2010

EECE 310 Lab Report for Experiment 10

MOS TRANSISTOR

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Section 3 Bench 5

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List of Figures and Tables

I. Objectives

The purpose of the following experiment is to investigate the characteristics of a Metal-Oxide-Semiconductor Field-Effect Transistor, also known as a MOSFET.
Another purpose of this lab is to study a MOSFET's applications as a:

- Voltage-Controlled Resistor.
- Logic Gate.
- Amplifier.
- Current Source.

II. Lab Equipment Used

- DDM: Digital Device Multimeter.
- Breadboard.
- Function Generator.
- Oscilloscope.
- The Tektronix PS 280-Power Supply

III. Lab Tools and Components Used

- Wire Stripper
- Wire Cutter

IV. Components Used

Theoretical Value	Measured Value	% error
100 Ω	100.39Ω	0.39
220 Ω	219Ω	0.45
330 Ω	335Ω	1.51
470 Ω	476Ω	1.27
560 Ω	550Ω	1.78
680 Ω	660Ω	2.94
820 Ω	808Ω	2.68
1 kΩ	1.007kΩ	0.7
3.3 kΩ	3.2kΩ	3.03
4.7 kΩ	4.678kΩ	0.468
10 kΩ	9.86kΩ	1.4
15 kΩ	14.98kΩ	0.134

- Connection Wires.
- Capacitors of value 10 uF.
- BS170 MOSFET

V. Experimental Procedure and Discussion

A. MOSFET Characteristics

A1.Circuit Diagrams

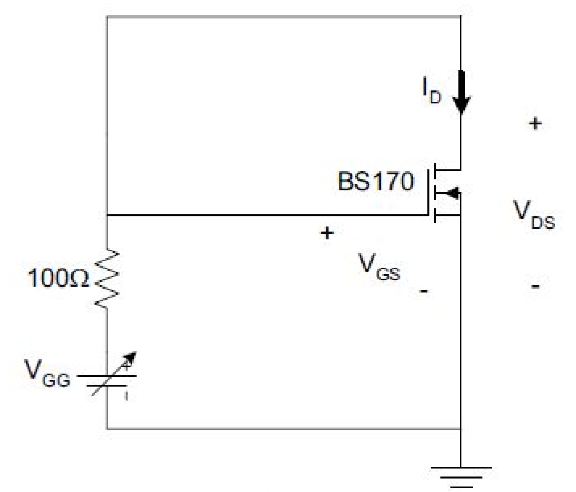


Fig. 1

A2. Detailed Experimental Procedure

i-Connect the circuit of Fig 1 on the breadboard, use a DDM to measure I_D.

ii-The connections allow us to determine the characteristics of the MOSFET, specifically the transconductance parameter k, and the threshold voltage V_T.
Those 2 characteristics allow us to calculate the drain current in saturation.
Where $I_D=(k/2)(V_{GS}-V_T)^2$ when $V_{GS}> V_T$ and $V_{DS} > V_{GS}-V_T$

In the given case $V_{DS} = V_{GS}$ and since V_T is positive in the current MOSFET, the transistor is in saturation whenever $V_{GS}> V_T$.

In order to calculate two variables we need two measurements. We measure V_{GS} when I_D=10mA and another time when I_D=25 mA.

A3.Measurements and Results

i- Starting with V_{GG}=0.5 V (on the Tektronix PS 280) slowly increase its value until I_D=10 mA(visible on the DDM) that occurs when V_{GS}=2.16V
Continue increasing until I_D=25 mA which happens when V_{GS}=2.43V

Solve for K and V_T using the 2 equations:
$10=(k/2)(2.16-V_T)^2$
$25=(k/2)(2.43-V_T)^2$
Which yields to $k=925.25\ mA/V^2$ and $V_T=2V$

ii - Calculation of error percentage.
Increase V_{GG} till $I_D=40$ mA, which yields a measured value of $V_{GS}=2.6V$
Meanwhile, according to the formula $V_{GS}= V_T+$ rad(2 I_D/k)
Calculated $V_{GS}=2.29$ V.

