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SCHOOL OF ELECTRONICS ENGINEERING
CONTINUOUS ASSESSMENT TEST - II
FALL SEMESTER 2024-2025

SLOT: B2

Programme Name & Branch	:	**B.Tech(ECE, BML)**
Course Code and Course Name	:	**BECE308L**
Faculty Name(s)	:	**Dr G Aarthi, Dr S Rajalakhsmi, Dr.N.Sangeetha, Dr.Subhra Sankha sarma, Dr.Tangudu Ramji & Dr.Jagana Bihari Padhy.**
Class Number(s)	:	**VL2024250102791,2793,2798,2803,2805,2807**
Date of Examination	:	**14.10.2024**
Exam Duration	:	**90 minutes** — **Maximum Marks: 50**

General instruction(s):

- Answer All Questions
- M - Max mark; CO – Course Outcome; BL – Blooms Taxonomy Level (1 – Remember, 2 – Understand, 3 – Apply, 4 – Analyse, 5 – Evaluate, 6 – Create)
- Course Outcomes (Type the CO statements covered in this question paper. Use the CO number as per the syllabus copy)
  CO3: Design the optical transmitters and receivers and evaluate their performances
  CO4: Estimate the system requirements for point to point communication

Q. No	Question and Key	M	CO	BL
1.	The minority carrier recombination lifetime for an LED is 10ns. When a constant d.c. drive current is applied to the device the optical output power is 200μW. (a) Determine the optical output power when the device is modulated with an rms drive current corresponding to the d.c. drive current at frequencies of 50MHz. It may be assumed that parasitic capacitance is negligible. (b) Further, determine the 3dB optical bandwidth for the device and estimate the 3dB electrical bandwidth assuming a Gaussian response.	10	3	4

11)

$\tau_i = 10 \times 10^{-9}$ s. , $f = 50$ MHz

$\omega = 2\pi f = 2 \times \pi \times 50 \times 10^6$.

$P_{dc} = 200\,\mu W = 200 \times 10^{-6}$ W.

i) $$P_e = \frac{P_{dc}}{[1+(\omega\tau_i)^2]^{1/2}}$$

$$= \frac{200 \times 10^{-6}}{[1+(2\times\pi\times 50\times10^6 \times 10\times10^{-9})^2]^{1/2}}$$

$$= \frac{200 \times 10^{-6}}{[1+9.869]^{1/2}} = \frac{200 \times 10^{-6}}{3.296} = 60.679 \times 10^{-6}\,W$$

ii) At 3dB optical Bandwidth $P_e = 0.5 P_{dc}$ or, $\frac{P_e}{P_{dc}} = \frac{1}{2}$

$$\therefore \frac{1}{[1+(\omega\tau_i)^2]^{1/2}} = \frac{1}{2}$$

$$1 + (\omega\tau_i)^2 = 4$$

$$\omega\tau_i = \sqrt{3}$$

$$f = \frac{\sqrt{3}}{2\pi\tau_i} = \frac{\sqrt{3}}{2\times\pi\times10\times10^{-9}}$$

$$= \frac{\sqrt{3}}{6.3\times10^{-8}} = \underline{27.4\,MHz}$$

	$f = \frac{1.73}{62.8 \times 10^{-9}}$ $= 0.02754 \times 10^{9}$ $f = 27.54 \times 10^{6}$ $\boxed{f = 27.54\ MHz}$ ⇒ for 3dB electrical Bandwidth. $B = \frac{f_{3dB\,optical}}{\sqrt{2}}$ $= \frac{27.54 \times 10^{6}}{\sqrt{2}}$ $= \frac{27.54 \times 10^{6}}{1.414}$ $= 19.47 \times 10^{6}$ $\boxed{B_{elect} = 19.47\ MHz}$			
2.	The total efficiency of an injection laser with a GaAs active region is 18%. The voltage applied to the device is 2.5 V and the bandgap energy for GaAs is 1.43 eV. (a)Calculate the external power efficiency of the device. (b) A gallium arsenide injection laser with a cavity of length 500 μm has a loss coefficient of 20 cm-1. The measured differential external quantum efficiency of the device is 45%. Calculate the internal quantum efficiency of the laser. The refractive index of gallium arsenide is 3.6.	10	3	4

Ans:

a) $\eta_{ep} = \eta_T \left(\frac{E_g}{V}\right) \times 100\%$

$= 0.18\left(\frac{1.43}{2.5}\right) \times 100\%$

$= 10.29\%$.

b) $g_{th} = \cancel{\beta J}\ \beta J_{th}$

$= \beta\left[\frac{1}{\beta}\left[\alpha + \frac{1}{L}\ln\left(\frac{1}{r}\right)\right]\right]$

w.k.t: $r = \left(\frac{n-1}{n+1}\right)^2 \Rightarrow \left(\frac{3.6-1}{3.6+1}\right)^2 = 0.31$

$\therefore g_{th} = \left[20 + \frac{1}{500\times10^{-4}}\ln\left(\frac{1}{0.31}\right)\right]$

$= 43.42\ cm^{-1}$

w.k.t $\eta_{ext} = \frac{\eta_{int}(g_{th} - \alpha)}{g_{th}}$

$\eta_{int} = \frac{\eta_{ext} \times g_{th}}{g_{th} - \alpha} \Rightarrow \frac{0.45 \times 43.42}{43.42 - 20}$

$= 0.83 \Rightarrow 83\%$.

