ELECTRONICS & COMMUNICATION ENGINEERING

GATE | PSUs

Electronic Devices & VLSI

Volume - I : Study Material with Classroom Practice Questions

Study Material with Classroom Practice solutions
To
Electronic Devices & VLSI

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Chapter 1 Basics of Semiconductor

Class Room Practice Solutions

01. Ans: (a)

Sol: $N_D = 5\times10^{22}\times\frac{1}{10^9}\,cm^{-3}$

$= 5\times10^{13}\ cm^{-3}$

According to mass action law

$np = n_i^2$

$n_n p_n = n_i^2$

$N_D\, p_n = n_i^2 \quad (\because n_n \simeq N_D)$

$p_n = \frac{n_i^2}{N_D}$

$p_n = \frac{(1.5\times10^{10})^2}{5\times10^{13}}$

$= 4.5\times10^{6}\ cm^{-3}$

02. Ans: (b)

Sol: According to law of mass action $n.p = n_i^2$

Where n_i = intrinsic carrier concentration.

N_D = doping concentration for a n- type material.

Majority carrier concentration

$n \cong N_D$

$p = \frac{n_i^2}{N_D}$

$p \alpha \frac{1}{N_D}$

03. Ans: (b)

Sol: V = 5V

L = 100 mm

$N_n = 3800\ cm^2/V\text{-sec}$

$N_p = 1800\ cm^2/V\text{-sec}$

$V_{dn} = \mu_n E$

$= 3800\times\frac{V}{L}$

$= 3800\times\frac{5}{100\times10^{-1}}$

= 1900 cm/sec

04. Ans: (d)

Sol: For the n-type semiconductor with $n = N_D$ and $p = n_i^2/N_D$, the hole concentration will fall below the intrinsic value because some of the holes recombine with electrons

05. Ans: (c)

Sol: $N_A = \frac{10^{15}}{1.6}$ acceptor / cm^3

$N_n = 4000\ cm^2/V\text{-sec}$

$N_p = 2000\ cm^2/V\text{-sec}$

$\sigma_p = p\, q\, \mu_p$

$= N_A q \mu_p$ ($\because$ 100% doping efficiency)

$= \frac{10^{15}}{1.6}\times1.6\times10^{-19}\times2000$

= 0.2 mho/cm

06. Ans: (d)

Sol: According to mass action law.

$np = n_i^2$

$n_n p_n = n_i^2$

$n_p p_D = n_i^2$

$n_p N_A \simeq n_i^2$

$N_D p_n \simeq n_i^2$

07. Ans: (a)

Sol: $R_H = 3.6\times10^{-4}\ m^3/c$

$\rho = 9\times10^{-3}\ \Omega\text{–m}$

Let us consider n-type semiconductor

$$R_H = \frac{1}{nq}$$

$$n = \frac{1}{qR_H}$$

$$= \frac{1}{1.6\times10^{-19}\times3.6\times10^{-4}}$$

$$= 1.736\times10^{22}\ m^{-3}$$

08. Ans: (b)

Sol: At equilibrium

No. of e^- density = No. of hole density

$\because$ given e^- density is $n(x_1) = 10\ n(x_2)$

$\Rightarrow n(x_1)$ is majority

$\Rightarrow n(x_2)$ is minority

$\therefore P(x_2) = 10P(x_1)$

09. Ans: (b)

Sol: $\rho_p = 3\times10^3\ \Omega-m$

$\mu_p = 0.12\ m^2/V\text{-sec}$

$V_H = 60mV$

$$\rho_p = \frac{1}{\sigma_p}$$

$$3\times10^3 = \frac{1}{pq\mu_p}$$

$$p = \frac{1}{3\times10^3\times1.6\times10^{-19}\times0.12}$$

$P = 1.736\times10^{16}\ m^{-3}$

$$R_H = \frac{1}{pq}$$

$$= \frac{1}{1.736\times10^{16}\times1.6\times10^{-19}}$$

$= 360\ m^3/C$

10. Ans: (b)

Sol: $J_{drift} = n\mu_n qE + p\mu_P qE$

$J_{drift} = [(n.q)\mu_n + (p.q)\mu_p]E$

$J_{drift} = [\rho_n\mu_n + \rho_p\mu_p]$

$J\alpha$ 'ρ'

$\downarrow$

Charge concentration

11. Ans: (c)

Sol: $D_n = 20\ cm^2/s$

$\mu_n = 1600\ cm^2/V-s$

$$\frac{D}{\mu} = kT = V_T$$

$$\Rightarrow V_T = \frac{20}{1600} = 12.5\,mV$$

12. Ans: (d)

Sol: Conductivity of a semiconductor, $\sigma = (n\mu_n + p\mu_P)q$

Where, $\mu_n \rightarrow$ mobility of electrons

$\mu_p \rightarrow$ mobility of holes

$n \rightarrow$ electron concentration

$p \rightarrow$ hole concentration

$q \rightarrow$ electron charge

13. Ans: (c)

Sol: $N_A = 2.29\times10^{16}$

$$E_{Fi} - E_{Fp} = kT\ln\left(\frac{N_A}{n_i}\right)$$

$$= 0.02586\ln\left(\frac{2.29\times10^{16}}{1.5\times10^{10}}\right)$$

$= 0.3682$ eV

$\simeq 0.37$ eV

14. Ans: (b)

Sol: Given,

2 wires $\therefore W_1$ & W_2

$d_2 = 2d_1$ where d = diameter of wire

$L_2 = 4L_1$ where L = length of wire

Relation between resistances of

W_1 & W_2

$$R = \frac{\rho.L}{A} = \frac{\rho L}{\pi r^2} \qquad r = \frac{d}{2}$$

$$R = \frac{\rho.L}{\pi\frac{d^2}{4}} = \frac{4\rho L}{\pi d^2} \qquad R \propto \frac{L}{d^2}$$

$$\frac{R_1}{R_2} = \frac{\frac{L_1}{d_1^2}}{\frac{L_2}{d_2^2}} = \frac{L_1}{d_1^2}\times\frac{d_2^2}{L_2} = \frac{L_1}{d_1^2}\times\frac{(2d_1)^2}{4L_1}$$

$$\Rightarrow \frac{R_1}{R_2} = 1 \qquad \therefore R_1 = R_2$$

15. Ans: (c)

Sol: Hall voltage, V_H is inversely proportional to carrier concentration

$$\Rightarrow \frac{V_{H2}}{V_{H1}} = \frac{P_1}{P_2} = \frac{P_1}{2P_1}$$

$$\therefore V_{H2} = \frac{1}{2}V_{H1}$$

16. Ans: (b)

Sol: $\frac{D}{\mu} = \frac{kT}{q} = V_T$

$$\therefore D = \frac{0.36\times1.38\times10^{-23}\times300}{1.6\times10^{-19}}$$

