FET AND MOSFET

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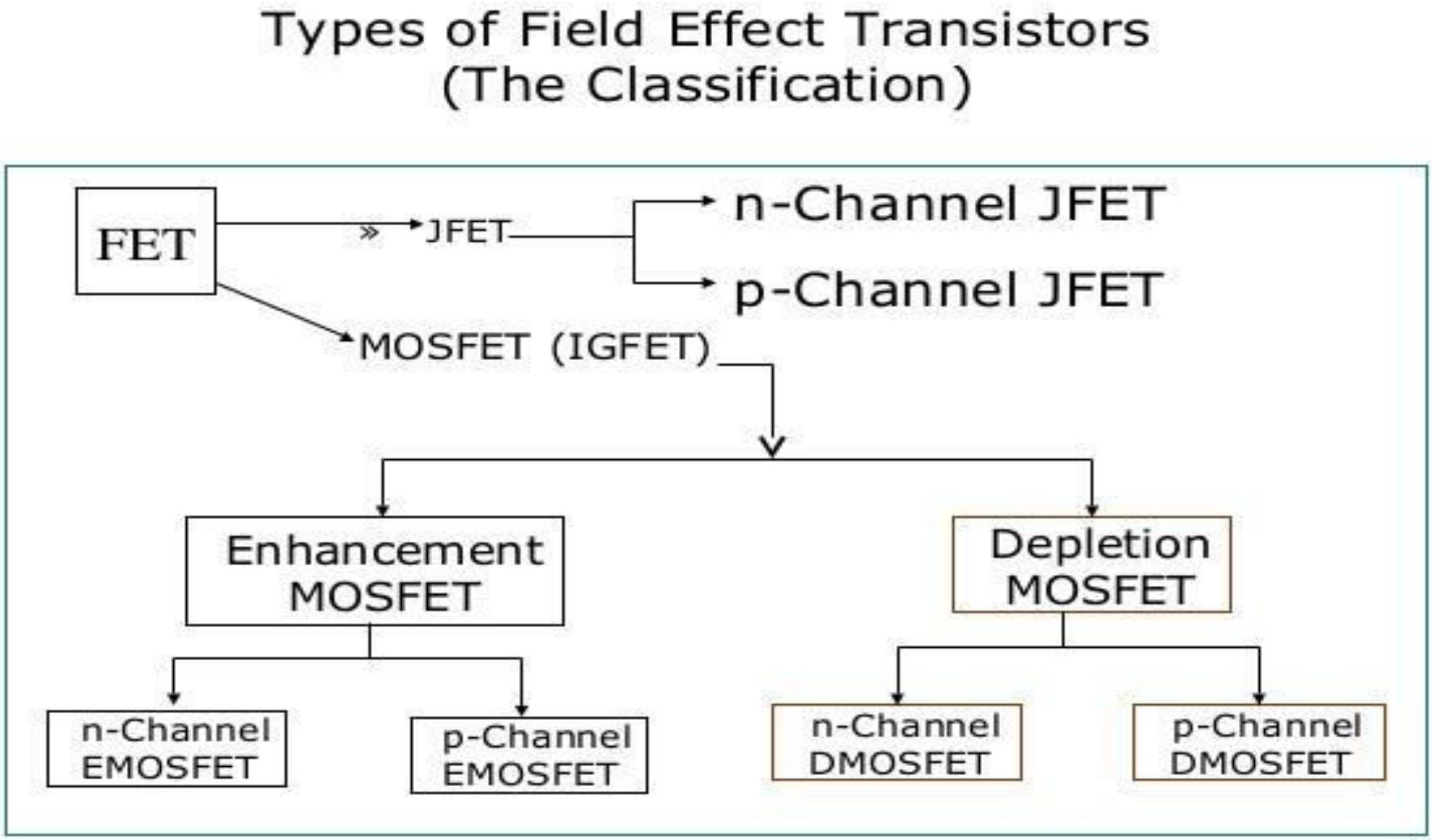
FET (Field Effect Transistor)

INTRODUCTION:--

The **field-effect transistor** (FET) is a transistor that uses an electric field to control the shape and hence the conductivity of a channel of one type of charge carrier in a semiconductor material. FETs are unipolar transistors as they involve single-carrier-type operation. The *concept* of the FET predates the bipolar junction transistor (BJT), though it was not physically implemented until *after* BJTs due to the limitations of semiconductor materials and the relative ease of manufacturing BJTs compared to FETs at the time.

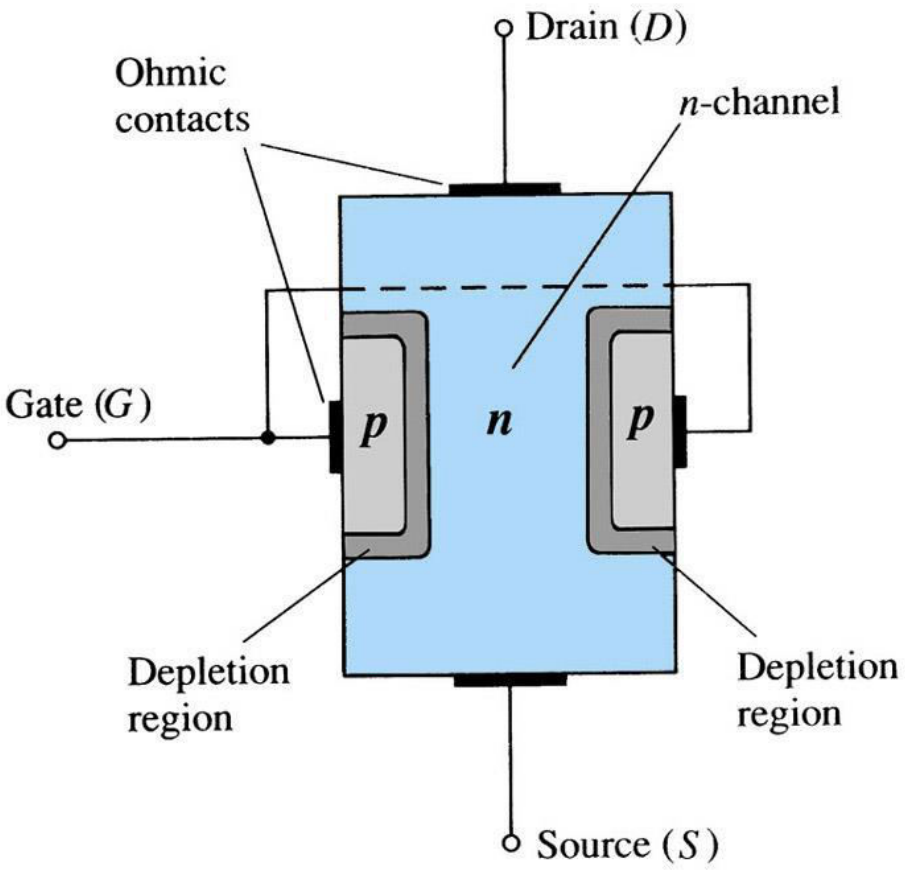
Classification



CONSTRUCTION OF THE JFET

- The *n-channel JFET consists of a uniformly doped n-type silicon semiconductor bar with ohmic contacts* at both ends and semiconductor junctions made on either sides of the bar.
- The top portion of the *n-type channel* is connected through the ohmic contact to a terminal called the drain (*D) while the lower end is connected to* the terminal referred to as the source (*S).*
- *The two p-type materials, fabricated on the two sides, are connected* together and then to the third terminal called gate (*G).*
- *The source terminal gets its name from the fact that* the carriers contributing to the current flow move out from the external circuit into the semiconductor at this electrode.
- The carriers travel through the bulk of the semiconductor and are subsequently collected at the drain electrode.
- The gate is called so because it controls the flow of charges though the bulk.

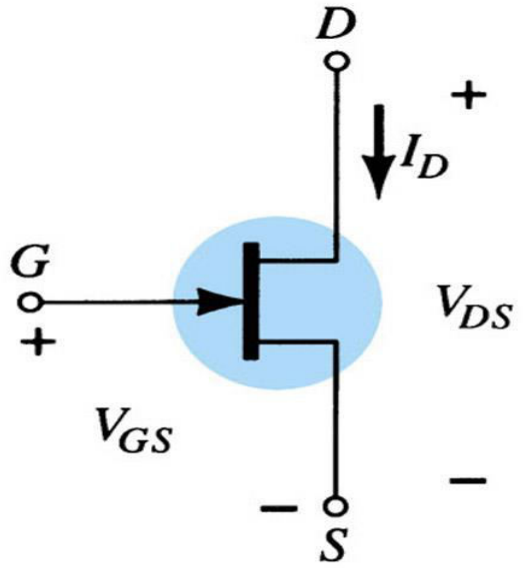
JFET CONSTRUCTION



Symbol of N CHANNEL FET

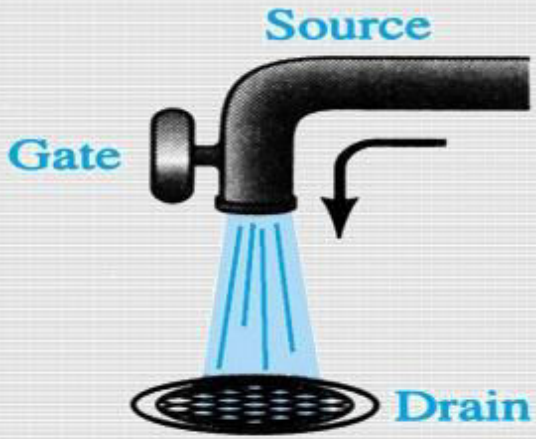
- **There are three terminals: Drain (D) and Source (S) are connected to n-channel**

