TECNICAS DE INTEGRACION

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II-2013

INVERSOR CMOS

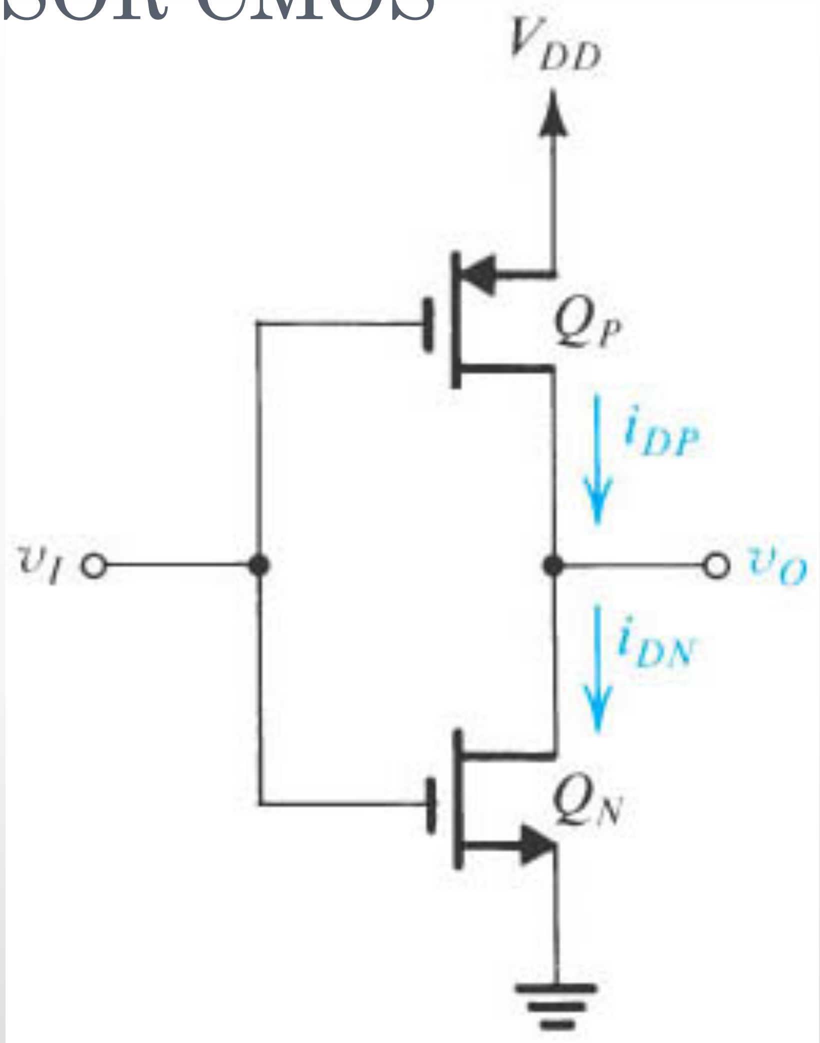


Figure 4.53 The CMOS inverter.

