Transistor

Example (1)

Transistor 2N3055 has the following parameters: maximum power dissipation at 25° C =115 mW, and derating factor = 0.66 281 mW/ ℃ This transistor is used at 78 ℃. Draw its new maximum power dissipation curve.

Solution:-

Temperature increment= 78 ℃- 25° C = 53° C

Power dissipation of transistor= 0.66 281 mW/ ℃ $\times$ 53° C =35 mW

New maximum power dissipation = 115 mW- 35 mW=80 mW

$P \;= 80\, mW \;= V_{CE} \times I_C$ or I_C=$\frac{P_{Cmax}}{V_{CE}}$

When V_{CE}= 60 V, then I_C=$\frac{80\, mW}{60}$ = 1.3 mA (point 1 in figure (1))

To get some other points with different V_{CE} values:

V_{CE} = 20 V, then I_C = $\frac{80\, mW}{60}$ =4 mA (point 2 in figure (1))

V_{CE} = 10 V, then I_C = $\frac{80\, mW}{10}$ =8 mA (point 3 in figure (1))

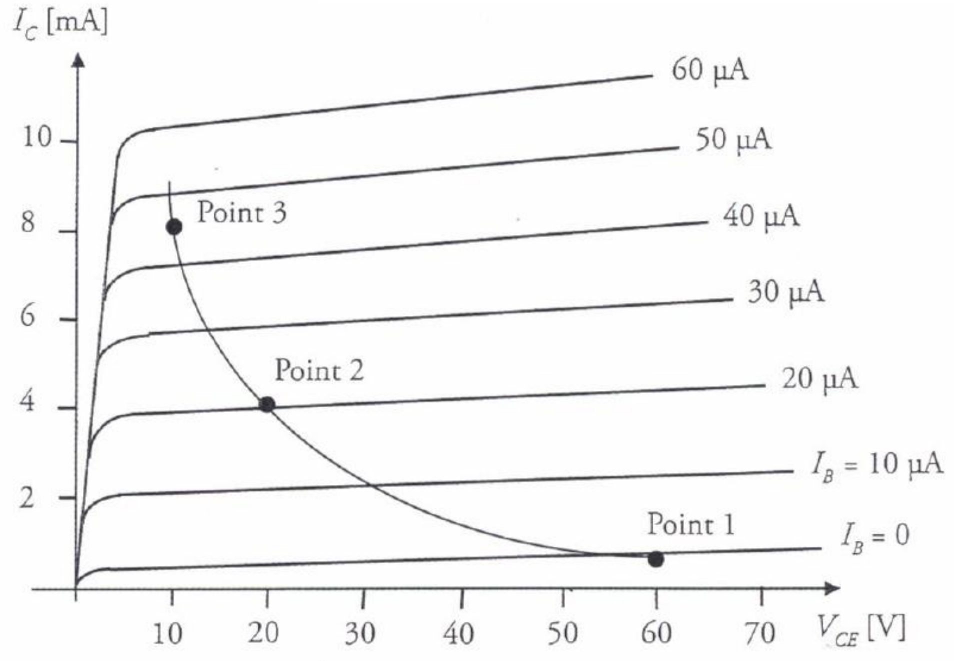
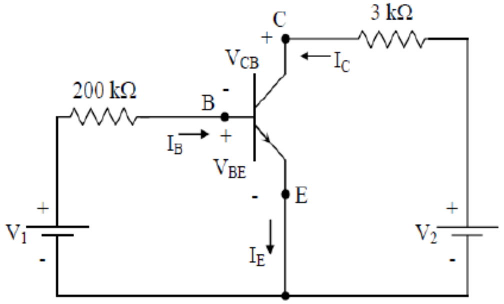


Figure (1)
Maximum power dissipation

Example (2)

For circuit shown in figure (1). Determine I_C , V_{CB}, V_1= 5V, V_2=10 V, β=100, R_B= 200 $K\boldsymbol{\Omega}$, R_c=3 $K\boldsymbol{\Omega}$



npn-type BJT in
Common-emitter Configuration

Figure (2)

Solution:-

I_B=$\frac{V_1 - V_{BE}}{R_B}$

I_B=$\frac{5-0.7}{200\times10^3}$ = 0.0215 mA

I_C= $\beta \times I_B$

I_C=100 $\times$ 0.0215=2.15 mA

V_{CB}= V_{CE}- V_{BE}

V_{CE}= V_2- $I_C \times R_c$

V_{CE}=10-2.15 $\times$3=3.55 V

V_{CB}=3.55 -0.7=2.85 V

Example (3)

An NPN Transistor has a DC base bias voltage, V_B of 10 V and an input base resistor, R_B of 100 kΩ. What will be the value of the base current into the transistor?

Solution:-

$$I_B = \frac{V_B - V_{BE}}{R_B} = \frac{10-0.7}{100\times10^3} = 93\ \mu A$$

Example (4)

An NPN Transistor has a DC current gain, β value of 200. Calculate the base current I_B required to switch a resistive load of 4 mA ?

Solution:-

$$I_B = \frac{I_c}{\beta} = \frac{4\times10^{-3}}{200} = 20\ \mu A$$

Example (5)

Find for the given npn BJT circuit shown in figure (3). Determine I_B, I_C, I_E, V_{CB}, β, α?

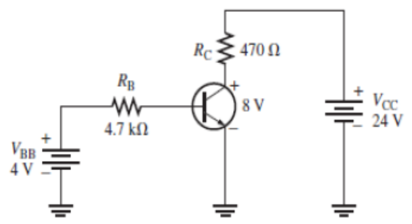


Figure (3)

Solution:-

$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{4-0.7}{4.7 \times 10^3} = 0.7\ mA$

$I_C = \frac{V_{CC} - V_{CE}}{R_C} = \frac{24-8}{470} = 34\ mA$

$I_E = I_C + I_B = 0.7\ mA + 34\ mA = 34.7\ mA$

$V_{CB} = V_{CE} - V_{BE} = 8-0.7 = 7.3$ V

$\beta = \frac{I_c}{I_B} = \frac{34mA}{0.7mA} = 48.57$

$\alpha = \frac{I_c}{I_E} = \frac{34\ mA}{34.7mA} = 0.9798$

Example (6)

A fixed bias circuit shown in figure (4) has V_{CC} = 24 V; R_B=390 kΩ; R_C=3.3 kΩ and V_{CE} = 10 V. Calculate β and determine new value of V_{CE} if β =100?

Solution:-

V_{CE}= V_{cc}- $I_C \times R_c$

10 = 24 - $I_C \times 3.3 \times 10^3$

$I_C = \frac{24-10}{3.3 \times 10^3}$ = 4.24 mA

$I_B = \frac{V_B - V_{BE}}{R_B} = \frac{24-0.7}{390 \times 10^3}$ = 59.74 μA

$\beta = \frac{I_c}{I_E} = \frac{4.24 \times 10^{-3}}{59.74 \times 10^{-6}}$ = 71

If β =100

$I_C = \beta \times I_B$

I_C= 100 × 59.74 μA = 5.974 mA

V_{CE}= V_{cc}- $I_C \times R_c$

V_{CE}= 24- 5.974 × 3.3=4.2858 mA

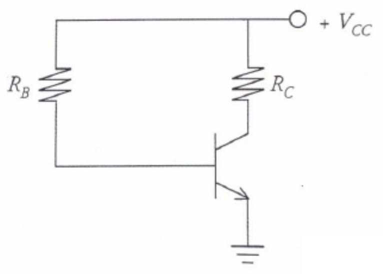


Figure (4)

Q7) Determine the operating point for the transistor shown in figure(5), which has β =100, R_B=500 kΩ, R_c=2.5 kΩ, V_{CC} = 20 V. Show the load line and the operating point on the load line?

Solution:-

$I_B = \frac{V_{cc} - V_{BE}}{R_B} = \frac{20-0.7}{500\times10^3}$ = 38.6 μA

$I_C = \beta \times I_B$ = 100 $\times$36.8 =3.68 mA

$V_{CE} = V_{cc} - I_C \times R_c$

V_{CE}= 20-3.68 $\times$2.5 =10.35 V

The coordinates of load line are $\left(0, \frac{V_{CC}}{R_c}\right)$ and $(V_{cc}, 0)$ which are $(0, 8mA)$ and $(20\ V, 0)$. The load-line and operating points are shown in figure (6).