Gate (G) is connected to the p-type material

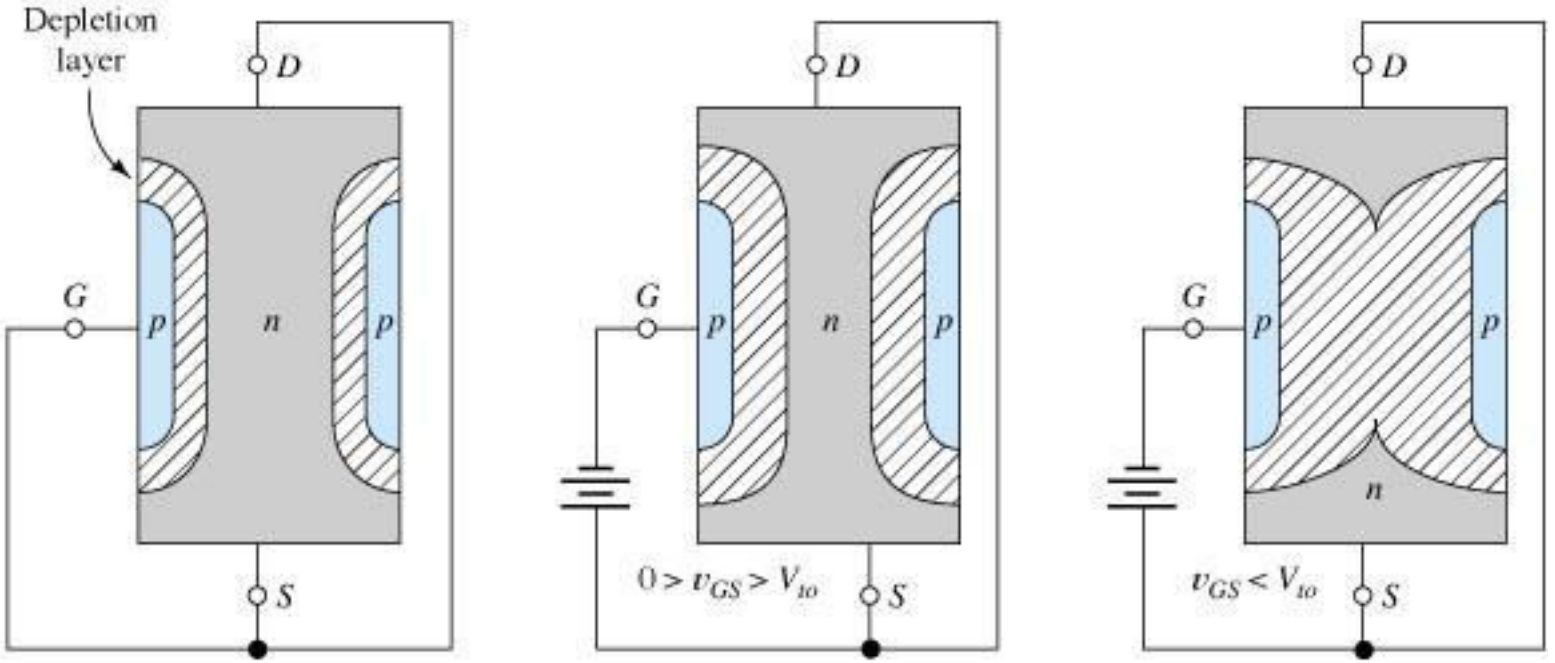


(a)

Water analogy for the JFET control mechanism



N-Channel JFET Operation & Working



(a) Bias is zero and depletion layer is thin; low-resistance channel exists between the drain and the source

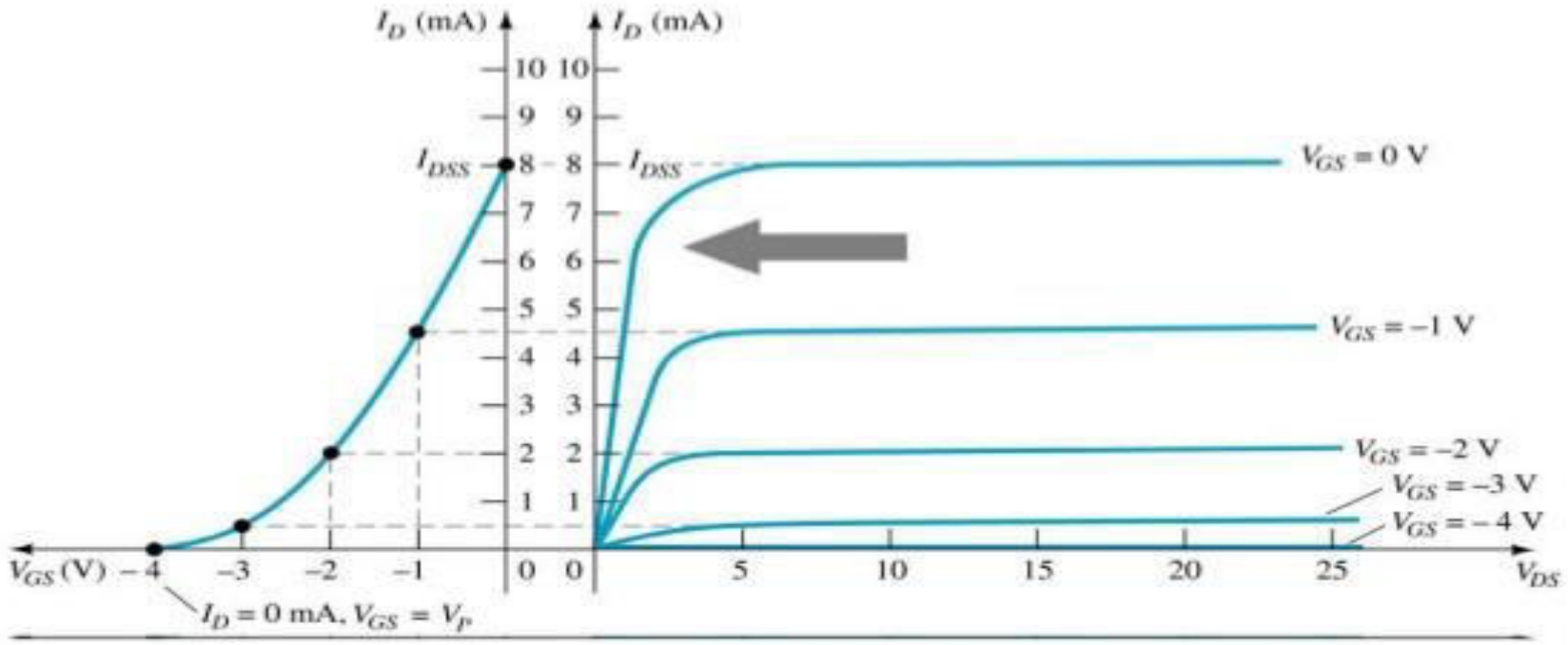
(b) Moderate gate-to-channel reverse bias results in narrower channel

(c) Bias greater than pinch-off voltage; no conductive path from drain to source

Transfer Characteristics

- The input-output transfer characteristic of the JFET is not as straight forward as it is for the BJT
- In a BJT, β (hFE) defined the relationship between I_B (input current) and I_C (output current).
- In a JFET, the relationship (Shockley's Equation) between V_{GS} (input voltage) and I_D (output current) is used to define the transfer characteristics, and a little more complicated (and not linear):

Transfer and Drain characteristics



JFET Transfer Characteristic Curve

JFET Characteristic Curve

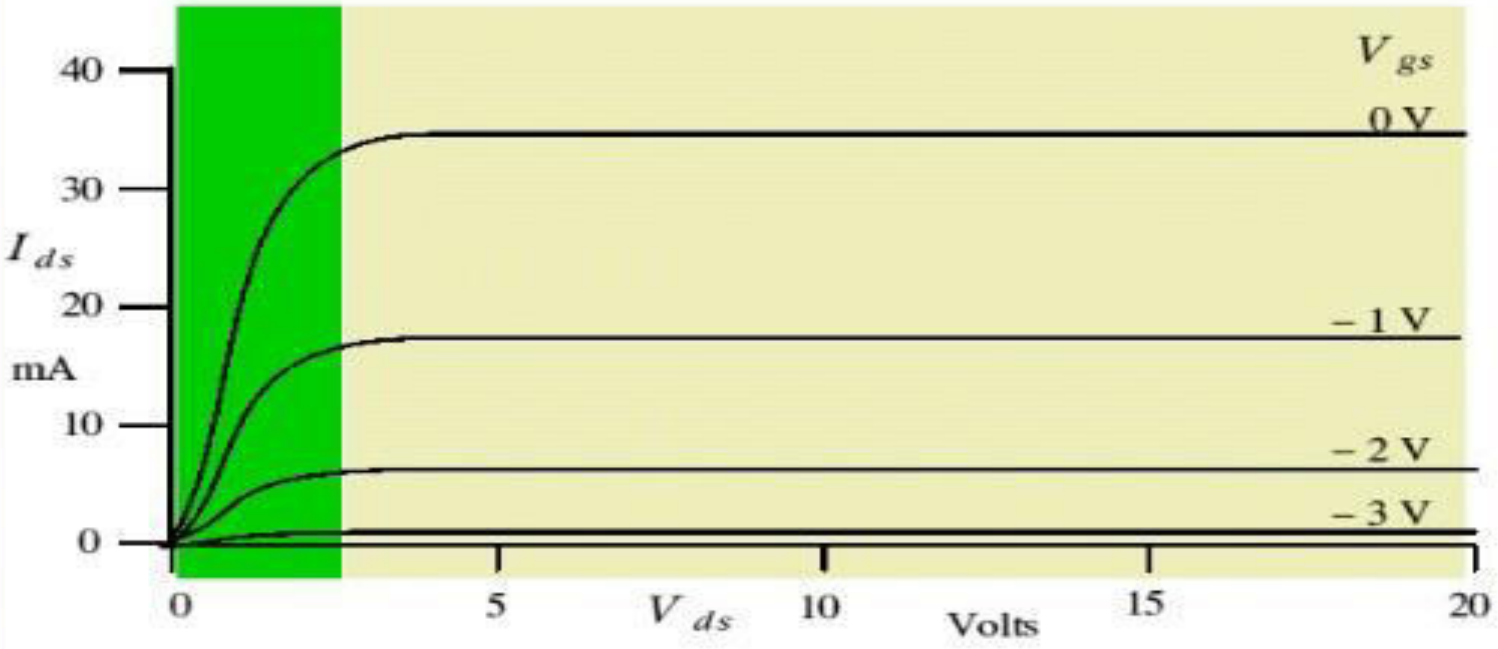
$V_{GS} < 0$, V_{DS} at some positive value

