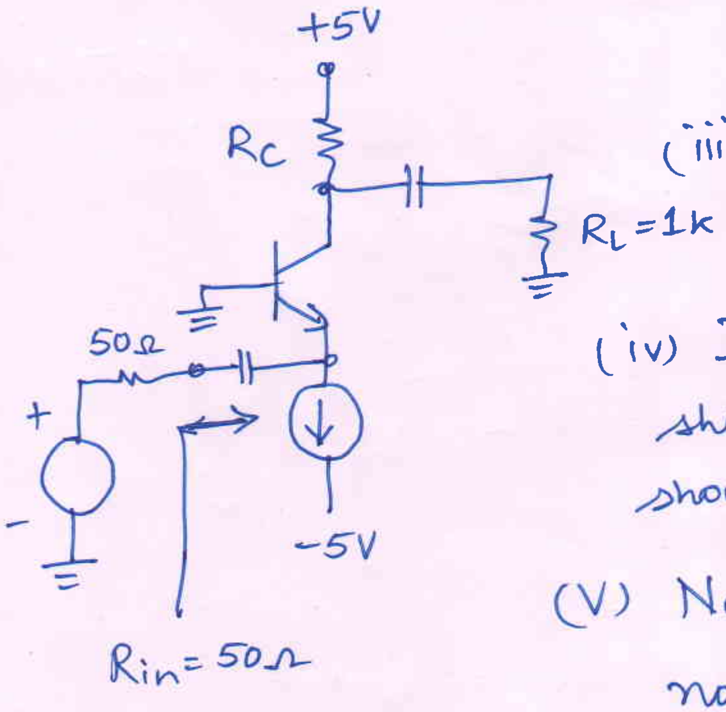
D3.140 Common Base Amplifier



Given (i) $R_{in} = 50\Omega$

(ii) $R_{sig} = 50\Omega$

(iii) Calculate I & R_C, G_{vo}, G_v

(iv) If $v_{be} = \max. \pm 10mV$ then there should be no distortion. This should decide Q point.

(V) Note β is not specified & will not be needed.

Given $R_{in} = R_{sig} = 50\Omega = r_e$. Calculate I as follows:

& based on r_e and g_m

$$r_e = \frac{\alpha}{g_m} = \frac{1}{g_m} \quad \therefore g_m = \frac{1}{r_e} = \frac{1}{50}$$

$$\because g_m = I/V_T \quad \therefore I = g_m \cdot V_T = \frac{1}{50} \times 25mV$$

$$\boxed{I = 0.5\,mA}$$

What should be V_C at Q point? It should be mid point between two extremes — cutoff or $V_C = 5V$ and saturation when $V_C = V_B - 0.5V$

$= 0 - 0.5V$.

So Q point should be between 5V & -0.5V.

