2015/2016 SEMESTER TWO 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. To enable an OTDR to give correct length measurements, the user must enter the :
- (a) Fibre core diameter into the instrument.
- (b) Refractive index of the fibre core into the instrument.
- (c) Refractive index of the fibre cladding into the instrument.
- (d) The fibre loss into the instrument.

A2. Which one of the following factors does not affect bandwidth of the optical fibre link ?
- (a) Fibre material dispersion.
- (b) Fibre loss.
- (c) Fibre modal dispersion.
- (d) Optical transmitter rise time.

A3. 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.

A4. Modal dispersion in silica glass fibre can be minimized by using :
- (a) Single mode step index fibre.
- (b) Single mode graded index fibre.
- (c) Multimode step index fibre fibre.
- (d) Multimode graded index fibre fibre.

A5. Responsivity of a light detector is defined as :
- (a) The spectral response of the detector.
- (b) The amount of optical power output given the input current.
- (c) The amount of time needed to respond to an optical input.
- (d) The amount of electrical current produced per unit optical power input.

A6. Light emitting diode is not suitable for a single mode optical communications link because:
- (a) Light emitting diodes do not have the 1310 nm low loss window.
- (b) The physical size of a light emitting diode is too big for single mode fibre.
- (c) Light emitting diodes suffer from thermal loss when coupled with single mode fibre.
- (d) Light emitting diodes do not have a very directional radiation pattern and hence will not efficiently couple light into single mode fibre.

A7. Photodiodes used as optical detectors normally are :
(a) Reversed biased.
(b) Forward biased.
(c) Unbiased.
(d) Thermoelectrically cooled.

A8. One of the advantages an APD receiver has over PIN receiver is that :
(a) It produces high gain.
(b) The circuitry is reversed biased.
(c) It produces less current.
(d) It produces less noise.

A9. For a long distance optical communication link, it is better to use an APD rather than a PIN photodiode because :
(a) The APD has a faster rise time than the PIN photodiode.
(b) PIN photodiode is not suitable for use with single mode fibre.
(c) The APD is more sensitive than the PIN photodiode.
(d) PIN photodiode only works at wavelengths above 1000 nm.

A10. Light is guided down a step index multimode fibre because of :
(a) Total Internal Reflection.
(b) Refraction.
(c) Dispersion.
(d) Total Internal Reflection & Refraction.

A11. The altitude of a GPS satellite in the space segment is :
(a) 3,578 km.
(b) 35,786 km.
(c) 2,020 km.
(d) 20,200 km.

A12. An orbit around the Earth with 12 hours period is called :
(a) Polar Earth Orbit (PEO).
(b) Low Earth Orbit (LEO).
(c) Geostationary Earth Orbit (GEO).
(d) Medium Earth Orbit (MEO).

A13. The function of SSPA in the satellites earth stations is :
(a) To translate the signal frequencies.
(b) To reduce the system noise.
(c) To boost the signal to a sufficient high power.
(d) To modulate the baseband signals.

A14. Which one of the following is not the reference axis of a three axis stabilized satellite :
(a) Roll.
(b) Yaw.
(c) Azimuth.
(d) Pitch.

A15. The satellite subsystem that produces shaped & contoured beam is the :
(a) Power subsystem.
(b) Transponder subsystem.
(c) Command, telemetry and control subsystem.
(d) Antenna subsystem.

A16. In FDM/FM/FDMA, the maximum number of voice channels that a satellite transponder can pack into a CCITT master-group is :
(a) 1000.
(b) 300.
(c) 900.
(d) 90.

A17. Geostationary communication satellites need to use battery power during :
(a) The summer solstice.
(b) The winter solstice.
(c) The vernal equinox.
(d) The night hours

A18. Which one of the following is not the type of power amplifier used in a satellite earth station ?
(a) Travelling wave tube amplifier (TWTA).
(b) Solid state power amplifier (SSPA).
(c) Reflex klystrons.
(d) Low noise amplifier (LNA).