$= 9.315\times10^{-3} m^2/sec$

Diffusion length, $L = \sqrt{D\tau}$

$= \sqrt{9.315\times10^{-3}\times340\times10^{-6}}$

$= 1.77\times10^{-3} m$

17. Ans: (a)

Sol: In intrinsic semiconductor,

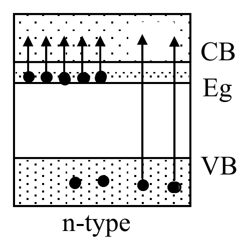
No. of e^- = No. of holes

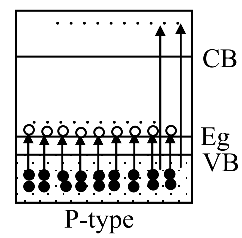
18. Ans: (a)

19. Ans: (b)

20. Ans: (a)

Sol: Both (A) and (R) are true, (R) is the correct explanation of (A)





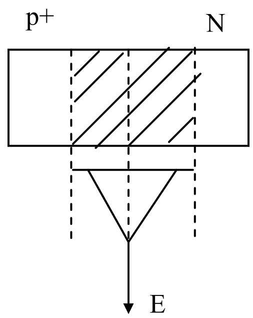
Chapter **2**

PN Junction Diode

Class Room Practice Solutions

01. Ans: (c)

Sol:



In P^+, '+' indicates heavily region and 'n' indicates lightly doped region.

02. Ans: (a)

Sol: $w = \sqrt{\dfrac{2\varepsilon V_0}{q}\left[\dfrac{1}{N_D} + \dfrac{1}{N_A}\right]}$

$$\frac{w_2}{w_1} = \sqrt{\frac{V_0 - V_{d2}}{V_0 - V_{d1}}}$$

$$\frac{w_2}{2\mu m} = \sqrt{\frac{0.8-(-7.2)}{0.8-(-1.2)}}$$

$w_2 = 4\ \mu m$.

03. Ans: (a)

Sol: $I = \left[\dfrac{AeD_P p_{n0}}{L_P} + \dfrac{AeD_n n_{P0}}{L_n}\right]$

$$\Rightarrow I = \frac{AeD_p p_{no}}{L_P}$$

$$\frac{I}{A} = \frac{eD_P p_{no}}{L_P}$$

$$= \frac{1.602\times10^{-19}\times12\times10^{12}}{1\times10^{-3}}$$

$= 1.92\ mA/cm^2$

04. Ans: (c)

Sol: $1\ mA = I_{GO}(e^{V_G/\eta V_T} - 1) = I_{SO}(e^{V_S/\eta V_T} - 1)$

$$\frac{I_{GO}}{I_{SO}} = \frac{e^{0.718/(2\times0.026)}}{e^{0.1435/(1\times0.026)}} \cong 4000 = 4\times10^3$$

05. Ans: (c)

Sol: In a PN Junction diode the dynamic conductance $g_m = \dfrac{\Delta I}{\Delta V}$, $g_m = \dfrac{I_C}{V_T}$

i.e. $g_m \propto I_C$

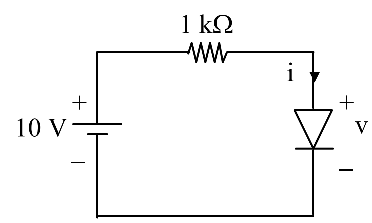
06. Ans: (d)

Sol: i – v characteristic of the diode

$i = \dfrac{v-0.7}{500}\ A,\ v \geq 0.7\,V$ ….. (1)

From the given circuit, Loop equation :

$v = 10 - 1000\ i,\ v \geq 0.7\ V$ ….. (2)



Eliminating 'v' from (1) and (2) :

$$i = \frac{10-1000\ i - 0.7}{500} = \frac{9.3}{500} - 2i$$

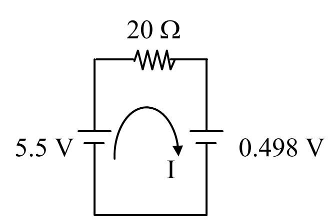
$$3i = \frac{9.3}{500},\quad i = \frac{3.1}{500}A = 6.2\ mA$$

07. Ans: (b)

Sol: Given,

$V_\gamma = 0.498\ V$

$V_T = 2\ mV$



$$\therefore\ I = \frac{5.5 - 0.498}{20}$$
$$= 0.2501 \Rightarrow 250\text{ mA}$$

08. Ans: (a)

Sol: Given $I_2^1 = I_1 \times 32$

Given $T_1 = 40°C$ $T_2 = ?$

$$I_2^1 = I_1\left(2^{\frac{T_2 - T_1}{10}}\right)$$

$$I_1 \times 32 = I_1\left(2^{\frac{T_2 - T_1}{10}}\right)$$

$$2^5 = 2^{\frac{T_2 - T_1}{10}}$$

$$\Rightarrow \frac{T_2 - T_1}{10} = 5$$

$T_2 - T_1 = 50$ $T_2 = 50 + T_1$

$T_2 = 90°C$

09. Ans: (b)

Sol: For either Si (or) Ge

$$\frac{dV}{dT} \cong -2.5\text{ mV}/^0C$$

To maintain constant current

$$\frac{(V_2 - 700mV)}{(40 - 20)}\ \frac{V}{°C} = -2.5 \times 10^{-3}\ \frac{V}{°C}$$

