Pb. calculate the forward and reverse resistance offered by a Si diode at $I_F = 100mA$ + $V_R = 75V$, $V_R = 60V$ + $I_R = 100nA$.

Solu: At $I_F = 100mA$, for Si $V_F = 0.7V$

forward resistance $R_F = \frac{V_F}{I_F} = \frac{0.7}{100mA} = \underline{7\,\Omega}$

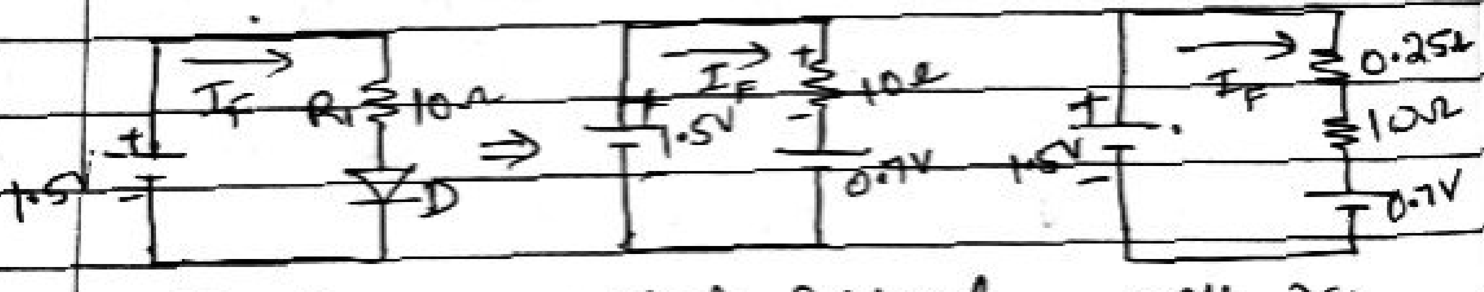
At $V_R = 50V$, $I_R = 100nA$,

reverse resistance $R_R = \frac{V_R}{I_R} = \frac{50V}{100nA} = \underline{500M\Omega}$

At $V_R = 75V$, $I_R = 100nA$,

$R_R = \frac{75V}{100nA} = \underline{750M\Omega}$

Pb. Calculate I_F for the diode circuit assuming that the diode has $V_F = 0.7V$ and $r_d = 0$. Recalculate current by taking $r_d = 0.25\Omega$



$r_d = 0\Omega$. (a)

Diode replaced as $V_T = 0.7V$ (b)

with $r_d + V_T$. (c)

By applying KVL to (b),

$$V - I_F \times 10\Omega - 0.7V = 0.$$

$$\frac{1.5V - 0.7V}{10\Omega} = I_F = \underline{80mA}.$$

Applying KVL to (c)

$$V - I_F R_1 - I_F \cancel{r_d} - 0.7V = 0$$

$$\frac{1.5 - 0.7}{(0.25 + 10)} = I_F = \underline{78mA}$$

Reduction in diode current as resistance increases.

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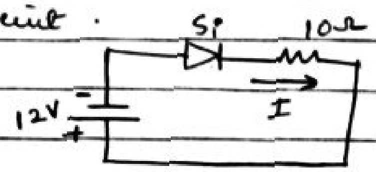
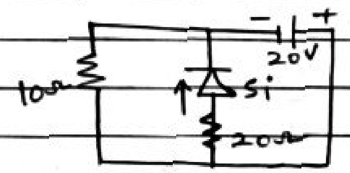
Diode circuits numericals.

1. Find the value of current I in the following circuit.

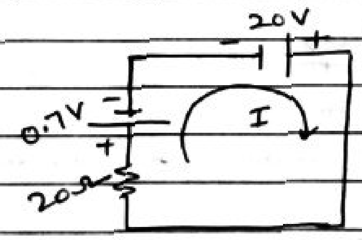


Soln The Si diode is reverse biased by −12V. So it does not conduct. ∴ $I = 0$.

