EDC UNIT IV- Transistor and FET Characteristics

Lesson-9: JFET and Construction of JFET
1. Transistor
Transistor Definition

The *transferred-resistance or transistor* is a multi-junction device that is capable of:

- Current gain
- Voltage gain
- Signal-power gain
2. Field Effect Transistor (FET)
Unipolar Field Effect Transistor (FET)

- Based on invention in 1948 by Bardeen, Brattain and Shockley
- Contains one type of carriers electrons or holes (unipolar)
The Field Effect Transistor (FET) and BJT

- The conventional bipolar transistor has two types of current carriers of both polarities (majority and minority) and FET has only one type of current carriers, p or n (holes or electrons).

- The BJT is current controlled and FET is voltage controlled current between two other terminals.
Fundamental difference between the voltage and current controlled Field Effect Transistor (FET) and BJT amplifiers, respectively.
Fundamental difference between JFET and BJT devices

- JFET junction is reverse-biased, the gate current is practically zero, and a very high impedance at input whereas the base current of the BJT is always some value greater than zero, for example, in \( \mu \text{As} \)
FET Definition

• Field effect transistor is a unipolar-transistor, which acts as a voltage-controlled current device and is a device in which current at two electrodes is controlled by the action of an electric field at another electrode.

• Field effect transistor is a device in which the current is controlled and transported by carriers of one polarity (majority) only and an electric field near the one terminal controls the current between other two.
Types of FETs

The family of FETs may be divided into:

- Junction FET
- Depletion Mode MOSFET
- Enhancement Mode MOSFET
3. Junction Field Effect Transistor (JFET)
JFET Definition

• JFET is a unipolar-transistor, which acts as a voltage controlled current device and is a device in which current at two electrodes is controlled by the action of an electric field at a p-n junction.

• Field effect transistor is a device in which the current is controlled and transported by carriers of one polarity (majority) only and an electric field at the p-n junction region controls the current between other two.
Basic structure of JFETs

- In addition to the channel, a JFET contains two ohmic contacts: the source and the drain.
- The JFET will conduct current equally well in either direction and the source and drain leads are usually interchangeable.
n-Junction FET and p-JFET Symbols
Junction FET (JFET)

- JFET consists of a piece of high-resistivity semiconductor material (usually Si) which constitutes a channel for the majority carrier flow and a gate.

- Conducting semiconductor channel between two ohmic contacts – source & drain. The magnitude of this current is controlled by a voltage applied to a gate, which is a reverse-biased.

(Ohmic contacts means following Ohm’s law \[I \propto V\] current proportional to \(V\) under constant physical condition.)
N channel JFET structure

- Source (S)
- Drain (D)
- Gate (G)
- Basic structure
- Depletion region
- N-channel

Diagram showing the structure of an N-channel JFET with labeled components.
N-channel JFET construction

- This transistor is made by forming a channel of N-type material in a *P-type substrate*.
- Three wires are then connected to the device.
- One at each end of the channel.
- One connected to the substrate.
- In a sense, the device is a bit like a PN-junction diode, except that there are two wires connected to the N-type side.
nJFET construction and Electric field n-JFET channel
n-Junction FETs and p-JFETs

- JFET is a high-input resistance device, while the BJT is comparatively low.
- If the channel is doped with a donor impurity, n-type material is formed and the channel current will consist of electrons.
- If the channel is doped with an acceptor impurity, p-type material will be formed and the channel current will consist of holes.
JFET Electric Field creation along the channel
JFET Electric Field Variation along the channel

![Diagram showing electric field variation along the channel.](image)

- $E_c$ is the electric field component.
- $X_0$, $X_1$, $X_3$ are points along the channel.
- $L'$ is less than $L$.
- $n = N_0$ is constant.
- $v = v_{sat}$ is constant.
- $d_i > d_0$ condition is noted in the upper right corner.
n- JFET and p-JFET

- N-channel JFET have greater conductivity than p-channel types, since electrons have higher mobility than do holes; thus n-channel JFETs are approximately twice as efficient conductors compared to their p-channel counterparts.
(a) The basic structure of the junction field effect transistor (JFET) with an n-channel. The two $p^+$ regions are electrically connected and form the gate. (b) A simplified sketch of the cross section of a more practical n-channel JFET.
Summary
We learnt

- Definitions of transistor, FET and JFET
- Construction JFET
- n-channel and p-channel JFET
End of Lesson 9