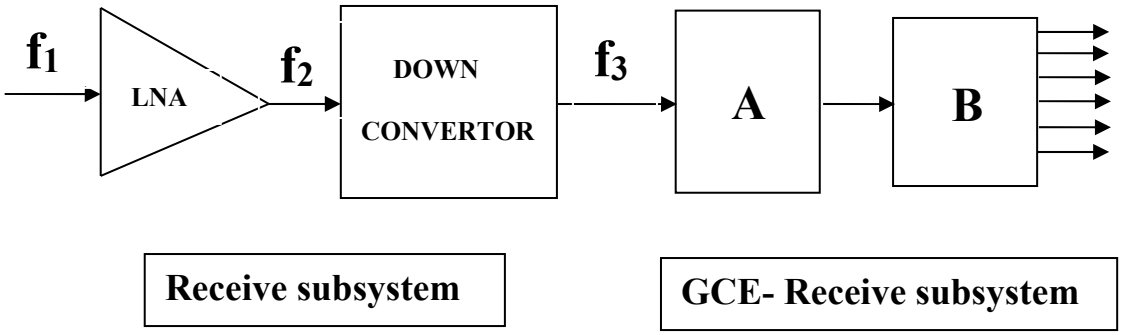
A19. The satellite subsystem responsible for removing the satellite from orbit is :
(a) Power supply subsystem.
(b) Propulsion subsystem.
(c) Stabilisation and attitude control subsystem.
(d) Transponder subsystem.

A20. Which one of the following is an international satellite organization ?
(a) AUSSAT.
(b) ST-1.
(c) ST-2.
(d) INMARSAT.

Section B [10 Marks Each]

B1. A satellite is orbiting above Earth equatorial with circular orbit at a speed of 5.56 km/s.
(a) Find its period of rotation in hrs. (6 marks)
(b) Is this a geostationary satellite ? Give reason to support your answer. (4 marks)

B2. The block diagram shows Receive & GCE-Receive subsystems of the satellite earth station :



(a) Name Box A and B in the above block diagram. (2 marks)
(b) State the functions of LNA and Down Converter. (2 marks)
(c) Identify the frequency values of f_1, f_2 and f_3 for the following frequency bands :
(i) Ku-band.
(ii) C-band (6 marks)

B3. A TVRO satellite dish located at Singapore has a gain of 45 dB and noise temperature of 100K. The dish is to be positioned to receive television programmers from the ST-2 satellite. The ST-2 satellite is located at 88.0^0 E and 38,000 km away from the TVRO site. If the EIRP from the ST-2 satellite's C-Band transponder is 11 kw, calculate :
(a) Figure of Merit of the TVRO site. (2 marks)
(b) Power received at the TVRO site in picowatt(pw) & dBm**.** (4 marks)
(c) C/N ratio at the TVRO site for a TV transmission bandwidth of 10 MHz**.** (4 marks)

B4. You have the following components available for setting up an optical fibre link :

ILD source	:	Output power 5mw; Risetime 1 ns
Step index fibre	:	Attenuation 2 dB/km; Dispersion 243.2 ps/km.
Optical connectors	:	Loss 0.5 dB each
Optical splices	:	Loss 0.2 dB each; Total of 20 splices
APD detector	:	Sensitivity -53 dBm; Risetime 2 ns
Safety margin	:	6 dB

(a) Use **power budget** analysis to determine the maximum link length. (4 marks)
(b) Find the maximum Bit Rate (in Mb/s) of the above link using NRZ signal. (4 marks)
(c) Suggest TWO ways to increase the operating Bit Rate of the fibre link. (2 marks)

Section C [20 Marks]

C1. (a) The multimode step index fibre has the following specifications :

- Numerical Aperture is 0.25
- Refractive index of the fibre core is 1.5.
- Core diameter is 62.5μm and operates at 1310nm wavelength

Determine:

(i) The refractive index of the fibre cladding. (2 marks)
(ii) The acceptance angle of the fibre. (2 marks)
(iii) The number of modes occurring in the fibre. (2 marks)
(iv) Name the TWO dominant dispersions in the fibre. (2 marks)

(b) Three ILD sources are available for use in the optical fibre link. Bandgap energies for ILD materials A, B and C at room temperature are 1.37, 2.21 and 0.95eV respectively.

(i) Calculate the wavelengths (in nm) emitted by the three ILDs. (3 marks)
(ii) Which of the above ILDs is most suitable for use in the fibre link? Give TWO reasons to support your choice. (3 marks)

(c) An optical fibre link is designed to achieve **maximum** bandwidth performance. State the type of optical fibre, source and wavelength to be used in the fibre link. Provide justifications for each of your choice. (6 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

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

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

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

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

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

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

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