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BASICS OF ELECTRONICS

PREPARED BY

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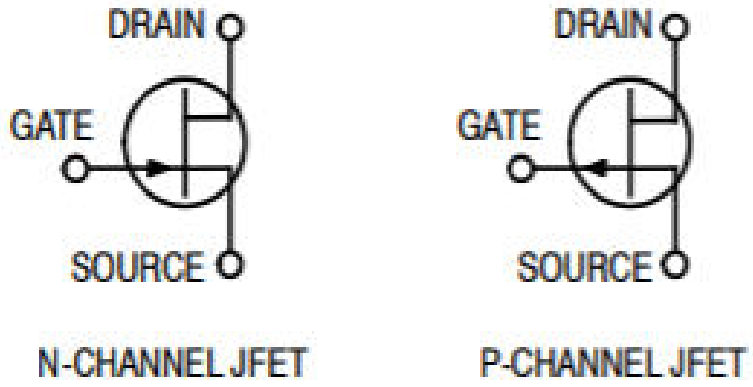
FIELD EFECT TRANSISTER

INTRODUCTION: There are two types of field-effect transistors, the Junction Field-Effect Transistor (JFET) and the “Metal-Oxide Semiconductor” Field-Effect Transistor (MOSFET), or Insulated-Gate Field-Effect Transistor (IGFET). The principles on which these devices operate (current controlled by an electric field) are very similar — the primary difference being in the methods by which the control element is made. This difference, however, results in a considerable difference in device characteristics and necessitates variances in circuit design, which are discussed in this note.



FET CHARECTERSTICS: The voltage V_{GS} applied to the Gate controls the current flowing between the Drain and the Source terminals. V_{GS} refers to the voltage applied between the Gate and the Source while V_{DS} refers to the voltage applied between the Drain and the Source.

Because a **Junction Field Effect Transistor** is a voltage controlled device, "NO current flows into the gate!" then the Source current (I_S) flowing out of the device equals the Drain current flowing into it and therefore ($I_D = I_S$).

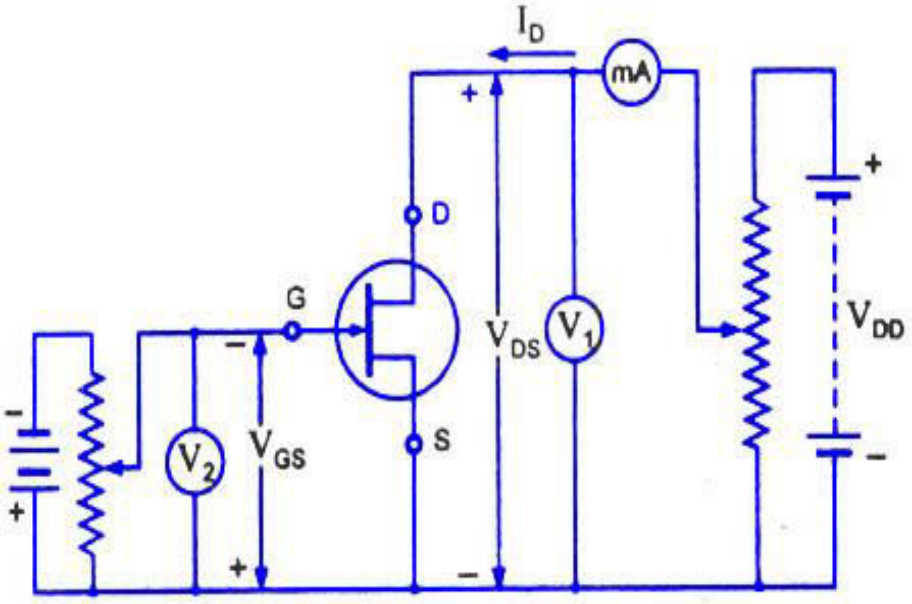
The characteristics curves example shown above, shows the four different regions of operation for a JFET and these are given as:

(1) Ohmic Region – When $V_{GS} = 0$ the depletion layer of the channel is very small and the JFET acts like a voltage controlled resistor.

