JFET Characteristics

Muhammad Adeel

M.Sc. Electronics (KU)

M.Phil. ISPA (KU)

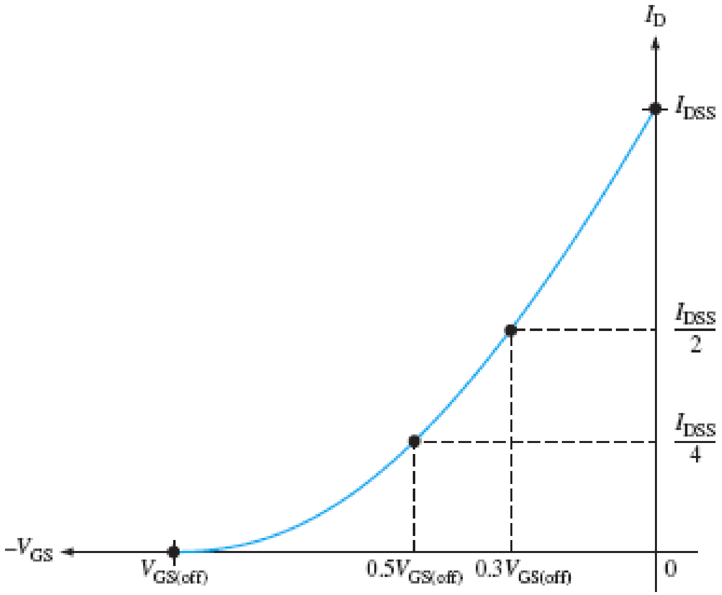
JFET Universal Transfer Characteristic

You have learned that a range of V_{GS} values from zero to $V_{GS(off)}$ controls the amount of drain current.

For an n-channel JFET, $V_{GS(off)}$ is negative, and for a p-channel JFET, $V_{GS(off)}$ is positive.

Because V_{GS} does control I_D, the relationship between these two quantities is very important.

The general transfer characteristic curve that illustrates graphically the relationship between V_{GS} and I_D is shown.
This curve is also known as a transconductance curve.



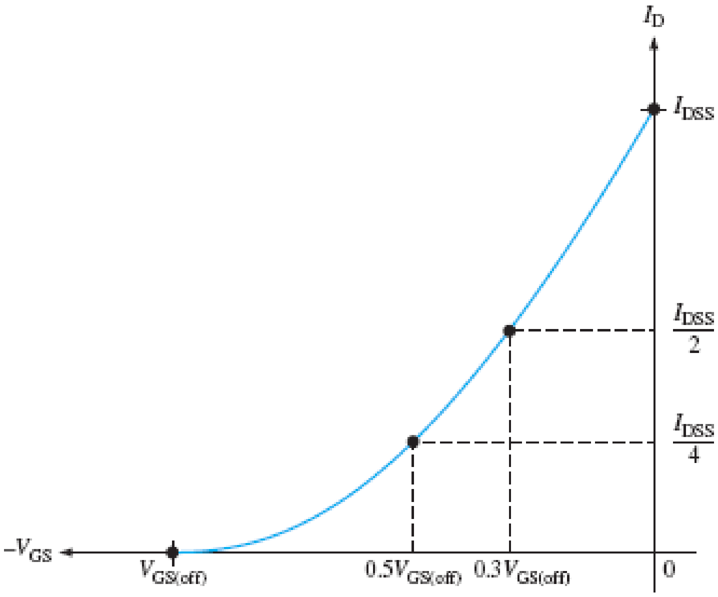
Notice that the bottom end of the curve is at a point on the V_{GS} axis equal to $_{VGS(off)}$, and
the top end of the curve is at a point on the I_D axis equal to I_{DSS}. This curve shows that

