EEE-2103: Electronic Devices and Circuits

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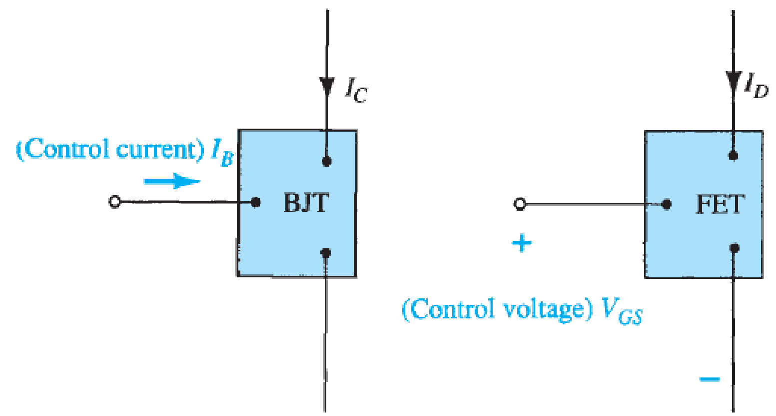
<u>**Field Effect Transistors**</u>

<u>FET vs BJT:</u>
FET and BJT are three-terminal devices.



BJT is current-controlled device.
JFET is voltage-controlled device.

BJT → *npn* and *pnp*.
JFET → *n*-channel and *p*-channel.

BJT → bipolar device = conduction level is function of two charge carriers.
FET → unipolar device = electron (*n*-channel) or hole (*p*-channel) conduction.

Input impedance → FET >> BJT.
Sensitivity to changes in applied signal → BJT >> FET.
AC voltage gain → BJT >> FET.
Temperature stability → FET >> BJT.
Size → BJT >> FET.

Field Effect Transistors

Types of FETs:

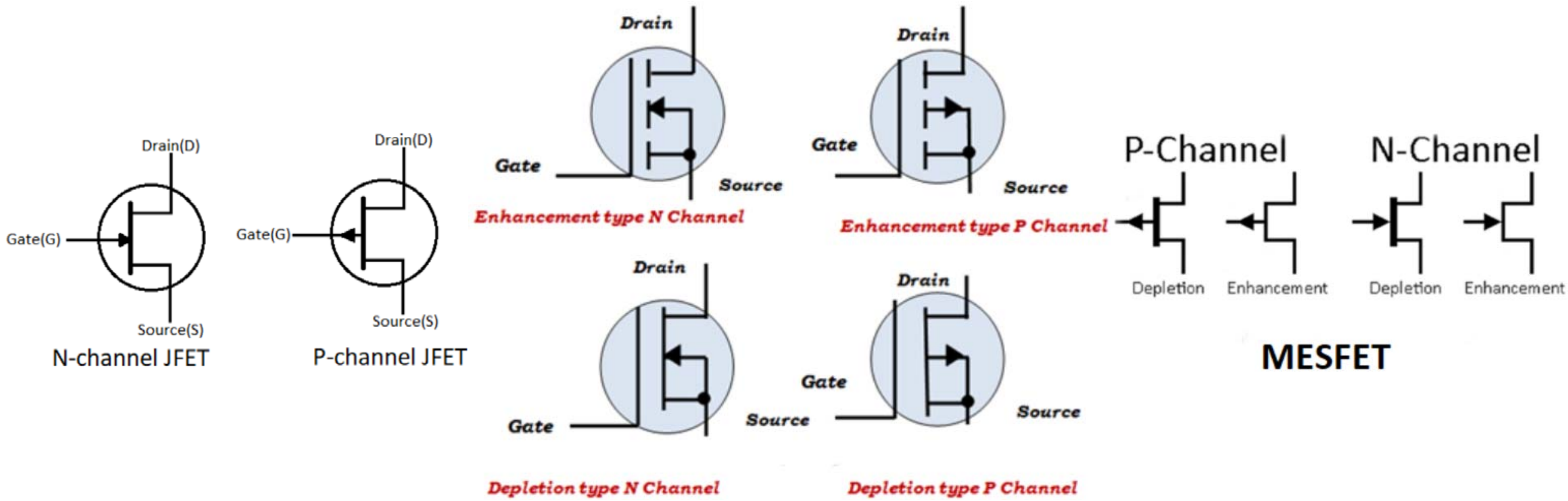
1) Junction field-effect transistor (JFET).

