Course Name:	Electronics Devices and Circuits	Semester:	III
Date of Performance:	06 / 10 / 2025	Batch No:	A1 (VLSI)
Student Name:	Anish Das	Roll No:	16015124005
Faculty Sign & Date:		Grade/Marks:	/25

Experiment No: 7

Title: Study DC analysisof n-channel MOSFET (Spice simulation)

Aim and Objective of the Experiment: Study of DC analysis of n-channel MOSFET

COs to be achieved:

CO2: Analyze MOSFET circuits for DC and AC operations

Theory:

The metal–oxide–semiconductor field-effect transistor (MOSFET) is a transistor used for amplifying or switching electronic signals. In MOSFETs, a voltage on the oxide-insulated gate electrode can induce a conducting channel between the two other contacts called source and drain. The channel can be of n-type or p-type, and is accordingly called an nMOSFET or a pMOSFET. Figure 1 shows the schematic diagram of the structure of an nMOS device before and after channel formation.

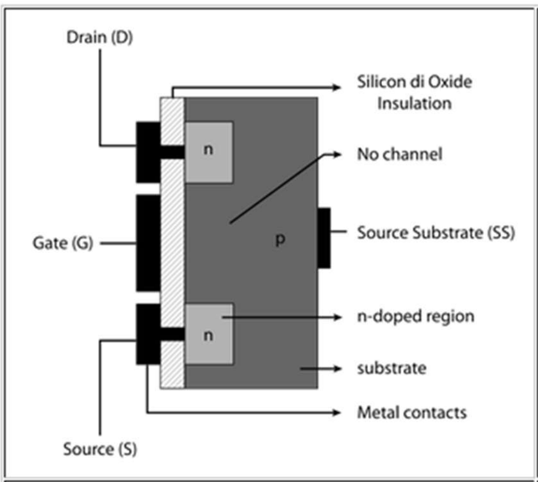


Fig. (1a): nMOSFET before channel formation

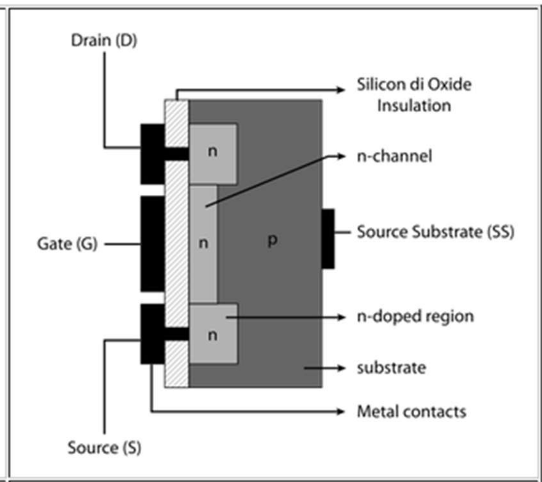
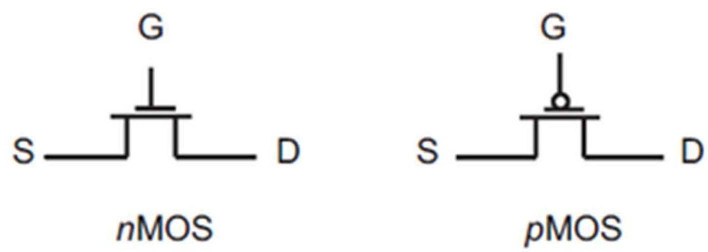


Fig. (1b): nMOSFET structure after channel formation



In a voltage divider MOSFET amplifier, DC analysis is performed to determine the quiescent or operating point (Q-point) of the transistor, ensuring it operates in the **saturation region** for proper amplification. The voltage divider network, formed by resistors R_1 and R_2, provides a stable gate voltage (V_G) that is independent of transistor parameters.

For an n-channel enhancement MOSFET, the source resistor R_S develops a voltage $V_S = I_D R_S$, and the gate-source voltage is

$$V_{GS} = V_G - V_S$$

If $V_{GS} > V_{TH}$, the MOSFET conducts, and the drain current in saturation is

