D. J. SANGHVI COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRONICS ENGINEERING
ELECTRONIC DEVICES SEM III
Homework Assignment 01

N.B. : **[Total Marks: 60]**

1) Write your **SAP ID** on the top of the first page.

2) This assignment is based on **PN junction and BJT** topic.

1. For a Si pn junction at T=300K, acceptor dopants and donor dopant have equal concentration of $10^{17}/cm^3$, $D_n = 25cm^2/s$, $D_p = 15cm^2/s$, $\tau_p = \tau_n = 50ns$, Area $=10^{-4}/cm^2$. Find the value of forward current for the forward-bias of 0.7V. **[15]**

2. Breakdown voltage of a zener diode is decided by ---------- **[02]**

3. Justify how Eber-moll model works for all operating modes of BJT ? **[08]**

4. An abrupt Si pn junction has $N_A = 10^{17}/cm^3$ on p-side and $N_D = 10^{16}/cm^3$ on n-side at 300K. **[10]**

   a) Draw an equilibrium energy-band diagram and calculate position's of fermi level on each side.

   b) Calculate V_{bi} from the energy-band diagram in a).

   c) Compare the results from a) with V_{bi} calculated from its formula.

5. A Si pn junction has $V_{bi} = 0.65V$ and acceptor concentration on p-side is 100 times greater than donor concentration on n-side. Find the width of depletion region and value of depletion capacitance per unit area when a reverse bias voltage of 10V is applied across it. **[10]**

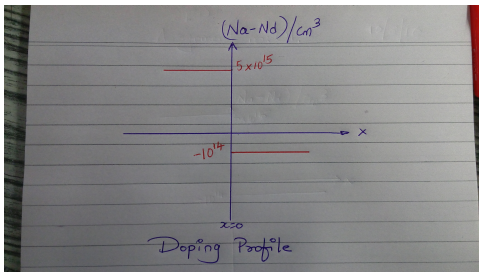
6. Justify why the space charge width increases with reverse-bias voltage in a pn junction diode ? **[05]**

7. A Si pn junction at T=300K has doping profile shown below: Estimate the following: **[10]**

   i) Built-in potential

   ii) x_n and x_p at zero bias

   iii) Sketch E-field Vs distance for the given situation.



Parameter	Emitter	Base	Collector
Dopant concentration (cm^{-3})	10^{18} (n-type)	10^{17} (n-type)	10^{15} (n-type)
Width (μm)	0.5	0.5	2
Minority-carrier lifetime (s)	10^{-7}	10^{-6}	10^{-5}

8. Consider a Si npn BJT with emitter area A = $10^{-7} cm^2$, maintained at room temperature (T = $300K$), with parameters for each of the regions as shown in the table above: **[EC 40]**

   Various current current components in base, emitter and collector are:

$$I_{Ep} = qA\frac{D_E}{L_E}p_{E0}\frac{\cosh\left(W_E'/L_E\right)}{\sinh\left(W_E'/L_E\right)}\left(e^{V_{BE}/V_t}-1\right)$$

$$I_{Cp} = -qA\frac{D_C}{L_C}p_{C0}\frac{\cosh\left(W_C'/L_C\right)}{\sinh\left(W_C'/L_C\right)}\left(e^{V_{BC}/V_t}-1\right)$$

$$I_{En} = qA\frac{D_B}{L_B}n_{B0}\left[\frac{\cosh\left(W/L_B\right)}{\sinh\left(W/L_B\right)}\left(e^{V_{BE}/V_t}-1\right)-\frac{1}{\sinh\left(W/L_B\right)}\left(e^{V_{BC}/V_t}-1\right)\right]$$

$$I_{Cn} = qA\frac{D_B}{L_B}n_{B0}\left[\frac{1}{\sinh\left(W/L_B\right)}\left(e^{V_{BE}/V_t}-1\right)-\frac{\cosh\left(W/L_B\right)}{\sinh\left(W/L_B\right)}\left(e^{V_{BC}/V_t}-1\right)\right]$$

   Suppose that the BJT is biased such that $V_{BE} = 0.60$ V and $V_{BC} = 0$ V

   a) Calculate emitter injection efficiency γ , base transport factor α_T.

   b) Calculate the terminal currents I_E, I_C and I_B.

Hint:
1. First calculate the built-in potential for each junction.
2. Then obtain the widths of the quasi-neutral emitter, base and collector regions:
3. Then determine the minority-carrier diffusivity and diffusion length for each of the quasi-neutral regions of the BJT, in order to calculate the various current components:

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