Error Percentage= (2.29-2.6)*100/2.29=13 %

B. MOSFET as a Voltage-Controlled Resistor

B1. Circuit Diagrams

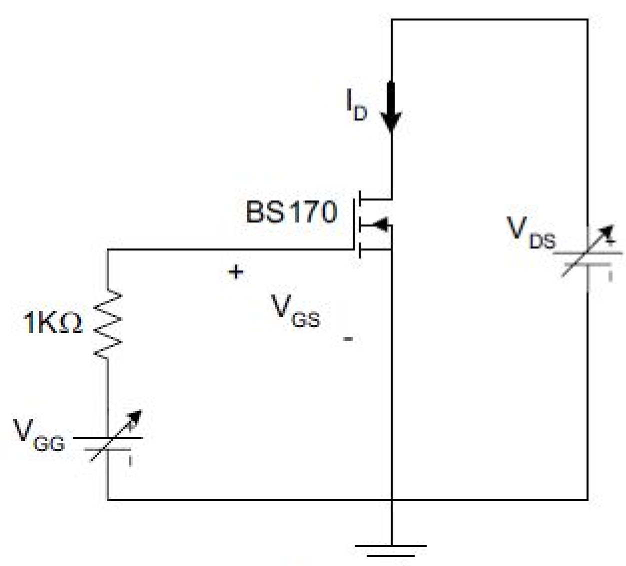


Fig. 2

B2. Detailed experimental procedure

Using connections of Fig.2 and the value of $V_T=2V$ (calculated above) set $V_{GG}= V_T+2V$

i- Using the power supply, apply V_{DS} , and measure I_D using a DDM.

