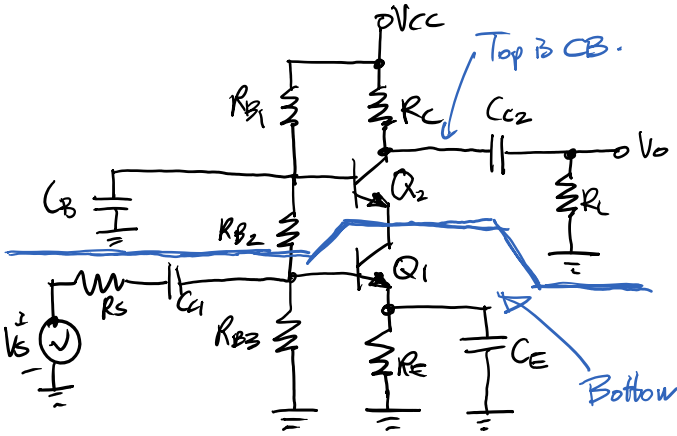
The Cascode

October 24, 2017 3:34 PM

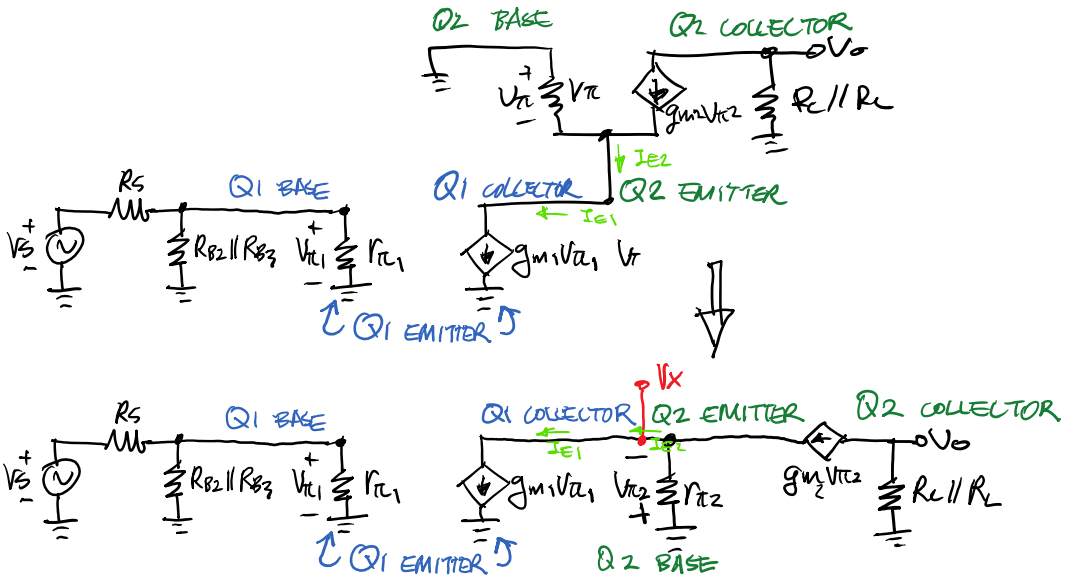


Problem with common emitter:
Miller effect → Big capacitance
→ limited bandwidth

Problem with common base:
small input impedance → small gain.

Usually C_B & C_E is very large. (since this model is very hard to analyze impedance)

Midband Small Signal Model



$$g_{m1}V_{\pi1} = g_{m2}V_{\pi2} + \frac{V_{\pi2}}{r_{\pi2}}$$

$$\frac{I_{C1}}{V_T}V_{\pi1} = \frac{I_{C2}}{V_T}V_{\pi2} + \frac{V_{\pi2}}{r_{\pi2}} \qquad g_{m2} = \frac{I_{C2}}{V_T} = \frac{\beta_2}{r_{\pi2}}$$

$$= \left(\frac{\beta_2 + 1}{r_{\pi2}}\right)V_{\pi2}$$

$$= \left(\frac{\beta_2+1}{\beta_2}\right)\frac{I_{C2}}{V_T}V_{\pi2}$$

$$I_{C1}V_{\pi1} = \left(\frac{\beta_2+1}{\beta_2}\right)I_{C2}V_{\pi2}$$

$$I_{C1}V_{\pi1} = I_{E2}V_{\pi2}$$

$I_{C1} = I_{E2}$ (Emitter of Q2 is connected to collector of Q1)

