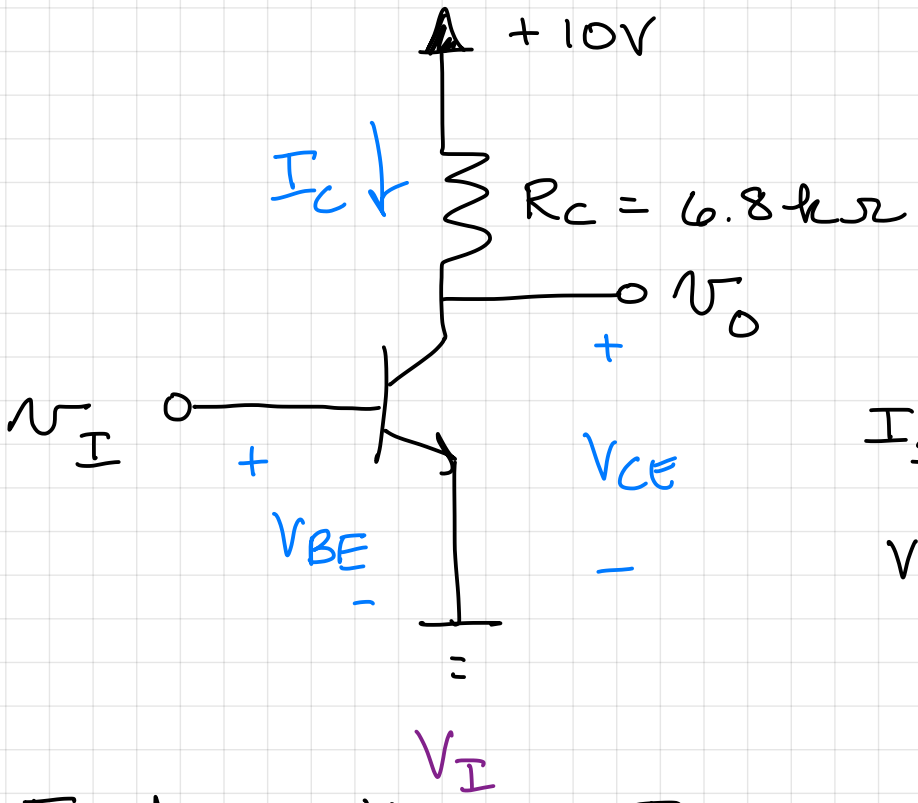


$I_S = 1 \times 10^{-15}\ A$

$V_{CEQ} = 3.2V$

V_O

a) Finding V_{BEQ}, I_{CQ}

$$I_{CQ} = \frac{10 - V_{CEQ}}{6.8} = \frac{10 - 3.2}{6.8} = 1mA$$

$$I_C = I_S \exp\left(\frac{V_{BEQ}}{V_t}\right)$$

$$1 \times 10^{-3} = 1 \times 10^{-15} \exp(V_{BEQ}/.025)$$

$$V_{BEQ} = 0.691\ V$$

b) $A_V = -\underbrace{\frac{I_{CQ}}{V_T}}_{g_m} R_C$

$$A_V = -\frac{(1\times10^{-3})(6.8\times10^{3})}{.025}$$

$$= -272 \text{ V/V}$$

c) let small signal of 5mV sine wave be superimposed on V_{BEQ}

$v_{ce} \Rightarrow \quad A_V = \frac{v_{ce}}{v_{be}}$

$v_{ce} = A_V \cdot v_{be}$

$= -272(.005)$

$v_{ce} = 1.36\text{V}$ peak sine wave

d) Drive Qpt to edge of saturation

$$v_{CE} = 0.3V$$

what is the change in v_{BE} to do so?

$$i_C = \frac{10 - 0.3}{6.8} = 1.43\,mA$$

$$v_{BE2} - v_{BE1} = V_T \ln\left(\frac{i_{C2}}{i_{C1}}\right)$$

$$\Delta v_{BE} = (0.025)\ln\left(\frac{1.43}{1}\right)$$

$$\Delta v_{BE} = 8.94\ mV$$

Example 2

NPN transistor

g_m, r_π, r_e at Q point

$\beta = 100$

$I_{CQ} = 1mA$

$V_T = 25mV$

$$g_m = \frac{I_{CQ}}{V_T} = \frac{1\,mA}{.025 \times 10^{-3}} = 40\frac{mA}{V}$$

