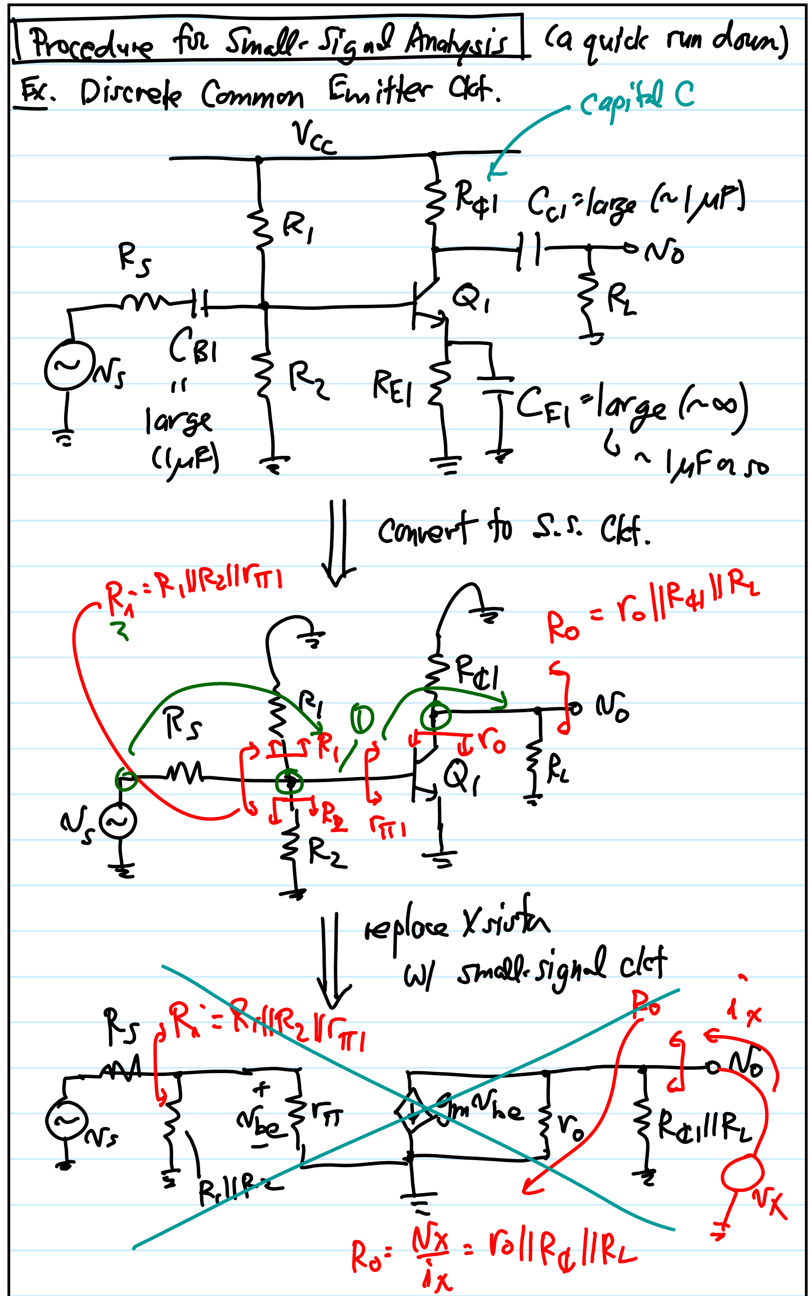
- Today:
  - Inspection analysis for input resistance, output resistance, and gain
- But first: Logistics
- Passed out sign up sheet for discussion sections
- Problem with the Wednesday section: 2:30-3:30 p.m. might not work
  - Possible to switch to Thursday, 2-3?
- Some people cannot make the Monday 5-7 lab
  - Solution: whenever the lab is such that instruments in the lab need to be used, the lab will be 4-6 on Monday; otherwise, it will be 5-7



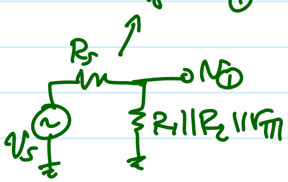
Procedure:

1. Find the DC operating pt. → get voltages & currents at all nodes & branches, respectively
2. Determine S.S. parameters for devices in the signal path (e.g., g_m, r_π, r_o, ...)
3. Convert the full ckt. to the S.S. ckt
   - ⇒ zero out DC sources
   - ⇒ short out large capacitors

4a) If needed, replace Xristor w/ its small-signal ckt.
   - ⇒ this should NOT be needed often
   - ⇒ when is it needed? → generally in cases where there is feedback!

