Analog electronics

Seventh lecture

JFET

& MOSFET.

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Third stage

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2022- 2023

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7.1. Biasing circuits of JFET

We know that the input resistance of a JFET is quite high compared to a bipolar transistor. Therefore, it should inculcate in mind that at the time of JFET biasing, its input resistance should in no way get lower. Therefore, for the achievement of this objective, the gate-source diode of a JFET is always revere-biased. Thus, negative V_{GS} is required for biasing an N channel JFET, whereas positive V_{GS} is needed for biasing P channel JFT. Contrarily, if the gate-source of JFET is forward biased instead of reverse bias, its high input resistance will drop suddenly. Thus, this device will lose its advantage due to which it has a preference over a BJT.

A JFET can be biased in the ohmic or active regions. When it is biased in the ohmic region, it is equal to the resistance. However, when it is biased in an active region, it becomes equivalent to a current source.

The methods commonly used for JFET biasing are as follows:

1. Gate Bias

2. Self-Bias

3. Voltage Divider Bias

4. Source Bias

5. Current Source Bias

7.1.1. Gate Bias

In this method of biasing, the negative gate voltage ($-V_{GG}$) is provided to the gate through biasing resistor (R_G), while the source of JFET is earth figure 1. In this method, as the bias voltage is supplied on the JFET gate, therefore, this method of biasing is called gate biasing. Drain current sets up due to providing a negative bias voltage to the gate, the value of which is lower than I_{DS}. When this drain current passes from R_D, drain voltages are generated parallel to it, values of which are as below.

$$V_d = V_{dd} - I_d R_d$$

This method of JFET biasing in an active region is quite unpopular because point Q becomes highly vulnerable/unstable due to gate biasing. However, the method is preferred for biasing in the ohmic region instead of the active region, because, the issue of stability of the Q point does not arise in the ohmic region.

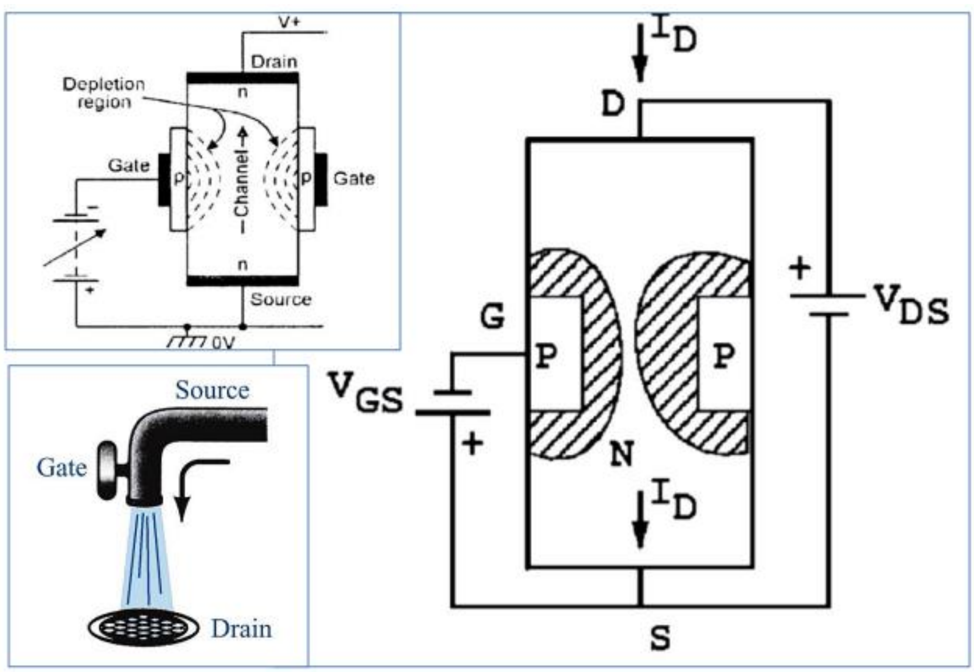

Figure 1: The circuit diagram of an n- channel JFET.

7.2. JFET amplifier

The figure below shows a basic common-source amplifier circuit containing an N-channel JFET. The characteristics of this circuit include high input resistance and a high voltage gain. The function of the circuit components in this figure is very similar to those in a bipolar junction transistor common-emitter amplifier circuit. C_1 and C_3 are the input and output coupling capacitors. R_1 is the gate return resistor. It prevents unwanted charge buildup on the gate by providing a discharge path for C_1. R_2 and C_2 provide source self-bias for the JFET, which operates like emitter self-bias. R_3 is the drain load resistor, which acts like the collector load resistor.

