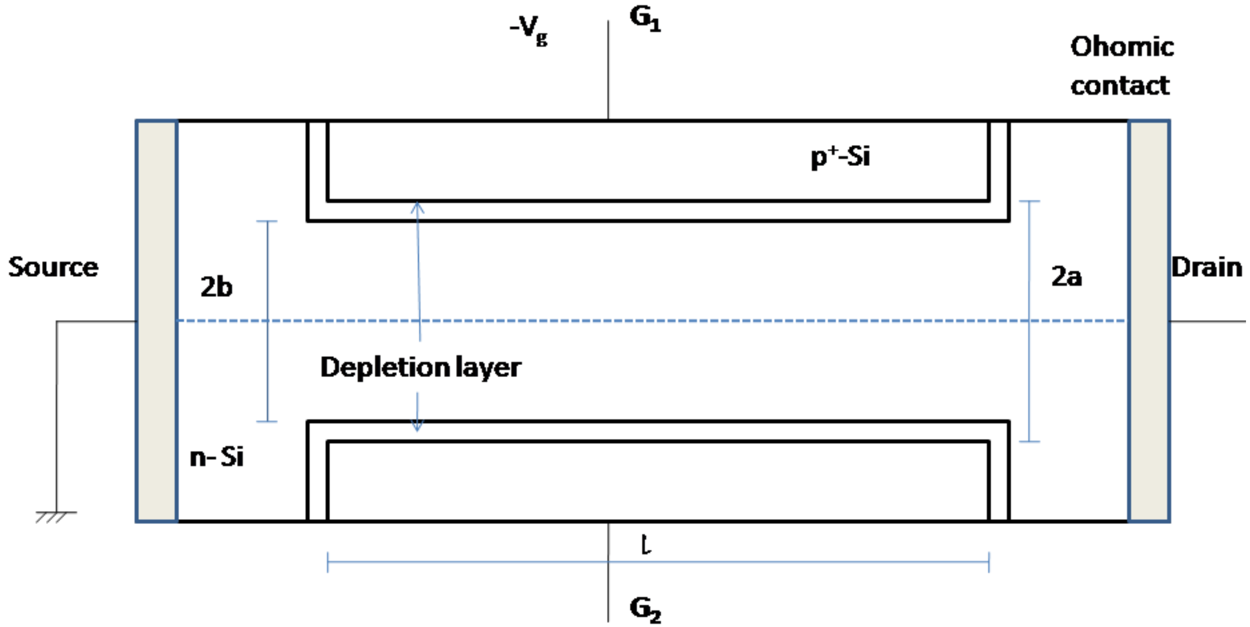
Field effect Transistor



Configuration of JFET

JFET configuration consisting of a single crystal n type semiconductor bar with Ohomic contacts at both ends and two p^+ contacts are applied at opposite sides. The two p^+ regions G_1 ,G2 are called gates and shorted at the left hand contacts. A small positive drain voltage V_d is applied at the right hand electrode (Drain) to the left hand electrode (source),As a result a current flows.

Let us first consider the special case when the drain voltage is extremely small.

In this case we may ignore any potential variation over the length of channel so the reverse potential between gate and channel constants at all points, As such channel cross section regarded to remain constant through out. Since the channel is lightly doped

Most the depletion layer widening take place over it. In that case width d_n of depletion ;layer is given by

$$d_n = (a-b) = \left[\frac{2\varepsilon_s(\Psi_0 + V_g)}{qN_d}\right]^{\frac{1}{2}} \qquad 1$$

A pinch off is said to occur when the gate voltage V_g is in sufficient magnitude to reduce the channel thickness b to 0. writing $V_p=V_g$ in above equation

$$V_p = \left[\frac{qN_d a^2}{qN_d} - \Psi_0\right] \qquad 2$$

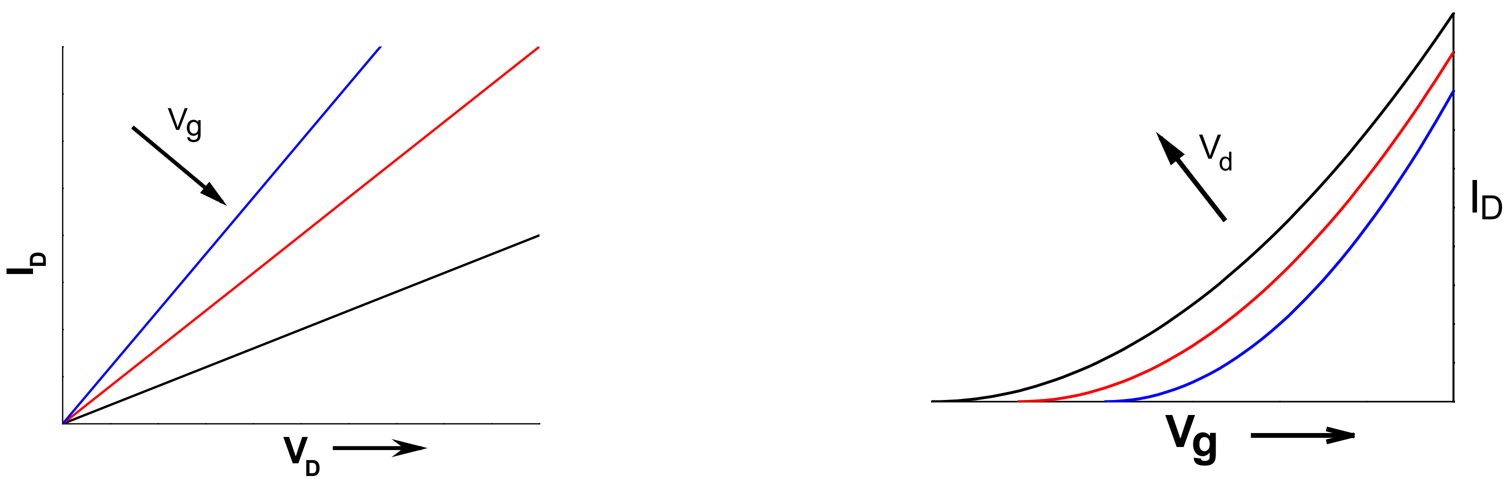
On substituting $qN_d/2\epsilon_s$ from equation 2 to 1