2. Calculate the current I in the circuit.



Soln. Here 10Ω is independent of 20V. Hence the equivalent circuit is

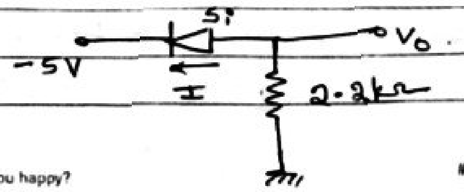


Applying KVL to the loop,

$$-0.7V + 20V - I \times 20\Omega = 0.$$

$$\therefore I = \frac{20 - 0.7}{20} = 0.965A = \underline{965mA}$$

3. For the circuit calculate I & V_o.



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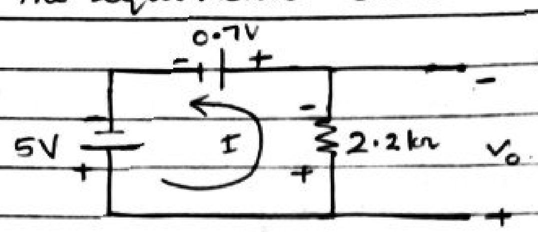
Soln The equivalent circuit is



Applying KVL, we have

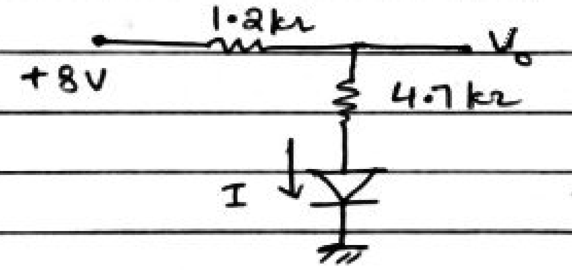
$$+5V - 2.2k\Omega \times I - 0.7V = 0.$$

$$\therefore I = \frac{5 - 0.7}{2.2k} = \underline{1.95mA}$$

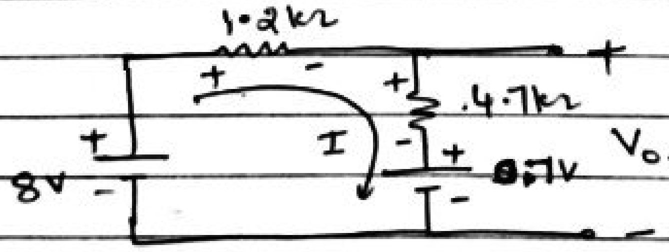
& $V_o = 1.95mA \times 2.2k\Omega$

$= \underline{4.3V}$

4. Calculate I & V_o for the given circuit



Sol: The equivalent circuit is shown as



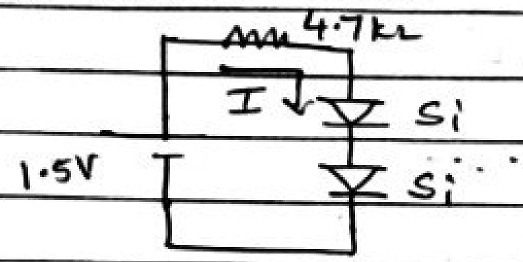
Applying KVL, we get

$$8V - I \times 1.2k\Omega - I \times 4.7k\Omega - 0.7V = 0$$

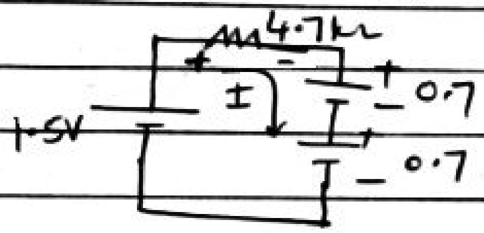
$$I = \frac{8 - 0.7}{(4.7 + 1.2)k\Omega} = \underline{1.237mA}$$

$$V_o = I \times 4.7 \times 10^3 + 0.7$$
$$= 1.237 \times 10^{-3} \times 4.7 \times 10^3 + 0.7$$
$$= \underline{6.51V}$$

