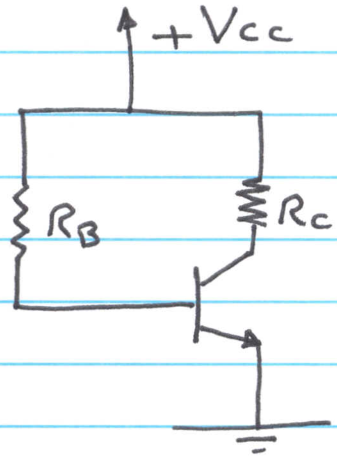
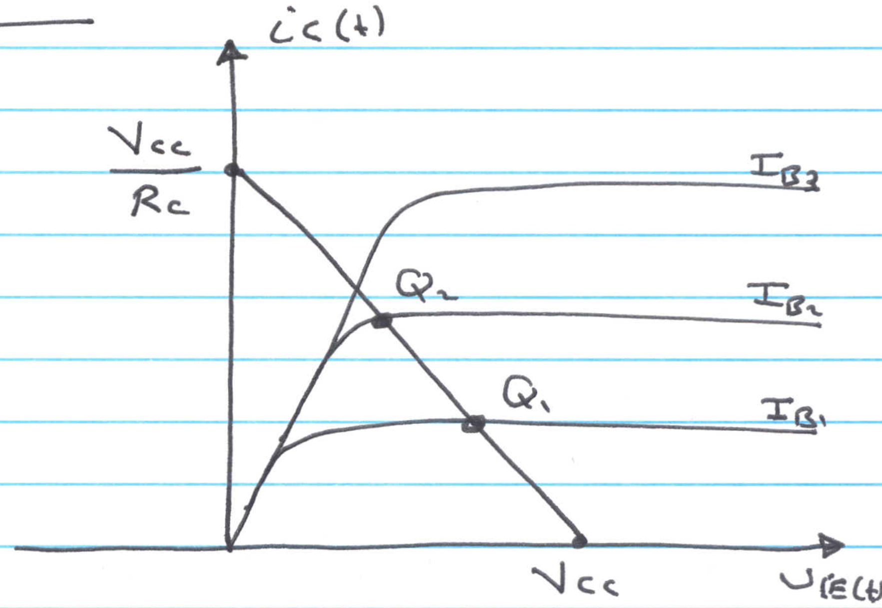
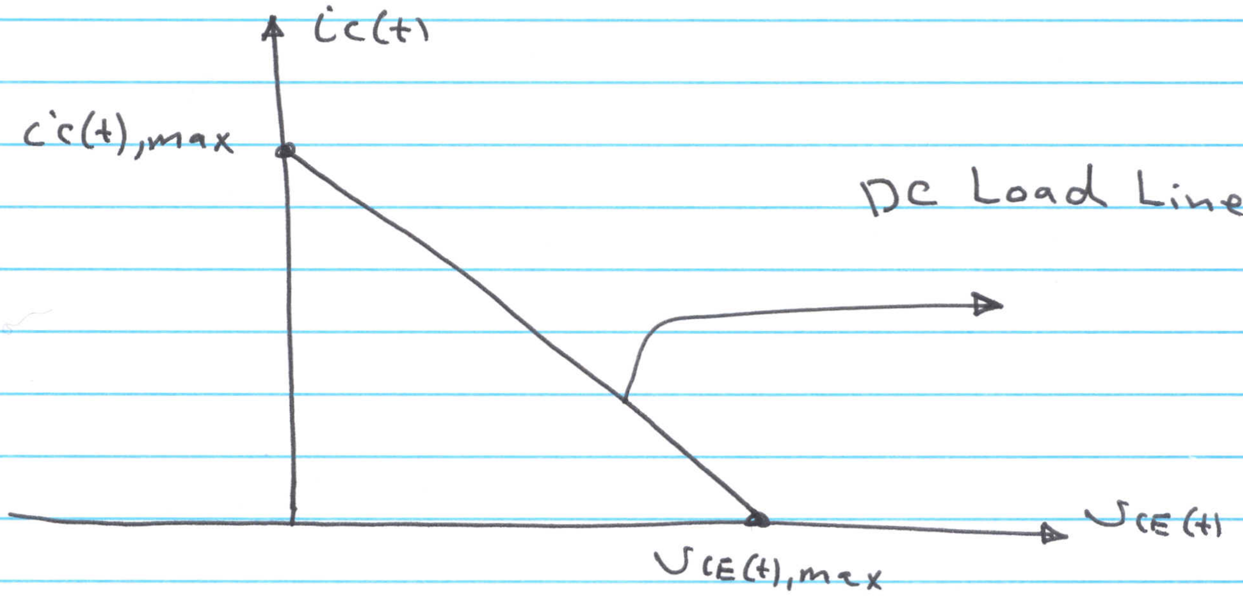
Graphical Method





