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ESC201 | **Mini-Quiz IV** | **18/02/2025**

Total Marks: 5 | **Time: 10 minutes**

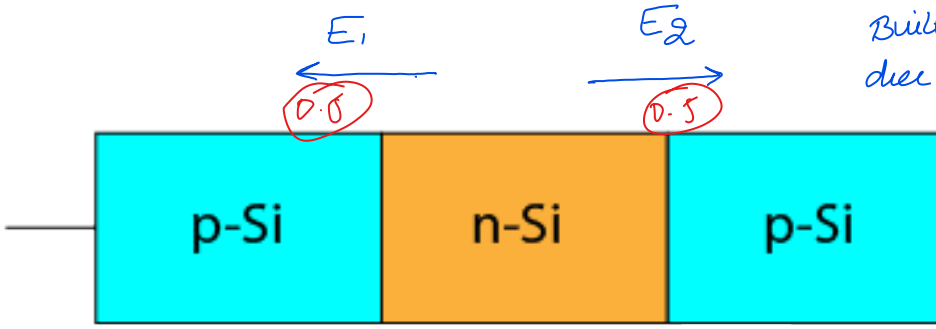
Instructions

- **Please write your name and roll number first.**
- **Read the question carefully and answer it in the question paper itself.**

1) For the back-to-back connected diodes shown below, the doping concentration of the p-type Si and n-type Si are $N_A = 10^{18}$ cm^{-3} and $N_D = 10^{16}$ cm^{-3}, respectively.

(a) Show the direction of electric field at the two depletion regions in the figure itself. **(1 mark)**

(b) Assume the **current source model** for the diodes and find out the voltage across the diodes D1 (V_{D1}) and D2 (V_{D2}) when a square wave with an amplitude of 5 V is applied to this system. [Take $\eta = 1$, $V_F = V\gamma = 0.7$ V and $V_T = 26\ mV$] **(4 marks)**



Built-in E-field due to diffusion of majority charge carriers.

Using simplest model for diode:

$V_{D1} = 0$ (SC)

$V_{D2} = 5$ V (OC)

when $V_{applied} = 5$V

$V_{D1} = 5$V & $V_{D2} = 0$

when $V_{applied} = -5$V

Note the difference! However, if someone used this model or similar, only deduct 1.5 marks if they have identified everything else correctly

V_{D} ⇒ I_D

$I = I_s\left(e^{\frac{V_D}{\eta V_T}} - 1\right)$

$\approx I_s\, e^{\frac{V_D}{\eta V_T}}$ if $V_D >> \eta V_T$

$\approx -I_s$ if $V_D << -\eta V_T$

this simply tells us that current I_s flows from n to p & not from p to n

→ Case-1 $V_{applied} = 5$V.

clearly; D_1 will be in forward bias & D_2 will be in reverse bias

→ since D_1 & D_2 are in series ⇒ $I_{D1} = I_{D2}$ & $V_{D1} + V_{D2} = 5$ V.

$\Rightarrow I_{D1} = I_s\left(e^{\frac{V_{D1}}{V_T}} - 1\right) = I_{D2} = I_s$ why? → In F.B, typically only V_γ drops across diode which means $I_{D2} = -\left[I_s\left(e^{\frac{-4.3\times10^{3}}{26}} - 1\right)\right] \approx -[-I_s] = I_s$

$\Rightarrow e^{\frac{V_{D1}}{V_T}} - 1 = 1 \Rightarrow \ln 2 = \frac{V_{D1}}{V_T} \Rightarrow V_{D1} = 0.69 \times 26mV$

$V_{D2} = 5 - V_{D1} = 4.99$ V ← & → $V_{D1} \approx 18$ mV clearly F.B. voltage is not large!

→ now; when $V_D = -5$V; $V_D + V_{D2} = -5$V; $I_{D1} = I_{D2}$ with D_1 in R.B & D_2 in F.B.

$\Rightarrow I_{D1} = I_s = I_s\left[e^{\frac{-V_{D2}}{V_T}} - 1\right] \Rightarrow V_{D2} \approx -18$ mV & $V_{D1} = -4.99$ V