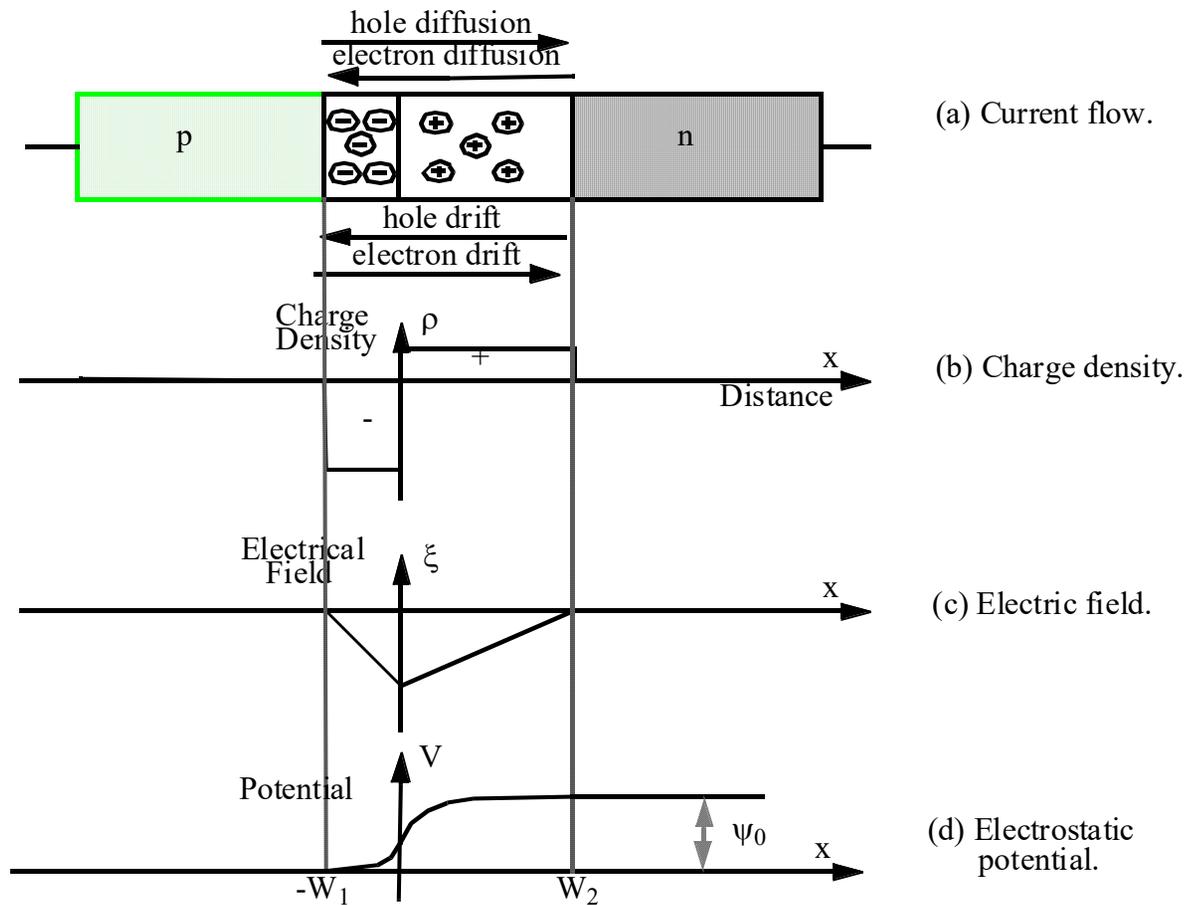
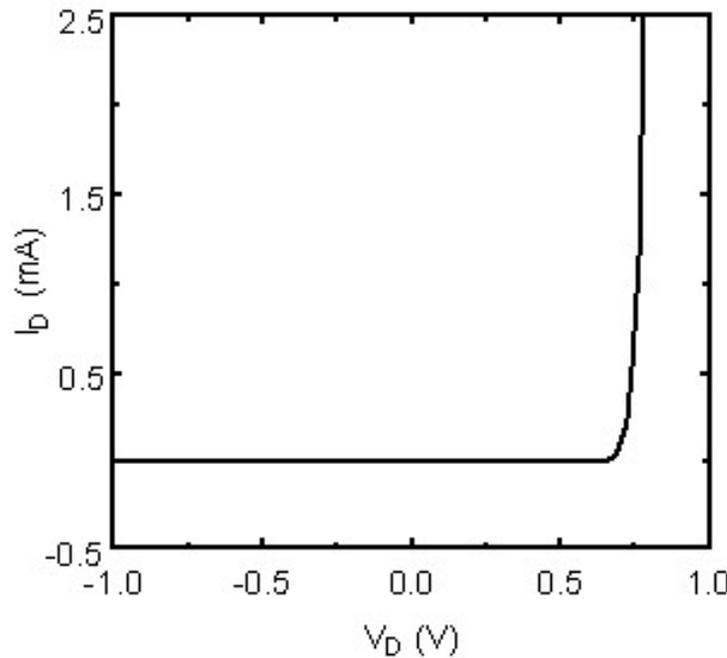