ii- Since the gate current of the MOSFET=0, $V_{GS}-V_T=2V$

B3. Measurements and Results

i-Table $V_{GS}-V_T=2V$

$V_{GS}-V_T=2V$	
$V_{DS}(V)$	$I_D(mA)$
0.1	6.67
0.2	13.4
0.3	21.2

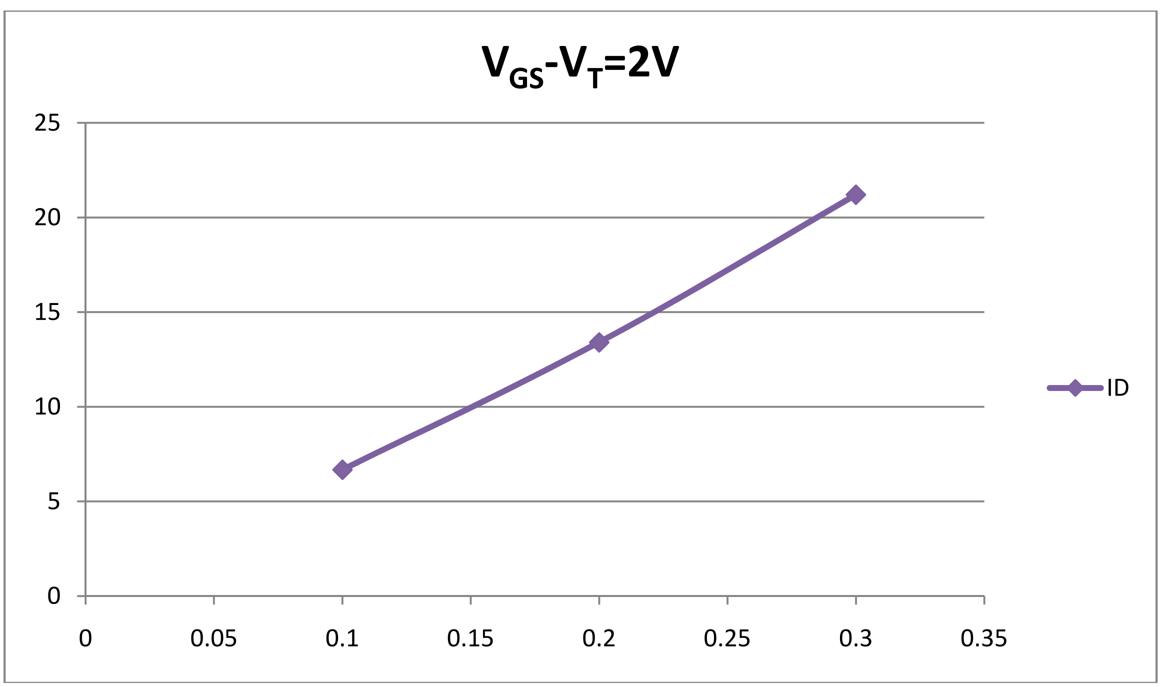
ii-Table $V_{GS}-V_T=3V$

$V_{GS}-V_T=3V$	
V_{DS} (V)	$I_D(mA)$
0.1	10.8
0.2	14.65
0.3	23.65

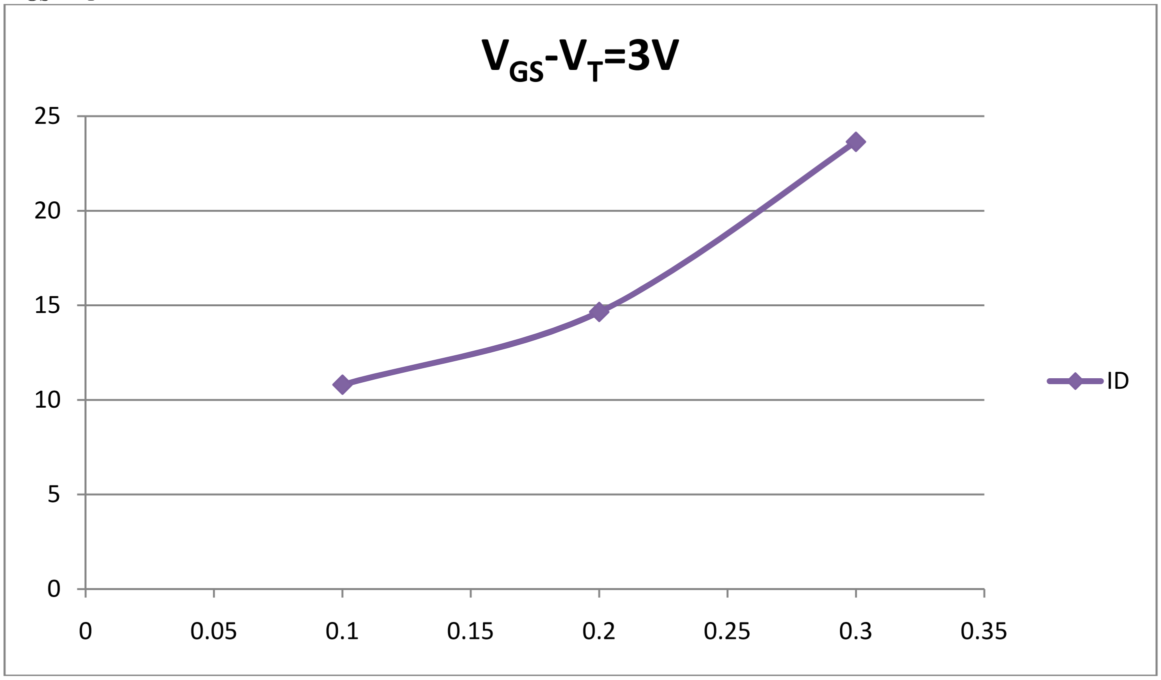
B4. Discussion

i-Curve for I_D versus V_{DS}

a- $V_{GS}-V_T=2V$



b- V_{GS}-V_T=3V



ii-Find the slope

a- V_{GS}-V_T=2V

Slope=(21.2-6.67)/0.2=72.45 mA/V

b- V_{GS}-V_T=3V

Slope=(23.65-10.8)/0.2=64.25 mA/V

iii-Find the resistance (Table)

V_{GS}-V_T(V)	R_{DS}(Ω)
2	13.80
3	15.56

R_{DS} is not constant but depends on V_{OV} therefore the MOSFET in this case is a voltage controller resistance, where R_D= $V_{DS/}$ I_D=1/(k V_{OV})

And since V and I are related by a straight line , it is called linear, or ohmic(Resistance).