4b) Analyze by inspection based on prior S.S. analysis experience! → this should be the case 99% of the time

$$A_v = \frac{v_{①}}{v_s}\cdot\frac{v_o}{v_{①}} = -\left(\frac{R_1\|R_2\|r_{\pi1}}{R_1\|R_2\|r_{\pi1}+R_s}\right)g_{m1}(R_{c1}\|R_L)$$

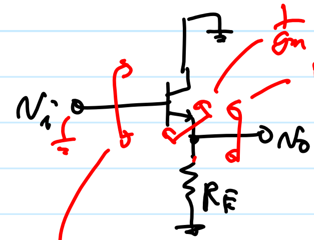


$$\frac{v_{①}}{v_s} = \frac{R_1\|R_2\|r_{\pi1}}{R_1\|R_2\|r_{\pi1}+R_s}$$

$$\frac{v_o}{v_{①}} = -G_m R_{ⓒ} = -g_{m1}(R_{c1}\|R_L\|r_o) \approx -g_{m1}(R_{c1}\|R_L)$$

g_{m1} ; $R_{ⓒ} = R_{c1}\|R_L\|r_o$; $r_o \gg R_L, R_{c1}$

Ex. Common-Collector:



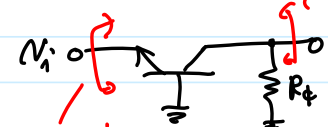
$R_o = \frac{1}{g_m}\|R_E$

$R_i = r_\pi + (\beta+1)R_E$

$$\frac{v_o}{v_i} = \frac{R_E}{r_e+R_E} = \frac{(\beta+1)R_E}{r_\pi+(\beta+1)R_E}$$

$\frac{1}{g_m} \sim \frac{\beta}{g_m} = r_\pi$

Ex. Common-Base:



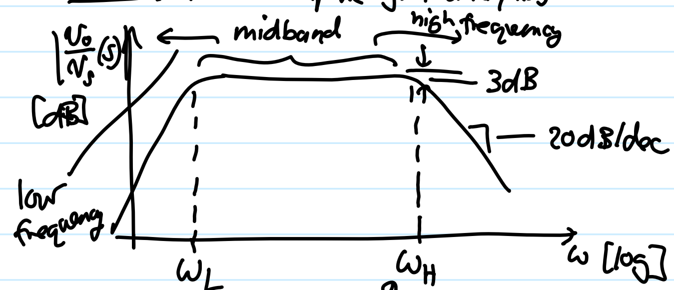
$R_o = r_o\|R_c$

$R_i \approx \frac{1}{g_m}$

$$\frac{v_o}{v_i} = g_m(r_o\|R_c) \approx g_m R_c$$

⇒ so far, we've been talking about "midband" analysis

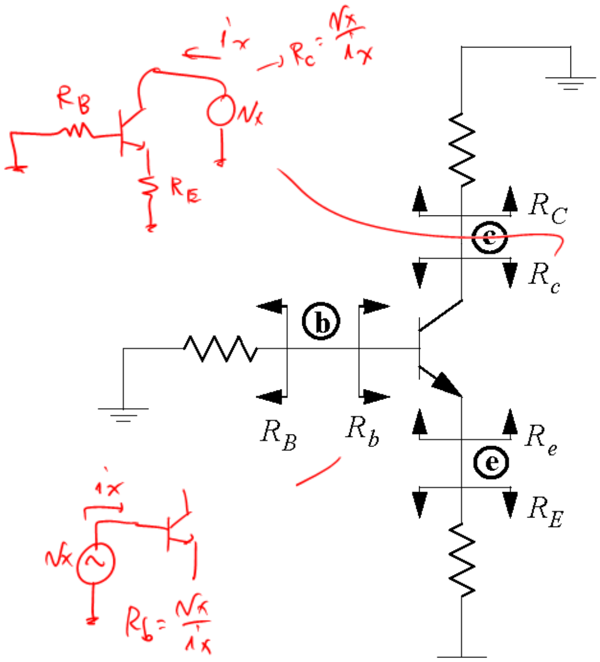
→ Bode Plot: (for the amp we just analyzed)



we want this!
use OCTC (open ckt time constant) analysis

Useful Inspection Formulas

The General Case (Midband)



Node Resistances:

$$R_{\textcircled{c}} = R_C \parallel R_c$$

$$R_{\textcircled{e}} = R_E \parallel R_e$$

$$R_{\textcircled{b}} = R_B \parallel R_b$$

$$R_b = (r_e + R_E)(\beta + 1) = r_\pi + (\beta + 1)R_E$$

$$R_e = \frac{r_\pi + R_B}{\beta + 1} \cong \frac{1}{g_m} + \frac{R_B}{\beta + 1}$$

$$R_c = r_o\left[1 + \frac{g_m R_E}{1 + (R_B / r_\pi)}\right]$$

Base-to-Collector Gain:

$$\frac{v_c}{v_b} = -G_m R_{\textcircled{c}} \qquad G_m = \frac{g_m}{1 + g_m R_E}$$