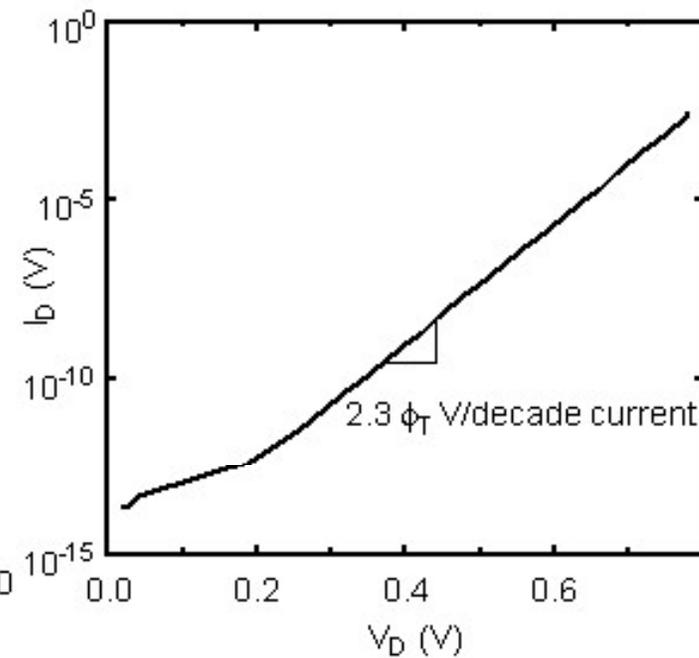
Depletion Region



Diode Current



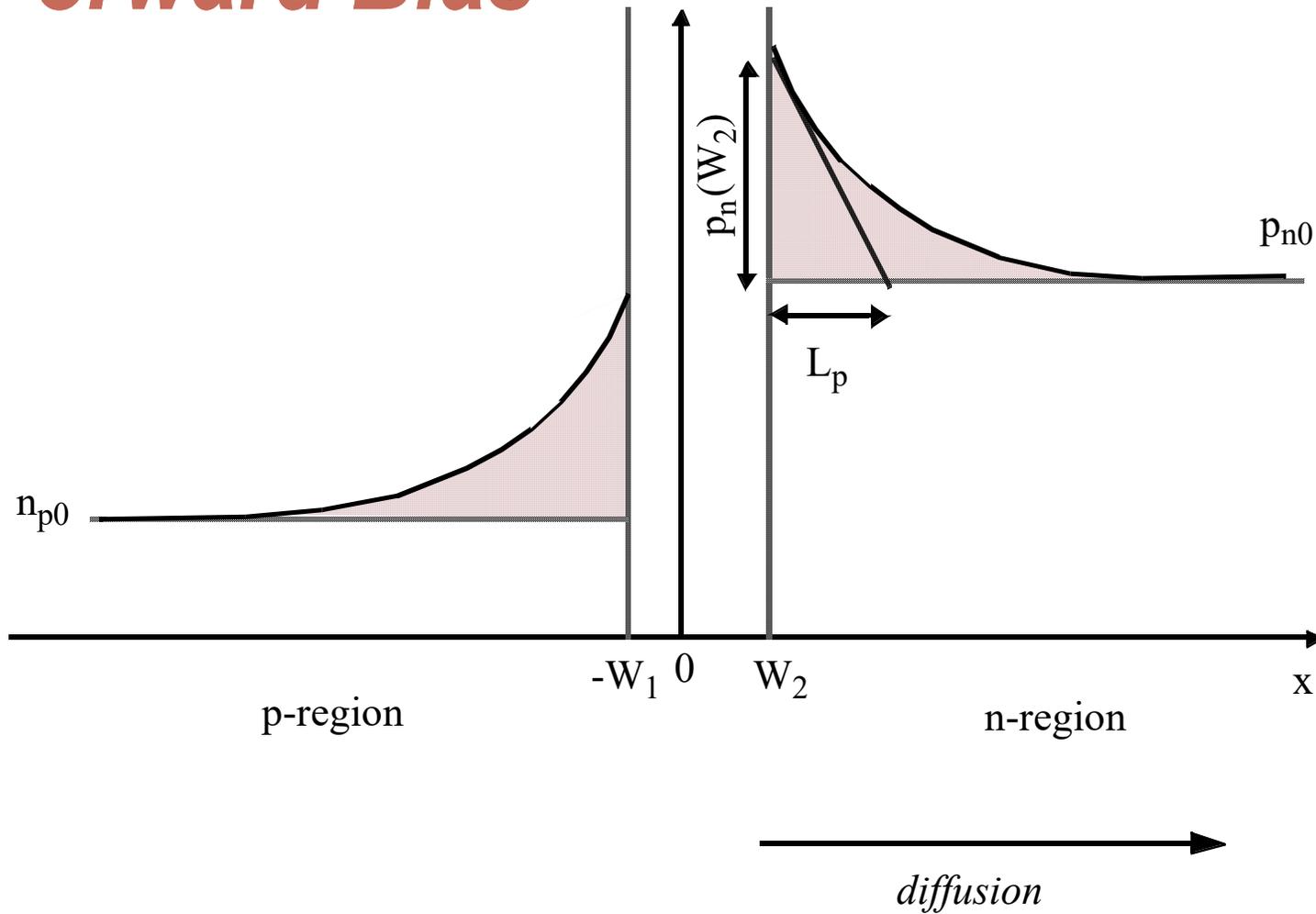
(a) On a linear scale.