C. MOSFET Logic Gate

C1. Circuit Diagrams

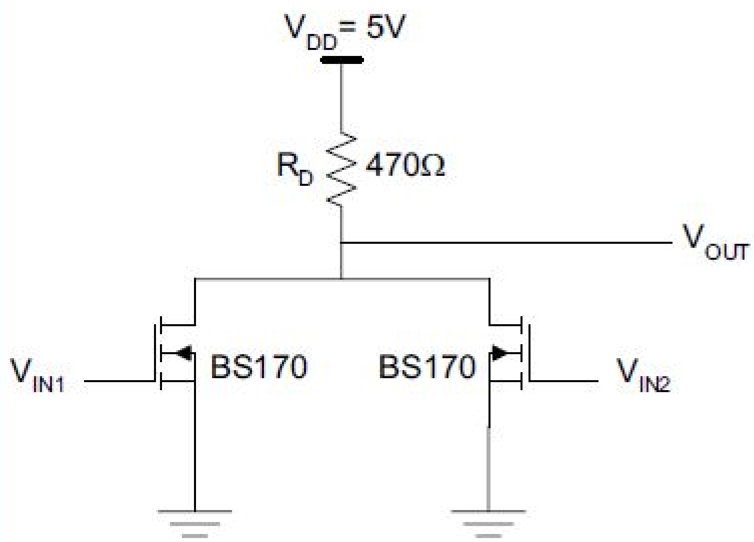


Fig. 3

C2. Detailed Experimental Procedure

i-Connect the circuit of Fig 3, measure V_{IN1} , V_{IN2} & V_{OUT} using a DDM

ii- This circuit implements a logic gate; we will determine in this part of the experiment the logic function of this gate and study its characteristics. There are two inputs IN1 and IN2, and one output OUT.

To build the truth table of this gate, we apply all possible combinations of inputs, and observe the output. Start with IN1 = logic **0** and IN2 = logic **0**. To get a logic **0**, we will connect the input nodes to ground. The value of the output in this case corresponds to logic **1**.

C3. Measurements and Results

Apply logic **1** at IN1, and logic **0** at IN2, and observe the output. Repeat for IN1 = logic **0**, IN2= logic **1**, and for IN1 = logic **1** and IN2 = logic **1**.

i-Table C-1

IN1 (Logic)	IN2(Logic)	Out(Logic)	V_{IN1}(V)	V_{IN2}(V)	V_{OUT} (V)
0	0	1	0.0	0.0	5.03
0	1	0	0.0	5	0.01
1	0	0	5.02	0.0	0.012
1	1	0	5.012	5.03	0.009

From the truth table indicates that the logic function of this gate is a NOR gate.

ii-Table C-2

V_{IN1}(V)	V_{OUT} (V)	MOSFET Region	Out(Logic)
0	4.995	Cut Off	1
0.8	4.995	Cut Off	1
1.6	4.993	Cut Off	1
2.4	0.31	Triode	0
3.2	0.05	Triode	0
4.4	0.026	Triode	0

C4. Discussions

i- The values of high that correspond to logic one are around 5, meanwhile the values of low that correspond to logic zero are around 0 or values in mV

When the MOSFET is in the ohmic(linear) region the output is low, since the MOSFETs acts as voltage controlled resistors. It is clear in the figure that a change in R_D would induce a change in the opposite sense in the MOSFET resistance behavior, and also in $V_{DS} = V_{OUT}$. In conclusion increasing the resistance would induce a Low (0 logic) output.

