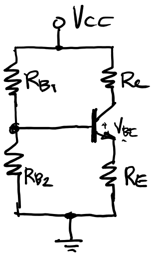
BJT Biasing

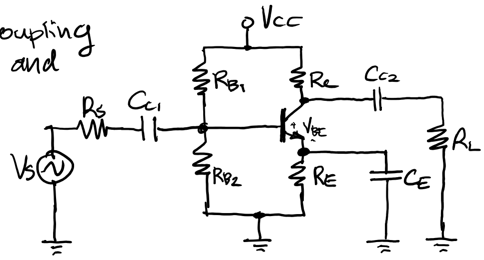
October 10, 2017 4:21 PM

Basic Bias Circuit:

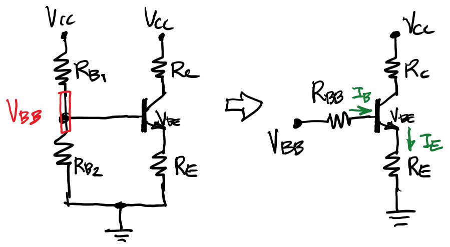
- Used for common-emitter and common-base transistors.



With Bypass & Coupling Capacitors, load, and Source:



Thevenin Transformation:



$$V_{BB} = V_{CC}\left(\frac{R_{B2}}{R_{B1}+R_{B2}}\right)$$

$$R_{BB} = R_{B1} \parallel R_{B2}$$

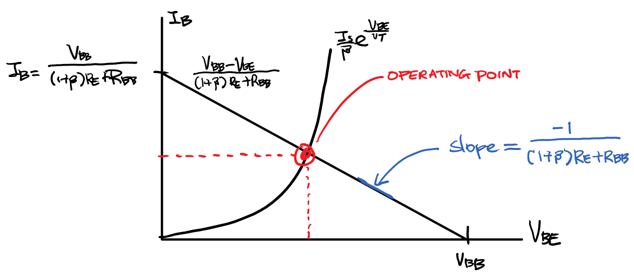
Using mesh analysis, we find I_B:

$$V_{BB} = I_B \cdot R_{BB} + V_{BE} + I_E \cdot R_E$$

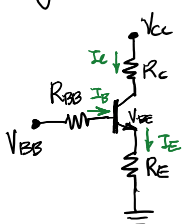
$$I_E = (1+\beta) I_B$$

$$\rightarrow I_B = \frac{V_{BB} - V_{BE}}{(1+\beta)R_E + R_{BB}}$$

Recall the relation: $I_B = \frac{I_C}{\beta} = \frac{I_S}{\beta} e^{\frac{V_{BE}}{V_T}}$, we plot the two and find operating point



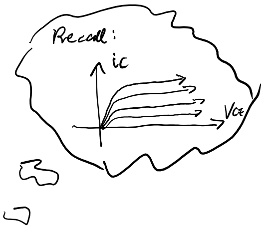
Finding DC operating point



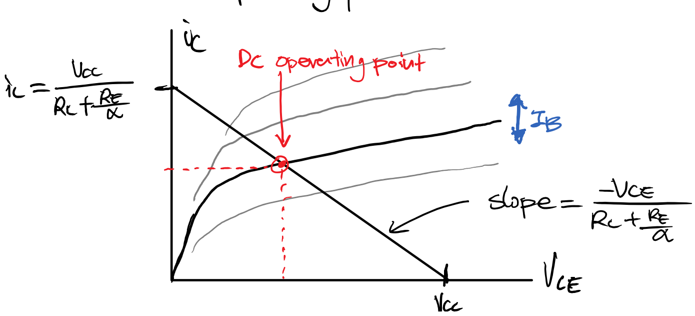
Start with mesh: $V_{CC} = I_C R_C + V_{CE} + I_E R_E$, $I_E = \frac{I_C}{\alpha}$

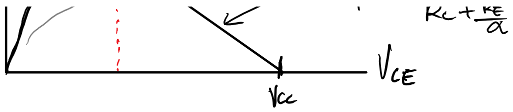
$$V_{CC} = I_C\left(R_C + \frac{R_E}{\alpha}\right) + V_{CE}$$

I_C as function of V_{CE}: $I_C = \frac{V_{CC} - V_{CE}}{\left(R_C + \frac{R_E}{\alpha}\right)}$