KVL : $V_{cc} = R_c I_c + V_{CE}$

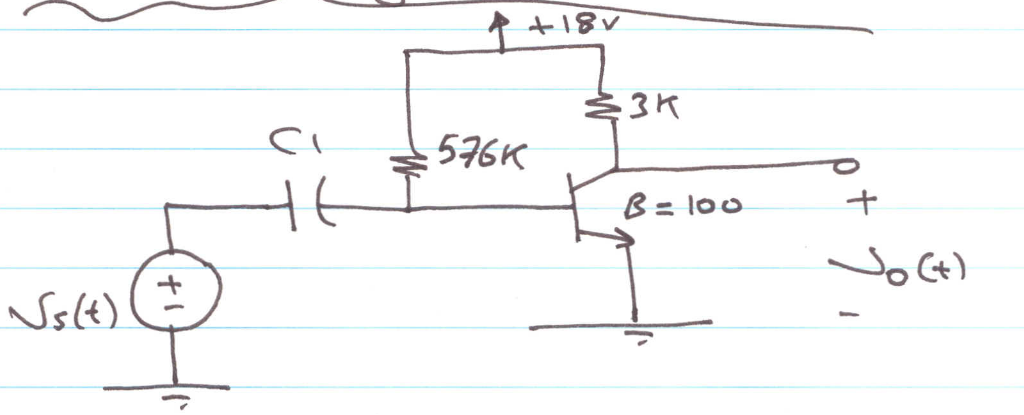
$$I_c = -\frac{1}{R_c} V_{CE} + \frac{V_{cc}}{R_c}$$



$$i_{c(t),max} = \frac{V_{cc}}{R_c} \qquad \text{Saturation}$$

$$v_{CE(t),max} = V_{cc} \qquad \text{Cutoff}$$

Small Signal BJT Amplifier



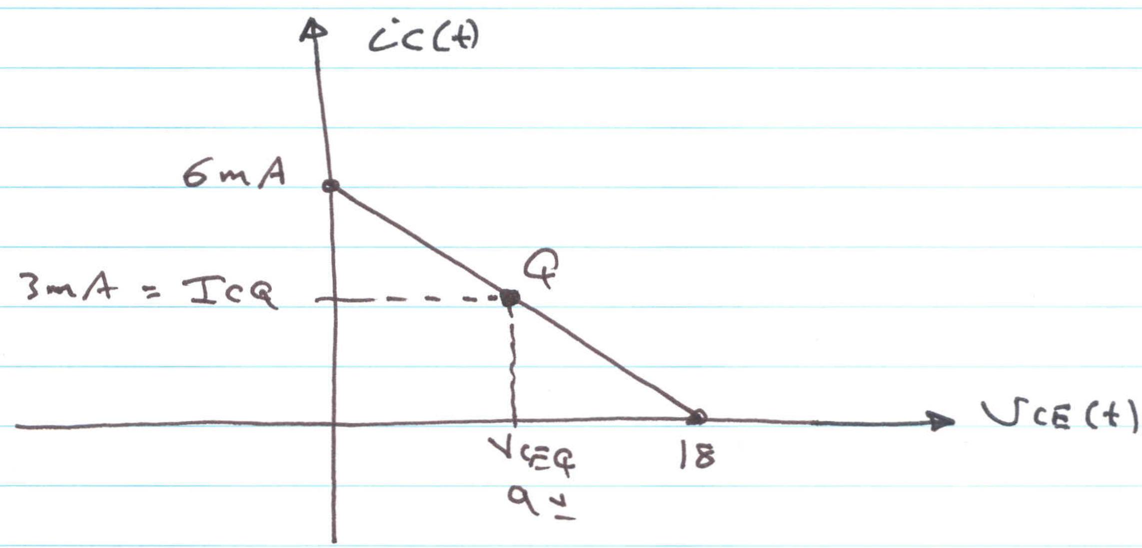
$$V_s(t) = 0.03 \sin \omega t \ \text{v}$$

