Problem set #6 – Part 1

(1)

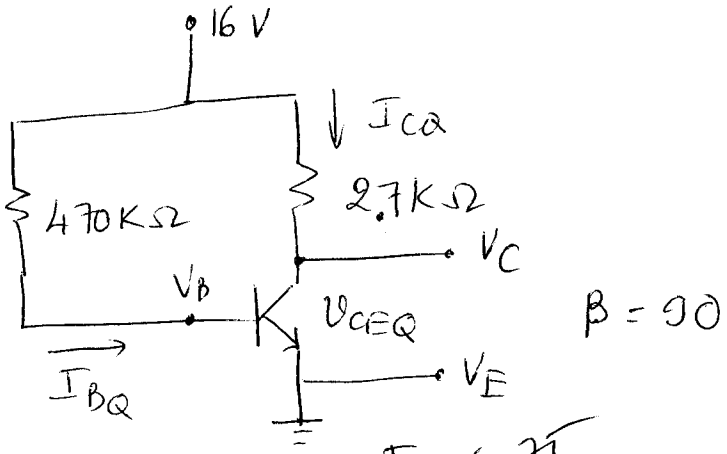


Fig 4.75

a) Find I_{BQ} :

$16 = 470K\Omega \cdot I_{BQ} + V_{BE}$ → 0.7

$\Rightarrow I_{BQ} = \frac{16 - 0.7}{470K\Omega} = \boxed{32.6\ \mu A}$ ✓

b) $I_{CQ} = ?$

$I_{CQ} = \beta I_{BQ} = 90 \cdot 32.6\mu A = 2.93\ mA$

$I_{C\,max} = \frac{16 - 0.2}{2.7K\Omega} = 5.85\ mA$

$\Rightarrow I_{CQ} < I_{C\,max} \Rightarrow \boxed{I_{CQ} = 2.93\ mA}$ ✓ (A.F regim)

c) $V_{CEQ} = ?$

$V_{CEQ} = 16\ V - 2.7K\Omega \cdot I_{CQ}$

$V_{CEQ} = 16\ V - 2.7K\Omega \cdot 2.93\ mA$

$\boxed{V_{CEQ} \simeq 8.09\ V}$ ✓

d) $V_C = ?$

$V_C = V_{CEQ} = \boxed{8.09\ V}$ ✓

e) $V_B = V_{BE} = \boxed{0.7\ V}$ ✓

f) $\boxed{V_E = 0\ V}$ ✓

Problem Set # 6 - Part 1

(4) Find Saturation current I_C for the fixed bias configuration of Fig 4.75

$$I_{C_{max}} = \frac{16V - 0.2V}{2.7K\Omega} = 5.85\,mA$$

(6)

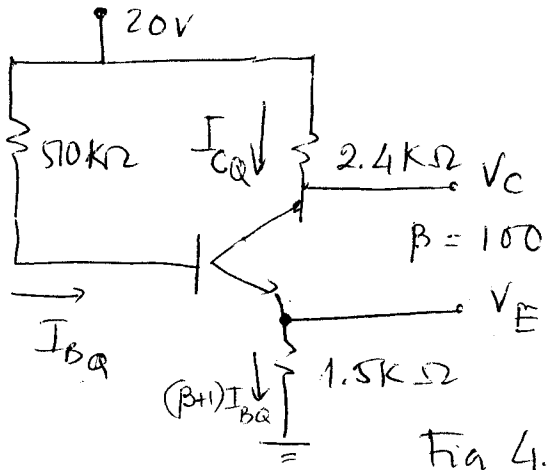


Fig 4.79

a) Find I_{BQ} ?

$$20V = 510K\Omega \times I_{BQ} + V_{BE} + 1.5K\Omega \cdot (\beta+1) I_{BQ}$$

($V_{BE} = 0.7$)

$$\Rightarrow I_{BQ}\left(510K\Omega + 1.5K\Omega \times 101\right) = 20 - 0.7$$

$$\Rightarrow I_{BQ} = \frac{20 - 0.7}{510K\Omega + 151.5K\Omega} = \boxed{29.2\,\mu A}$$ ✓

b) $I_{CQ} = ?$

$$I_{CQ} = \beta I_{BQ} = 29.2\mu A \times 100 = 2.92\,mA$$

$$I_{C_{max}} = \frac{20V - 0.2V}{2.4K\Omega + \left(\frac{\beta+1}{\beta}\right) \cdot 1.5K\Omega} \approx \frac{19.8V}{3.9K\Omega} = 5.07mA$$ ✓

