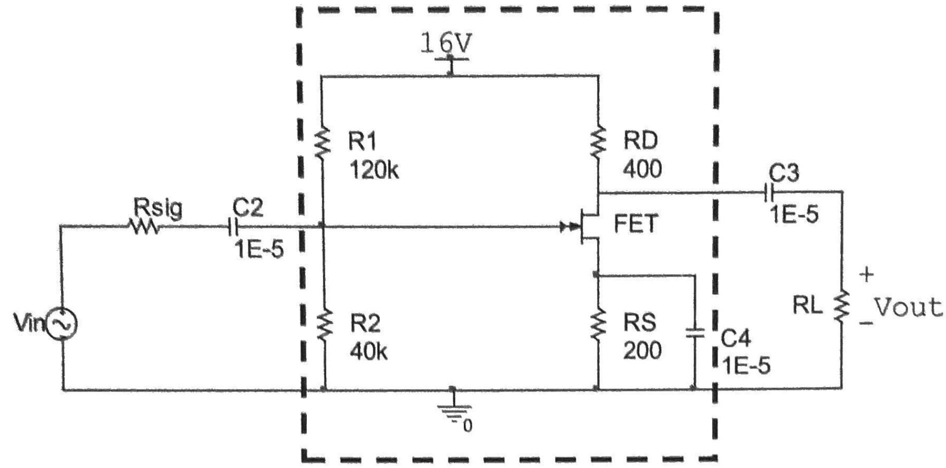
Homework 14

Reading: Chapters 10.1-6 (FET discussion)

Problem 1) Common Source with Cs and the Miller Theorem

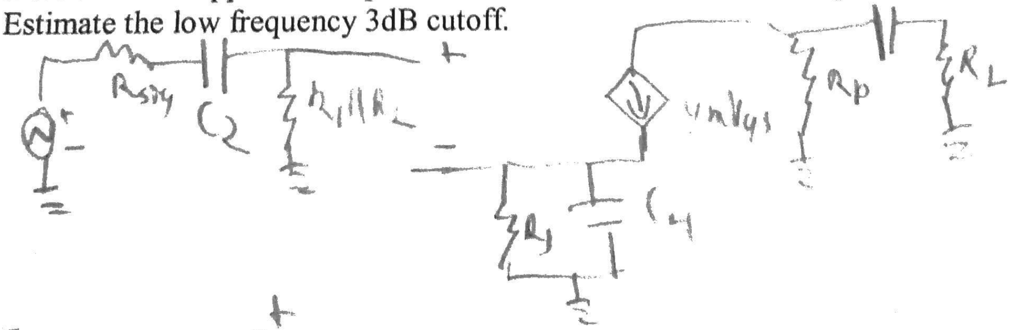


The NMOSFET in the above circuit has characteristics VTN = 2.2V, and Kn = 400mA/V^2
(DC bias characteristics from previous homework, you have calculated the DC bias characteristics and sketched the small signal model. The g_m value is 0.08 A/V.)

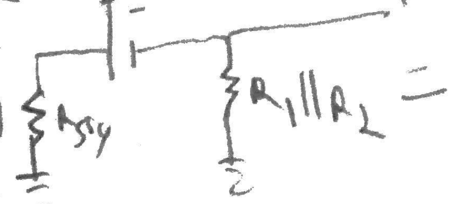
Rsig = 100Ω
RL = 1kΩ

a) For each external capacitor, determine the equivalent resistance seen by that capacitor when all other external capacitors are short circuited.
b) Determine the approximate pole associated with each external capacitor.
c) Estimate the low frequency 3dB cutoff.

A: overall



For C2:

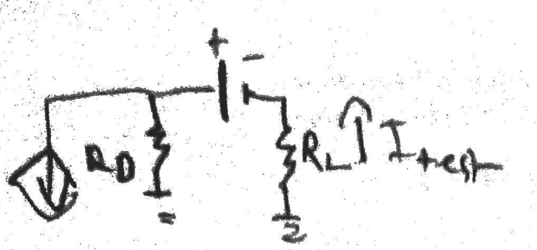


$R_{seen} = R_{sig} + R_1 || R_2 = \underline{30.1k\ \Omega}$

$Pole = \frac{1}{RC} = \underline{3.322\ rad/s}$

Part B →

For C_3:

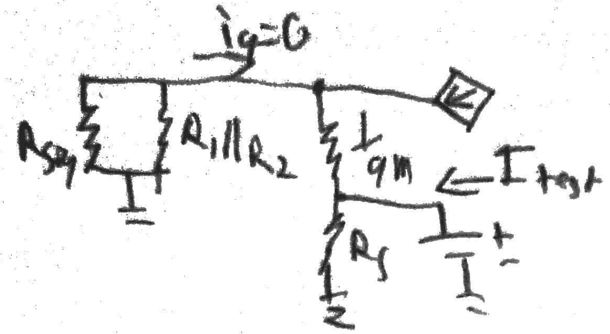


$R_{seen} = R_D + R_L = \underline{1.4k\ \Omega}$

$Pole = \frac{1}{RC} = \underline{71.43\ Rad/s}$

part B ↗

For C_4:



$R_{seen} = \frac{1}{g_m} \| R_S = \underline{11.76\ \Omega}$

$Pole = \frac{1}{R_C} = \underline{8503\ rad/s}$

part B ↗

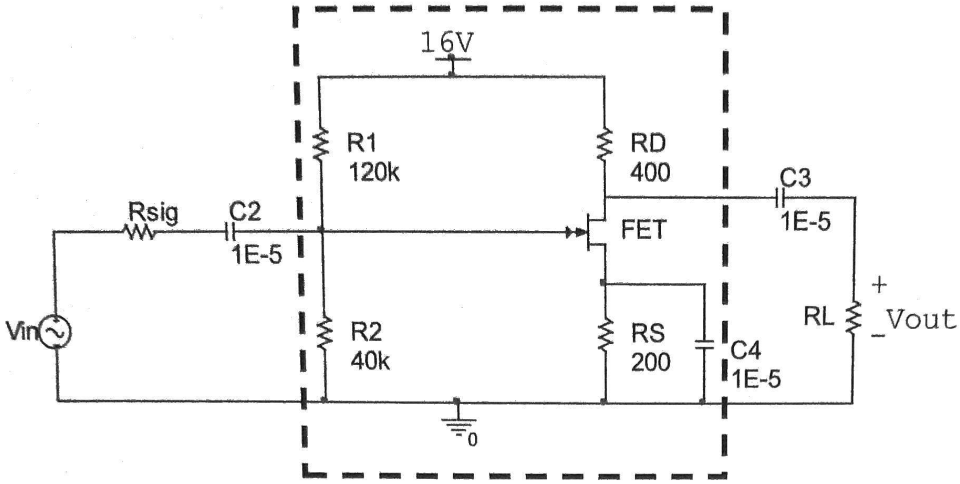
C:

Z_{C_2} & $Z_{C_3} \to 0$ $\quad Z_{C_4} \to \infty$ $\quad R_{seen} = \frac{1}{g_m} \| R_S = 11.76\ \Omega$

pole $= 8503\ rad/s$

dominant pole $\to$ $\underline{\omega_{3dB} = 8500\ rad/s}$

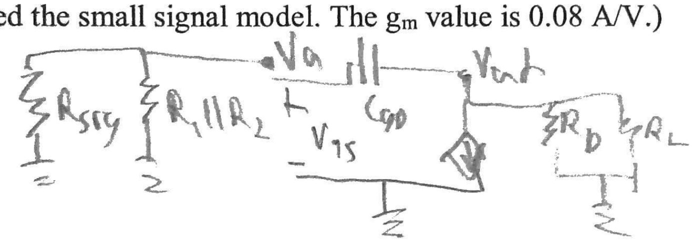
Problem 2) Miller Theorem and C_{GD} pole approximation



The NMOSFET in the above circuit has characteristics VTN = 2.2V, and Kn = 400mA/V²
(DC bias characteristics from previous homework, you have calculated the DC bias characteristics and sketched the small signal model. The g_m value is 0.08 A/V.)