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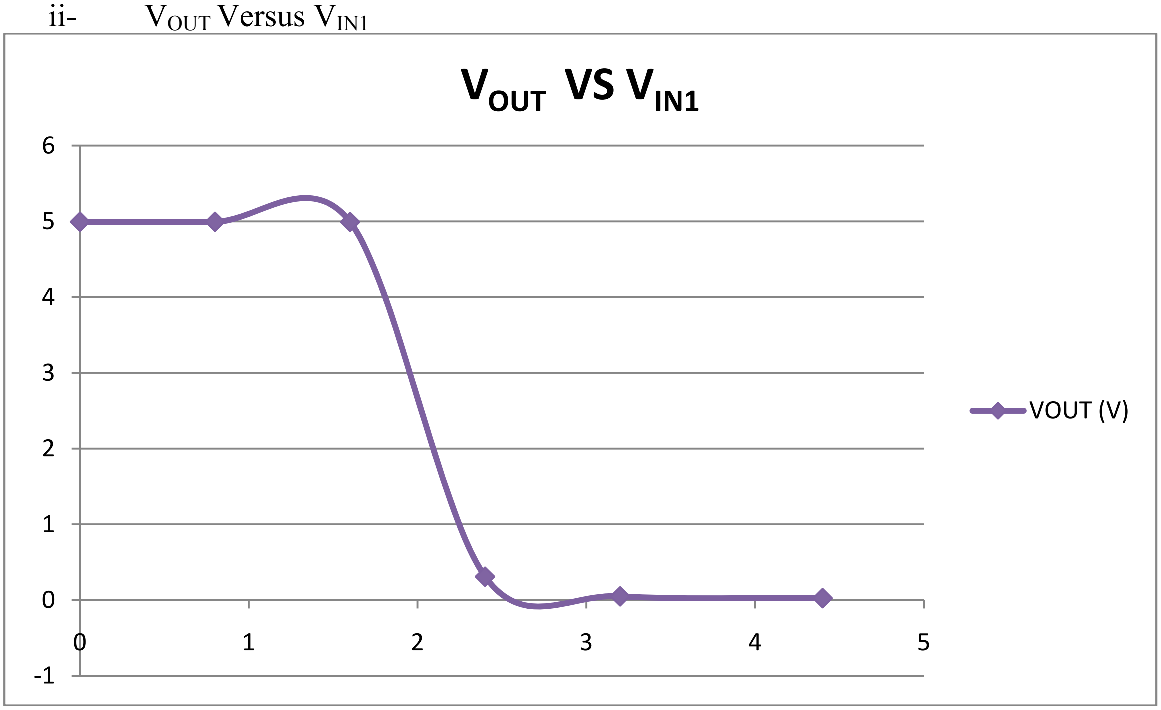
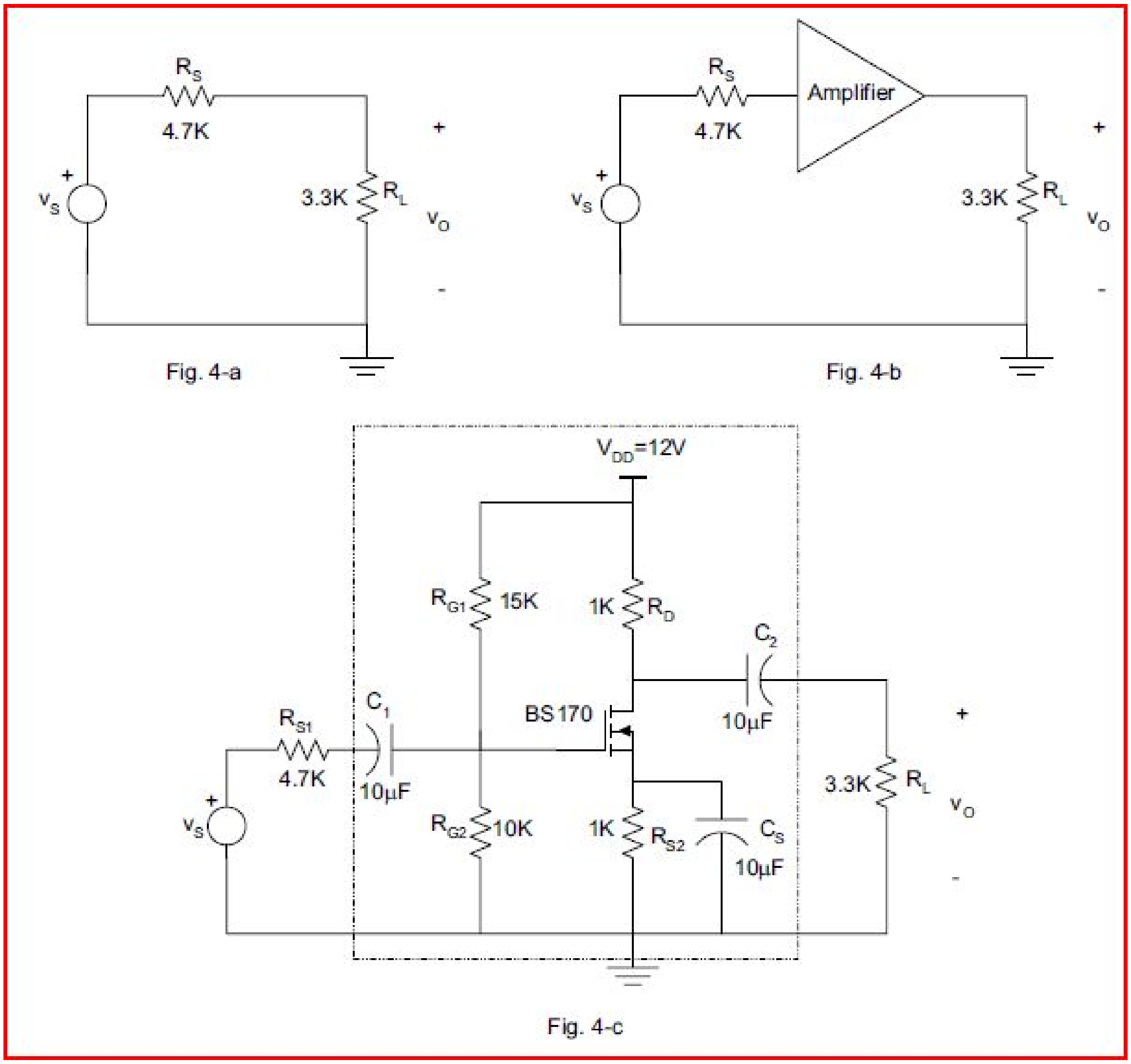
ii- V_{OUT} Versus V_{IN1}