$\Rightarrow I_{CQ} < I_{C_{max}} \Rightarrow \boxed{I_{CQ} = 2.92mA}$ (Active region).

c) $V_{CEQ} = ?$

$$V_{CEQ} = 20V - 2.4K\Omega \times I_{CQ} - \frac{(\beta+1)}{\beta} I_{CQ} \cdot 1.5K\Omega$$

$$V_{CEQ} = 20V - 2.4K\Omega \times 2.92mA - \frac{101}{100} \cdot 2.92 \times 1.5K\Omega$$

$$\boxed{V_{CEQ} = 8.56\,V}$$ ✓

Problem set # 6 – Part 1

(6) (cont.)

d) $V_C = ?$

$$V_C = V_{CEQ} + 1.5K\Omega \times \frac{\beta+1}{\beta} \cdot I_C$$

$$V_C = 8.56 + 1.5K\Omega \times \frac{101}{100} \cdot 2.92$$

$$\boxed{V_C = 12.98\ V}$$ ✓

e) $V_B = ?$

$$V_B = V_{BE} + V_E = 0.7 + \frac{\beta+1}{\beta} \cdot 1.5K\Omega \cdot I_{CQ}$$

$$V_B = 0.7 + \frac{101}{100} \times 1.5K\Omega \times 2.92 \Rightarrow$$

$$\boxed{V_B = 5.12\ V}$$ ✓

f) $V_E = ?$

$$V_E = \frac{\beta+1}{\beta} \cdot I_{CQ} \cdot 1.5K\Omega$$

$$\boxed{V_E = 4.42\ V}$$ ✓

Problem set #6 Part 1

(11)

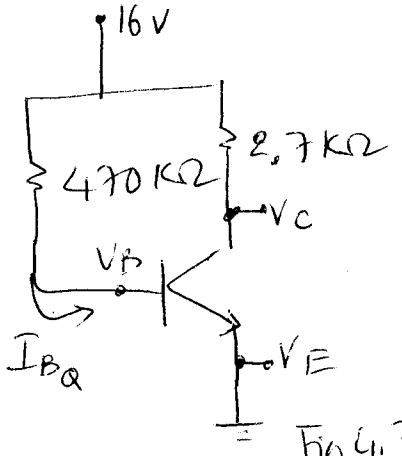


Fig 4.75

a) $I_C \propto V_{CE} = ?$

$\beta = 90 \Rightarrow$ ✓

$I_C = 2.93$ mA

$V_{CE} = 8.09$ V ✓

Did in page 1 ↓ See solution in Problem Set #6 Part 1 - page 1

b) $\beta = 135$ $I_C, V_{CE} = ?$

$I_{Cmax} = \frac{16 - 0.2}{2.7} = 5.85$ mA ; $I_{BQ} = 32.6\,\mu A$ (see page 1)

$I_{CQ} = \beta I_{BQ} = 135 \times 32.6\,\mu A = \boxed{4.4\text{ mA}}$ ✓

$I_{CQ} < I_{Cmax} \Rightarrow I_{CQ} = 4.4$ mA (A. F region)

$V_{CE} = 16\text{ V} - 2.7\text{ K}\Omega \cdot I_{CQ} = 16 - 2.7 \times 4.4$

$\boxed{V_{CE} = 4.12\text{ V}}$ ✓

c) $\%\Delta I_C = \left|\frac{I_{C\,part\,b} - I_C}{I_{Cmax\ a}}\right| \times 100\% = \left|\frac{4.4 - 2.93}{2.93}\right| \times 100\% = \boxed{50\%}$ ✓

$\%\,\Delta V_{CE} = \left|\frac{V_{CE(b)} - V_{CE(a)}}{V_{CE(a)}}\right| \times 100\% = \left|\frac{4.12 - 8.09}{8.09}\right| \times 100\% = \boxed{49\%}$ ✓

d) Fig 4.79 → I_C and V_{CE} ?

