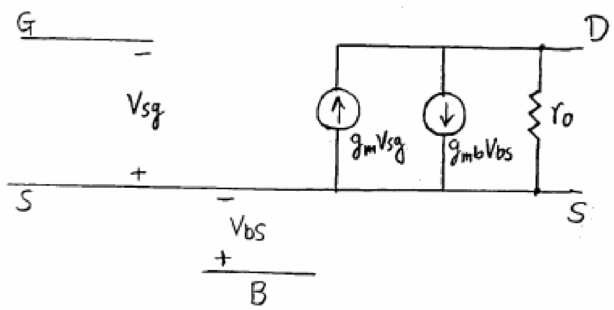
ENEE408D

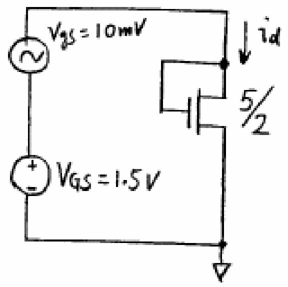
HW #9 Solution   Spring,2003

Problem 9.1

The small signal model of P-channel MOSFET is shown below:



Problem 9.3

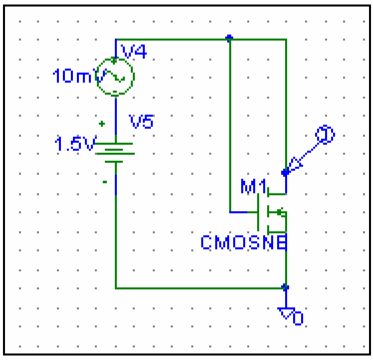


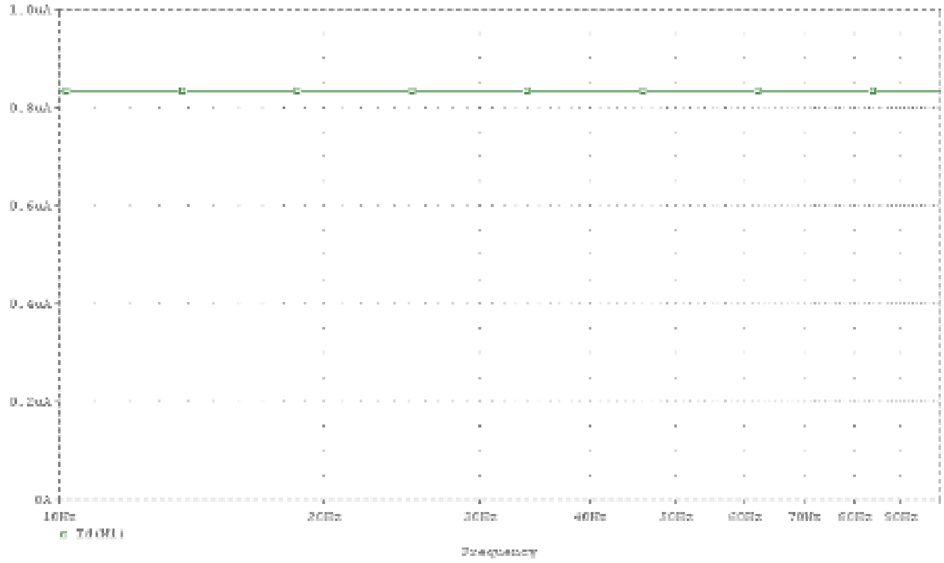
MOSFET operates in satulation region. $V_{THN} = 0.83V$

$$g_m = \beta (V_{GS} - V_{THN}) = k_{PN} \times \frac{W}{L} (V_{GS} - V_{THN})$$

$$= 50\mu A/V^2 \times \frac{5\mu m}{2\mu m} \times (1.5v - 0.83v) = 83.75\mu A/V$$

$$i_d = g_m v_{gs} = 83.75\mu A/V \times 0.01V \approx \underline{0.838\mu A}$$





Problem 9.4

1. Method one:

Generally, id = $\dfrac{\partial i_D}{\partial v_{DS}}$ vds.

$\dfrac{\partial i_D}{\partial v_{DS}}$ = (βn/2)*(VGS-Vthn)^2*λ = (50/2)*(15/5)*(1.5-0.83)*0.06 = 2.02uA/V.

id = 2.02ua/V * 100mV = 202 nA.

