American University of Beirut
Department of Electrical and Computer Engineering

EECE 310 – Electronics I
Quiz 2 – December 16, 2006
Closed Book – No Programmable Calculators
120 minutes
Penalty is 5 to 1

Name: ______________________________ ID number: _______________

Use
$n_i \approx 1.25\times10^{10}$ / cm^3
D_p = 12 cm^2/s, D_n= 34 cm^2/s
μ_p = 480 cm^2/V.s, μ_n = 1350 cm^2/V.s.
$q = 1.6\times10^{-19}$ C, $V_T \approx 25$ mV, $\varepsilon_{Si} = 1.04 \times 10^{-12}$ F/cm

1 µm = 10^{-4} cm
1 fF = 10^{-15} F

Neglect body effect

Questions 11 to 15 are not included in Fall 2008-2009 Quiz 2

1- A MOSFET is biased in the saturation region at a fixed V_{DS}, and at I_D = 2 mA, and V_{OV} = 1 V. Find the increase in the drain current (in mA) when the gate-to-source voltage increases by 10 mV.

a) 0.08 b) 0.07 c) 0.04 d) 0.05 e) 0.06

2- A MOSFET with $k'_n(W/L)$ = 1 mA/V^2, V_t = 1.3 V, and λ = 0.04 V^{-1}, is biased at V_{GS} = 2 V, V_{DS} = 4 V. Find the value of r_o (in KΩ) for this MOSFET.

a) 88.9 b) 102.0 c) 61.7 d) 69.2 e) 78.1

Consider the two-stage amplifier shown in Figure 1. Assume G = 2 mA/V.

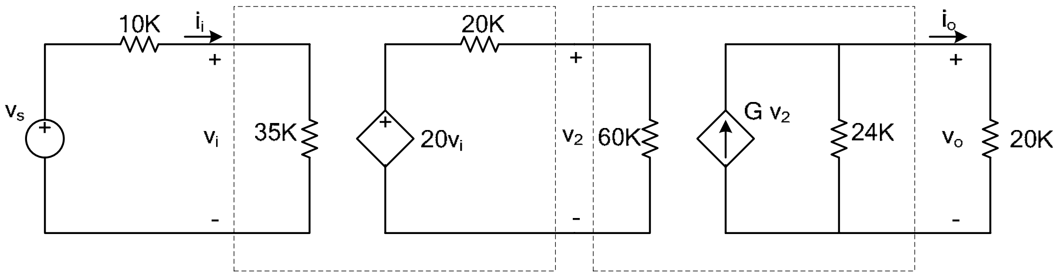


Figure 1

3- Find the value of the input resistance (in KΩ).

a) 30 b) 35 c) 40 d) 45 e) 50

4- Find the value of the output resistance (in KΩ).

a) 15 b) 27 c) 24 d) 21 e) 18

5- Find the voltage gain of the amplifier (v_o/v_i).

a) 257.1 b) 307.3 c) 284.2 d) 344.7 e) 327.3

6- Find the current gain (i_o/i_i).

a) 517.0 b) 572.7 c) 614.6 d) 639.5 e) 642.9

Consider the amplifier shown in Figure 2. The capacitors are very large.

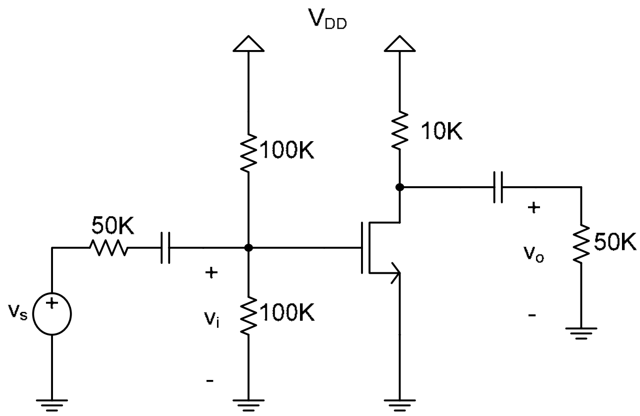


Figure 2

7- The MOSFET is biased such that g_m = 1.2 mA/V and r_o = 55 KΩ. Find the small-signal voltage gain of the amplifier (v_o/v_s).

a) –2.7 b) –3.1 c) –3.5 d) –3.9 e) –4.3

8- Assume that the gain from gate to drain v_o/v_i is –6. The drain of the MOSFET is biased at a DC voltage of 5 V. What should be the DC voltage at the gate (in V) in order to have a signal swing of +/– 2.0 V at the drain, while keeping the MOSFET in saturation? The transistor has V_t = 1 V.

a) 3.67 b) 3.90 c) 4.60 d) 4.37 e) 4.13

Consider the common-source MOSFET amplifier shown in Figure 3. *Neglect channel-length modulation.*

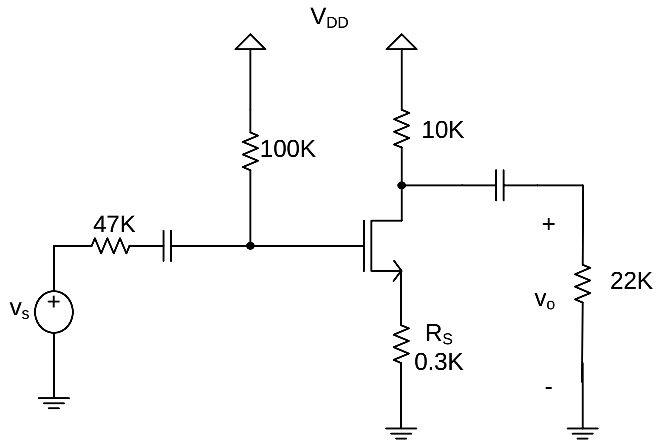
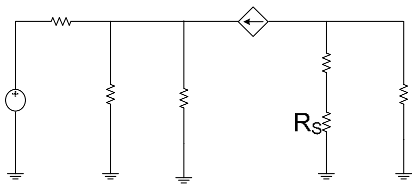
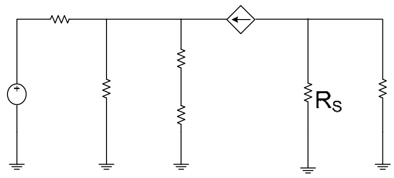
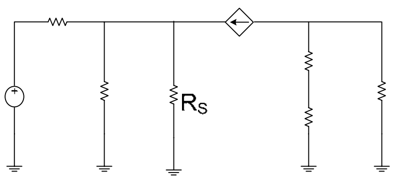


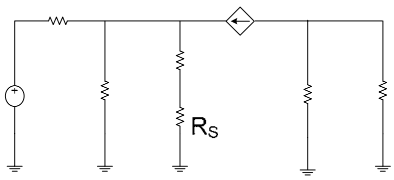
Figure 3

9- Which of the following circuits corresponds to its small-signal equivalent?

a) 

b) 

c) 

d) 

10- Find the voltage gain v_o/v_s for the amplifier. The MOSFET small-signal transconductance is g_m= 1.8 mA/V.

a) –5.5 b) –4.8 c) –2.6 d) –3.8 e) –3.2

11- A voltage of magnitude 8 V is applied across the ends of a bar of intrinsic Silicon having a cross-sectional area of 0.25 cm^2. How long should the bar be (in cm) in order to have a current of 12 µA flowing through it?

a) 0.76 b) 0.69 c) 0.61 d) 0.46 e) 0.53

For a particular PN junction, the acceptor concentration is 5×10^{16}/cm^3, and the donor concentration is 3×10^{12} /cm^3.

12- Find the junction potential (in V) if no external bias is applied.

a) 0.46 b) 0.69 c) 0.63 d) 0.57 e) 0.52

13- Find the concentration of holes (in cm^{-3}) in the n-type material.

a) 5.2×10^6 b) 5.2×10^8 c) 5.2×10^7 d) 5.2×10^4 e) 5.2×10^5

14- Find the depletion capacitance (in fF) when an 8 V reverse-bias is applied across this diode. The junction cross-sectional area is 500 μm^2. The width of the depletion region is given by $W = \sqrt{\frac{2\varepsilon_{Si}}{|q|}(V_o + V_R)\left(\frac{1}{N_A}+\frac{1}{N_D}\right)}$.

a) 26 b) 8.5 c) 2.7 d) 0.86 e) 0.27

15- The hole concentration in the n-type material of a PN junction diode under forward bias is described by:

$$p(x) = 10^5 + 10^{17} e^{-x/L_p} \qquad \text{holes/cm}^3$$

with L_p = 3 μm. Given that the cross-sectional area of the junction is 240 μm^2, find the hole diffusion current (in mA) that flows in the n-material at x = 2 μm.

a) 0.26 b) 0.39 c) 0.53 d) 0.66 e) 0.79

To analyze the circuit shown in Figure 4, we use the MOSFET characteristics shown in Figure 5.

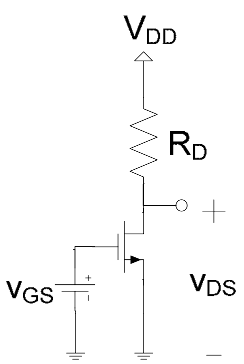


Figure 4

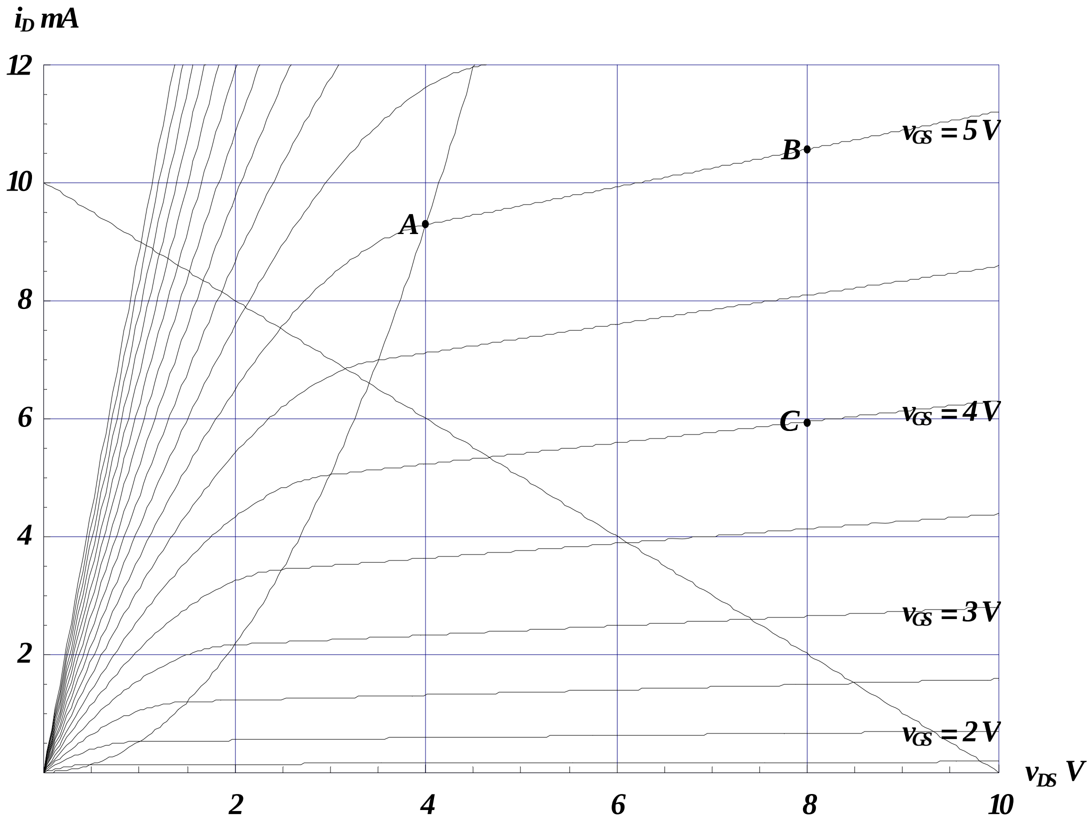


Figure 5

Figure 5 shows the characteristics for an NMOS transistor for a set of values of V_{GS}. The lowest value of V_{GS} is 1.5 V, the highest value is 10 V, with a step size of 0.5 V. Also a load line for the resistor R_D in the drain branch is shown in the figure. The values for i_D at the three points ***A***, ***B***, and ***C*** shown on the graph are:
$i_{D(A)}$ = 9.28 mA
$i_{D(B)}$ = 10.56 mA
$i_{D(C)}$ = 5.94 mA