5. Calculate the value of diode current I in the circuit below.



Sol: The equivalent circuit is

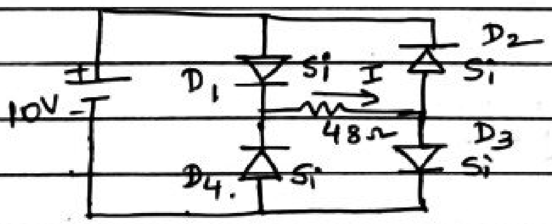


Applying KVL,

$$1.5V - 0.7V - 0.7 - I \times 4.7k\Omega = 0$$

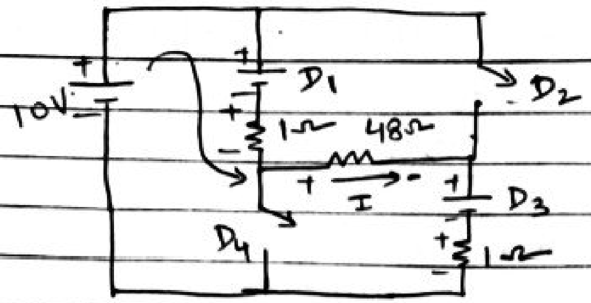
$$I = \frac{1.5 - 1.4}{4.7k\Omega} = \underline{0.021mA.}$$

6. Calculate I in the circuit.



consider r_d of Si = 1Ω

soln In the circuit, for a supply of 10V, only diodes D_1 & D_3 gets forward biased. D_2 & D_4 are open switches. Equivalent circuit is as below.



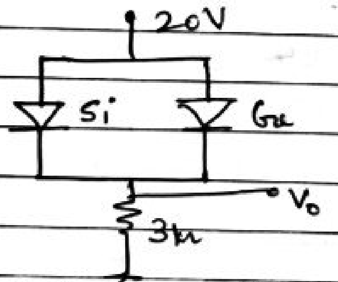
Applying KVL

$$10V - 0.7V - I(1\Omega + 48\Omega + 1\Omega) - 0.7V = 0$$

$$I = \frac{10V - 1.4V}{50\Omega} = 0.172A$$

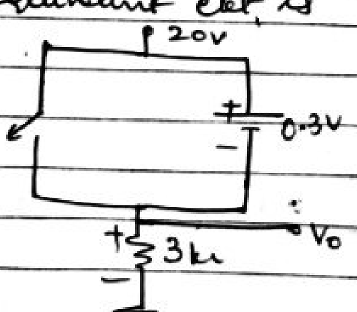
$$= 172 \text{ mA}$$

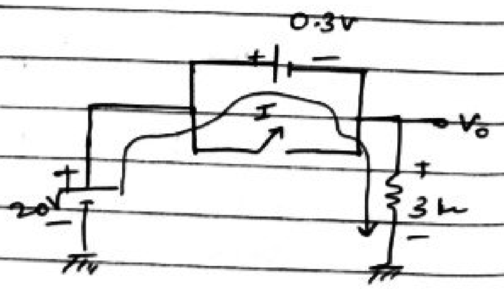
8. Calculate the current in the circuit & V_o.



Here Ge gets forward biased first once 20V is switched ON. Si never gets to switch ON.

Equivalent ckt is





$$20 - 0.3 - I \times 3k\Omega = 0$$

$$\therefore I = \frac{20 - 0.3}{3k\Omega} = 6.56 \text{ mA}$$

$$V_o = I \times 3k\Omega = 19.7V$$

Date

Rectifier circuits : Numericals.

1. A sinusoidal voltage of peak value 40V + frequency 50Hz is applied to a HWR without filter. It has a load $R_L = 800\Omega$ with $R_f = 8\Omega$. Calculate a) peak, dc and rms value of load current
b) Dc o/p power
c) Ac i/p power &
d) Rectifier efficiency.