2) Metal-oxide-semiconductor field-effect transistor (MOSFET).

   i) Depletion type MOSFET.

   ii) Enhancement type MOSFET.

3) Metal-semiconductor field-effect transistor (MESFET).



Construction of JFETs

Source →

through which majority carriers enter into channel.

Drain →

through which majority carriers leave from channel.

Gate →

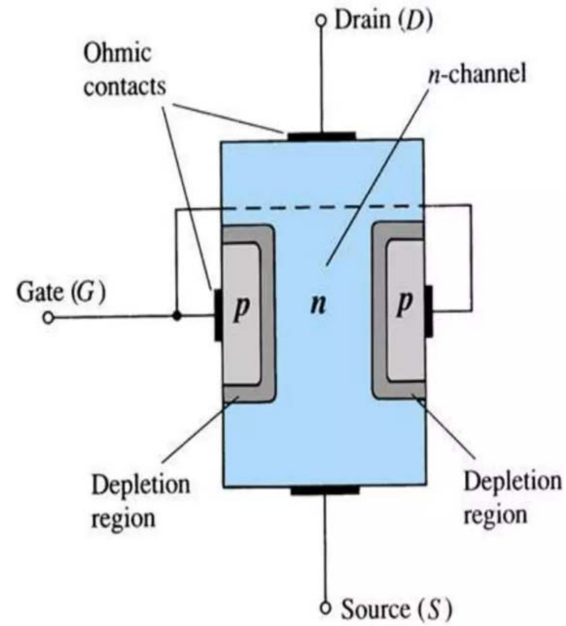
two internally connected heavily doped impurity region.

Channel →

region between source and drain.
sandwiched between two gates.

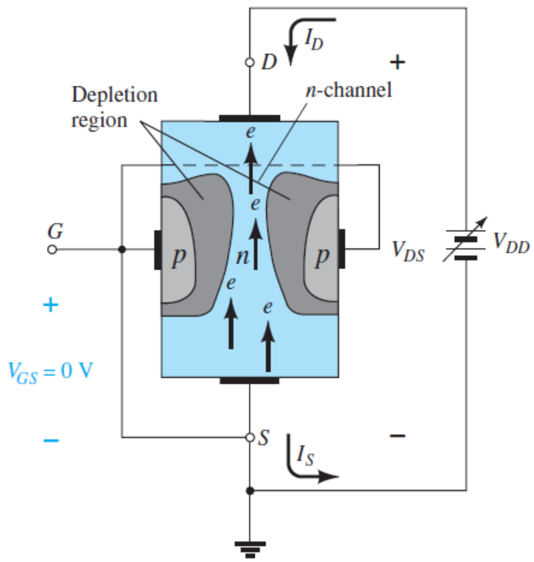
No-bias condition →

two *p*-*n* junctions.
depletion region at each junction.



