Lecture 32

- Last time:
  - Frequency response of the CE as voltage amp
  - The Miller approximation
- Today:
  - Frequency response of voltage and current buffers
  - Start multi-stage amplifiers: Chapter 9

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.

Voltage Gain \( A_{VC\pi} \) Across \( C_\pi \)

\[
A_{VC\pi} =
\]

Note: this voltage gain is neither the two-port gain nor the "loaded" voltage gain.

\[
C_{in} = C_\mu + C_M = C_\mu + (1 - A_{VCx}) C_\pi
\]
Bandwidth of CC Amplifier

Input low-pass filter’s –3 dB frequency:

$$\omega_p^{-1} = (R_S \parallel R_{in}) \left( C_\mu + \frac{C_\pi}{1 + g_m R_L} \right)$$

Substitute favorable values of $R_S$, $R_L$:

$R_S \approx 1 / g_m \quad R_L >> 1 / g_m$

$$\omega_p^{-1} \approx \left( \frac{1}{g_m} \right) \left( C_\mu + \frac{C_\pi}{1 + BIG} \right) \approx C_\mu / g_m$$

Bandwidth of the Common-Base Current Buffer

Same procedure: start with two-port model and capacitors
Two-Port CB Model with Capacitors

No Miller-transformed capacitor!

Unity-gain frequency is on the order of $\omega_T$ for small $R_L$

Summary of Single-Stage Amplifier Frequency Response

- CE, CS: suffer from Miller-magnified capacitor for high-gain case
- CC, CD: Miller transformation $\rightarrow$ nulled capacitor $\rightarrow$ “wideband stage”
- CB, CG: no Millerized capacitor $\rightarrow$ wideband stage (for low load resistance)
Multi-Stage Amplifiers: Chap. 9

- First topic: voltage and current sources (9.4)
- Generating a voltage: use a current source to set $V_{GS}$ (or $V_{BE}$)

Modeling the Voltage Source

Find $i_{OUT}$ versus $v_{OUT}$ MOSFET is off or saturated: why?

$$i_{OUT} = i_{D,SAT} - I_{REF} = \mu_n C_{ox} \left( \frac{W}{2L} \right) (v_{GS} - V_{Th})^2 (1 + \lambda_n v_{DS}) - I_{REF}$$

Typical operating point: $i_{OUT} = 0$ A
Small-Signal Source Resistance

\[ R_S = \left( \frac{d_i_{OUT}}{d v_{OUT}} \bigg|_{v_{OUT}=0} \right)^{-1} = \frac{v_I}{i_I} \]

Equivalent Circuit:

Using a Voltage Source to Make a Current Source

[Diagram of a circuit using a voltage source to make a current source]