At $V_{IN1=}$ 2.4 V the output switches. That occurs when V_{IN1}=$V_{GS} > V_T$

D. MOSFET as an Amplifier

D1.Circuit Diagrams



D2. Detailed experimental procedure

i-Connect the figure 4-a with the voltage source equal to a 100mV pk-pk 10KHz sin signal.

ii-Use an oscilloscope to measure Vo, voltage and current gain.

D3.Measurements And Results

i-	Value
V_S pk-pk	103mV
V_I pk-pk	74mV
V_O pk-pk	16mV
Gain (V/V)	0.216

The current gain is 1, since it is the same node.

ii- Measurement Calculation.

DC Values	Measured	Calculated	Error %
I_D	2.59 mA	0	1
V_{GS}	4.823V	5	3.669
V_{DS}	6.93 V	7	1.01

D4.Discussion

The presence of a capacitance limits the MOSFET.

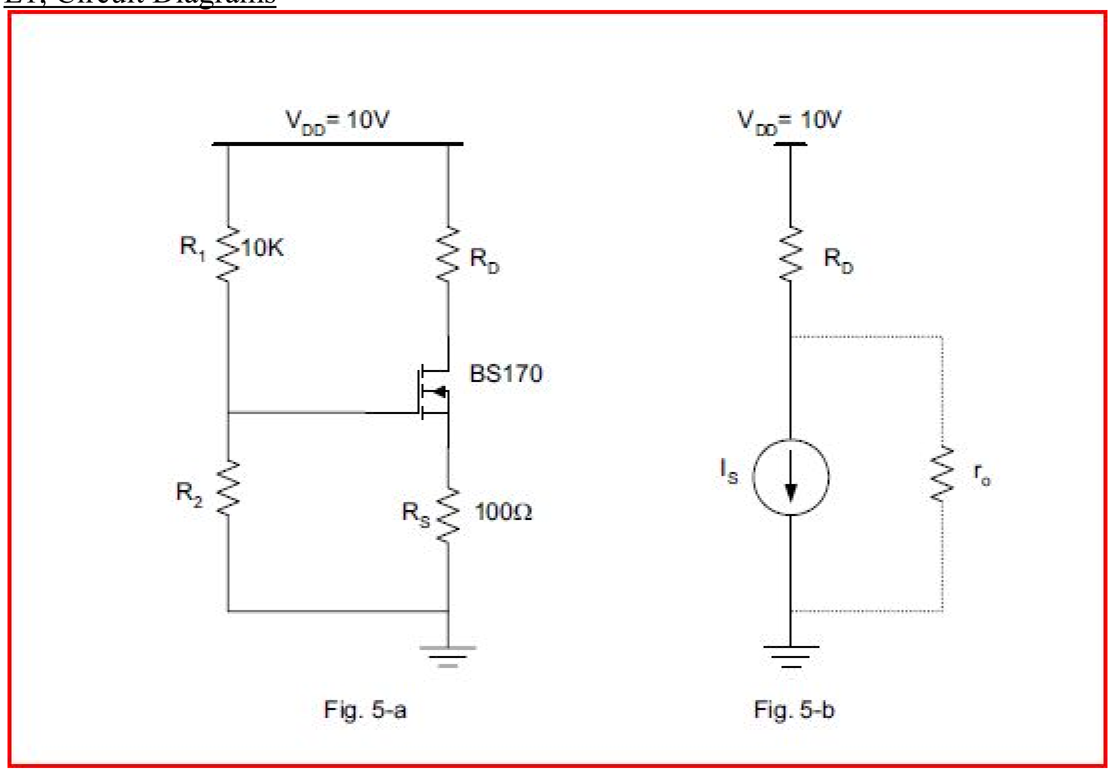
Where at low frequencies, the gain decreases due to the increase of the capacitors performance, which is similar to an open circuit behavior. C2 affects the voltage output in reducing it, and thus reducing the gain.

