2016/2017 SEMESTER ONE EXAMINATION

Diploma in Electrical & Electronic Engineering
3rd Year FT

SATELLITE & OPTICAL COMMUNICATION

Time Allowed: 2 Hours

Instructions to Candidates

1. The examination rules set out on the last page of the answer booklet are to be complied with.
2. This paper consists of **THREE** sections :

   Section A - 20 Multiple Choice Questions, 2 marks each.

   Section B - 4 Short Questions, 10 marks each.

   Section C - 1 Long Questions, 20 marks each.
3. **ALL** questions are **COMPULSORY**.
4. All questions are to be answered in the answer booklet.
5. Start each question in Sections B and C on a new page.
6. Fill in the Sections B and C Question Numbers, in the order that they were answered, in the boxes found on the front cover of the answer booklet under the column "Question Answered".
7. This paper consists of 8 pages, inclusive of formula sheets.

SECTION A

MULTIPLE CHOICE QUESTIONS [2 marks each]

1. Please **tick** your answers in the **MCQ box** behind the front cover of the answer booklet.

2. No marks will be deducted for incorrect answers.

A1. In a single mode fibre link, which one of the following parameters is not considered when calculating the maximum link length?
- (a) Material dispersion
- (b) Fibre loss
- (c) Receiver sensitivity
- (d) Modal dispersion

A2. Light Emitting Diode (LED) operation relies on:
- (a) Spontaneous emission of photons.
- (b) Spontaneous emission of electrons.
- (c) Stimulated emission of photons.
- (d) Stimulated emission of electrons.

A3. Non-coherent light is emitted at PN junction through the process of:
- (a) Spontaneous emission of photons.
- (b) Stimulated emission of photons.
- (c) Absorption of photons.
- (d) Scattering of photons.

A4. Which one of the following statements is true for "Population Inversion" occurring in ILD?
- (a) Many electrons remain in the lower energy level.
- (b) Many electrons remain in the higher energy level.
- (c) Many electrons remain in the depletion layer.
- (d) Many electrons remain in the intrinsic layer.

A5. In APD, the high carrier multiplication is caused by:
- (a) High forward biased voltage.
- (b) High reverse biased voltage.
- (c) High population inversion.
- (d) High threshold voltage.

A6. The maximum link length of an optical fibre link is NOT limited by which one of the following mechanisms:
- (a) Total Internal Reflection (TIR).
- (b) Fibre attenuation.
- (c) Fibre dispersion.
- (d) Optical source output power.

A7. "Impact ionisation" operation only occurs in:
(a) PIN detector.
(b) LED source.
(c) APD detector.
(d) ILD source

A8. Which one of the following statements is correct:
(a) A Laser diode has a narrow spectral width.
(b) A Laser diode has a wider spectral width.
(c) A LED diode has a narrow spectral width.
(d) A LED diode has a wider line width.

A9. Absorption losses in fibre result from:
(a) The fracture in the fiber.
(b) The microbending in the fiber.
(c) The water bands (OH^- ions) in the fiber.
(d) The modal dispersion in the fiber.

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A10. Below the diode "threshold current", the diode works as a:
(a) PIN detector.
(b) LED source.
(c) APD detector.
(d) ILD source.

A11. What is the altitude, in km, of a GPS satellite orbit:
(a) 20,200.
(b) 35,786.
(c) 42,164.
(d) 24.

A12. The Down Converter (DC) is part of a:
(a) Transmit GCE subsystem.
(b) Receive GCE subsystem.
(c) Transmit subsystem.
(d) Receive subsystem.

A13. Which one of the following parameters is not the important performance characteristics of an earth station antenna:
(a) Figure of merit (G/T).
(b) Sidelobe radiation pattern.
(c) Cross Polar Interference (XPI).
(d) FSPL.

A14. Which one of the following types of dish antenna is not used in an earth station:
(a) Axisymmetric dual reflector type.
(b) Single reflector type.
(c) Dual reflector cassegrain type.
(d) Dual reflector gregorian type.