The phase shift of 180 degrees between input and output signals is the same as that of common-emitter transistor circuits. The reason for the phase shift can be seen easily by observing the operation of the N-channel JFET. On the positive alternation of the input signal, the amount of reverse bias on the P-type gate material is reduced, thus increasing the effective cross-sectional area of the channel and decreasing source-to-drain resistance. When resistance decreases, current flow through the JFET increases. This increase causes the voltage drop across R_3 to increase, which in turn causes the drain voltage to decrease. On the negative alternation of the cycle, the amount of reverse bias on the gate of the JFET is increased and the action of the circuit is reversed. The result is an output signal, which is an amplified 180-degree-out-of-phase version of the input signal.

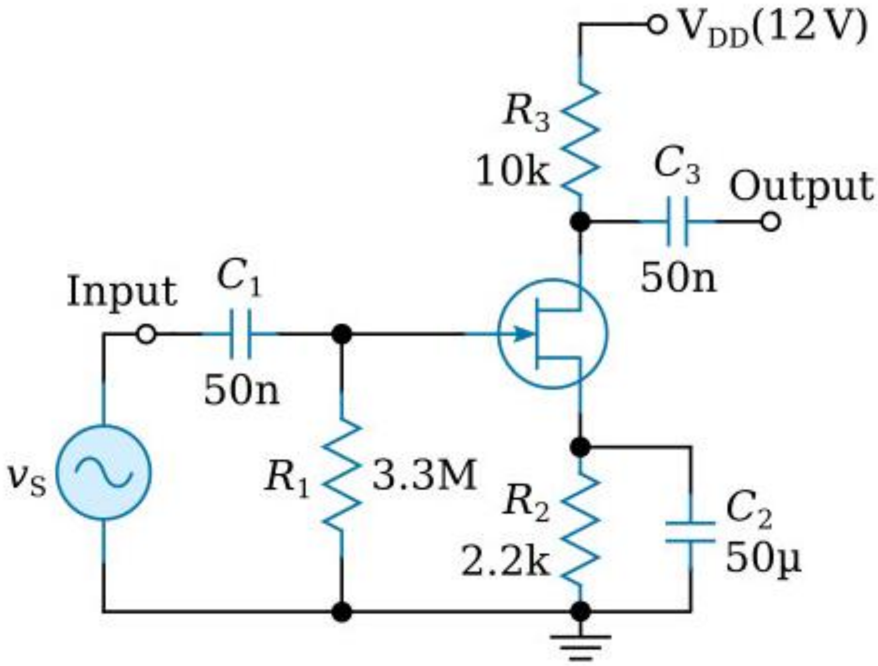

Figure 2: JFET common source amplifier.

7.3. Applications of JFET

1. JFET is used as a switch.

2. Used as an amplifier.

3. Used as a buffer.

4. Used in the oscillatory circuits because of its low frequency drift.

5. Used in digital circuits, such as computers, LCD and memory circuits because of their small size.

7.4. MOSFET

The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) transistor is a semiconductor device that is widely used for switching purposes and for the amplification of electronic signals in electronic devices.

A MOSFET is a four-terminal device having source(S), gate (G), drain (D) and body (B) terminals. In general, the body of the MOSFET is in connection with the source terminal thus forming a three-terminal device such as a field-effect transistor. MOSFET is generally considered as a transistor and employed in both the analog and digital circuits. And the general structure of this device is as below:

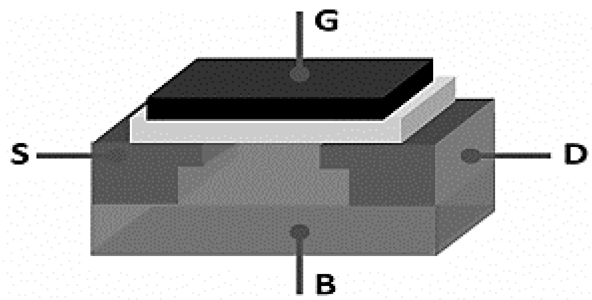

Figure (3) MOSFET Construction

From the above MOSFET structure, the functionality of MOSFET depends on the electrical variations happening in the channel width along with the flow of carriers (either holes or electrons). The charge carriers enter into the channel through the source terminal and exit via the drain.

A MOSFET can function in two ways:

- Depletion Mode.
- Enhancement Mode.