$\rightarrow V_2 = 650\text{ mV} \cong 660\text{ mV}$

10. Ans: (b)

Sol: $C = \dfrac{\varepsilon_0\varepsilon_r A}{d} \Rightarrow \dfrac{C}{A} = \dfrac{\varepsilon_0\varepsilon_r}{d}$

$$= \frac{11.7 \times 8.85 \times 10^{-12}}{10 \times 10^{-6}}$$

$= 10\ \mu F$

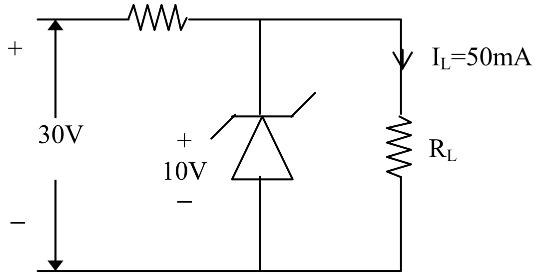
Chapter **3**

Zener Diode

Class Room Practice Solutions

01. Ans: (d)

Sol:



$V_s = 30 - 10 = 20V$

$$\text{Power dissipation} = \frac{V_s^2}{R_s}$$

$$= \frac{20^2}{200} = 2\ W$$

02. Ans: (c)

Sol: Power rating of Zener diode = 5 mW

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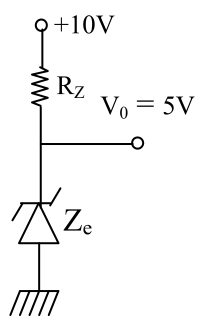
$I_Z V_Z = 5 \times 10^{-3}$

$$I_Z = \frac{5\times10^{-3}}{5} = 1\,\text{mA}$$

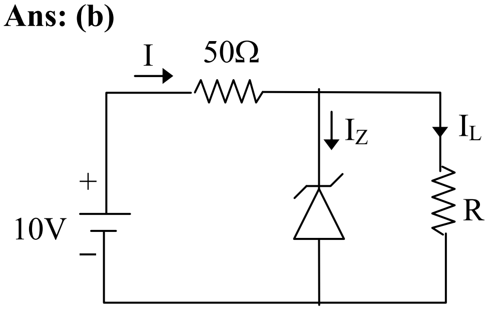
: Current flows through the circuit is = 1 mA

$$R_Z = \frac{10-5}{1\text{m}} = 5K\Omega$$



03. Ans: (b)

Sol:



Given that, $V_z = 6V$

$I_{zmin} = 5mA$

$R_{min} \Rightarrow I_L max$

$$I = \frac{10-6}{50} = \frac{4}{50} = 80\,\text{mA}$$

$I = I_{zmin} + I_{Lmax}$

$I_{Lmax} = 75\ mA$

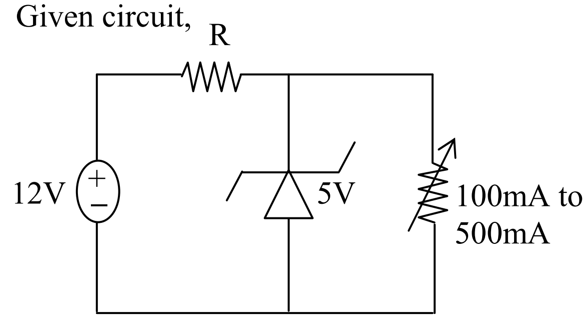
$$R_{L\,min} = \frac{V_z}{I_{L\,max}} = \frac{6}{75\times10^{-3}} = 80\,\Omega$$

04. Ans: (b)

Sol: In –ve cycle of i/p diode forward biased, so replace by short circuit, so o/p = i/p with –12V in o/p only option 'b' exists, so using method of elimination answer is b.

05. Ans: (d)

Sol: Given circuit,



Given, source voltage

$V_s = 12V$

$I_{Lmin} = 100\ mA$

$I_{Lmax} = 500\ mA$

$V_z = 5V$

$I_{z\,min} = 0A$

$$\therefore R = \frac{V_s - V_z}{I_{z\,min} + I_{L\,max}}$$

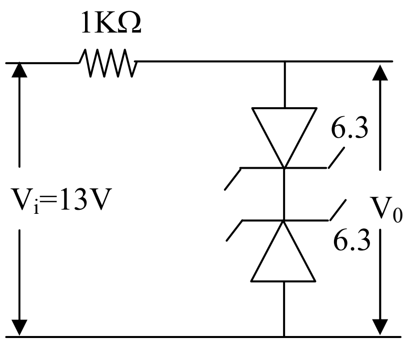
$$R = \frac{12-5}{500\text{mA}}$$

$$R = \frac{7\times10^3}{500}$$

$$R = \frac{70}{5}\Omega \quad R = 14\,\Omega$$

06. Ans: (c)

Sol: Given circuit,



$V_0 = 0.6 + 6.3 = 6.9$ V

07. Ans: (a)

Sol: The ideal characteristic of a stabilizer is constant output voltage with low internal resistance

08. Ans: (a)

Sol:

- In PN junction diode break down depends on doping. As doping increases breakdown voltage decreases.
- In Zener diode breakdown is less than 6 V
- It has Negative Temperature coefficient (operate in R. B)
- Avalanche diode breakdown greater than 6 V.

09. Ans: (b)

Sol: 'A' is correct and 'R' is correct but 'R' is **Not** the correct explanation of 'A' because DC voltage stabilizer circuit can be implemented by using other components like Op-Amp also. There is no need that only Zener diode to be used.

Chapter 4 Special Purpose Diodes

Class Room Practice Solutions

01. Ans: (a)

Sol: Tunnel diode

It is highly doped S.C (1 : 10^3)

It is an abrupt junction (step) with both sides heavily doped made up of Ge (or) GaAs

It carries both majority and minority currents.

It can be used as oscillator

Operate in Negative Resistance region

Operate as fast switching device

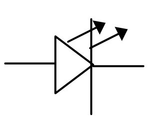
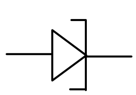
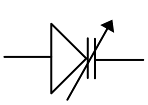
02. Ans: (c)

Sol: The values of voltage (V_D) across a tunnel-diode corresponding to peak and valley currents are V_P and V_V respectively. The range of tunnel-diode voltage V_D for which the slope of its I-V_D characteristics is negative would be $V_P \leq V_D < V_V$

03. Ans: (c)

04. Ans: (a)

Sol:

Symbol	Circuit name	Applications
	LED	Direct Band gap
	Tunnel diode	Fast Switching circuits
	Varactor diode	Electronic Tuning

05. Ans: (a)

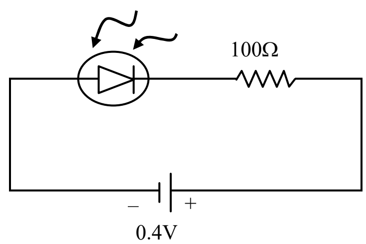
Sol: The tunnel diode has a region in its voltage current characteristics where the current decreases with increased forward voltage known as its negative resistance region. This characteristic makes the tunnel diode useful in oscillators and as a microwave amplifier.