JFET Characteristic Curve..

- For negative values of V_{GS}, the gate-to-channel junction is reverse biased even with $V_{DS}=0$
- Thus, the initial channel resistance of channel is higher.
- The resistance value is under the control of V_{GS}
- If V_{GS} = pinch-off voltage(V_P)

  The device is in cutoff ($V_{GS}=V_{GS(off)} = V_P$)
- The region where I_D constant – The saturation/pinch-off region
- The region where I_D depends on V_{DS} is called the linear/ohmic region

Characteristics for n-channel JFET

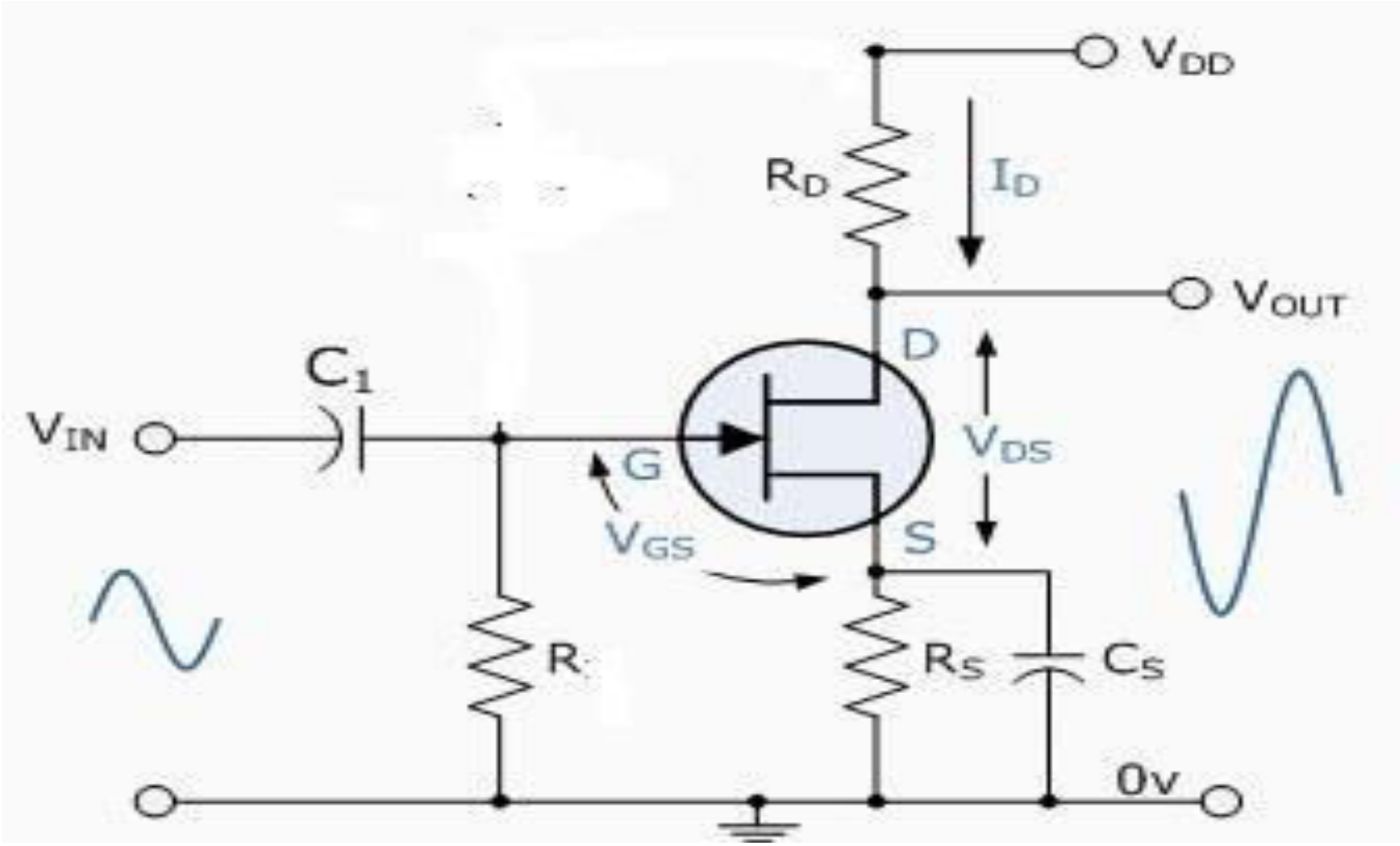


'Characteristic curves for a typical N-channel JFET.

JFET Parameters

- 1) Drain resistance (rd) :-- (VDS/ ID) VGS
- 2) Transconductance (gm):--(ID / VGS) VDS
- 3) Amplification factor (μ):--(VDS / VGS) ID

JFET as an amplifier



Applications of JFET

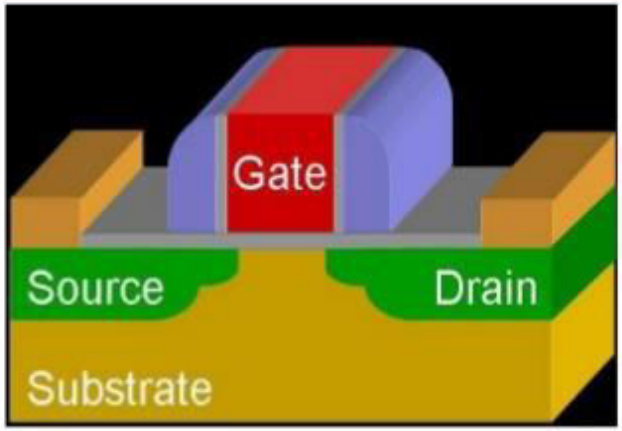
- JFET are used as an Amplifier.
- JFET are used for mixer operation of FM and TV recievers.
- It can be used as voltage variable resistor.
- It can be used for computer memories because of small size.

Advantages of JFET over BJT

- 1) It has higher input impedance than that of the BJT.
- 2) It has negative temperature coefficient of resistance and hence better thermal stability.
- 3)It has small size,longer life and high efficiency.
- 4)It has low noise level.
- 5)It has high power gain
- 6) It has square law characteristics

MOSFET

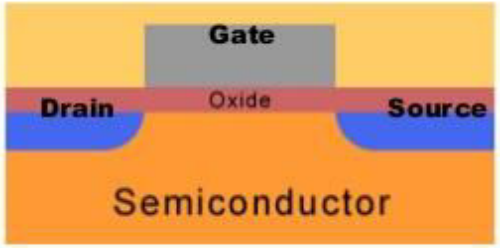
WHAT IS MOSFET….???



➢ The **metal–oxide–semiconductor field-effect transistor** (**MOSFET**, **MOS-FET**, or **MOS FET**) is a transistor used for amplifying or switching electronic signals.