(b) On a logarithmic scale (forward bias).

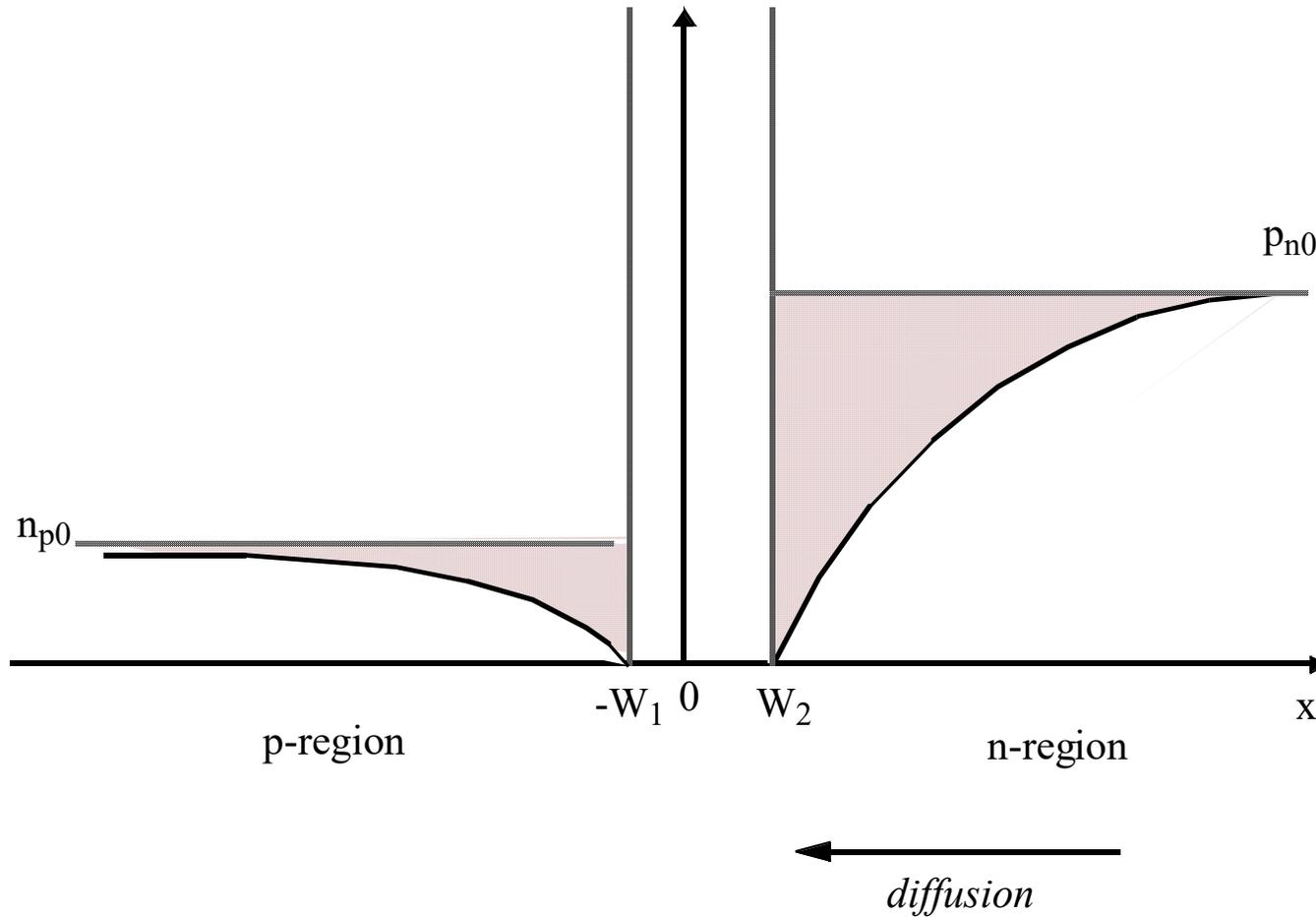
$$I_D = I_S \left(e^{V_D / \phi_T} - 1 \right)$$