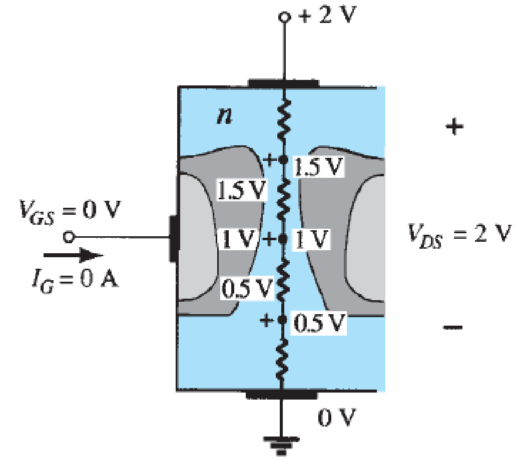
Characteristics of JFETs

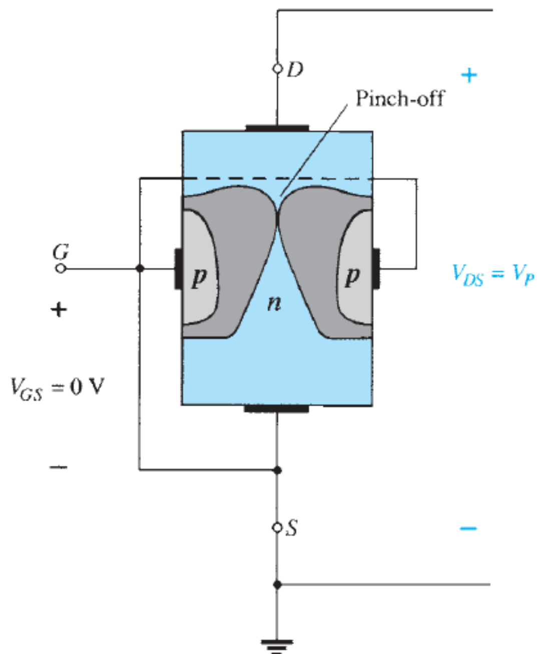
V_{GS} = 0 V, V_{DS} = Some +ve value

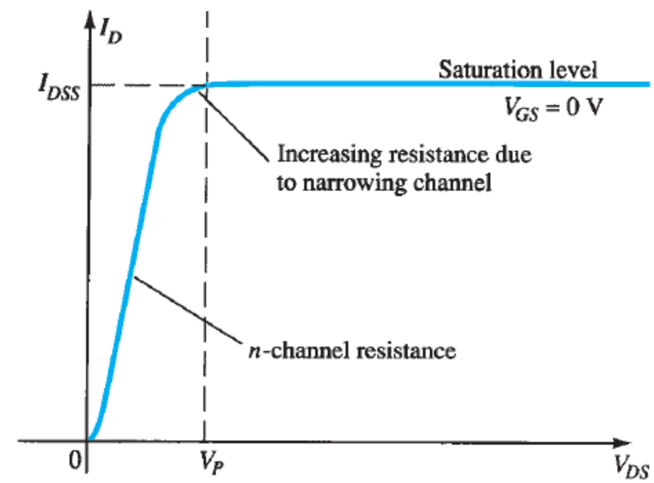


Depletion region is wider near top of both p-type

Reason for change in width →







Characteristics of JFETs

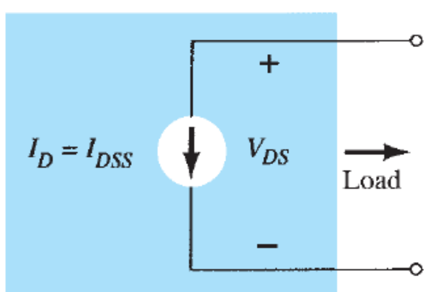
I_D does not drop off at pinch-off →

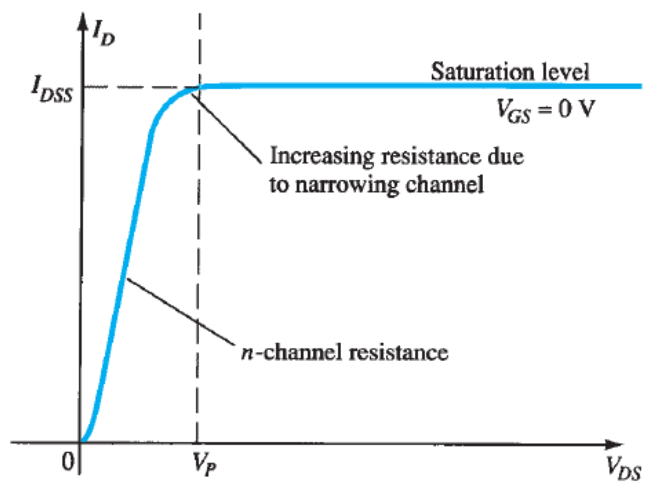
absence of I_D = absence of different potential levels through n-channel.
loss of depletion region distribution.