DC Analysis

$$I_B = \frac{18 - V_{BE}}{R_B} = \frac{18 - 0.65}{576K} = 30 \mu A$$

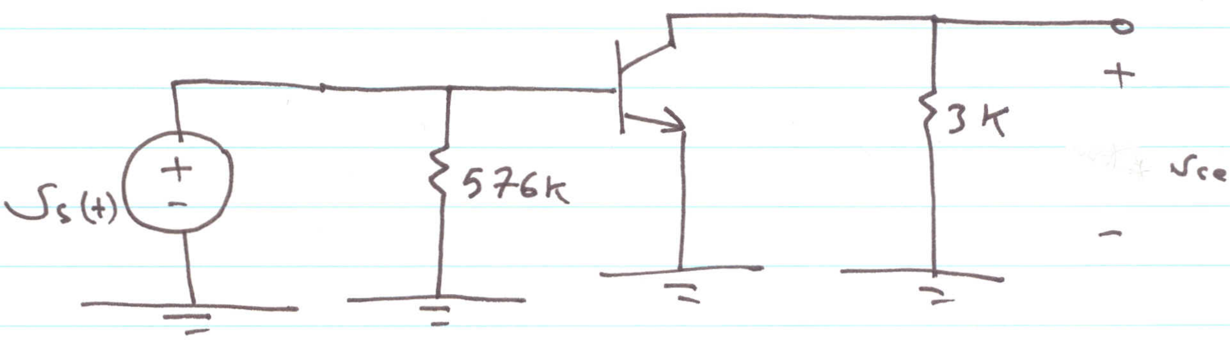
$$I_C = \beta I_B = 3 mA$$

$$V_{CE} = V_{CC} - R_C I_C = 9 \ \text{v}$$



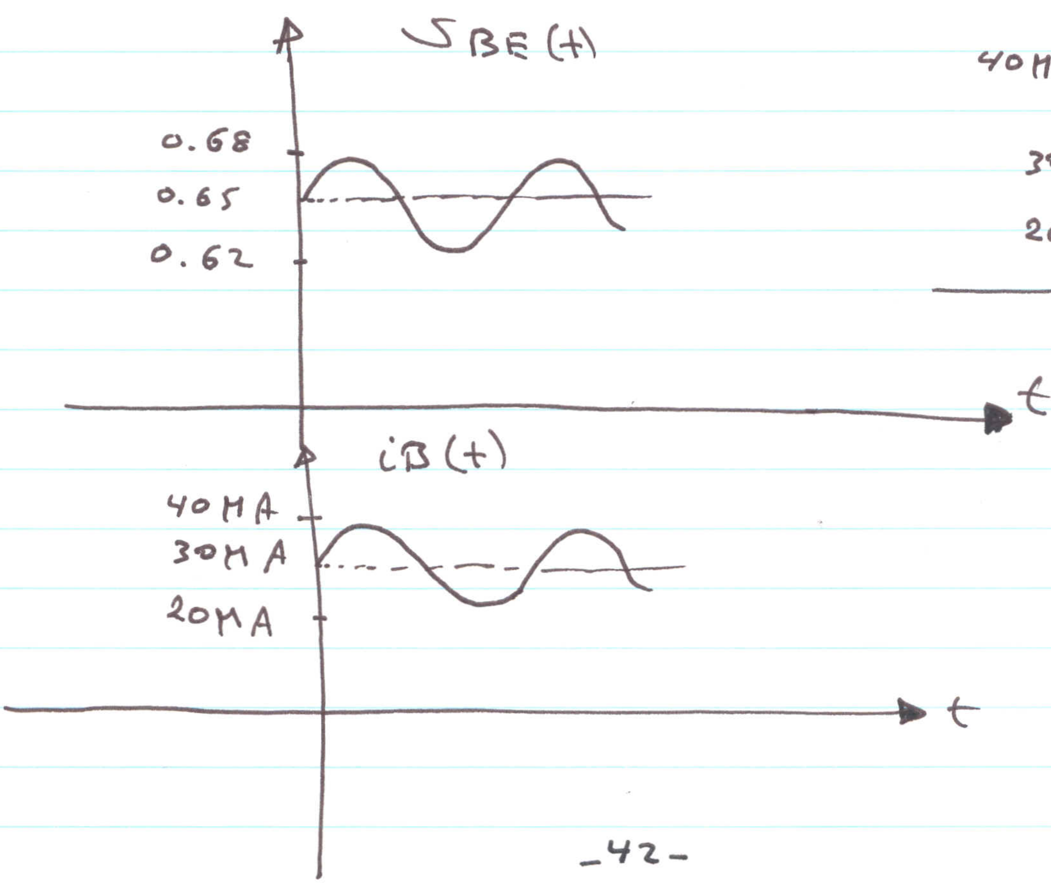
$$v_{BE}(t) = V_{BE} + v_{be}$$
$$i_C(t) = I_{CQ} + i_c$$
$$v_{CE}(t) = V_{CEQ} + v_{ce}$$

