2016/2017 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. 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.

A2. 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).

A3. 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.

A4. Which one of the following is not the reference axis of a three axis stabilized satellite :
- (a) Roll.
- (b) Yaw.
- (c) Azimuth.
- (d) Pitch.

A5. 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.

A6. 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.

A7. 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

A8. Which one of the following is not the type of power amplifier used in a satellite earth station ?
(a) Travelling wave tube amplifier.
(b) Solid state power amplifier.
(c) Reflex klystrons.
(d) Low noise amplifier.

A9. 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.

A10. Which one of the following is not the geostationary satellite ?
(a) GOES.
(b) ASIASAT.
(c) ST-2.
(d) NOAA.

A11. Graded index multimode fiber is used to :
(a) Reduce modal dispersion.
(b) Reduce material dispersion.
(c) Remove modal dispersion.
(d) Remove material dispersion.

A12. Losses incurred as light rays travel through fiber are the result of :
(a) Reflection and absorption.
(b) Refraction and reflection.
(c) Scattering and absorption.
(d) TIR and absorption.

A13. Responsivity of a photodetector is defined as :
(a) The spectral response.
(b) The amount of current produced per unit light power input.
(c) The amount of time needed to respond to an input.
(d) The amount of power output given the input current.

A14. Material dispersion can be minimized by using laser source with centre wavelength of :
(a) 1550 nm.
(b) 850 nm.
(c) 950 nm.
(d) 1310 nm.

A15. 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.

A16. The length of an optical fiber link is limited by which one of the following mechanisms :
(a) Dispersion.
(b) Refraction.
(c) Total Internal Reflection.
(d) Reflection.

A17. Which one of the following factors does not affect the bandwidth of an optical fiber link ?
(a) Fiber material dispersion.
(b) Fiber loss.
(c) Fiber modal dispersion.
(d) Optical transmitter rise time.

A18. What makes dispersion zero at 1310 nm wavelength in single mode fibers ?
(a) Waveguide and modal dispersions cancel each other out.
(b) Waveguide dispersion equals the sum of material and modal dispersions.
(c) Modal and material dispersions cancel each other out.
(d) Waveguide and material dispersions cancel each other out.

A19. Material dispersion in silica glass fiber can be minimized by using a laser source with centre operating wavelength of :
(a) 1550 nm.
(b) 1310 nm.
(c) 950 nm.
(d) 850 nm.

A20. Identify the incorrect statement :
(a) To attain total internal reflection in a fiber, the cladding refractive index must be smaller than the core refractive index.
(b) In glass, the reflective index varies with wavelength.
(c) A large acceptance angle implies a large numerical aperture.
(d) The numerical aperture of a fiber depends on the line width of the source used.

Section B [10 Marks Each]

B1. A C-band satellite communication link has the following parameters :

Earth satellite station transmitter output power	:	50 dBW.
Earth satellite transmitting antenna gain	:	65 dB.
Satellite receiving antenna gain	:	15 dB.
Satellite receiver equivalent noise temperature	:	100K.
Satellite transponder bandwidth	:	36 MHz.

Uplink distance : 42,500 km, Downlink distance : 38,500 km

Calculate:

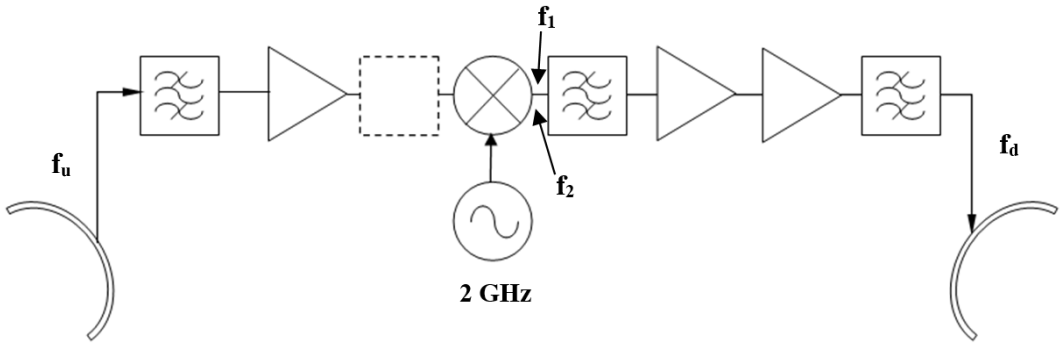
(a) The received signal power in nw at the satellite transponder input. (4 marks)

(b) The C/N ratio at the satellite transponder input. (6 marks)

B2. (a) Name 2 international satellite organizations and 2 national satellite organizations. Which satellite organization is responsible for mobile communication? (5 marks)

(b) A satellite is in a circular equatorial orbit travelling with a velocity of 5 km/s. Find the altitude & orbital period (in hour) of the satellite above the equator. (5 marks)

B3. The following block diagram shows the transponder subsystem of a communication satellite:



(a) Name the three blocks that perform the "Amplification" function. (3 marks)

(b) Name the three blocks that perform the "Frequency Translation" function. (3 marks)

(c) If the transponder subsystem operates at C-band, state the uplink and downlink frequencies & the two frequencies (f_1 & f_2) appeared after the mixer. (4 marks)

B4. An optical fiber link operating at 1550 nm is set up using an ILD source, 10 km length of single mode fiber, and a PIN photodiode.

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

(b) Name the dominant dispersion occurs in the fiber. (1 mark)

(c) 9×10^{10} photons/sec are incident onto the PIN photodiode which has a responsivity of 0.8 A/W. Find the current (in nA) generated at photodiode output terminal. (5 marks)

Section C [20 Marks]

C1. A 40 km long single mode fiber link is being designed to work at a NRZ bit rate of 500 Mbps with a BER of 10^{-9}. The following components are used in the fiber link :

Transmitter	Receiver
Output power = 2 mw	Sensitivity at 10^{-9} BER = Unknown
Source rise time = 500 ps	Detector rise time = Unknown
Connector loss = 0.5 dB	Connector loss = 0.5 dB

Fiber
Available on 1 km drums
Material dispersion = 16 ps/km
Attenuation = 0.72 dB/km
Splicing loss = 0.35 dB each

Calculate :

(a) The required receiver sensitivity in dBm, if the safety margin is to be 6 dB. (8 marks)
(b) The required receiver rise time in ps. (10 marks)
(c) The above components are to be used in another fiber link with 90 km length. Determine the number of repeaters required. (2 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

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

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

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

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

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