The room for swing is $5V - (-0.5V) = 5.5V$

The Q point should be set $5.5V/2 = 2.75V$ from both extremes 12

$$\therefore I_C R_C = 2.75V$$

$$\because I_C = 0.5\,mA$$

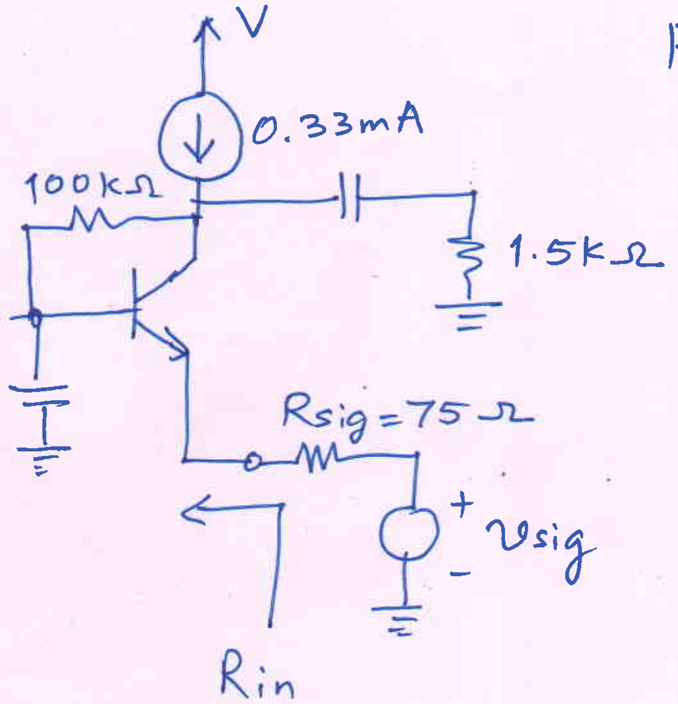
$$R_C = 2.75V/0.5\,mA = \boxed{5.5K}$$

$$G_{vo} = \frac{\alpha R_C}{R_{sig} + r_e} \qquad \bullet\ G_v = \frac{\alpha(R_C \parallel R_L)}{R_{sig} + r_e}$$

$$= \frac{(5.5K \parallel 1K)}{50\Omega + 50\Omega} = \frac{(5.5K \times 1K)/(6.5K)}{100\Omega}$$

$$G_{vo} = \boxed{55\ V/V} \qquad G_v = \boxed{8.4\ V/V}$$

3.141



Find Rin, G_v

Given $\beta = 100$.

$$I_C = 0.33\,mA = \frac{1}{3}\,mA$$

$$g_m = \frac{0.33\,mA}{25\,mV} = \frac{1}{3\times 25} = \frac{1}{75}\,\mho$$

$$r_e = \frac{1}{g_m} = 75\,\Omega$$

$$G_v = \frac{v_o}{v_{sig}} = \frac{\alpha\,(R_C \| R_L)}{R_{sig} + r_e} = \frac{1.5k}{75+75} = \boxed{10}$$

Let us Calculate DC Voltage:

DC resistance of $v_{sig} = 0$.

$$V_E = I_E \cdot R_{sig} \approx \frac{1}{3}\,mA \times 75\,\Omega = \boxed{25\,mV}$$

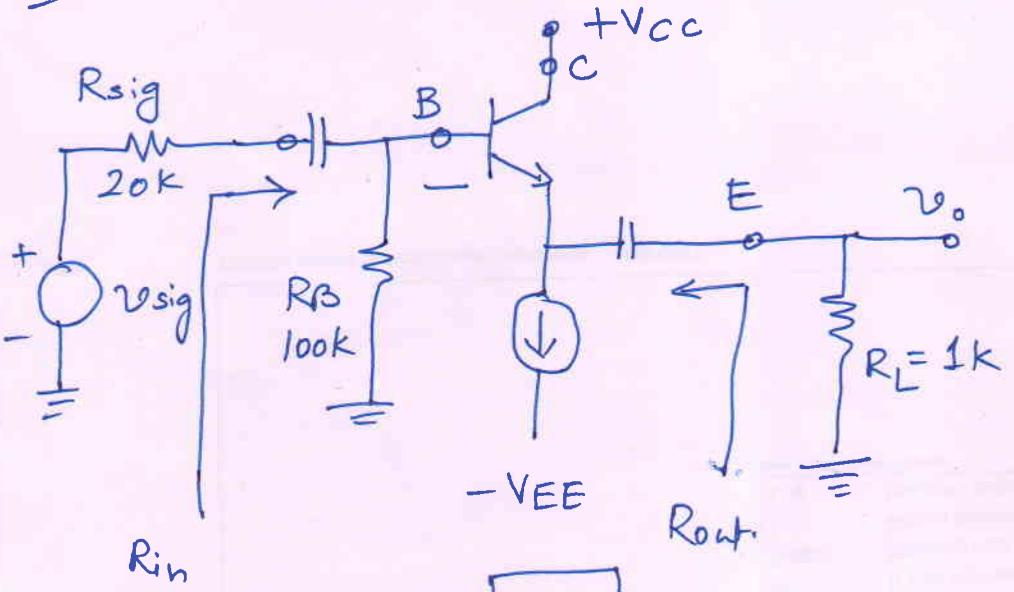
$$V_B = V_E + 0.7V = 25\,mV + 700\,mV = \boxed{725\,mV}$$