A15. The typical dish antenna used in a satellite earth station must have:
(a) Equal gain at its mainlobe & sidelobe.
(b) Maximum gain at its sidelobe.
(c) Minimum gain at its mainlobe.
(d) Sidelobe gain below a certain prescribed level.

A16. For an INTELSAT earth station, the cross polar interference for a satellite link is set at:
(a) 10 dB.
(b) 20 dB.
(c) 30 dB.
(d) 40 dB.

A17. The reason for an INTELSAT standard A antenna using a closed loop antenna tracking system is that:
(a) The antenna has a very narrow beam width.
(b) The antenna has a very wide beam width.
(c) The antenna has a very narrow band width.
(d) The antenna has a very wide band width.

A18. The Ku band frequencies used by communication satellites are:
(a) 6/8 GHz.
(b) 4/6 GHz.
(c) 12/14 GHz.
(d) 14/16 GHz.

A19. The round trip propagation delay between two earth stations through a geostationary satellite is due to:
(a) the spinning of the satellite.
(b) the reflection of the electromagnetic wave at the antennae reflector.
(c) the high altitude of satellite.
(d) the rotation of the Earth.

A20. One of the advantages that the Ku band has over the C band in satellite communication is that:
(a) It has less propagation delay.
(b) Free Space Path Loss (FSPL) is lower.
(c) It suffers less atmospheric losses.
(d) It will not cause interference to terrestrial microwave links.

Section B [10 Marks Each]

B1. An optical fibre operating at 1310 nm wavelength, has a core refractive index of 1.485 and a cladding refractive index of 1.476.

(a) If it is a step index multimode fibre, sketch the refractive index profile and calculate the bandwidth of a 3 km optical fibre. (4 marks)

(b) If it is a graded index multimode fibre, sketch the refractive index profile and calculate the bandwidth of a 3 km optical fibre. (4 marks)

(c) If it is a single mode fibre, calculate the core diameter of the fibre. (2 marks)

B2. An optical fibre link is operating at 1550 nm wavelength, using an ILD source connected to a length of single mode fibre and a PIN photodiode.

(a) Give TWO advantages of using the ILD source. (4 marks)

(b) State the condition required to achieve at the ILD junction before laser light can be emitted and hence name the type of emission occurred at the ILD junction. (4 marks)

(c) Calculate the maximum possible bandgap energy of the ILD source in eV. (2 marks)

B3. An optical fibre link is required to cover a distance of 25 km.

The following data for the system components are given:

- The fibre has an attenuation of 0.5 dB/km.
- Fibre modal dispersion is 20ns/km, material dispersion is 0.2ns/km.
- 24 splices with a loss of 0.5dB per splice.
- 2 connectors with 1dB loss each.
- ILD transmitter has an output power of 2dBm and rise time of 6ns.
- APD detector has a rise-time of 2ns.

(a) If a system safety margin of 6 dB is to be reserved, determine the required sensitivity for the receiver. (4 marks)

(b) Calculate the maximum system Bit Rate of the optical link in Mb/s using NRZ signal. (6 marks)

B4. (a) Explain how individual voice channels are frequency division multiplex onto a CCITT mastergroup in FDMA system. (6 marks)

(b) Calculate the maximum number of voice channels to be multiplexed into a CCITT mastergroup in FDMA system. (2 marks)

(c) Name the main disadvantages of the FDMA system compared to TDMA system. (2 marks)

Section C [20 Marks]

C1. (a) Name TWO factors affecting Free Space Path Loss in satellite communication link. (4 marks)

(b) For C band & Ku band satellite communication links, calculate the difference in total Free Space Path Loss (up & down links) in dB.
You may assume the same uplink & downlink path for C band & Ku band. (6 marks)

(c) A C-band uplink satellite communication system has the following parameters:

EIRP	**G/T**	**FSPL**
98 dBw	-5.3 dBK^{-1}	200 dB

(i) Determine the uplink distance in km. (3 marks)

(ii) Determine the earth station transmitter output power in kw, if the transmitting antenna gain is 64 dB. (3 marks)

(iii) Determine the uplink C/N ratio for a 36 MHz bandwidth signal. (4 marks)

******* End of Paper *******

Constants & Formulas Sheet

Gravitational constant $G = 6.673 \times 10^{-11}\ Nm^2 Kg^{-2}$

Mass of Earth $M_e = 5.975 \times 10^{24}$ Kg , Radius of Earth = 6378 km

Boltzmann's constant $k = 1.38 \times 10^{-23}$ J/K

Speed of light $c = 3 \times 10^8$ m/s

Plank's constant $h = 6.626 \times 10^{-34}$ Js

Electron charge $e = 1.602 \times 10^{-19}$ C

$$v = \sqrt{\frac{Gm_e}{r}}$$

$$S(\Theta) = 52 - 10\log_{10}\left(\frac{D}{\lambda}\right) - 25\log(\Theta) \quad dBi$$ For D < 100λ

$$S(\Theta) = 29 - 25\log_{10}(\Theta) \quad dBi$$ For 2.0^0 spacing

$$S(\Theta) = 32 - 25\log_{10}(\Theta) \quad dBi$$ For 2.9^0 spacing

$$L_{dB} = 20\log\left(\frac{4\pi d}{\lambda}\right) = 32.44 + 20\log[d] + 20\log[f]$$

$$(C)_{dBw} = (P_T)_{dBw} + (G_T)_{dB} + (G_R)_{dB} - (L)_{dB}$$

$$\left(\frac{C}{N_0}\right)_{dBHz} = (P_T)_{dBW} + (G_T)_{dB} + \left(\frac{G_R}{T}\right)_{dB} - (L)_{dB} - (L_o)_{dB} - 10\log K$$

$$\left(\frac{C}{N}\right)_{dB} = \left(\frac{C}{N_0}\right)_{dBHz} - 10\log B$$

$$\left(\frac{C}{N}\right)^{-1}_{Total} = \left(\frac{C}{N}\right)^{-1}_{Up} + \left(\frac{C}{N}\right)^{-1}_{Down}$$

$$n_1 Sin\Theta_1 = n_2 Sin\Theta_2 \qquad NA = Sin\Theta_a = \sqrt{n_1^2 - n_2^2}$$

$$\Delta = \frac{n_1^2 - n_2^2}{2n_1^2} \qquad \Delta\tau = \frac{Ln_1}{c}\left(\frac{n_1 - n_2}{n_2}\right) \qquad v = \frac{c}{n}$$

$$V = \frac{\pi d}{\lambda}(NA) \qquad n(r) = n_1\sqrt{1 - 2\Delta\left(\frac{r}{a}\right)^{\alpha}} \qquad a \le \frac{2.405\lambda}{2\pi\sqrt{n_1^2 - n_2^2}}$$

For step-index multimode

$$M = \frac{V^2}{2} \qquad \sigma = \frac{n_1 L\Delta}{c\sqrt{12}}$$

For graded index

$$M = \frac{V^2}{4} \qquad \sigma = \frac{n_1 L\Delta^2}{c\sqrt{48}}$$

$$B = \frac{0.35}{\sigma} \qquad B = \frac{0.35}{t_{sys}} \qquad f = \frac{c}{\lambda}$$

$$\lambda = \frac{hc}{E_g} \qquad \lambda = \frac{1.24}{E_g} \qquad D = \frac{ct}{2n}$$

$$I_p = (r_e)(e) \qquad P_o = (r_p)(hc/\lambda) \qquad R = \frac{\eta\lambda e}{hc}$$

$$t_f = \sqrt{t_{modal}^2 + t_{material}^2} \qquad t_{sys} = 1.1\sqrt{t_f^2 + t_s^2 + t_d^2}$$