UNIT IX

ELECTRONIC DEVICES

Numerical Problems Worksheet

Formulae of this Unit:

1. $I = I_0\left[exp\left(\frac{eV}{nk_BT}\right) - 1\right]$
2. $R = \frac{V_i - V_z}{I}$
3. $I_E = I_C + I_B$
4. $\alpha = \frac{I_C}{I_E}$
5. $\beta = \frac{I_C}{I_B}$
6. $\alpha = \frac{\beta}{1+\beta}$
7. $\beta = \frac{\alpha}{1-\alpha}$
8. $r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$
9. $r_o = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$
10. $A_V = \beta\left(\frac{R_{out}}{R_{in}}\right)$
11. (a) OR operation, Y= A+B

    (b) AND operation Y=A.B

    (c) NOT operation Y= $\overline{A}$
12. Combination of gates
    (a) NAND gate is combination of AND and NOT gates.
    (b) NOR gate is combination of NOT and OR gates.
    (c) XOR gate is combination of two NOT gates, two AND gates and one OR gate.

Level -01

(Numerical direct formula Based)

Q.1 : What is relation between voltage gain and trans conductor of a trimester amplifier?

Ans :- Voltage gain = Trans – Conductance X Output resistance.

Q. 2 : A transistor is being used as a common emitter amplifier. What is the value of phase difference, if any ,between the collector-emitter voltage and input signal?

Ans.: 180^0 or π radian

Q.3. Write is the phase relationship between the output and input voltage in the common faze transmitter amplifier?

Ans: Output voltage is in phase with the input signal voltage.

Q.4. Write the relation between current gains ∞ or β.

Ans : $\beta = \frac{\infty}{1-\infty}$

Q.5. Calculate the Current gain β of a transistor, if the current gain ∞ = 0.98

Ans: $\beta = \frac{\infty}{1-\infty} = \frac{0.98}{1+100}$ 49.

Q. 6 For a Transmitter the value of β is 100, what is the value of ∞ .

Ans $\infty = \frac{\beta}{1+\beta} = \frac{100}{1+100} = 0.99$

Q.7. When the voltage drop across a p.n. Junction is increased from 0.65 v to 0.70, the charge in the diode current is 5 ma . What is the dynamic resistance of the diode ?

Ans. Here ,

$\Delta V = 0.7 - 0.65 = 0.05$ V

$\Delta I = 5mA = 5 \times 10^{-3}$ A

Dynamic resistance of junction diode is

$rd = \frac{\Delta V}{\Delta I} = \frac{0.05}{5 \times 10^{-3}} = 10\ \Omega$

Q.8. p – n – p transistor circuit, the collector is 10 ma , If 90 % of the reach the Collector, find emitter and base currents.

Ans: Here, I E = 10 m A

As 90 % of the holes reach the collector, so the collector current ,

I c = 90 % of I E = 90/100 IE

I E = 100/900 Ic = 100/90 x 10 = 11 m A.

Base Current, I B = I E – I c = 11-10 = 1 mA.

Q.9. A photodiode is fabricated froma semi conductor with band gap of 2.8 e V . Can it detect a wa$_{ve}$ of 6000 nm? Justify.

Ans : Energy Corresponding to Wave length 6000 nm is

$$E = \frac{hc}{\pi} = \frac{6.6 \times 10\text{-}34 \times 3 \times 108}{6000 \times 10\text{-}9} \text{ joule}$$

$$= 3.3 \times 10\text{-}20 \text{ J}$$

$$= \frac{3.3 \times 10\text{-}20}{1.6 \times 10\text{-}19} \quad 0.2\text{eV}$$

The photon energy (E = 0.2 ev) of given waveleanth is much less then band gap (Eg.) , hance it caneot detevt the given wavelength.

Q.10. The number of silicon atoms per m3 is 5 x 1022 atom per 33 of Anesenice and 5 x 1020 per m3 atoms of Indian. Calculate the number of electrons and holes . Given that Ni = 1.5 X 1016 per m3 . In the material N-type on P-Type?

Ans : Arnesic is n-type impurty and indium is P-type impurity Number of electron, ne = n0 – nA = 5 x 1022 – 5 x 1020= 4.95 x 1022m-3

We have, ni2 = nenh

Given, ni = 1.5 x 1016 m -3

$$\text{Number of holes, } ne = \frac{ni2}{ne} = \frac{(1.5 \times 1016)2}{4.95 \times 1022}$$

nh = 4.54 x 109m-3

as ne > ne ; so the material is an n-type semiconductor.

