

Project 14

MOSFET Amplifiers

Objective: This project will show the biasing, gain, frequency response, and impedance properties of the MOSFET common source and common drain amplifiers.

Components: 2N7000 MOSFET

Introduction:

Two of the most popular configurations of small-signal MOSFET amplifiers are the common source (CS) and common drain (CD) configurations. These two circuits are shown in Figures 14-1 and 14-2 respectively. The common source and common drain amplifiers, like all MOSFET amplifiers, have the characteristic of high input impedance. The value of the input impedance for both amplifiers is basically limited only by the biasing resistors R_{G1} and R_{G2} . Values of R_{G1} and R_{G2} are usually chosen as high as possible to keep the input impedance high. High input impedance is desirable to keep the amplifier from loading the signal source. One popular biasing scheme for the CS and CD configurations consists of the voltage divider R_{G1} and R_{G2} . This voltage divider supplies the MOSFET gate with a constant DC voltage. This is very similar to the BJT biasing arrangement described in Project 9. The main difference with the BJT biasing scheme is that ideally no current flows from the voltage divider into the MOSFET.

The CS and CD MOSFET amplifiers can be compared to the CE and CC BJT amplifiers respectively. Like the CE amplifier, the CS amplifier has a negative voltage gain and an output impedance approximately equal to the drain resistor (collector resistor for the CE amplifier). The CD amplifier is comparable to the CC amplifier with the characteristics of high input impedance, low output impedance, and less than unity voltage gain. The corner frequencies of the CS and CD frequency response can also be approximated using the short circuit and open circuit time constant methods described in Project 9. A comparison of the small signal model for the BJT (Figure 9-1) and the FET (Figure 14-3) shows the similarity between the two devices in terms of the small signal analysis models.

The 2N7000 MOSFET used in this project is a n-channel enhancement-type MOSFET. For the enhancement-type MOSFET, the gate to source voltage must be positive and no drain current will flow until V_{GS} exceeds the positive threshold voltage V_T . V_T is a parameter of each particular MOSFET and is temperature sensitive. This parameter sensitivity to temperature is one reason for establishing a stable DC bias. The 2N7000 MOSFET data sheet lists the minimum and maximum values of V_T as 0.8 V and 3.0 V respectively.

Design:

Design a common source amplifier as shown in Figure 14-1 with the following specifications:

1. use a 2N7000 MOSFET and a 20 volt DC supply
2. midband gain $V_O/V_I \geq 6.0$
3. low cutoff frequency $F_L \leq 100$ Hz
4. V_O symmetric swing ≥ 3.0 volts peak (6 V p - p)
5. load resistor $R_L = 5$ k Ω
6. source resistance $R_I = 50$ Ω (this is in addition to the Tektronix function generator's internal resistance)

Design a common drain amplifier as shown in Figure 14-2 with the following specifications:

1. use a 2N7000 MOSFET and a 20 volt DC supply
2. midband gain $V_O/V_I \geq 0.5$
3. low cutoff frequency $F_L \leq 100$ Hz
4. V_O symmetric swing ≥ 5.0 volts peak (10 V p - p)
5. load resistor $R_L = 200$ Ω
6. source resistance $R_I = 50$ Ω (this is in addition to the Tektronix function generator's internal resistance)