Chapter 5 Optoelectronic Devices

Class Room Practice Solutions

01. Ans: (a)

Sol:



By KVL,

$0.4 - 100\times 1.8 \times 10^{-3} - V_P = 0$

$V_P = 0.4 - 100 \times 1.8 \times 10^{-3}$

$= 0.22$ V

$V_P = r_p I$

$$r_p = \frac{V_P}{I}$$

$$= \frac{0.22}{1.8\times10^{-3}}$$

$= 122.22\ \Omega$

02. Ans: (b)

Sol: If illumination doubled then current passing through the photo diode is doubled

$I_D = 2\times1.8 = 3.6$mA

Voltage across photo diode is

$= 0.4 - 3.6\times10^{-3}\times100$

$= 0.4 - 0.36$

$V_p = r_p I_p$

$$r_p = \frac{V_p}{I_p} = \frac{0.04}{3.6}\times10^3$$

$= 0.01111\times10^3$

$= 11.11\Omega$

03. Ans: (b)

Sol: Avalanche photo diodes are preferred over PIN diodes in optical communication because Avalanche photo diodes are (APDs), extracted from avalanche gain and excess noise measurement and higher sensitivity. PIN diodes generate more noise.

04. Ans: (c)

05. Ans: (a)

Sol: Give,

$E_g = 1.12$ eV,; $\lambda_1 = 1.1\ \mu$m

$\lambda_2 = 0.87\ \mu$m; E_{g2} =?

$$E_g = \frac{12400\,A^0}{\lambda} \Rightarrow E_g \alpha \frac{1}{\lambda}$$

$$\frac{E_{g_1}}{E_{g_2}} = \frac{\lambda_2}{\lambda_1}$$

$$\Rightarrow E_{g_2} = E_{g_1} \times \frac{\lambda_1}{\lambda_2}$$

$$= 1.12\times\frac{1.1}{0.87}$$

$= 1.416$ eV

06. Ans: (a)

Sol: Sensitivity of photo diode depends on light intensity and depletion region width.

07. Ans: (d)

Sol: $I_D = \dfrac{24-1.8}{820} = 0.02707$ A

$= 27.07$ mA

08. Ans: (c)

Sol: Photo diode operate in R.B

: Photo diode works on the principle of photo electric effect.

09. Ans: (b)

10. Ans: (b)

Sol: $\lambda = 890\ A^o$

$$\lambda = \frac{1.24\times10^{-6}}{E_G}\ m$$

$$= \frac{1.24\times10^{-6}}{890\times10^{-10}}$$

$= 13.93$ eV

11. Ans: (d)

Sol: Solar cell converts optical (sunlight) energy into electrical energy.

12. Ans: (b)

Sol: $R = 0.45$ A/W

$P_0 = 50\ \mu W$

$$R = \frac{I_P}{P_0}$$

$I_P = R\,P_0$

$= 0.45 \times 50$

$= 22.5\ \mu A$

Load current $= I_P + I_0$

$= 22.5\ \mu A + 1\mu A$

$= 23.5\ \mu A$

13. Ans: (d)

Sol: LED: F.B

Photo diode: R.B

Zener diode: R.B

Ordinary diode: F.B

Tunnel diode: F.B

Variable capacitance diode: R.B

Avalanche diode: R.B

14. Ans: (c)

Sol: Tunnel diode is always operated in forward bias and light operated devices are operated in reverse bias. (Avalanche photo diode).

15. Ans: (b)

Sol: LEDS and LASER's are used in forward bias

Photo diodes are used in reverse bias

Chapter **6**

Bipolar Junction Transistor

Class Room Practice Solutions

01. Ans: (b)

Sol: $\alpha = \beta/(1+\beta) = 0.9803$

$\alpha = \beta^*\gamma^*$

$\rightarrow \beta^* = 0.9803/0.995 = 0.9852$

02. Ans: (d)

Sol: $I_C = 4mA$

$r_0 > 20k\Omega$

$r_0 = \frac{V_A}{I_C}$

$\frac{V_A}{I_C} > 20k\Omega$

$V_A > 20k\Omega \times I_C$

$V_A > 20 \times 10^3 \times 4 \times 10^{-3}$

$V_A > 80$

03. Ans: (d)

Sol: $V_A = 100$ V

$I_C = 1$ mA

$V_{CE} = 10$ V

$I_{CQ}\left(1+\frac{V_{CE}}{V_A}\right) = I_C$

$I_{CQ} = \frac{1}{1+\frac{10}{100}}$

$= 0.909$ mA

04. Ans: (b)

Sol: The phenomenon is known as "Early Effect" in a bipolar transistor refers to a reduction of the effective base-width caused by the reverse biasing of the base-collector junction.

05. Ans: (a)

Sol: Given $\alpha = 0.995$, $I_E = 10mA$,

$I_{co} = 0.5mA$

$I_{CEO} = (1 + \beta)\, I_{CBO}$

$I_{CEO} = \left(1+\frac{\alpha}{1-\alpha}\right)I_{CBO}$

$I_{CEO} = (1+199) \times 0.5 \times 10^{-6}$

$I_{CEO} = 100\mu A$

06. Ans: (b)

Sol: I_{CBO} is greater than I_{CO}. Reverse leakage current double for every Ten degrees rise in temp

07. Ans: (b)

08. Ans: (a)

Sol: $\alpha = 0.98$

$I_B = 40\ \mu A$

$I_{CBO} = 1\ \mu A$

$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = 49$

For a CE active BJT

$I_C = \beta\, I_B + (1+\beta)\, I_{CBO}$

$= 49 \times 40 \times 10^{-6} + 50 \times 10^{-6}$

$= 2.01$ mA

09. Ans: (b)

Sol: $I_{CBO} = 0.4\ \mu A$

$I_{CEO} = 60\ \mu A$

$I_{CEO} = (1+\beta)\, I_{CBO}$

$1+\beta = \frac{I_{CEO}}{I_{CBO}}$

$= \frac{60}{0.4} = 150$

$\beta = 150 - 1$

$= 149$

$$\alpha = \frac{\beta}{1+\beta}$$

$$= \frac{149}{150} = 0.993$$

10. Ans: (c)

11. Ans: (a)

Sol: 'A' and 'R' are correct and 'R' is the correct explanation of 'A'.
At very high temperature, extrinsic semiconductors will behave as intrinsic i.e., charge carriers will remains constant.