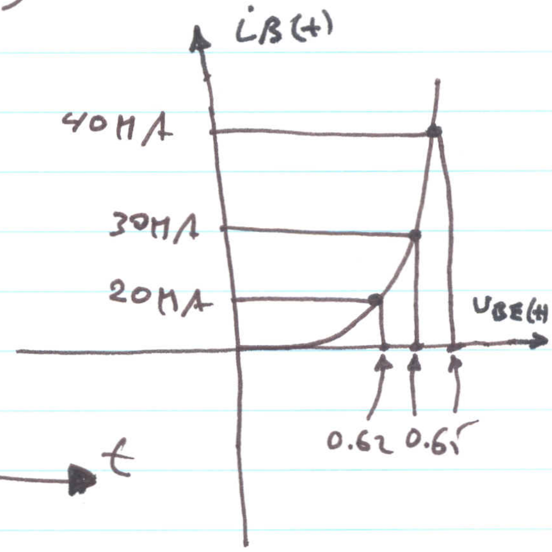
ac equivalent CKT



$$v_{be} = v_s(t) = 0.03 \sin \omega t \ V$$

$$\therefore v_{BE}(t) = 0.65 + 0.03 \sin \omega t \ V$$





when $v_{BE}(t) = 0.65\,V$; $i_B(t) = 30\,\mu A$

$v_{BE}(t) = 0.68\,V$; $i_B(t) = 40\,\mu A$

$v_{BE}(t) = 0.62\,V$; $i_B(t) = 20\,\mu A$

