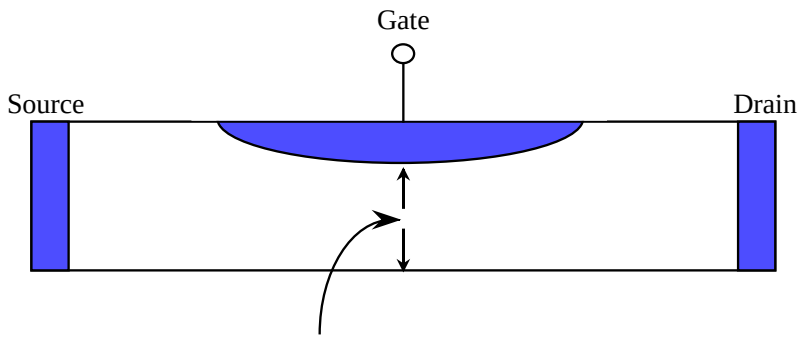
Chapter 9

JFET AND MESFET

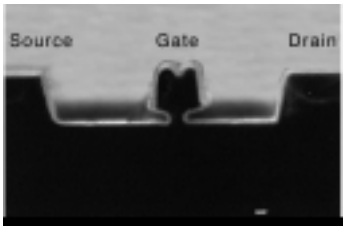
FIELD EFFECT TRANSISTORS: JFET AND MESFET

Gate-semiconductor is a reverse biased *p-n* junction or a Schottky junction.

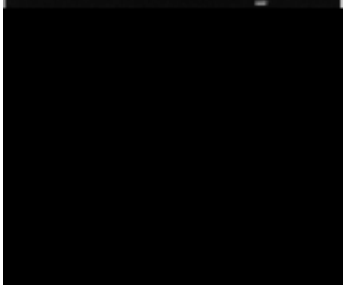


The physical principle behind the FET involves the use of a gate to alter the charge in a channel. The gate potential changes thus result in corresponding changes in the current flow.

Cutoff cross-section of a 0.1 μm MESFET



Top view of the MESFET



MESFETs and JFETs are important devices for high-speed, low-noise amplifiers, D/A and A/D converters, and much “front-end” processing where high speed is critical. These devices exploit materials, like GaAs, InP, and InGaAs, that have transport properties that are superior to Si.

JFET is more useful if it is difficult to get a high Schottky barrier—usually the case in narrow bandgap semiconductors.

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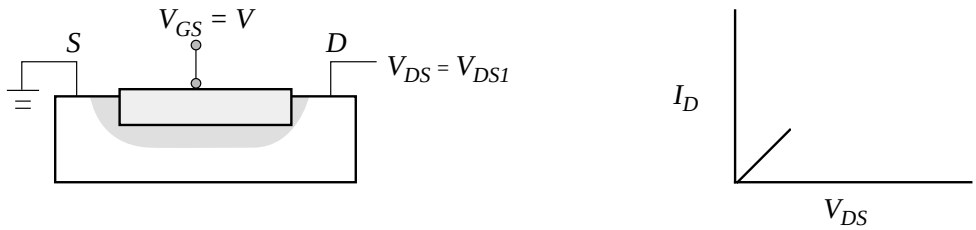
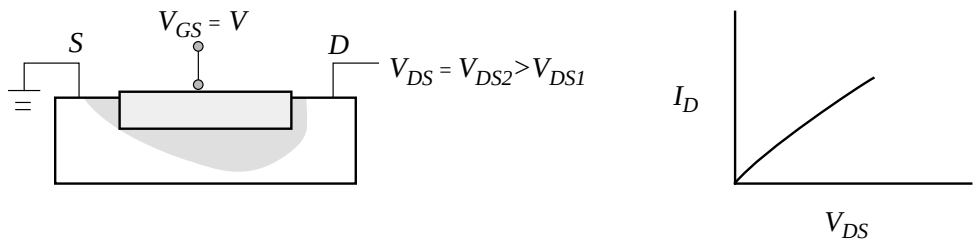
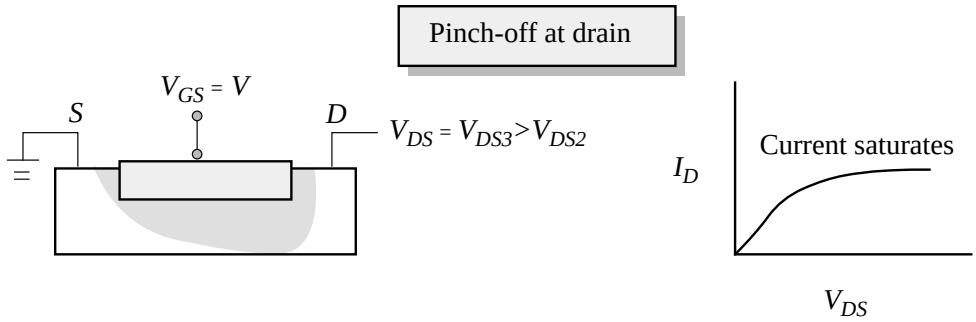
CURRENT-VOLTAGE RELATION IN A FET: A CONCEPTUAL PICTURE