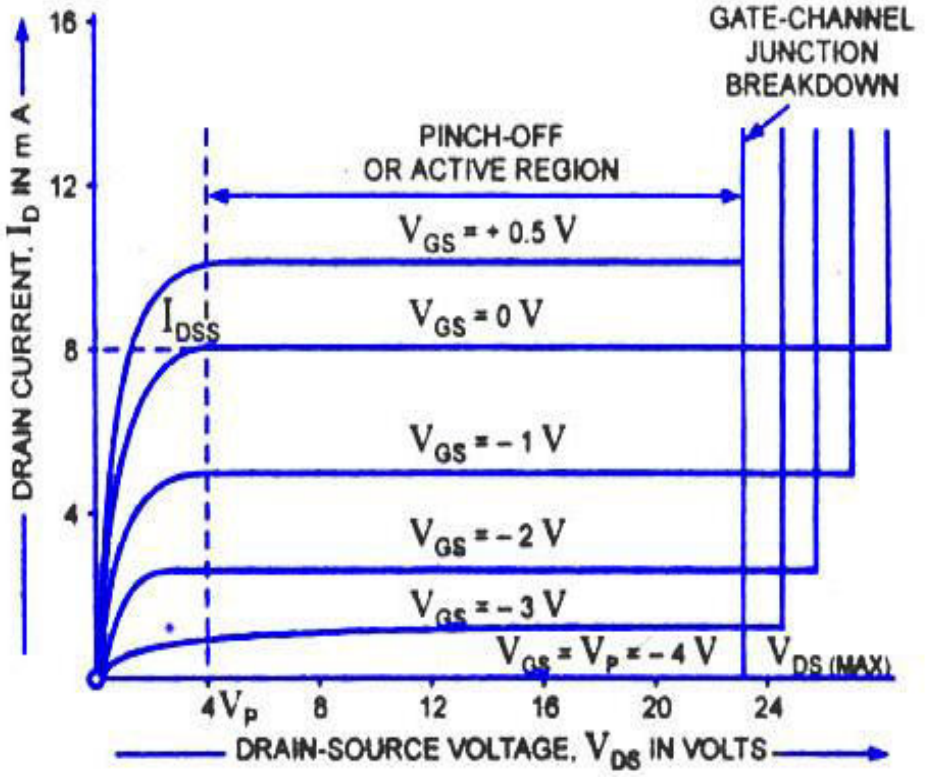
(2) Cut-off Region – This is also known as the pinch-off region were the Gate voltage, V_{GS} is sufficient to cause the JFET to act as an open circuit as the channel resistance is at maximum.

(3) Saturation or Active Region – The JFET becomes a good conductor and is controlled by the Gate-Source voltage, (V_{GS}) while the Drain-Source voltage, (V_{DS}) has little or no effect.

(4) Breakdown Region – The voltage between the Drain and the Source, (V_{DS}) is high enough to causes the JFET's resistive channel to break down and pass uncontrolled maximum current.



Circuit Diagram For Determining Drain Characteristic With External Bias For An N-Channel JFET



JFET Drain-Characteristics With External Bias

MOSFET

MOSFET's operate the same as JFET's but have a gate terminal that is electrically isolated from the conductive channel.

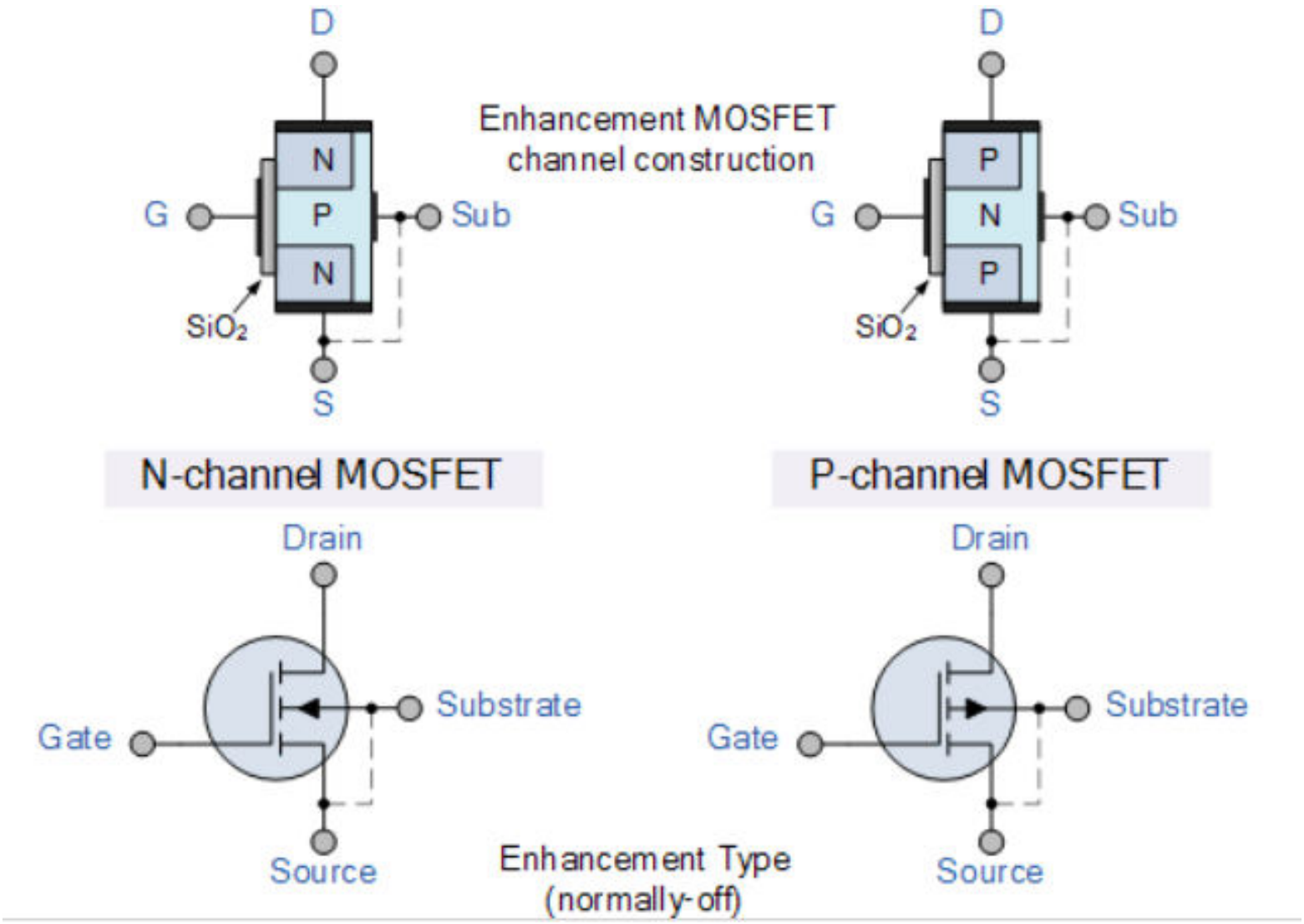
As well as the Junction Field Effect Transistor (JFET), there is another type of Field Effect Transistor available whose Gate input is electrically insulated from the main current carrying channel and is therefore called an **Insulated Gate Field Effect Transistor**. The most common type of insulated gate FET which is used in many different types of electronic circuits is called the **Metal Oxide Semiconductor Field Effect Transistor** or **MOSFET** for short.