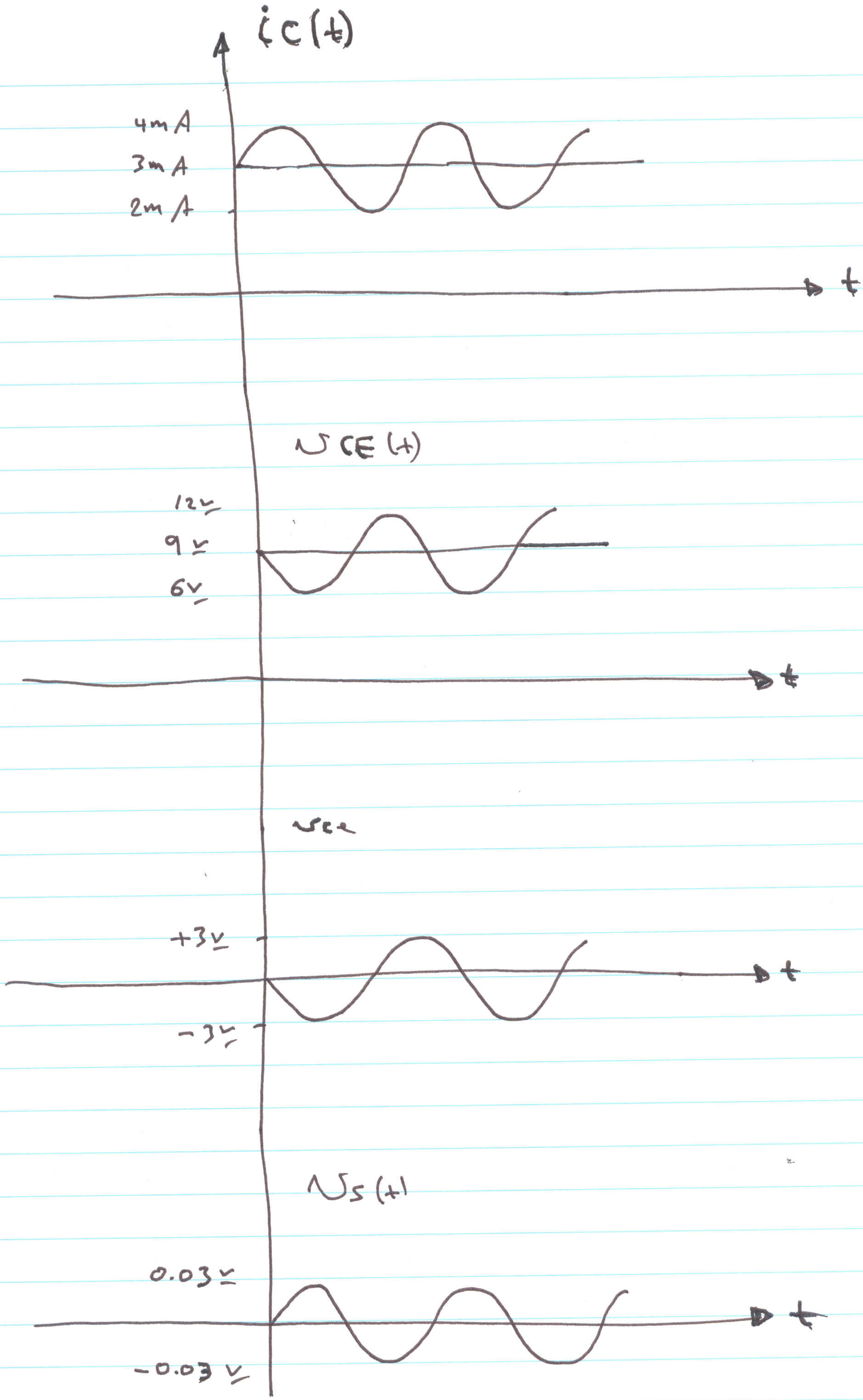
using $i_C(t) = \beta\, i_B(t)$

and $v_{CE}(t) = V_{CC} - R_C\, i_C(t)$

when $i_B(t) = 30\,\mu A$; $i_C(t) = 3\,mA$
$v_{CE}(t) = 9\,V$

when $i_B(t) = 40\,\mu A$; $i_C(t) = 4\,mA$
$v_{CE}(t) = 6\,V$

when $i_B(t) = 20\,\mu A$; $i_C(t) = 2\,mA$
