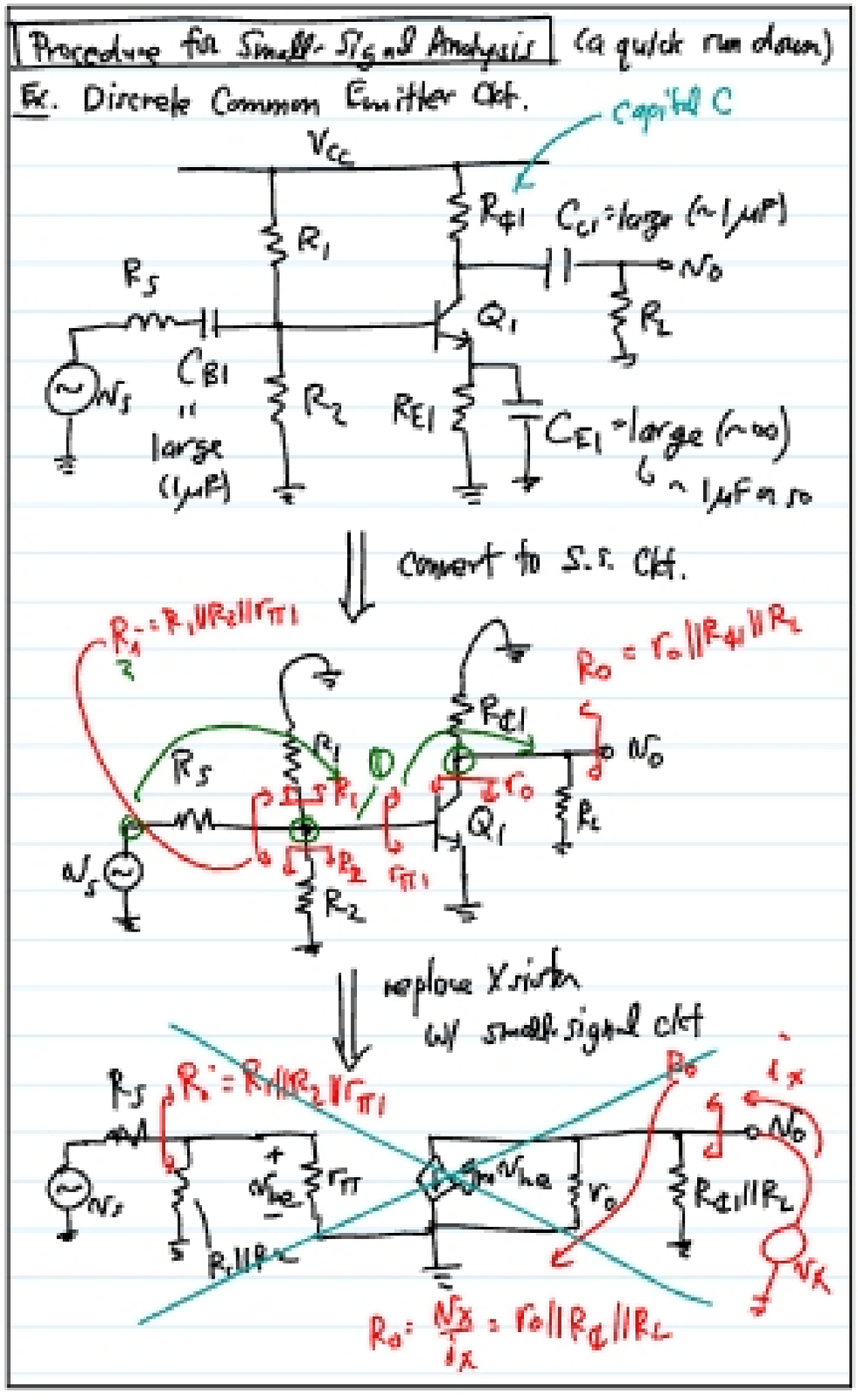
EE 140: Analog Integrated Circuits
Lecture 4: Inspection Analysis

CTN 1/29/09

- 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

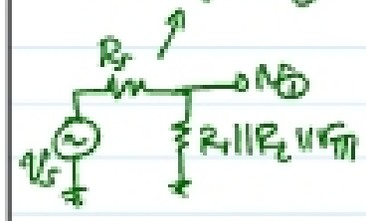
② Determine S.S. parameters for devices in the signal path (e.g., g_m, r_π, r_o, ...)

