

Lecture #16: The Junction Field Effect Transistor (JFET)

ECEN5355
Lecture # 16
9/30/98

Device Structure
Principle of Operation
Current derivation
Saturation current
transconductance

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JFET Current derivation

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$$\phi_i - V_T = V_P \quad V_T = \phi_i - \frac{qN_d d^2}{2\epsilon_s} \quad V_P = \frac{qN_d d^2}{2\epsilon_s}$$

$$J = qnv = qN_d \mu_n \mathcal{E} = -qN_d \mu_n \frac{dV_C(y)}{dy}$$

$$I_D = -JW(d - x_n(y))$$

$$x_n(y) = \sqrt{\frac{2\epsilon_s(\phi_i - V_G + V_C(y))}{qN_d}}$$

$$\int_0^L I_D dy = qN_d \mu_n dW \int_0^{V_D} \left(1 - \sqrt{\frac{\phi_i - V_G + V_C}{V_P}}\right) dV_C$$

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JFET Current derivation

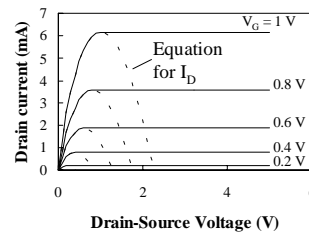
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$$\int_0^L I_D dy = qN_d \mu_n dW \int_0^{V_D} \left(1 - \sqrt{\frac{\phi_i - V_G + V_C}{V_P}}\right) dV_C$$

$$I_D = qN_d \mu_n d \frac{W}{L} (V_C \Big|_0^{V_D} - \frac{(\phi_i - V_G + V_C)^{3/2}}{\sqrt{V_P}} \Big|_0^{V_D})$$

$$I_D = q\mu_n N_d d \frac{W}{L} \left[V_D - \frac{2}{3} \left(\frac{(\phi_i - V_G + V_D)^{3/2}}{\sqrt{V_P}} - \frac{(\phi_i - V_G)^{3/2}}{\sqrt{V_P}} \right) \right]$$

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$$I_D = q\mu_n N_d d \frac{W}{L} \left[V_D - \frac{2}{3} \left(\frac{(\phi_i - V_G + V_D)^{3/2}}{\sqrt{V_P}} - \frac{(\phi_i - V_G)^{3/2}}{\sqrt{V_P}} \right) \right]$$

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JFET Saturation current

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$$I_D = q\mu_n N_d d \frac{W}{L} \left[V_D - \frac{2}{3} \left(\frac{(\phi_i - V_G + V_D)^{3/2}}{\sqrt{V_P}} - \frac{(\phi_i - V_G)^{3/2}}{\sqrt{V_P}} \right) \right]$$

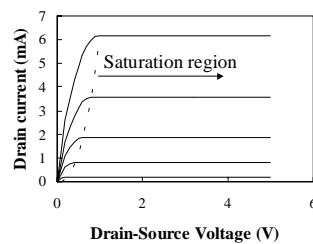
$$V_G = V_G = V_G$$

$$I_{D,sat} = q\mu_n N_d d \frac{W}{L} \left[V_G - V_T - \frac{2}{3} \left[V_P - \frac{(\phi_i - V_G)^{3/2}}{\sqrt{V_P}} \right] \right]$$

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JFET I-V Characteristics

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$$I_{D,sat} = q\mu_n N_d d \frac{W}{L} \left[V_G - V_T - \frac{2}{3} \left[V_P - \frac{(\phi_i - V_G)^{3/2}}{\sqrt{V_P}} \right] \right]$$

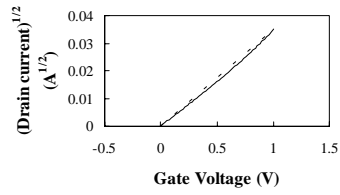
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JFET Transfer Curve

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$V_D \geq V_{D,sat}$

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$$I_{D,sat} = q\mu_n N_d d \frac{W}{L} \left[V_G - V_T - \frac{2}{3} \left(V_P - \frac{(\phi_s - V_G)^{3/2}}{\sqrt{V_P}} \right) \right]$$

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