Today:
• Short-Circuit Time Constant Analysis for Low Frequency Cut-Off
• Active Loads

Last Time:

\[ \omega_L = \frac{e_i \omega_p j}{j \omega_p R_j} = \frac{e_i \omega_p C_j R_j}{j \omega_p} \]

where \( C_j \) is various large (>10 nF) capacitors in the circuit (e.g., bypass caps.)
\( R_j \) is the driving point resistance seen between the terminals of \( C_j \) determined with:

1. all large capacitors short-circuited, except \( C_j \), which is replaced by the test voltage source for \( R_j \) determination.
2. all independent sources eliminated (i.e., short voltage sources, open current source)
3. open all H.F. capacitors (i.e., small caps in the pF range, or <1 nF)

Ex: Deform to L.F. Response of the C.E. Amplifier

- \( \omega_v = \frac{1}{T_v} = \frac{1}{(R_s + \frac{R_g}{r_1} + \frac{R_2}{r_2})C_B} \)
- For readily, can go to Sedra & Smith

- \( \omega_p = \frac{1}{T_p} = \frac{1}{R_s C_B} \)

- \( T_c = \frac{(R_L + \frac{R_1}{r_1} R_2)}{C_c} \)

- \( V_p = \frac{1}{T_c} = \frac{1}{(R_s + R_b)C_c} \)
Active Loads

- Why use active loads?
  - Gain: $\frac{V_{out}}{V_{in}} = g_{m}R_{D}$
  - $V_{out} = V_{D}$, load (resistor)

- $V_{D} = R_{D}$

- $V_{D}$ must:
  - $0 < N_{D}$
  - $N_{D}$ drive device

- Raise $g_{m}$ to raise $I_{D}$
  - Supply $V_{D}$ limits the amount of gain you can get

- Influence $R_{D} \rightarrow$ but same problem also aren't

(c) $V_{CE}$: short $C_{B+} C_{C}
\frac{1}{g_{m} + \frac{R_{L}+R_{L},R_{L}}{R_{L}+R_{L},R_{L}} (R+I)}$

$R_{L} = R_{L}+R_{L},R_{L}$

$V_{CE} = R_{L}+R_{L},R_{L}$

$W_{P} = \frac{1}{C_{E}} + \frac{1}{R_{P} C_{E}}$

and finally:

$W_{L} = W_{P} + W_{P} + W_{P}$

Layout:

1kΩ resistor → long, snaking piece of polySi → fn big!

- What would be ideal?

To solve these issues, we use active load!

Diode-Connected Enhancement Load

Diode-Connected PType Load

PMOS Current Source Load
Diode-Connected Enhancement-Load

\[ V_{dd} \]

\[ I_{d} = \frac{1}{g_{m}} \]

\[ R_{L} = \frac{1}{g_{m} + g_{mb}} \]

How about this?

\[ V_{dd} \]

\[ I_{X} = \frac{V_{ds} - V_{th}}{g_{m}} \]

\[ R_{L} = \frac{1}{g_{m} + g_{mb}} \]

\[ V_{ds} = -g_{m} V_{gs} + g_{ds} (V_{gs} - V_{th}) + g_{mb} V_{th} \]

\[ P_{s} = \frac{V_{dd}}{I_{X}} = \frac{1 + g_{m} R_{D}}{g_{m} + g_{mb}} \]

\[ R_{s} \approx \frac{1}{g_{m} + g_{mb}} + R_{D} \]

\[ R_{D} = \frac{V_{gs}}{I_{X}} \]

\[ R_{L} = \frac{1}{g_{m} + g_{mb}} \]

\[ \text{Apply to a C.S. Oct.} \]

\[ \frac{I_{D}}{I_{D}} = \frac{V_{dd}}{2 g_{m} C_{L} V_{D}^{2}} \]

\[ A_{V} = -\frac{1}{1+n} \frac{g_{m}}{V_{dd}^{2} C_{L} V_{D}^{2}} \]

\[ \frac{1}{1+n} \sqrt{\frac{W}{L}} \]
Diego-Connected PMOS Load

\[ A_N = \frac{g_{m1}}{g_{m2}} = \frac{\mu_n(W/L)_1}{\mu_p(W/L)_2} \]

PMOS Current Source Load

\[ A_N = \frac{V_D}{V_i} = \frac{g_{m1}}{g_{d1} + g_{d2}} = \frac{g_{m1}}{g_{d2}} \text{ if } g_{d2} \text{ is huge, } (r_o \text{ huge) } \]

But requires \( V_{BSAS} \)