OPERACIÓN INVERSOR

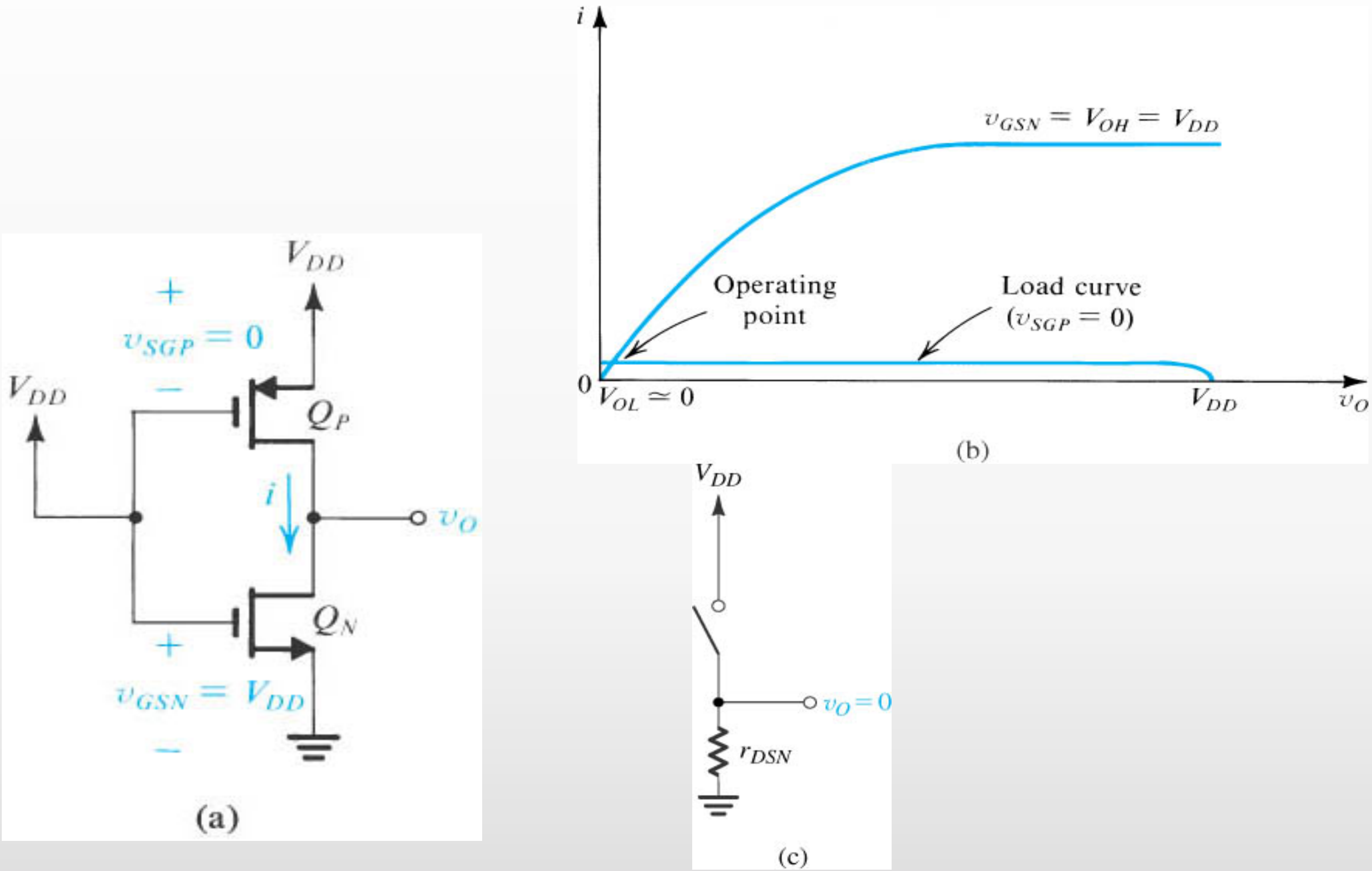


Figure 4.54 Operation of the CMOS inverter when v_I is high: **(a)** circuit with $v_I = V_{DD}$ (logic-1 level, or V_{OH}); **(b)** graphical construction to determine the operating point; **(c)** equivalent circuit.