③ Convert the full ckt. to the S.S. ckt
⇒ zero out DC sources
= short out large capacitors

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

⑤ Analyze by inspection based on prior S.S. analysis experience! → this should be the case 99% of the time

$$A_V = \frac{V_{O1}}{V_i}\cdot\frac{V_o}{V_{O1}} = -\left(\frac{R_1 \| R_2 \| r_{\pi 1}}{R_1 \| R_2 \| r_{\pi 1} + R_S}\right) g_{m1}(R_{D1} \| R_L)$$

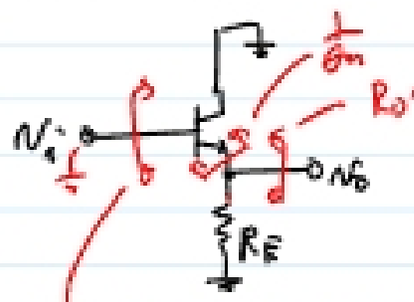


$$\frac{V_{O1}}{V_S} = \frac{R_1 \| R_2 \| r_{\pi 1}}{R_1 \| R_2 \| r_{\pi 1} + R_S}$$

$$\frac{V_o}{V_{O1}} = -G_m R_D = -g_{m1}(R_{D1} \| R_2 \| r_o) \approx -g_{m1}(R_{D1} \| R_L)$$

g_{m1} ; $R_D = R_{D1} \| R_2 \| r_o$; $r_o \gg R_L$ or R_{D1}

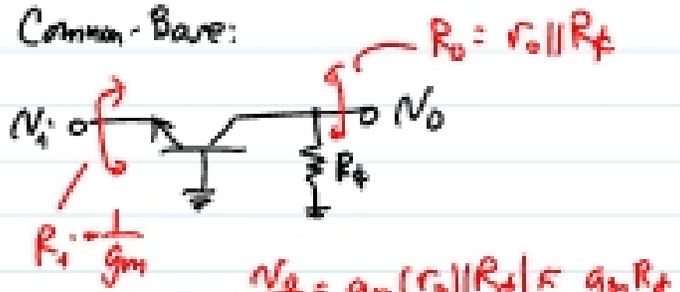
Ex. Common-Collector:



$$\frac{V_o}{V_i} = \frac{R_E}{r_\pi + R_E} = \frac{(\beta+1)R_E}{r_\pi + (\beta+1)R_E}$$

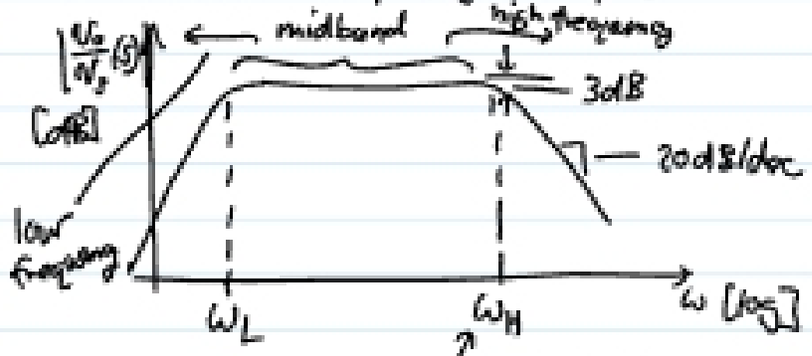
$$\frac{1}{g_m} = \frac{\beta}{g_m} = r_\pi$$

Ex. Common-Base:



$$\frac{V_o}{V_i} = g_m(r_o \| R_E \| \infty \; g_m R_E$$

⇒ so far, we've been talking about "midband" analysis
→ Bode Plot: (for the amp we just analyzed)

