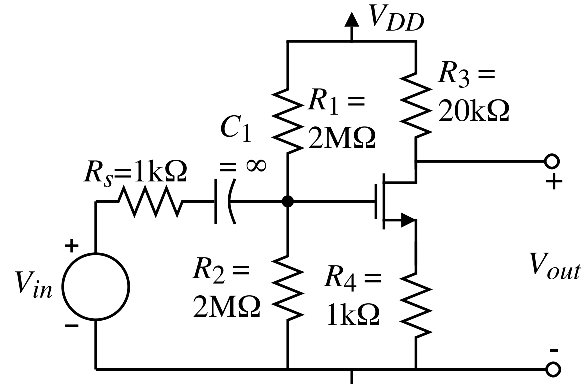
QUIZ NO. 10 - SOLUTIONS

(Average score = 6.4/10 of those taking the quiz.)

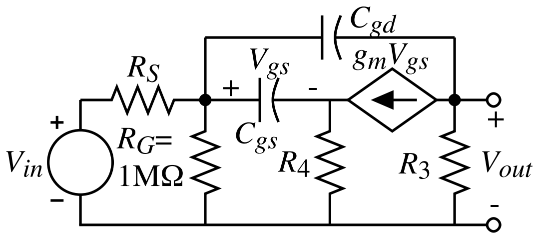
The FET in the amplifier shown has g_m = 1mA/V, $r_d = \infty$, C_{gd} = 0.5pF, and C_{gs} = 10pF. (a.) Find the midband gain, V_{out}/V_{in}. (b.) Find the upper -3dB frequency, f_H, in Hz.



S04Q10P1

Solution

(a.) The small-signal model for this problem is given below.



S04Q10S1

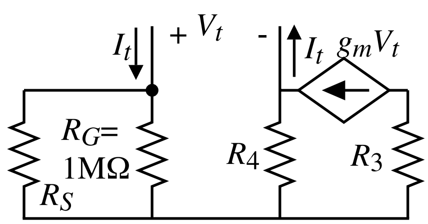
The MBG is given as

$$\frac{V_{out}}{V_{in}} = \left(\frac{V_{out}}{V_{gs}}\right)\left(\frac{V_{gs}}{V_g}\right)\left(\frac{V_g}{V_{in}}\right)$$

$$= (-g_m R_3)\left(\frac{1}{1+g_m R_4}\right)\left(\frac{R_G}{R_G+R_S}\right)$$

$$= (-20)(0.5)(0.999) = \underline{\underline{-9.9\text{V/V}}}$$

(b.) Both the direct analysis and the Millers method are not attractive for this problem. The direct method is too complicated and because of R_4, the Miller capacitance is not in parallel with C_{gs}. Therefore, we will use the OTC method.

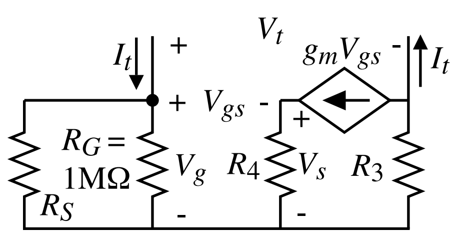


S04Q10S1A

R_{cgsO}: From the model shown to the right we write,

$$V_t = I_t(R_S \| R_G) + (I_t - g_m V_t)R_4$$

$$\therefore \quad R_{cgsO} = \frac{R_S \| R_G + R_4}{1+g_m R_4} = \frac{2.001\text{k}\Omega}{2} = 1\text{k}\Omega$$



S04Q10S1B

R_{cgdO}: From the model shown to the right we write,

$$V_t = V_g + (I_t + g_m V_{gs})R_3$$

but $\quad V_{gs} = V_g - V_s = V_g - g_m V_{gs} R_4$

or $\quad V_{gs} = \left(\frac{1}{1+g_m R_4}\right) V_g$

$$\therefore \quad V_t = V_g + \left(\frac{g_m R_3}{1+g_m R_4}\right) V_g + I_t R_3 = \left(\frac{1+g_m R_3}{1+g_m R_4}\right) V_g + I_t R_3 = I_t(R_S \| R_G)\left(\frac{1+g_m R_3}{1+g_m R_4}\right) + I_t R_3$$

or $\quad R_{cgdO} = 20\text{k}\Omega + 0.999\text{k}\Omega\left(\frac{21}{2}\right) = 30.49\text{k}\Omega$ (this was a tough one)

Finally,

$$\omega_H \approx \frac{1}{R_{cgsO}C_{gs} + R_{cdsO}C_{gd}} = \frac{10^9}{1\cdot 10 + 30.49\cdot 0.5} = 39.61\text{Mrads/sec} \rightarrow \underline{\underline{6.30\text{MHz}}}$$