OPERACIÓN INVERSOR

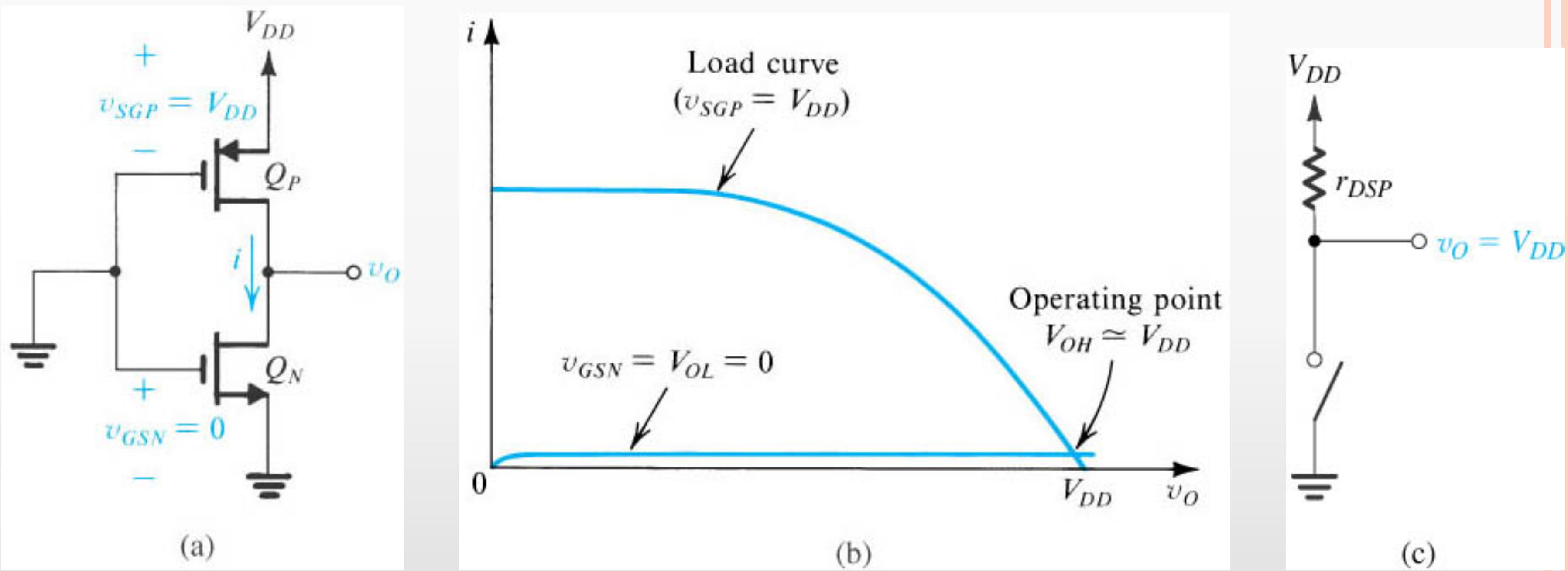


Figure 4.55 Operation of the CMOS inverter when v_I is low: **(a)** circuit with $v_I = 0$ V (logic-0 level, or V_{OL}); **(b)** graphical construction to determine the operating point; **(c)** equivalent circuit.