12. Ans: (b)

Sol:

Junction		Region of operation
E - B	C - B	
F. B	F.B	Saturation Region
F.B	R.B	Active Region
R.B	F.B	Inverse active Region
R.B	R.B	Cut-off Region

13. Ans: (c)

Sol: High power transistors are made of Si to withstand high temperature
: Silicon is an indirect band gap material.

Chapter 7

Junction Field Effect Transistor

Class Room Practice Solutions

01. Ans: (d)

Sol: $V_G \rightarrow 4.2$ V to 4.4 V

$I_D \rightarrow 2.2$ mA to 2.6 mA

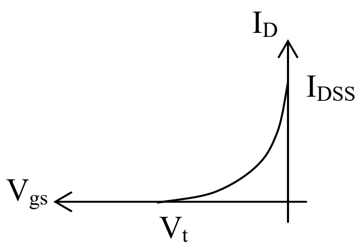
$$g_m = \frac{\Delta I_D}{\Delta V_{GS}}$$

$$= \frac{(2.6-2.2)\times 10^{-3}}{4.4-4.2}$$

= 2 m℧

02. Ans: (c)

Sol:



$V_{gs} = V_t$ $I_D = 0$

$V_{gs} = 0$ $I_D = I_{DSS}$

03. Ans: (b)

Sol: $I_{Dmax} = I_{Dss} = 10$ mA

$V_P = -4V$

$V_{GS} = -1$ V

$$I_D = I_{DSS}\left(1-\frac{V_{GS}}{V_P}\right)^2$$

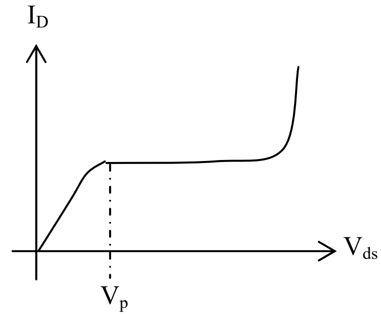
$$= 10\times 10^{-3}\left(1-\frac{-1}{-4}\right)^2$$

$$= 10\times 10^{-3}\times\left(\frac{3}{4}\right)^2$$

= 5.625 mA

04. Ans: (d)

Sol:



Drain current remains constant at pinch off region even if the drain voltage increases.

05. Ans: (c)

Sol: JFET acts as a voltage controlled current source

06. Ans: (a)

Sol: Mobility of electron is higher than mobility of hole

Si

Electron mobility : 1350 $cm^2/v-s$

Hole mobility : 450 $cm^2/v-s$

Ge

Electron mobility : 3600 $cm^2/v-s$

Hole mobility : 1800 $cm^2/v-s$

: Low leakage current means high input impedance

: Reverse bias increases, channel width reduces (wedge shaped)

07. Ans: (c)

Sol: $V_P = -8$ V

$I_{DSS} = 12$ mA

From the given circuit,

$V_G = -5$ V

$V_S = 0$ V

$V_{GS} = -5$ V

V_{DS} at which pinch –off region means

$(V_{DS})_{min} = V_{GS} - V_P$

$= -5 - (-8)$

$= -5 + 8$

$= 3$ V

08. Ans: (d)

Sol: P. Voltage controlled device –FET (3)

Q. Current controlled device –BJT (1)

R. Conductivity modulation device-- IMPATT diode (4)

S. Negative conductance device -UJT (2)

09. Ans: (d)

Sol: $I_{DSS} = 12$ mA

$V_P = -6$ V

$V_{GS} = 0$ V

$V_{DS} = 7$ V

At $V_{GS} = 0V$, $I_D = I_{DSS}$

$$= 12mA \quad \left(\because I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2 \right)$$

10. Ans: (d)

Sol:

Device :	Application
A. Diode	Rectifier (3)
B. Transistor	Amplifier (1)
C. Tunnel diode	Oscillator (2)
D. Zener diode	Reference Voltage (4)

11. Ans: (a)

Sol: $$g_{m0} = \left|\frac{2I_{DSS}}{V_p}\right| = \frac{2 \times 25 \times 10^{-3}}{10} = 5$$

12. Ans: (b)

Sol: BJT is current controlled current source

$(R_i = 0 \,;\, R_o = \infty)$

Gain × B.W is high

FET is voltage controlled current source

$(R_i = \infty \,;\, R_o = 0)$

Gain × B.W is low

UJT is a negative resistance device and can be used as an oscillator

UJT can be used as switch but can't be amplification

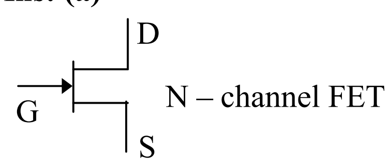
13. Ans: (a)

Sol: In FET majority carriers only exist.

In BJT majority & minority carriers exist.

14. Ans: (a)

Sol:



Input resistance of FET is of the order of tens (or) hundreds of mega ohms (MΩs)

: V_{gs} is reverse bias.