Solu. Given: $V_m = 40V$, $f = 50Hz$.
$R_L = 800\Omega$, $R_f = 8\Omega$

a) Peak value of the load current I_m is

$$I_m = \frac{V_m}{R_L + R_f} = \frac{40}{800+8} = \underline{49.5mA}$$

$$I_{dc} = \frac{I_m}{\pi} = \frac{49.5mA}{\pi} = \underline{\underline{15.757mA}}.$$

$$I_{rms} = \frac{I_m}{2} = \frac{49.5mA}{2} = \underline{\underline{24.75mA}}.$$

b) DC power to load. $P_{dc} = I_{dc}^2 R_L$

$$= (15.757 \times 10^{-3})^2 \times 800$$

$$= \underline{\underline{198.45\,mW}}$$

c) Ac i/p Power. $P_{ac} = I_{rms}^2 (R_L + R_f)$

$$= (24.75mA)^2 (800+8)$$

$$= 494.95mW.$$

d) Efficiency $\eta = \frac{P_{dc}}{P_{ac}} = \frac{198.45mW}{494.95mW}$

$$= 0.4009.$$

$$\% \eta = \underline{\underline{40.09\%}}.$$

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2. An input to a HWR is 23 sin 314t. If $R_f = 50\Omega$ and $R_L = 500\Omega$ determine,

i) Dc load voltage ii) Rms load voltage iii) Rectification efficiency iv) dc power delivered to the load.

Solu. Given $V_{in} = V_m \sin \omega t$

$= 23 \sin 314t$

$R_f = 50\Omega \quad R_L = 500\Omega$

i) $V_{dc} = I_{dc} \times R_L$

$I_{dc} = \frac{I_m}{\pi}$, $I_m = \frac{V_m}{R_f + R_L} = \frac{23}{50+500}$

$= \underline{41.81 mA}$

$\therefore I_{dc} = \frac{41.81 mA}{\pi} = 13.31 mA$

$\therefore V_{dc} = 13.31 mA \times 500\Omega = \underline{6.65 V}$

ii) $V_{Rms} = \underline{I_{rms} \times R_L}$

$I_{rms} = \frac{I_m}{2}$, $I_m = \frac{V_m}{R_f + R_L}$

$= \frac{23}{550} = \underline{41.81 mA}$

$I_{rms} = \frac{41.81 mA}{2}$

$= \underline{20.90 mA}$

$\therefore V_{rms} = 20.90 mA \times 500\Omega$

$= \underline{10.45 V}$

iv) $P_{dc} = I_{dc}^2 \times R_L$

$= (13.31 mA)^2 \times 500$

$= \underline{88.57 mW}$

iii) $\eta = \frac{0.406}{1 + R_f/R_L} = \underline{36.91 \%}$

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3. In a Full wave bridge rectifier, the transformer secondary voltage is 100 sin ωt. The forward resistance of each diode is 25Ω & load resistance is 950Ω. Calculate
a) dc o/p V_g, b) ripple factor c) Efficiency,

Solu. $V_S = V_m \sin\omega t = 100 \sin\omega t$

$V_m = 100 \quad R_f = 25\Omega \quad R_L = 950\Omega$

a) $V_{dc} = I_{dc} R_L$

$I_{dc} = \frac{2I_m}{\pi}, \quad I_m = \frac{V_m}{2R_f + R_L} = \frac{100}{2\times 50 + 950}$

$I_m = \frac{100}{1000} = \underline{\underline{100mA}}$

$\therefore I_{dc} = \frac{100mA \times 2}{\pi} = \underline{63.66mA}$

$\therefore V_{dc} = I_{dc}R_L = 63.66mA \times 950$

$= \underline{\underline{60.478V}}$

b) ripple factor (γ)

$\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$

$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{100mA}{\sqrt{2}} = \underline{\underline{70.71mA}}$

$\gamma = \sqrt{\left(\frac{70.71mA}{63.66mA}\right)^2 - 1} = \sqrt{1.233 - 1}$

$= \sqrt{0.2337} = 0.4834$

$\% \gamma = \underline{\underline{48.34\%}}$

$\% \eta = \frac{P_{dc}}{P_{ac}} = \frac{I_{dc}^2 R_L}{I_{rms}^2 (2R_f + R_L)} = \frac{3.85}{5\times 10^{-3}(1000)}$

$= 0.77$

$\eta = \underline{\underline{77\%}}$

4. A bridge rectifier uses 4 diodes with rms voltage of 110V. Forward resistance of each diode is 25Ω with load R_L of 1kΩ. Find i) max value of current ii) DC value of current through the load iii) DC load voltage.

Solu: Given $V_{rms} = 110V$, $R_f = 25\Omega$, $R_L = 1k\Omega$

$$V_{rms} = \frac{V_m}{\sqrt{2}} \quad \therefore V_m = V_{rms} \times \sqrt{2}$$
$$= \underline{\underline{155.56V}}$$

i) $I_m = \frac{V_m}{2R_f + R_L} = \frac{155.56}{50 + 1 \times 1000} = \underline{\underline{148.15 mA}}$

ii) $I_{dc} = \frac{2 I_m}{\pi} = \frac{2 \times 148.15mA}{\pi} = \underline{\underline{94.36mA}}$

iii) $V_{dc} = I_{dc} \times R_L = 94.36 mA \times 1K\Omega$
$= \underline{\underline{94.36V}}$

With capacitor filter

1. Determine the ripple factor of a bridge rectifier using a capacitor filter. The load used is $2k\Omega$ while dc o/p vg is 12V. Assume supply frequency of 50Hz and ideal diodes. The capacitor of $100\mu F$ is used in the filter circuit.

Soln. given: $R_L = 2k\Omega$. $V_{dc} = 12V$ $f = 50Hz$

ideal diodes, $C = 100\mu F$.

$$\gamma = \frac{1}{4\sqrt{3}\, f C R_L} = \frac{1}{4\sqrt{3} \times 50 \times 2\times10^3 \times 100\times10^{-6}}$$

$$= \frac{1}{69.28}$$

$$= 0.0144$$

$$\%\, \gamma = \underline{1.44\,\%}$$

2. Calculate the value of capacitor C that has to be used for filter of a Bridge rectifier to get a ripple factor of 0.01. The rectifier supplies current to a load of $2k\Omega$ while the supply frequency is 50Hz.

Soln. given $\gamma = 0.01$ (1%), $R_L = 2k\Omega$, $f = 50Hz$.

$$\gamma = \frac{1}{4\sqrt{3}\, f C R_L} \quad \therefore C = \frac{1}{4\sqrt{3}\, f R_L \times \gamma}$$

$$C = \frac{1}{4\sqrt{3} \times 50 \times 2\times10^3 \times 0.01} = \frac{1}{6928.203}$$

$$= 0.000144 3$$

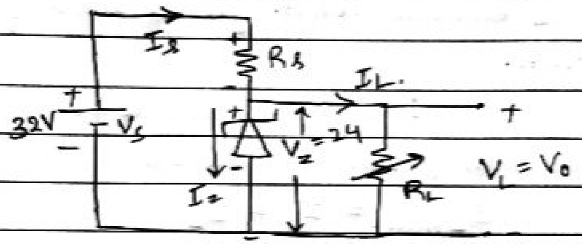
$$= \underline{144.3\mu F}$$

Date

Numericals.

1. A 24 V, 600 mW zener diode is used for providing a 24 V stabilized supply to a variable load from a 32 V supply. Calculate
i) Value of series resistance required
ii) Zener current when the load is 1200 Ω.

Solu: Circuit diagram:



given; $V_z = 24V$, $P_z = 600mW$, $V_s = 32V$.

(i) without load R_L ie $I_L = 0$ for $R_L = 0$.

We know that $I_s = I_z + I_L$. (from the ckt)

since $I_L = 0$, $I_s = I_{z\,max}$.

$$P_z = I_z V_z.$$

$$\therefore I_z = \frac{P_z}{V_z} = \frac{600mW}{24V} = 25mA = I_{Z\,max}$$

$$I_s = I_{z\,max} = 25mA$$

Applying KVL,

$$V_s - I_s R_s - V_z = 0.$$

$$32 - 25mA \times R_s - 24 = 0$$

$$\therefore R_s = \frac{32V - 24V}{25mA} = 320\Omega.$$

The value of series resistance to be connected in the circuit is $R_s = 320\Omega$

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ii) with load R_L:

WKT $I_s = I_L + I_z$.

also $V_z = V_o = V_L = I_L R_L$

$$\Rightarrow V_z = I_L R_L.$$

Given $V_z = 24V$ & $R_L = 1200\Omega$.

$$\therefore I_L = \frac{V_z}{R_L} = \frac{24V}{1200\Omega} = 20mA$$

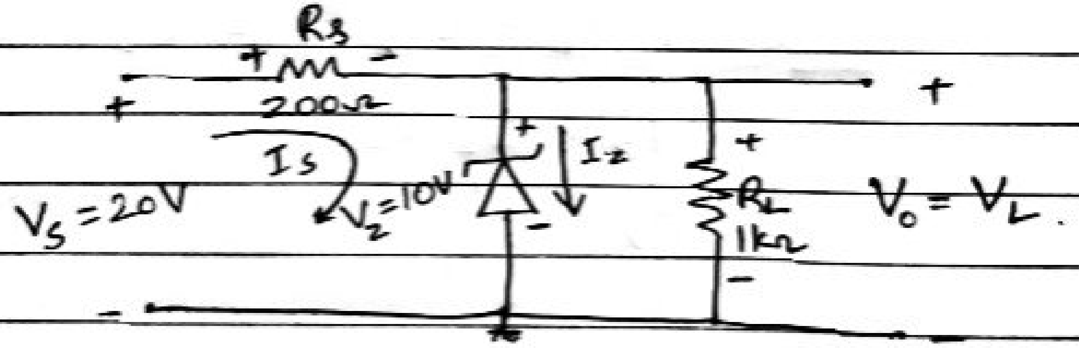
Load current through a load of 1200 Ω is 20 mA.

∴ At maximum load of 1200 Ω, minimum zener current is

$$I_{Z\,min} = I_s - I_L$$

$$= 25mA - 20mA = 5mA$$

2. A circuit has a zener diode connected a/c the load with following details. Find I_s, I_L & P_z.



soln

Given, $V_s = 20V$, $R_s = 200\Omega$. $V_z = 10V$, $R_L = 1k\Omega$.

To find I_s, I_L and Power P_z.

Applying KVL to the i/p loop, we get

$$V_s - I_s R_s - V_z = 0.$$

$$20V - I_s \times 200\Omega - 10V = 0.$$

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$$\therefore I_s = \frac{20V - 10V}{200\Omega} = \underline{\underline{50mA}}.$$

wkt $V_L = V_o = I_L R_L = V_z$.

$$\Rightarrow V_z = I_L R_L.$$

$$\therefore I_L = \frac{V_z}{R_L} = \frac{10V}{1\times10^3} = \underline{\underline{10mA}}$$

The load current through a load of 1kΩ is $\underline{\underline{10mA}}$

To find the current through zener & hence the power dissipation.

wkt $I_s = I_z + I_L$

$$\therefore I_z = I_s - I_L$$

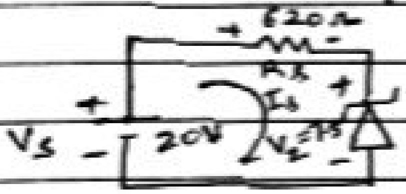
$$= 50mA - 10mA = \underline{\underline{40mA}}$$

∴ The power dissipated is

$$P_z = V_z I_z.$$

$$= 10V \times 40mA = \underline{\underline{400mW}}$$

3. A circuit uses a zener with $V_z = 7.5V$. Find the diode current and max power dissipation in the absence of load.



Given: $V_s = 20V$

$V_z = 7.5V$

$R_s = 620\Omega$.

to find P_z with $R_L = 0$.