$$I_D = 0 \qquad \text{when } V_{GS} = V_{GS(off)}$$

$$I_D = \frac{I_{DSS}}{4} \qquad \text{when } V_{GS} = 0.5V_{GS(off)}$$

$$I_D = \frac{I_{DSS}}{2} \qquad \text{when } V_{GS} = 0.3V_{GS(off)}$$

$$I_D = I_{DSS} \qquad \text{when } V_{GS} = 0$$

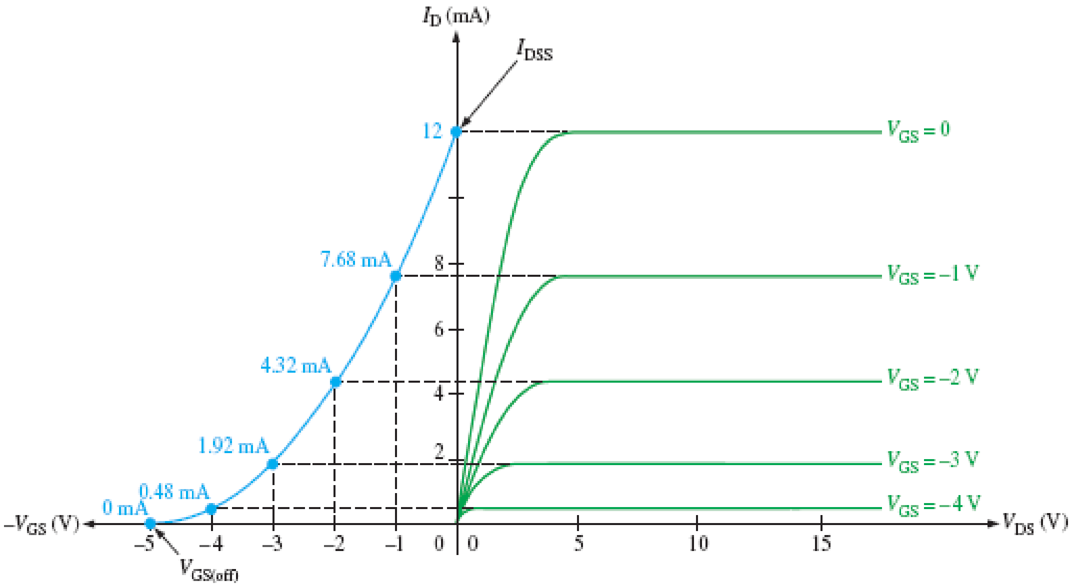


The transfer characteristic curve can also be developed from the drain characteristic curves by plotting values of I_D for the values of V_{GS} taken from the family of drain curves at pinch-off, as illustrated in Figure for a specific set of curves.

Each point on the transfer characteristic curve corresponds to specific values of V_{GS} and I_D on the drain curves.

For example, when V_{GS} = -2 V, I_D = 4.32 mA.

Also, for this specific JFET, $V_{GS(off)}$ = -5V and I_{DSS} = 12 mA. V_{GS} =



A JFET transfer characteristic curve is expressed approximately as

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

Example

The partial datasheet in Figure 8–14 for a 2N5459 JFET indicates that typically $I_{DSS} = 9$ mA and $V_{GS(off)} = -8$ V (maximum). Using these values, determine the drain current for $V_{GS} = 0$ V, -1 V, and -4 V.

Solution For $V_{GS} = 0$ V,

$$I_D = I_{DSS} = \mathbf{9\ mA}$$

For $V_{GS} = -1$ V, use Equation 8–1.

$$I_D \cong I_{DSS}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)^2 = (9\text{ mA})\left(1 - \frac{-1\text{ V}}{-8\text{ V}}\right)^2$$

$$= (9\text{ mA})(1 - 0.125)^2 = (9\text{ mA})(0.766) = \mathbf{6.89\ mA}$$

For $V_{GS} = -4$ V,

$$I_D \cong (9\text{ mA})\left(1 - \frac{-4\text{ V}}{-8\text{ V}}\right)^2 = (9\text{ mA})(1 - 0.5)^2 = (9\text{ mA})(0.25) = \mathbf{2.25\ mA}$$