: In reverse bias very small leakage current I_{CO} flows through the gate

Chapter **8**

MOSFET

Class Room Practice Solutions

01. Ans: (c)

Sol: $V_T = 1$

$V_{DS} = 5 - 1 = 4$ V

$V_{GS} = 3 - 1 = 2$ V

$V_{GS} - V_T = 2 - 1 = 1$ V

$V_{DS} > V_{GS} - V_T$

$4 > 1 \rightarrow$ Saturation

02. Ans: (d)

03. Ans: (d)

Sol: $$\frac{I_{D_2}}{I_{D_1}} = \frac{K_n[V_{GS2} - V_T]^2}{K_n[V_{GS1} - V_T]^2}$$

$$\frac{I_{D_2}}{1\,mA} = \frac{[1400-400]^2}{[900-400]^2}$$

$$I_{D_2} = 4\,mA$$

04. Ans: (d)

Sol: $A = 1$ sq μm $= 10^{-12}$ m^2

$d = 1\ \mu m = 1 \times 10^{-6}$ m

$N_D = 10^{19}/cm^3$

$n_i = 10^{10}$

No. of holes = concentration × volume

Volume = A × d = 10^{-18} m

$$p = \frac{n_i^2}{n} = \frac{10^{20}}{10^{19}}$$

$$= 10\ holes/cm^3 = 10 \times 10^6\ holes/m^3$$

$\therefore$ No. of holes $= 10 \times 10^6 \times 10^{-18}$

$= 10^{-11}$ holes

≈ 0

05. Ans: (b)

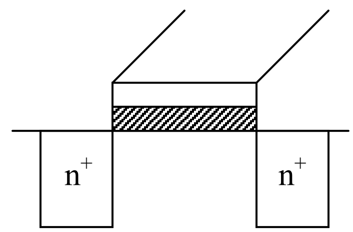
06. Ans: (b)

Sol: $$C_{sbo} = \frac{\in_{si} A}{d}$$

d = 10 nm

$\in_{si} = \in_{rsi} \in_0$

$= 11.7 \times 8.9 \times 10^{-12}$ F/m



$A = (0.2\mu\times1\mu)+(0.2\mu\times1\mu)+(0.2\mu\times1\mu)$

$= 3(0.2\mu\times1\mu) = 0.6 \times 10^{-12}$ m^2

$$C_{sbo} = \frac{11.7\times8.9\times10^{-12}\times0.6\times10^{-12}}{10\times10^{-9}}$$

$C_{sbo} = 6.24 \times 10^{-15}$

≈ 7 pF

In practical IC, this cap will provided to front and back sides also then area may be

$A = (0.6\times10^{-12})+(0.2\mu\times1\mu)+(0.2\mu\times1\mu)$

$A = 0.68 \times 10^{-12}$ m^2

$$C_{sbo} = \frac{11.7\times8.9\times10^{-12}\times0.68\times10^{-12}}{10\times10^{-9}} = 7fF$$

07. Ans: (a)

Sol: $L_{ov} = \delta = 20$ m

d = 10 nm, w = 1 μm

$\in_{rsi} = 11.7$, $\in_{rox} = 3.9$

$\in_0 = 8.9 \times 10^{-12}$ F/m

$$C_{ov} = C_{ox}\, w\, L_{ov} = \frac{\in_{ox}}{t_{ox}} w\, L_{ov}$$

$$= \frac{\epsilon_{rox}\,\epsilon_0}{t_{ox}} w\,L_{ov}$$

$$= \frac{3.9\times8.9\times10^{-12}\times1\times10^{-6}\times20\times10^{-9}}{1\times10^{-9}}$$

$$= 0.69 \times 10^{-15} = 0.69 \text{ fF} \approx 0.7 \text{ fF}$$

08. Ans: (a)

Sol: $A = 1 \times 10^{-4}$ cm^2

$\epsilon_{si} = 1 \times 10^{-12}$ F/cm

$\epsilon_{ox} = 3.5 \times 10^{-13}$ F/cm

$C_0 = 7$ pF

$$C_0 = C_{ox}\,A = \frac{\epsilon_{ox}\,A}{t_{ox}}$$

$$t_{ox} = \frac{\epsilon_{ox}}{C_0} A = \frac{3.5\times10^{-13}\times1\times10^{-4}}{7\times10^{-12}}$$

$$= 5\times10^{-6} \text{ cm} = 50 \text{ nm}$$

09. Ans: (b)

Sol: $$\frac{C_0 C_d}{C_0 + C_d} = 1\text{pF}$$

$$\frac{7\,C_d}{C_d + 7} = 1 \Rightarrow C_d = \frac{7}{6}\text{pF}$$

$$C_d = C_{dep}\,A = \frac{\epsilon_{si}}{d} A$$

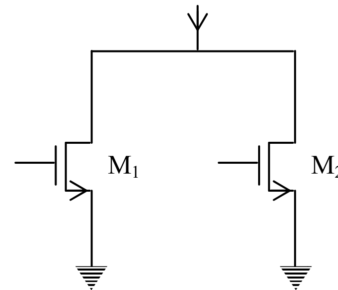
$$d = \frac{\epsilon_{si}}{C_d} A$$

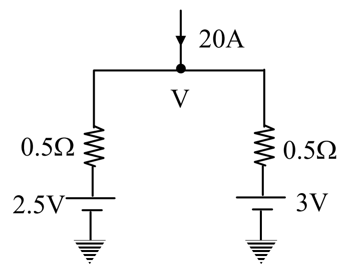
$$= \frac{1\times10^{-12}}{\frac{7}{6}\times10^{-12}}(1\times10^{-4})\,\text{cm} = 0.857\,\mu\text{m}$$

10. Ans: (b)

11. Ans: (a)

Sol:





$$20 = \frac{V-2.5}{0.5} + \frac{V-3}{0.5}$$

V = 7.75 Volts

$$I_{D_1} = \frac{7.75-2.5}{0.5} = 10.5\text{A}$$

$$I_{D_2} = \frac{7.75-3}{0.5} = 9.5\,\text{A}$$

Chapter 9 Biasing

Class Room Practice Solutions

Biasing

01. Ans: (c)

Sol: $R_D = \frac{V_{DD} - V_D}{I_D} = \frac{20V - 12V}{2.5mA} = 3.2\,K\Omega$

In self bias

$V_{GS} = -I_D R_S$

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_p}\right)^2$$

$$V_{GS} = V_P\left(1 - \sqrt{\frac{I_D}{I_{DSS}}}\right)$$

$V_{GS} = -1.06$ V

$$R_S = \frac{V_{GS}}{-I_D} = \frac{-1}{-2.5} = 400\,\Omega$$

02. Ans: (b)

Sol: $V_G = V_{GS} + I_D R_S$

$$I_D = \frac{16-8}{1.8K} = 4.4\,mA$$

$$V_G = \frac{16\times 47}{138} = 5.45\,V$$

$$R_S = \frac{V_G - V_{GS}}{I_D} = \frac{5.4-(-2V)}{4.4m} = 1.68K\Omega$$

03. Ans: (c)

Sol: $V_{DS} = V_{DD} - I_D(R_D + R_S)$

$= 30\text{ V} - 4\text{ mA}(3.3K + 1.5K)$

$V_{DS} = 10.8$ V

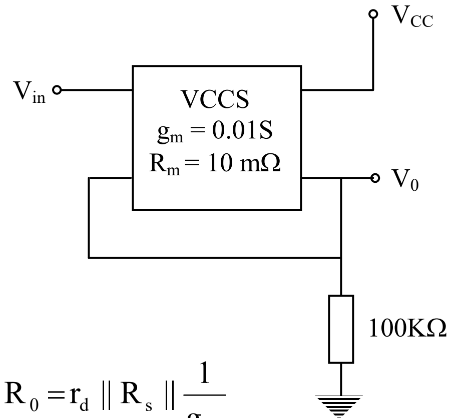
04. Ans: (b)

05. Ans: (a)

06. Ans: (b) (By Printing Mistake in Volume-I Answer (c) is wrong, Correct answer is (b))

Sol: By observing,

The circuit is common drain i.e., source follower circuit.



$$R_0 = r_d \,||\, R_s \,||\, \frac{1}{g_m}$$

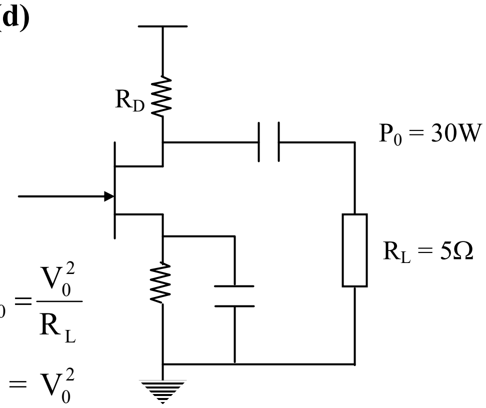
$= 10\text{ M}\Omega \,||\, 100\text{ K}\Omega \,||\, 100\,\Omega$

$= 100\,\Omega$

FREQUENCY ANALYSIS

01. Ans: (d)

Sol:



$$P_0 = \frac{V_0^2}{R_L}$$

$30 \times 5 = V_0^2$

$V_0 = 12.25$ V

$$A_V = \frac{V_0}{V_i}$$

$A_{v\,(dB)} = 20 \log_{10} A_v$

$$20 = 20\log_{10} A_v$$

$$A_v = 10^1 = 10$$

$$\frac{V_0}{V_i} = 10$$

$$V_i = \frac{V_0}{10} = \frac{12.25}{10}\,V = 1.225\,V$$

02. Ans: (b)

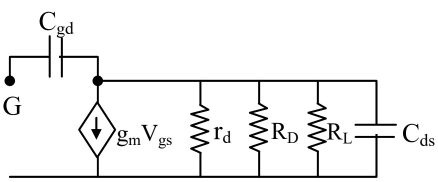
Sol: $A_{v(dB)} = 20\log_{10} A_v$

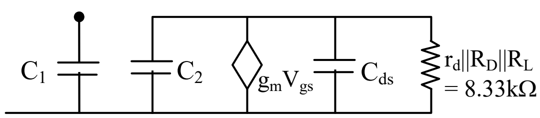
$$50 = 20\log_{10} A_v$$

$$A_v = 10^{(5/2)} = 316.228$$

03. Ans: 6.123 ×10^6 Hz

Sol: Small signal equivalent

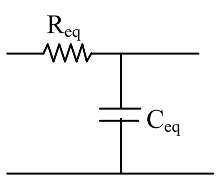




$$C_2 = C_{gd}\left(1 - \frac{1}{A_v}\right),$$

A_v = mid-band,

gain = $g_m(r_d||R_D||R_L) = -16.66$



$$C_2 = 2pF\left(1 - \frac{1}{-16.66}\right) = 2.12\ pF$$

$$f_H = \frac{1}{2\pi C_{eq} f_{eq}}$$

$C_{eq} = 1 + 2.12 = 3.12$ pF, $f_{eq} = 8.33k\Omega$

$\Rightarrow f_H = 6.123 \times 10^6$ Hz

MOSFET BIASING

01. Ans: (b)

Sol:

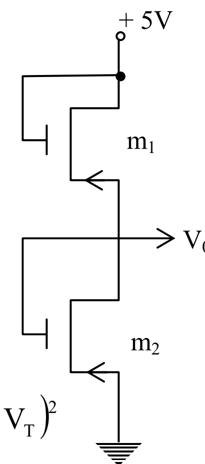
$V_T = 0.8$

$K_n = 30 \times 10^{-6}$

$$\left(\frac{W_1}{L}\right)_1 = \left(\frac{W}{L}\right)_2 = 40$$

$$V_{D_1} = +5$$

$$I_{D_1} = I_{D_2}$$



$$\frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_1 (V_{GS_1} - V_T)^2$$

$$= \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_2 (V_{GS_2} - V_T)^2$$

$$V_{GS_1} = V_{D_1} - V_0$$

$$= +5 - V_0$$

$$V_{GS_2} = V_{G_1} - V_S$$

$$= V_0 - 0 = V_0$$

$$\left(\frac{W}{L}\right)_1 (5 - (V_0) - 0.8)^2 = \left(\frac{W}{L}\right)_2 (V_0 - 0.8)^2$$

$$V_0 = 2.5V$$

02. Ans: (a)

Sol: $\left(\frac{W}{L}\right)_1 (V_{GS_1} - V_T)^2 = \left(\frac{W}{L}\right)_2 (V_{GS_2} - V_T)^2$

$$40\,(4.2 - V_0)^2 = 15(V_0 - 0.8)^2$$

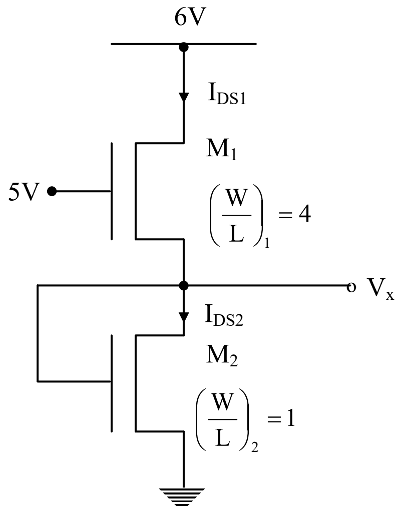
$$V_0 = 2.91\ V$$

03. Ans: (c)

Sol: From figure $I_{DS1} = I_{DS2}$.

