## Lecture 4: Inspection Analysis

- **Announcements**:
- Inspection formula sheet handed out in class
  - It's also online
- HW#1 due tomorrow at 8 a.m. in the EE140/240A box near 125 Cory
- No labs this week
- ------------------------------------
- **Lecture Topics**:
  - Procedure for Small Signal Analysis
  - Inspection Formulas
  - 1-Tx Amplifier Examples
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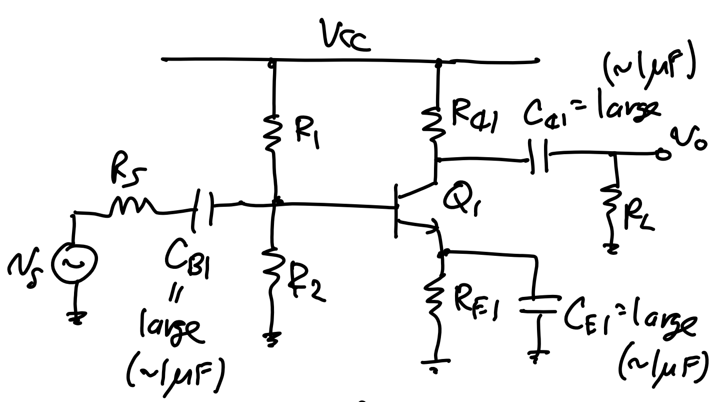
**Procedure for Small-Signal Analysis**

Ex. Discrete Common-Emitter Ckt.

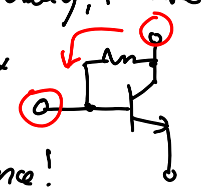



Want $R_i$, $R_o$, & gain $= \frac{v_o}{v_s}$.

## Procedure:

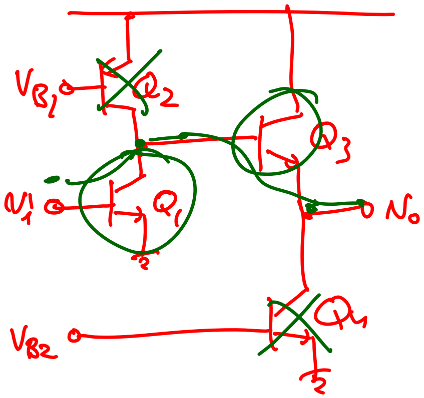
1. Find the DC operating pt. — get voltages & currents at all nodes & all branches, respectively
2. Determine the small-signal (s.s.) parameters for devices in the signal path (e.g., $g_m$, $r_\pi$, ...)
3. Convert the full ckt. to the s.s. ckt.
   - ⇒ zero out the dc sources
     - DC voltage source → short
     - DC current source → open
   - ⇒ short out large capacitors

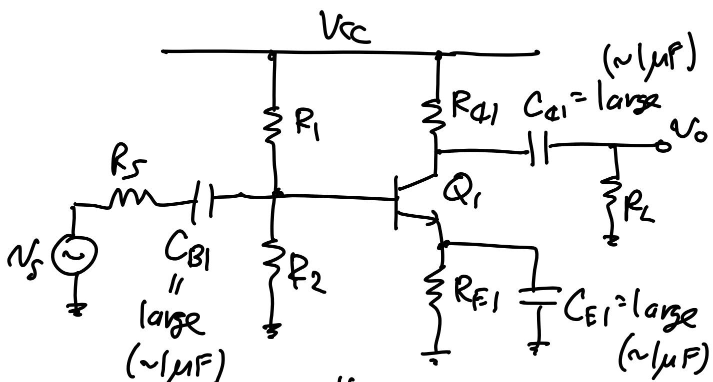
(4a) If needed, replace the Xsistor w/ its model (e.g., hybrid-π, T, ...)
- ⇒ this should NOT be needed often
- ⇒ when is it needed? → generally, in cases where there is feedback! →