g_m ↑ mA/V

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{40\ mA/V} = 2.5\ k\Omega$$

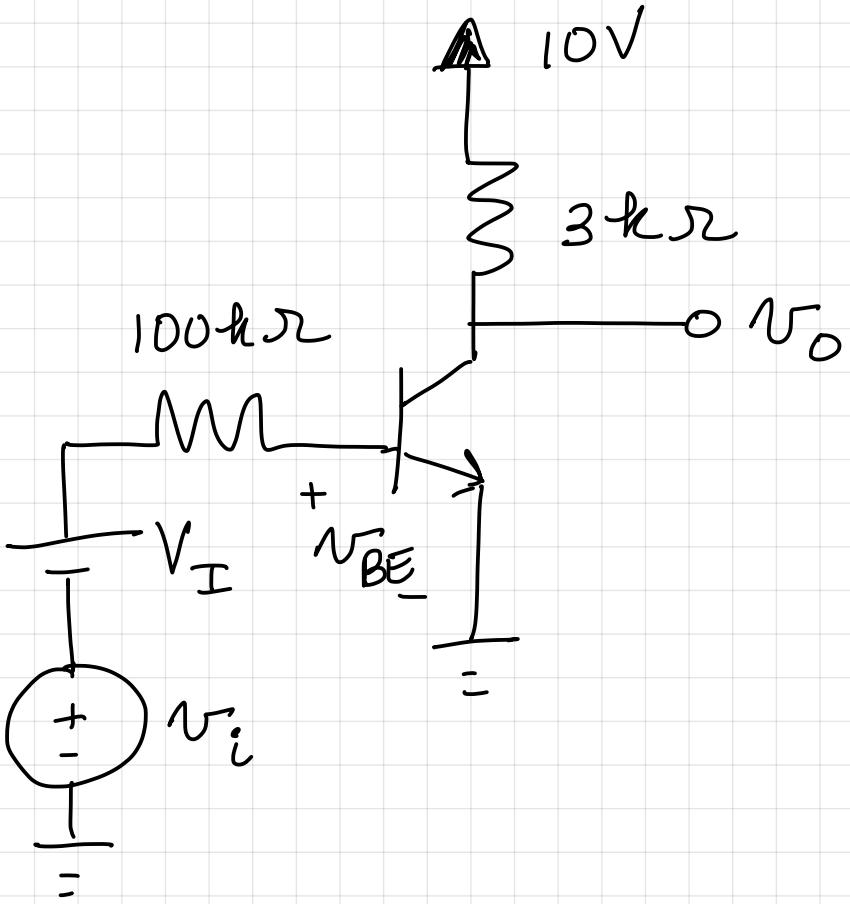
$$r_e \cong \frac{1}{g_m} = \frac{1}{40\ mA/V} = 25\Omega$$