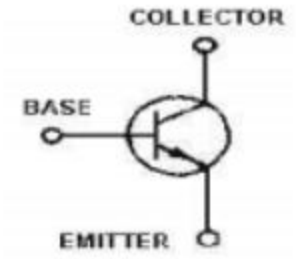
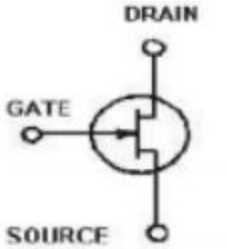
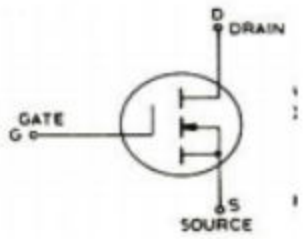
The main difference this time is that MOSFETs are available in two basic forms:

Depletion Type – the transistor requires the Gate-Source voltage, (V_{GS}) to switch the device "OFF". The depletion mode MOSFET is equivalent to a "Normally Closed" switch.

Enhancement Type – the transistor requires a Gate-Source voltage, (V_{GS}) to switch the device "ON". The enhancement mode MOSFET is equivalent to a "Normally Open" switch.

The symbols and basic construction for both configurations of MOSFETs are shown below.



Parameters	Bipolar Junction Transistor (BJT)	Junction Field Effect Transistor (JFET)	Metal Oxide Semiconductor Field Effect Transistor (MOSFET)
Symbol			
Definition	BJT is known as Biploar Junction Device because it uses both electrons and holes for conduction.	JFET is known as unipolar device because current is due to one charge carriers i.e. electrons or holes.	MOSFET is known as unipolar device because current is due to one charge carriers depending on type of MOS.
Input Resistance	BJT offers low input resistance.	JFET offers large input resistance order of $1M\Omega$ to $5M\Omega$.	MOSFET offers very large input resistance.
Biasing used	Fixed bias, Collector base bias, Voltage divider biasing.	Self bias& Voltage divider biasing.	In DMOSFET we use self bias and voltage divider biasing, in EMOSFET we use feedback bias and voltage divider biasing.
Operating Region	Active, Saturation & Cut off region.	Ohmic & Pinch off region	Linear & Saturation region

Operating Region	Active, Saturation & Cut off region.	Ohmic & Pinch off region	Linear & Saturation region
Thermal Runaway	Thermal runaway occurs at high temperature.	No thermal runaway.	No thermal runaway.
Type of device	Current controlled device.	Voltage controlled device.	Voltage controlled device
Terminals	Base, Emitter & Collector.	Gate, Drain & Source.	Gate, Drain, Source .
Input current	Input current is order of mA (milli ampere).	Gate current is order of nA (nano ampere).	Gate current is order of pA (pico ampere).
Applications	Low Current application.	Low voltage application.	Since power consumption is less used in CMOS circuits