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Seat No. _______

King Mongkut's University of Technology Thonburi

Final Examination 2/2016

EIE 423 Optical Communications — **EIE Juniors and Seniors**

Wednesday 17 May 2017 — 9:00 a.m. – 12:00 a.m.

Instructions:

1. There are 6+1 bonus problem problems on 3 pages (cover not included).
2. Each problem weighs 20 points.
3. Please calculate your results to 4 significant figures.
4. Textbooks and class notes are allowed into the examination room.
5. Students are allowed to bring a calculator to the examination.
6. Do all your work in the given booklet.

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.

0-2470-9063

This examination has been approved by ENE department committees.

(Assoc. Prof. Rardchawadee Silapunt)

Head of Electronics and Telecommunication Engineering Department

1. (a) A system has -10 dB of loss. Compute its efficiency (P_{out}/P_{in}).

   (b) Compute the reflectance at an AlGaAs-to-air boundary at normal incidence. Compute the transmission loss in decibels if a refractive index of AlGaAs is 3.6.

   (c) The optical fiber whose core diameter is 50 micron supports 302 modes. If its core refractive index is 1.48 and the wavelength is 1550 nm, what would be the cladding refractive index of this fiber?

2. Consider a PIN photodiode characteristic shown in Fig. 1. Assume that the reverse bias applied to the diode is -15 V and the load resistance is 1 MΩ.

   (a) What is the responsivity of this photodiode?

   (b) What is the the dynamic range of this photodiode?

   (c) Estimate the minimum detectable power for this photodiode whose dark current is 2 nA .

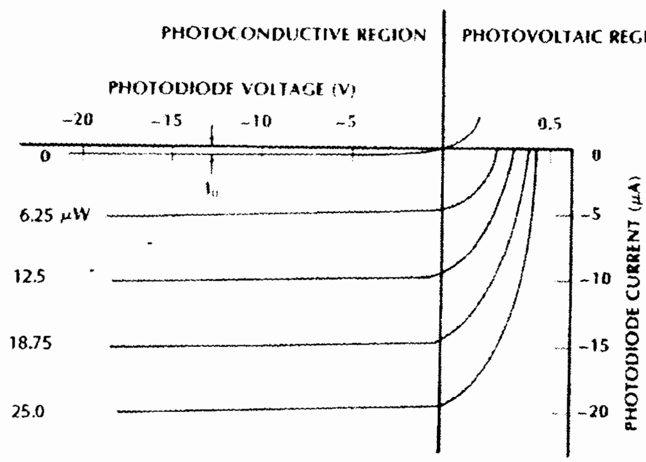

Fig. 1 The PIN diode for problem 2(a) to 2(c)

3. (a) What is the level of returned power in dB reflected into a pigtailed light source from a connection with an end gap between the two fibers being attached shown in Fig. 2? The fibers are made of glass with $n_1 = 1.5$.

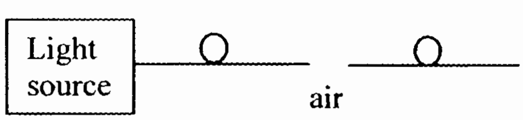

Fig. 2 Connection between Pigtailed light source and fiber.

(b) Due to the reflections at the interfaces and imperfections in the polarizers and the faraday rotator, the acceptable insertion loss and isolation are less and greater than 1 dB and 30 dB, respectively. Is the isolator depicted in Fig. 3 an acceptable one? Show all your work.

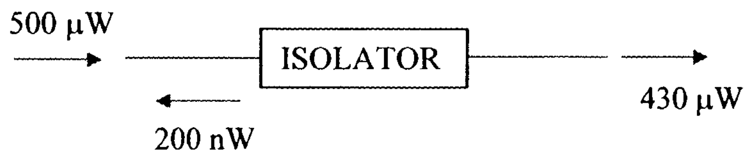

Fig. 3 Isolator with measured powers.