$I_{CQ} = 2.92$ mA

$V_{CEQ} = 8.56$ V

e) Change $\beta = 150$, I_C, V_{CE} ? of Fig. 4.79

$I_{Cmax} = \frac{20\text{V} - 0.2\text{V}}{2.4\text{K} + 1.5} = 5.07$ mA

$I_{BQ} = \frac{V_{CC} - 0.7}{510\text{K} + 150 \times 1.5\text{K}} = 0.026$ mA

$I_{CQ} = \beta I_{BQ} = 150 \times 0.026\text{ mA} = 3.93$ mA ✓

$I_{CQ} < I_{Cmax} \Rightarrow$ Active F region $\Rightarrow \boxed{I_{CQ} = 3.93\text{mA}}$

e) $I_{CQ} = 3.93\,mA$ ✓

$V_{CEQ} \cong 20V - 3.93 \times (2.4 + 1.5) = \boxed{4.67\,V}$

f) $\%\Delta I_C = \left|\frac{I_{C(e)} - I_{C(d)}}{I_{C(d)}}\right| = \left|\frac{3.93 - 2.92}{2.92}\right| \times 100\% = \boxed{34.6\%}$ ✓

$\%\Delta V_{CE} = \left|\frac{V_{CE(e)} - V_{CE(d)}}{V_{CE(d)}}\right| = \left|\frac{4.67 - 8.56}{8.56}\right| \times 100\% = \boxed{45.4\%}$ ✓

g)

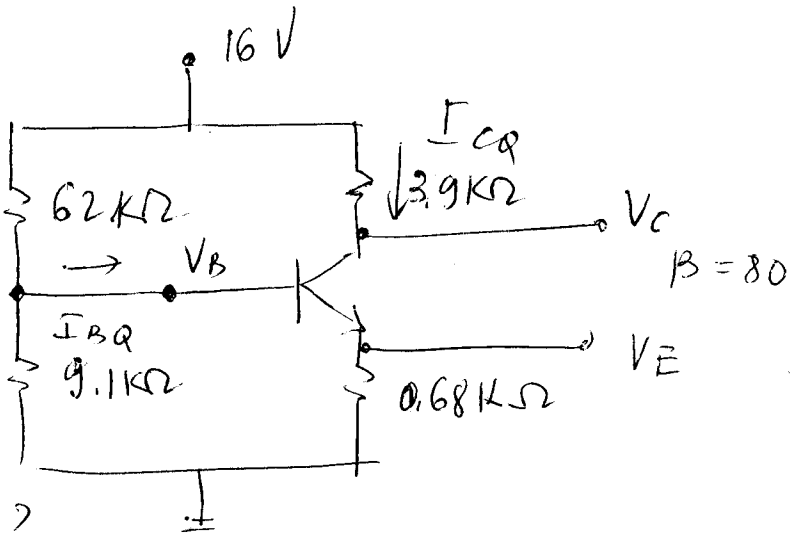
Fig 4.75	$\%\Delta I_C = 50\%$	$\%\Delta V_{CE} = 49\%$
Fig 4.79	$\%\Delta I_C = 34.6\%$	$\%\Delta V_{CE} = 45.4\%$

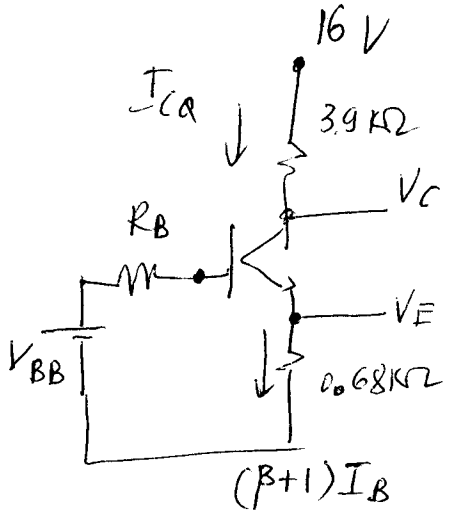
✓

The circuit in Fig 4.79 seems to be less sensitive to changes in β. ✓

Problem Set # 6 – Part 1

(12)





(a) I_{BQ} ?

$$V_{BB} = \frac{16\ V * 9.1K\Omega}{62K + 9.1K\Omega} = 2.05\ V$$

$$R_B = 62K\Omega // 9.1K\Omega = \frac{62 \times 9.1}{62 + 9.1} = 7.93\ K\Omega$$

$$I_{BQ} = \frac{V_{BB} - 0.7}{R_B + (\beta+1) R_E} = \frac{2.05V - 0.7}{7.93K\Omega + 81 \times 0.68\ K\Omega} = \boxed{21.4\ \mu A}\ \checkmark$$

(b) $I_{CQ} = ?$

$$I_{Cmax} = \frac{16V - 0.2}{3.9K\Omega + 0.68K\Omega} = 3.45\ mA$$

$$I_{CQ} = \beta I_{BQ} = 80 \times 21.4\mu A = 1.71\ mA < I_{Cmax}$$

$$\Rightarrow \boxed{I_{CQ} = 1.71\ mA}\ \checkmark \text{ (Active F. region).}$$