CARACTERISTICA V-I

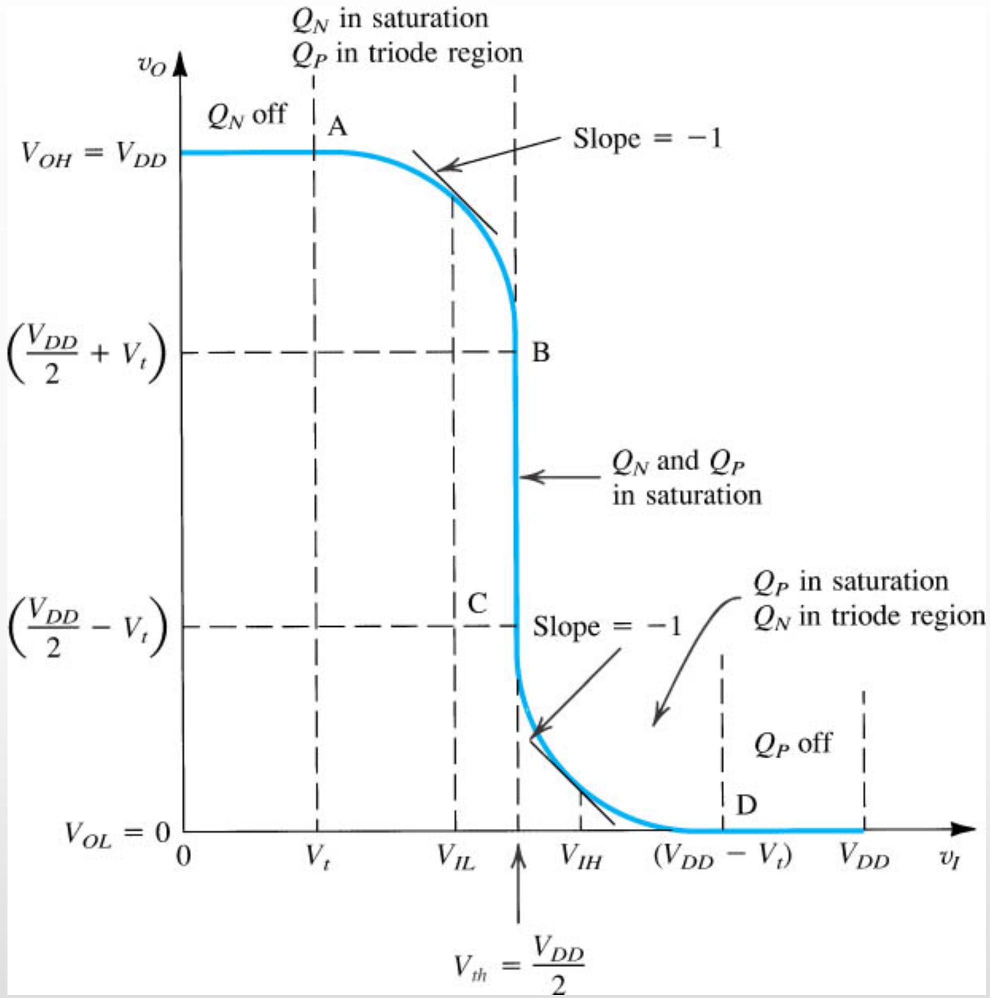


Figure 4.56 The voltage transfer characteristic of the CMOS inverter.