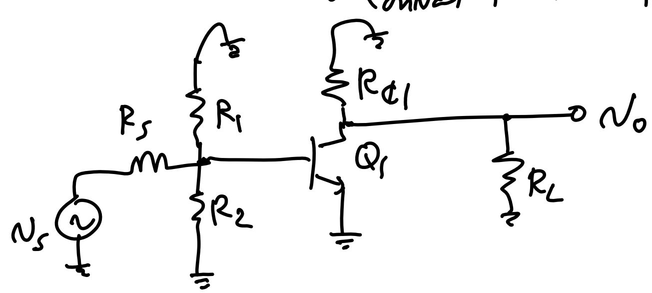
(4b) Analyze by inspection based on prior s.s. anylsis experience!
- ↙ This should be 99% of the time
- ↘ Don't draw the hybrid-π model!

Signal paths (to answer a question that came up)




⇓ Convert to S.S. ckt.



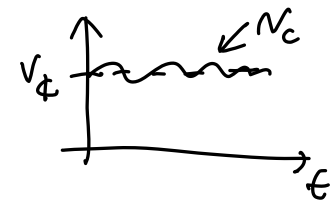

Nomenclature:

$V_C$ ← DC ("capital")

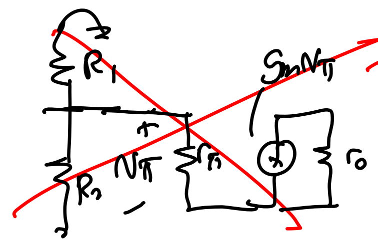
$v_c$ ← small-signal

$V_c$ → full signal

$V_c = V_C + v_c$

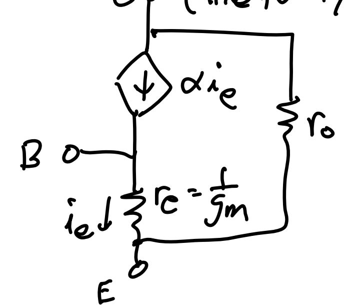



What did I not do? Didn't draw the hybrid-π



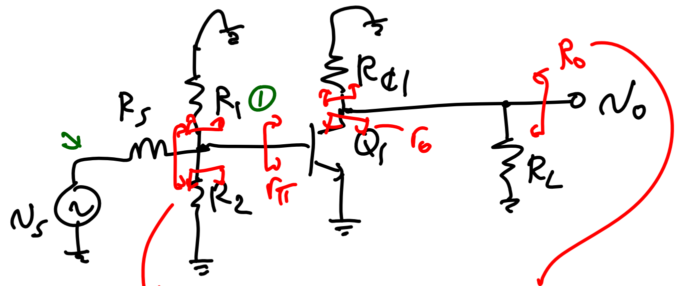

→ waste of time!

T-Model – S.S. equiv. ckt. for a transistor (like the hybrid-π model → equivalent)



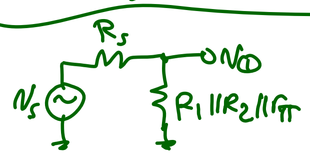
- Now, go through the inspection analysis sheet
  - Show how some things are a bit easier to visualize w/ the T-model
  - Others easier to visualize with the hybrid-pi
- Then, back to the small-signal analysis example:

S.S. Ckt:




$R_i = R_1 \| R_2 \| r_\pi$ $\quad R_o = R_L \| R_{C1} \| r_o$

$$\text{Gain} = \frac{v_o}{v_s} = \frac{v_①}{v_s} \cdot \frac{v_o}{v_①} = -\left(\frac{R_1 \| R_2 \| r_\pi}{R_1 \| R_2 \| r_\pi + R_S}\right) g_{m1}(R_{C1} \| R_L)$$