Forward Bias



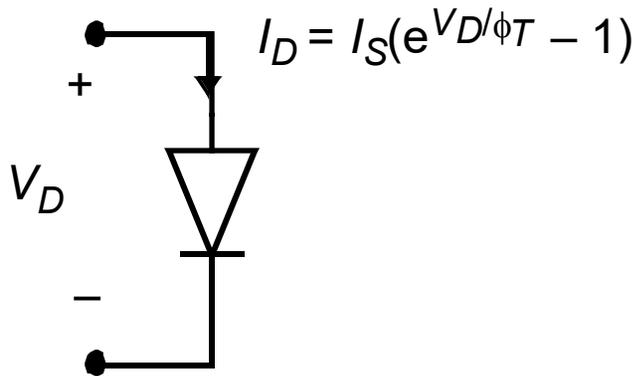
Typically avoided in Digital ICs

Reverse Bias

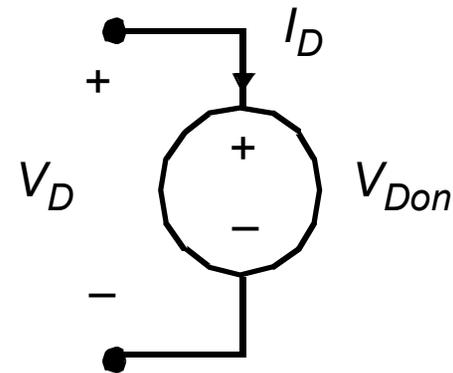


The Dominant Operation Mode

Models for Manual Analysis

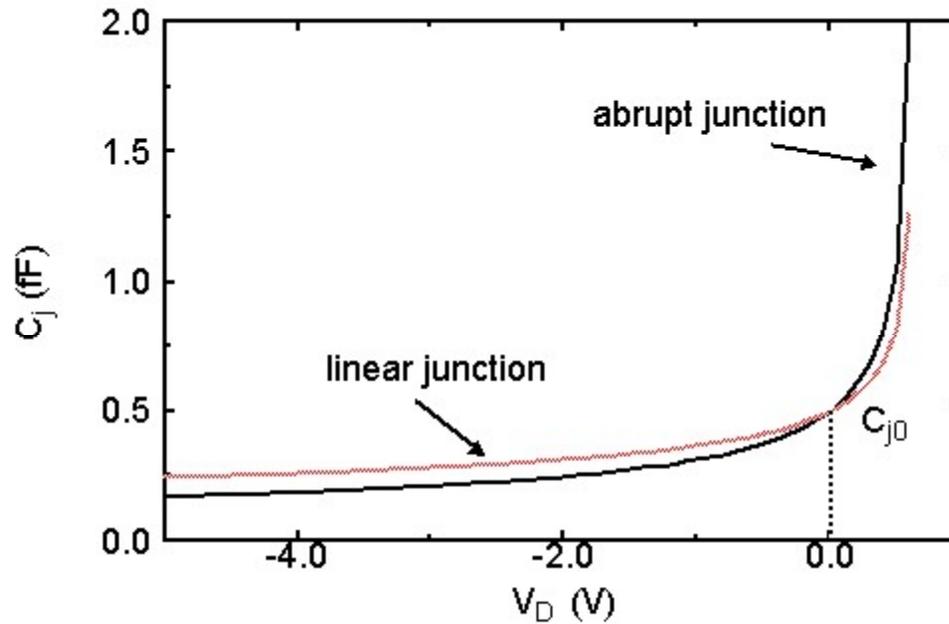