LEVEL –II

Moderate difficulty level

Q.1. When the voltage drop across a p-n junction diode is incrase from 0.65 v to 0.70 v , the change in the diode current is 5mA. What is the dynamic resistance of the diode?

Ans : $$r_d = \frac{\Delta v}{\Delta I}$$

$$= \frac{0.70 - 0.65}{5\text{x}10\text{-}3}$$

$$= \frac{0.05}{5 \times 10\text{-}3}$$

$$= 10\Omega.$$

Q.2. Diode used in figure has a constant voltage drop at 0.5 V at all current and a maximum power rating of 100mw. What should be the value of resistance R, conected in series for maximum current.

Ans : $$\text{Current , } I = \frac{P}{V}$$

$$= \frac{100 \times 10\text{-}13}{}$$

0.5

=0.2 A

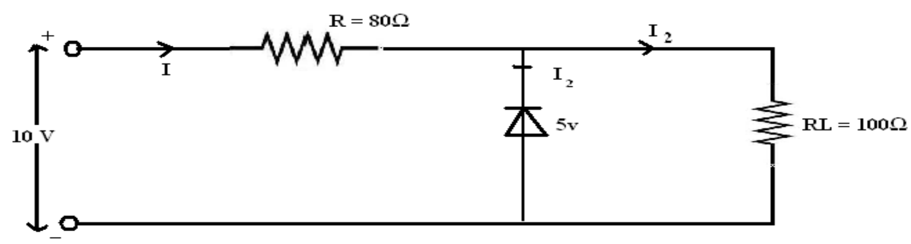
From Circuit ,

IR +0.5 = 1.5

i.e., 0.2 +0.5 = 1.5

i.e. $R = \frac{1.5 - 0.5}{0.2} = 5\ \Omega$.

Q.9. On the figure shown, find out the current passing through R_L and Ze_{ne}r diode :



Ans : Here,

V2 = 5V

Voltage drop across R = Input voltage – V_2

= 10 – 5 = 5v

= I_L = V2 5v 5 x 10^{-2}A

Here,

Current through R,

$I = \frac{\text{Voltage drop across R}}{R} = \frac{5V}{80\Omega}$ 6.25 x 10^{-2} A

Applying Kirchoff's Law :

$I = I_2 + I_L$

$I_2 = I - I_L$

= 6.25 x 10^{-2}

= 1.25 x 10^{-2}A.

Q.4. A common emitter transistor has current gain of 100. If emitter current is 8.08 m A, find the base and collector current.

Ans: Here,

B = 100

IE = 8.08 MA

Using, $\frac{IC}{\ }$ = B

IB

We get

$Ic = BI_B = 100\ I_B$

Using , IE =IB + IC

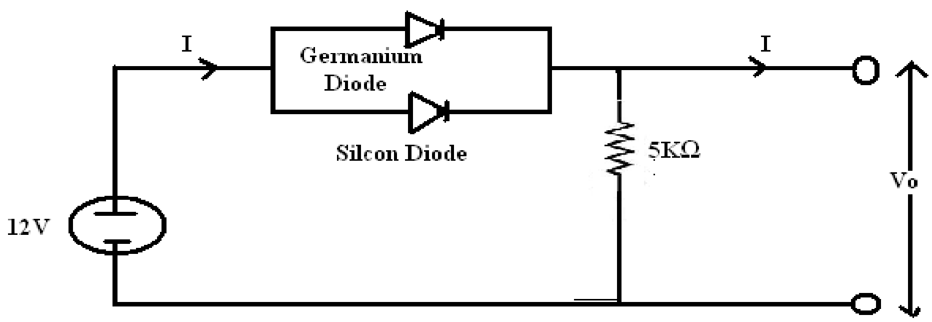
We get

IE = 101 IB

Or, $IB = \frac{IE}{101} = \frac{8.08}{101} = 0.08mA$

From Eq^n (i) IC = 100 x 0.08 = 8ma.

Q 5. (I) Calculate the value of output voltage V0 and Current I if Silicon diode and germanium diode conduct at 0.7 v and 0.3 v respectively (refer figure)



(II) If now Germanium diode is coneected 12 v in reverse polarity , find new value of V0 and I.