$$\frac{1}{2}\mu_n C_{0x}\left(\frac{W}{L}\right)_1 (V_{GS_1} - V_t)^2$$

$$= \frac{1}{2}\mu_n C_{0x}\left(\frac{W}{L}\right)_2 (V_{GS_2} - V_t)^2$$



$$\therefore\ 4(5 - V_x - V_t)^2 = 1(V_x - V_t)^2$$

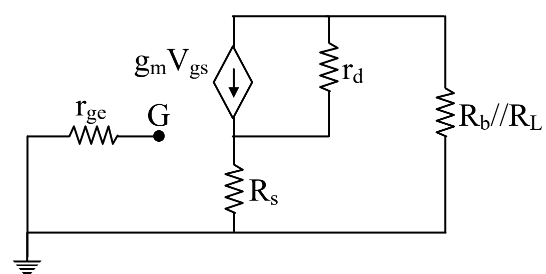
$$(\because V_{GS1} = V_G - V_x = 5 - V_x)$$

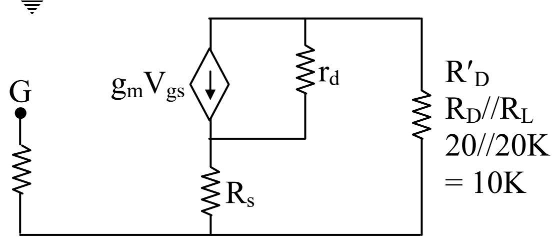
$$\Rightarrow 2(5 - V_x - V_t) = (V_x - V_t)$$

$$\therefore\ V_x = 3V$$

04. Ans: ≈-7

Sol:





$$A_V = \frac{-g_m r_d R'_D}{R'_D + R_s + r_d + g_m r_D . R_s}$$

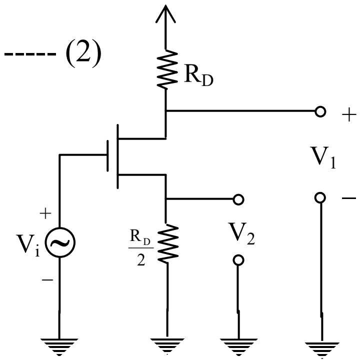
$$= \frac{5 \times 10K \times 10K}{10K + 1K + 10K + 5mA/V.10K.1K}$$

$$= -7.042$$

05. Ans: (d)

Sol: $\frac{V_2}{V_i} = \frac{g_m R_s}{1 + g_m R_s}$ ----- (1)

$\frac{V_1}{V_i} = \frac{-g_m R_D}{1 + g_m R_s}$ ----- (2)



(1) ÷ (2) ⇒

$$\frac{V_2}{V_1} = \frac{R_s}{-R_D}$$

$$\frac{V_2}{V_1} = \frac{-1}{2}$$

$V_1 = -2V_2$

06. Ans: (c)

Sol: $I_{DSS} = 6$ mA

$V_P = -3$ V

$V_{GSQ} = 1V$

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

$$= 6\times10^{-3}\left(1 - \frac{1}{-3}\right)^2$$

$= 10.667$ mA

From the given circuit

$V_S = I_D \times 0.75\ k\Omega$

$= 10.667\times10^{-3}\times0.75\times10^3$

$= 8$ V

$V_{GSQs} = 1$ V

$V_G - V_S = 1$ V

$V_G = V_S + 1$

$= 9$ V

$$9 = \frac{18R_2}{R_2 + 110M\Omega}$$

$\Rightarrow R_2 = 110\ M\Omega$

Chapter 10 CMOS & Device Technology

Class Room Practice Solutions

01. Ans: (c)

Sol: $\overline{A(B+C)+DE}$

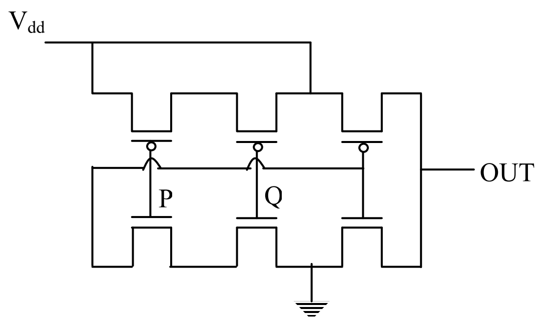
After option (c) as above answer

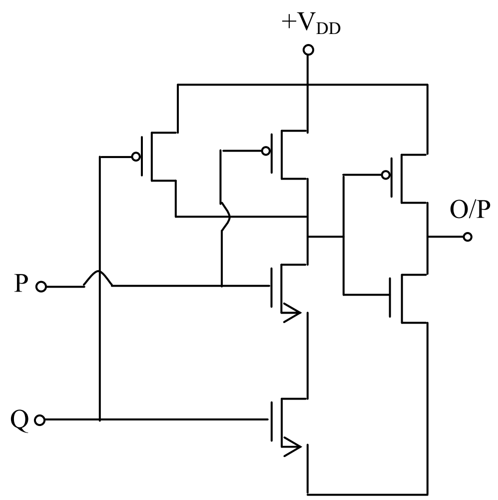
02. Ans: (a)

Sol: $\overline{\bar{x}_1 + x_2}$

03. Ans: (d)

Sol:





AND gate

04.

Sol: $\overline{(A+B)C.clk}$

$y=\overline{(A+B)C.1}$

$y=\overline{(A+B)C} \;=\bar{A}\,\bar{B}+\bar{C}$

05. Ans: (b)

Sol: $n=\dfrac{1}{2Nf}$

$n=\dfrac{1}{2\times5\times10\times10^{6}}=10^{-8}\,\text{sec}=10\,\text{n sec}$

Device Technology Key

01. (c) 02. (b) 03. No Answer
04. (b) 05. (a)