CURRENT INCREASES AS DRAIN BIAS IS INCREASED



CHANNEL STARTS TO BECOME TOTALLY DEPLETED AT THE DRAIN SIDE



CHANNEL IS PINCHED-OFF AND CURRENT SATURATES

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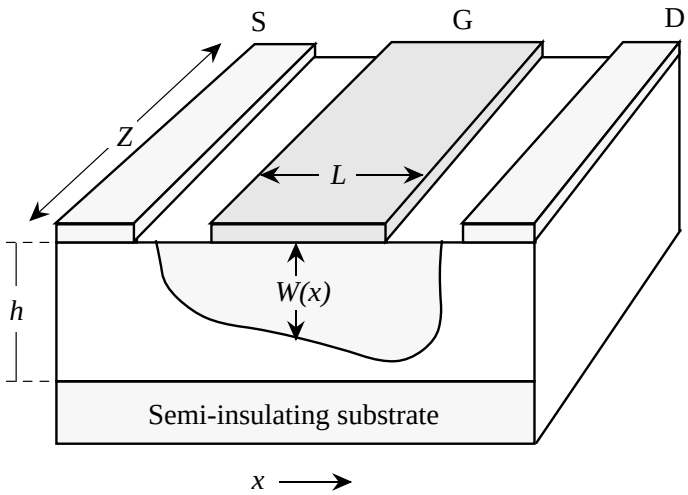
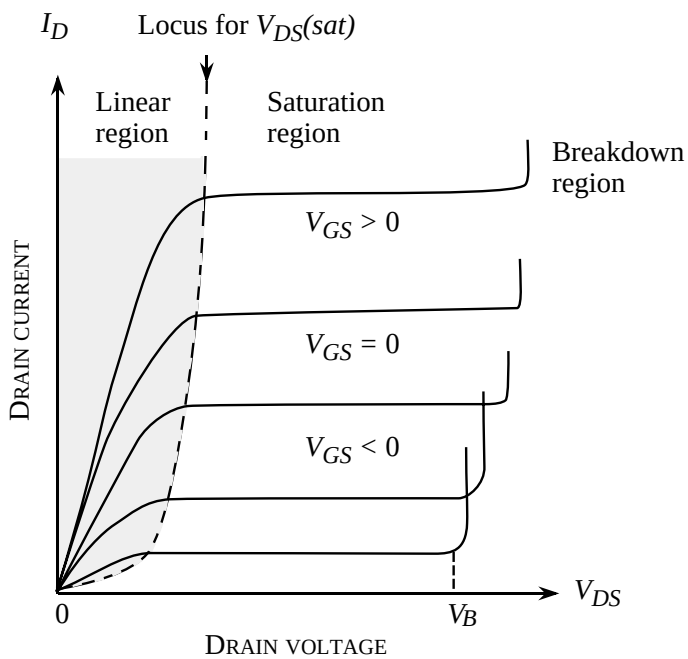
CURRENT-VOLTAGE RELATIONS IN A MESFET



A schematic of a MESFET along with the depletion region



LINEAR REGIME: $g_o = \frac{e\mu_n N_d Z h}{L}$

$$I_D = g_o \left[1 - \left(\frac{V_{bi} - V_{GS}}{V_p} \right)^{1/2} \right] V_{DS}$$

$$V_p = \frac{e N_d h^2}{2\varepsilon}$$

SATURATION REGIME:

$$V_{DS}(sat) = V_p - V_{bi} + V_{GS}$$

$$I_D(sat) = g_o \left[\frac{V_p}{3} - V_{bi} + V_{GS} + \frac{2(V_{bi} - V_{GS})^{3/2}}{3 V_p^{1/2}} \right]$$

At high V_{DS} values the device breaks down.