$$I_D = \frac{1}{2} k (V_{GS} - V_{TH})^2$$

where $k = \mu_n C_{ox}(W/L)$. The drain voltage is

$$V_D = V_{DD} - I_D R_D$$

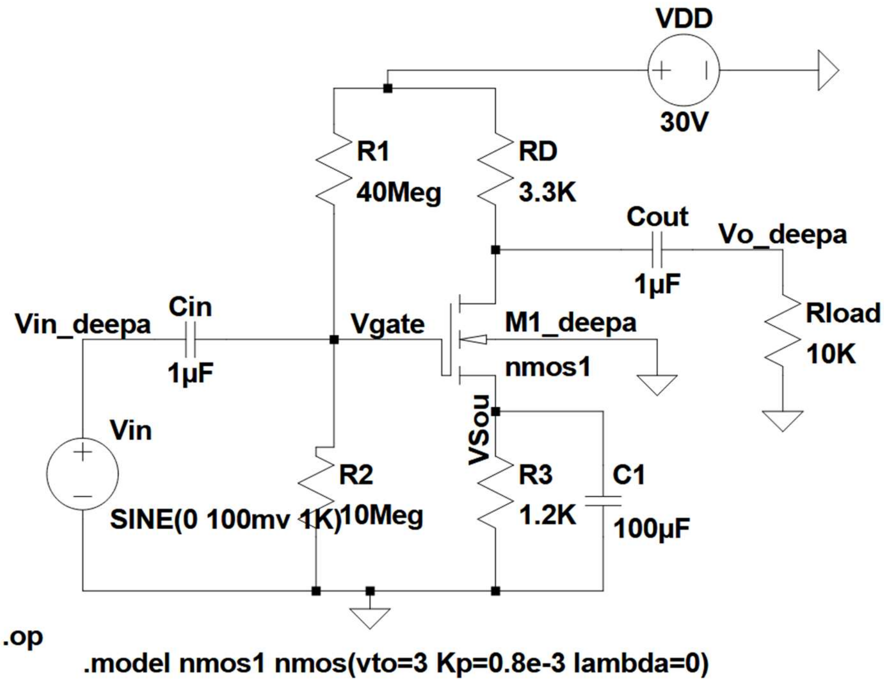
and the drain-to-source voltage is

$$V_{DS} = V_D - V_S$$

The Q-point is defined by the values of I_D and V_{DS}. Proper design ensures V_{DS} remains high enough to keep the MOSFET in saturation. The voltage divider bias provides thermal stability and minimizes variation in I_D due to transistor parameter changes, resulting in consistent amplifier performance.

Circuit Diagram:

N-channel NMOS circuit in Common Source configuration



Stepwise-Procedure:

1. Open a new Schematic and create it as per above circuit diagram.
2. Note down the parameters as per the observation table.
3. Select DC Operating point in simulation tab and Note down the Quiscent point of the amplifier

Observation Table:

1. DC Operating parameters:

Parameters	Theoretical	Practical
ID	1.11 mA	1.11 mA
VG	6 V	6 V
VS	1.332 V	1.33 V
VGS	4.668 V	4.67 V

Parameters	Theoretical	Practical
I_D	1.11×10^{-3} A	1.11×10^{-3} A
V_G	6 V	6 V
V_S	1.332 V	1.33 V
V_{GS}	4.668 V	4.67 V

Calculations:

$$V_G = V_{DD} \times \frac{R_2}{R_1+R_2}$$

$$= 30 \times \frac{10\times10^{6}}{(10+40)10^{6}}$$

$$= \frac{300}{50}$$

$$\therefore V_G = 6V$$

$$V_S = I_D R_S$$

$$= (1.11\times10^{-3})(1.2\times10^{3})$$

$$\therefore V_S = 1.332V$$

05

$$V_{GS} = V_G - V_S$$

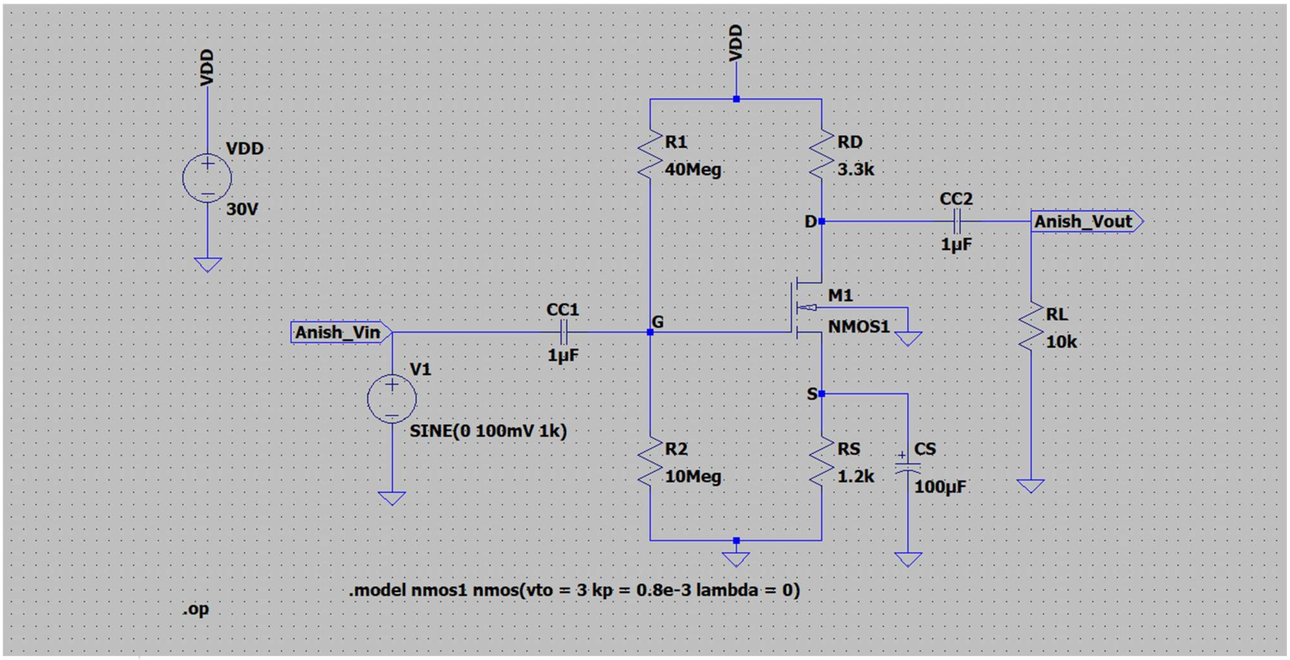
$$= 6 - 1.332$$

$$\therefore V_{GS} = 4.668 V$$

13/10/25

Waveform

DC Operating Point screenshots



* C:\Users\ETRX\Downloads\anish.asc

```
       --- Operating Point ---

V(d):            26.3333        voltage
V(g):            6              voltage
V(s):            1.33333        voltage
V(vdd):          30             voltage
V(anish_vout):   2.63333e-13    voltage
V(anish_vin):    0              voltage
Id(M1):          0.00111111     device_current
Ig(M1):          0              device_current
Ib(M1):          -2.76867e-11   device_current
Is(M1):          -0.00111111    device_current
I(Cc2):          -2.63333e-17   device_current
I(Cs):           1.33333e-16    device_current
I(Cc1):          6e-18          device_current
I(R1):           6e-07          device_current
I(R2):           6e-07          device_current
I(Rd):           0.00111111     device_current
I(Rs):           0.00111111     device_current
I(Rl):           2.63333e-17    device_current
I(Vdd):          -0.00111171    device_current
I(V1):           6e-18          device_current
```

Post Lab Subjective/Objective type Questions: (hand written)

1. What is the purpose of DC analysis in a voltage divider MOSFET amplifier circuit?
2. Why is a voltage divider biasing network preferred for MOSFET amplifiers?
3. Write the condition for the MOSFET to operate in the saturation region.
4. What is the mathematical expression for the drain current (IDI_DID) in the saturation region?
5. Define the Q-point. Why is it important in amplifier design?

Post-lab Questions.

1) →
DC Analysis sets the correct biasing so that the MOSFET remains in the saturation region and the input AC signal can vary without distortion.

2) →
Voltage Divider Bias gives stable operating point (Q-point) and reduces dependency on transistor variations, ensuring consistent amplifier performance.

3) →
For a MOSFET to operate in the saturation (active) region the following condition must be satisfied:

$V_{DS} \geq V_{GS} - V_{TH}$

where

V_{DS} = Drain to Source Voltage

V_{GS} = Gate to Source Voltage

V_{th} = Threshold Voltage.

This is the region used for amplification

4)
→ The mathematical expression for the drain current (I_D) of a mosfet in the saturation region is:

$$I_D = \frac{1}{2} k (V_{GS} - V_{th})^2$$

where :

I_D = Drain Current

$k = \mu_n C_{ox} \frac{W}{L}$ (process transconductance parameter)

V_{GS} = Gate-to-source Voltage

V_{th} = Threshold Voltage.

5)
→ Q-Point (Quiescent Point) is the operating point of a transistor or MOSFET on its characteristic curve - defined by the DC values of drain current (I_D) and drain-to-source (V_{DS}) when no input signal is applied.

Its importance in Amplifier Design are :

① Ensures linear operation : Keeps the MOSFET in the saturation region so that output signal isn't distorted.

(2) Provides signal symmetry: Allows equal swing for positive and negative parts of the AC signal.

(3) Stability: A well-chosen Q-point prevents cutoff or saturation due to temperature or parameter variations.

Conclusion: (to be written in own words)

Conclusion:

From this experiment, we learn to study & perform DC-Analysis of n-channel MOSFET using LTSpice. A MOSFET is a transistor used for switching or amplifying signals. The channel used is of n-type, hence, the name n-channel MOSFET. The DC Analysis is performed to set the correct biasing so that the MOSFET remains in saturation region. Thus, by DC Analysis, we find I_D & V_{DS} and set the Q-point, which ensures linear amplification.

05

13/10/25

Signature of faculty in-charge with Date: