Q.2 a. Show that any two orthogonal plane waves can be combined into a linearly polarized wave.

Answer: Page no. 28 of text book.

b. Determine the maximum possible core diameter which can give a single mode operation for a graded index fibre having a parabolic refractive index profile with core refractive index of 1.45 and a relative index difference of 1.5%. The wavelength of operation being 0.85 µm.

Answer:

The maximum normalised frequency for a single mode operation is given by

$$V = 2.4\left[1 + \frac{2}{2}\right]^{1/2}$$

$$V = 2.4\sqrt{2}$$

The maximum core radius is obtain by the relation:

$$V = \frac{2\pi a n_1 (2\Delta)^{1/2}}{\lambda}$$

$$a = \frac{V\lambda}{2\pi n_1 (2\Delta)^{1/2}} = \frac{2.4\sqrt{2} \times 0.85 \times 10^{-6}}{2\pi \times 1.45 \times (2 \times 0.015)^{1/2}}$$

$$= 1.83\ \mu m$$

The maximum core diameter which can support single mode operation will be

$$2a = 3.66\ \mu m$$

Q.4 a. Explain with neat sketch temperature dependent behaviour of the optical power as a function of the bias current for a particular laser diode.

Answer: Page no.182-183 of text book.

b. A P-N Photodiode has a quantum efficiency of 50% at a wavelength of 0.9 µm. Calculate:
(i) its responsivity at 0.9µm
(ii) the received optical power if mean photocurrent is 10^{-6} amp
(iii) the corresponding number of received photons at this length

Answer:

i: (i) Responsivity is given by

$$R = \frac{\eta e \lambda}{hc}$$

$$R = \frac{0.5 \times 1.6 \times 10^{-19} \times 0.9 \times 10^{-6}}{6.626 \times 10^{-34} \times 3 \times 10^{8}} = 0.36 \, A/W$$

(ii) Received optical power

$$P_o = \frac{I_p}{R} = \frac{10^{-6}}{0.36} = 2.78 \, \mu W$$

(iii) Number of received photons

$$r_e = \frac{\eta P_o \lambda}{hc}$$

$$= \frac{0.5 \times 2.78 \times 10^{-6} \times 0.9 \times 10^{-6}}{6.626 \times 10^{-34} \times 3 \times 10^{8}}$$

$$r_e = 1.26 \times 10^{13} \text{ photon/sec}$$

c. An LED has an injection efficiency of 80 % and light extraction efficiency of 60%. If overall efficiency is 2.5% and non radiative life time is 10ns. Calculate the radiative lifetime.

Answer:

overall efficiency = Injection efficiency × light extraction efficiency × Radiative recombination η.

$$\eta_{total} = \eta_{inj} \times \eta_{ex} \times \eta_r$$

$$\eta_r = \frac{\eta_{total}}{\eta_{inj} \times \eta_{ex}} = \frac{0.025}{0.80 \times 0.60} = 0.052$$

$$= 5.2\,\%$$

$$\eta_r = \frac{\tau_{nr}}{\tau_{nr} + \tau_r} = \frac{1}{1 + \frac{\tau_r}{\tau_{nr}}}$$

$$\tau_r = \left[\frac{1}{\eta_r} - 1\right] \tau_{nr} \qquad \tau_{nr} = 10\,ns.$$

$$= \left[\frac{1}{0.052} - 1\right] \times 10 \times 10^{-9}$$

$$= 182.3\,\eta$$

Q.7 a. Explain the following:
(i) CTB
(ii) CSO
(iii) Multichannel Frequency Modulation

Answer: Page no. 370-371 of Text book.

b. Explain reflection effects on RIN and its limiting conditions.

Answer: Page no. 364-365 of Text book.

Q.8 a. Explain briefly:

(i) First-window transmission distance
(ii) Transmission distance for single-mode links

Answer: Page no. 333-334 of Text book.

Text book

Optical Fiber Communications, Gerd Keiser, 3rd Edition, McGraw Hill Publications, 2000