Solⁿ. wkt $I_s = I_L + I_z$.

since $R_L = 0$, $I_s = I_{z\,max}$.

Applying KVL,

$$V_s - I_s R_s - V_z = 0.$$

$$20 - I_s \times 620 - 7.5 = 0.$$

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$$\therefore I_s = I_{z\,max} = \frac{20V - 7.5V}{620\Omega} = \underline{20.16mA}$$

$\therefore$ max zener current $I_{z\,max} = \underline{20.16mA}$

Power dissipation in zener is

$$P_z = I_z V_z$$

$$= 20.16mA \times 7.5V$$

$$= \underline{\underline{151.2mW}}$$

Date

Numericals.

1. Calculate I_C & I_E for a transistor that has $\alpha = 0.95$ and $I_B = 100\mu A$. Determine the value of β for the transistor.

Soln: Given $\alpha = 0.98$, $I_B = 100\mu A$.

$$I_E = I_C + I_B.$$

$$I_C = \beta I_B.$$

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

$$I_C = \beta I_B \Rightarrow 49 \times 100 \times 10^{-6} A = 49 \times 10^{-3} A$$
$$= \underline{4.9 mA}$$

$$\& \; I_E = 4.9 \times 10^{-3} + 100 \times 10^{-6}$$
$$= \underline{5 mA}$$

2. Calculate α and β for $I_C = 1mA$ and $I_B = 25\mu A$. Determine the new base current to give $I_C = 5mA$.

Soln:
$$\beta = \frac{I_C}{I_B} = \frac{1mA}{25\mu A} = \underline{\underline{40}}.$$

$$I_E = I_C + I_B = 1mA + 25\mu A = \underline{\underline{1.025 mA}}$$

$$\alpha = \frac{I_C}{I_E} = \frac{1mA}{1.025mA} = \underline{\underline{0.976}}$$

$$I_{B_{new}} = \frac{I_C}{\beta} = \frac{5mA}{40} = \underline{125\mu A}$$

3. Determine β and I_E for transistor where

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$I_B = 50\mu A$ and $I_c = 3.65 mA$.

Solu: $I_B = 50\ \mu A$, $I_C = 3.65 mA$ — given

$I_E = I_B + I_C \Rightarrow 50\mu A + 3.65 mA$

$= \underline{3.70 mA}$

$\beta = \frac{I_C}{I_B} = \frac{3.65 mA}{50\mu A} = \underline{73}$

4. A transistor has $I_C = 3mA$ and $I_E = 3.03 mA$. Find β of the transistor used. Assuming no change in the base current, find the new collector current when transistor is replaced with a new one with β of 70.

Solu given, $I_C = 3 mA$, $I_E = 3.03 mA$

$I_B = I_E - I_C$

$= 0.03 mA = \underline{30\mu A}$.

$\beta = \frac{I_C}{I_B} = \frac{3mA}{30\mu A} = \underline{100}$.

New collector current when transistor is replaced with $\beta = 70$ is

$I_C = \beta I_B \Rightarrow 70 \times 30 \times 10^{-6}$

$I_C = \underline{2.1 mA}$

5. Find I_C & I_E for a transistor with $\alpha = 0.99$ & $I_B = 20\mu A$.

Solu: given $\alpha = 0.99$ $I_B = 20\mu A$.

wkt $I_C = \beta I_B$

$= \frac{\alpha}{1-\alpha} \cdot I_B$

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$$I_C = \frac{0.99}{1-0.99}(20\times10^{-6})$$

$$= \underline{\underline{1.98 mA}}$$

$$I_E = I_C + I_B = (1.98 + 0.02) mA$$

$$I_E = \underline{\underline{2mA}}$$