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MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

SIXTH SEMESTER B.Tech. (E & C) DEGREE END SEMESTER EXAMINATION

APRIL 2018

SUBJECT: OPTICAL FIBER COMMUNICATION (ECE - 4011)

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to candidates

- Answer **ALL** questions.
- **Assume h = 6.626 x 10^{-34} Js , c = 2.998 x 10^{8} m/s , e or q = 1.602 x 10^{-19} C**
- Missing data may be suitably assumed.

1A. Using simple ray theory, describe the mechanism for the transmission of light within an optical fiber. Briefly discuss with the aid of a suitable diagrams what is the acceptance angle for an optical fiber? Derive the relationship between the fiber numerical aperture and the refractive indices for the fiber core and cladding. (Provide appropriate labelled diagrams).

1B. The velocity of light in the core of a step index fiber is 2.01×10^{8} m s^{-1} and the critical angle at the core–cladding interface is 80°. Determine i) the core's refractive index, ii) numerical aperture iii) the acceptance angle for the fiber in air with the assumption that it has a core diameter suitable for consideration by ray analysis.

1C. Sketch neatly the intensity profile for LP_{03} and LP_{23}

(5+3+2)

2A. Explain stimulated Brillouin scattering and determine the threshold optical power for SBS for a long SM fiber with an attenuation of 0.2 dB/km, core diameter of 8 μm and operating at a wavelength of 1.55μm with laser source bandwidth of 500 MHz.

2B. A typical SM fiber has a zero-dispersion wavelength of 1.31 μm with a dispersion slope of 0.08 ps nm^{-2} km^{-1}. Determine the total first-order dispersion for the fiber at the wavelength of 1.55 μm. When the material dispersion and profiles dispersion are 13.5 ps nm^{-1} km^{-1} and 0.4 ps nm^{-1} km^{-1} respectively, determine the waveguide dispersion at this wavelength.

2C. Sketch the dispersion virsus wavelength characteristics for single-mode fiber, dispersion shifted fiber and dispersion flattened fiber.

(5+3+2)

3A. An optical amplifier operating at a signal wavelength of 1.3 μm, with an optical bandwidth of 900 GHz. The device has a spontaneous emission factor of 1.5, the mode number is equal to 2 and the ASE noise signal power at the output of the amplifer is 40.84 μW. Determine : i) the gain (in dB) of the amplifier, ii) the noise figure (in dB) of the amplifier iii) the OSNR (in dB) at the output of the amplifier, if the received signal power is 2 μW.

3B. A photodiode has a quantum efficiency of 65% when photons of energy 1.5×10^{-19} J are incident upon it. Determine i) at what wavelength is the photodiode operating, ii) the responsivity iii) the incident optical power required to obtain a photocurrent of 2.5 μA when the photodiode is operating as described above.

3C. Explain 2R optical regeneration.

(5+3+2)

4A. Consider a point-to-point link connecting two nodes separated by 50 km. This link was constructed with standard single-mode fiber and a 2.5 Gb/s system is deployed over the link. The transmitter uses a directly modulated 1310 nm DFB laser. The receiver uses perfectly efficient pin photodiodes and assume, that they can be modeled as ideal quantum limited receivers. The bit error rate requirement for this system is 10^{-12}. Assume α_{dB} = 0.2 dB/km and that NRZ modulation is used.

(i) Design a link for above given specifications and draw a labelled diagram illustrating this configuration.

(ii) Is this system loss limited or dispersion limited? Briefly explain your reasoning.

(iii) What is the required receiver sensitivity (in mW and dBm)?

(iv) What would be the resulting average photocurrent?

(v) What would be the required launch power (in dBm)?

4B. An optical fiber system is to be designed to operate over a 6 km length without repeaters. The rise time for LED together with its drive circuit is 12 ns. Taking a typical LED spectral width of 40 nm, we have a material-dispersion-related rise time degradation of 21 ns over 6-km link. Assuming, that the receiver has a 25 MHz bandwidth, the contribution to the rise-time degradation from receiver is 14 ns. The modal-dispersion-induced fiber rise time is 4 ns. From system rise time considerations, estimate the maximum bit rate that may be achieved on the link when using an NRZ and RZ format. Justify your choice of format based on the result obtained.

4C. An optical fiber system uses fiber cable which exhibits a loss of 7 dB km^{-1}. Average splice losses for the system are 1.5 dB km^{-1}, and connector losses at the source and detector are 4 dB each. After safety margins have been allowed, the total permitted channel loss is 37 dB. Assuming the link to be attenuation limited, determine the maximum possible transmission distance without a repeater.

(5+3+2)

5A. Define optical crosstalk ratio and explain the different types of linear crosstalk with help of a diagram for classification of linear crosstalk.

5B. Explain the upstream transmission in WDM PON, with neatly labelled diagram from WDM PON architecture.

5C Briefly explain the basic operation of an optical coherent receiver with a block diagram.

(5+3+2)