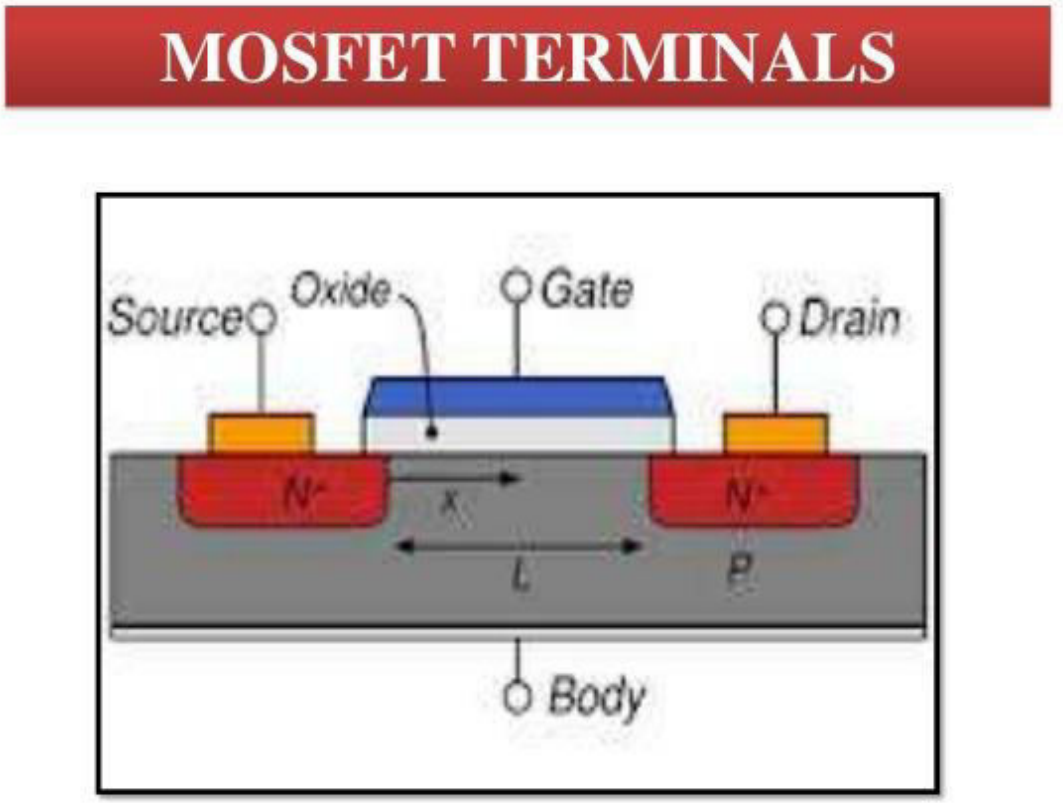
CONSTRUCTION

MOSFET



- Metal Oxide Semiconductor Field Effect Transistor
- Source (Arsenic, Phosphorous, Boron)
- Drain (Arsenic, Phosphorous, Boron)
- Gate (Aluminum, Polysilicon)

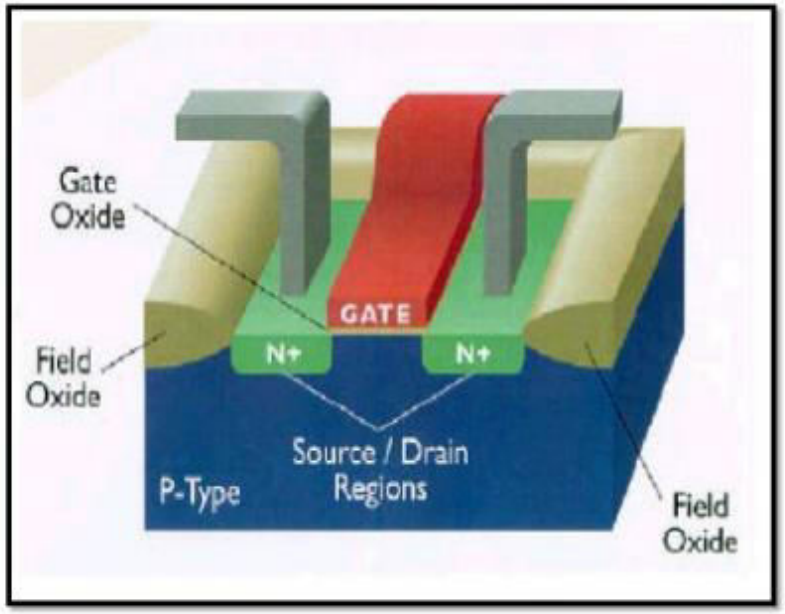
Internal Diagram



TYPES

TYPES OF MOSFET

- n - MOS FET
- p – MOS FET
- CMOS FET



Types of MOSFETS

n-channel Enhancement Mode (nMOSFET)	p-channel Enhancement Mode (pMOSFET)
n-channel Depletion Mode (nMOSFET)	p-channel Depletion Mode (pMOSFET)

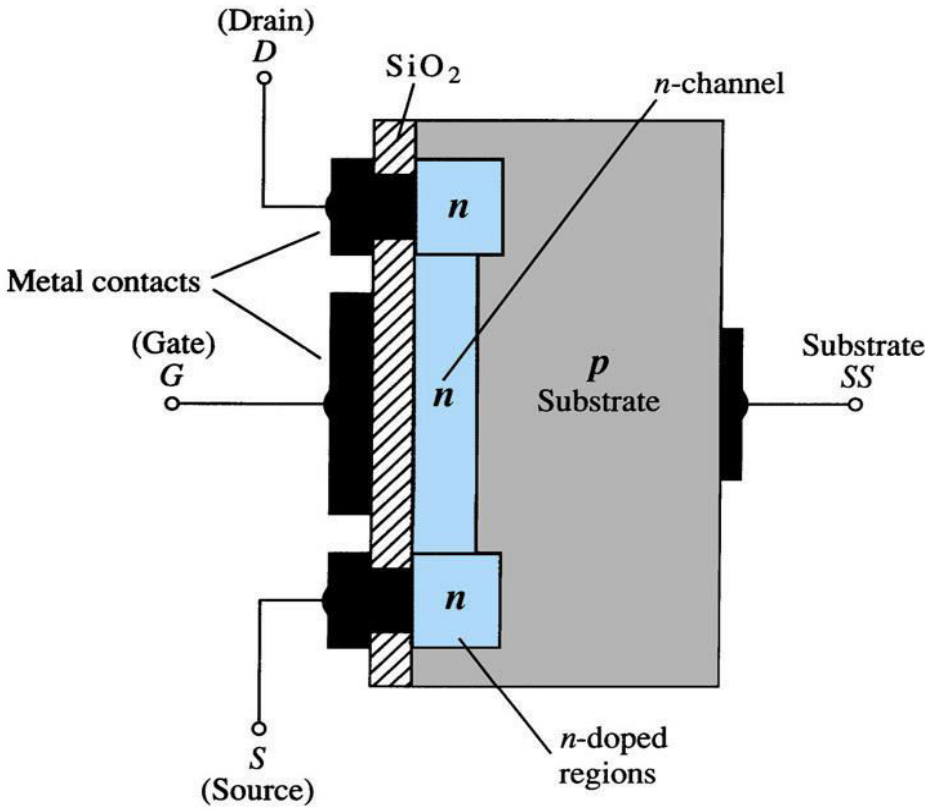
MOSFET (Metal Oxide Semiconductor FET)

There are two types of MOSFET's:

- Depletion mode MOSFET (D-MOSFET)
  - Operates in Depletion mode the same way as a JFET when VGS ≤ 0
  - Operates in Enhancement mode like E-MOSFET when VGS > 0

- Enhancement Mode MOSFET (E-MOSFET)
  - Operates in Enhancement mode
  - IDSS = 0 until VGS > VT (threshold voltage)

Depletion MOSFET N channelConstruction



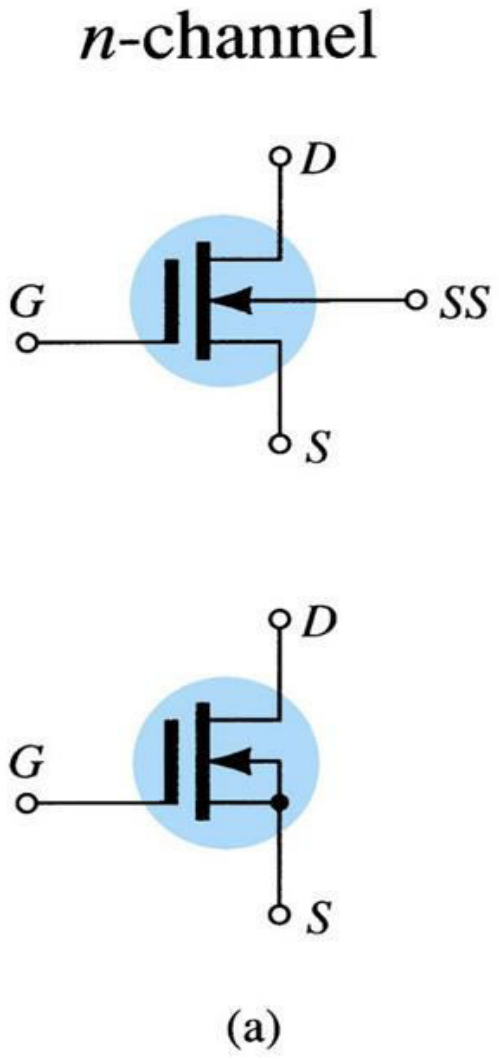
The Drain (D) and Source (S) leads connect to the to n-doped regions