RESPUESTA INVERSOR

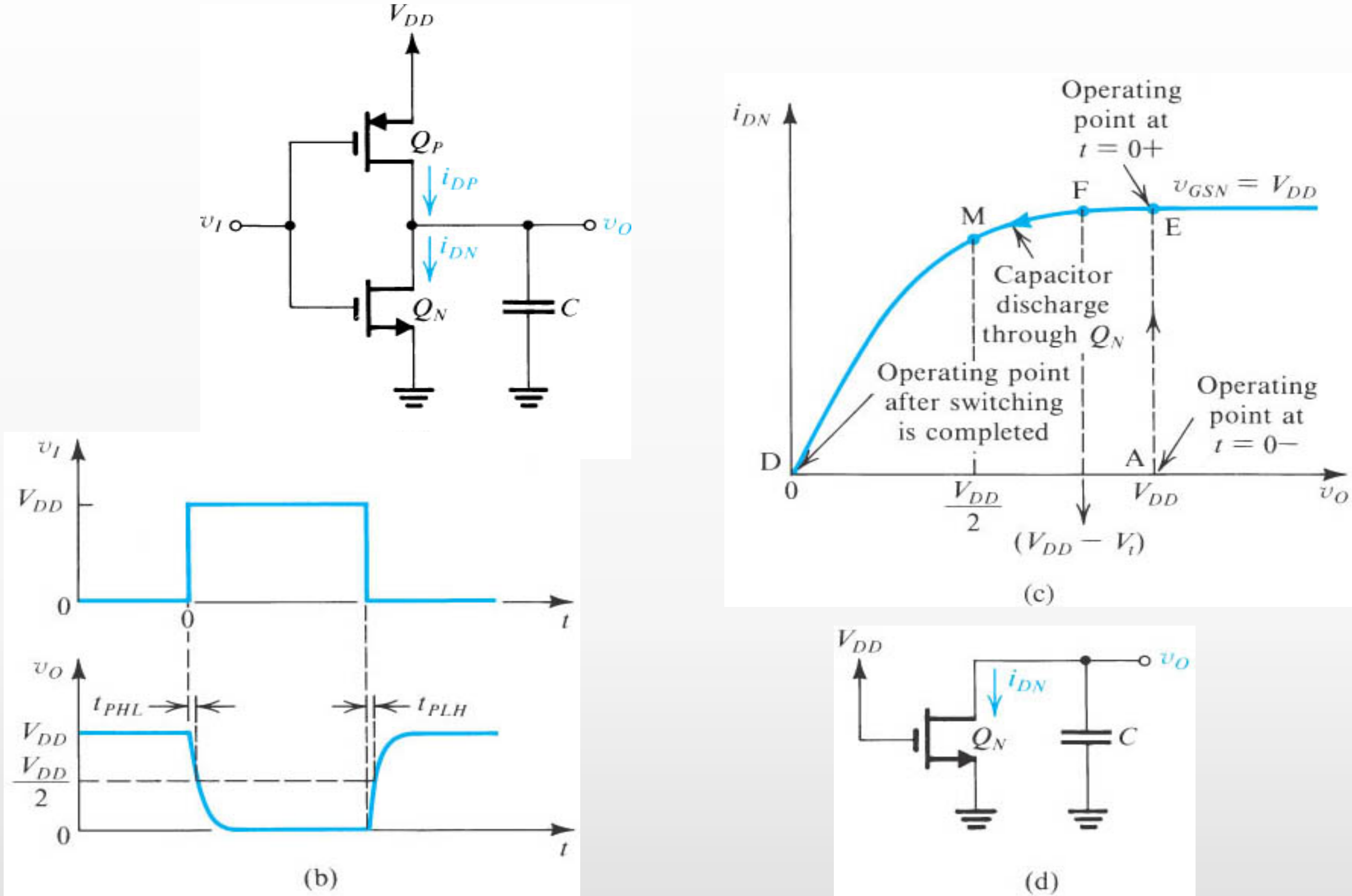
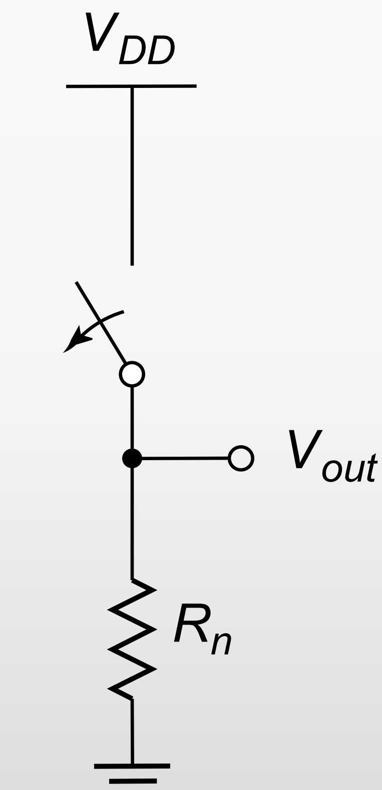
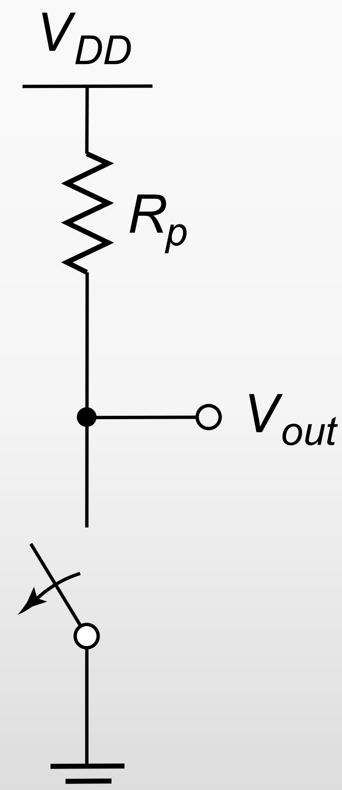


Figure 4.57 Dynamic operation of a capacitively loaded CMOS inverter: **(a)** circuit; **(b)** input and output waveforms; **(c)** trajectory of the operating point as the input goes high and C discharges through Q_N; **(d)** equivalent circuit during the capacitor discharge.