$$I_B = I_C/100 = \frac{1}{3mA} \cdot \frac{1}{100} = \frac{1\,mA}{300} = 3.33\,\mu A$$

$$V_C = V_B + I_B \times 100k = 725\,mV + 3.3\,\mu A \times 100k$$

$$= \boxed{1058\,mV}$$

3.142 Emitter Follower Circuit



$I = 1\,mA$

$\beta = 100$

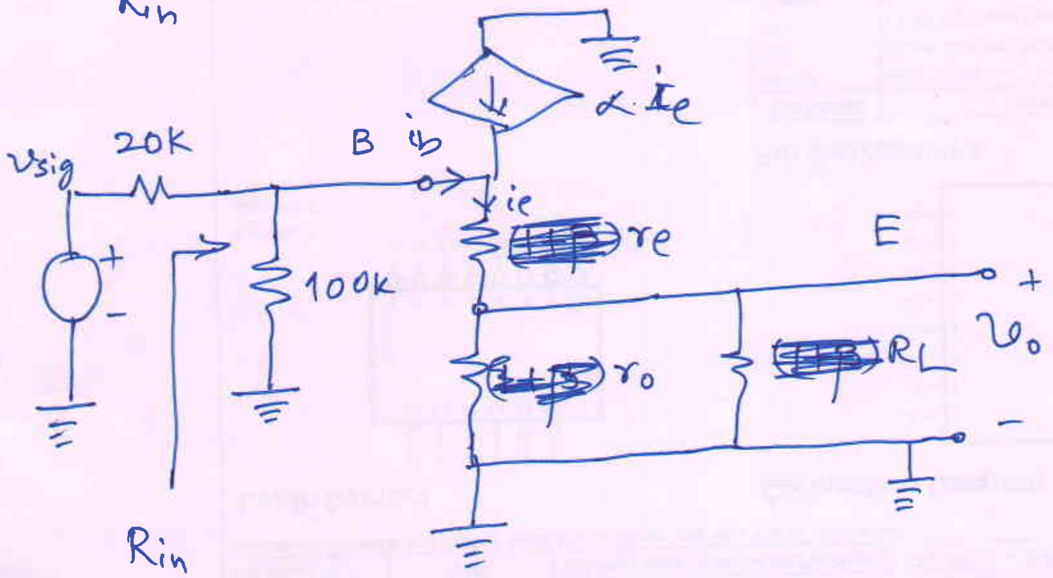
$V_A = 100\,V$

$R_B = 100K$

