OPTICAL FIBRE SYSTEMS TUTORIAL QUESTIONS

Q1. When are the phase and group velocities equal ?
If they are not equal what is the consequence?

Q2. A 1 hour lecture script is stored on a computer hard disk in ASCII format (i.e. 1 character = 8 bits). Estimate the total number of bits assuming 200 words per minute and an average of 5 letters per word. How long will it take to transmit the data at a bit rate of 1GBit/s?
(480000 bits, 480 μs)

Q3. A laser source launches 120 μW of optical power into an optical fibre of length 8km. The mean optical output at the end of the fibre is 3μW .
Calculate:

(a) The overall signal attenuation in dB.
(b) The signal attenuation per kilometre
(c) The output power of the laser source in dBm.
(d) The output power of the fibre in dBm

Q4 Sketch a digital NRZ bit stream 010111101110 assuming a bit rate of 10Gb/s. What is the duration of the shortest and widest optical pulse? What is the peak power when an average power of 2mW is launched into the fibre?

Q5. A step index multi-mode fibre has a core index of refraction of 1.5 and an index step Δ of 0.02. Calculate the maximum angle which a guided ray may have relative to the axis (a) inside the fibre, (b) in air outside the fibre before launching. (c) Calculate the maximum time delay difference per kilometre between the axial ray and a guided non-axial and hence find the maximum bit rate if the fibre is 10km long. (d) What is the value of the numerical aperture of the fibre?
Ans.

(a) 11.5° to axis
(b) 17.4° to axis
(c) 10^{-7} s/km, max bite rate = 1MB/s
(d) NA = 0.3

Q6. Calculate the numerical aperture of a step-index fibre having indices of 1.48 and 1.46. What is the maximum acceptance angle for this fibre if the external medium is air, with n=1.00?

Q7. A continuous 12 km-long optical fibre link has a loss of 1.5 dB/km. (a) What is the minimum optical power level that must be launched into the fibre to maintain an optical power level of 0.3 μW at the receiving end? (b) What is the required input power if the fibre has a loss of 2.5 dB/km?

Q8. A laser source launches 120 μW of optical power into an optical fibre of length 8km. The mean optical output at the end of the fibre is 3μW .
Calculate:

(a) The overall signal attenuation in dB.
(b) The signal attenuation per kilometre
(c) The output power of the laser source in dBm.
(d) The output power of the fibre in dBm

Answers 16dB, 2dB/km, -9.2dBm, -25.2dBm

Q9. An optical fibre link consists of a transmitter, a single mode optical fibre and a photodetector. The transmitter operates at 1.55μm, has a linewidth $\Delta\lambda$ of 1nm, launches a power Pmax = 10mW into the fibre, and transmits digital pulses with a 1:1 mark:space ratio at a rate of 1 Gbits/s. The fibre has a total optical loss (fibre only) α of 0.2 dB/km and a dispersion coefficient D of 15 ps/(km.nm). The detector detects all light which reaches the end of the link and requires a minimum power of Pmin = 0.1mW at this bit rate.
Calculate the maximum length of the link if no margin is required for the system. Describe any assumptions made.
If a margin of 18 dB is required for the system, calculate the maximum transmission distance.

Q10. Dry Fibres have low loss over a spectral region 1.3 to 1.6 μm. Estimate the capacity of a WDM system covering this entire region using 40 Gb/s optical channels spaced apart by 0.4nm.

Q11. The C and L spectral bands cover a wavelength range from 1.53 to 1.61 μm. How many channels can be transmitted when the channel spacing is 0.8nm? What is the effective bit rate – distance product when a WDM signal covering the two bands using 10 Gb/s channels I stransmitted over 2000km?

Q12. An 800nm optical receiver needs at least 1000 photons to detect 1 bits accurately. What is the maximum possible length of the fibre link for a 100Mb/s lightwave system designed to transmit -10dBm of average power? Fibre loss is 2dB/km at 800nm. Assume an NRZ format and 1:1 mark space ratio for the optical pulse.