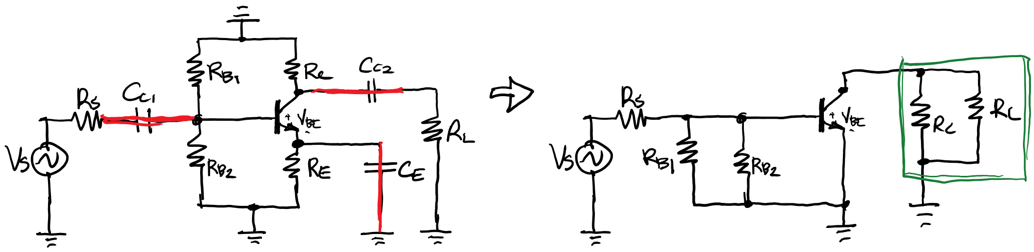
DC operating point is the intersection of I_C and characteristic curves



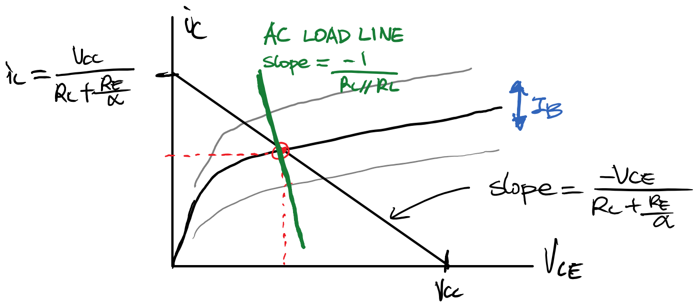


Finding AC Operating Point.

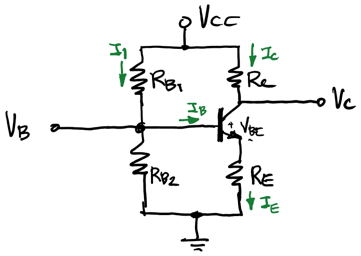
In AC small signal model, DC sources → 0
capacitors → SC



Thus our load line is $\frac{-1}{R_C // R_L}$



First Version of the 1/3 Rule:



① $V_B = \frac{1}{3} V_{CC}$

② $V_C = \frac{2}{3} V_{CC}$

③ $I_1 = \frac{I_E}{\sqrt{\beta}}$

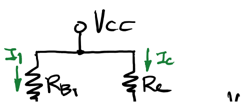
or

$I_1 = 0.1\, I_E$

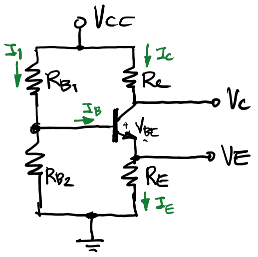
From the 3 rules, we proceed to calculate.

- $I_C = \frac{V_{CC} - V_C}{R_C} = \frac{\frac{1}{3} V_C}{R_C}$ → $R_C = \frac{V_{CC}}{3 I_C}$
- $I_1 = \frac{I_E}{\sqrt{\beta}} = \frac{V_{CC} - V_B}{R_{B1}} = \frac{\frac{2}{3} V_{CC}}{R_{B1}}$ → $R_{B1} = \frac{2V_{CC}}{3 I_1} = \frac{2 V_{CC} \sqrt{\beta}}{3 I_E}$
- $I_B = I_1 - \frac{V_B}{R_{B2}} = \frac{I_E}{\sqrt{\beta}} - \frac{V_B}{R_{B2}} = \frac{I_E}{\sqrt{\beta}} - \frac{\frac{1}{3} V_{CC}}{R_{B2}}$ → $R_{B2} = \frac{R_{B1}}{2}\left(\frac{1}{1 - 1/\sqrt{\beta}}\right)$
- $I_E = \frac{V_E}{R_E} = \frac{\frac{1}{3} V_{CC} - V_{BE}}{R_E}$ → $R_E = \left(\frac{\frac{1}{3} V_{CC} - V_{BE}}{I_E}\right)$, usually $V_{BE} = 0.7V$

Second Version of the 1/3 Rule:



① $V_C = \frac{2}{3} V_{CC}$



① $V_C = \frac{2}{3} V_{CC}$

② $V_E = \frac{1}{3} V_{CC}$

③ $I_1 = \frac{I_E}{\sqrt{\beta}}$

OR

$I_1 = 0.1 I_E$

$\rightarrow R_C = \frac{V_{CC}}{3 I_C} \approx R_E$

$\rightarrow R_{B1} = \frac{\frac{2}{3}V_{CC} - V_{BE}}{I_E / \sqrt{\beta}}$

$\rightarrow R_{B2} = \frac{\frac{1}{3}V_{CC} + V_{BE}}{\left(\frac{1}{\sqrt{\beta}} - \frac{1}{\beta+1}\right) I_E} \approx \frac{\left(\frac{1}{3}V_{CC} + V_{BE}\right)\sqrt{\beta}}{I_E}$ for large β.

Usually $V_{BE} = 0.7V$