delta T/L \times 2nc)^{1/2}$ $\qquad \frac{\Delta T}{L} = 10 \times 10^{-9}$ sec/km

$= (10 \times 10^{-9} \times 2 \times 1.45 \times 3 \times 10^5)^{1/2}$

$= 0.0933$

$B = \frac{2nc}{L NA^2} = \frac{2 \times 1.45 \times 3 \times 10^5}{10 \times 0.087} = 1$ Mb/s

2) A single mode fibre has $n_1 - n_2 = 0.005$. Calculate the core radius if the fibre is to have a cut off wavelength of $1 \mu m$. Estimate the spot size W and fraction of power of the mode inside core if this fibre is used at $\lambda = 1.3 \mu m$. Take $n_1 = 1.45$.

Solution: $V = ak(n_1^2 - n_2^2)^{1/2}$, $V_{min} = 2.405$

$n_1 - n_2 = 0.005$ if $n_1 = 1.45$, then $n_2 = 1.445$

$k = \frac{2\pi}{\lambda} = 2\pi \times 10^6$, $a = \frac{V_{min}}{2\pi \times 10^6 \times (1.45^2 - 1.445^2)^{1/2}}$

$a = 3.24 \ \mu m$

From Eq. (2.2.45) of Agrawal

$$\frac{W}{a} \simeq 0.65 + 1.619 V^{-3/2} + 2.879 V^{-6}$$

If we change $\lambda = 1.3\ \mu m$, then

keeping a the same V would change to

$$V = ak \cdot (n_1^2 - n_2^2)^{1/2} = 3.24 \times 10^{-6} \times \frac{2\pi}{1.3 \times 10^{-6}} (1.45^2 - 1.445^2)^{1/2}$$

$$= 1.884$$

$$\frac{w}{a} = 0.65 + 1.619 \times (1.884)^{-3/2} + 2.879 \times (1.884)^{-6}$$

$w = 4.3481\ \mu m$ (so field extends in cladding)

$$T = \frac{P_{core}}{P_{cladding}} = 1 - \exp\left(-\frac{2a^2}{w^2}\right)$$

$$= 0.6706$$

Approximately % 67 percent of power is

carried in core.

3) A 1.3 μm fibre cable system has 50 km length and requires at leas 0.3 μW at receiver. Fibre loss is 0.5 dB/km. Fibre is spliced every 5 km with two connectors of each 1 dB loss, and splice loss is 0.2 dB. Determine the minimum power that must be launched into the fibre.

Solution: Total loss = Fibre Loss × Length (L)

$+$ No of splices (9) $\times 0.2\ dB +$ Number of splices $\times 2 \times 1\ dB$

$= 0.5 \times 50 + 9 \times 0.2\ dB + 18 \times 1 = 44.8\ dB$

$P_r(z = 50\ km) = P_i(z=0) - 44.8\ dB$

$P_i = -35.2288 + 44.8 = 9.5712\ dBm$

$= 9.0598\ mW$