(a) Ideal diode model



(b) First-order diode model

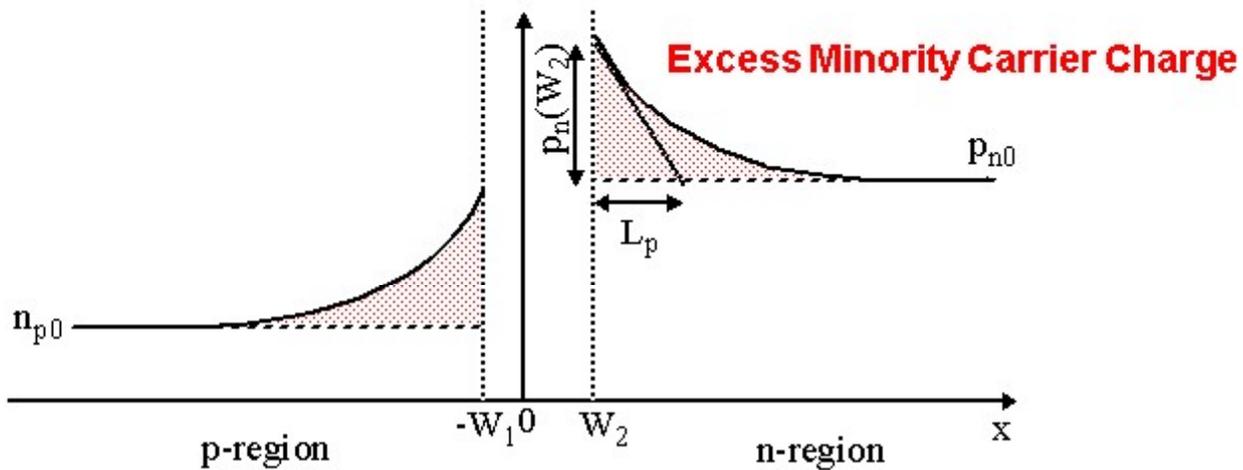
Junction Capacitance



$$C_j = \frac{C_{j0}}{(1 - V_D / \phi_0)^m}$$

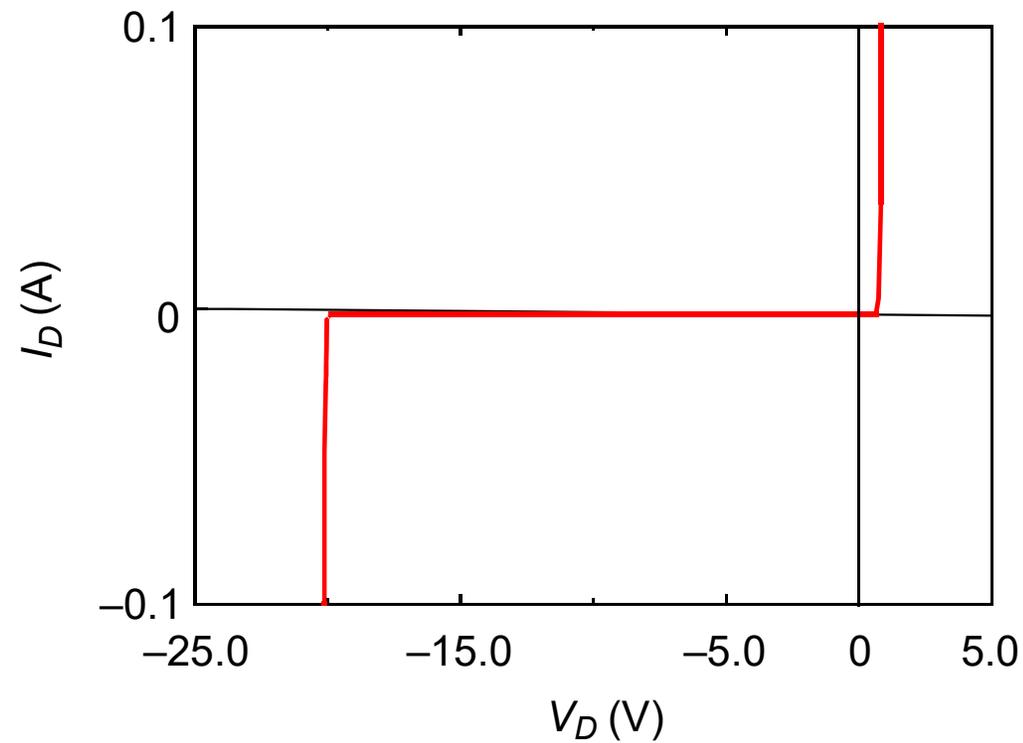
$m = 0.5$: abrupt junction
 $m = 0.33$: linear junction

