Lec 29

1-stage opamps - cannot drive resistive loads

\[ G_m \]

\[ V_o \]

\[ C \cdot D \cdot \text{amp } X (\text{swing limit problem}) \]

\[ (1\text{-stage opamp}) \]

\[ V_1 \rightarrow + \]

\[ V_2 \rightarrow - \]

\[ Z_L \]

\[ \text{Opamp (w} = \text{sat}) \]
Two-stage opamp

1) DC gain

\[
\frac{G_{m_1} G_{m_2}}{G_o_1 G_o_2}
\]

w/ resistive load \( R_L \ll G_{o_1}, G_{o_2} \)

\[
DC \text{ gain} = \frac{G_{m_1} G_{m_2}}{G_{o_1} G_{o_2}}
\]

+ optimize 1st stage for DC gain

2) \( W_n = \frac{G_{m_1}}{C} \)
\[ \left( \frac{V_o}{\text{Vin}} \right) \]

3) \[ W_n = \frac{G_m}{C} \]

\[ \begin{align*}
\text{2 poles} \\
\text{1 zero}
\end{align*} \]

\[ \frac{G_{m1}(G_{m2} - 8C)}{\left\{ G_{o1} G_{o2} + 3 \left[ C(G_{m2} + G_{o1} + G_{o2}) \right] + G_{o1} C_1 + G_{o2} C_2 \right\} + \Delta^2 (C_1 C + C_2 C + C_1 C_2)^2} \]
DC gain looks ok

\( z_1 = + \frac{Gm_v}{C} \) (RHP zero)

\( ax^2 + bx + c = 0 \quad \Rightarrow \quad \alpha, \beta \) are not

\( \alpha, \beta \) are far apart

\( \alpha \approx -\frac{C}{b}, \quad \beta \approx -\frac{b}{a} \)

for an opamp: \( \beta_1 = \text{dominant pole} \)

\( \beta_2 = \text{N-D. pole} \)

\[ \beta_1 \approx -\frac{C}{b} = -\frac{G_{o_1}, G_{o_{2}}}{b} \]

\[ = \frac{G_{o_1}}{C \left( \frac{G_{m_v}}{G_{o_{2}}} + 1 + \frac{G_{o_1}}{G_{o_{2}}} \right) + C_1 + \frac{G_{o_1}}{G_{o_{2}}} C_2} \]

\[ = \frac{G_{o_1}}{C \cdot \left( \frac{G_{m_v}}{G_{o_{2}}} \right)} = \frac{G_{o_1} G_{o_{2}}}{G_{m_v} C} \]
\[ p_2 = \frac{-b}{a} = -\frac{c(C_{m_2} + G_{0_2} + V_{0_2}) + C_{1}h_{21} + C_{1}h_{22}}{C_2 + \frac{C + C_1}{C + C_1}} \]

divide \( \text{VR & DR} \) by \( \frac{C + C_1}{C + C_1} \)

\[ p_1 = -\frac{C_{m_1}G_{m_1} + C_{0_1} + C_0}{\frac{C_2}{C + C_1} + \frac{C_1}{C + C_1}} \]

pole @ node \( Y \)

\[ \frac{C_{eff}}{C_{eff}} \]

\[ V_0 \]

\[ C_2 \]

\[ C \]

\[ C_1 \]

\[ C \]

\[ C_1 \]

\[ G_{m_1} \]

\[ C_0 = \frac{G_{m_1}C}{C + C_1} \]