Final Exam
12/15, Friday, 7-10 pm
Here.
7 Questions
Topics:
- Differential amp
- Multistage
- Frequency Response
- Current source/mirrors
- Op Amp. (Non-Ideal)
- Device (MOSFET)
- DC (Large-Signal)
- Closed Book, 4 pages of Notes
- Calculator
Useful Metric for Diff Amps: CMRR

- **Common Mode Rejection Ratio (CMRR)**
  - Define: $a_{vd}$: differential gain, $a_{vc}$: common mode gain
    
    $$CMRR = \left( \frac{a_{vd}}{a_{vc}} \right)$$
  
  - CMRR corresponds to ratio of differential to common mode gain and is related to received signal-to-noise ratio
    
    $$V_{od} = a_{vd} V_{sig} + a_{vc} V_{noise}$$
    
    $$\Rightarrow \frac{Signal}{Noise} = \left( \frac{a_{vd}}{a_{vc}} \right) \left( \frac{V_{sig}}{V_{noise}} \right) = CMRR \left( \frac{V_{sig}}{V_{noise}} \right)$$

Courtesy: M.H. Perrott
Differential Amplifier with Current-Source Loads

\[ A_d = \frac{v_{od}}{v_{id}} = g_{m1} \left( r_{o1} \parallel r_{o3} \right) \]

\( Q_3 \) and \( Q_4 \) are PMOS current sources (active loads)

From half-circuit

\( R_0 \sim 100 \text{k}\Omega \)
Cascode Differential Amplifier

Cascode configurations for both amplifying transistors and current source loads.

From half-circuit

\[ A_d = \frac{v_{od}}{v_{id}} = g_m \left( R_{on} \parallel R_{op} \right) \]

\[ R_{on} = (g_m r_o) r_1 \]

\[ R_{op} = (g_m r_5) r_7 \]

If all transistors are identical,

\[ R_{on} = R_{op} = g_m r_o^2 \]

\[ A_d = \frac{1}{2} g_m r_o^2 \]
Differential Input, Single-End Output

Differential-in, Differential-out

Differential input, Single-ended Output
MOS Differential Pair with Current Mirror Load

AC equivalent circuit for differential input

Current mirror forces small-signal currents through Q₃ and Q₄ to be the same
→ output currents = 2x that of half circuit

Same gain differential