Summer 2023

EEE/ETE 111L

Analog Circuits-I Lab (Sec-11)

Faculty: Professor Dr. Monir Morshed (DMM)

Instructor: Rokeya Siddiqua

Lab Report 08: Study of Switching Characteristics.

Date of Performance:
07 October 2023

Date of Submission:
14 October 2023

Group no.: **05**

1. Mahmudul Hasan- 2011551043
2. Sabrina Haque Tithi- 2031265642
3. Afrin Akter- 2112246642
4. Joy Kumar Ghosh – 2211424642
5. **Sazid Hasan- 2211513642**

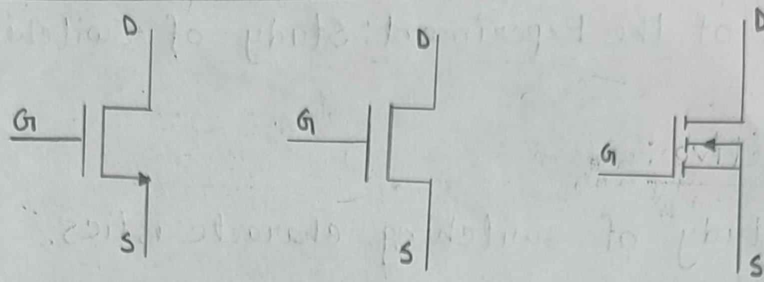
Name of the Experiment: Study of Switching Characteristics.

Objective:

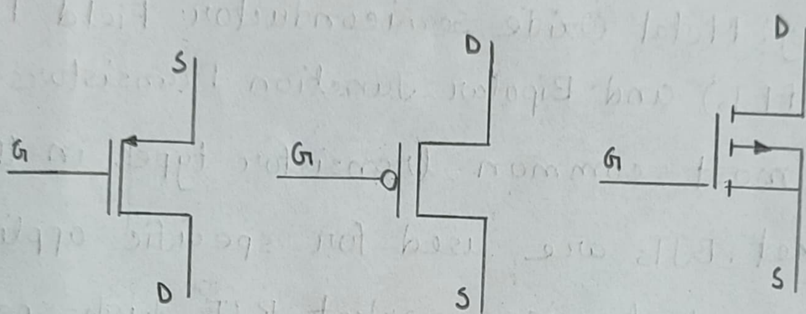
- Study of switching characteristics.
- Learn about MOSFET transistor.

Theory: Metal Oxide semiconductor Field Effect Transistor (MOSFETs) and Bipolar Junction Transistors (BJTs) are the most common transistor types in the electronics market. BJTs are used for specific applications like analog electronics, ~~market, BJTs~~ high-speed circuits and power electronics. FETs are charge-controlled devices, while BJTs are current or voltage-controlled. There are two main types of FET transistors: Junction Field-effect Transistors (JEFT) and metal oxide ~~semicondu~~ semiconductors field-effect transistors (MOSFET). MOSFETs are commonly used as switches in analog and digital circuits, serving as analog multiplexors for data input selection.

MOSFETs come in four ~~variants~~ varieties: enhancement n-type, enhancement p-type, depletion n-type, and depletion p-type. The type depends on whether the current flowing through the channel is an electron current or a hole current and whether the channel between the drain and source is induced or physically implemented.