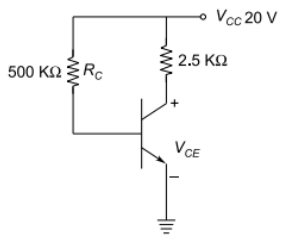


Figure (5)

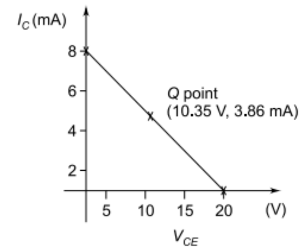


Figure (6)

Q8) For the circuit shown in figure (7). Determine I_E , I_B, I_C and V_{CE} if β=75 and R_c=2.5 kΩ, R_B=10 kΩ, R_E=1 kΩ, V_{CC} = 8 V , V_E = 2 V, V_{BE} = 0.7 V ?

Solution:-

For input loop:-

$V_E - I_B R_B - V_{BE} - I_E R_E$=0

$V_E - I_B R_B - V_{BE} - (\beta + 1) I_B R_E$=0

$I_B = \frac{V_E - V_{BE}}{R_B + (\beta+1) R_E}$

$I_B = \frac{2-0.7}{10\times10^3+(75+1)\times1\times10^3} = 15.1\ \mu A$

$I_C = \beta \times I_B = 75 \times 15.1 = 1.13\ mA$

$I_E = I_C + I_B = 15.1 \times 10^{-3}\ mA + 1.13\ mA = 1.15\ mA$

$V_{cc} - I_C \times R_c - V_{CE} - I_E \times R_E + V_E = 0$

$8 - 1.13 \times 2.5 - V_{CE} - 1.15 \times 1 + 2 = 0$

$V_{CE} = 7.01$ V

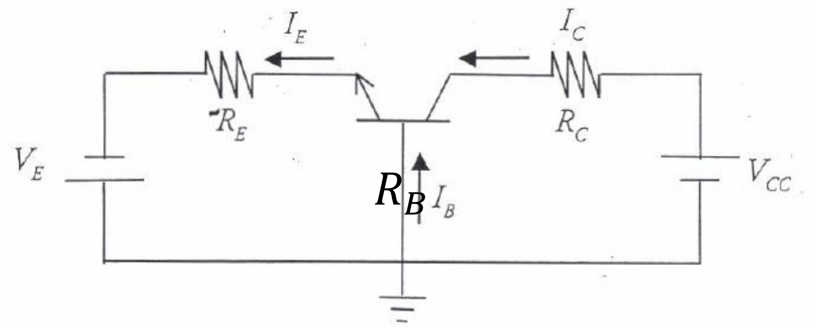


Figure (7)

Q9) For figure (8). Determine Q-point and DC load-line.

Solution:-

$I_B = \frac{V_{cc} - V_{BE}}{R_1 + (\beta+1)\ R_E}$

$I_B = \frac{20-0.7}{2.7 \times 10^6 + (100+1) \times 3.3 \times 10^3}$ = 6.363 μA

$I_C = \beta \times I_B$ = 100 ×6.363 =0.636 mA

$I_E = I_C + I_B$ =0.643 mA

$V_{CE} = V_{cc}$ - $I_C \times R_c$ - $I_E \times R_E$

V_{CE} =20-0.636 ×10-0.643 ×3=11.52 V

Q point at I_C =0.636 mA and V_{CE}= 11.52 V .

