E151 Lecture 17 – CE Dynamics and Miller

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Disclaimer

These are notes for Prof. Spencer to give the lecture, they were not intended as a reference for students. Students asked for them anyway, so I’m putting them up as a courtesy. Remember that they are not intended as a substitute for attending lecture.
Describe BJT Small Signal Speed Limit with $f_T$

How fast can we go?
- Often measured with frequency where $A_i$ drops to 1

\[ V_o = V_{be} \]
\[ V_{be} = \frac{i_e}{g_m} \cdot \frac{R/(C_e+C_m)}{R+1/(C_e+C_m)} = \frac{f_T}{1+s(C_e+C_m)} \]
\[ s_T = \frac{1}{2\pi \cdot g_m} \]

Dynamic Model of CE Amplifier

- Separates into gain + dynamics, get gain from DC circuit
- RHP zero → negative feedthrough
- This is unsustainable ... need approximation methods

For Clarity:

\[
\frac{1 - sC_m}{g_m} \frac{1 + s(C_p(R_L + R_s||R_s) + g_mR_LR_s||R_s) + C_nR_s||R_s + s^2C_pC_nR_LR_s||R_s}{1 + s(C_p(R_L + R_s||R_s) + g_mR_LR_s||R_s) + C_nR_s||R_s + s^2C_pC_nR_LR_s||R_s}
\]
First Simplification: CE Amplifier PZ Plot

- We can simplify our life by noticing poles are real & widely separated

\[ \text{poles usually real or widely separated} \]

- Communicating caps ... icky ... can't just thevenize
- Assumed \( \tau_1 \gg \tau_2 \) so we can pull \( \tau_1 \) straight from \( s \) coefficient
  - True because of \( gm*Rl \) term
  - Why is our voltage gain in here?

The Miller Effect

\[ \begin{align*}
    i &= \frac{v_i - v_o}{2} \\
    &= \frac{v_i}{2} \cdot (1 - A) \\
    \frac{v_i}{x} &= \frac{Z_{\text{eq}}} {1 - A}
\end{align*} \]

- Thevenin impedance is boosted by gain across a feedback element!
- Caps in feedback around negative gain appear bigger by \( 1+A \)
The Miller Approximation for a CE

- Let’s just calculate the first pole & assume that Cmu sees the DC gain

Issues with Miller Approximation

- Not conservative:
  - lose zero and 2nd pole, so ignore lots of stability implications
  - Approximation of \( \tau_1 \) loses a Cmu*Rc term, appears a bit faster

- Kind of CE specific,
  - relies on av falling across tricky feedback cap
  - lets us convert C_mu to grounded

- Even so, gives good intuition about caps in feedback!