Lecture 21

• Last time:
  – Frequency response of the CS as voltage amp
  – The Miller theorem

• Today:
  – Gain-bandwidth product for CS amplifier
  – Frequency response of voltage buffers (CD)

CE Amplifier using Miller Approx.
Use Miller to transform $C_\mu$
Output Miller cap is ignored*

Analysis is straightforward now … single pole!
*Consistent with text: it would add a 2nd pole

Gain-Bandwidth Product

Result from Miller:
\[ \omega_{p1}^{-1} \approx \left( R_S \right) C_{gS} + \left( 1 + g_m R'_{out} \right) C_{gS} \]

Low-frequency gain:
\[ A_c = \frac{V_{out}}{V_i} \bigg|_{R_{in}, R_o} = -g_m R'_{out} \]

Comparison with “Exact Analysis”

Miller result:
\[ \omega_{p1}^{-1} = \]

Exact result:
\[ \omega_{p1}^{-1} = \left( R_S \parallel r_i \right) \left( C_s + \left( 1 + g_m R'_{out} \right) C_{\mu} \right) + R'_{out} C_{\mu} \]

missing term in Miller result
Gain-Bandwidth Product

Considering only the first pole (assuming zero and 2nd pole are at much higher frequencies):

\[ |A(j\omega)|_{\omega_p} = \frac{A_{\omega}}{1 + j\omega/\omega_p} = \frac{A_{\omega}}{\omega/\omega_p} = A_{\omega} \omega_p/\omega \]

| \[A(j\omega') = 1 \Rightarrow \omega' = A_{\omega} \omega_p \] |

For common-source amplifier:

\[ |A_{\omega_p}| = \frac{g_m R'_d}{R_s C_p + R_s (1 + g_m R'_d) C_{gd}} \]

Special case: \( R_s \approx R_L \ll r_{\omega_c} \)

\[ |A_{\omega_p}| \approx \frac{g_m R'_d}{R_s (C_p + g_m R'_d) C_{gd}} \ll \omega_p \]

not good!

\[ > 1 \]

CD Frequency Response

- The following slides are based on a bipolar equivalent to the CD amplifier. The small-signal circuit has the same topology, with these substitutions:
  - \( C_e \rightarrow C_{gs} \)
  - \( C_p \rightarrow C_{gd} \)
  - \( r_e \rightarrow \infty \)

Common-Collector Amplifier

Procedure:
1. Small-signal two-port model
2. Add device (and other) capacitors
Two-Port CC Model with Capacitors

Find Miller capacitor for $C_\pi$ — note that the base-emitter capacitor is between the input and output.