Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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SIXTH SEMESTER B.TECH. (E & C) DEGREE END SEMESTER EXAMINATION
JUNE 2019
SUBJECT: OPTICAL FIBER COMMUNICATION (ECE - 4011)

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

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

1A. i) Derive the relationship between the fiber numerical aperture and the refractive indices for the fiber core and cladding. (Provide appropriate labelled diagrams).

ii) Estimate the maximum core diameter for an optical fiber with the relative refractive index difference of 1.5% and core refractive index of 1.48, in order that it may be suitable for single-mode operation. It may be assumed that the fiber is operating at a wavelength of 0.85 μm. Further, estimate the new maximum core diameter for single-mode operation when the relative refractive index difference is reduced by a factor of 10.

1B. Describe with the aid of simple ray diagrams:
(i) the multimode step index fiber (ii) the multimode graded index fiber.
Compare the advantages and disadvantages of these two types of fiber for use as an optical channel.

1C. With the help of a neat and labelled diagram for TDM PON architecture, explain the upstream transmission.

(4+3+3)

2A. Explain stimulated Raman scattering and determine the threshold optical power for SRS for a long SM fiber with an attenuation 0.35 dB/km, core diameter of 8 μm and operating at a wavelength of 1.5μm with laser source bandwidth of 700 MHz.

2B. i) The light output from the GaAs LED is coupled into a step index fiber with a numerical aperture of 0.2, a core refractive index of 1.4 and a diameter larger than the diameter of the device.

ii) Calculate the optical power emitted into air as a percentage of the internal optical power for the device when the transmission factor at the crystal–air interface is 0.68. The refractive index of GaAs may be taken as 3.6.

iii) When the optical power generated internally is 50% of the electric power supplied, calculate the external power efficiency.

iv) Calculate the coupling efficiency into the fiber when the LED is in close proximity to the fiber core.

v) Calculate optical loss in decibels, relative to the power emitted from the LED, when coupling the light output into the fiber.

vi) Calculate the loss relative to the internally generated optical power in the device when coupling the light output into the fiber (assuming there is a small air gap between the LED and the fiber core).

(5+5)

3A. An SOA operating at a signal wavelength of 980 n m produces a gain of 20 dB with an optical bandwidth of 800 GHz. This device has a spontaneous emission factor of 1.5 and the mode number is equal to 2. Determine : i) the noise figure of the amplifier, ii) the ASE noise signal power at the output of the amplifier and iii) the OSNR (in dB) at the output of the amplifier if the received signal power is 8 μW.

3B. Describe the different optical amplifier configurations. Also, compare EDFA and SOA.

(5+5)

4A. With neat and labelled diagrams, describe the operation of *p-i-n* photodiode. A silicon *p–i–n* photodiode has an intrinsic region with a width of 20 μm and a diameter of 500 μm in which the drift velocity of electrons is 105 m/s. When the permittivity of the device material is 10.5×10^{-13} F/cm, calculate: (i) the drift time of the carriers across the depletion region; (ii) the junction capacitance of the photodiode.

4B. Define the quantum efficiency and the responsivity of a photodetector. Derive an expression for the responsivity of an intrinsic photodetector in terms of the quantum efficiency of the device and the wavelength of the incident radiation. Determine the wavelength at which the quantum efficiency and responsivity are equal. Sketch the responsivity vs wavelength for an ideal photodiode and a typical photodiode.

(5+5)

5A. An optical fiber system is to be designed to operate over a 8 km length without repeaters. The rise times of the chosen components are:

LED	4 ns
Fiber (intermodal)	0.8 ns km^{-1}
Fiber (intramodal)	0.1 ns km^{-1}
APD	2 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.

5B. A D–IM analog optical fiber link of length 2 km employs an LED which launches mean optical power of −10 dBm into a multimode optical fiber. The fiber cable exhibits a loss of 3.5 dB/km with splice losses calculated at 0.7 dB/km. In addition, there is a connector loss at the receiver of 1.6 dB. The pin photodiode receiver has a sensitivity of −25 dBm for an SNR of 50 dB and with a modulation index of 0.5. It is estimated that a safety margin of 3 dB is required. Assuming there is no dispersion–equalization penalty:

i) Draw a labelled diagram illustrating this link configuration

ii) Perform an optical power budget for the system operating under the above conditions and ascertain its viability.

iii) Estimate any possible increase in link length which may be achieved using an injection laser source which launches mean optical power of 0 dBm into the fiber cable. In this case the safety margin must be increased to 7 dB.

(5+5)