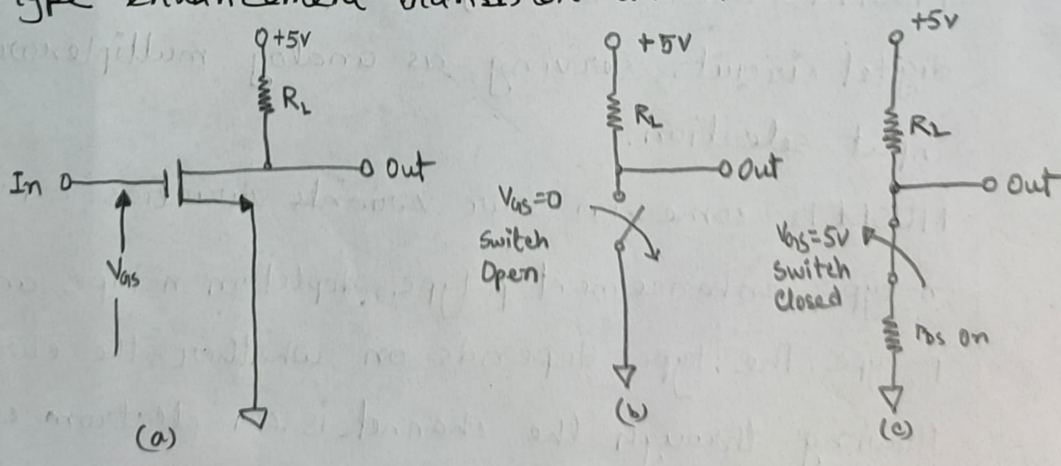


Symbols for Enhancement NMOS Transistor

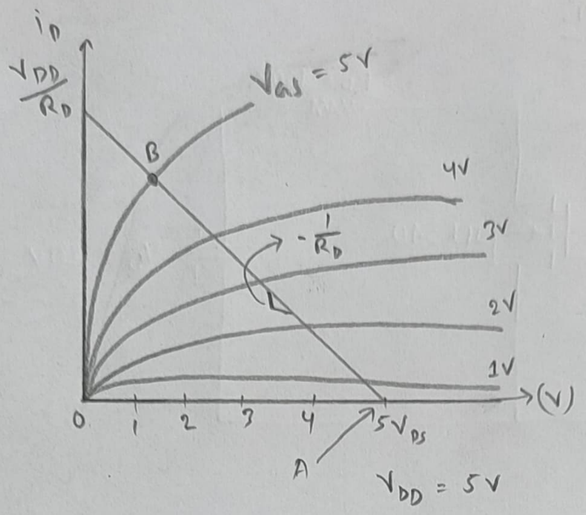


Symbols for Enhancement PMOS Transistor

MOSFET switches are frequently used in along and digital circuits. Switches in analog circuits can be utilized in various applications, such as data acquisition systems, which act as analog multiplexors and let the user choose from multiple data inputs. Below is a straightforward illustration of a switching circuit based on an n-type enhancement transistor and a resistor.



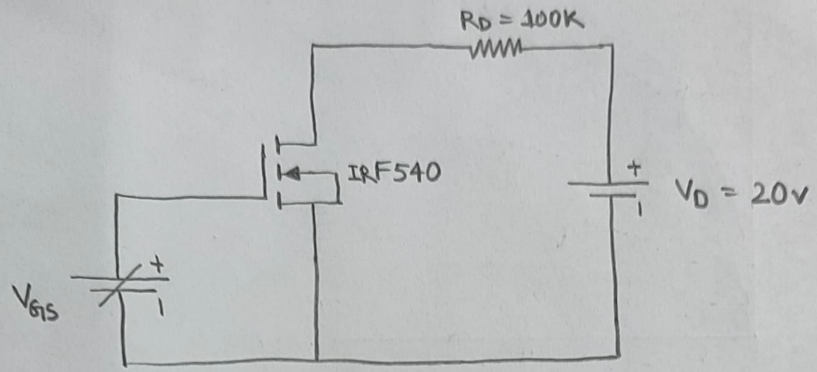
NMOS transistor switch



List of Equipment:

Serial No.	Component Details	Specification	Quantity
1.	MOSFET	IRF540	1 piece Each
2.	Resistor	100KΩ	1 piece Each
3.	POT		1 Unit
4.	Trainer Board		1 Unit
5.	DC Power Supply		2 Unit
6.	Digital Multimeter		1 Unit
7.	Chords & Wire		as required

Circuit Diagram:



Data Table:

$V_{DD} = 15v$				$V_{DD} = 20v$			
V_{GS} (V)	V_{DS} (V)	V_L (V)	I_D (mA)	V_{GS} (V)	V_{DS} (V)	V_L (V)	I_D (mA)
0v	14.73v	0v	0mA	0v	19.67v	0v	0mA
1v	14.43v	0v	0mA	1v	19.55v	0v	0mA
2v	14.21v	0v	0mA	2v	19.27v	0v	0mA
3v	0v	15.11v	0.15mA	3v	0v	20.11v	0.1997mA
4v	0v	15.11v	0.15mA	4v	0v	20.11v	0.1997mA
5v	0v	15.11v	0.15mA	5v	0v	20.11v	0.1997mA
6v	0v	15.11v	0.15mA	6v	0v	20.12v	0.1997mA

Questions & Answer:

01. Metal-oxide semiconductor field-effect transistors (MOSFETs) are ~~prep preff~~ preferred for switch applications over bipolar junction transistor (BJTs) for several reasons including:

i. High input impedence: MOSFETs have a very high input impedence, which means that they require very little current to turn on. This makes them idal for driving from microcontrollers and other low-power devices.

ii. Fast switching speeds: MOSFETs can switch on & off very quickly, making them ideal for high-frequency applications such as switch-mode power supplies & motor controllers.

iii. Low on-resistance: When a MOSFET is turn on, it has a very low resistance between the drain and source terminals. This means that it can conduct large currents with minimal power Loss.

iv. High efficiency: MOSFETs are very efficient switches, meaning that they waste very Little power. This is important for applications where battery life is a concern.

v. Scalability: MOSFETs can be scaled to a wide range of sizes, from small devices suitable for low-power applications to Large devices capable of handling high currents and voltages.