16- What is the value of the resistor R_D in Ω?

a) 1000 b) 800 c) 750 d) 1100 e) 1200

17- What is the value of V_A in V? Use points *A* and *B* on the graph. *Hint*: Use the MOSFET current equation in saturation.

a) 10 b) 25 c) 30 d) 20 e) 15

18- What is the value of V_t in V? Use points *B* and *C* on the graph. *Hint*: Use the MOSFET current equation in saturation.

a) 1.0 b) 0.9 c) 0.8 d) 0.7 e) 0.6

19- In the circuit, V_{GS} is set at 2.5 V. Construct a second load line for the case when the supply voltage V_{DD} is *reduced by* 2 V. Find the value of V_{DS} (in V) at the new quiescent point *Q*.

a) 4.3 b) 3.4 c) 6.6 d) 7.3 e) 5.7

Consider the circuit shown in Figure 6. For the MOSFET, $k'_n(W/L) = 1$ mA/V^2, $V_t = 0.7$ V, and $\lambda = 0$. Assume R = 1400 Ω.

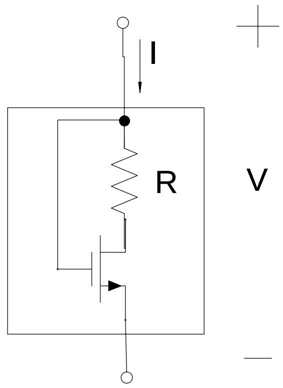


Figure 6

20- The condition for operation of the MOSFET in the saturation region, rather than in the triode (linear) region, is:

a) I ≤ 0.5 mA
b) I ≥ 0.5 mA
c) V ≤ 1.4 V
d) V ≥ 0.7 V

21- For I = 0.5 mA, what is the value of V (in V)?

a) 1.60 b) 2.41 c) 2.58 d) 2.21 e) 1.70

In the circuit shown in Figure 7, the NMOS transistor is characterized by $k'_n(W/L) = 1$ mA/V^2, $V_t = 1$ V and $\lambda = 0$. The PMOS transistor is characterized by $k'_p(W/L) = 0.25$ mA/V^2, $|V_t| = 1$ V and $\lambda = 0$.

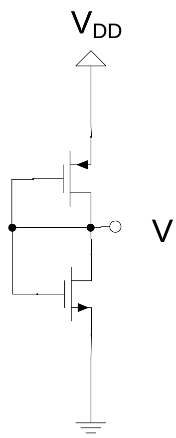


Figure 7

22- Given that V = 5 V, what is the value of I_D in mA?

a) 12.5 b) 8.0 c) 4.5 d) 0.5 e) 2.0

23- If V_{DD} = 8 V, what is the voltage V (in V) at the connected gates?

a) 3.67 b) 2.33 c) 2.67 d) 3.00 e) 3.33

The NMOS transistor in the circuit of Figure 8 is characterized by $k'_n(W/L) = 0.5$ mA/V^2, $V_t = 1$ V, and $\lambda = 0$. The MOSFET is biased at $I_D = 0.5$ mA.
Assume $V_{DD} = 8$ V.

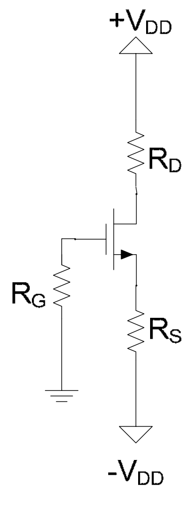


Figure 8

24- Assuming operation in the saturation region, find R_D (in KΩ) if the drain voltage to ground $V_D = 2$ V.

a) 14 b) 12 c) 6 d) 8 e) 10

25- Find R_S (in KΩ).

a) 5.17 b) 7.17 c) 9.17 d) 11.17 e) 13.17