Passive Loads vs Active Loads

- MOS diff amp loads are generally transistors on ICs
Active Loads

- MOS diff amp loads are generally transistors in ICs
Two Stage OpAmp

M8-PMOS1
L=10E-6
W=150E-6
S
D
VMTR14
3.441 V
IREF
25UA

M1-PMOS1
L=8E-6
W=120E-6
S
D
VIN1
0V
VID
0.000 pV

M2-PMOS1
L=8E-6
W=120E-6
S
D
M3-NMOS1
L=10E-6
W=50E-6
S
D
M4-NMOS1
L=10E-6
W=50E-6
S
D
M5-PMOS1
L=10E-6
W=150E-6
S
D
M6-NMOS1
L=10E-6
W=100E-6
S
D
M7-PMOS1
L=10E-6
W=150E-6
S
D

IOUT
27.405 µA
ID5
ID7
30.746 µA

VDD
5V

VOUT
-939.937 mV

VSS
-5V

Lecture 26-3
Two Gain Stages

$V_{diffout} = V_i$

$I_{REF}$
Two Stage OpAmp

- The overall gain is the product of the two stage gains
Compensation
$r_{in} = R_L$
Common Gate Configuration

- Common gate configuration acts as a current buffer (just like common base)
Cascode

- Cascade of common source and common gate stages.
- Broader frequency band than common source
- Higher output impedance than common source
Cascode - increased output impedance

\[ r_{out} = \]
Cascode current source - increased output impedance

\[ r_{out} = \]
Problem from previous year’s exam#3

Calculate the midband gain \( \frac{v_o}{(v_1-v_2)} \) as a function of I (the reference current) for the two-stage CMOS opamp shown below. Assume that all of the biasing is working properly. Show all of your work!

\[
\begin{align*}
\lambda_p &= 0.02 \\
\lambda_n &= 0.01 \\
\mu_p C_{ox} &= 20 \mu A/V^2 \\
\mu_n C_{ox} &= 20 \mu A/V^2
\end{align*}
\]
1. Calculate currents of M5 and M8

Calculate the midband gain \( \frac{v_o}{(v_1 - v_2)} \) as a function of I (the reference current) for the two-stage CMOS opamp shown below.
Assume that all of the biasing is working properly. Show all of your work!

\[
\begin{align*}
\lambda_p &= 0.02 \\
\lambda_n &= 0.01 \\
\mu_p C_{ox} &= 20 \mu A/V^2 \\
\mu_n C_{ox} &= 20 \mu A/V^2
\end{align*}
\]
2. Calculate gain $A_{\text{diff}}$ of the differential stage M5-M1-M2-M3--M4

Calculate the midband gain ($v_o/(v_1-v_2)$) as a function of $I$ (the reference current) for the two-stage CMOS opamp shown below. Assume that all of the biasing is working properly. Show all of your work!

\[
\lambda_p = 0.02 \\
\lambda_n = 0.01 \\
\mu_p C_{ox} = 20 \mu A/V^2 \\
\mu_n C_{ox} = 20 \mu A/V^2
\]

\[
g_m = \sqrt{2\mu_n C_{ox} \frac{W}{L}} \sqrt{I_D}
\]
3. Calculate gain of the second stage

Calculate the midband gain \( \frac{v_o}{(v_1-v_2)} \) as a function of \( I \) (the reference current) for the two-stage CMOS opamp shown below. Assume that all of the biasing is working properly. Show all of your work!

\[
\lambda_p = 0.02 \\
\lambda_n = 0.01 \\
\mu_p C_{ox} = 20\mu A/V^2 \\
\mu_n C_{ox} = 20\mu A/V^2
\]
4. Combine gain of both stages

Calculate the midband gain \( \frac{v_o}{(v_1 - v_2)} \) as a function of \( I \) (the reference current) for the two-stage CMOS opamp shown below. Assume that all of the biasing is working properly. Show all of your work!

\[
\begin{align*}
\lambda_p &= 0.02 \\
\lambda_n &= 0.01 \\
\mu_p C_{ox} &= 20 \mu A/V^2 \\
\mu_n C_{ox} &= 20 \mu A/V^2
\end{align*}
\]