In addition to these advantages, MOSFETs are also relatively inexpensive and easy to manufacture. This makes them a popular choice for a wide range of applications.

02. Difference between MOSFET and JFET:

MOSFETs and JFETs are both types of field-effect transistors (FETs), which means that they use an electric field to control the flow of current through the device. However, there are some key differences between the two types of FETs:

Construction:

i. JFETs are constructed with a ~~pin~~ PN junction between the gate and channel terminals.

ii. MOSFETs are constructed with a metal-oxide-semiconductor (MOS) capacitor between the gate and channel terminals.

Operation:

i. In a JFET, the electric field across the PN junction controls the width of the depletion region, which in turn controls the flow of current through the channel.

ii. In a MOSFET, the electric field across the MOS capacitor controls the formation of an inversion layer in the channel, which in turn controls the flow of current through the channel.

Characteristics:

i. JFETs have a lower input impedance than MOSFETs.

ii. MOSFETs have a higher switching speed than JFETs.

iii. MOSFETs are more susceptible to damage from electrostatic discharge (ESD) than JFETs.

Applications:

i. JFETs are often used in low-noise applications, such as audio amplifiers and preamplifiers.

ii. MOSFETs are often used in high-power applications, such as switch-mode power supplies and motor controllers.

Discussion:

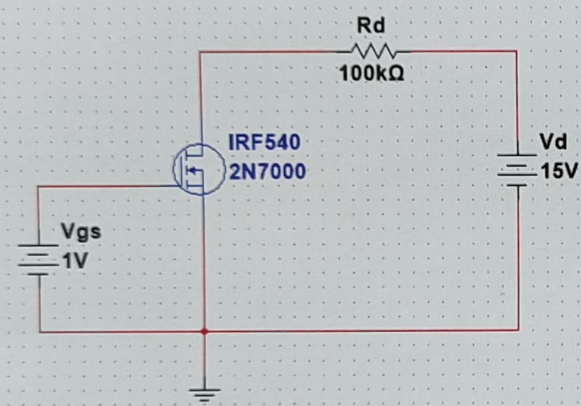
In this experiment, we studied the characteristics of switching. We also learned a lot about MOSFET transistors. We observed how it works & measured the threshold voltage of IRF540 MOSFET, which was 3 Volts. We found that before applying 3 volts, the current across load resistance was 0. After applying 3 volts, the current passes though the load resistance at a constant rate of 0.15 mA. In this experiment, first, we face a problem regarding MOSFET. It was passing current at 2 volts. Then we changed the MOSFET and took a new one. After that, it started working perfectly. Hence, we completed our experiment successfully and learnt about the characteristics of switching MOSFET.

Attachment:

1. Simulation
2. Signed Data Table

Table of Contribution:

No.	Name	ID	Contribution
1.	Afrin Akter	2112246642	Measured V_{DS} & V_L when $V_{DD}=15V$, operating DC power supply
2.	Suzid Hasan	2211513642	Measured V_{DS} & V_L when $V_{DD}=15V$, Lab report writing, circuit build
3.	Joy Kumer Ghosh	2211424642	Measured V_{DS} & V_L when $V_{DD}=20V$, simulation
4.	Sabrina Haque Tithi	2031265642	Measured V_{DS} & V_L when $V_{DD}=20V$, calculations on data table
5.	Mahmudul Hasan	2011551043	Absent.



Grapher View

Parameter Sweep | Parameter Sweep

Lab - 08 - 01
Device Parameter Sweep

	Variable, Parameter setting	Operating point value
1	V(1), vwgs dc=0	14.99999
2	I(RD), vwgs dc=0	-99.83040 p
3	V(1), vwgs dc=1	14.99999
4	I(RD), vwgs dc=1	-101.83039 p
5	V(1), vwgs dc=2	14.99999
6	I(RD), vwgs dc=2	-103.83039 p
7	V(1), vwgs dc=3	1.67017 m
8	I(RD), vwgs dc=3	-149.98330 u
9	V(1), vwgs dc=4	925.15567 u
10	I(RD), vwgs dc=4	-149.99075 u
11	V(1), vwgs dc=5	677.02638 u
12	I(RD), vwgs dc=5	-149.99323 u
13	V(1), vwgs dc=6	552.98376 u
14	I(RD), vwgs dc=6	-149.99447 u