$$r_e = \frac{r_\pi}{(1+\beta)} = 24.75\Omega$$

$\beta \rightarrow$ larger $\quad \beta + 1 \approx \beta$

$\alpha \approx 1$

Example 3

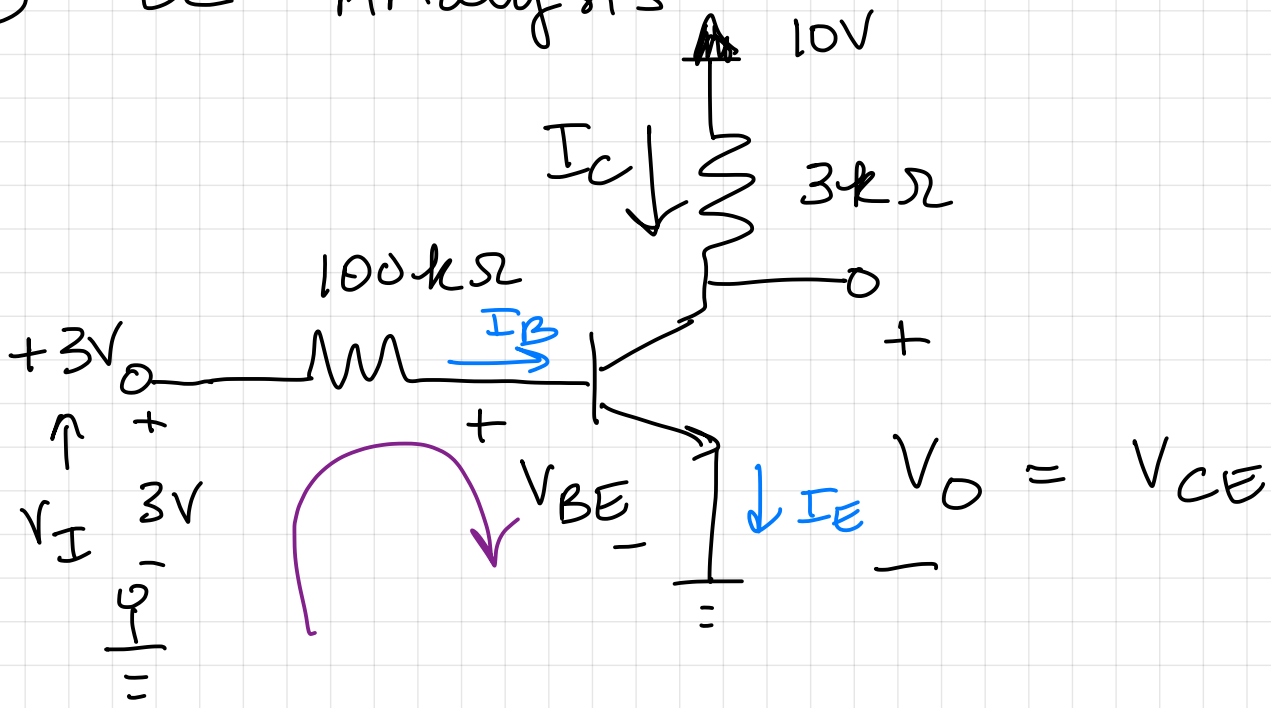


$\beta = 100$

$V_{BE} = 0.7V$

$V_I = 3V$

① DC Analysis



by KVL: $3 - 100(I_B) - V_{BE} = 0$

$$I_B = \frac{3 - 0.7}{100} = 0.023\,mA$$

$$I_C = \beta I_B = 100(.023mA)$$

$$\boxed{I_{CQ} = 2.3mA}$$

$$V_{CEQ} = V_{OQ} = 10 - I_{CQ} R_C$$
$$= 10 - (2.3)(3)$$

$V_C > V_B$ are in active $\Leftarrow$ $V_{CEQ} = V_{OQ} = 3.1V$

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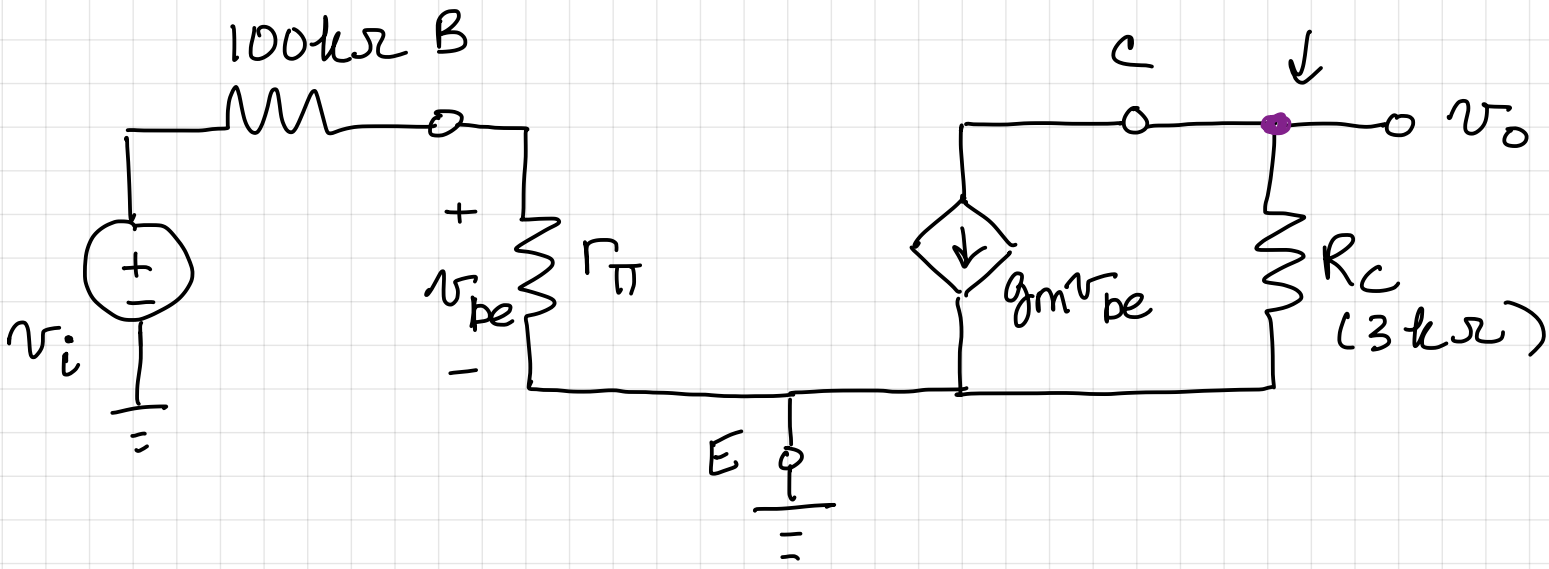
② small signal

$$g_m = \frac{I_{CQ}}{V_T} = \frac{2.3}{.025} = 92\frac{mA}{V}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{92\,mA/V} = 1.09\,k\Omega$$



$$\frac{v_o}{v_i} \Rightarrow \qquad g_m v_{be} + \frac{v_o}{R_C} = 0$$

$$\frac{v_o}{R_C} = -g_m v_{be}$$

$$\frac{v_o}{v_{be}} = -g_m R_C$$

$$g_m = \frac{I_C}{V_T}$$

$$v_{be} = v_i \left(\frac{r_\pi}{r_\pi + 100\text{k}\Omega} \right)$$

$$\frac{v_{be}}{v_i} = \frac{(1.09)}{(1.09 + 100)}$$

$$\frac{v_o}{v_{be}} \cdot \frac{v_{be}}{v_i} = \frac{v_o}{v_i} = -92(3)\left(\frac{1.09}{100+1.09}\right)$$

$$\frac{v_o}{v_i} = -2.98 \text{ V/V}$$