Lecture 5: MOS Inspection Analysis

- **Announcements:**
  - Lab#1 is online
    - Labs start next week → go to your lab section
  - Lecture Topics:
    - Multi-Tx Amplifier Examples
    - MOS Inspection Analysis

- Last Time:
  - Multi-Tx inspection analysis
  - Continue with this

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

\[ I = 0.7V \]

\[ V_{CC} \]

\[ R_E \]

\[ R_F \]

\[ R_G \]

\[ R_H \]

\[ R_O \]

\[ V_{BE} \]

First, get DC open-circuit pt.

\[ I_{C1} = I_{C2} = \frac{I_{EE}}{2} \rightarrow r_m = \frac{r_{22}}{r_{11}} = \frac{r_{11}}{r_{21}} \]

\[ r_{01} = r_{02} = r_0 \]

\[ V_{gs1} = V_{gs2} = V_m \]

\[ V_{gs} = V_{BE} \]

\[ I_{CE} = \frac{0.7V}{R_E} \]

\[ I_{CE} = \frac{I_{CE}}{2} \]

\[ V_{BE} = V_{BE} - V_{EE} \]

\[ R_{E1} = \frac{1}{g_m} \]

\[ R_{E2} = 10k \]

\[ R_{F1} = R_{F2} = (\beta+1)R_E \]

\[ R_{O1} = R_{O2} = (1 + \frac{g_m}{g_m} G_m) \]

\[ R_{O2} = R_{O2} \]

\[ R_{O2} = R_{O2} \]

\[ R_{O2} = R_{O2} \]

\[ R_{O2} = R_{O2} \]

\[ R_{O2} = R_{O2} \]

Assume \( r_{11} \), \( r_{22} \) are very large.
\[
\frac{V_o}{V_s} = \left( \frac{2g_m}{R_f + 2r_{inf}} \right) \frac{1}{2} g_m R_f
\]

**Reminder:** Inspection analysis might not work when there is feedback:

- Feedback → not really impossible
- (until the last mod)

Feedback → actually impossible if recognize contain this:

- You came up with it!

\[
R_f' = (c' + 1) R_f
\]

\[
R_{f'} = (c' + 1) R_f
\]

\[
R_f + r_{inf}' = (c' + 1) R_f
\]

\[
G_m = \frac{1}{r_{inf} + r_{inf}'}
\]

\[
G_{m2} = \left( \frac{g_m^2}{r_{inf2} + r_{inf2}'} \right)
\]

\[
G_m = \frac{1}{r_{inf} + r_{inf}'}
\]

\[
G_{m2} = \left( \frac{g_m^2}{r_{inf2} + r_{inf2}'} \right)
\]
MOS Inspection Analysis

For now, ignore Body effect (i.e., ignore g_m_b)

Use the same inspection formulas as bipolar,
but use β → ∞, \( r_{TH} = \frac{β}{g_m} → ∞ \)

[Diagrams of MOS and bipolar circuits]

Ex. Common-Source Common-Drain Cascade

⇒ For the bipolar, "Inspection Formula, yada?

\[
\begin{align*}
R_b &= \frac{1}{g_m + R_E} (\beta + 1) \quad \text{β} → ∞ \quad R_b = ∞ \\
R_e &= \frac{R_b}{\beta + 1} \quad \text{β} → ∞ \quad R_e = \frac{1}{g_m} \\
R_c &= \frac{V_o}{1 + \frac{g_m R_E}{1 + R_A/R_T}} \quad \text{β} → ∞ \quad R_d = R_o (1 + g_m R_s)
\end{align*}
\]
\[ \frac{V_o}{V_s} = \frac{V_o}{V_o - \frac{V_o}{V_o}} = \frac{V_o}{V_o - \frac{V_o}{V_o}} \]

Problem: Simulate via SPICE → the gain will be 80-90% of what is calculated using the problem if \( g_m \) in the source follower is the difference between \( b_m \) and \( M_1 \).

Source Follower: (will subtract hybrid-\( \pi \) models!)

\[ A_N = \frac{g_m}{g_m + g_m} = \frac{1}{1 + \eta}, \quad \eta = \frac{1}{2V_{SB} + 2V_T} \]

To make it '1', do this:

- \[ = \text{not always practical!} \]

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Effect of $g_{mb}$ on Impedance

\[ \begin{align*}
N_s &= -N_X \\
N_d &= -N_X \\
R_s &= \frac{1}{g_{mt} + g_{mb} + g_{ds}}
\end{align*} \]

\[ R_s \approx \frac{1}{g_{mt} + g_{mb}} \]

More extensive analysis shows that other inspection formulas change to accommodate a grounded body by replacing "$g_m$" in the numerator with "$g_{mt} + g_{mb}$".

End up with the following:

\[ \text{over} \]