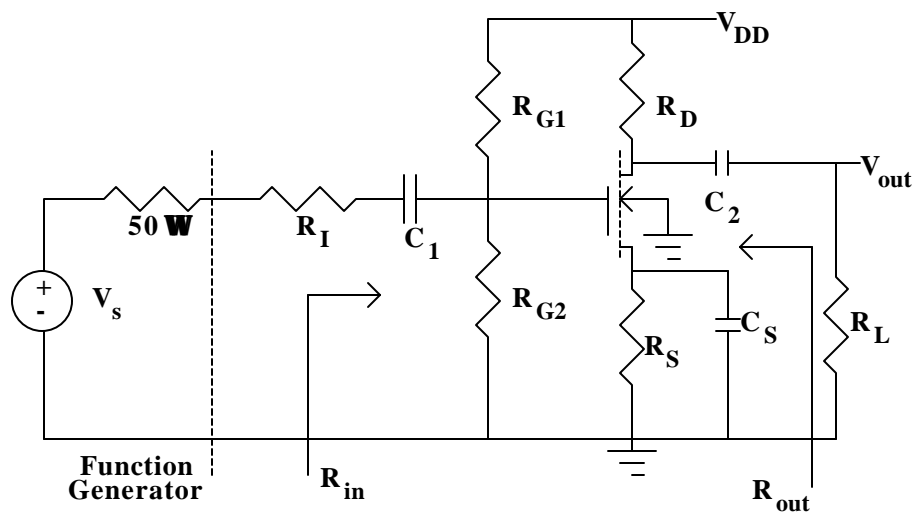


Figure 14 - 1: Common Source MOSFET Amplifier

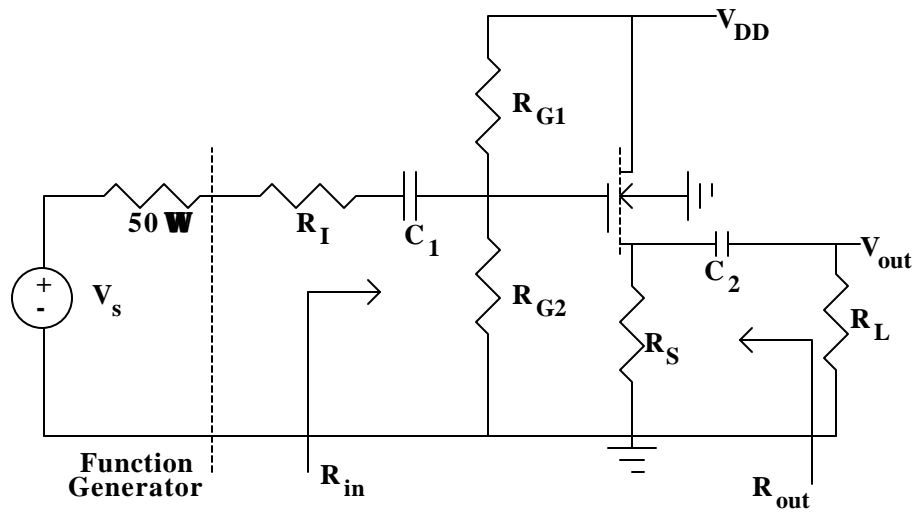


Figure 14 - 2: Common Drain MOSFET Amplifier

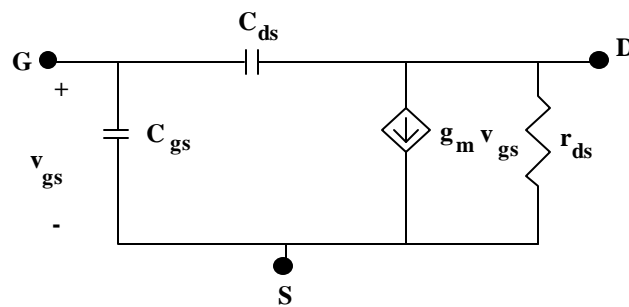


Figure 14 - 3: Small Signal FET Model

Lab Procedure: (steps 1 & 2 may be omitted if done prior to this lab period and the same FET is used)

Note:

The MOSFET can be easily damaged by static electricity, so careful handling is important

1. Find the value of the threshold voltage V_T and conductivity parameter K from the digital curve tracer (remember the relation $I_D = K[V_{GS} - V_T]^2$ in the saturation region).
2. Determine the value of r_{ds} from the digital curve tracer. The slope of the transistor I_D - V_{DS} curves in the active region is $1/r_{ds}$.
3. Construct the CS circuit shown in Figure 14-1. Remember R_I is installed in addition to the internal $50\ \Omega$ resistance of the function generator.
4. Verify that the specifications have been met by measuring the Q-point, midband voltage gain, and peak symmetric output voltage swing. Note any distortion in the output signal.
5. Adjust the output signal to obtain the maximum, non-distorted output voltage swing. Is the design specification met?
6. Observe the loading affect by replacing R_L first by $500\ \Omega$ and then by $25\ k\Omega$. Note any changes in the output signal and comment on the loading affect.
7. Use computer control to record and plot the frequency response. Find the corner frequencies and bandwidth to verify that the specifications have been met.
8. Measure the input impedance seen by the source [look at the current through R_I and the node voltage on the transistor side of R_I] and the output impedance seen by the load resistor [look at the open circuit voltage and the current through and voltage across R_L]. Verify that the input impedance specification has been met.
9. Construct the CD circuit shown in Figure 14-2. Remember R_I is installed in addition to the internal $50\ \Omega$ resistance of the function generator.
10. Repeat steps 4-8.

Questions:

1. Compare the gain, frequency response, input impedance, and output impedance of the CS amplifier with the results from the CE amplifier. Compare the CD amplifier with the CC amplifier. Comment on the differences/similarities.