$v_{CE}(t) = 12\,V$

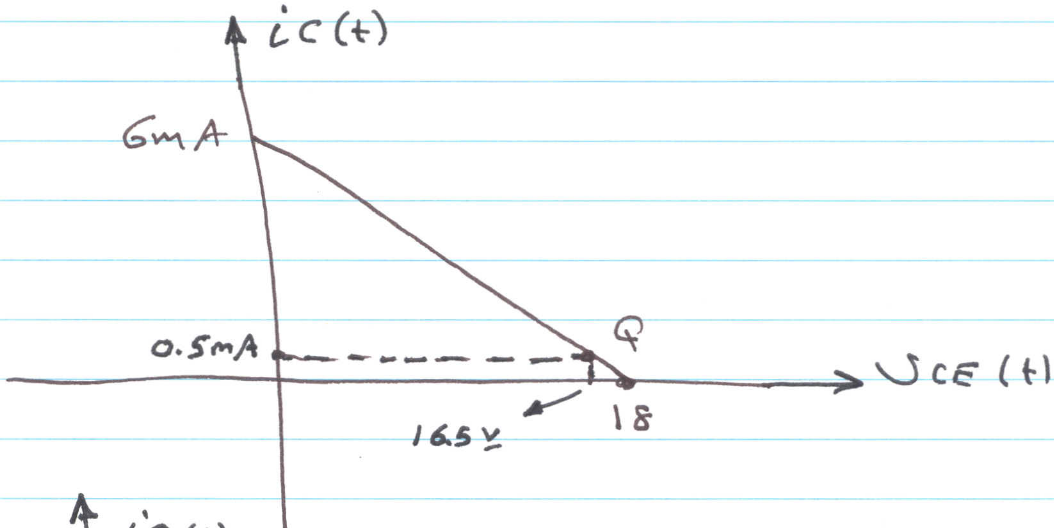

ic(t)
4mA
3mA
2mA
t
vCE(t)
12v
9v
6v
t
vce
+3v
-3v
t
vs(t)
0.03v
-0.03v
t

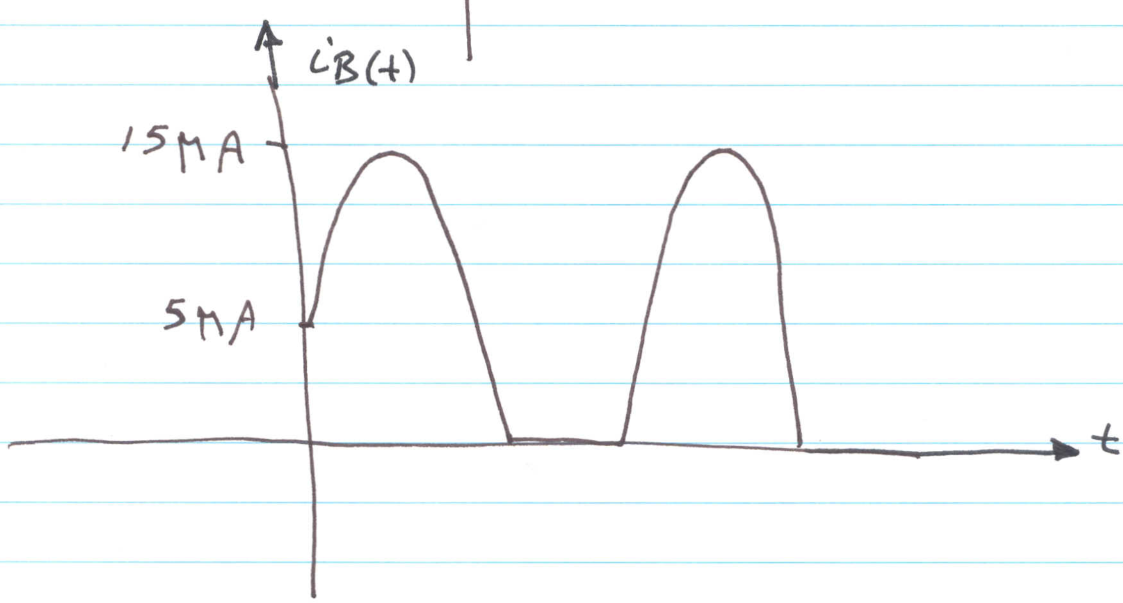
let $R_B = 3.47\,M\Omega$

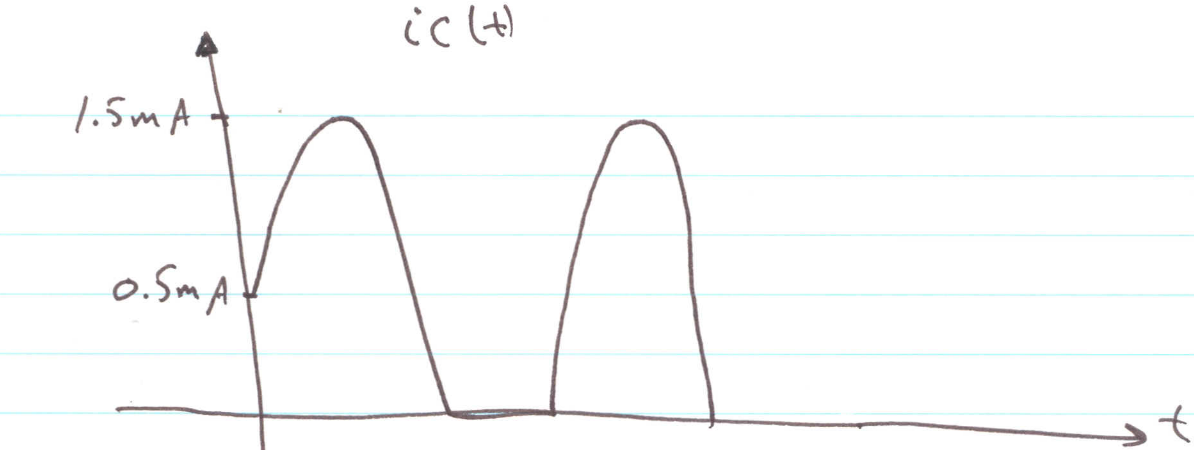
$$I_B = \frac{18 - 0.65}{3.47M} \cong 5\,\mu A$$

