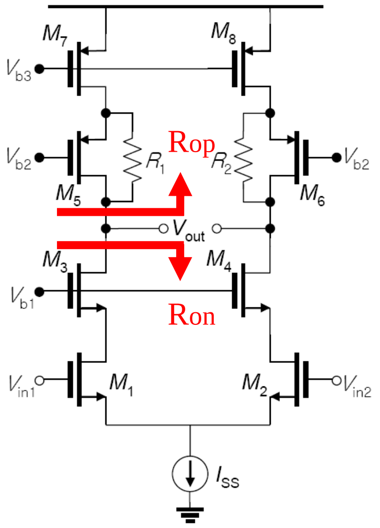
School of Electrical Engineering and Computer Science, Seoul National University

Quiz 2	Subject	Professor	Student ID#	Student Name	Score
Date: 2009.09.16	Microelectronics 2	Jong-Ho Lee			

1. Assume that each odd-numbered MOS transistor on left path of telescopic differential pair in the circuit shown below has the same properties as each even-numbered MOS transistors on the right path. For example, M_1 and M_2 are symmetric, and this relation is valid for other transistor pairs. Resistors R_1 and R_2 are also symmetric. Tail current source is ideal. All transistors have an output resistance r_o due to a finite Early voltage V_A. Answer for the following questions.



(a) Compute the differential gain of the circuit. R_1 (=R_2) can have an arbitrary resistance value.

Answer)

Using half circuit analysis,
Rop = R1//ro5 + ro7{1+gm5(R1//ro5)}
≈ ro7gm5(R1//ro5)
Ron = ro3 + ro1(1+gm3ro3)
≈ ro1gm3ro3
Av = -gm1(Rop//Ron)
(gm1 = gm2, gm3 = gm4, gm5 = gm6, gm7 = gm8)
(ro1 = ro2, ro3 = ro4, ro5 = ro6, ro7 = ro8)

(b) Repeat (a) when R_1 (=R_2) is infinite.

Answer)

Rop ≈ ro7gm5ro5 (R1(=R2) = ∞)
Av = -gm1(Rop//Ron) = -gm1(Ron// ro7gm5ro5)

(c) Calculate the differential gain when R_1 (=R_2) is 0 Ω, and pMOSFETs M_7 and M_8 are changed to nMOSFETs. Assume that $r_o >> 1/g_m$.

Answer)

R1(=R2) = 0 means R1(=R2) path will be short and so M5(M6) will be negligible.
M7(=M8) => nMOSFET means the output impedance in M7(=M8) is $\frac{1}{g_{m7}}(\frac{1}{g_{m8}}) \| r_{o7}(r_{o8})$ ·

Rop = $\frac{1}{g_{m7}} (r_o \gg 1/g_m)$

Ron ≈ ro1gm3ro3

Rout = Rop//Ron ≈ $\frac{1}{g_{m7}}$ $(r_o \gg 1/g_m)$

$$\boldsymbol{A_v = -g_{m1}\frac{1}{g_{m7}} = -\frac{g_{m1}}{g_{m7}}}$$

Use front side only