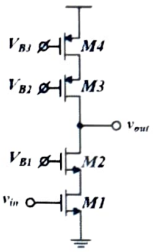
1. For the cascode amplifier below, assume all transistors have the same gm and the same ro. If for all transistors VA = 10 V and Vov = 140 mV, then the voltage gain in dB (20*log|Av|) is approximately equal to _____ dB.

1 $A_V = G_m R_{out}$

2 $G_m = g_m$ and $R_{out} = g_m r_o^2 \cdot \frac{1}{2}$

3 $A_V = (g_m r_o)^2 \cdot \frac{1}{2} = \left(\frac{2I_D}{V_{ov}} \cdot \frac{V_A}{I_D}\right)^2 \cdot \frac{1}{2} = \left(\frac{2V_A}{V_{ov}}\right)^2 \cdot \frac{1}{2}$

4 $A_V = 10204\ V/V \approx 80\ dB$

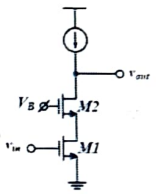


2. For the shown cascode amplifier, if Vout decrease below its minimum value, the first transistor to come out of saturation (enter triode) is _____.

∞ V_{DS1} is defined by the strong voltage V_B

∞ When Vout decrease, V_{DS2} decrease

∞ M2 is the first



3. The cascode amplifier boosts the gain compared to a simple CS amplifier by boosting _____.

A	Rout	B	Gm	C	Rin	D	Gm and Rout

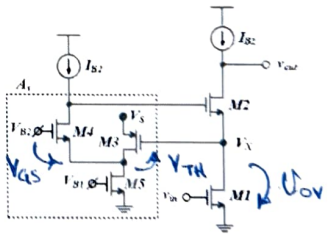
4. For the shown regulated cascode amplifier, assume all transistors have the same VTH and Vov. The maximum output swing is achieved when VB2 is set to less than _____.

max output swing is @ Vout = 2Vov

∴ M1 needs $V_{DS} = V_{ov}$ at least

∴ $V_{B2} = V_{GS} + V_{TH} + V_{ov}$

$= 2V_{TH} + 2V_{ov}$

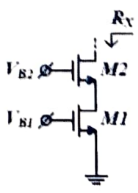


5. You are required to design an NMOS cascode that has Rx = 500k ohm and ID = 0.5 mA. What is the W/L that you are going to use?
Assume μ*Cox = 400 uA/V^2, VA = 10 V, and M1 and M2 are identical.

1 $R_x = g_m r_o^2 = \frac{2I_D}{V_{ov}} \cdot \left(\frac{V_A}{I_D}\right)^2 = 500\ k\Omega$

2 $V_{ov} = 0.8\ V$

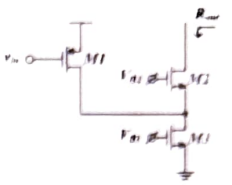
3 $I_D = \frac{\mu C_{ox}}{2} \frac{W}{L} \cdot V_{ov}^2 = 0.5\ mA \rightarrow \frac{W}{L} = 3.9$



6. Assume all transistors have the same Vov and same VA, and M1 and M2 have the same bias current (hint: what is the current in M3?). Rout is approximately equal to gm2 * ro2^2/a where "a" is equal to _____

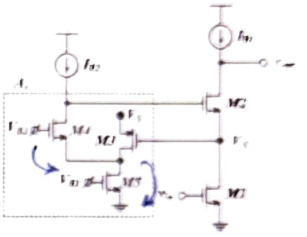
Hint: ro depends on both VA and ID.

1. M1 and M2 have same I_D → M3 has $2I_D$
2. $r_{o3} = \frac{1}{2} r_{o1,2}$
3. $R_{out} = r_{o1,2}\, g_{m_2} * (\frac{1}{2} r_{o1,2} \parallel r_{o1,2}) = \frac{1}{3} g_{m_2} r_{o1,2}^2$



7. For the shown regulated cascode amplifier, assume all transistors have the same VTH and Vov. The minimum valid value for VB2 is equal to _____.

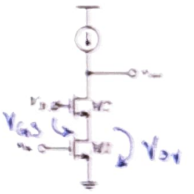
$$V_{B2\,min} = V_{GS} + V_{OV} = V_{TH} + V_{OV} + V_{OV}$$
$$= V_{TH} + 2V_{OV}$$



8. For the shown cascode amplifier, assume M1 and M2 have the same VTH and Vov. The maximum output swing is achieved when VB is set to _____.

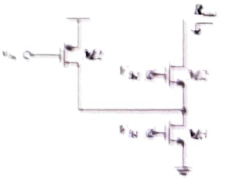
max Swing @ $V_{out\,min} = 2V_{OV}$

$\therefore V_B = V_{GS} + V_{OV} = V_{TH} + 2V_{OV}$



9. Assume all transistors have the same gm and same ro. Rout is approximately equal to gm2*ro2^2/a where "a" is equal to _____

1. $R_{out} = g_{m2}\, r_{o2}\, (r_{o3} \parallel r_{o1})$
2. If all transistors have the same g_m and r_o
3. $R_{out} = g_m r_o^2 \cdot \frac{1}{2}$



10. Assume the following:

M1 and M3 have the same bias current (hint: what is the current in M2?)

M2, M3, M4, and M5 have the same VA (Hint: what is the relation between their ro?)

M3 and M4 have the same gm (hint: do we need gm2 and gm5 to calculate the gain?)

gm1 = 2 * gm3

ro1 = ro3 / 4

The gain is approximately equal to a * (gm3 * ro3)^2 where "a" is equal to _____.

1. $A_V = G_m R_{out}$
2. $G_m = g_{m1} = 2 g_{m3}$
3. $R_{out} = g_{m4} r_{o4} r_{o5} \parallel g_{m3} r_{o3} (r_{o2} \parallel r_{o1})$
   $= g_{m3} r_{o3}^2 \parallel g_m r_{o3} (\frac{1}{2} r_{o3} \parallel \frac{1}{4} r_{o3})$
   $= g_{m3} (r_{o3}^2 \parallel \frac{1}{6} r_{o3}^2) = g_{m3} r_{o3}^2 \cdot \frac{1}{7}$

$A_V = \frac{2}{7} (g_{m3} r_{o3})^2 = 0.29 (g_{m3} r_{o3})^2$