Inversor CMOS Modelo Primer Orden Análisis DC



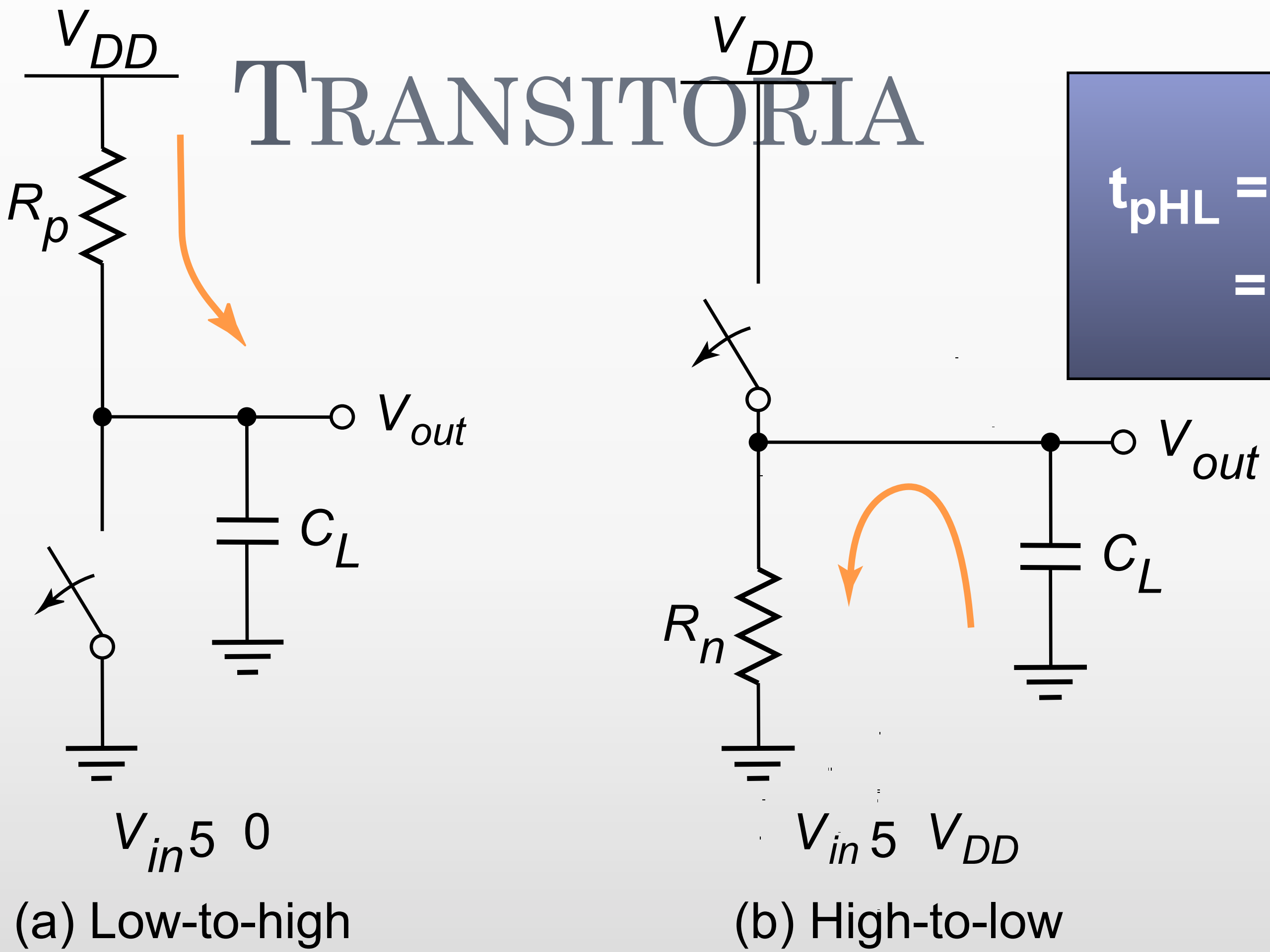
V_{in} 5 V_{DD}



