QUIZ NO. 9 - SOLUTION

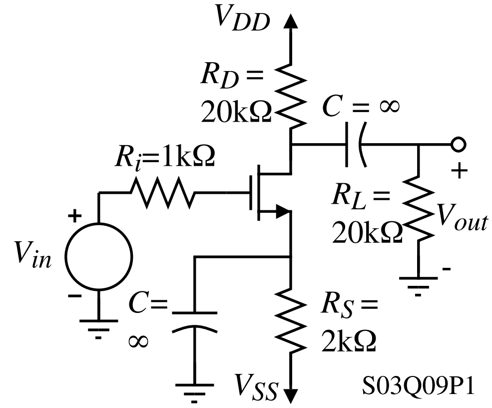
(Average score = 7.1/10 of the number of students taking this quiz.)

A NMOS amplifier is shown. Assume that the small-signal parameters of the MOSFET are g_m = 1mS, $r_{ds} = \infty$, C_{gs} = 9pF, and C_{gd} = 1pF.

a.) Find the midband voltage gain of this amplifier, V_{out}/V_{in}.

b.) Find the value of the upper -3dB frequency, f_H, in Hz, first using the Miller approximation and secondly using the open-circuit time constant approach.

c.) Which of the two answers for f_L in part b.) is the most accurate and why?



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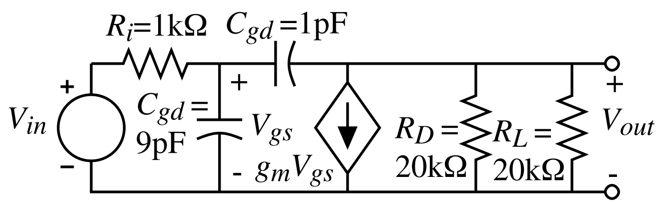
Solution

a.) The small-signal model for all three parts of this problem is shown.

The MBG is easily found by inspection as,



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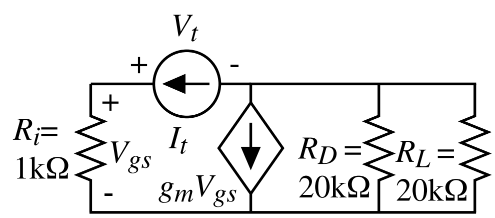
$$\frac{V_{out}(0)}{V_{in}(0)} = -g_m(R_D || R_L) = \underline{\underline{-10 \text{ V/V}}}$$

b.) The Miller approximation gives the following capacitance between gate and source.

$$C_{eq} = C_{gs} + (1\text{-MBG})\, C_{gd} = 9\text{pF} + (1+10)1\text{pF} = 20\text{pF}.$$

$$\therefore \quad \omega_H = \frac{1}{R_S C_{eq}} = \frac{1}{1\text{K}\cdot 20\text{pF}} = 50 \text{ Mrads/sec.} \quad \rightarrow \quad f_H = \frac{50\text{x}10^6}{2\pi} = \underline{\underline{7.96\text{MHz}}}$$

The OCTC approach requires finding R_{cgsO} and R_{cgdO}. These are found as,



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$$R_{cgsO} = R_i = 1\text{k}\Omega$$

$$R_{cgdO} = ?$$

$$V_t = V_{gs} + (I_t + g_m V_{gs})10\text{k}\Omega$$

$$= I_t R_i + (I_t + g_m I_t R_i)10\text{k}\Omega$$

$$\therefore \quad R_{cgdO} = \frac{V_t}{I_t} = R_i + (1 + g_m R_i)10\text{k}\Omega = 1\text{k}\Omega + (1+1)10\text{k}\Omega = 21\text{k}\Omega$$

$$\therefore \quad \omega_H = \frac{1}{R_{cgsO}C_{gs} + R_{cgdO}C_{gd}} = \frac{1}{1\text{K}\cdot 9\text{pF} + 21\text{K}\cdot 1\text{pF}} = \frac{1000}{30}\text{x}10^6 = 33.3\text{x}10^6 \text{ rads/sec.}$$

Thus, $f_H = \dfrac{33.3\text{x}10^6}{2\pi} = \underline{\underline{5.3\text{MHz}}}$

c.) The answer given by the OCTC method is more correct because the impedance of C_{gd} at ω_H for the Miller approach turns out to be $(1/50\text{ x}10^6\cdot 10^{-12})$ = 20kΩ which is not that much greater than $R_L || R_D$ = 10kΩ.