These N-doped regions are connected via an n-channel

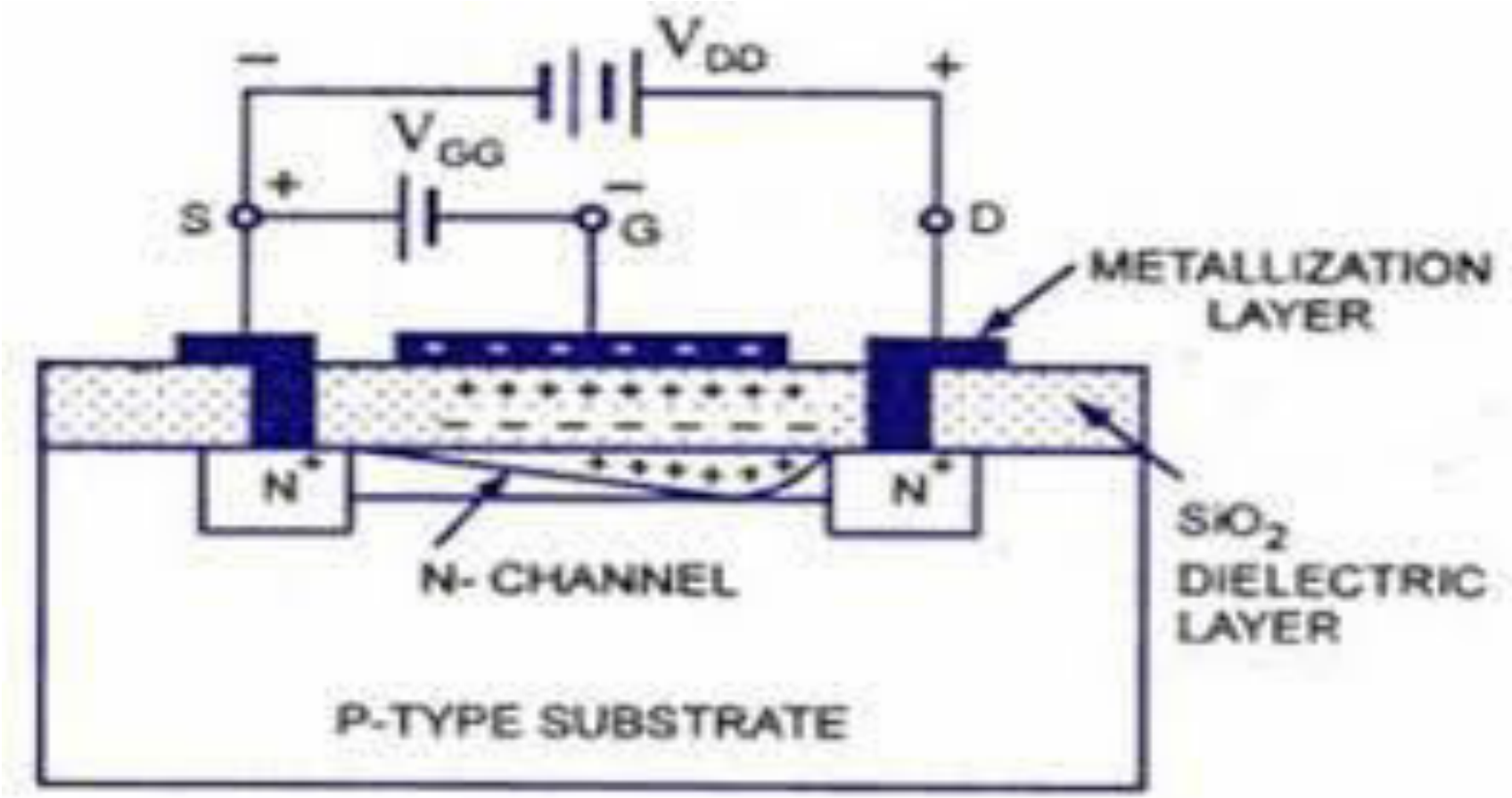
This n-channel is connected to the Gate (G) via a thin insulating layer of SiO_2

The n-doped material lies on a p-doped substrate that

D-MOSFET Symbols



Working of DMOSFET(Depletion mode)

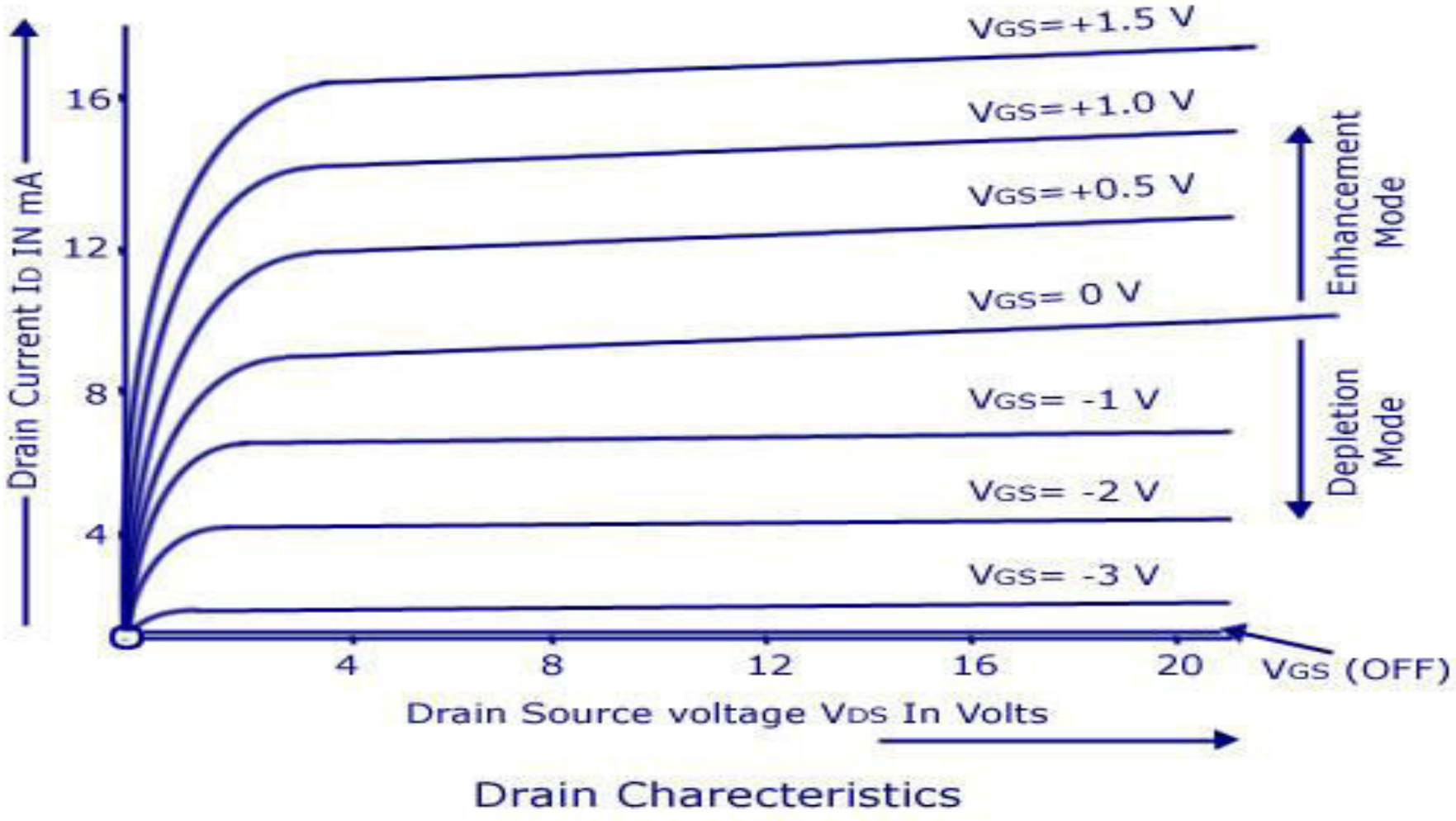


Depletion Mode Operation

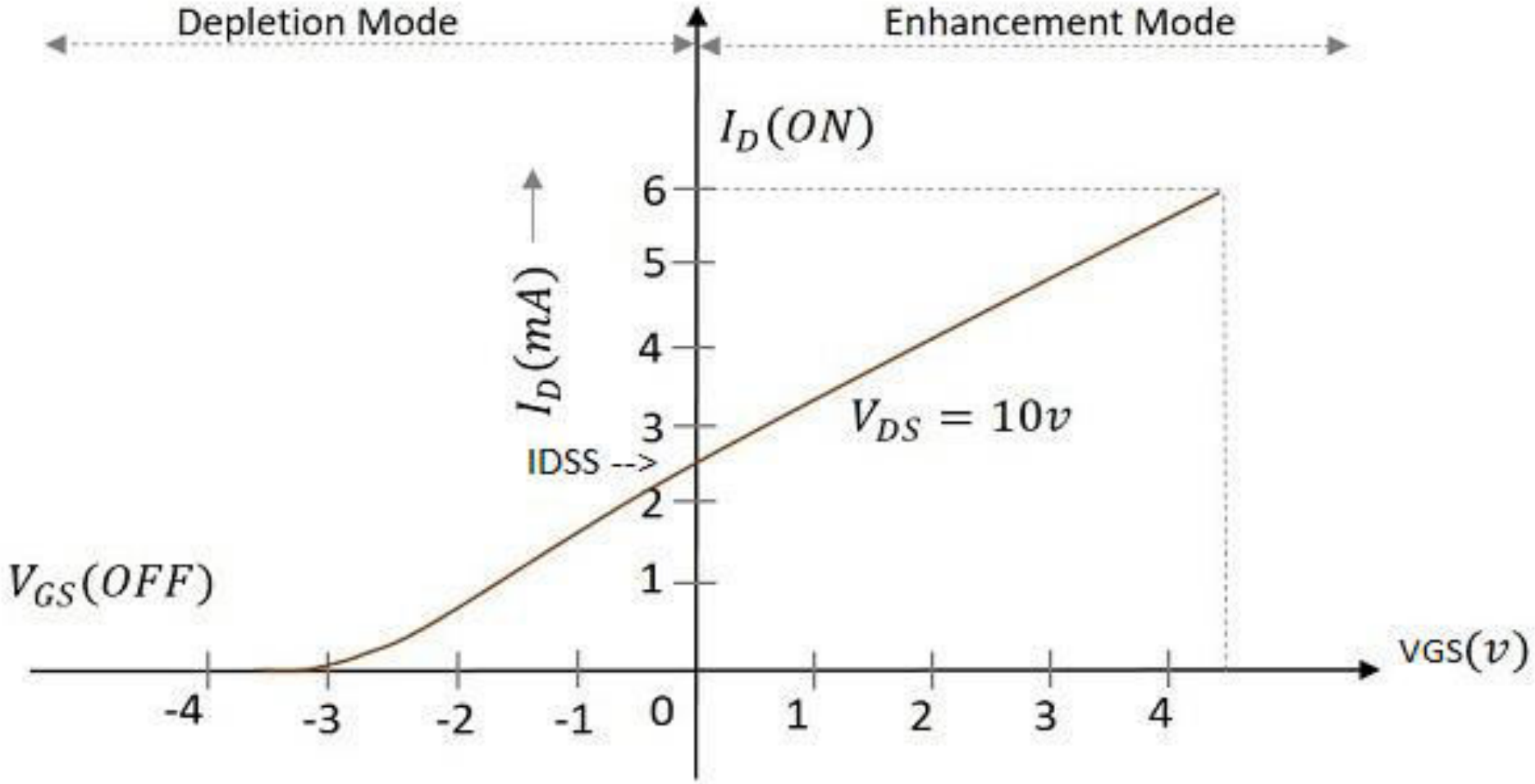
Working of DMOSFET(Enhancement mode)