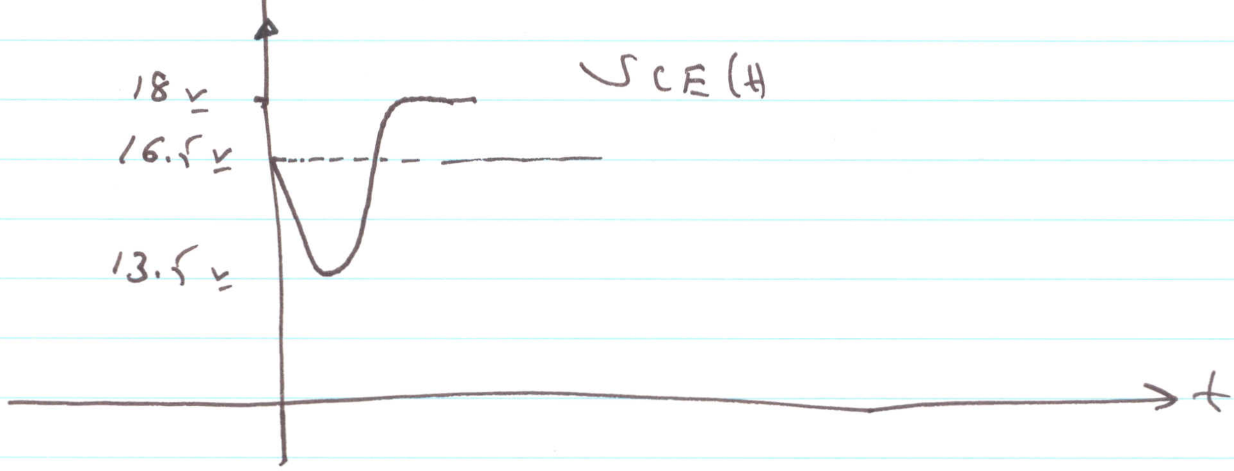
$I_C = 0.5\,mA$

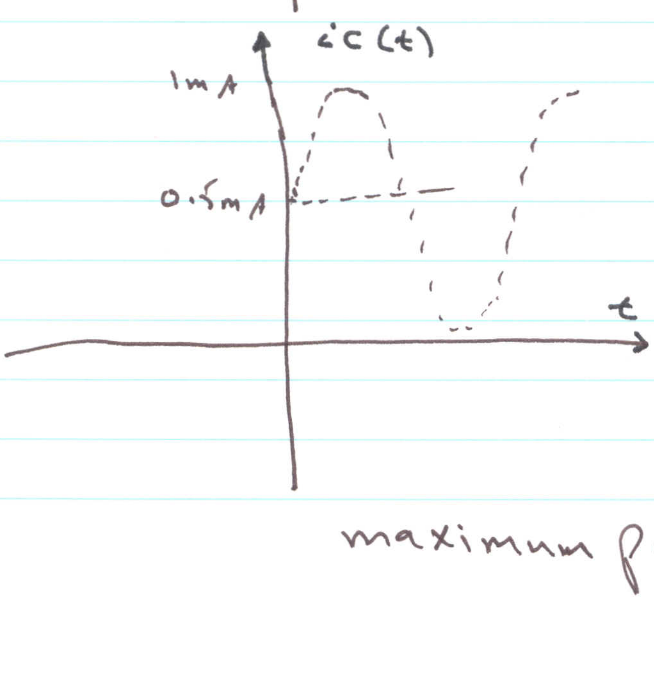
$V_{CE} = 16.5\,V$

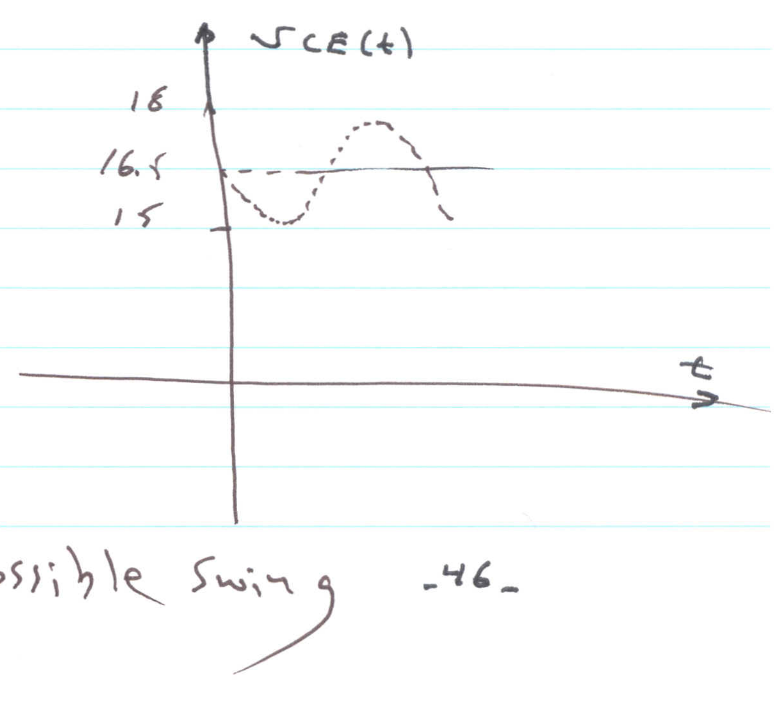








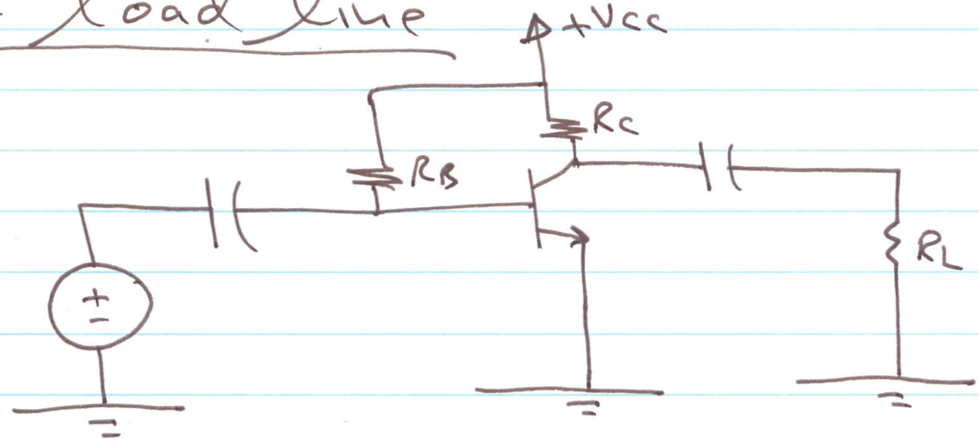


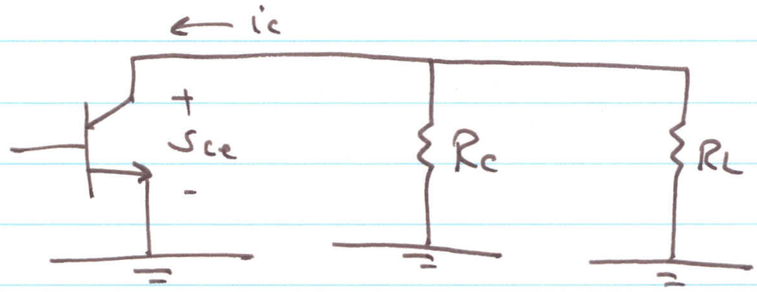


maximum possible swing

-46-

ac load line





$$v_{ce} = -(R_C \| R_L)\, i_c$$

$$v_{ce} = -R_{ac}\, i_c$$

$$v_{CE}(t) - V_{CEQ} = -R_{ac}\left(i_C(t) - I_{CQ}\right)$$

To find $i_C(t),_{max}$, set $v_{CE}(t) = V_{CE,sat} \approx 0$

$$\therefore\ i_C(t),_{max} = I_{CQ} + \frac{V_{CEQ}}{R_{ac}}$$

To find $v_{CE}(t),_{max}$, set $i_C(t) = 0$

