THE UNIVERSITY OF ADELAIDE
AUSTRALIA

SUPPLEMENTARY EXAMINATION FOR THE DEGREE OF B.E.

Semester 2 2003

1290 OPTICAL COMMUNICATIONS (ELEC ENG 4002)

Official Reading Time: 10 mins
Writing Time: 90 mins
Total Duration: 100 mins

Instructions:

- This is a closed book examination.
- Attempt **ALL** THREE questions.
- All questions carry equal marks; part marks are given in brackets where appropriate.
- Begin each answer on a new page.
- Examination materials must not be removed from the examination room.
- **ANSWERS TO QUESTIONS SHOULD BE EXPRESSED CLEARLY AND WRITTEN LEGIBLY. THESE ASPECTS OF PRESENTATION WILL BE TAKEN INTO ACCOUNT IN ASSESSMENT.**

Materials:

- One Pink Book
- The use of calculators is permitted, this equipment to be supplied by the candidate. No pre-recorded material nor calculator instruction book is permitted, and calculators with remote communication links will be barred from the examination room.
- Formulae sheets (3 pages) are attached at the end of the paper.

DO NOT COMMENCE WRITING UNTIL INSTRUCTED TO DO SO.

Question 1 begins on page 2

1. A video signal having a bandwidth of 4.8 MHz is transmitted over a 10-km path. We want to design a system so that the SNR at the receiver is 48 dB. Analog modulation is used. Spectral wavelength used is $\lambda_0 = 1.3$ μm.

   The receiver is an InGaAs PIN photodiode.
   Responsivity; $\rho = 0.6$ A/W
   Dark Current; $I_d = 5$ nA
   Junction capacitance; $C_d = 5$pF
   Noise figure; F = 2 at 300°K
   Assume 100% modulation (m = 1).

   (a) Calculate the load resistor R_L for the receiver. Comment on why you would not use this value in practice. (2 marks)

   (b) Assume the system is thermal noise limited and hence calculate the power needed at the photodiode receiver to achieve the specified SNR, using the value of R_L calculated in (a). (6 marks)

   (c) The available power from a laser diode source is $P_{ave} = 10$ mW. What is the available power budget left over for losses? (3 marks)

   (d) Calculate the signal current. Assuming 4 V reverse bias on the photodiode, demonstrate if saturation and dark current will be negligible or not. (4 marks)

   (e) Calculate the thermal noise and shot noise powers, hence demonstrate if the assumption in (b) was justified or not. (5 marks)

2. Continuing with the same system as in question 1:

   (a) Assume
   (i) laser diode coupling efficiency into the fibre is $\eta = 0.1283$,
   (ii) there are two connectors with one dB loss each,
   (iii) there are 10 splices with 0.15 dB loss each.

   If the loss in the fibre is 1 dB/km, calculate the total losses and hence the available power margin. (7 marks)

You are reminded to clearly highlight your answers with a double underline, otherwise marks may be deducted.

Question 2(b) follows on page 3.

(b) Find the system rise time t_S and photodetector rise time t_{PD}. (2 marks)

(c) Given the laser diode rise time is t_{LS} = 1 ns, calculate the remaining rise time budget for the fibre and comment. (3 marks)

(d) Given $(f_{3dB} \times L)_{opt}$ = 500 MHz × km, find the actual fibre rise time for the full 10 km.
[Hint: $(f_{3dB} \times L)_{elec} = 0.71\ (f_{3dB} \times L)_{opt}$ and $t_F/L = 0.35/(f_{3dB} \times L)_{elec.}$]
Hence find the rise time margin. Comment why this is not a good design in practice.

(8 marks)

3. (a) The equilibrium length of a multimode fibre is 2 km. The modal pulse spread is 25 ns for a 1 km length. The light source emits at 800 nm and has a spectral width of 50 nm. Compute the optical 3 dB bandwidth of a 5 km length of this fibre. You may assume that at λ_0 = 800 nm, M = 115 ps/nm/km. (10 marks)

(b) A fibre has a numerical aperture, NA = 0.2588. A light source is coupled to it which emits 75% of its light into a 60 degree full-cone angle, 50% into a 30 degree cone and 25% into a 15 degree cone.
(i) What is the coupling efficiency when this source and fibre are connected?
(ii) If the refractive index of the core is 1.45, what is the loss due to reflections?

(10 marks)

You are reminded to clearly highlight your answers with a double underline, otherwise marks may be deducted.