Electronic Circuits

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FETs vs. BJTs

Similarities:

- Amplifiers Switching devices
- Impedance matching circuits

- FETs are voltage controlled devices.
 BJTs are current controlled devices.

- FETs have a higher input impedance.

 BJTs have higher gains.

 FETs are less sensitive to temperature variations and are more easily integrated on ICs.
 FETs are generally more static sensitive than BJTs.

FET Types

•JFET: Junction FET

•MOSFET: Metal-Oxide-Semiconductor FET

***D-MOSFET:** Depletion MOSFET ***E-MOSFET:** Enhancement MOSFET

JFET Construction There are two types of JFETs The n-channel is more widely used. There are three terminals: •Drain (D) and Source (S) are connected to the n-channel $\bullet \textbf{Gate} \, (\mathbf{G}) \text{ is connected to the } p\text{-type material} \\$

JFET Operation: The Basic Idea

JFET operation can be compared to a water spigot.

The source of water pressure is the accumulation of electrons at the negative pole of the drain-source voltage.

The drain of water is the electron deficiency (or holes) at the positive pole of the applied voltage.

The control of flow of water is the gate voltage that controls the width of the n-channel and, therefore, the flow of charges from source to drain.



JFET Operating Characteristics

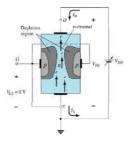
There are three basic operating conditions for a JFET:

- $\begin{array}{ll} \bullet & V_{GS}=0,\,V_{DS}\, increasing \;to \;some \;positive \;value \\ \bullet & V_{GS}<0,\,V_{DS}\, at \;some \;positive \;value \\ \end{array}$
- Voltage-controlled resistor

JFET Operating Characteristics: $V_{GS} = 0 \text{ V}$

Three things happen when V_{GS} = 0 and V_{DS} is increased from 0 to a more positive

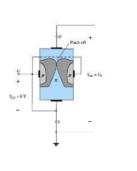
- · The depletion region between p-gate and n-channel increases as electrons from n-channel combine with holes from p-gate.
- Increasing the depletion region, decreases the size of the n-channel which increases the resistance of the
- Even though the n-channel resistance is increasing, the current (I_D) from source to drain through the nchannel is increasing. This is because \boldsymbol{V}_{DS} is increasing.



JFET Operating Characteristics: Pinch Off

If $V_{GS}=0$ and V_{DS} is further increased to a more positive voltage, then the depletion zone gets so large that it pinches off the n-channel.

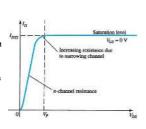
This suggests that the current in the n-channel (I_D) would drop to 0A, but it does just the opposite—as V_{DS} increases, so does I_D



JFET Operating Characteristics: Saturation

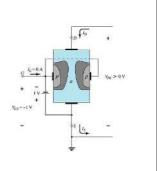
At the pinch-off point:

- Any further increase in V_{GS} does not produce any increase in $I_D,\,V_{GS}$ at pinch-off is denoted as V_p.
- $\boldsymbol{I}_{\mathrm{D}}$ is at saturation or maximum. It is referred to as Inco
- The ohmic value of the channel is



JFET Operating Characteristics

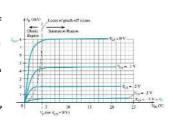
As $V_{\rm GS}$ becomes more negative, the depletion region increases.



JFET Operating Characteristics

As V_{GS} becomes more negative:

- The JFET experiences pinch-off at a lower voltage (V_p) .
- $\label{eq:loss} \begin{array}{ll} \bullet & I_D \ decreases \ (I_D < I_{DSS}) \ even \\ & though \ V_{DS} \ is \ increased. \end{array}$
- $\begin{aligned} & Eventually \ I_D \ reaches \ 0 \ A. \\ & V_{GS} \ at \ this \ point \ is \ called \ V_p \\ & or \ V_{GS(off)}.. \end{aligned}$



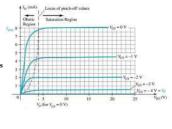
Also note that at high levels of $V_{\rm DS}$ the JFET reaches a breakdown situation. I_D increases uncontrollably if $V_{\rm DS}\!>\!V_{\rm DSmax}$

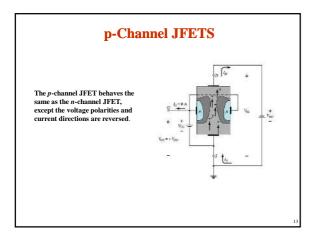
JFET Operating Characteristics: Voltage-Controlled Resistor

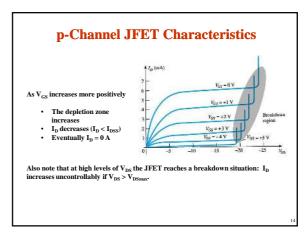
pinch-off point is called the

The JFET can be used as a variable resistor, where \mathbf{V}_{GS} controls the drain-source resistance (r_d). As V_{GS} becomes more negative, the resistance