Meanwhile at high frequencies, the gain increases, since the capacitance acts a short circuit.

The voltage gain of a BJT is lower, than that of an amplifier.

E. MOSFET as a Current Source.

E1, Circuit Diagrams



E2.Detailed Experimental Procedure

i-Connect fig 5-a , which is similar but not a BTJ, this circuit doesn't use a Zener Diode.

ii-Use the values of K and V_T found previously.

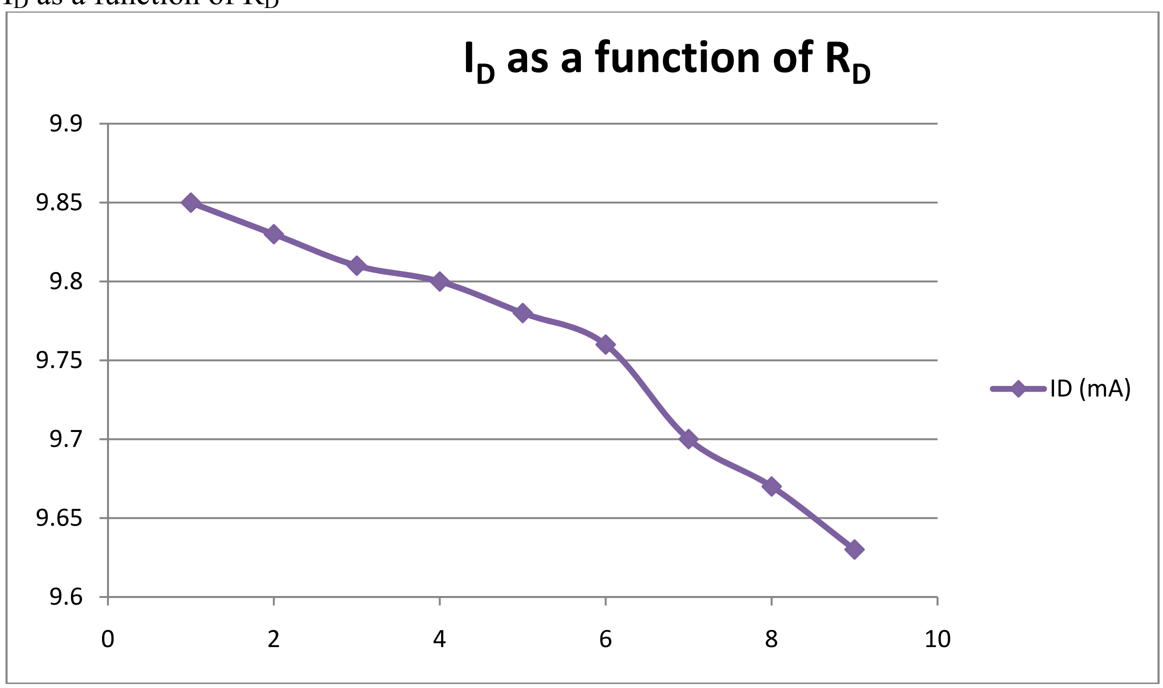
E3.Measurements and results

i-R_D, I_D and V_{DS}

R_D	I_D (mA)	V_{DS} (V)
0 Ω	9.85	9.9
100 Ω	9.83	7.9
220 Ω	9.81	6.8
330 Ω	9.8	5.7
470 Ω	9.78	4.4
560 Ω	9.76	3.56
680 Ω	9.7	2.54
820 Ω	9.67	1.17
1 kΩ	9.63	0.25