4. The optical system consists of a laser emitting 5 mW at 1550 nm, a 100-km long fiber cable with attenuation 0.2 dB/km, and a PIN photodiode of responsivity 0.8 A/W. The load resistance is 50 Ω, the receiver's bandwidth is 10 MHz, and its temperature is 300 K. The addition losses also include 12-dB coupling loss from source to fiber and 10-dB loss from splices and connectors. Compute: (a) Received optical power (b) SNR in dB (c) Is this a 'thermal-noise limited' or 'quantum-noise limited' case? (d) If the amplifier with power gain of 5 dB and noise figure of 3 dB, what would be the new SNR in dB?

5. Do "Rise-time analysis" to check if the equipment listed below are suitable for the system with R_{RZ} = 40 MHz. The equipment: Light source with rise time = 1.5 ns, λ = 1.3 μm, $\Delta\lambda$ = 30 nm; The 10 km multimode GRIN fiber (n_1 = 1.48, n_2 = 1.46) with 0.23 dB/km attenuation and 2-km equivalent length; a photodiode with transit time 2 ns has a capacitance of 20pF and load resistor of 100 Ω.

6. Five-terminal bidirectional linear bus network (T-network) is depicted in Fig. 4. If the transmitter in terminal 1 with power of 5 mW is sending a signal to each receiver. Receivers in terminal 3, 4, and 5 are receiving 0.1774 mW, 0.0849 mW, and 0.0659 mW, respectively. Single-mode fibers with 0.2 dB/km attenuation, 1-dB loss connector, and 0.1 dB per splice are used in this network. The adjacent channels are equally separated by 5 km, for

example, distance from #1 to #2 is 5 km and from #1 to #5 is (4x5) km. Assume that all couplers used in this system are typical, what would be the tap loss, throughput loss, and splitting ratio of each coupler?

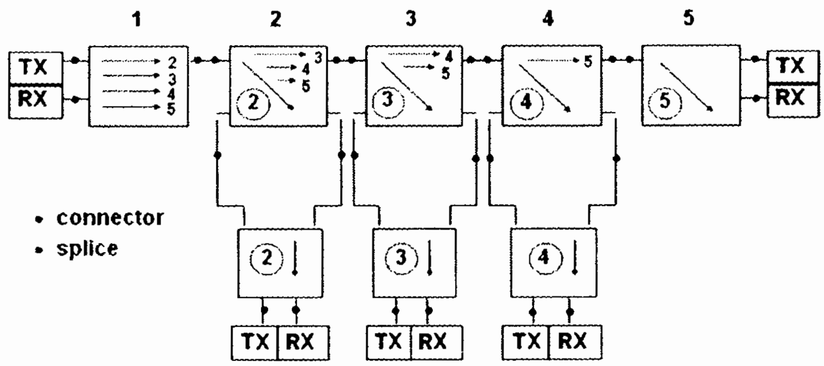

Fig. 4 T-network for problem 6

Bonus problem (optional)

(10 points) A 5x5 star coupler with excess loss of 2 dB is used to interconnect 5 stations. The distance from star coupler to each transmitter or each receiver is equal at 2.5 km. The fiber, the connector, and splice loss are the same type as problem 6. If station 1 is a transmitter sending a signal with the same amount as in problem 6, what would be received power at the rest of the stations (#2 #3 #4 and #5).

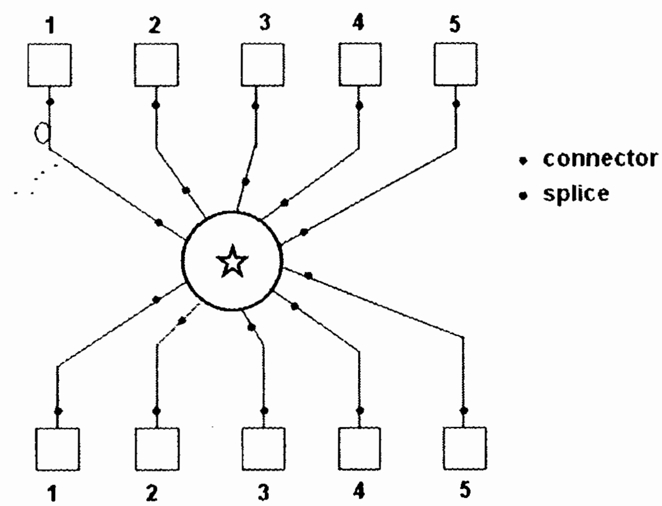

Fig. 5 Star network for bonus problem