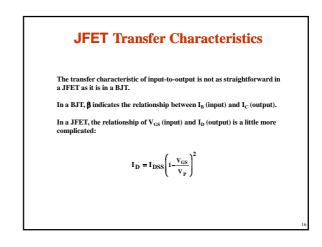


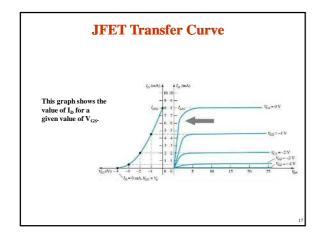


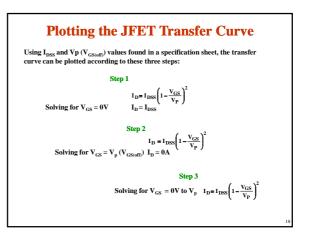




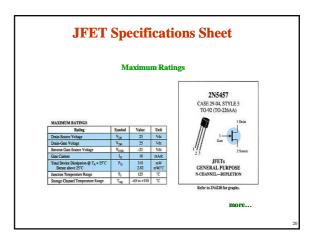
N-Channel JFET Symbol

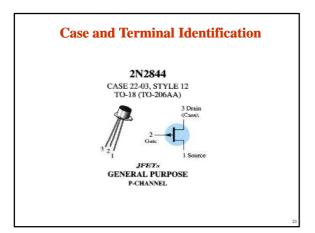


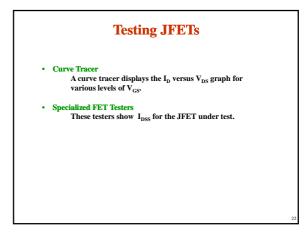


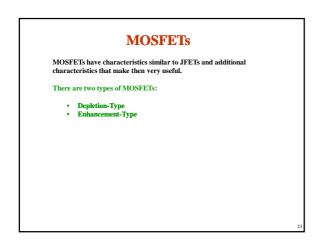


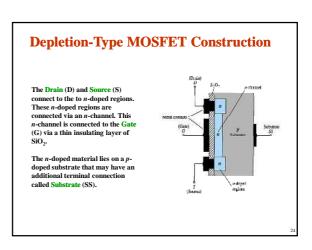


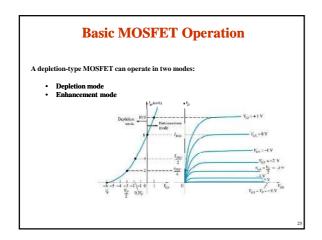


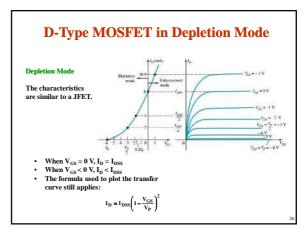


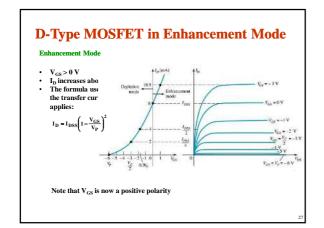


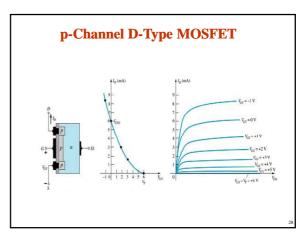


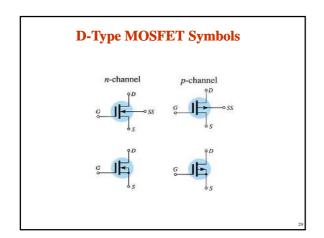


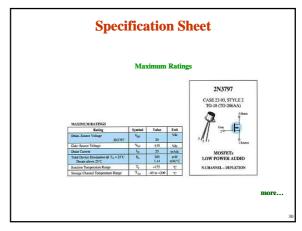


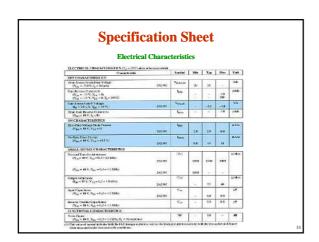


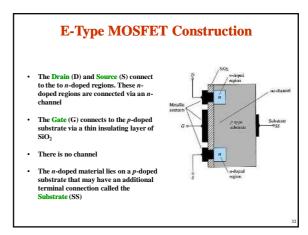


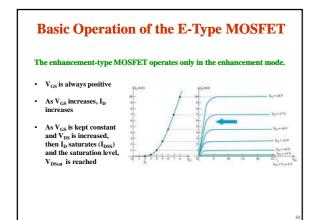


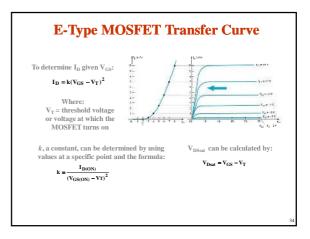


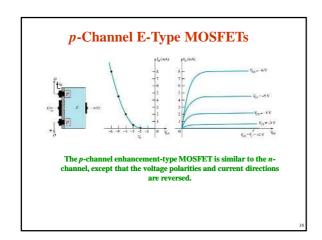


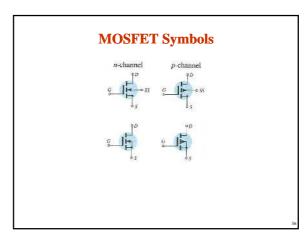


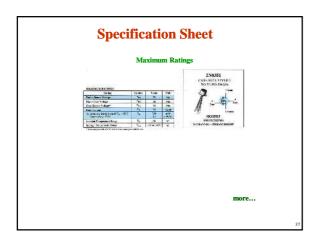


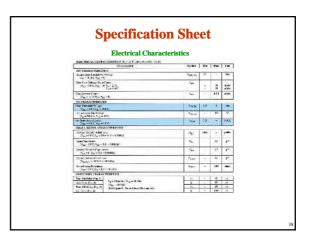












Handling MOSFETs

MOSFETs are very sensitive to static electricity. Because of the very thin SiO₂ layer between the external terminals and the layers of the device, any small electrical discharge can create an unwanted conduction.

Protection

- · Always transport in a static sensitive bag
- Always wear a static strap when handling MOSFETS
- Apply voltage limiting devices between the gate and source, such as back-to-back Zeners to limit any transient voltage.

VMOS Devices VMOS (vertical MOSFET) increases the surface area of the device. Advantages - VMOS devices handle higher currents by providing more surface area to dissipate the heat. - VMOS devices also have faster switching times.

