Reg. No.										

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.
- **Take 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. Explain graded index optical fiber with the help of an expression for the possible refractive index profile. Using simple ray theory concepts, discuss the transmission of light through this fiber and explain how it reduces intermodal dispersion. Provide appropriate labelled diagrams.

1B. Starting from Maxwell's equations derive the following wave equation for the electrical field in bulk silica (the material from which optical fiber is made)

$$\nabla^2 E = \frac{n^2}{c^2}\frac{\partial^2 E}{\partial t^2}$$ State clearly how physical properties of the fiber are taken into account.

1C. A step index fiber in air has a numerical aperture of 0.16, a core refractive index of 1.45 and a core diameter of 60 μm. Determine the normalized frequency for the fiber when light at a wavelength of 0.9 μm is transmitted. Further, estimate the number of guided modes propagating in the fiber.

(5+3+2)

2A. Explain stimulated Raman scattering. Determine the threshold optical power for SRS for a long SM fiber with an attenuation 0.4 dB/km, core diameter of 6 μm and operating at a wavelength of 1.5μm with laser source bandwidth of 600 MHz.

2B. Explain microscopic bending loss in an optical fiber with a labelled diagram.

2C. A typical SM fiber has a zero-dispersion wavelength of 1.31 μm with a dispersion slope of 0.09 ps nm^{-2} km^{-1}. Determine the total first-order dispersion for the fiber at the wavelength of 1.28 μm.

(5+3+2)

3A. An SOA operating at a signal wavelength of 1.3 μm produces a gain of 20 dB with an optical bandwidth of 900 GHz. The device has a spontaneous emission factor of 1.5 and the mode number is equal to 2. Determine i) the ASE noise signal power at the output of the amplifier ii) the noise figure of the amplifier and iii) the OSNR (in dB) at the output of the amplifier if the received signal power is 4 μW.

3B. Define optical regeneration and mention the different stages involved in optical regeneration. Also, explain why 2R OR is required in optical networks

3C. The total efficiency of an injection laser with a GaAs active region is 18%. The voltage applied to the device is 2.5 V and the bandgap energy for GaAs is 1.43 eV. Calculate the external power efficiency of the device.

(5+3+2)

4A. Consider a point-to-point link connecting two nodes separated by 60 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. Assume that they can be modelled as an ideal quantum limited receivers. The bit error rate requirement for this system is 10^{-12}. Let α_{dB} = 0.4 dB/km and NRZ modulation is used.

(i) Design a link for the 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 an 8 km length without repeaters. The rise times of the chosen components are:

LED	8 ns
Fiber (intermodal)	5 ns km^{-1}
Fiber (intramodal)	2 ns km^{-1}
PIN photodiode	7 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 engineer has the following components.

(i) GaAlAs laser diode operating at 850 nm and capable of coupling 1mW (0dBm) into a fibre.

(ii) Ten sections of cable each of which is 500 m long, has a 4-dB/km attenuation and has connectors on both ends.

(iii) Connector loss of 2dB/connector

(iv) A PIN photodiode receiver with sensitivity of -45 dBm

(v) An avalanche photodiode receiver with sensitivity of -56 dBm

Using these components, the engineer wishes to construct a 5 km link operating at 20 Mb/s. Which receiver should be used if a 6 dB system operating margin is required? Provide reasonable justification using power link budget.

(5+3+2)

5A. Explain the optical crosstalk and different types of linear crosstalk with help of a diagram.

5B. Explain the functionality of an optical add-drop multiplexers with the help of an appropriate diagram.

5C What is the advantage of using WDM PON over TDM PON ?

(5+3+2)