Diffusion Capacitance



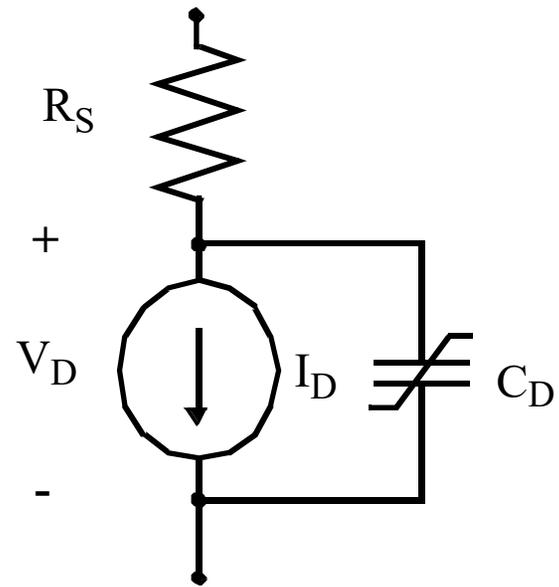
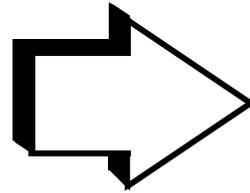
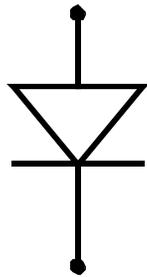
$$C_d = \frac{dQ_D}{dV_D} = \tau_T \frac{dI_D}{dV_D} \approx \frac{\tau_T I_D}{\phi_T}$$

Secondary Effects



Avalanche Breakdown

Diode Model



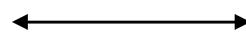
SPICE Parameters

Parameter Name	Symbol	SPICE Name	Units	Default Value
Saturation current	I_S	IS	A	1.0 E-14
Emission coefficient	n	N	-	1
Series resistance	R_S	RS	Ω	0
Transit time	τ_T	TT	sec	0
Zero-bias junction capacitance	C_{j0}	CJ0	F	0
Grading coefficient	m	M	-	0.5
Junction potential	ϕ_0	VJ	V	1

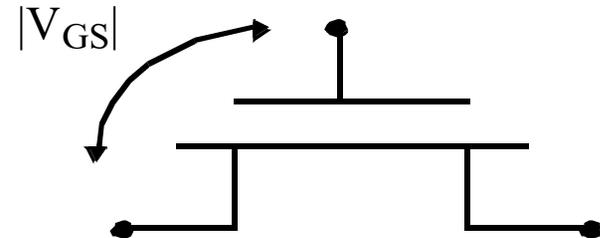
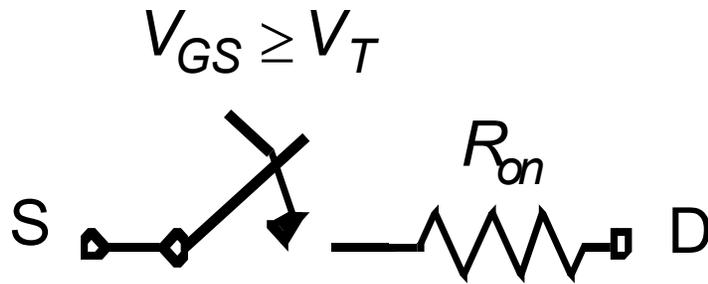
First Order SPICE diode model parameters.

What is a Transistor?

A Switch!



An MOS Transistor



The MOS Transistor

