Quiz 5	Subject	Professor	Student ID#	Student Name	Score
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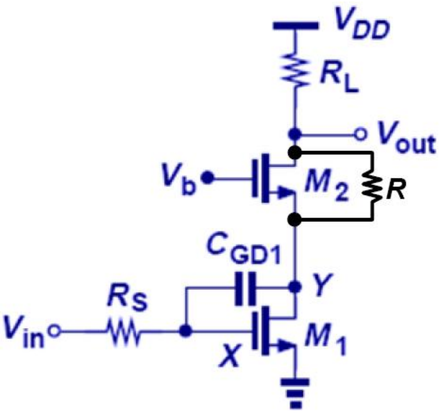
1. Assume that MOS transistor M_2 has no back-bias effect (γ=0, g_{mb}=0). It is also assumed that g_{m1} is equal to g_{m2}. All transistors have infinite output resistance (λ=0). Answer for the following questions.



(a) Compute the pole frequencies at nodes X, Y, and output when R is 0 Ω. Consider transistor capacitances in the calculation of the pole frequencies. (4)

Answer)

When R is $0\,\Omega$, M_2 is negligible.

Besides, the node Y is the same as node output.

We can obtain a low frequency gain,

$A_v = -g_{m1}R_L(r_{o1} = \infty)$.

Using Miller's Theorem,

$$C_X = C_{GS1} + (1 + g_{m1}R_L)C_{GD1}$$

$$C_Y = C_{DB1} + \left(1 + \frac{1}{g_{m1}R_L}\right)C_{GD1} = C_{out}$$

$$\boldsymbol{w_{p,X} = \frac{1}{R_s C_X}}\ ,\quad \boldsymbol{w_{p,Y}(= w_{p,out}) = \frac{1}{R_L C_Y}}$$

(b) Repeat (a) when R is infinite. (4)

Answer)

When R is infinite, a low frequency gain from X to Y is

$$A_v = -g_{m1}\frac{1}{g_{m2}} \cong -1 \quad (r_{o1,}r_{o2} = \infty, g_{m1} = g_{m2}).$$

$$C_X{}' = C_{GS1} + (1+1)C_{GD1} = C_{GS1} + 2C_{GD1}$$

$$C_Y{}' = C_{DB1} + C_{GS2} + 2C_{GD1} + C_{SB2}$$

$$C_{out}{}' = C_{GD2} + C_{DB2}$$

$$\boldsymbol{w_{p,X}{}' = \frac{1}{R_s C_X{}'}}\ ,\quad \boldsymbol{w_{p,Y}{}' = \frac{1}{\frac{1}{g_{m2}} C_Y{}'}}\ ,\quad \boldsymbol{w_{p,out}{}' = \frac{1}{R_L C_{out}{}'}}$$

(c) Compare the pole frequencies at node X in (a) and (b). (2)

Answer)

Compared with the Miller approximation results obtained in (a), the input pole in (b) has risen considerably. $(g_m R_L \gg 1)$

$$\boldsymbol{\therefore w_{p,X} < w_{p,X}{}'}$$

Use front side only