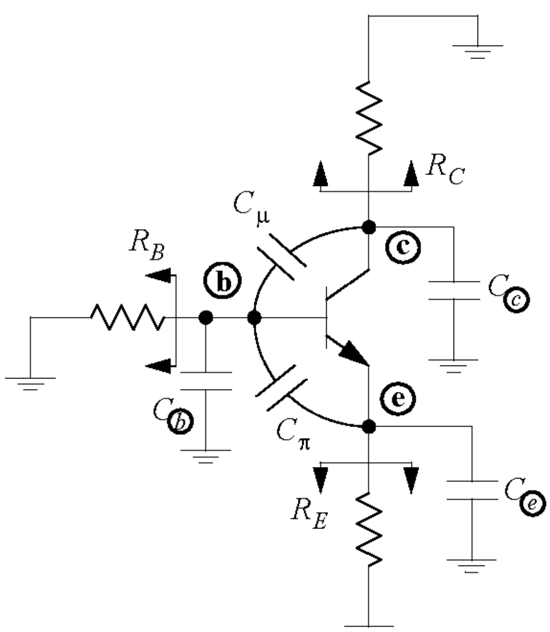
Emitter-to-Collector Gain:

$$\frac{v_c}{v_e} = -G_m R_{\textcircled{c}} \qquad G_m = -\left(\frac{r_\pi}{r_\pi + R_B}\right) g_m$$

Base-to-Emitter Gain:

$$\frac{v_e}{v_b} = \frac{R_E \parallel r_o}{R_E \parallel r_o + r_e}$$

High Frequency Analysis



$$\omega_H = \frac{1}{\tau_{\textcircled{b}} + \tau_{\textcircled{c}} + \tau_{\textcircled{e}} + \tau_{\mu o} + \tau_{\pi o}}$$

$$\tau_b = C_{\textcircled{b}} R_{\textcircled{b}} \qquad \tau_{\pi o} = C_\pi R_{\pi o}$$

$$\tau_c = C_{\textcircled{c}} R_{\textcircled{c}} \qquad \tau_{\mu o} = C_\mu R_{\mu o}$$

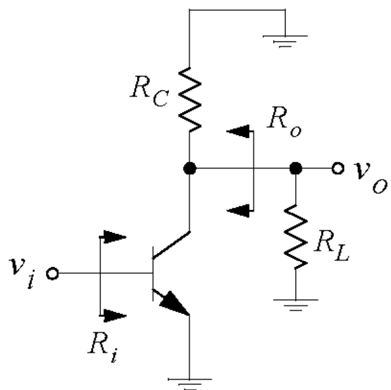
$$\tau_e = C_{\textcircled{e}} R_{\textcircled{e}}$$

$$R_{\pi o} = r_\pi \parallel \frac{R_B + R_E}{1 + g_m R_E}$$

$$R_{\mu o} = R_{\textcircled{b}} + R_{\textcircled{c}} + G_m R_{\textcircled{c}} R_{\textcircled{b}}$$

Frequent Cases (Midband)

Common Emitter

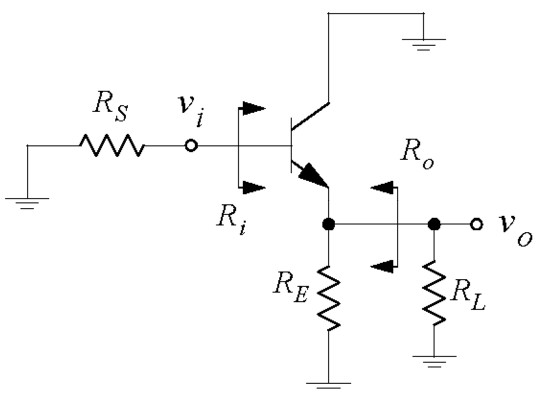


$$R_i = r_\pi$$

$$R_o = r_o \| R_C \approx R_C$$

$$\frac{v_o}{v_i} = -g_m(r_o \| R_C \| R_L) \approx -g_m(R_C \| R_L)$$

Common Collector (Emitter Follower)

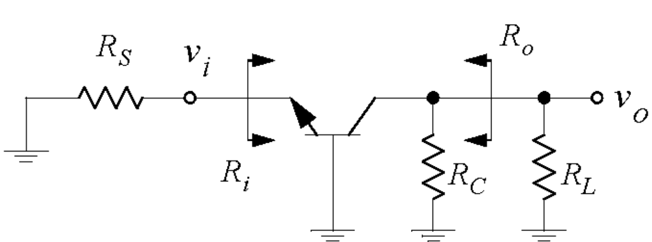


$$R_i = r_\pi + (\beta + 1)(r_o \| R_E \| R_L)$$
$$\approx r_\pi + (\beta + 1)(R_E \| R_L)$$

$$R_o \cong \left(\frac{1}{g_m} + \frac{R_S}{\beta + 1}\right) \| R_E$$

$$\frac{v_o}{v_i} = \frac{(r_o \| R_E \| R_L)}{(r_o \| R_E \| R_L) + r_e} = \frac{(\beta + 1)(r_o \| R_E \| R_L)}{(\beta + 1)(r_o \| R_E \| R_L) + r_\pi} \approx \frac{(\beta + 1)(R_E \| R_L)}{(\beta + 1)(R_E \| R_L) + r_\pi}$$

Common Base



$$R_i = r_e \cong \frac{1}{g_m}$$

$$R_o = r_o(1 + g_m R_S) \| R_C \approx R_C$$

$$\frac{v_o}{v_i} \cong g_m(R_C \| R_L)$$