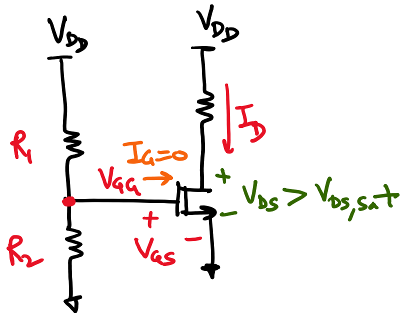
ECE 310 - Lecture 31

Friday, April 13, 2018 10:29 AM

Resistive Divider Biasing:



$(V_{GS}, V_{DS}, I_D) \leftarrow$ DC operating point

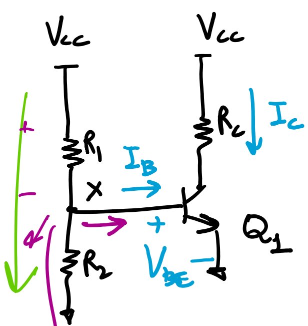
↳ g_m, r_o

THz

300 GHz – 1 THz

InP, GaAs BJTs

Ignoring $I_B \simeq 0$ (assuming $I_B \ll I_C$)



Ex 5.8

$$V_x = V_{cc} - \left(\frac{V_{cc}}{R_1+R_2} + I_B\right)R_1$$

$$V_x = \frac{R_2}{R_1+R_2} V_{cc} = V_{BE}$$

$$v_T = \frac{kT}{q} = 26\,mV \text{ @ } 300K$$

$$I_C \simeq I_S e^{(V_{BE}/v_T)}$$

$I_S = 10^{-17}$ A, $\beta = 100$, $R_1 = 17k\Omega$, $R_2 = 8k\Omega$, $V_{cc} = 2.5V$

