SLOT: A1+TA1

REG. NO.:

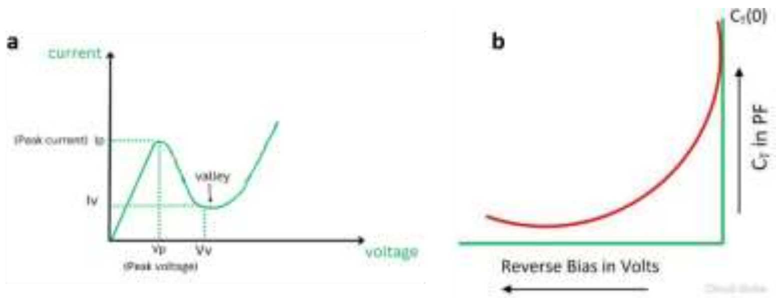
VIT
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF ELECTRONICS ENGINEERING (SENSE)
CONTINUOUS ASSESSMENT TEST - II
FALL SEMESTER 2025-2026

Programme Name & Branch : B.Tech Electronics Engineering (VLSI Design and Technology)
Course Code : BEVD201L
Course Name : PHYSICS OF SEMICONDUCTOR DEVICES
Faculty Name(s) : Dr.Prachi Sharma, Dr.T.Pradheep
Class Number(s) : VL2025260102590
Date of Examination :
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 Outcome Statements:
  CO 2: Analyze the PN junction diode characteristics
  CO 3: Understand the principles of optoelectronic devices.
  CO 4: Teach the modelling of PN Junction, MOS capacitors, and MOSFETs

<table>
<tr><th>Q. No</th><th>Question</th><th>M</th><th>CO</th><th>BL</th></tr>
<tr><td>1.</td><td>Describe the Schematic diagram, operating principle, advantages and disadvantages of the following diode characteristics
Answer
a.Tunnel diode
b.varactor diode

</td><td>10</td><td>2</td><td>3</td></tr>
<tr><td>2.</td><td>a) Assume $D_B = 3D_E$, $W_E = 3W_B$, $N_B = 10^{18}$ cm^{-3}, and $n_{iB}^2 = n_i^2$. What is β for N_E equals to 10^{21} cm^{-3} and 10^{22} cm^{-3} and a SiGe base with ΔE_{gB} = 60 meV</td><td>10</td><td>3</td><td>4</td></tr>
</table>

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<table>
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$$\beta \approx \left(\frac{D_B}{D_E}\right)\left(\frac{W_E}{W_B}\right)\left(\frac{N_E}{N_B}\right)\exp\left(\frac{\Delta E_{gB}}{kT}\right)$$

$$\beta \approx (3)\cdot(3)\cdot\frac{N_E}{10^{18}\ \mathrm{cm}^{-3}}\cdot\exp\left(\frac{60\ \mathrm{meV}}{25.85\ \mathrm{meV}}\right)$$

Calculate the exponential term:

$$\exp\left(\frac{60}{25.85}\right)\approx\exp(2.321)\approx 10.18$$

The full expression for β is:

$$\beta \approx 9\cdot\frac{N_E}{10^{18}\ \mathrm{cm}^{-3}}\cdot 10.18$$

$$\beta \approx 91.62\cdot\frac{N_E}{10^{18}\ \mathrm{cm}^{-3}}$$

Case 1: $N_E = 10^{21}\ \mathrm{cm}^{-3}$

For $N_E = 10^{21}\ \mathrm{cm}^{-3}$:

$$\beta_1 \approx 91.62\cdot\frac{10^{21}\ \mathrm{cm}^{-3}}{10^{18}\ \mathrm{cm}^{-3}}$$

Emitter Doping (N_E)	DC Current Gain (β)
$10^{21}\ \mathrm{cm}^{-3}$	$\mathbf{91,620}$
$10^{22}\ \mathrm{cm}^{-3}$	$\mathbf{916,200}$

b) Discuss quantitatively how increasing emitter doping affects β and emitter injection efficiency. Also, explain how reducing base width would affect β and collector current linearity.

Reducing the neutral base width (WB) is highly beneficial for the DC current gain (β) because it improves both the emitter injection efficiency and the base transport factor.

Reducing the base width severely degrades the collector current linearity

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<tr><td>3.</td><td>

A monocrystalline silicon solar cell is being tested under Standard Test Conditions (STC), where the solar irradiance (G) is 1000 W/m^2.The measured parameters of the cell are:

- Dimensions (Area): 156 mm×156 mm
- Open-Circuit Voltage (Voc): 0.65 V

</td><td>10</td><td>3</td><td>5</td></tr>
</table>

- Short-Circuit Current (Isc): 9.20 A
- Fill Factor (FF): 0.78

Calculate the efficiency (η) of the solar cell.

1. Calculate the Active Area of the Cell (A)

The dimensions must be converted from millimeters (mm) to meters (m) for consistency with the irradiance unit (W/m2).

1 m=1000 mm

- Length =156 mm=0.156 m
- Width =156 mm=0.156 m

$A=Length\times WidthA=0.156\ m\times 0.156\ mA=0.024336\ m2$

2. Calculate the Incident Solar Power (Pin)

The input power is the solar irradiance multiplied by the cell's area.