- VGS : Apply positive voltage to gate terminal
- N channel: Enriched with more electrons.
- Drain Current: increases

Drain Characteristics (D MOSFET)

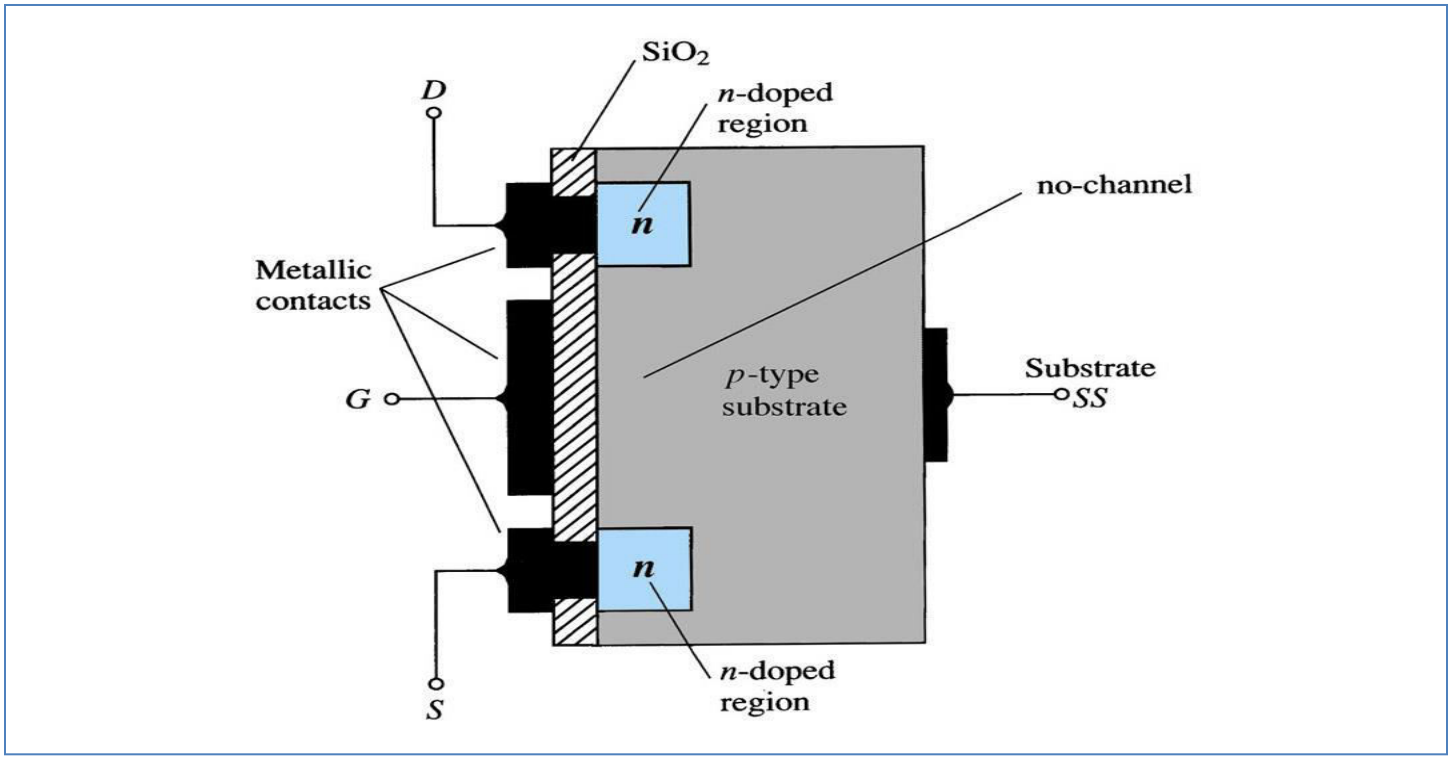


Transfer Characteristics (D MOSFET)



Transfer Characteristics of a DMOSFET

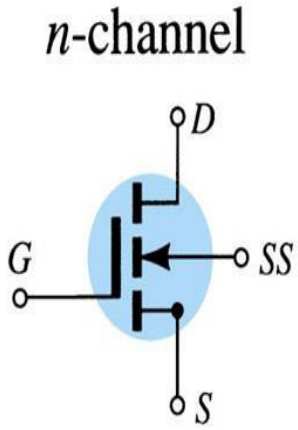
Enhancement MOSFET(N channel) Construction

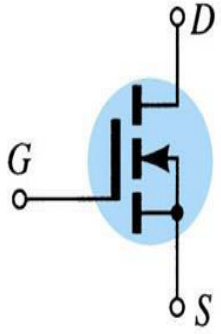


The Drain (D) and Source (S) connect to the to n-doped regions

These n-doped regions are not connected via an n-channel without an external voltage. The Gate (G) connects to the p-doped substrate via a thin insulating layer of SiO_2. The n-doped material lies on a p-doped

