American International University- Bangladesh
Department of Electrical and Electronic Engineering
Analog Electronics 2 Laboratory

Title: Study of MOSFET Differential Amplifier

Abstract:

The objective of this experiment is to investigate 1) common mode voltage gain and 2) differential mode voltage gain of the simple differential amplifier using enhancement mode NMOS transistors.

Introduction:

The MOSFET is by far the most widely used transistor in both digital and analog circuits, and it is the backbone of modern electronics. One of the most common uses of the MOSFET in analog circuits is the construction of differential amplifiers. The latter are used as input stages in op-amps, video amplifiers, high-speed comparators, and many other analog-based circuits. MOSFET differential amplifiers are used in integrated circuits, such as operational amplifiers, they provide high input impedance for the input terminals. A properly designed differential amplifier with its current-mirror biasing stages is made from matched-pair devices to minimize imbalances from one side of the differential amplifier to the other.

Theory:

The general topology of a differential amplifier is shown below. Two active devices are connected to a positive voltage supply via passive series elements. The transistors must be a matched pair (i.e., two matched MOSFETs or two matched BJTs). The "pull up" loads are similarly matched to each other. The lower terminals of the active devices are connected together, and a dc current source pulls current down toward the negative voltage bus to affect the bias. The controlling input ports of the devices are connected to input signals.

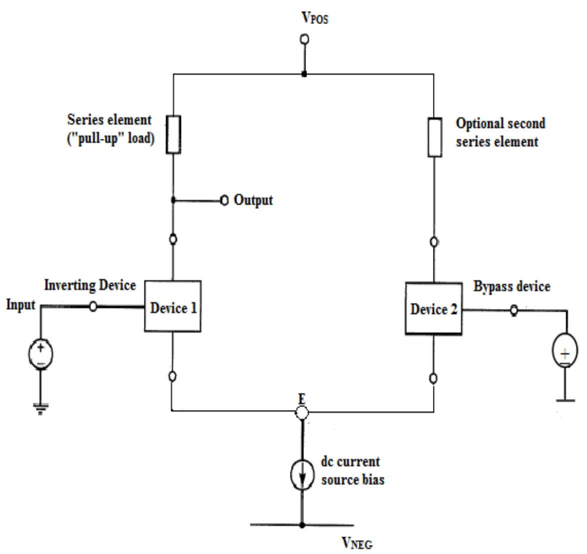

Figure 1: General topology of a differential amplifier

If the input signals are designated v1 and v2, they can be decomposed into two linear combinations, one called the differential mode, and the other the common mode. The differential mode is defined by the following equation:

$$v_{idm} = v_1 - v_2$$

Similarly, the common mode, equal to the average value of the signals, is defined by:

$$v_{icm} = \frac{v_1 + v_2}{2}$$

These definitions allow the actual input signals v1 and v2 to be expressed as linear combinations of their differential and common modes:

$$v_1 = v_{icm} + \frac{v_{idm}}{2}$$

And

$$v_2 = v_{icm} - \frac{v_{idm}}{2}$$

Because the small-signal model of the amplifier is linear, its total response will be equal to the superposition of its responses to, respectively, the differential and common modes of the input signals.

Pre-Lab Homework:

Sketch the chip layout and show the wiring connections based on the block diagram and pin Configuration.

Apparatus:

MOSFET 2N7000	:	2 pc(s)
Opamp 741	:	1 pc(s)
Potentiometer 200Ω	:	2 pc(s)
Resistor 100 Ω	:	3 pc(s)
Resistor 20 Ω	:	1 pc(s)

Precautions:

MOSFETs must be handled with care to avoid damaging them; try to avoid touching the gate terminal (middle pin) as the static charge on your fingers can be enough to blow the gate capacitor. When you place the MOSFETs in your bread board, take care to get the drain and source oriented properly as these discrete MOSFETs do not have interchangeable sources and drains. If the differential pair is not working properly, double check the correct orientations.

Circuit Diagram:

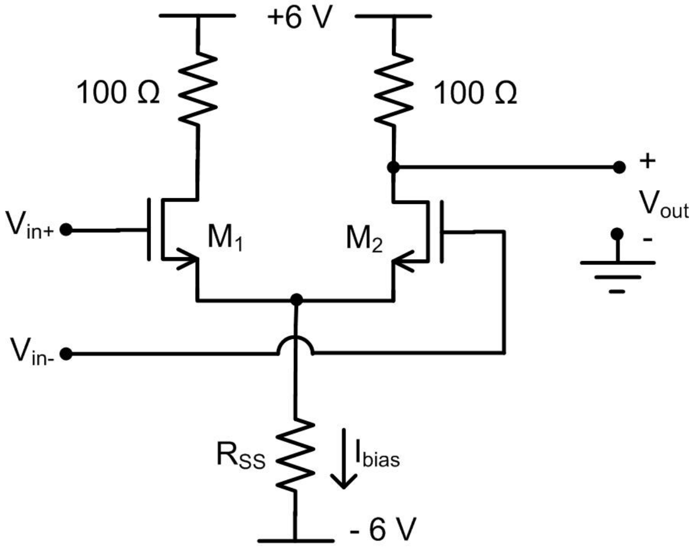

Figure 2: Differential amplifier schematic.

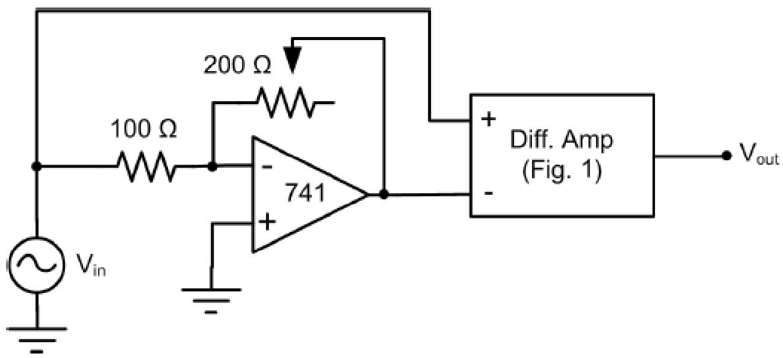

Figure 3: Measurement set-up for differential mode voltage gain.

Experimental Procedure:

1. DC Biasing: Construct the circuit in figure 01. Connect both V_{in+} and V_{in-} to ground (0 V), and adjust the potentiometer until I_{bias} about 80 mA. Measure and record V_{S1} = V_{S2}, V_{D1}, and V_{D2}.
2. Common mode voltage gain measurement: Connect a 1kHz sinusoidal signal of 500mV$_{(p-p)}$ to both inputs, V_{in+} and V_{in-}. Measure and record V_{cm} and V_{out}.

3. Differential voltage gain measurement: Construct the circuit in figure 02. Measure and record V_{in} and V_{out}.

Results:

1. Common mode voltage gain measurement: Compute and record the common mode gain, $A_{cm} = V_{out}/V_{cm}$.
2. Differential voltage gain measurement: Compute and record the differential mode gain, $A_d = V_{out}/V_{in}$.

Simulation:
Compare the simulation results with your experimental data/ wave shapes and comment on the differences (if any).

Discussion and Conclusions: Interpret the data/findings and determine the extent to which the experiment was successful in complying with the goal that was initially set. Discuss any mistake you might have made while conducting the investigation and describe ways the study could have been improved.

Reference(s):

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