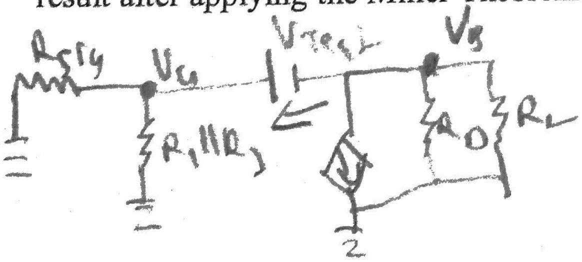
Cgs = 50pF
Cgd = 20pF

Rsig = 100Ω
RL = 1kΩ



a) Only considering C_{GD} (C_{GS} open circuited) draw the small signal and identify the two nodes associated with the feedback capacitor, C_{GD}.
b) Determine the Miller gain, A_M, associated with those two nodes.
c) Redraw the circuit, representing the feedback capacitor as an input side and an output side capacitance.
d) Approximate the pole associated with the input side of the circuit and the pole associated with the output side of the circuit.
e) For those two poles, approximately determine the high frequency 3dB point.
f) Repeat the C_{GD} pole calculation without using the Miller Theorem, replacing the capacitor with a test voltage and finding R_{EQ} using circuit analysis. Does the result after applying the Miller Theorem compare to the result obtained in part e?

A:



$V_G = V_{Test} + V_B$

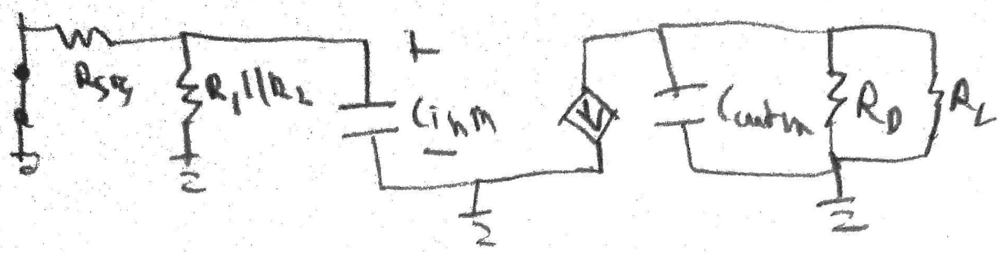
$\frac{V_B + 1}{R_{sig}||R_1||R_2} + g_m(V_B + 1) + \frac{V_B}{R_D||R_L} = 0$

$V_B = -0.96V$

$V_G = 0.037V$

B: $A_n = \frac{V_{out}}{V_{in}} = \underline{-25.72}$

C:



D: $P_{in} = \frac{1}{R_{sig} \| R_1 \| R_2 \cdot C_{in}}$

$\underline{= 2.103 \cdot 10^7}$

$C_{inm} = C_{gD}(1 + g_m(R_D \| R_L))$

$= 4.77 \cdot 10^{-10}$

$P_{out} = \frac{1}{R_D \| R_L \cdot C_{out\,m}}$

$\underline{= 1.68 \cdot 10^7}$

$C_{out\,m} = C_{gD}(1 + \frac{1}{g_m(R_D \| R_L)})$

$= 21 \cdot 10^{-11}$

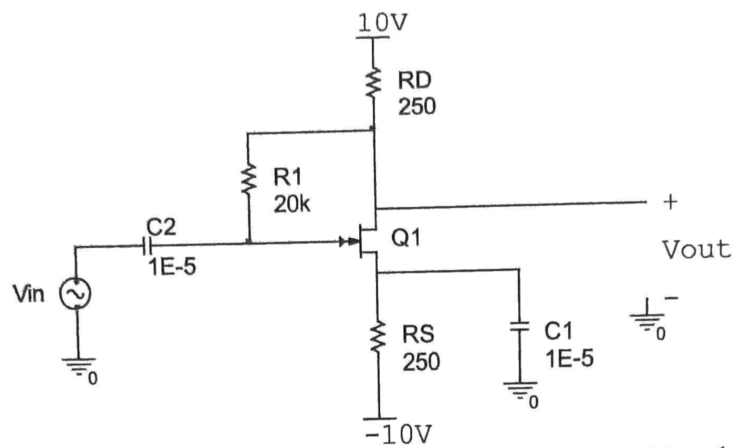
E: $\frac{1}{\frac{1}{P_{in}} + \frac{1}{P_{out}}} = P_{3dB} = \underline{1.87 \cdot 10^7}$

F: $R_{sze} = R_{sig} \| R_1 \| R_2 + R_D \| R_L = 385.37$

$P = \frac{1}{385.37 \cdot 20 \cdot 10^{-12}} = \underline{1.3 \cdot 10^8}$

__It does not compare well__

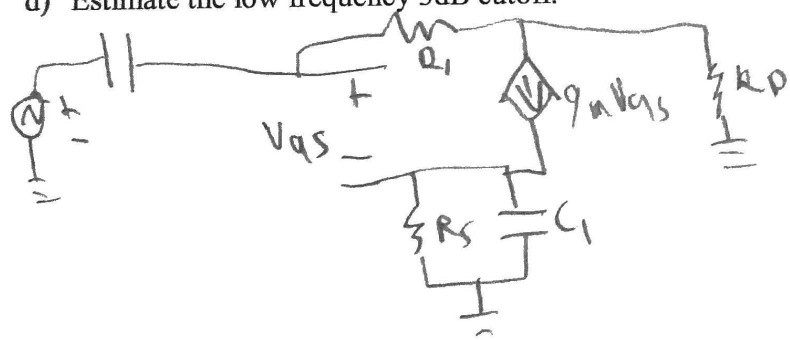
Problem 3) Common Source with Cs and the Miller Theorem



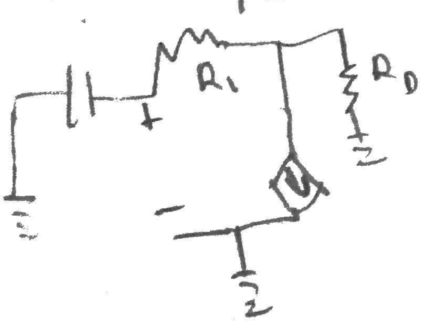
The NMOSFET in the above circuit has characteristics VTN = 2.2V, and Kn = 40mA/V^2 (DC bias characteristics from previous homework)

a) Apply the Miller Theorem to the resistor R1, representing it as an equivalent input side and output side resistance in the small signal model.
b) Using this equivalent circuit, for each external capacitor, determine the equivalent resistance seen by that capacitor when all other external capacitors are short circuited.
c) Determine the approximate pole associated with each external capacitor.
d) Estimate the low frequency 3dB cutoff.

A:



B: For short C1:

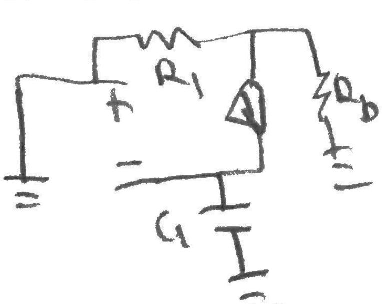


$R_{seen} = R_1 + R_D = 20250\ \Omega$

For short C2:

$R_{seen} = \frac{1}{g_m} \| R_S$

$= 30.96\ \Omega$



C: $P_{short\,C_1} = \frac{1}{RC} = \underline{4.938}$

$P_{short\,C_2} = \frac{1}{RC} = \underline{3229.974}$

D: lower pole $\omega_{3dB} = \underline{4.938 \text{ rad/s}}$