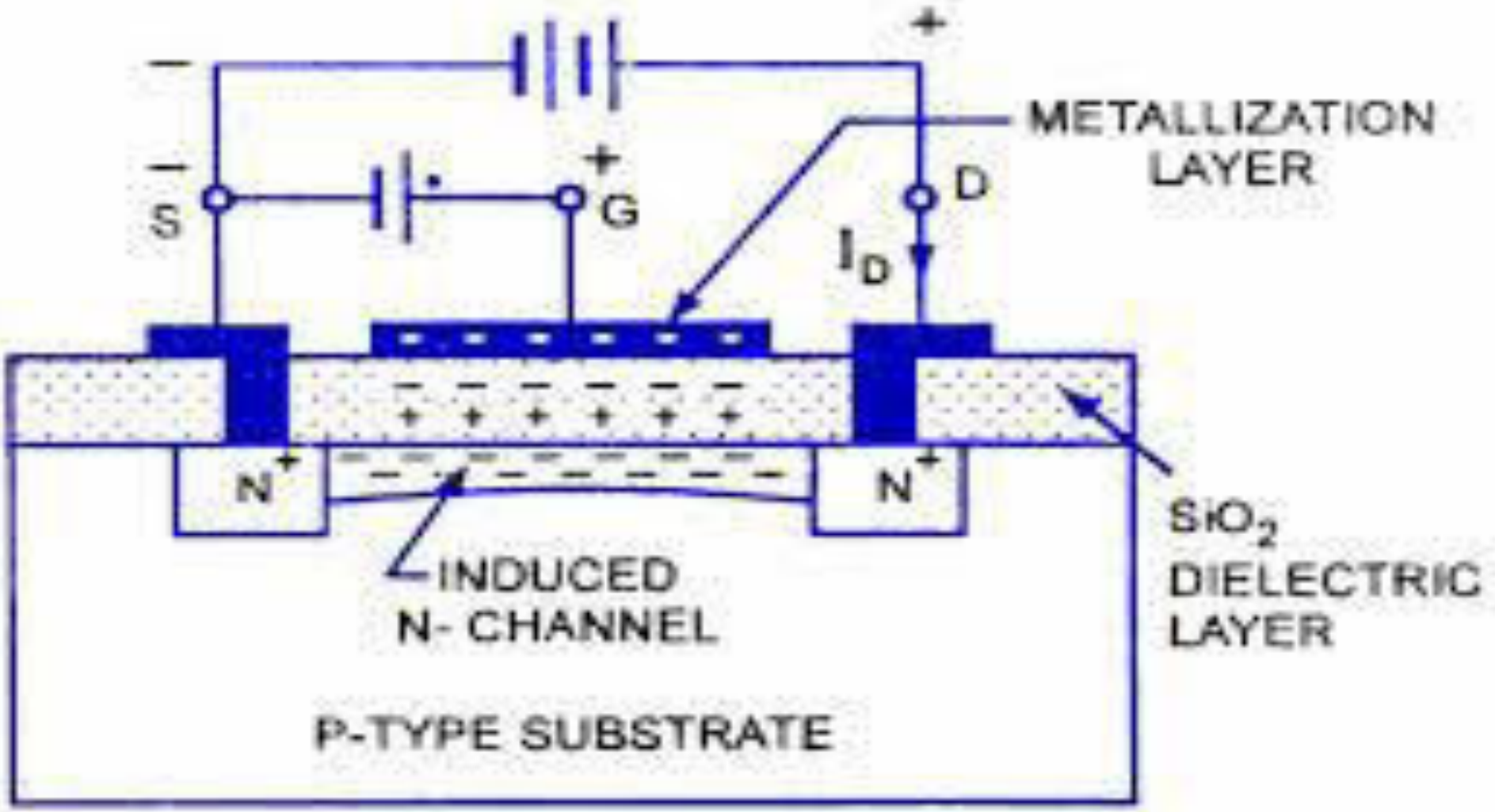
E-MOSFET Symbols





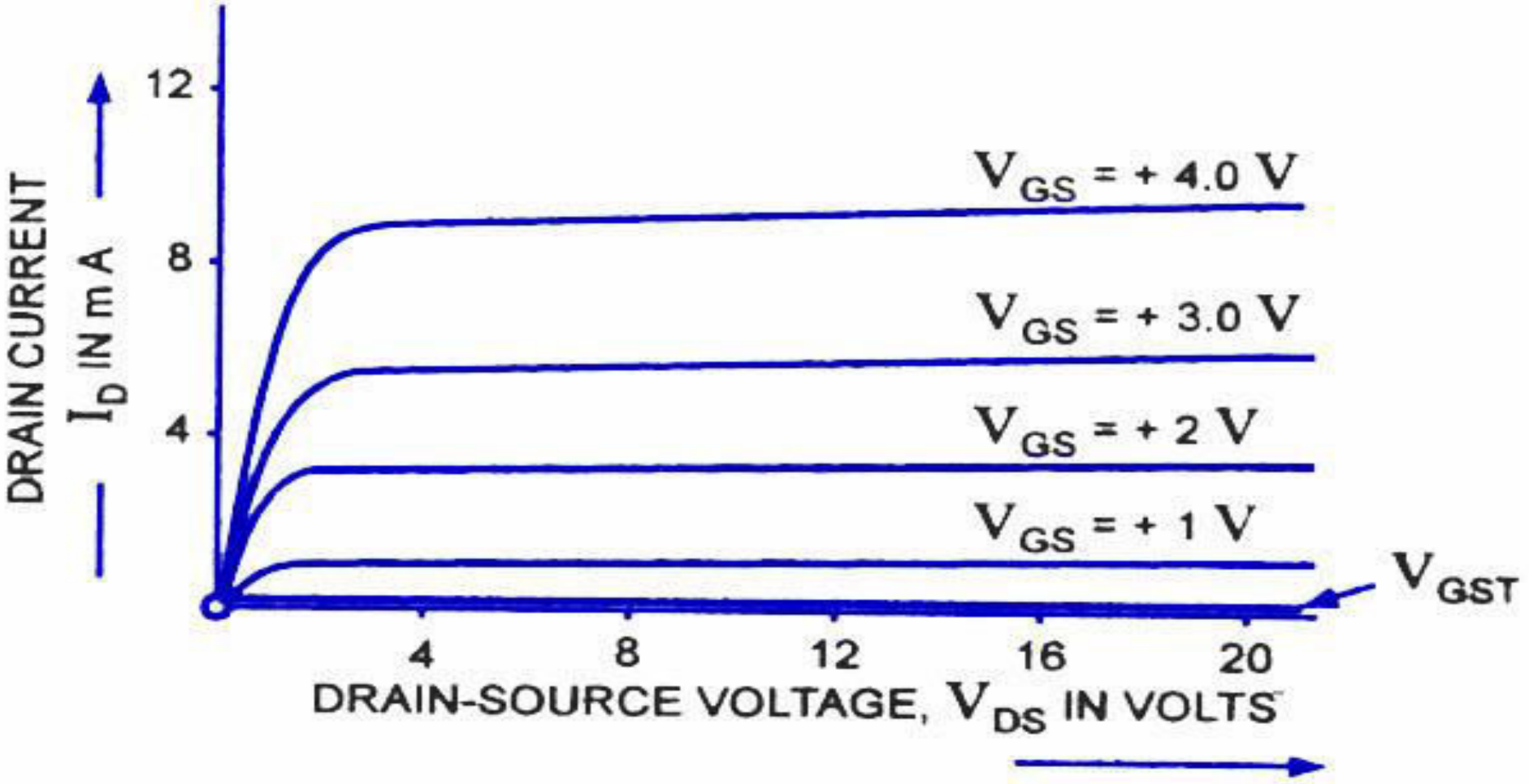
(a)

Working E MOSFET(N channel)



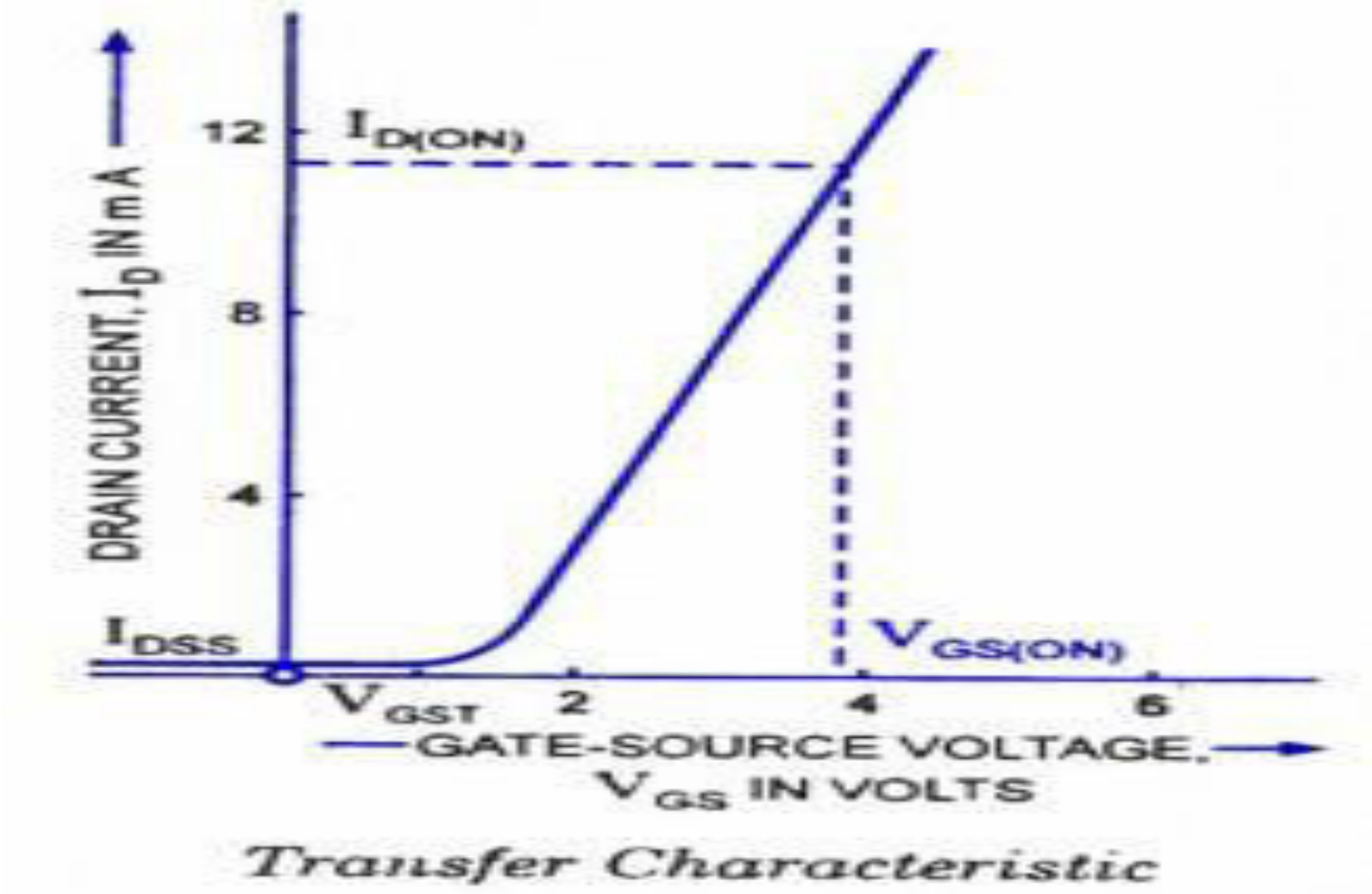
Operation of N-Channel E-MOSFET

Drain characteristics E MOSFET (N channel)