$$\rightarrow V_{\pi1} = V_{\pi2}$$

$$\rightarrow V_x = -V_{\pi1} = -V_{\pi2}$$

$\rightarrow V_{\pi 1} = V_{\pi 2}$

$\rightarrow V_x = -V_{\pi 1} = -V_{\pi 2}$

↑ Needed for Miller Theorem

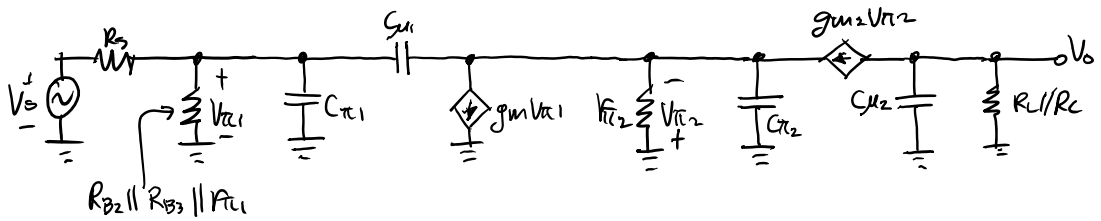
$$A_M = \frac{V_o}{V_{\pi 2}} \cdot \frac{V_{\pi 2}}{V_{\pi 1}} \cdot \frac{V_{\pi 1}}{V_s}, \quad \frac{V_{\pi 2}}{V_{\pi 1}} = 1$$

$$= \frac{V_o}{V_{\pi 2}} \cdot \frac{V_{\pi 1}}{V_s}$$

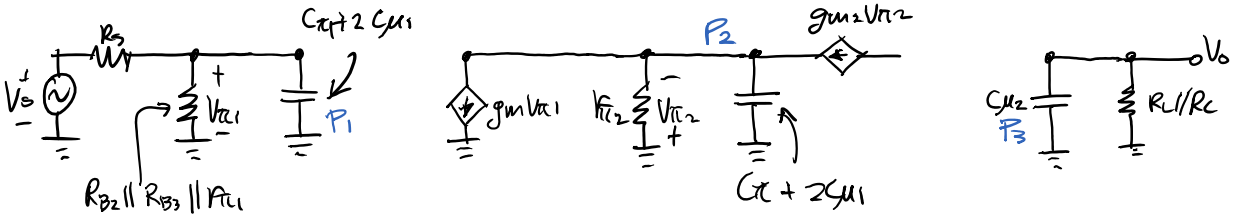
$$= -\frac{g_{m2} V_{\pi 2} \times R_C \| R_L}{V_{\pi 2}} \cdot \frac{V_s \cdot R_{B2} \| R_{B3} \| r_{\pi 1}}{(R_s + R_{B2} \| R_{B3} \| r_{\pi 1}) V_s}$$

$$= -g_{m2}(R_C \| R_L) \cdot \frac{R_{B2} \| R_{B3} \| r_{\pi 1}}{R_s + R_{B2} \| R_{B3} \| r_{\pi 1}}$$

High Frequency



MILLER:

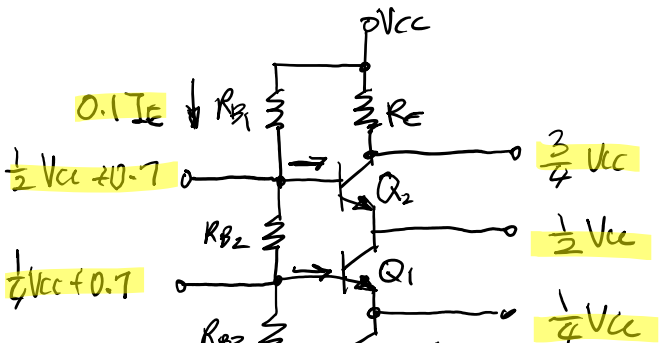


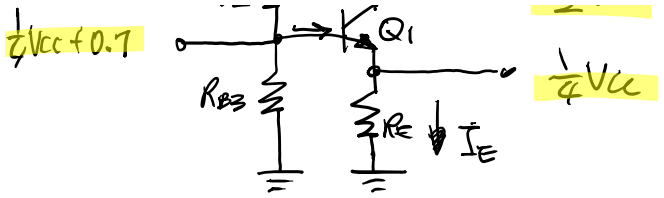
$$\omega_{HP1} = \frac{1}{(C_{\pi 1} + 2C_{\mu 1})(R_s \| R_{B2} \| R_{B3} \| r_{\pi 1})}$$

$$\omega_{HP2} = \frac{1}{\left(\frac{r_{\pi 2}}{1+g_{m2}}\right)(C_{\pi 2} + 2C_{\mu 1})}$$

$$\omega_{HP3} = \frac{1}{(C_{\mu 2})(R_L \| R_C)}$$ ← possible dominant pole.

Biasing Cascode




½Vcc + 0.7
Q1
RB3
RE
IE
½Vcc