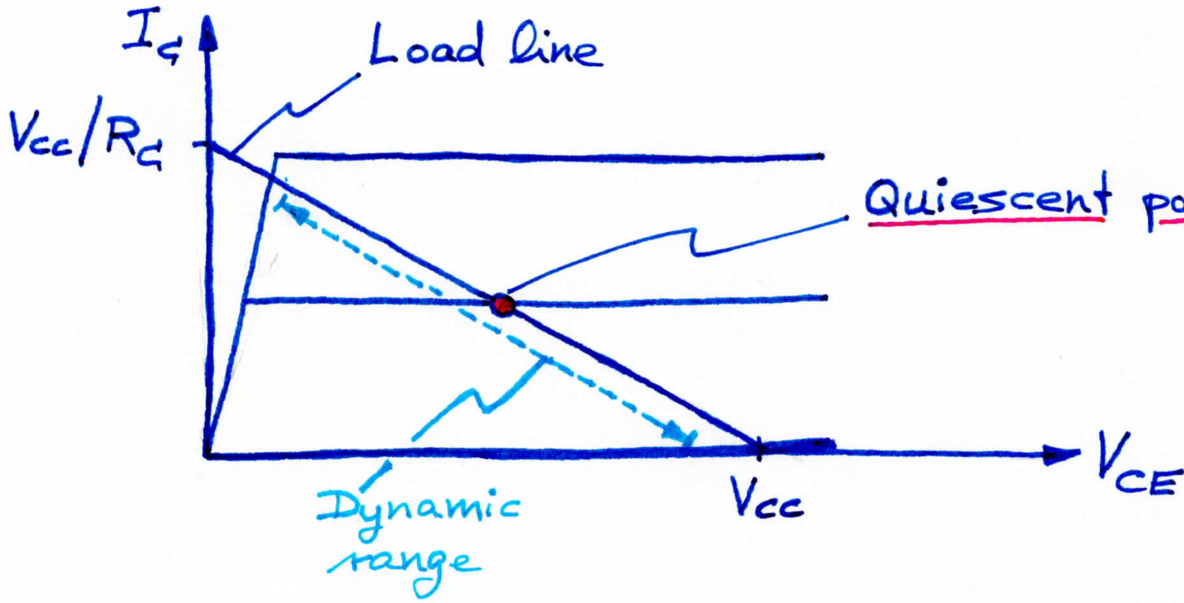
Quiescent point (Q-point)

Quiescent ⇒ Origin of word ? ⇒ Quiet ⇒ static ⇒ no dynamic signal ⇒ DC

Quiescent point of BJT ? We choose the Q-point

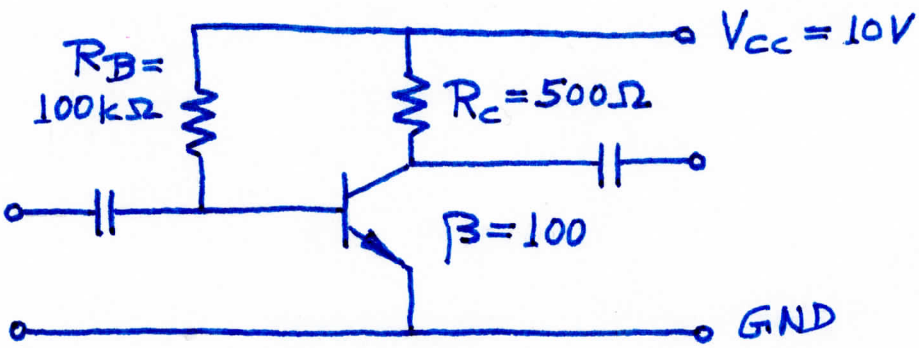


Q : Where do we choose the Q-point to be located?

⇒ Frequently in middle of load line.

⇒ Bias network of transistor determines the quiescent point.

1st exercise : Determine Q-point of the following circuit



Base current: $I_B = \dfrac{V_{CC} - V_{BE}}{R_B} = \dfrac{10V - 0.7V}{100k\Omega} = 93\mu A$

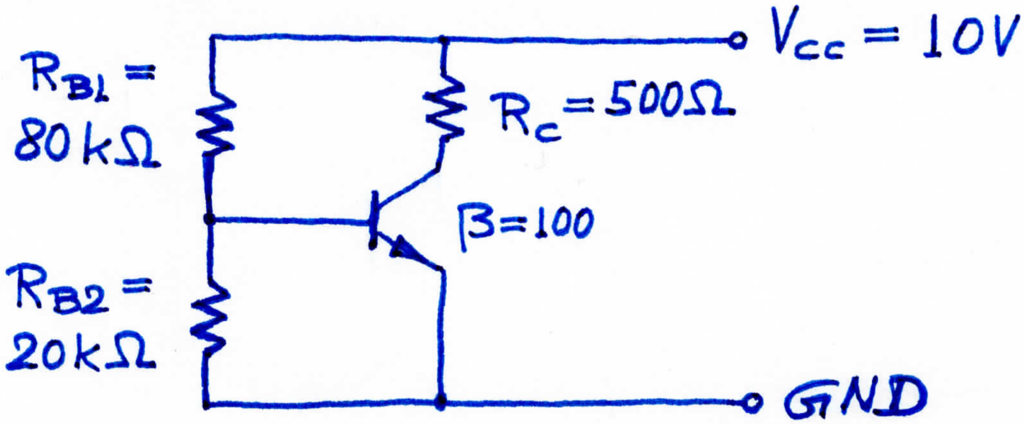
$\Rightarrow I_C = \beta I_B = 100 \times 93\mu A = \underline{9.3\,mA}$ (Q-point)

$\Rightarrow V_{CE} = V_{CC} - R_C I_C = 10V - 500\Omega \times 9.3mA = 10V - 4.65V$

$= \underline{5.35V}$ (Q-point)

Q: Where is the Q-point located?