$$b = a\left[1-\left(\frac{\Psi_0+V_g}{\Psi_0+V_p}\right)^{\frac{1}{2}}\right] \qquad 3$$

The channel conductance under a gate bias V_g may then be expressed as

$$G=\sigma_n \frac{2bW}{l}=\frac{2q\mu_n N_d W_a}{l}\left[1-\left(\frac{\Psi_0+V_g}{\Psi_0+V_p}\right)^{\frac{1}{2}}\right] \qquad 4$$

Where W denote the width of the FET perpendicular to the plane of the paper



(a) (b)

Static characteristics of a JFET for smaller drain voltage

(a) Drain characteristic (b) Transfer characteristics

When the applied drain voltage is large

so that potential drop over the channel length is not negligibly small the reverse bias across the gate and a point in the channel as one moves from the drain to source decreases . Consequently the depletion layer assumes the shape of a characteristic wedge which tends to converge toward drain of FET. To analysis its general mode of operation we will concentrate upon lean infinitesimal length Δx of the channel at that particular point becomes [V_g+V(x)]. We may also treat the channel to be uniform cross section because it has an infinitesimal length Δx .Regarding the voltage drop to be ΔV along the length of Δx of the channel.

$$I_d = \frac{2q\mu_n N_d W a}{\Delta x}\left[1-\left(\frac{V_x - V_g}{V_p}\right)^{\frac{1}{2}}\right]\Delta V_x \qquad 5$$

Rearranging and integrating

$$\frac{I_d}{2q\mu_n N_d W a}\int_0^l dx = \int_0^{V_d}\left[1-\left(\frac{V_x - V_g}{V_p}\right)^{\frac{1}{2}}\right]\Delta V_x$$

Integrating

$$I_d = G_0\left[V_d - \frac{2}{3}V_p\left(\frac{V_d + V_g}{V_p}\right)^{3/2} + \frac{2}{3}V_p\left(\frac{V_g}{V_p}\right)^{3/2}\right] \qquad 6$$

This is valid before Pinch off

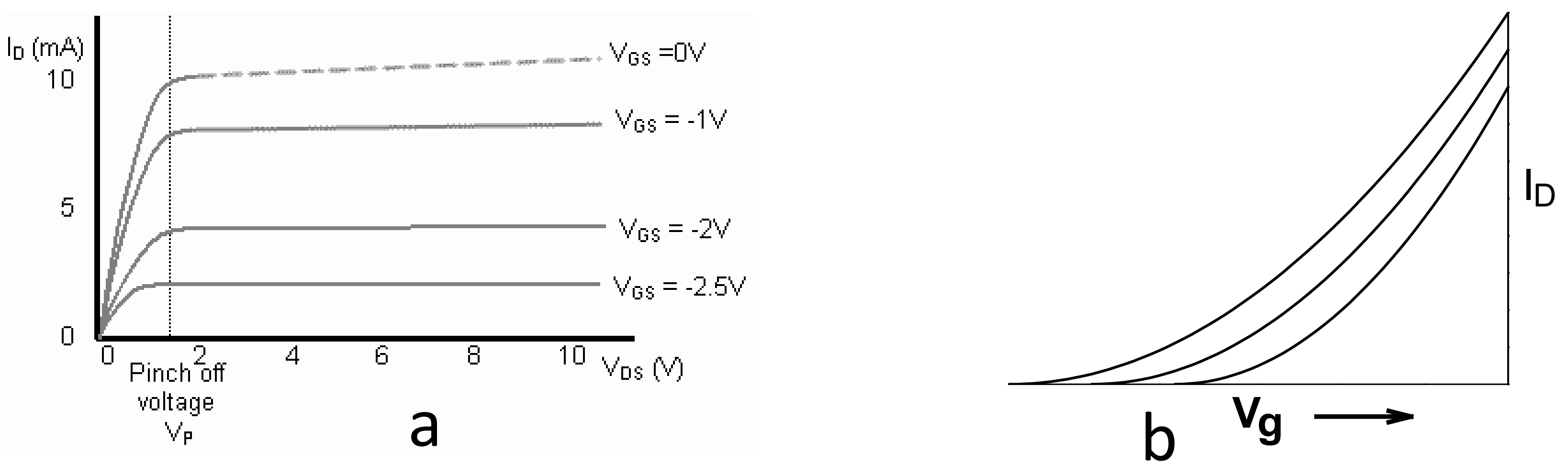
Pinch off voltage in this case may be obtained from equation (6) by imposing $dI_d / dV_d = 0$

We then obtain $V_p = V_d + V_g$ 7

Saturation drain current may be obtained from equation (6) by imposing equation (7) on it.

We can get

$$I_d = G_0 \{(V_p / 3) - V_g [1 - (2/3)(V_g / V_p)^{1/2}]\} \quad 8$$



Static characteristics of a JFET for larger drain voltage

(a) Drain characteristic (b) Transfer characteristics