Discussions 4/19/04

Miller Effect

\[ I_1 + I_2 = 0 \]
\[ I_1 = \frac{V_x}{\frac{1}{z_1} + V_y} = \frac{V_x}{z_1} \]
\[ I_2 = \frac{V_y - V_x}{\frac{1}{z_2}} = \frac{V_y - V_x}{z_2} \]

\[ \Rightarrow \text{Solve to find } z_1 \text{ and } z_2 \]

in terms of \( A, z \)

\[ A = \frac{V_y}{V_x} \]

\[ z_1 = \frac{z}{1 - A} \]
\[ z_2 = \frac{z}{1 - A \cdot z} \]

Dominant Pole Estimation

1. Set all capacitance \( C_j = 0 \) except for \( C_i \)
2. Find resistance seen by \( C_i \)
3. Calculate \( R_i C_i \)
4. \( \omega_{50} = \frac{1}{\sum R_i C_i} \)
First Step: Identify Capacitors

\[ \text{Gain} \quad \frac{V_2}{V_1} = -\frac{1}{g_m(\frac{1}{g_{m2}})} \approx -1 \]

should we include this in S-S calculation? NO!

2nd Step: Millivolt all capacitance, and combine/lump capacitors together whenever we can.

How to get this?

\[ \frac{1}{\frac{1}{j\omega C_{g_{d1}}} + \frac{1}{j\omega C_{g_{d2}}}} = \frac{1}{\frac{1}{j\omega C_{g_{d1}}} + \frac{1}{j\omega C_{g_{d2}}}} \]

Pole associated with node 1:

\[ \left( \frac{1}{j\omega C_{g_{d1}}} + \frac{1}{j\omega C_{g_{d2}}} \right) R_s \]

\[ \frac{1}{C_3} \left( \frac{1}{\frac{1}{j\omega C_{g_{d1}}} + \frac{1}{j\omega C_{g_{d2}}}} \right) \]

\[ W_{3dB} = \frac{2C_{g_{d1}} R_s + C_2 \left( \frac{1}{C_{g_{d2}} + \frac{1}{R_{s1}} + \frac{1}{R_{s2}}} \right) + C_3 \left( \frac{1}{C_{g_{d1}} + \frac{1}{R_{s1}} + \frac{1}{R_{s2}}} \right)}{C_3 \left( \frac{1}{C_{g_{d1}} + \frac{1}{R_{s1}} + \frac{1}{R_{s2}}} \right)} \]
Step 3

Low Frequency Gain

\[ \text{Gain (low frequency)} = -g_m \left( \frac{1}{j\omega} \right) = -1 \]

Transfer Function

\[ \frac{V_{out}(s)}{V_{in}(s)} = \frac{-1}{1 + j\omega/W_{3dB}} \]

---

Multistage Amplifier

Some Results

\[ \frac{V_{out}}{V_{in}} = g_m R_1 g_m R_2 \]

What dominant pole?

Gain from \( \frac{V_2}{V_1} = -g_m R_1 = \frac{V_2}{V_2} \)

\[ W_{3dB} = \left( R_1 || R_2 \right) \left( C_{gds2} g_m R_2 \right) \]

\[ H(j\omega) = \frac{V_{out}(s)}{V_{in}(s)} = \frac{g_m g_m R_1 R_2}{1 + j\omega/W_{3dB}} \]

Small Signal:

\[ C_{gds2} \left( 1 + g_m R_1 \right) \]