$Pin=G\times APin=1000\ W/m2\times 0.024336\ m2Pin=24.336\ W$

3. Calculate the Maximum Electrical Output Power (Pmax)

The maximum power is determined from the key electrical parameters (Voc, Isc, and FF).

$Pmax=Voc\times Isc\times FFPmax=0.65\ V\times 9.20\ A\times 0.78Pmax=4.6548\ W$

4. Calculate the Solar Cell Efficiency (η)

Finally, divide the output power by the input power and multiply by 100 to get the percentage.

$\eta=PinPmax\times 100\%\eta=24.336\ W4.6548\ W\times 100\%\eta\approx 0.19127\times 100\%$
$\eta\approx 19.13\%$

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4.	(i) Explain the diode that converts light to electrical energy. (ii) Why different colours of light are emitted from a diode? (iii) Compare OLED Vs. AMOLED. (i)Photodiode (ii) The different colors of light emitted from a Light Emitting Diode (LED) are determined exclusively by the energy band gap of the semiconductor material used to construct the diode. (iii) **Amoled VS Oled Display** **Durability** An important difference between AMOLED and OLED is that OLED displays generally last longer than AMOLED displays. AMOLED's faster energy transfer can wear down the hardware more quickly. **Energy Efficiency** OLED displays tend to be more energy-efficient compared to AMOLED displays, which can consume more power, especially during high-performance tasks like gaming. **Cost** AMOLED displays are generally more expensive. **Picture Quality** AMOLED offers sharper picture quality due to better energy architecture within the monitor. This results in smoother graphics and better viewing angles.	10	3	4
5.	Consider an NPN BJT common-emitter amplifier circuit with voltage-divider bias. • Supply Voltage: V_{CC}=15 V • Base Resistors: R_1=39 kΩ, R_2=8.2 kΩ • Collector Resistor: R_C=3.3 kΩ • Emitter Resistor: R_E=1 kΩ • DC Current Gain: β_{DC}=100	10	3	2

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- Base-Emitter Voltage: V_{BE}=0.7 V (typical for a silicon BJT)

Calculate V_B, I_E, I_C, and V_{CE}.

The base voltage is set by the voltage divider (R_1 and R_2) across V_{CC}. We assume the base current (I_B) is small enough to ignore loading, which is a good initial approximation for voltage-divider bias.

$$V_B = V_{CC}\left(\frac{R_2}{R_1 + R_2}\right)$$

$$V_B = 15\ \mathrm{V}\left(\frac{8.2\ \mathrm{k\Omega}}{39\ \mathrm{k\Omega} + 8.2\ \mathrm{k\Omega}}\right) = 15\ \mathrm{V}\left(\frac{8.2\ \mathrm{k\Omega}}{47.2\ \mathrm{k\Omega}}\right)$$

$$V_B \approx \mathbf{2.606}\ \mathrm{V}$$

The emitter voltage (V_E) is found by subtracting V_{BE} from V_B.

$$V_E = V_B - V_{BE}$$

$$V_E = 2.606\ \mathrm{V} - 0.7\ \mathrm{V} = 1.906\ \mathrm{V}$$

The emitter current (I_E) is then found using Ohm's law across the emitter resistor (R_E):

$$I_E = \frac{V_E}{R_E}$$

$$I_E = \frac{1.906\ \mathrm{V}}{1\ \mathrm{k\Omega}}$$

$$I_E \approx \mathbf{1.906}\ \mathrm{mA}$$

The collector current (I_C) is related to the emitter current (I_E) by the DC current gain (β_{DC}):

$$I_C = \alpha_{DC} I_E$$

where $\alpha_{DC} = \frac{\beta_{DC}}{1+\beta_{DC}}$

Since β_{DC} is large ($\beta_{DC} = 100$), α_{DC} is close to 1:

$$\alpha_{DC} = \frac{100}{101} \approx 0.9901$$

$$I_C = 0.9901 \times 1.906\ \mathrm{mA}$$

$$I_C \approx \mathbf{1.887}\ \mathrm{mA}$$

(Note: For practical BJT analysis, it is often assumed $I_C \approx I_E$, which would give $I_C \approx 1.906\ \mathrm{mA}$. We use the more accurate formula here.)

$$V_{CC} = I_C R_C + V_{CE} + I_E R_E$$

earranging for V_{CE}:

$$V_{CE} = V_{CC} - I_C R_C - I_E R_E$$

sing the calculated currents:

$$V_{CE} = 15\text{ V} - (1.887\text{ mA} \times 3.3\text{ k}\Omega) - (1.906\text{ mA} \times 1\text{ k}\Omega)$$

$$V_{CE} = 15\text{ V} - 6.227\text{ V} - 1.906\text{ V}$$

$$V_{CE} = 15\text{ V} - 8.133\text{ V}$$

$$V_{CE} \approx 6.867\text{ V}$$

Parameter	Value
V_B **(Base Voltage)**	2.606 V
I_E **(Emitter Current)**	1.906 mA
I_C **(Collector Current)**	1.887 mA
V_{CE} **(Collector-Emitter Voltage)**	6.867 V

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