$$V_x = 2.5 \times \frac{8k\Omega}{25k} = 0.8V$$

$$I_C = I_S e^{V_{BE}/v_T} = \boxed{231\,\mu A}$$

$$\underbrace{V_{CE}}_{V_{DS}} = V_{cc} - I_C \times R_c = 1.345V$$

$$V_{BE} = 0.8V$$

$\because V_{CE} > V_{BE} \Rightarrow Q_1$ is in FA Region

$\beta = 100$

$$I_B = \frac{I_C}{\beta} = \boxed{2.3\mu A}$$

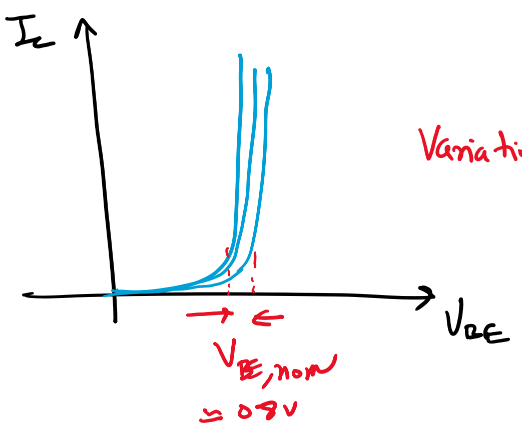
for I_B to be negligible, we need

$$I_B \ll \frac{V_{CC}}{R_1+R_2}$$

$$\frac{2.5}{25k}$$

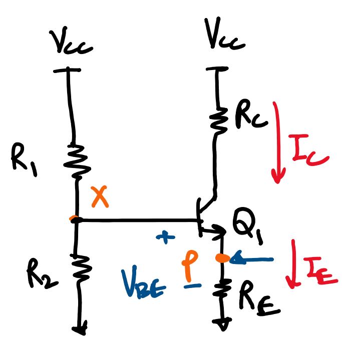
$$2.3\mu A \ll 100\mu A$$

Burning power here



Variations in BJT nominal V_{BE} $\Rightarrow$ $V_{BE,nom} \simeq 0.8V$

4-Resistance Biasing



If Q_1 is in FAR $\Rightarrow$ $\beta >> 1$

assume I_B can be neglected $(I_B \simeq 0)$

$I_E \simeq I_C$

$$V_P = V_X - V_{BE} \rightarrow (1)$$

$$I_E \simeq I_C = \frac{V_P}{R_E} = I_s e^{V_{BE}/V_T} \rightarrow (2)$$

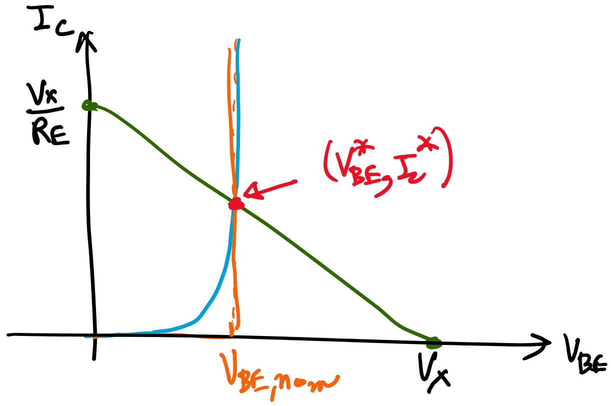
Solve for V_{BE}, I_C

$$\frac{V_X - V_{BE}}{R_E} = I_s e^{V_{BE}/V_T}$$

$$\frac{V_x - V_{BE}}{R_E} = I_s e^{V_{BE}/V_T}$$

$\rightarrow V_{BE} = ?$

* Use load line



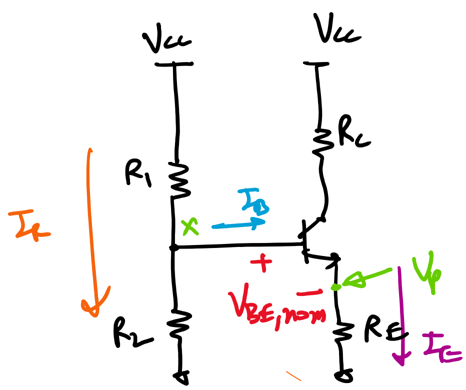
* for MOSFET, we used to solve quadratics

↳ here, we have exponential equation

If BE junction is forward-biased, we can assume that

$V_{BE} \simeq V_{BE,nom} = 0.8V$

Si ⇒ 0.65V to 0.8V



$I_B \ll I_R$

$$V_p \simeq \overbrace{\frac{V_{cc} \cdot R_2}{R_1 + R_2}}^{1V} - \overbrace{V_{BE,nom}}^{0.8V}$$

$$I_E = \frac{V_p}{\underset{1k\Omega}{R_E}} = \frac{0.2V}{1k\Omega} = 200\mu A$$

Check whether Q_1 is in FAR

$V_{CE} > V_{BE}$

↓

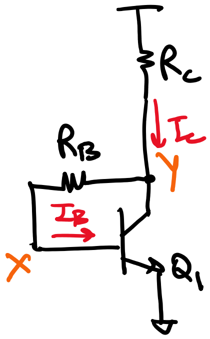
$V_{cc} - I_C R_C$

$\uparrow$

$= I_E$

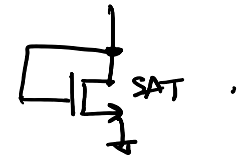
$I_B = \frac{I_C}{\beta}$

$R_E \Rightarrow$ desensitizes I_C w.r.t manufacturing variations in $V_{BE,nom.}$



$V_X = V_Y - I_B \cdot R_B$

V_{BE} V_{CE}



$V_{BE} < V_{CE}$

* Q_1 is always in FAR

$$V_Y = V_{CC} - I_C R_C \longrightarrow (1)$$

Also,

$$V_Y = I_B R_B + V_{BE} \longrightarrow (2)$$

$$= R_B \cdot \frac{I_C}{\beta} + V_{BE}$$

(1) & (2) give

$$I_C = \frac{V_{CC} - V_{BE}}{R_C + \frac{R_B}{\beta}}$$

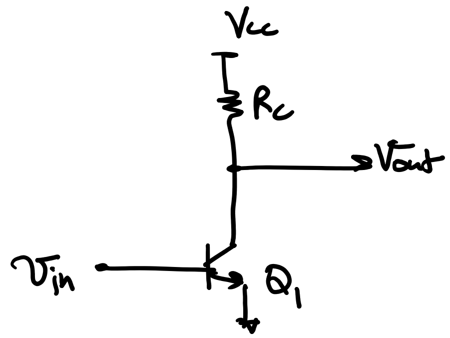
for lower sensitivity to 'β' $\Rightarrow$ $R_C \gg \frac{R_B}{\beta}$

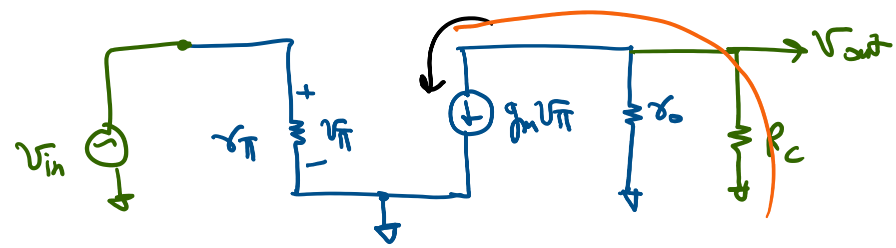
Friday, April 13, 2018 11:10 AM

CE Amplifier

CS

$$A_v = \frac{v_{out}}{v_{in}} = ?$$





$$v_{out} = -g_m v_\pi (r_o \| R_c)$$

$$= -g_m v_{in} (r_o \| R_c)$$

$$r_o = \frac{V_A}{I_c}$$

$$A_v = \frac{v_{out}}{v_{in}} = \boxed{-g_m (r_o \| R_c)}$$

CE with Emitter Degeneration