V_{in} 5 0

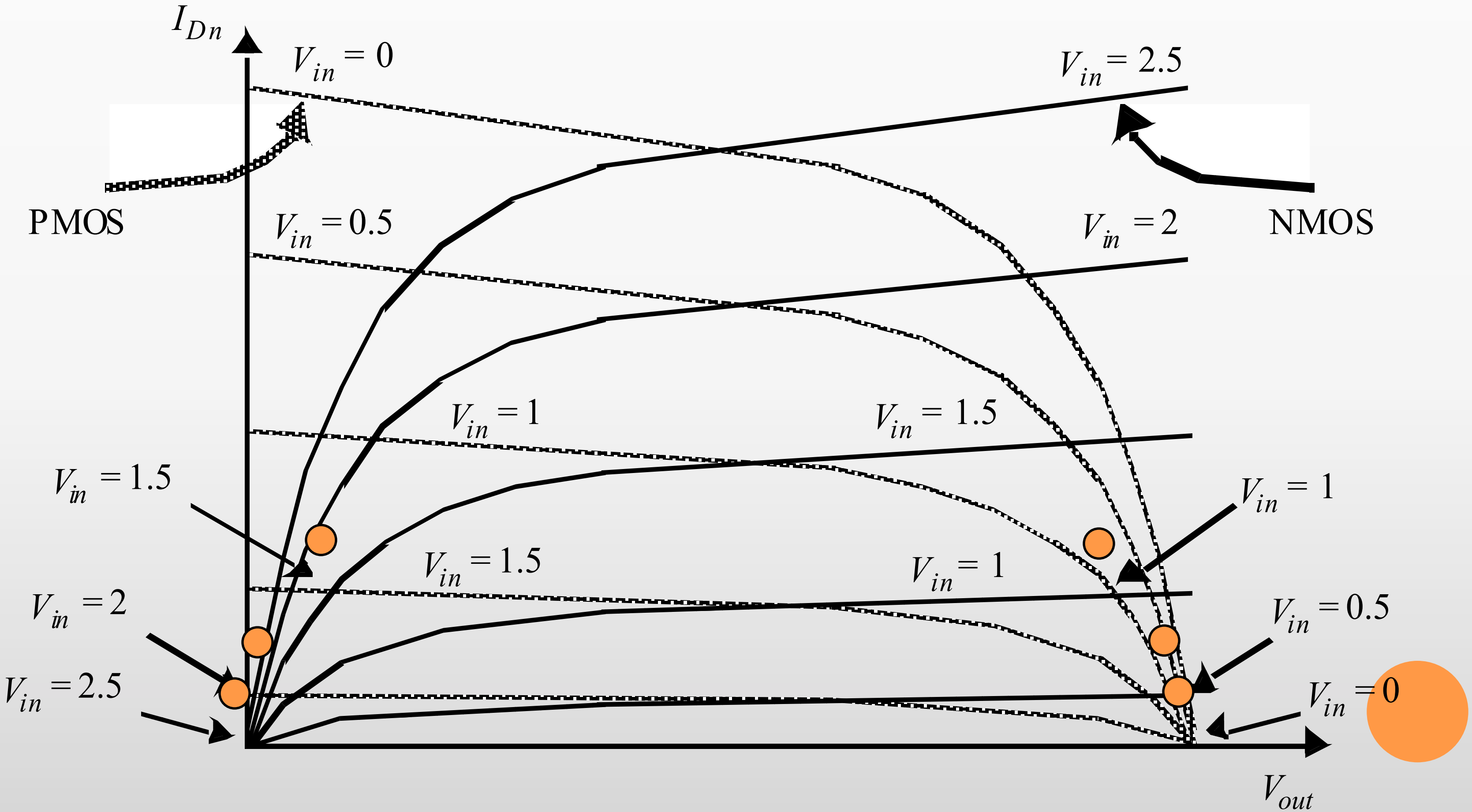
$$V_{OL} = 0$$
$$V_{OH} = V_{DD}$$
$$V_M = f(R_n, R_p)$$

