Cascaded Amplifier
(cascode)
MOS Amplifiers
Amplifier Biasing
Current Sources and Mirrors
Review

- biasing high gain amplifiers is inherently challenging.
  - use differential structure
    CMFB to establish operating point

- cascaded amplifiers can be used for gain enhancement
  - be sure biasing appropriately due
  - Am & R0 of each stage affects overall
  - FB for cascades of more than 2 stages causes stability concerns
  - even with 2-stage cascades, FB must be addressed appropriately to circumvent stability problems
\[
\begin{aligned}
\begin{cases}
(U_0 - U_1) g_{02} + g_{m2} (-U_1) = 0 \\
U_1 (g_{01} + g_{02} + g_{m2}) + g_{m1} U_1 = U_0 g_{02} + g_{m2} (-U_1) \\
V_1 = U_0 \frac{g_{02}}{g_{01} + g_{m1}} \\
U_1 (g_{01} + g_{02} + g_{m1} + g_{m2}) = g_{02} U_0 = g_{m1} U_1
\end{cases}
\end{aligned}
\]
\[ V_o = V_i \frac{(-g_{m1}g_{o2} + g_{m2})}{g_{o1}g_{o2}} = -\left(\frac{g_{m1}}{g_{o1}}\right)\left(\frac{g_{m2}}{g_{o2}}\right) \]

Cascade circuit has excellent gain and is widely used.
$$\frac{V_0}{V_i} = \left( -\frac{g_m}{g_c} \frac{g_m^2}{g_o} \right) \left( \frac{1}{g_{o3}} \frac{1}{1 + \frac{g_m^2}{g_o, g_{o3}}} \right)$$

$$\approx -\left( \frac{g_m}{g_{o1}} \frac{g_m^2}{g_{o2}} \right) \left( \frac{g_{o2}}{g_{o3}} \right) = -\frac{g_m}{g_o}$$
\[
\frac{50}{\nu_1} = -\frac{1}{2} \left( \frac{g_{m1}}{g_{m2}} \frac{g_{m2}}{g_{m1}} \right)
\]
\[ \frac{U_o}{V_i} = \left( \frac{g_{m3}}{g_{03}} \right) \left( \frac{g_{m2}}{g_{02}} \frac{g_{m1}}{g_{01}} \right) \]
Darlington Configuration

- High input impedance
- Current gain \( \beta^2 \)

Diffusional Amplifier
MOS Transistors

\[ -\frac{1}{B_f} \]

\[ g_m \cdot r_{os} \]

\[ g_s \]

\[ g_{rs} \]

\[ g_{m} \cdot V_{by} \]

\[ g_o \]