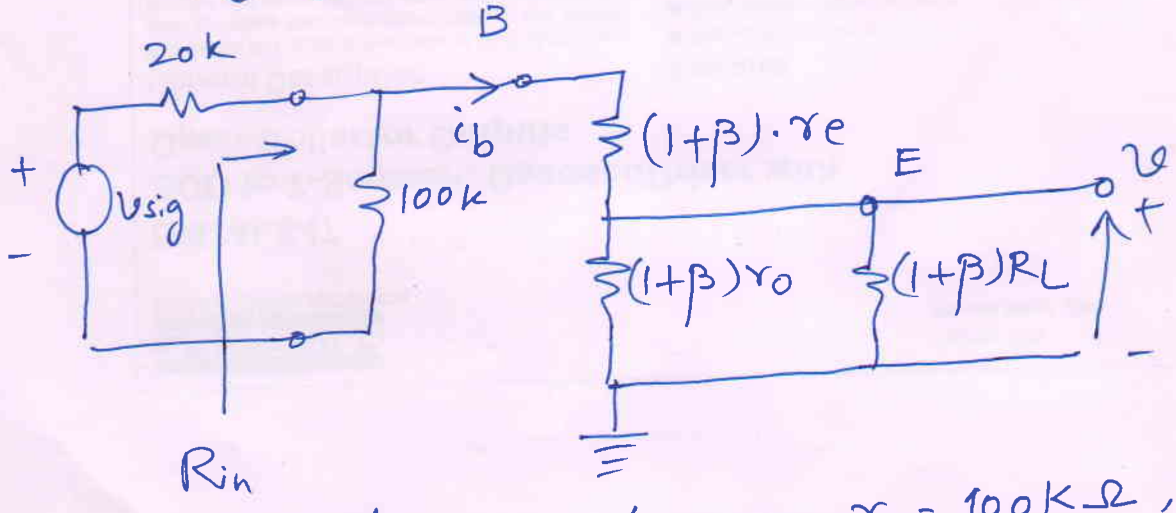
$R_{sig} = 20K$

$R_L = 1K$

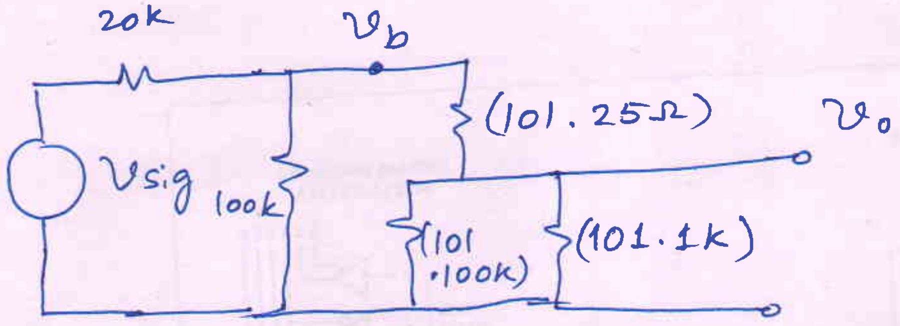
Find R_{in}, v_b/v_{sig} and v_o/v_{sig}, R_{out}.



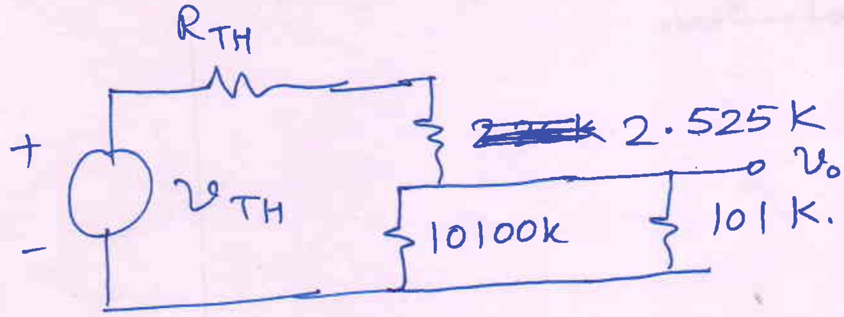
Note that r_e, $(r_o \| R_L)$ has current i_e. Now we reflect resistors in emitter circuit in base by multiplying them with $(1+\beta)$