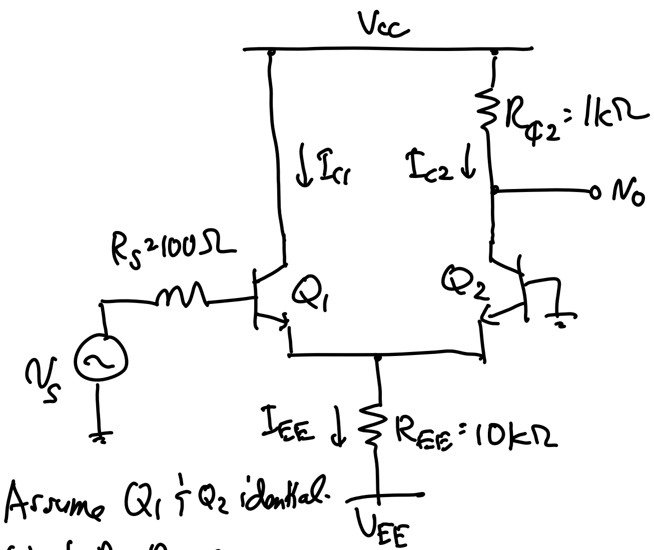

$$\frac{v_①}{v_s} = \frac{R_1 \| R_2 \| r_\pi}{R_1 \| R_2 \| r_\pi + R_S}$$

$$\frac{v_o}{v_①} = -G_m R_© = -g_{m1}(r_{o1} \| R_{C1} \| R_L) \approx -g_{m1}(R_{C1} \| R_L)$$

$$G_m = \frac{g_{m1}}{1 + g_{m1} R_{E1}} = g_{m1} \quad (R_{E1} = 0)$$

$R_© = R_{C1} \| r_{o1} \| R_L$

**Inspection Analysis of a Multi-Transistor Ckt.**




Assume $Q_1$ & $Q_2$ identical.

Want $R_i$, $R_o$, gain.

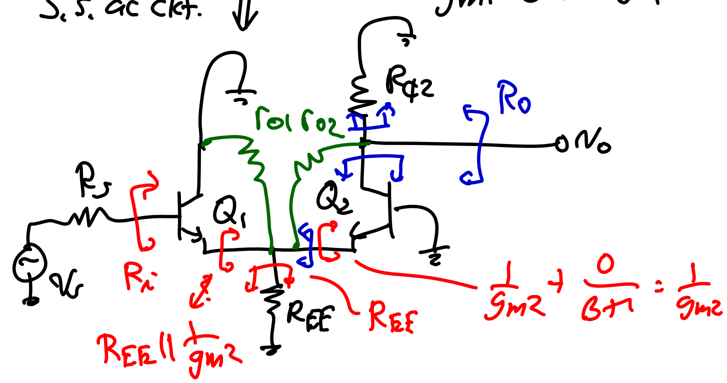
First, get DC operating pt.

$I_{C1} = I_{C2} = \frac{I_{EE}}{2} \rightarrow r_{\pi 1} = r_{\pi 2} = r_\pi$

$r_{o1} = r_{o2} = r_o$

$g_{m1} = g_{m2} = g_m$

S.S. ac ckt. ⇓



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

$= r_{\pi 1} + (\beta+1)\left(R_{EE} \| \frac{1}{g_{m2}} \| r_{o1} \| r_{o2}\right)$

$\| r_{o1} \| r_{o2}$ for completeness! (but usually they are big, so can be ignored!)

$R_o = R_{\phi 2} \| r_{o2}\left(1 + \frac{g_{m2}\left(\frac{1}{g_m}\right)}{1+0}\right) = R_{\phi 2} \| 2r_{o2} \approx R_\phi$

$\frac{1}{g_m} \leftarrow R_{EE} \| \left(\frac{1}{g_{m1}} + \frac{R_S}{\beta+1}\right) \| r_{o1} \| r_{o2}$

Assume $r_{o1}$ & $r_{o2}$ are very large.
Also, given that $R_S$ = small, which it usually is...