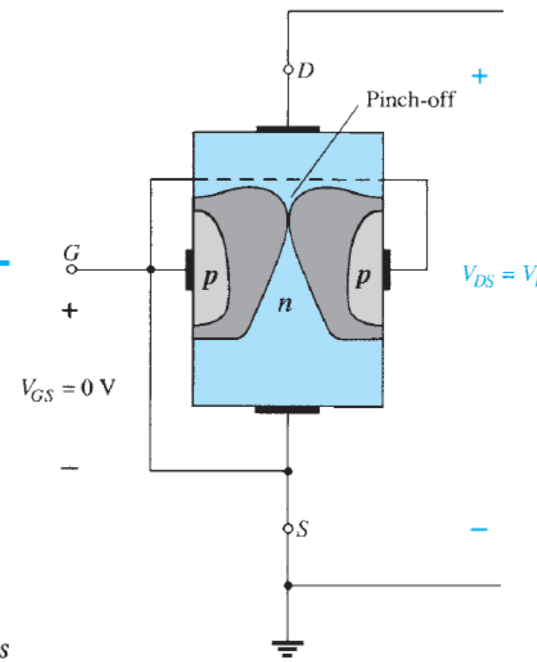
$V_{DS} > V_P$ →

region of close encounter between two depletion regions increases in length.
level of I_D remains same.
JFET = characteristics of current source.
current is fixed at $I_D = I_{DSS}$

I_{DSS} = maximum drain current
Condition = V_{GS} = 0 V and $V_{DS} > |V_P|$.





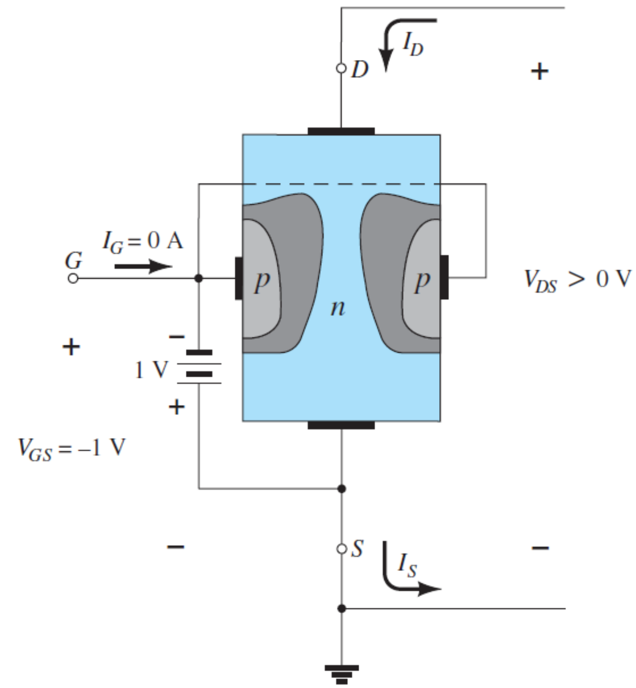


Characteristics of JFETs

$V_{GS} < 0$ V →

V_{GS} is controlling voltage of JFET.