(c) V_{CEQ} ?

$$V_{CEQ} = 16\ V - I_{CQ}(3.9K\Omega + 0.68K\Omega)\ \checkmark$$

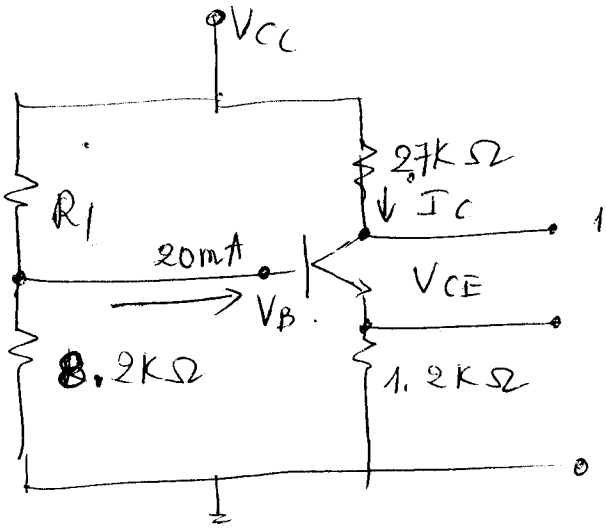
$$V_{CEQ} = 16V - 1.71\ (4.58)K\Omega = \boxed{8.17\ V}\ \checkmark$$

d) $V_C = ?$ $\quad V_C = 16 - 3.9K\Omega \times 1.71 = \boxed{9.33}\ V$.

e) $V_E = I_{CQ} \frac{(\beta+1)}{\beta} \cdot 0.68K\Omega = 1.71 \times 0.68 = \boxed{1.16\ V}$ ✓

f) $V_B = V_E + 0.7 = 1.16 + 0.7 = \boxed{1.86\ V}$ ✓

(14)



$\beta = 100$

Fig 4.84.

a) $I_C = ?$ given

We have $I_{BQ} = 20\mu A$ $\Rightarrow I_{CQ} = \beta I_{BQ} = 100 \times 20\mu A = \boxed{2mA}$ ✓

b) $V_E = ?$

$V_E = (\beta+1) I_{BQ} \cdot 1.2K\Omega = (101) \cdot 20\mu A \times 1.2K\Omega = \boxed{2.42V}$ ✓

c) $V_{CC} = ?$ given

$V_{CC} = 2.7K\Omega I_{CQ} + 10.6V$

$\Rightarrow V_{CC} = 2.7K\Omega \cdot 2mA + 10.6V = \boxed{16V}$ ✓

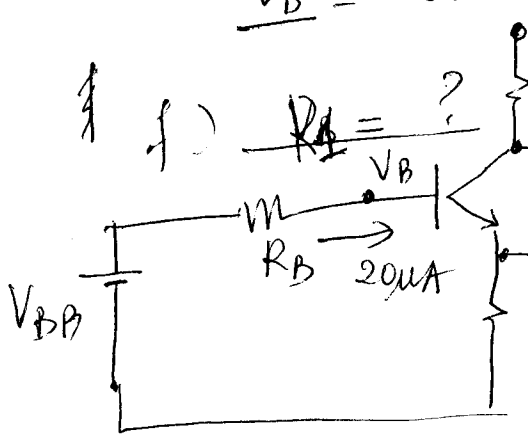
d) $V_{CE} = ?$

$V_{CE} = 10.6V - V_E = 10.6V - 2.42V$

$\boxed{V_{CE} = 8.18V}$ ✓

e) $V_B = 0.7 + V_E = 0.7V + 2.42V = \boxed{3.12V}$ ✓

f) $R_B = ?$



$V_{BB} = \frac{V_{CC} \cdot 8.2}{R_1 + 8.2K\Omega}$ → 16 V

$R_B = \frac{R_1 \cdot 8.2K\Omega}{R_1 + 8.2K\Omega}$

$V_{BB} = R_B \cdot 20\mu A \times 10^{-3} + V_B$ ✓

$\frac{16 \times 8.2}{R_1 + 8.2} = \frac{R_1 \cdot 8.2}{R_1 + 8.2} \times \frac{20 \times 10^{-3}}{mA} + 3.12V$

$(3.12 \cdot R_1 + 0.164 R_1) = 16 \times 8.2 - 25.58$

$\Rightarrow \boxed{R_1 = 32.16K\Omega}$ ✓