Shri Vile Parle Kelvani Mandal's
Dwarkadas J. Sanghvi College of Engineering
Approved by AICTE, New Delhi and Affiliated to the University of Mumbai

Department of Electronics Engineering

Academic Year : 2015

MID-TERM TEST I

Subject : Electronic Devices

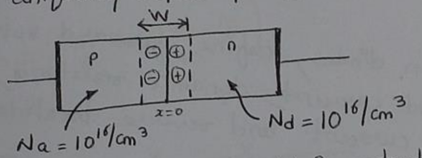
SE Sem III

Date: 09/09/2015
Marks: 20

Time:- 1 hour

Note: Attempt any two questions.

Q1. Given is a uniformly doped p-n junction (Si) in thermal equilibrium:-



at $T = 300K$

$V_{bi} = V_t \ln\left[\frac{N_a N_d}{n_i^2}\right]$

a) Derive the expression for build-in potential (2m)

b) From the given information, calculate V_{bi} → 0.697 (1m)

c) Draw EBD of given device in equilibrium and under forward applied bias. (2m)

d) Find 'W' for zero-applied bias and a reverse bias of 8V. (2m)
→ $W = 4.17\times10^{-5}$ cm |0V
$W = 1.47\times10^{-4}$ cm |8V

e) Find max E-field under zero-applied bias. (1m)
→ $E_m = \frac{-2V_{bi}}{W} = -33.4$ kV/cm

f) Draw small-signal model for this device. (1m)

g) $I = I_0\left[\exp\left(\frac{V_a}{V_t}\right) - 1\right]$ is ideal p-n junction diode current. Write formula for I_0 ? What it is called? (1m)
→ $I_0 = \left[\frac{qAD_p p_{no}}{L_p} + \frac{qAD_n n_{po}}{L_n}\right]$

Given data:
$q = 1.6\times10^{-19}$ C
$n_i = 1.5\times10^{10}/cm^3$
$\epsilon_{Si} = 11.7\times 8.854\times10^{-14}$

— Turn over —

Q2. a) Explain working and characteristics of N-channel JFET ? (5m)

b) For a JFET, gm is transconductance. (2m)
Show that: $g_m = -\frac{2}{V_P} I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)$
starting from I_{Dsat} expression.

c) Compare zener and Avalanche breakdown mechanisms (2m)

d) Explain how JFET works as a voltage controlled resistor (with the help of characteristics) (1m)

Q3 a) For the pn diodes, define forward voltage drop, max forward current, dynamic resistance, reverse saturation current and reverse breakdown voltage (2m)

b) Max Electric field in a reverse-bias Si pn junction is 3×10^5 V/cm. The doping concentration are $N_d = 4 \times 10^{16}/cm^3$ and $N_a = 4 \times 10^{17}/cm^3$ (3m)
Magnitude of the reverse-bias voltage is 7.18 V

$V_{bi} = V_t \ln\left[\frac{N_a N_d}{n_i^2}\right]$

$|E_m| = \left[\frac{2q(V_{bi}+V_R)}{\epsilon} \frac{N_a N_d}{(N_a+N_d)}\right]^{1/2}$

c) Attempt the following questions:
i) Junction potential across a p-n junction (1m)
A) decreases with increasing doping concentration
B) increases with decreasing bandgap
C) does not depend on doping concentration
[✓ D) increases with increase in doping concentration]

ii) Justify that space-charge width increases with reverse-biased voltage in a pn junction diode. (2m)

— Turn over —

$I = I_0 \left(\exp\left(\frac{V_a}{V_t}\right) - 1\right)$

Q3 c)

iii) For a Si pn junction at T=300K, (3m)

$N_a = N_d = 10^{17}/cm^3$, $D_n = 25\ cm^2/s$, $D_p = 15\ cm^2/s$,

$\tau_p = \tau_n = 50\ ns$. $A = 10^{-4}\ cm^2$

Find value of reverse-saturation current. (I_0)

$I_0 = 1.428 \times 10^{-15}\ A$

OR

iii) Explain the deviations from ideal characteristics (I-V) in a p-n junction. Draw practical I-V curve. Explain the factors responsible for high-current in reverse-bias before breakdown. (3m)

$$I_0 = qA\left[\frac{D_p}{L_p} p_{n0} + \frac{D_n}{L_n} n_{p0}\right]$$

—— X —— X ——

$$I_0 = qA n_i^2 \left[\frac{D_p}{L_p} \times \frac{1}{N_d} + \frac{D_n}{L_n} \times \frac{1}{N_a}\right]$$

$L_p^2 = D_p \tau_p \Rightarrow L_p = \sqrt{D_p \tau_p} = 8.66 \times 10^{-4}\ cm$

$L_n^2 = D_n \tau_n \Rightarrow L_n = \sqrt{D_n \tau_n} = 1.118 \times 10^{-3}\ cm$