$$\therefore\ v_{CE}(t),_{max} = V_{CEQ} + R_{ac}\, I_{CQ}$$

For Maximum symmetrical Swing

$$I_{CQ} = \frac{1}{2} i_c(t)_{,max}$$

$$i_c(t)_{,max} = I_{CQ} + \frac{V_{CEQ}}{R_{ac}} = 2 I_{CQ}$$

$$\therefore \boxed{I_{CQ} = \frac{V_{CEQ}}{R_{ac}}}$$

For DC Condition

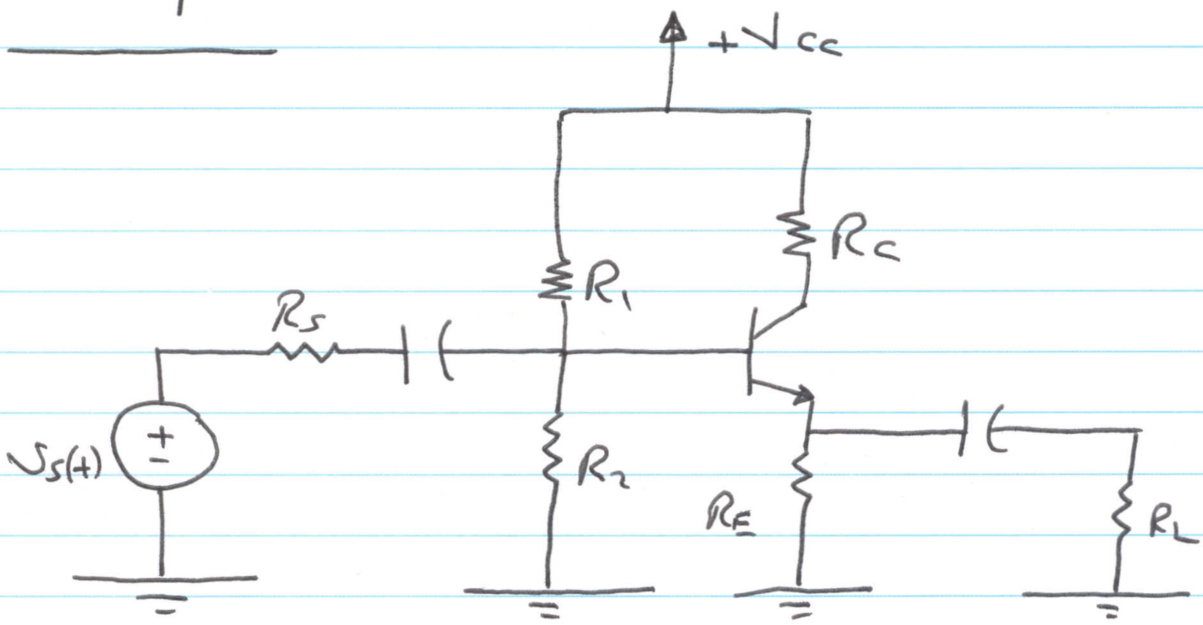
$$V_{CC} = R_C I_C + V_{CE}$$

$$V_{CC} = R_{dc} I_C + V_{CE}$$

$$V_{CC} = R_{dc} I_C + R_{ac} I_C$$

$$\therefore I_{CQ} = \frac{V_{CC}}{R_{ac} + R_{dc}}$$

Example



For maximum symmetrical swing

$$I_{CQ} = \frac{V_{CC}}{R_{ac} + R_{dc}}$$

$$R_{dc} = R_C + R_E$$

$$R_{ac} = R_C + R_E \parallel R_L$$

$$V_{CEQ} = R_{ac} \, I_{CQ}$$