2nd exercise: Determine Q-point of circuit below



Do R_{B1} & R_{B2} act as voltage divider?

⇒ No ⇒ Why not? ⇒ $V_{BE} = 0.7V$

Calculate I_B.

$$I_{RB2} = \frac{V_{BE}}{R_{B2}} = \frac{0.7V}{20k\Omega} = 35\mu A$$

$$I_{RB1} = \frac{V_{CC} - V_{BE}}{R_{B1}} = \frac{9.3V}{80k\Omega} = 116\mu A$$

$$\Rightarrow I_B = I_{RB1} - I_{RB2} = 116\mu A - 35\mu A = 81\mu A$$

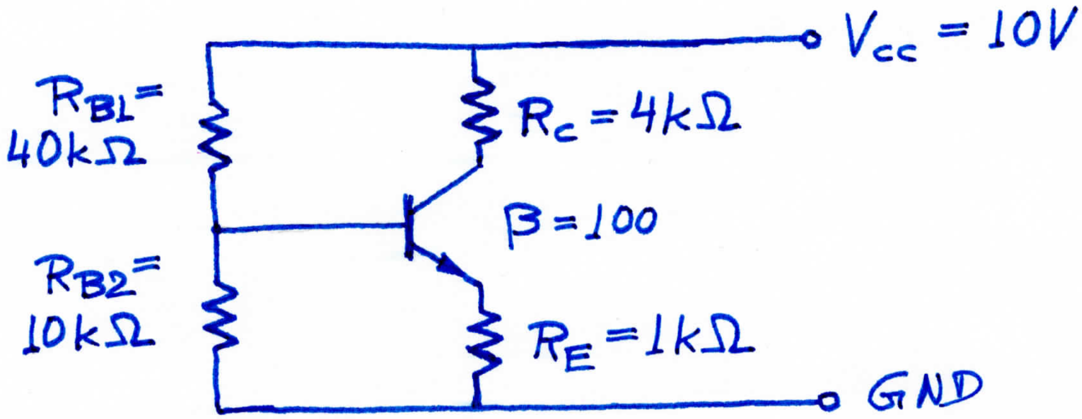
$$\Rightarrow I_C = \beta I_B = 100 \times 81\mu A = \underline{\underline{8.1\ mA}}$$

$$\Rightarrow V_{CE} = V_{CC} - R_C I_C = 10V - 500\Omega \times 8.1mA =$$

$$= 10V - 4.05V = \underline{\underline{5.95V}}$$

Q: Where is the Q-point located?

3rd exercise: Determine Q-point of circuit below.



Q: Do R_{B1} & R_{B2} act as voltage divider?

We do not know. Let us assume that R_{B1} & R_{B2} act as voltage divider.

$$\Rightarrow V_{Base} = V_B = 10V \frac{R_{B2}}{R_{B1}+R_{B2}} = 10V \frac{10k\Omega}{50k\Omega} = 2.0V$$

$$\Rightarrow I_E = \frac{2V - 0.7V}{R_E} = \frac{1.3V}{1k\Omega} = 1.3\,mA$$

$$\Rightarrow I_B = \frac{I_E}{\beta+1} \approx \frac{I_E}{\beta} = \frac{1.3mA}{100} = 13\,\mu A$$

Voltage divider carries about $200\mu A \left(\frac{10V}{40k\Omega + 10k\Omega}\right)$.

Load is $13\mu A$. $\Rightarrow$ R_{B1} & R_{B2} indeed act as voltage divider!

Next, we calculate I_C and V_{CE} of Q-point.

As calculated above $I_E = 1.3\,mA$

Collector current $\underline{\underline{I_C}} = \alpha I_E \approx I_E = \underline{\underline{1.3\,mA}}$

CE voltage: $\underline{\underline{V_{CE}}} = V_{CC} - V_{RE} - V_{RC}$

$= 10V - 1.3mA\,1k\Omega - 1.3mA\,4k\Omega$

$= 10V - 1.3V - 5.2V = \underline{\underline{3.5V}}$

Q: Where is the Q-point located on the load line? $\Rightarrow$ Near the middle.

Q: Does the Q-point analysis provide us with I_E? $\Rightarrow$ Yes, of course.

Q: Which quantity can we calculate from I_E? $\Rightarrow$ $r_E = V_t / I_E$

Q: Why do we need r_E? $\Rightarrow$ Small-signal analysis