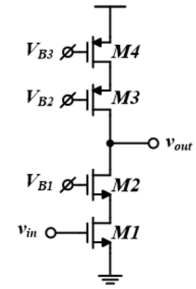
1. For the cascode amplifier below, assume all transistors have the same gm and the same ro. If for all transistors VA = 10 V and Vov = 140 mV, then the voltage gain in dB (20*log|Av|) is approximately equal to __________ dB.

$A_v = G_m R_{out}$

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

$A_v = \frac{1}{2} \times (g_m r_o)^2 = \frac{1}{2} \times \left(\frac{2I_D}{V_{ov}} . \frac{V_A}{I_D}\right)^2 = \frac{1}{2} \times \left(\frac{2V_A}{V_{ov}}\right)^2$

$A_v = 10204 \frac{v}{v} = 80\ dB$

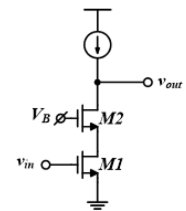


2. For the shown cascode amplifier, if Vout decrease below its minimum value, the first transistor to come out of saturation (enter triode) is _______.

$\because V_{DS1}$ is defined by the strong voltage V_B

$\therefore$ When V_{out} decrease $\rightarrow V_{DS2}$ decrease

$\therefore$ M2 come out of saturation 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

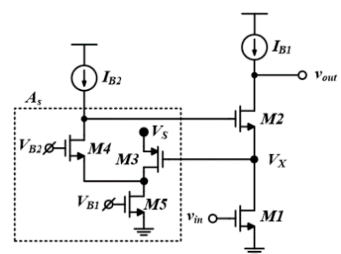
4. For the shown regulated cascode amplifier, assume all transistors have the same VTH and Vov. The maximum output swing is achieved when VB2 is set to less than ______.

maximum output swing is at $V_{out} = 2V_{ov}$

$\therefore$ M1 V_{DS} must be at least equal V_{ov}

$\therefore V_{B2} = V_{GS} + V_{TH} + V_{ov}$

$\therefore V_{B2} = 2V_{TH} + 2V_{ov}$

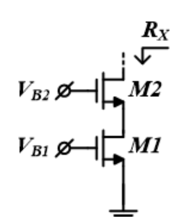


5. You are required to design an NMOS cascode that has Rx = 500k ohm and ID = 0.5 mA. What is the W/L that you are going to use?
Assume µ*Cox = 400 uA/V^2, VA = 10 V, and M1 and M2 are identical.

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

$V_{ov} = 800\ mv$

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

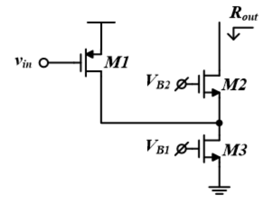


6. Assume all transistors have the same Vov and same VA, and M1 and M2 have the same bias current (hint: what is the current in M3?). Rout is approximately equal to gm2 * ro2^2/a where "a" is equal to ________
Hint: ro depends on both VA and ID.

1 | M1 and M2 have same $I_D \rightarrow \therefore$ M3 has $2I_D$

2 | $r_{o3} = \frac{1}{2} r_{o1,2}$

3 | $R_{out} = r_{o1,2} \times g_{m2} \times \left(\frac{1}{2} r_{o1,2} \parallel r_{o1,2}\right) = \frac{1}{3} \times g_{m2} r_{o1,2}^2$

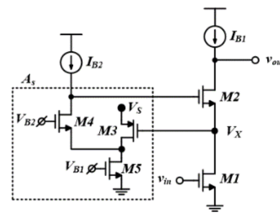


7. For the shown regulated cascode amplifier, assume all transistors have the same VTH and Vov. The minimum valid value for VB2 is equal to _________.

1 | $V_{B2}|\text{minimum} = V_{GS4} + V_{ov5}$

2 | $V_{B2} = V_{TH} + V_{ov} + V_{ov}$

3 | $V_{B2} = V_{TH} + 2V_{ov}$

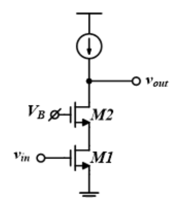


8. For the shown cascode amplifier, assume M1 and M2 have the same VTH and Vov. The maximum output swing is achieved when VB is set to ______.

1 | maximum output swing is at $V_{out} = 2V_{ov}$

2 | $V_B = V_{GS} + V_{ov}$

3 | $V_B = V_{TH} + 2V_{ov}$

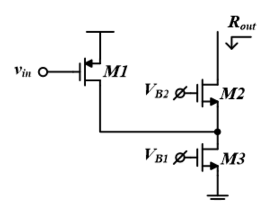


9. Assume all transistors have the same gm and same ro. Rout is approximately equal to gm2*ro2^2/a where "a" is equal to ________

1 | $R_{out} = g_{m2} r_{o2} (r_{o3} \parallel r_{o1})$

2 | $\because$ All transistors have the same g_m and $r_o \rightarrow R_{out} = \frac{1}{2} \times g_m r_o^2$

3 | $\therefore a = \frac{1}{2}$



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 | $\because G_m = g_{m1} = 2g_{m3}$

3 | $R_{out} = g_{m4} r_{o4} r_{o5} \parallel g_{m3} r_{o3} (r_{o2} \parallel r_{o1})$

$$= g_{m3} r_{o3}^2 \parallel g_{m3} r_{o3} \left(\frac{1}{2} r_{o3} \parallel \frac{1}{4} r_{o3} \right) = g_{m3} \left(r_{o3}^2 \parallel \frac{1}{6} r_{o3}^2 \right) = \frac{1}{7} \times g_{m3} r_{o3}^2$$

4 | $A_v = \frac{2}{7} \times (g_{m3} r_{o3})^2 = 0.29 \times (g_{m3} r_{o3})^2$