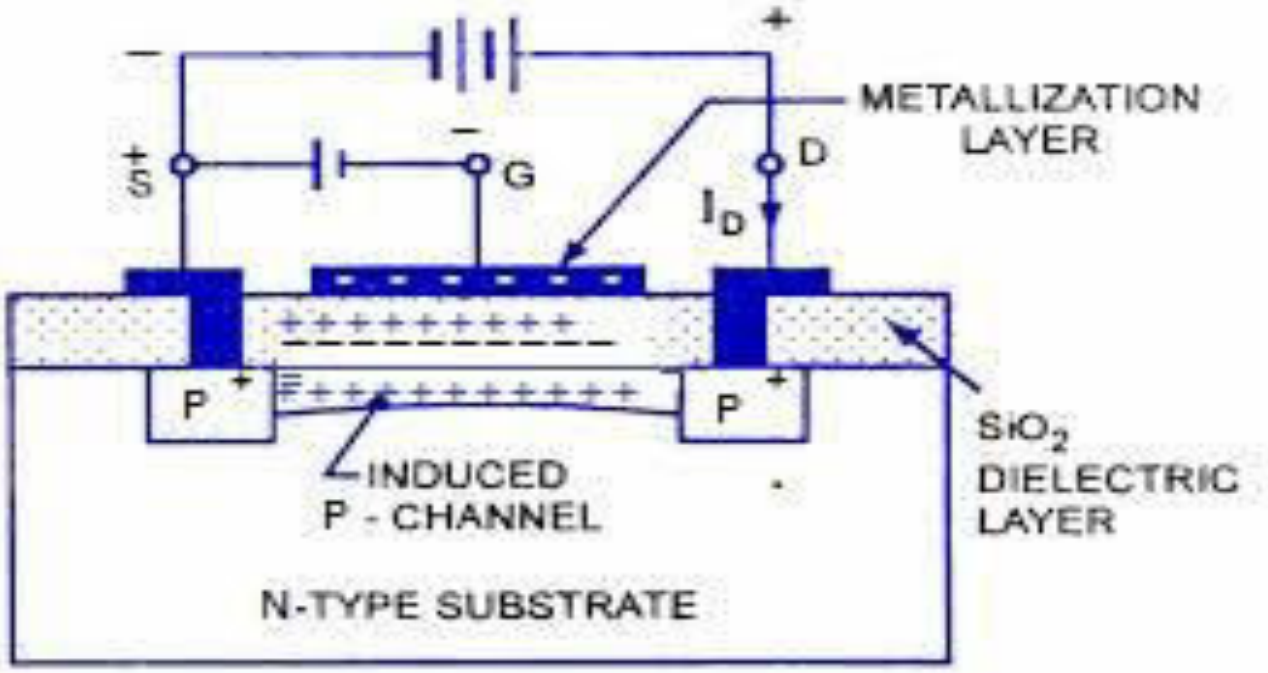
Drain Characteristics

Transfer characteristics E MOSFET(N channel)



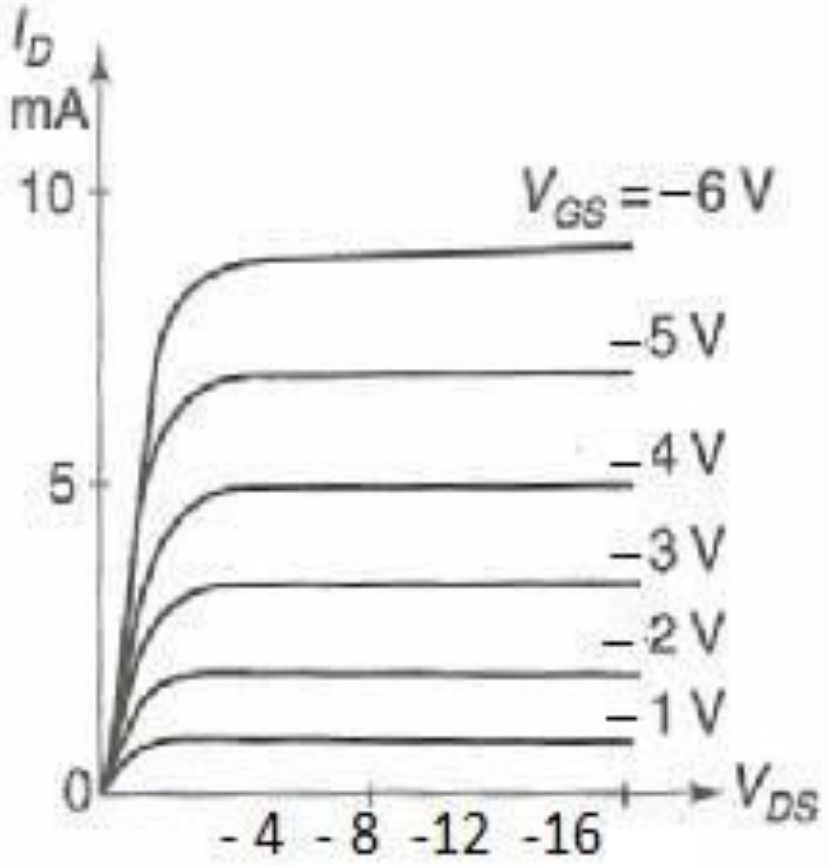
Transfer Characteristic

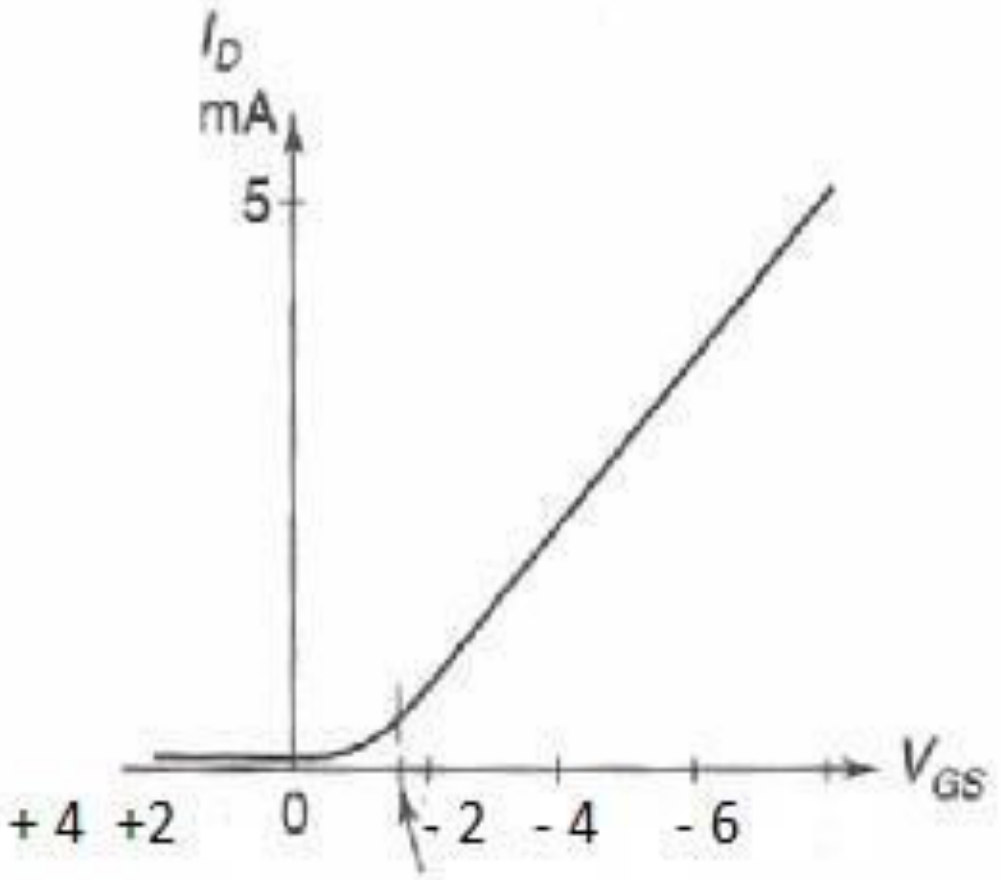
Working of EMOSFET(P channel)



Operation of N-Channel E-MOSFET

Drain & Transfer characteristics E MOSFET (P channel)





Enhancement MOSFET Drain Characteristics

Merits of MOSFET

1. It has very high input impedance
   Approx.= 10^{11} to 10^{15} Ω

2. Requires very small space for fabrication.

3.lower power consumption and high noise immunity.

4.MOSFET Transconductance increases with drain current ,it gives less distortion.

Difference between E MOSFET & D MOSFET

1. E MOSFET Consists induced channel where as D MOSFET Consists inbuilt diffused channel.

2. E MOSFET operates only in Enhancement mode where as D MOSFET operates in both Enhancement & Depletion mode.

3.In E MOSFET no current ID flows when VGS = 0 while in D MOSFET significant current flows when VGS = 0

De merits of MOSFET

1. MOSFET requires very careful handling.

2.MOSFET is highly susceptible to overload voltages pick from any stray or static charges and may destroy it.

Applications of MOSFET

1. MOSFET are used in Switch mode power supply(SMPS) & are widely used in battery charging applications.

2. They can be used as Hi-Fi Amplifiers when configured in complementary pairs.

3.MOSFET provide large output current with a small input.This Characteristics in transducer drivers for high power devices like motor and CFL bulbs

MOSFET Applications

- Used as amplifiers.
- Used in the applications of power electronics and switch mode power supplies.
- MOSFETs are used as oscillators in radio systems.
- Used in automobile sound systems and in sound reinforcement systems

Comparision of MOSFET with JFET

1.Principle of operation:-- In MOSFET the conductivity of channel is controlled by the transverse electric field across capacitor where as in JFET conductivity of channel is controlled by the transverse electric field across reverse biased PN junction.

2. Input Resistance:-- Input Resistance of JFET is of the order of 10 8 to 10 9 ohms where as Input Resistance of MOSFET is very high of the order of 10 10 to 10 15 ohm.

Comparision of MOSFET with JFET

3. Output Resistance:-- Output Resistance of MOSFET is of the order of 1 to 50K ohm10 8 to 10 9 ohms where as output Resistance of JFET is very high of the order of 0.1 to 1 Megaohm.

4.Mode of operation :-- DMOSFET operates in both Enhancement & Depletion mode while JFET operates only in depletion mode.

5.MOSFETs are easier to fabricate than JFET.

Thank you