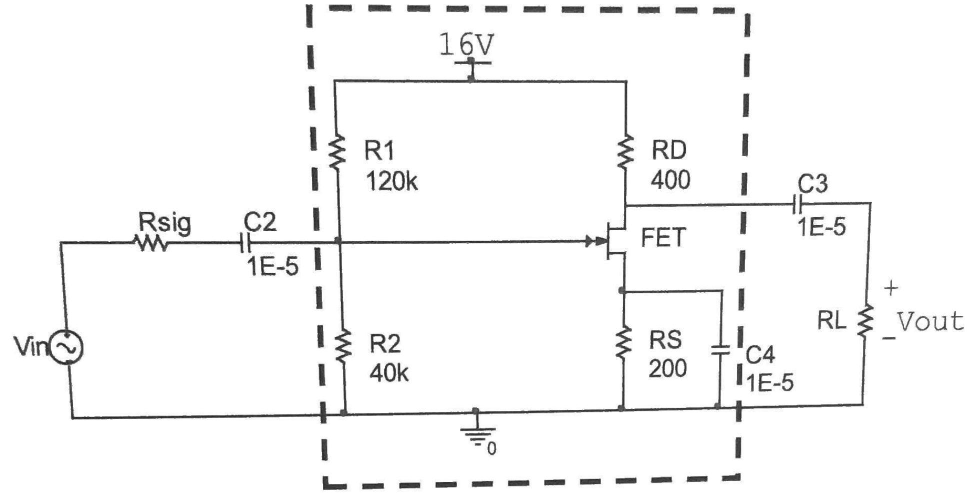
ECSE-2050

Introduction to Electronics
Summer 2020 **Name** ____________________

Homework 13

Reading: 7.1, 7.2-5 (FET discussion)
Problem 1) Common Source with Cs



The NMOSFET in the above circuit has characteristics VTN = 2.2V, and Kn = 400 mA/V²

a) Determine the gate-source voltage, VGS, and the drain current, ID.
b) Determine the small signal transconductance, g_m.
c) Sketch the small signal model of the circuit.
d) For Rsig = 0 and RL → ∞, determine the open circuit gain, Avo = $Vout_o/Vin_o$.
e) Using the dashed box to define the input and output impedance, find Rin and Rout.
f) Redraw the circuit, using the general amplifier model with Rin, Rout and Avo.

g) If Vcc dropped to 12V, determine the new open circuit gain, Avo. You will need to recalculate your DC bias terms and get the new g_m.

h) For Vcc = 16V, Rsig = 50Ω and RL = 5kΩ, determine the overall gain, Av.
i) For Vcc = 16V, Rsig = 20kΩ and RL = 800Ω, determine the overall gain, Av.

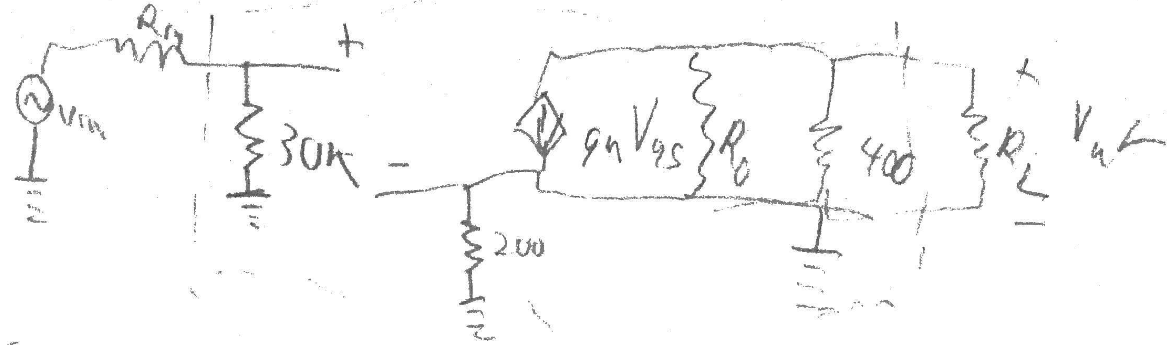
A: $V_g = 4V = \frac{1}{2} \cdot .4 (V_{GS} - 2.2)^2 \cdot 200 + V_{GS}$ $\quad V_{GS} = 2.48V$ $\quad I_D = 15.68\,mA$

$V_{DS} = 16 - I_D(600) = 6.59\,V$

B: $g_m = .112$

$V_{cc} - I_D(600) - V_{ds} = 0$

C:



D: Source transformation: $A_{V_0} = -g_m(r_0 \| R_D) = -13$

E: $R_{in} = 30K$ $R_{out} = R_0 \| R_D = 116.8$

F:

G: $3V = \frac{1}{2} \cdot 4(V_{gs} - 2.2)^2 \cdot 200 + V_{gs}$ $\underline{V_{GS} = 2.38}$ $\underline{I_D = 6.41\,mA}$

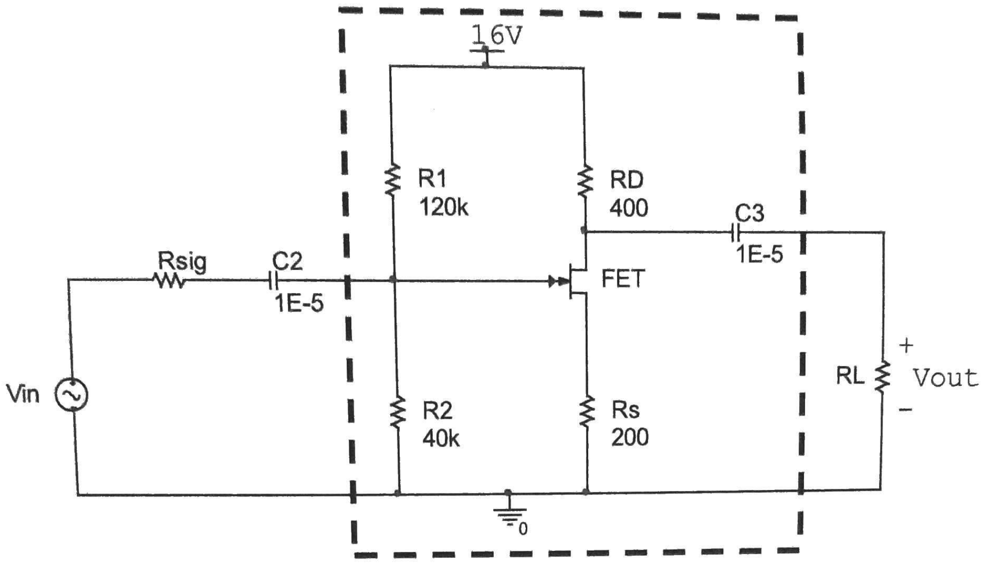
$\underline{g_m = 0.072}$ $V_{ds} = 8.112\,V$ $R_0 = 165$

$A_{V_0} = -8.41$

H: $A_V = \left(\frac{50}{50+30k}\right) -13 \left(\frac{5k}{5k+116.8}\right) = -0.021$

I: $A_V = \frac{20k}{20k+30k} (-13) \left(\frac{800}{800+116.8}\right) = -4.54$

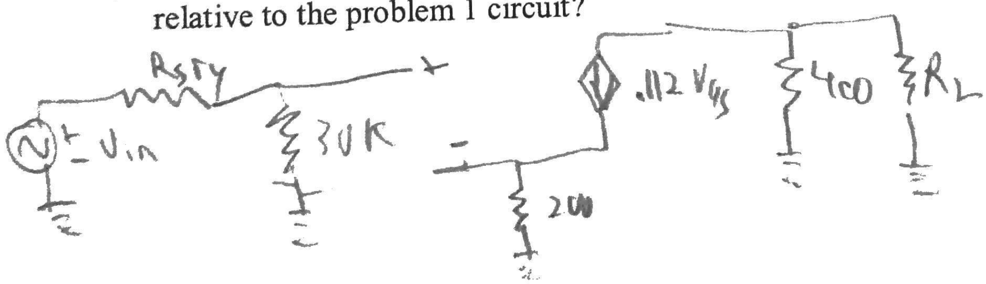
Problem 2) Common source without source capacitor



The NMOSFET in the above circuit has characteristics VTN = 2.2V, and Kn = 400 mA/V^2
(The same DC bias circuit as problem 1.)

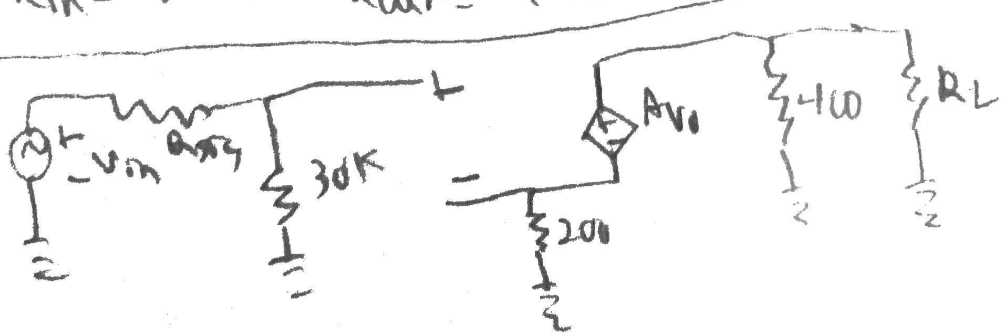
a) Sketch the small signal model, leaving Rsig and RL in symbolic form.
b) Based on the dashed box, determine Rin, Rout and Avo.
c) Redraw the circuit, using the general amplifier model with Rin, Rout and Avo, leaving Rsig and RL in symbolic form.
d) For this circuit, is the gain approximation Avo ~ - RD/RS reasonable?
e) If Vcc dropped to 12V, determine the new open circuit voltage gain, Avo.
f) Was the gain of this circuit less sensitive to variations in the bias conditions relative to the problem 1 circuit?

A:



B: Rin = 30K Rout = 400 Avo = -.97

C:

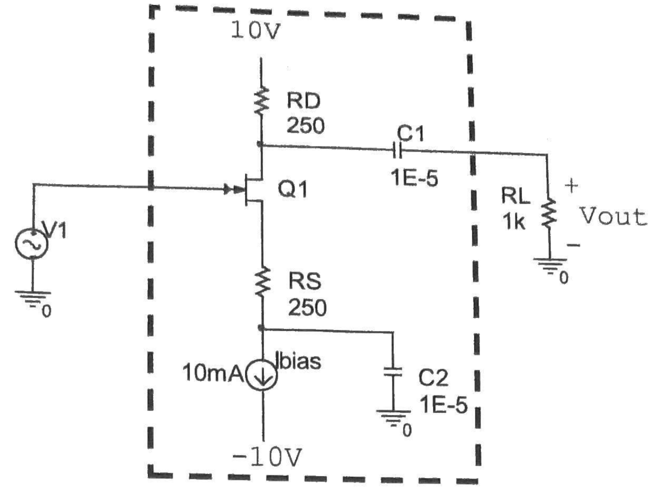


D: It is not reasonable. It is 2 times as large which is a substantial gain.

E: $$\frac{-0.072 \times 400}{1+0.072 \times 400} = -.96 = A_{vo}$$

F: The gain was incredibly less sensitive.

Problem 3) Common source without source capacitor



The NMOSFET in the above circuit has characteristics, VTN = 2.2V, and Kn = 40 mA/V^2.

(The same DC bias circuit as problem 4b in HW12.)

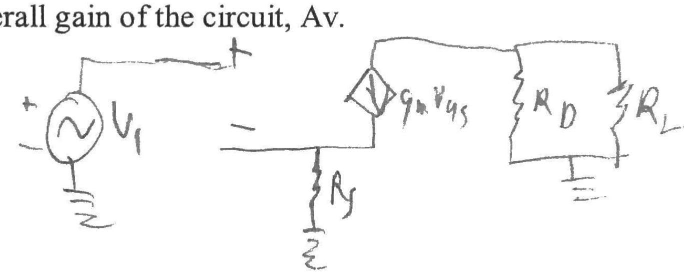
a) Sketch the small signal model.

b) Based on the dashed box, determine Rin, Rout and Avo.

c) Redraw the circuit, using the general amplifier model with Rin, Rout, RL and Avo,

d) Determine the overall gain of the circuit, Av.

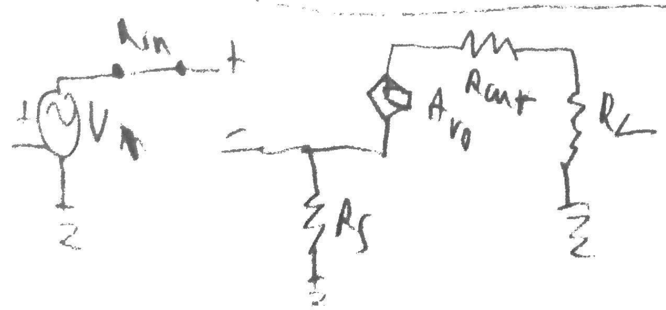
A: $I_d = 10mA$



B: $R_{in} = 0$ $R_{out} = R_D$ $A_{vo} = -0.98$

$V_{gs} = 0 + 10V - 10mA \cdot 250 = 7.5$ $g_m = .212$

C:



$A_{vo} = -0.98$

$R_{in} = 0$

$R_{out} = 250$

$R_L = 1k$

D: $A_V = -0.785$