Calculate $g_m = 40\,m\mho$ $r_o = 100K\Omega$, $r_e = 25\Omega$



Replace 20k & 100k by thevenin equivalent



$$R_{TH} = \frac{20k \times 100k}{20k + 100k} = \frac{2000 k.k.}{120 k} = 16.66 K$$

$$V_{TH} = \frac{100 K}{100 K + 20} . v_{sig} = 0.833 \; v_{sig}.$$

$$v_o = \frac{100 K}{100k + 2.525 k + 16.66 k} . v_{TH}$$

$$= \frac{100 K}{119.19 K} \times 0.833 \times v_{sig}.$$

$$\boxed{\therefore \frac{v_o}{v_{sig}} = 0.698} = G_v.$$

$$\frac{v_o}{v_b} = \frac{100 K}{100 k + 2.525 k} = \boxed{0.975.}$$

$$\frac{v_b}{v_{sig}} = \frac{100 + 2.525K}{100K + 2.525K + 16.66K}$$

$$\boxed{= 0.8601}$$

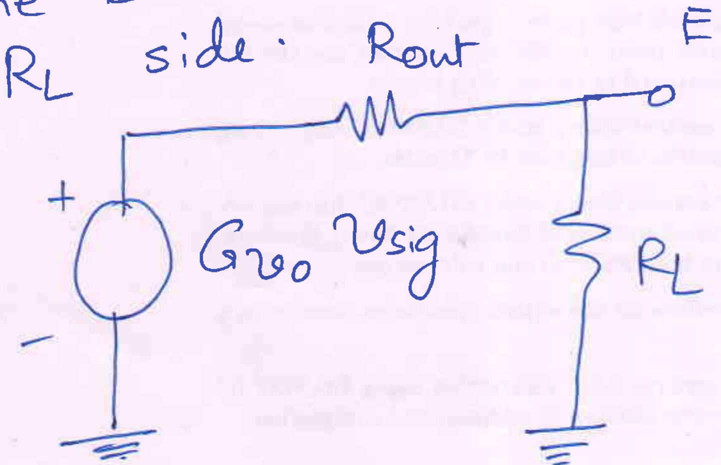
$$R_{in} = 100K \,\|\, (2.525K + 100K)$$

$$= 100k \,\|\, 102.525K$$

$$= \boxed{50.61K}$$

If v_{sig} is a sine wave what should be the max. value at which BJT will remain Conducting? At this v_{sig} what is v_b?

The BJT appears as a Thevenin Model from R_L side:



When Output signal goes negative the signal current in R_L will flow from GND into Emitter. When this becomes equal to DC biasing current I, BJT goes into cutoff.

The most negative signal output voltage $\hat{V}^o$ can be given as

$$\frac{\hat{V}^o}{R_L} = I \text{ (dc bias current)}$$

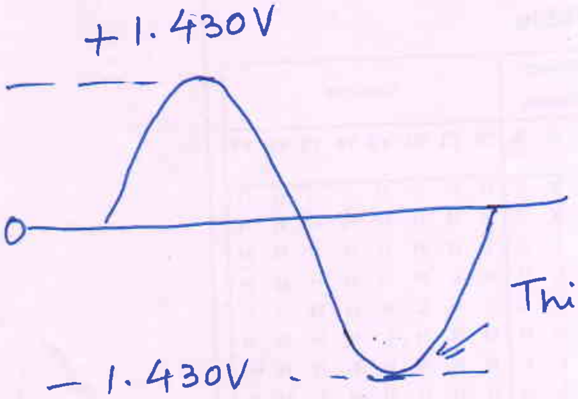
ac signal peak value

or $\hat{V}^o = I \cdot R_L$

or $G_v \cdot \hat{V}_{sig}^o = I \cdot R_L$

$\therefore$ max. permissible signal voltage (negative swing)

$$= \frac{I \cdot R_L}{G_v} = \frac{1\,mA \times 1K}{0.698} = \boxed{1.430V}$$



This will cause BJT to go in cutoff.

v_b at this v_{sig} = $0.8601 \times 1.430 = \boxed{1.230V}$

$$R_{out} = r_o \,\|\, \left(r_e + \frac{R_{sig} \,\|\, R_B}{\beta+1}\right)$$ Note Low Output Resist.

$$= 100K \,\|\, \left(25\Omega + \frac{16.66K}{101}\right) = 100K \| = \boxed{191.3\,\Omega}$$