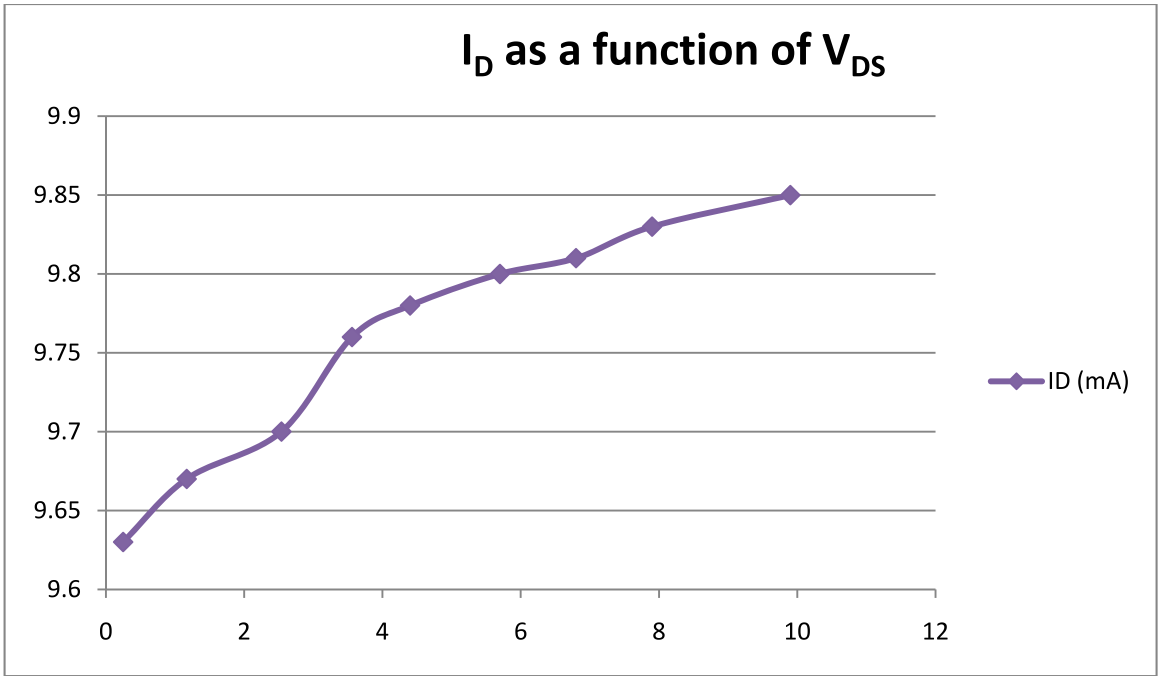
E4.Discussions

I_D as a function of R_D



I_D is not constant but is approximately stable when R is between 0 and 330 ohms.

I_D as a function of V_{DS}



The current is approximately constant when V varies between 9.9 and 5.7 V, this is when V_{DS} is in Saturation, since it is somehow independent of voltage at this region.

R_o=1/slope=(9.9-0.25)/(9.85-9.63)=43.863 ohms

VI-References

The lab manual in addition to the in Lab.

VII-Mistakes and Problems faced in the Labs

Me and my fellow classmates were bothered a lot during the lab, as usual, the equipment is old and worn out therefore tend to malfunction.

For example, the instructor had to change our oscilloscope twice in order to get an acceptable reading.

In addition to the fact that the transformer wires were loose, and some didn't even have wires, we had to wait to attach a wire or 2 sometimes, which would fall back shortly after.

VIII Signature

I HAVE NEITHER GIVEN NOR RECEIVED AID ON THIS REPORT NOR HAVE I CONCEALED ANY VIOLATION OF THE AUB STUDENT CODE OF CONDUCT.