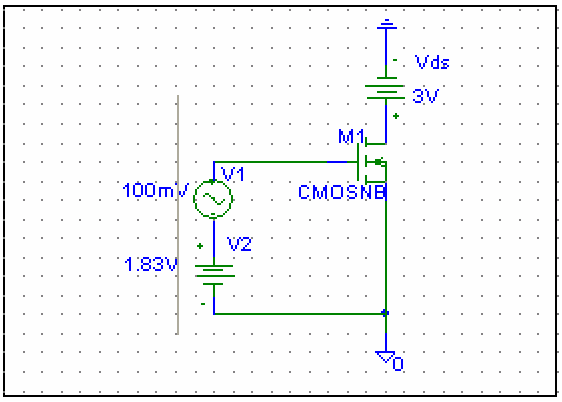
2. Method Two-small signal model.

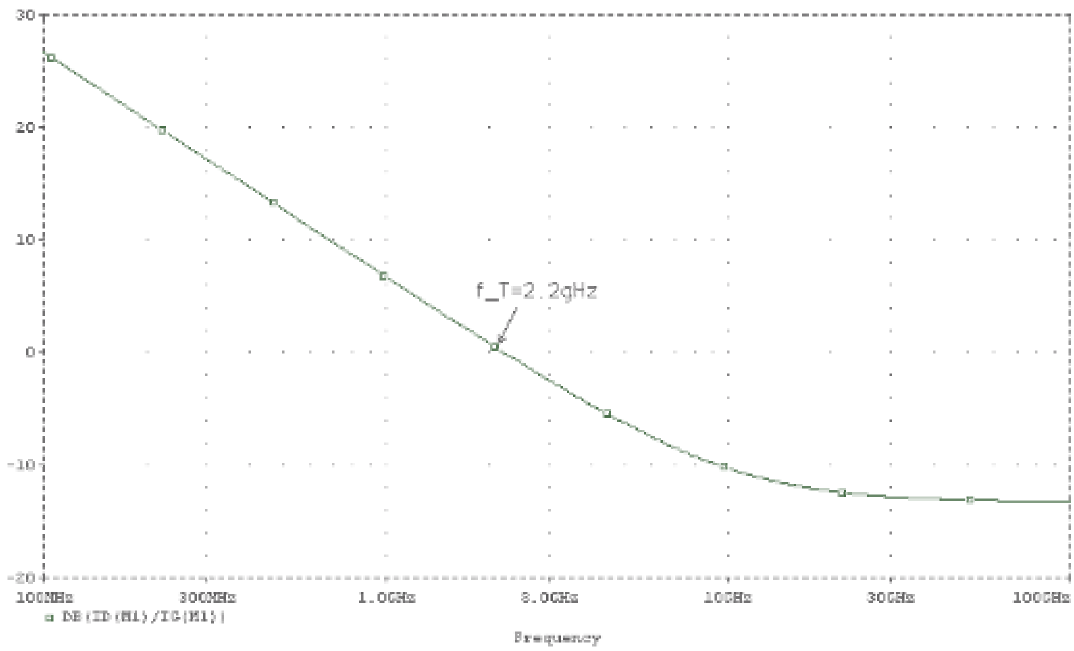
ID = (βn/2)*(VGS-Vthn)^2 and r0 = 1/(λ*ID) . **Plug into the values ==> r0 = (1/2.02) V/uA.**

id = vds/r0 = 100mV/[(1/2.02) V/uA] = 202 nA.

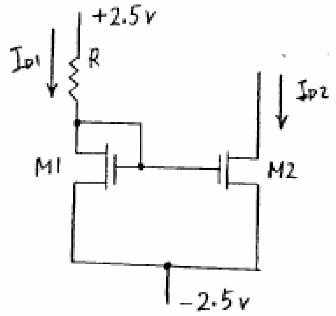
Problem 9.12

ANS: The circuit, netlist and plots are shown in the following figure and VGS = 1.83v. For n-channel, SPICE simulation gives f_T = 2.2ghz. Notice it is depend on the VGS value. At f_T |id/ig| =1 and at DC |id/ig| = ∞.





Problem 20.1



$$R = \frac{2.5 - V_{GS} - (-2.5)}{I_{D1}} = \frac{2.5 - 1 - (-2.5)}{1\,\mu A} = 4\,M\Omega$$

$$I_{D1} = I_{D2} = \frac{K_P}{2}\frac{W}{L}(V_{GS} - V_{THN})^2$$

$$\Rightarrow 1\,\mu A = \frac{50\,\mu A/V^2}{2} \times \frac{W}{L} \times (1V - 0.83V)^2$$

$$\Rightarrow \frac{W}{L} \simeq 1.38 \Rightarrow W_1 = W_2 = 7\,\mu m, \; L_1 = L_2 = 5\,\mu m$$

Problem 20.4

If the size of M2 increased to 30/5, $I_{D2} = I_{D3} = 20\,\mu A$.

V_{GS2} does not change, but V_{SG3} changes to about 1.32V.

Problem 20.13