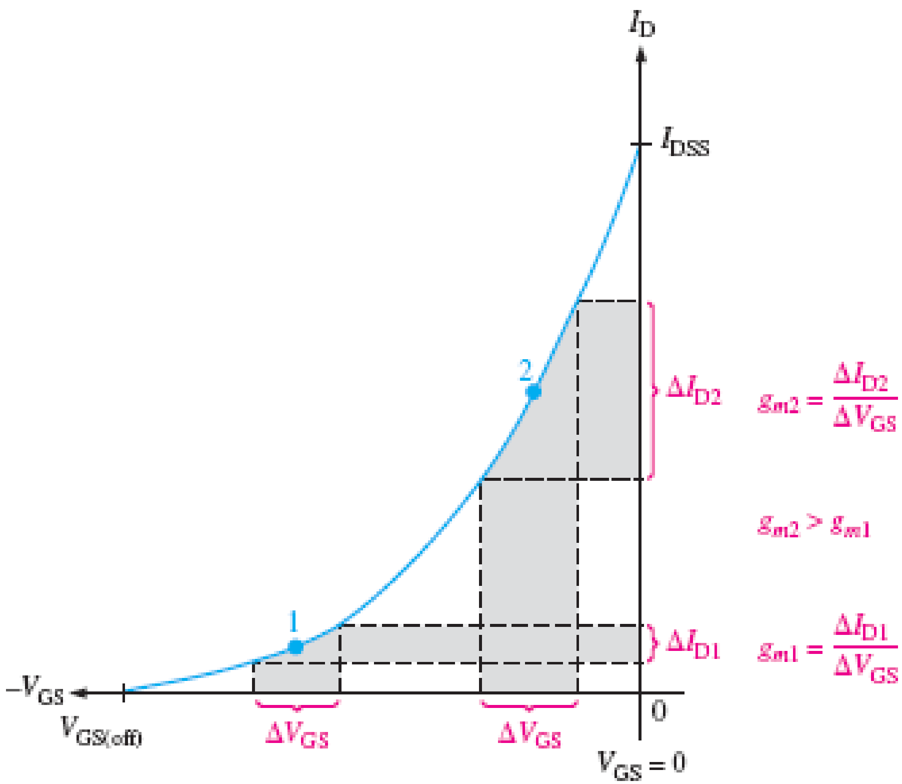
JFET Forward Transconductance

The forward transconductance (transfer conductance), g_m, is the change in drain current ΔI_D for a given change in gate-to-source voltage ΔV_{GS} with the drain-to-source voltage constant.
It is expressed as a ratio and has the unit of siemens (S).

$$g_m = \frac{\Delta I_D}{\Delta V_{GS}}$$

Because the transfer characteristic curve for a JFET is nonlinear, g_m varies in value depending on the location on the curve as set by V_{GS}.

The value for gm is greater near the top of the curve (near V_{GS} 0) than it is near the bottom (near $V_{GS(off)}$), as illustrated in Figure.



Given g_{m0}, you can calculate an approximate value for gm at any point on the transfer characteristic curve using the following formula:

$$g_m = g_{m0}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)$$

When a value of g_{m0} is not available, you can calculate it using values of I_{DSS} and $V_{GS(off)}$. The vertical lines indicate an absolute value (no sign).

$$g_{m0} = \frac{2I_{DSS}}{|V_{GS(off)}|}$$

Input Resistance

As you know, a JFET operates with its gate-source junction reverse-biased, which makes the input resistance at the gate very high.

This high input resistance is one advantage of the JFET over the BJT. (Recall that a bipolar junction transistor operates with a forward-biased base-emitter junction)

JFET datasheets often specify the input resistance by giving a value for the gate reverse current, I_{GSS}, at a certain gate-to-source voltage. The input resistance can then be determined using the following equation, where the vertical lines indicate an absolute value (no sign):

$$R_{IN} = \left| \frac{V_{GS}}{I_{GSS}} \right|$$