FREQUENCY RESPONSE OF MOS AMPLIFIERS

I. OBJECTIVES

-To study the frequency response of CS, CD and CG MOS Amplifiers

II. INTRODUCTION AND THEORY

Figure 1 shows a single-stage MOS transistor amplifier that can be configured as CS, CD or CG by defining the position of the input and output signal.
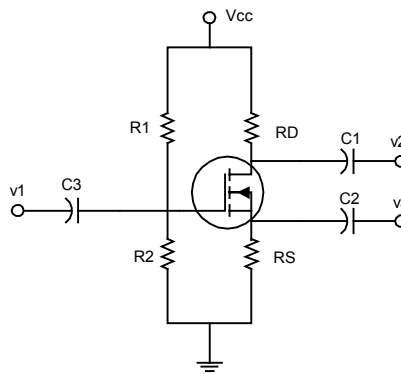

Figure **1** Generalized MOS amplifier stage

Figure 2 shows the three basic configurations of single-stage MOS amplifiers. Notice the difference between the relative positions of the input-output signals. The bypass capacitors C_1, C_2 and C_3 are large enough so that they effectively produce a short circuit in frequencies equal or higher than the midband frequency of the amplifiers. This type of short circuits is called AC short circuit. The AC short circuit has no effect on the initial setting of the DC current or voltages of the amplifier, in other words it has no effect on the quiescent point of the amplifier. A signal generator with an output resistance R is attached to the amplifier input.
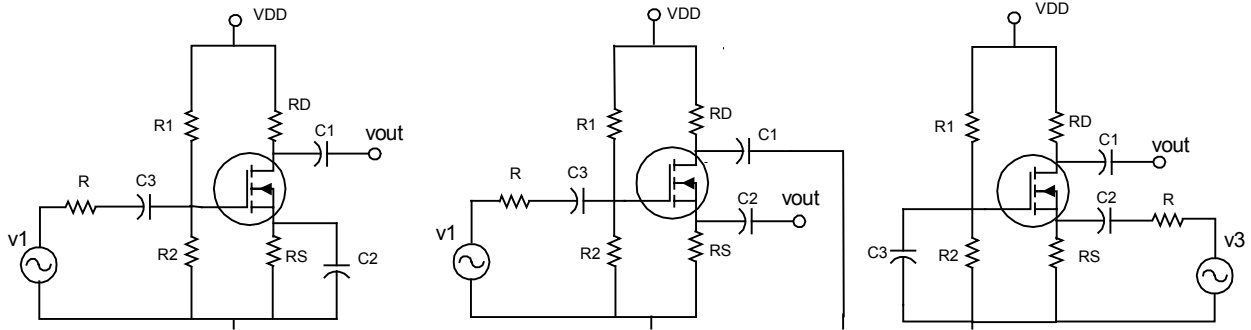
Figure **2** Circuit configurations of the MOS amplifiers

Figure 3 shows the three terminals of the MOS transistor, the small-signal equivalent circuit and the high-frequency equivalent circuits. The small-signal equivalent circuit is used to conduct the ac analysis of the amplifier in the midband frequency range where the effects of all type of capacitance are neglected. In high-frequency operations, the effect of the internal capacitances of the MOS transistor (or any other active devices for example BJT or Op_Amp) cannot be ignored. The internal capacitances are not lumped elements but their effect will appear at high frequencies. The effect of the internal capacitances can be observed as a gradual (nonlinear) drop in the amplifier gain as the frequency gets higher than certain limit. In figure 3 the internal capacitances are represented by the capacitances C_{gs}, C_{gd} and C_{ds} in the high-frequency equivalent circuit. The effect of the capacitance C_{ds} at high frequencies can be seen as an ac short circuit between the drain and the source. The effect of the capacitance C_{gd} is seen as negative feedback from drain to the gate. The effect of the capacitance C_{gs} can be seen as an ac short circuit that can reduce the input signal level to zero. The first step in conducting an ac analysis of MOS transistor circuit operating at high frequencies is to replace the device with the high-frequency equivalent circuit and all DC voltage and current sources by a shot circuit. The resulting circuit consists of a number of resistors, input signal and the internal capacitances of the device C_{gs}, C_{gd} and C_{ds}. This is an active RC circuit. In some transistor circuits such as oscillators or tuned amplifiers, the external circuit (all elements attached to the terminal of the active device) could contain two types of the reactive elements inductor and capacitor. In such a case the high-frequency equivalent circuit is RLC circuit. In this experiment the circuit is an active RC circuit. This circuit could be reduced to a single resistance, a single capacitance and input signal by applying Miller's theorem to separate nodes in the circuit and Thevenin's theorem to compute the equivalent resistances seen by each capacitor in the circuit.
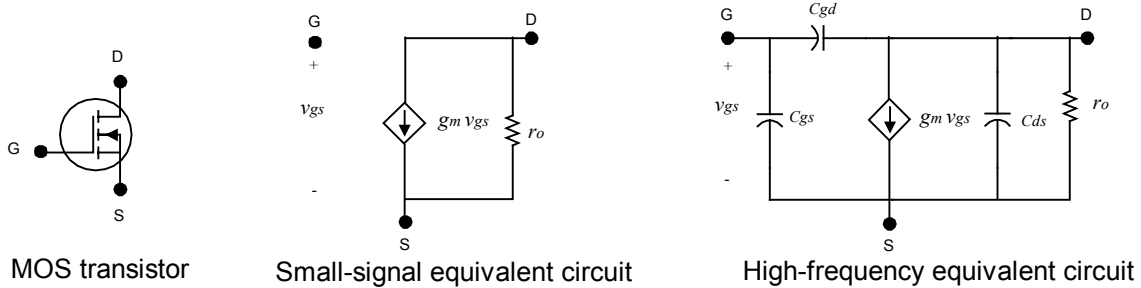
MOS transistor   Small-signal equivalent circuit   High-frequency equivalent circuit

Figure **3**

III. PROCEDURE

From the folder that was downloaded in the previous session, access the three schematics as shown below.

1- Open **highfmos1** circuit. Make sure that the Ground point is initialized to zero.
2- Conduct a frequency domain analysis in the frequency range 10Hz-100 KHz.

3- Tabulate the upper 3dB frequency and the mid-band gain in dB.
4- Now remove the bypass capacitor and tabulate midband gain and upper 3dB frequency. Compare the two cases, one with the bypass capacitor and the other without it. What are the striking differences?

5- Open **highfmos2** circuit.
6- Conduct a frequency domain analysis in the frequency range 10 Hz – 1 MHz

7- Tabulate the upper 3dB frequency and the mid-band gain in dB
8- Open **highfmos3** circuit.
9- Conduct a frequency domain analysis in the frequency range 10 Hz – 1 MHz

10- Tabulate the upper 3dB frequency and the mid-band gain in dB