7.4.1. P-Channel MOSFET

The P-Channel MOSFET has a P-Channel region located in between the source and drain terminals. It is a four-terminal device having the terminals as gate, drain, source, and body. The drain and source are heavily doped p+ region and the body or substrate is of n-type. The flow of current is in the direction of positively charged holes.

When we apply the negative voltage with repulsive force at the gate terminal, then the electrons present under the oxide layer are pushed downwards into the substrate. The depletion region populated by the bound positive charges which are associated with the donor atoms. The negative gate voltage also attracts holes from the p+ source and drain region into the channel region.

7.4.2. N- Channel MOSFET

The N-Channel MOSFET has an N- channel region located in between the source and drain terminals. It is a four-terminal device having the terminals as gate, drain, source, body. In this type of Field Effect Transistor, the drain and source are heavily doped n+ region and the substrate or body are of P-type.

The current flow in this type of MOSFET happens because of negatively charged electrons. When we apply the positive voltage with repulsive force at the gate terminal then the holes present under the oxide layer are pushed downward into the substrate. The depletion region is populated by the bound negative charges which are associated with the acceptor atoms.

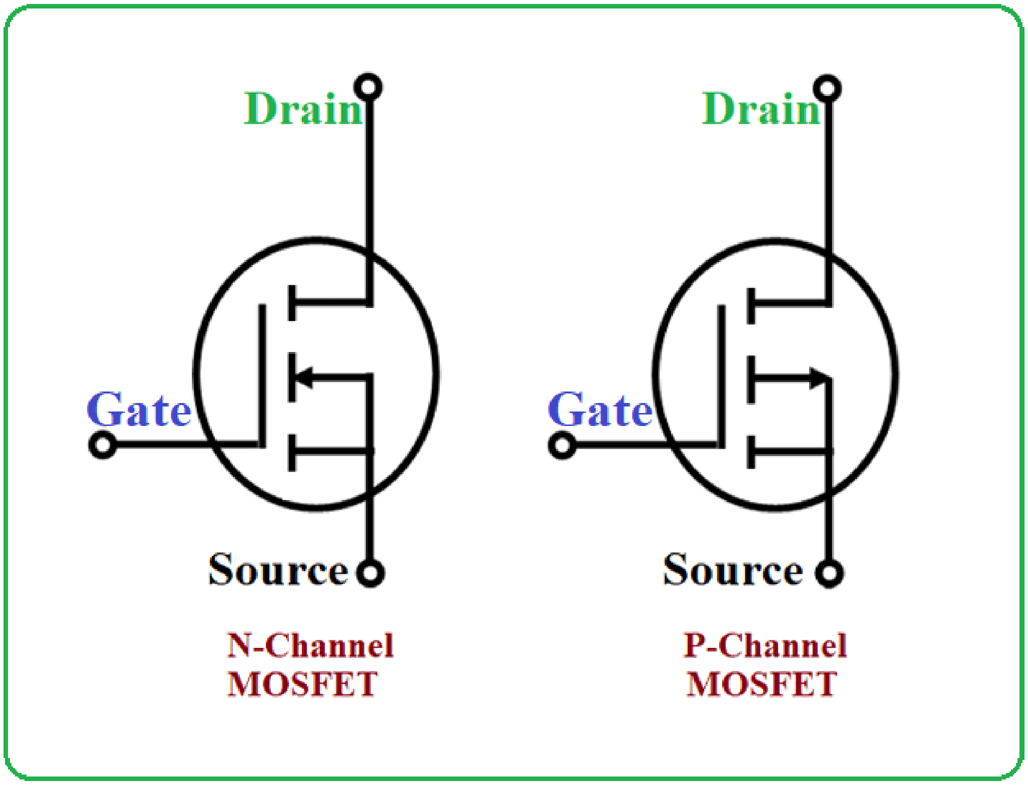

Figure (4) Symbol of n-channel and p-channel MOSFET.

7.5. Advantages of MOSFET

1. It generates enhanced efficiency even when functioning at minimal voltage levels.

2.There is no presence of gate current this creates more input impedance which further provides increased switching speed for the device.

3. These devices can function at minimal power levels and uses minimal current.

7.6. Applications of MOSFET

1. Amplifiers made of MOSFET are extremely employed in extensive frequency applications.

2. The regulation for DC motors are provided by these devices.

3. As because these have enhanced switching speeds, it acts as perfect for the construction of chopper amplifiers.

4. Functions as a passive component for various electronic elements

7.7. References

Electronics principles (fourth edition) by Malvino.