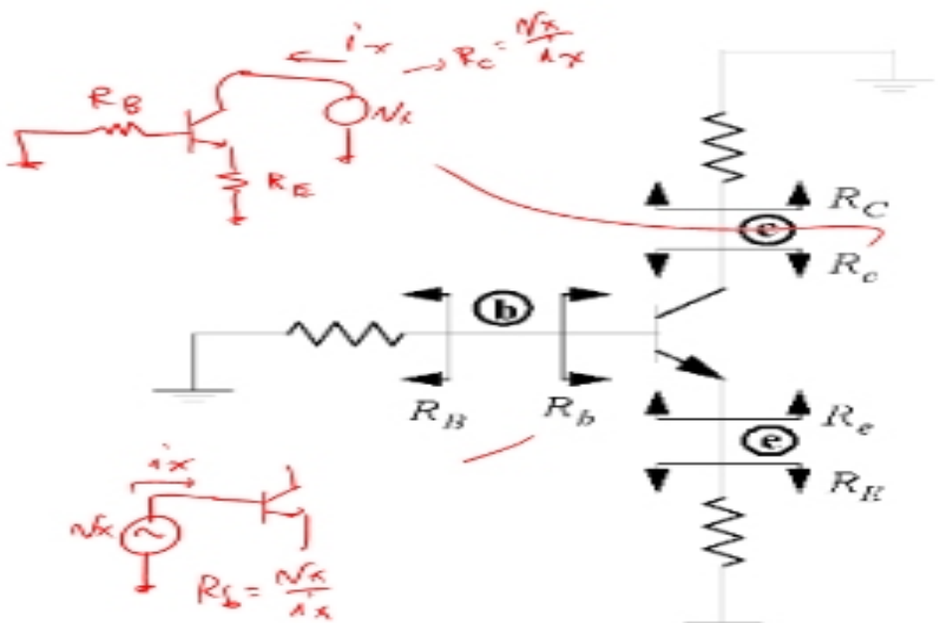


we want this!

use OCTC (open ckt time constant) analysis

Useful Inspection Formulas

The General Case (Midband)



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

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

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

Base-to-Collector Gain:

$$\frac{v_c}{v_b} = -G_m R_{⑥} \qquad G_m = \frac{g_m}{1 + g_m R_E}$$

Emitter-to-Collector Gain:

$$\frac{v_c}{v_e} = G_m R_{⑥} \qquad G_m = -\left(\frac{r_\pi}{r_\pi + R_B}\right) g_m$$

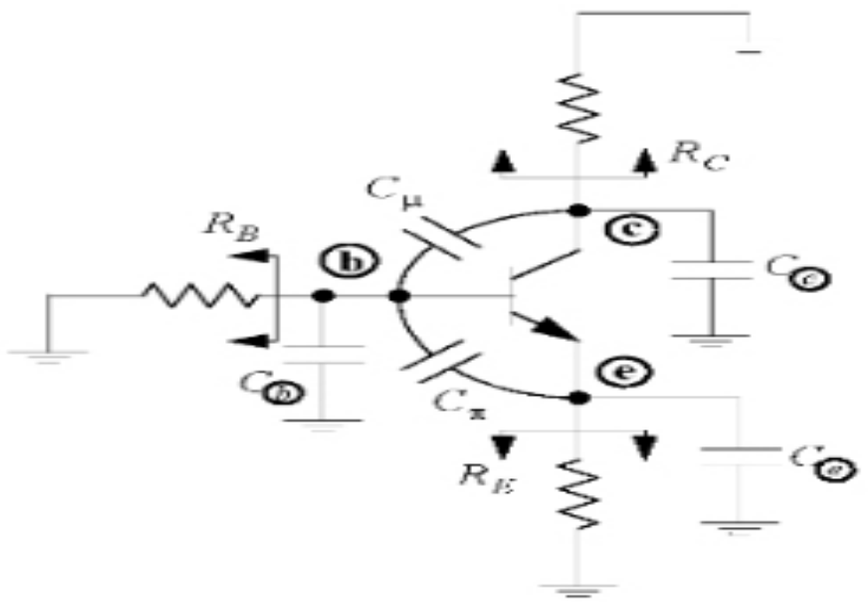
Base-to-Emitter Gain:

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

Node Resistances:

$$R_{⑥} = R_C \parallel R_c$$
$$R_{⑥} = R_E \parallel R_e$$
$$R_{⑥} = R_B \parallel R_b$$

High Frequency Analysis



$$\omega_H = \frac{1}{\tau_{⑥} + \tau_{⑥} + \tau_{⑥} + \tau_{\mu o} + \tau_{\pi o}}$$

$$\tau_b = C_{⑥} R_{⑥} \qquad \tau_{\pi o} = C_\pi R_{\pi o}$$
$$\tau_c = C_{⑥} R_{⑥} \qquad \tau_{\mu o} = C_\mu R_{\mu o}$$
$$\tau_e = C_{⑥} R_{⑥}$$

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

$$R_{\mu o} = R_{⑥} + R_{⑥} + G_m R_{⑥} R_{⑥}$$