## **Discrete Semiconductor Devices**



Junction Field N Channel: Apply a negative voltage to the gate to deplete the channel of carriers – Drain to Source Effect Transistor Voltage must be positive – when  $v_{GS} = V_P$  then the channel is pinched off – no current flows (JFET) <u>P Channel</u>: Apply a positive voltage to the gate to deplete the channel of carriers – Drain to Source N Channel: Voltage must be negative – when  $v_{GS} = V_P$  then the channel is pinched off – no current flows Equations for N channel (for P channel:  $V_P \ge 0$ ,  $v_{DS} \le 0$ ,  $\lambda = \frac{1}{V_{DS}} \le 0$ ) G P Channel: Cutoff Region:  $i_{D} = 0$  $v_{GS} \leq V_P$ , Triode Region:  $V_P \le v_{GS} \le 0 \quad \& \quad v_{DS} \le v_{GS} - V_P$  $i_D = I_{DSS} \left[ 2 \left( 1 - \frac{v_{GS}}{V_P} \right) \left( \frac{v_{DS}}{-V_P} \right) - \left( \frac{v_{DS}}{V_P} \right)^2 \right]$ Saturation Region  $V_P \le v_{GS} \le 0 \quad \& \quad v_{DS} \ge v_{GS} - V_P$  $i_D = I_{DSS} \left( 1 - \frac{v_{GS}}{V} \right)^2 \left( 1 + \lambda v_{DS} \right)$  $v_{GS} = \text{Gate to Source Voltage}(V)$  $v_{DS}$  = Drain to Source Voltage (V)  $V_{P}$  = Pinchoff Voltage (V) Where:  $i_{D} = Drain Current (A)$  $I_{DSS}$  = Drain to source current with gate & source shorted together (A) $\lambda = \frac{1}{V_{\star}}, \quad V_A = \text{Early Voltage}(V)$ Small Signal  $g_m = \left(\frac{2I_{DSS}}{|V_p|}\right) \left(1 - \frac{V_{GS}}{|V_p|}\right) \quad \text{or} \quad g_m = \left(\frac{2I_{DSS}}{|V_p|}\right) \sqrt{\frac{I_D}{I_{DSS}}}$  $r_o = \frac{|V_A|}{I_D}$ ÐD  $g_m$  = Transconductance of JFET (A.V<sup>-1</sup>)  $r_o =$ Output resistance ( $\Omega$ )  $V_{GS} = DC$  bias gate to source voltage (V)  $I_{D} = DC$  bias drain current (A) Ф

Metal Oxide Semiconductor Field Effect Transistor (MOSFET)



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## **Diodes**