3.	a. A silicon pin photodiode has a quantum efficiency of 85% when photons of energy 7.4 X 10^{-19} J are incident upon it. At what wavelength is the photodiode operating? Find the responsivity. Calculate the incident optical power required to obtain a photocurrent of 7.9 μA, when the photodiode is operating as described above.	5	3	4

	Lamda=2.69 micro metre R=0.184 A/W P0=42.9 micro watt			
	b. The quantum efficiency of a particular silicon RAPD is 92% for the detection of radiation at a wavelength of 1.3 μm. When the incident optical power is 2.9 μW, the output current from the device (after avalanche gain) is 33 μA. Determine, the multiplication factor of the photodiode under these conditions.	5	3	4
	R=0.96 A/W Ip=2.784 microwatt M=11.85			
4.	A germanium APD (with x=1.0) operates at a wavelength of 1.40 μm where its responsivity is 0.45A W^{-1}. The dark current is 200 nA at the operating temperature of 260 K and the device capacitance is 4 pF. Determine the maximum possible SNR when the incident optical power is 9 x 10^{-7} W and the post detection bandwidth without equalisation is 580 MHz.	10	3	4

B2-slot

4.) $\lambda = 1.40\,\mu m$, $x = 1.$ $R = 0.45\,A/W$

$I_D = 200\,nA$ $T = 260K$ $C = 4\,pF$ $P_0 = 9\times10^{-7}\,W$

$B = 580\,MHz$

$$R_L = \frac{1}{2\times3.14\times4\times10^{-12}\times580\times10^{6}} = 68.6\,\Omega$$

Thermal noise

$$\langle i_t^2 \rangle = \frac{4KTB}{R_L} = \frac{4\times1.381\times10^{-23}\times260\times580\times10^{6}}{68.6}$$

$$= 12.13\times10^{-15}$$

Photo current $I_p = \dfrac{\eta P_0 q\lambda}{hc} = \dfrac{0.45\times9\times10^{-7}\times1.602\times10^{-19}\times1.40\times10^{-6}}{6.626\times10^{-34}\times2.998\times10^{8}}$

$$= 45.69\,nA$$

$$\frac{S}{N} = \frac{M_{op}^2\, I_p^2}{2qB(I_p+I_d)M_{op}^2 + \frac{4KTB}{R_L}}$$

$$M_{op}^2 = \frac{4KTF_n}{qR_L(I_p+I_d)}$$

$$M_{op} = \left[\frac{4KTF_n}{qR_L(I_p+I_d)}\right]^{1/2}$$

$$M_{opt} = \left[\frac{4 \times 1.381 \times 10^{-23} \times 260 \times}{1.602 \times 10^{-19} \times 68.6 \times (45.6 + 200) 10^{-9}}\right]^{1/2}$$

$$= \left[\frac{1.43624 \times 10^{-20}}{2.699 \times 10^{-24}}\right]^{1/2}$$

$$= [5320]^{1/2} = 72.9 = 73$$

$$\frac{S}{N} = \frac{M_{op}^2 I_p^2}{2qB(I_p + I_d) M_{op}^2 + \frac{4KTB}{R_L}}$$

$$= \frac{5320 \times (45.6 \times 10^{-9})^2}{\left[2 \times 1.602 \times 10^{-19} \times 580 \times 10^{6} (45.6 + 200) 10^{-9} \times 5320 + 12.13 \times 10^{-15}\right]}$$

$$= \frac{1.106 \times 10^{-11}}{2.428 \times 10^{-13} + 12.13 \times 10^{-15}}$$

	$= 43.38$ $\frac{S}{N} = 10 \log 43.38$ $= 16.37$ $= 16.37\ dB$			
5.	A transmitter has an output power of 0.1 mW(-10 dBm). It used a fiber having NA of 0.25, attenuation of 6 dB/km and a fiber length of 0.5 km. The link contains 2 connector with individual connector loss of 2 dB. The link margin is 4 dB and data rate of 1 Gbps for the targeted Q-factor of 6. (a)Find the actual output power in dBm. (b) Estimate the link power budget of the above system, when the receiver sensitivity is -35 dBm. (c)If it is required to design the system for 3 km, how many repeaters are required to achieve the targeted Q-factor.	10	4	4

P_s = -10dBm

Since NA = 0.25

Coupling loss = -10log (NA^2)

= -10log (0.25^2)

= 12 dB

Fiber loss = α_f x L

l_f = (6dB/km) (0.5km) l_f = 3 dB

Connector loss = 2 (2 dB)

l_c = 4 dB Design margin P_m = 4 dB

Actual output power Pout = Source power – (Σ Losses) P_{out} = 10dBm – [12 dB + 3 + 4 + 4]

P_{out} = **-33 dBm**

Since receiver sensitivity given is – 35 dBm.

P_{min} = **-35 dBm**

2 (c)

$-10-(-35) = 12+4+4+6\cdot L$

$\Rightarrow \quad L = \dfrac{25-20}{6}$

$= 0.83$ km.

⇒ The system will work upto 0.83 km.

⇒ To design 3 km. link distance no. of repeaters required are 3 km/0.83 km = 3.61 ≅ 4 no.