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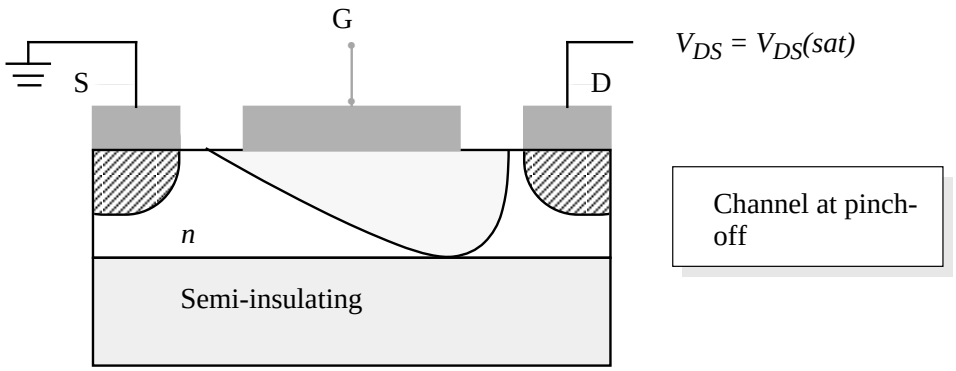
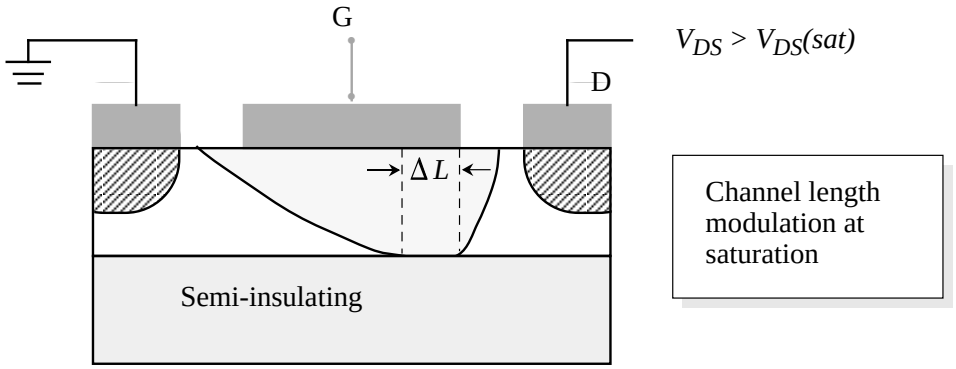
CHANNEL LENGTH MODULATION AND OUTPUT CONDUCTANCE

Current $\propto \frac{1}{L}$

"Effective channel length" decreases once $V_{DS} > V_{DS}(sat)$





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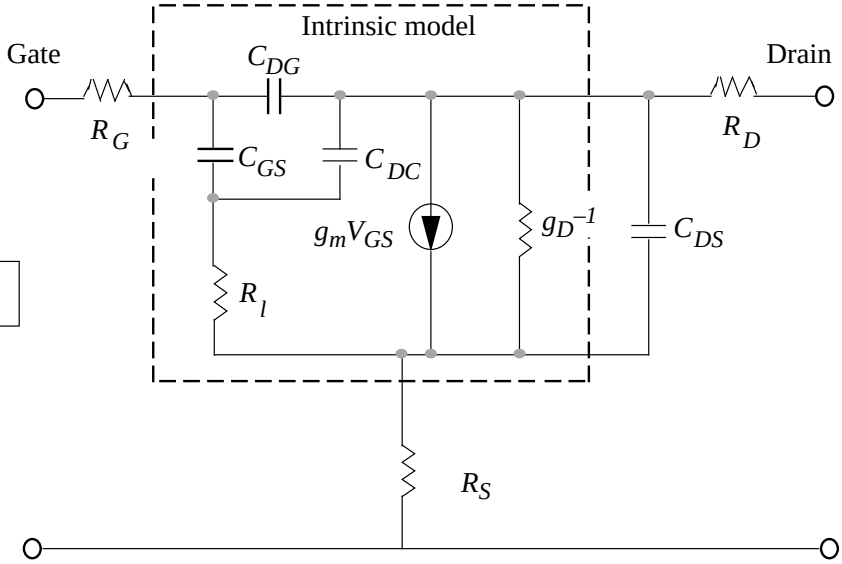
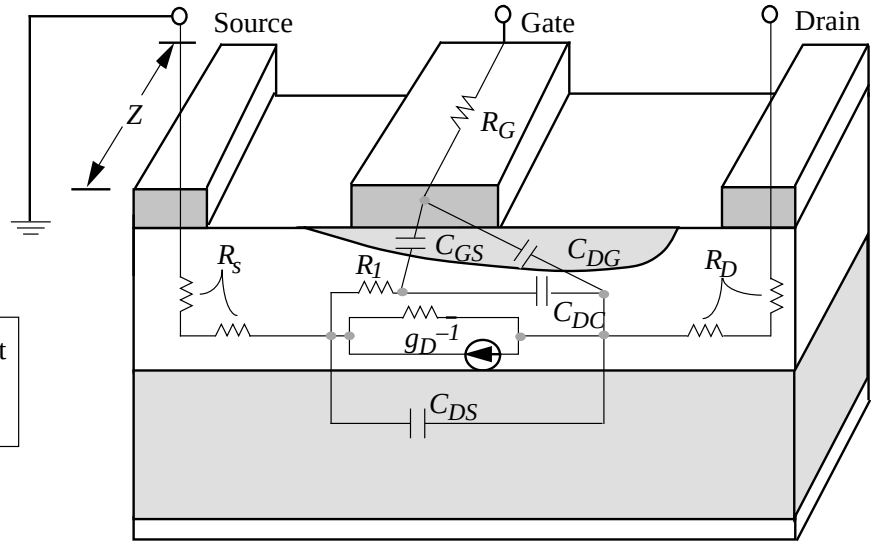
SMALL SIGNAL MODEL FOR A MESFET



Circuit model



Important circuit parameters in a MESFET

Cutoff frequency

$$f_T = \frac{g_m}{2\pi C_G} = \frac{1}{2\pi\, t_{tr}}$$

t_{tr} = transit time

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