“In the name of God”

Tutorial of ECE 340 Course

Instructor: Professor Karim

Seyyed Mojtaba Pourjaafari

Winter 2020

4.1 Figure 1 shows a discrete-circuit amplifier. The input signal v_{sig} is coupled to the gate through a very large capacitor (shown as infinite). The transistor source is connected to ground at signal frequencies via a very large capacitor (shown as infinite). The output voltage signal that develops at the drain is coupled to a load resistance via a very large capacitor (shown as infinite). All capacitors behave as short circuits for signals and as open circuits for dc.

(a) If the transistor has $V_t = 1V$, and $k_n = 4\ mA/V^2$, verify that the bias circuit establishes $V_{GS} = 1.5\ V, I_D = 0.5mA,$ and $V_D = +7\ V$. That is, assume these values, and verify that they are consistent with the values of the circuit components and the device parameters.

(b) Find g_m and r_o if $V_A = 100\ V$.

(c) Draw a complete small-signal equivalent circuit for the amplifier, assuming all capacitors behave as short circuits at signal frequencies.

(d) Find R_{in}, $\frac{v_{gs}}{v_{sig}}$, $\frac{v_o}{v_{gs}}$, and $\frac{v_o}{v_{sig}}$.

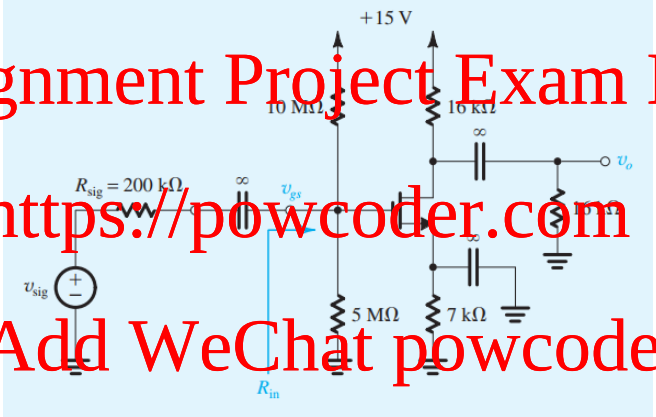

Figure 1

4.2 The NMOS transistor in the CS amplifier shown in Figure 2 has $V_t = 0.7\ V$ and $V_A = 50\ V$.

(a) Neglecting the Early effect, verify that the MOSFET is operating in saturation with $I_D = 0.5\ mA$ and $V_{OV} = 0.3\ V$. What must the MOSFET's k_n be? What is the dc voltage at the drain?

(b) Find R_{in} and G_v.

(c) If v_{sig} is a sinusoid with a peak amplitude $\widehat{v_{sig}}$, find the maximum allowable value of $\widehat{v_{sig}}$ for which the transistor remains in saturation. What is the corresponding amplitude of the output voltage?

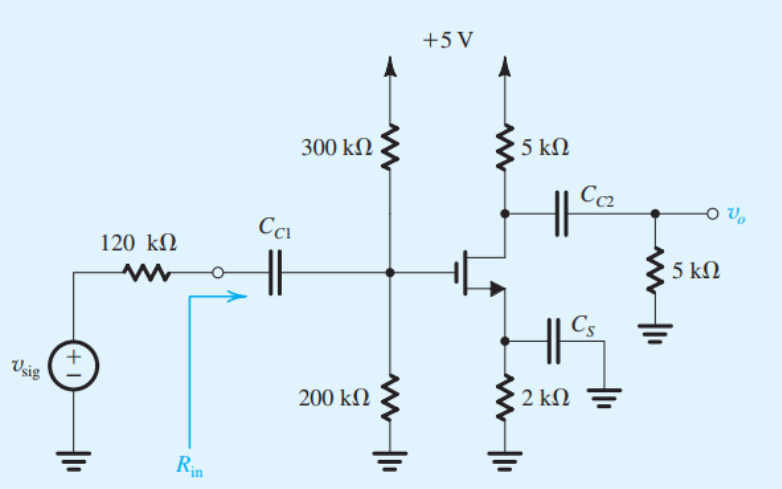

Figure 2

4.3 The MOSFET in the circuit of Figure 3 has $V_t = 0.8V$, $k_n = 5\frac{mA}{V^2}$ *and* $V_A = 40\,V$.

(a) Find the values of R_s , R_D *and* R_G so that $I_D = 0.4\ mA$, the largest possible value for R_D is used while a maximum signal swing at the drain of $\pm 0.8\ V$ is possible, and the input resistance at the gate is 10 $M\Omega$.

(b) Find the values of g_m and r_o at the bias point.

(c) If terminal Z is grounded, terminal X is connected to a signal source having a resistance of 1 $M\Omega$, and terminal Y is connected to a load resistance of 10 $k\Omega$, find the voltage gain from signal source to load.

(d) If terminal Y is grounded, find the voltage gain from X to Z with Z open-circuited. What is the output resistance of the source follower?

(e) if terminal X is grounded and terminal Z is connected to a current source delivering a signal current of 50 μA and having a resistance of 100 $k\Omega$, find the voltage signal that can be measured at Y.

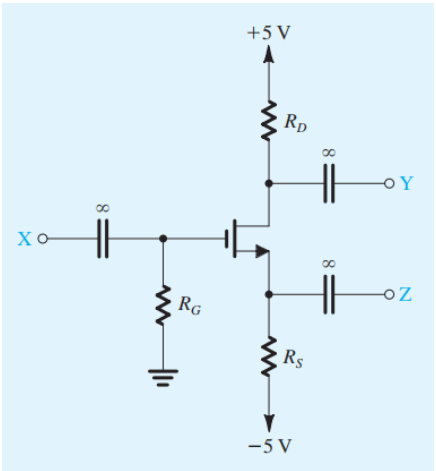

Figure 3