Selected Page:Parameter Sweep

------ Checking SPICE netlist for Lab - 08 - 01 - Wednesday, October 11, 2023, 10:44:44 PM ------

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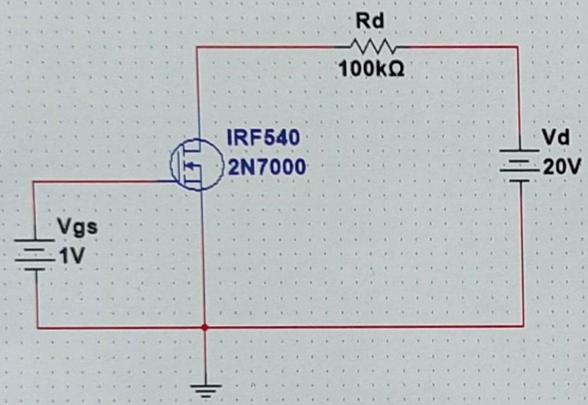
Parameter sweep

Design Toolbox

Lab - 08 - 01

Lab - 08 - 01



Grapher View

File Edit View Graph Trace Cursor Legend Tools Help

Parameter Sweep | Parameter Sweep | Parameter Sweep

Lab - 08 - 01
Device Parameter Sweep

	Variable, Parameter setting	Operating point value
1	V(1), vgs dc=0	19.99999
2	I(RD), vgs dc=0	-129.90221 p
3	V(1), vgs dc=1	19.99999
4	I(RD), vgs dc=1	-131.90220 p
5	V(1), vgs dc=2	19.99999
6	I(RD), vgs dc=2	-133.90220 p
7	V(1), vgs dc=3	2.22739 m
8	I(RD), vgs dc=3	-199.97773 u
9	V(1), vgs dc=4	1.23360 m
10	I(RD), vgs dc=4	-199.98766 u
11	V(1), vgs dc=5	902.72030 u
12	I(RD), vgs dc=5	-199.99097 u
13	V(1), vgs dc=6	737.31950 u
14	I(RD), vgs dc=6	-199.99263 u

Selected Diagram:Device Parameter Sweep

Hierarchy | Visibility | Pr

Lab - 08 - 01 *

------ Checking SPICE netlist for Lab - 08 - 01 - Wednesday, October 11, 2023, 10:45:46 PM ------

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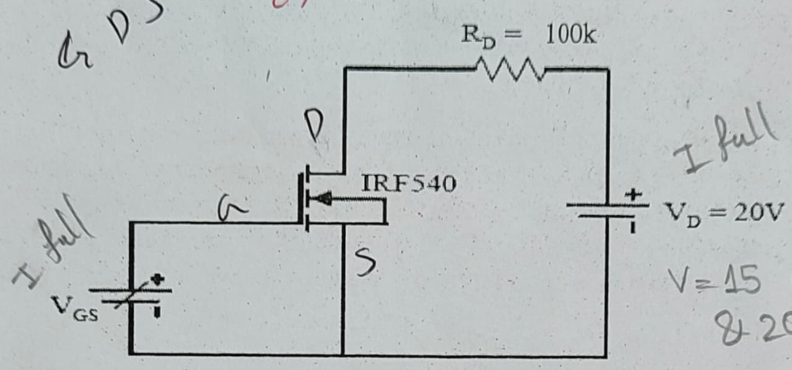
NORTH SOUTH UNIVERSITY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Experimental Setup:

Riddiqua

07.10.23



V=15 থেকে start & 20 দুইটা দিয়েই করতে হবে

Procedure:

1. Set V_{GS} to zero and record the V_{DS}, V_L and I_D.
2. Increase the gate voltage V_{GS} gradually and record the readings.
3. Take reading until I_D = 20mA (or the saturation current of the MOSFET).
4. Note the condition of V_{DS} and I_D of steps 1 and 3.
5. Repeat the experiment for V_{DD} = 15 Volts.

$V_{DD} = 15V$				$V_{DD} = 20V$			
V_{GS}	V_{DS}	V_L	I_D (mA)	V_{GS}	V_{DS}	V_L	I_D (mA)
0 V	14.73V	0 V	0mA	0V	19.67V	0 V	0 mA
1V	14.43V	0 V	0mA	1V	19.55V	0 V	0 mA
2V	14.21V	0 V	0mA	2V	19.27V	0 V	0 mA
3V	0V	15.11V	0.15mA	3V	0V	20.11V	0.1997 mA
4V	0V	15.11V	0.15mA	4V	0V	20.11V	0.1997 mA
5V	0V	15.11V	0.15mA	5V	0V	20.11V	0.1997 mA
6V	0V	15.11V	0.15mA	6V	0V	20.12V	0.1999 mA