Seat No. _____

King Mongkut's University of Technology Thonburi

Final Examination 1/2015

EIE 423 Optical Communications — **ENE Junior international students**

Friday 27 November 2015 — 1:00p.m. – 4:00 p.m.

Instructions:

1. There are 5 problems and 3 pages (cover not included). Each problem is worth 20 points.
2. Please calculate your results to 4 significant figures.
3. This is an open-book and open-note exam.
4. Students are allowed to bring a calculator to the examination.
5. **Do all your work in the given working book.**

Students have to raise his or her hand when they finish working on their examinations. Otherwise, they will not be allowed to come out of the examination room.

Bringing exam papers with students outside the exam room are not allowed.

Academic dishonesty during the exam may result in expulsion or permanent dismissal from the university.

Name.....

Student ID.....Seat No.....

This exam is given by Apichai Bhatranand. Tel. 0-2470-9063

This examination has been approved by ENE department committees.

R. Silapunt

(Assoc. Prof. Rardchawadee Silapunt)

Head of Electronic and Telecommunication Engineering Department

1. True or False

a) Optical fiber is dielectric waveguide.

b) Light sources convert optical signal to electrical signal.

c) A photo-detector acts like a modulator.

d) Optical fiber yields low attenuation and very wide bandwidth.

e) Refractive index means ratio of light velocity in air to a particular medium.

f) A single mode fiber supports only one pattern of electric field.

g) Zero reflection only occurs for the s-polarization.

h) Total reflection occurs when incident angles are greater or equal to a Brewster angle.

i) Multimode fibers are widely used to reduce multimode dispersion.

j) The loss in a signal power as light travels along the fiber is called dispersion.

k) The fiber core has higher refractive index with the cladding.

l) The operation of fiber-optic cable is based on the principle of light absorption.

m) The speed of light in water is faster than it is in air.

n) Material dispersion is caused by the wavelength dependence of the index of refraction.

o) The bandwidth of optical fibers is limited by fiber attenuation.

p) The photocurrent is equal to the number of electrons emitted per second times the electron charge.

q) Laser light is stimulated emission.

r) Photodiodes used in optical communication are reversed bias.

s) OTDR can determine the length of a fiber and locations of connectors or splices.

t) The effective number of modes for GRIN fiber is less than SI fiber.

2. (a) An optical fiber has a core with refractive index 1.50 and a cladding width refractive index of 1.46. Determine the maximum acceptance angle of this fiber.

   (b) Compute the responsivity of a silicon APD operating at 0.82 micron and having a 0.8 quantum efficiency if its gain is 40. How much optical power in dBm is needed by this detector to produce 25 nA?

3. (a) A 4-port directional coupler has a 4:1 splitting ratio and an excess loss equal to 2 dB. The coupler's directionality is 40 dB. Compute the throughput loss (L_{THP}) and the tap loss (L_{TAP}).

   (b) Consider the full-duplex network shown in Fig. 1. A directional coupler in (a) is used with connectors (one at each coupler port, one at the transimitter, and one at the receiver) having 1 dB of loss. The 100-km fiber link is used in this network with attenuation of 0.02 dB/km. Compute the total loss in dB from transmitter to receiver.

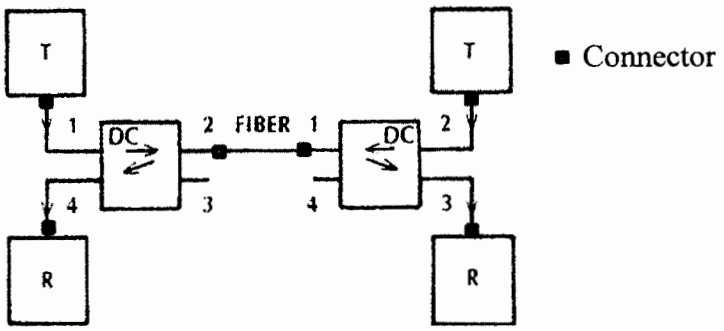

Fig. 1 Full-duplex network. T = Transmitter, R = Receiver, and DC = Directional Coupler.

4. An optical communication system consists of: LASER: 5 mW at 1.55 micron, a 250 km long optical fiber with 0.02 dB/km attenuation, and a photodetector of responsivity 0.5 A/W and 1 nA dark current. The load resistance is 50 Ω; the receiver's bandwidth is 20 MHz, and its temperature is 27°C. Other losses include 15-dB coupling loss and other 10-dB loss caused by connectors and splices. Compute:

    a) optical power reaching the receiver.

    b) photocurrent at the receiver.

    c) Thermal-noise power in W.

    d) shot-noise power in W.

    e) SNR in dB

    f) Is it thermal-noise-limited or shot-noise-limited case?

5. Consider the 30 Mbps link with:

    - LED: rise time = 8 ns, spectral width = 30 nm, wavelength = 830 nm.
    - Fiber: 3-km long GRIN fiber with core index = 1.48, cladding index = 1.45, and equilibrium length = 5 km.
    - Photodiode: Transit time 4 ns, R_L = 1kΩ, C_d = 1 pF.

    Do 'rise-time-budget' analysis whether these components can carry RZ coding.