Ans.: (I) Germanium diode conducts at 0.3 v only , so curret will prefer to pass through germanium diode so,

V0 = 12 – 0.3 = 11.7 v

And,

$I = \frac{11.7}{5 \times 10^3}$

= 2.34 mA

(II) When germanium diode is reversed biased, the current will flow through the silicon diode.

Then,

V0 = 12 – 0.7 = 11.3 v

And ,

$I = \frac{11.3}{5 \times 10^3}$ 2.26 mA

Q.6 In a common –emitter transistor amplifier, the input resistance is 200Ω , RL = 20KΩ. Find (i) voltage gain and (ii) Power gain . Goven current gain B = 10.

Ans: Here ,

Ri = 200 Ω , RL = 20 k Ω

$= 2 \times 10^4\ \Omega$

(i) Voltage gain, $A_v = \beta\ {}^{RL}/_{RI}$

$$= \frac{10 \times 2 \times 10^4}{200} 10^3 = 10^3$$

(ii) Power Gain $B^2\ {}^{RL}/_{Ri}$ $= \frac{(10)^2 \times 2 \times 10^4}{200}$

$= 10^4$

Q.7. A full wave rectifier is built with help of two diodes each having resistance is 1.2 10-3 Ω. A.C. input signal has

(i) Maximum value of applied voltage
(ii) r.m.s. value of current
(iii) Current
(iv) Efficiency
(v) Ripple factor

Ans : (i) Vo = Io + (RL + RF)

$= \frac{1}{24} (6+1.2)10^3$

$= 300V$

(ii) Irma $= \frac{Io}{\sqrt{2}} = \frac{1}{24 \times \sqrt{2}}$

$= 29.46 \times 10^3 A$

(i) Id.c $= 2\left(\frac{Io}{\pi}\right)$

$= \frac{2 \times 1}{24 \times 3.14}$

$= \frac{2 \times 1}{26.5 \times 10^3}$ (* there are 2 diodes)

(ii) N $= 8^2\left(\frac{RL}{Rf + RL}\right)$

$= 8.12\left(\frac{6.10^3}{(6+1.2)10^3}\right)$

$= \frac{8.12}{1.2}$

$= 67.7\ \%$

(iii) Ripple factor, $\left\{\left(\frac{Irms}{\ }\right)^2 - 1\right\}^{1/2} = \left\{\left(\frac{29.5}{\ }\right)^2 - 1\right\}^{1/2} = 0.48$

Iav	26.5

Q.8. For a common emitter amplifier , current gain = 50. If the emitter current is 6.6 mA, Calculate gain , when emitter is working as common-base amplifier.

Ans. Here

$\beta = 50$

$I_E = 6.6mA$

Step 1. Since $\beta = \frac{IC}{IB}$

$= Ic = \beta I_B = 50I_B$

Step 2. Now ,

$I_E = Ic + I_B$

$6.6 = 50I_B + I_B$

$I_B = \underline{6.6} = 0.129$ mA

Hence, $Ic = 50 \times \frac{6.6}{51} = 6.47mA$

Step 3. $B = \frac{\infty}{1- \infty}$ or, $\infty = \frac{\beta}{1+ \beta}$

$= \frac{50}{51} = 0.98$

Q.9. For a transistor with $\beta = 75$ the maximum collector current for an emitter current of 5mA ?

Abs :- Here,

$\beta = 75$

$I_E = 5mA$

Step 1 :-

Using

$\beta = \frac{\infty}{1- \infty}$ we get,

$75 = \frac{\infty}{1-\infty}$ or, $75 – 75 \infty = \infty$

Or, $76\infty = 75$ or, $\infty = \frac{75}{76} \times 5$

Step 2.,

$\infty = Ic$ $Ic = \infty I_E = \frac{75}{76} \times 5 = 4.93mA.$

Q.10. In n p n transistor circuit, the collector current is 10 mA. If 95%of the electron emitted reach the collector, what is the base current ?

Ans : Step 1 :-

$I_c = 95\ \%$

$I_E = 0.95 I_E$

$I_E = \frac{I_c}{0.95}$

$= \frac{10}{0.95}$ ($\because$ $I_c = 10$ mA)

$= 10.53$ mA

Step 2 :-

Now , $I_E = I_C + I_B$

$IB = I_E + I_C$

$= 10.53 - 10$

0.53mA