$V_{CE} = V_c$-V_E= V_{cc}- $I_C \times R_c$ - $I_E \times R_E$

$I_C \cong I_E$

$V_{CE} = V_{cc}$- $I_C \times (R_c + R_E)$

When $V_{CE} = 0$

I_C=$\frac{V_{cc}}{R_c+R_E}$

I_C=$\frac{20V}{(10+3.3)k\Omega}$=1.504 mA

When I_C=0

$V_{CE} = V_{cc}$

$V_{CE} = 20$ V

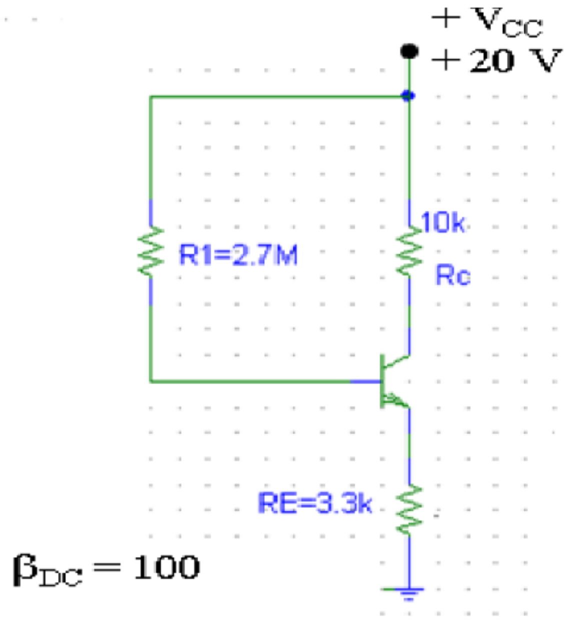


Figure (8)

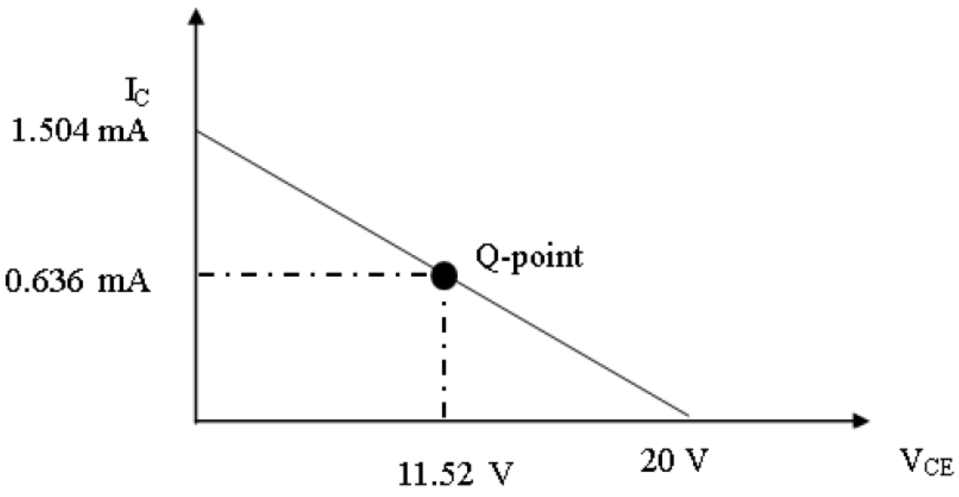


Figure (9)

Q10)Calculate Q point values for circuit shown in figure (10), V_{cc}=10V, R_B=100 kΩ, R_c=10 kΩ , β=100 ?

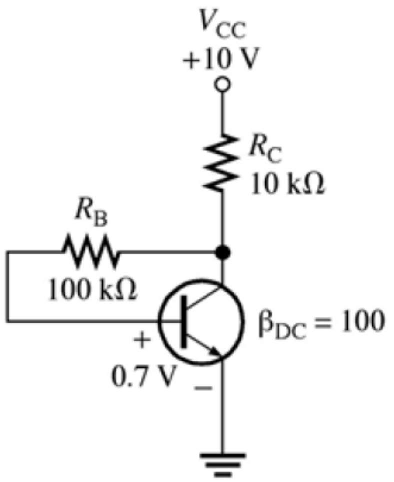


Figure (10)

Solution:-

I_B=$\frac{V_{cc}-V_{BE}}{R_B+(\beta+1)\ R_C}$=$\frac{(10-0.7)}{100+(100+1)\times 10}$=8.38 μA

I_C= $\beta \times I_B$= 100 ×8.38 =0.838 mA

V_{CE}= V_{cc}- $R_C \times (I_c + I_B)$=10-10 ×(0.838+0.00838)=1.536 V

Q point at V_{CE} 1.536 V and I_C= 0.838 mA

At cut-off and saturation mode

V_{CE}= V_{cc}- $R_C \times (I_c + I_B)$

$I_c >> I_B$

V_{CE}= V_{cc}- $R_C \times I_c$

When V_{CE}=0

I_c=$\frac{V_{cc}}{R_C}$=$\frac{10}{10\text{k}\Omega}$=1 mA

When I_c=0

V_{CE}= V_{cc}

V_{CE}=10