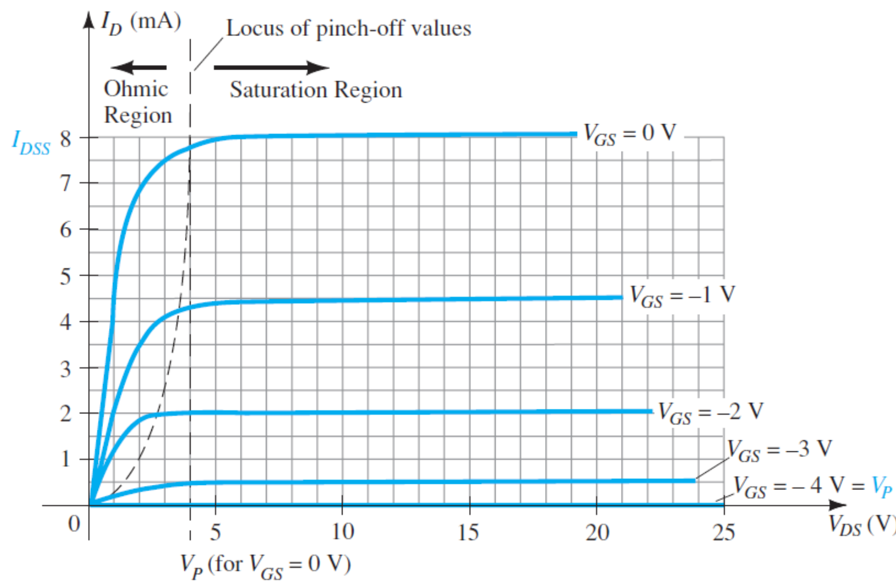
For *n*-channel, V_{GS} is made more and more -ve.



Effect of applied negative-bias →

Establish depletion regions = obtained with $V_{GS} = 0$ V at lower levels of V_{DS}.

Reach saturation level at lower level of V_{DS}.



Characteristics of JFETs

Ohmic or voltage-controlled resistance region →

JFET is employed as variable resistor.

resistance is controlled by applied V_{GS}.

V_{GS} becomes more and more negative = resistance level increases.

$r_d = \frac{r_o}{(1-V_{GS}/V_P)^2}$

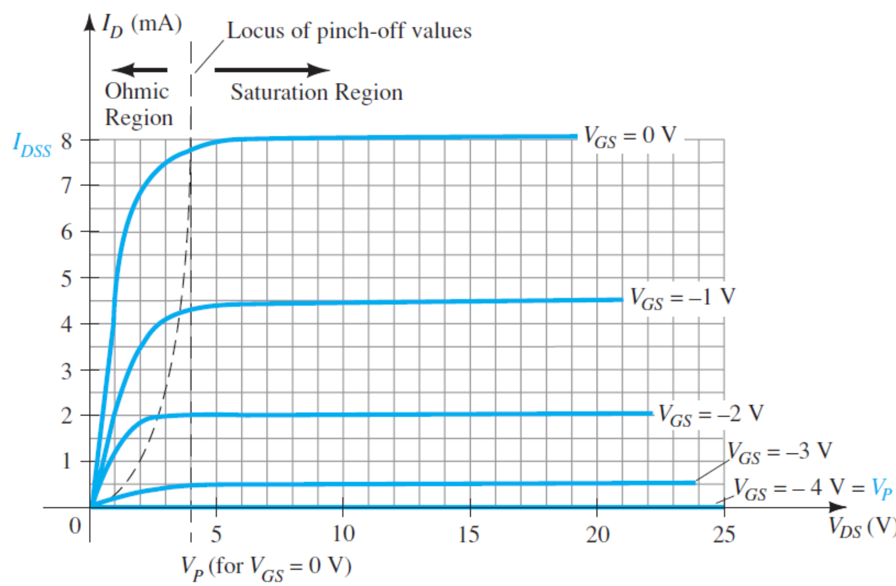
r_o = resistance with V_{GS} = 0 V

r_d = resistance at particular level of V_{GS}.

For n-channel JFET →

r_o = 10 kΩ (V_{GS} = 0 V, V_P = -6 V)

r_d = 40 kΩ at V_{GS} = -3 V.



Characteristics of JFETs

Transfer characteristics = plot of I_D versus V_{GS}.
Shockley's equation →

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

I_{DSS}, V_P = constants.
V_{GS} = control variable.

nonlinear relationship between I_D and V_{GS},
curve grows exponentially with decreasing $|V_{GS}|$.