Inversor CMOS: Respuesta Transitoria

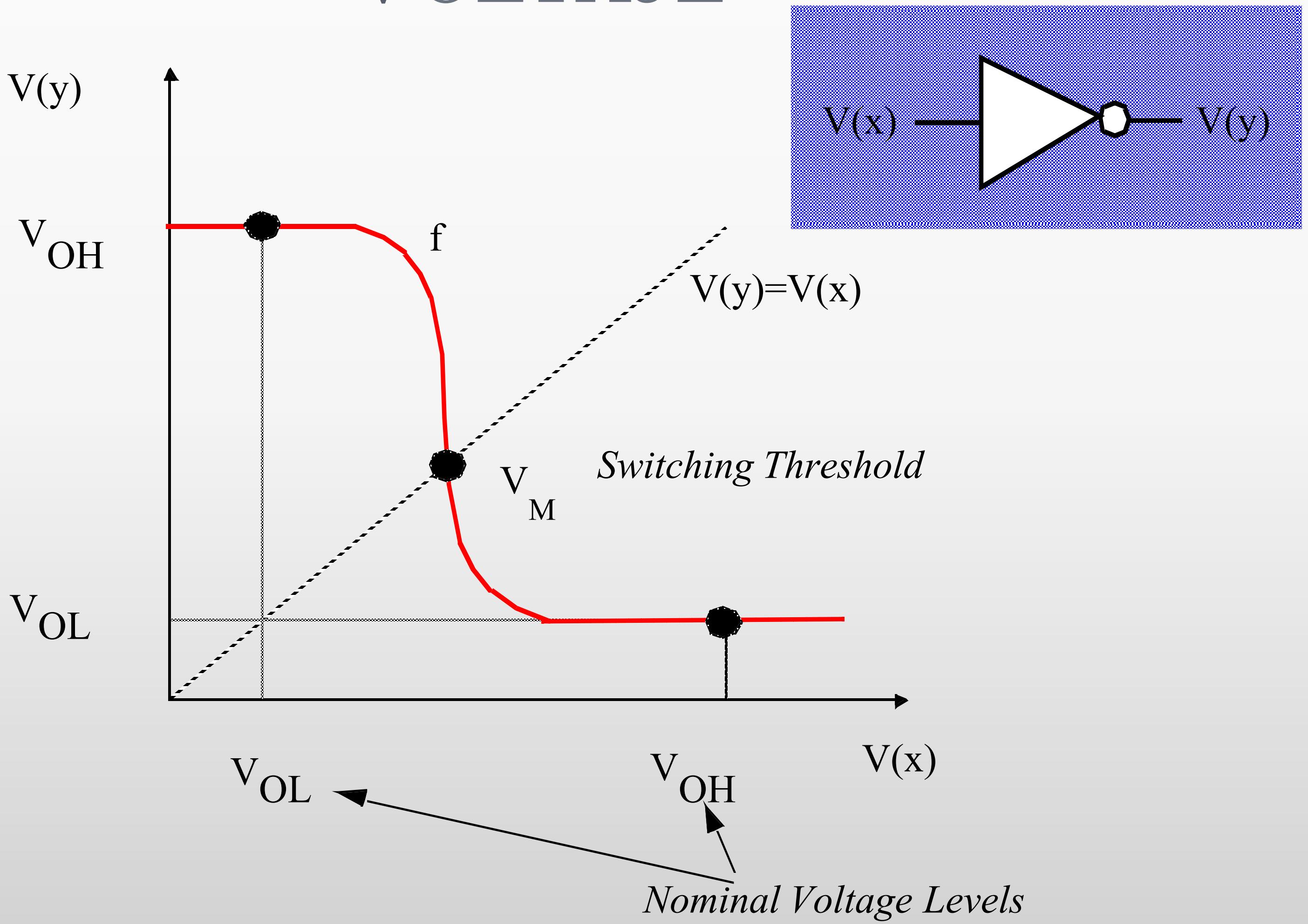


$$t_{pHL} = f(R_{on}.C_L)$$
$$= 0.69\ R_{on}C_L$$

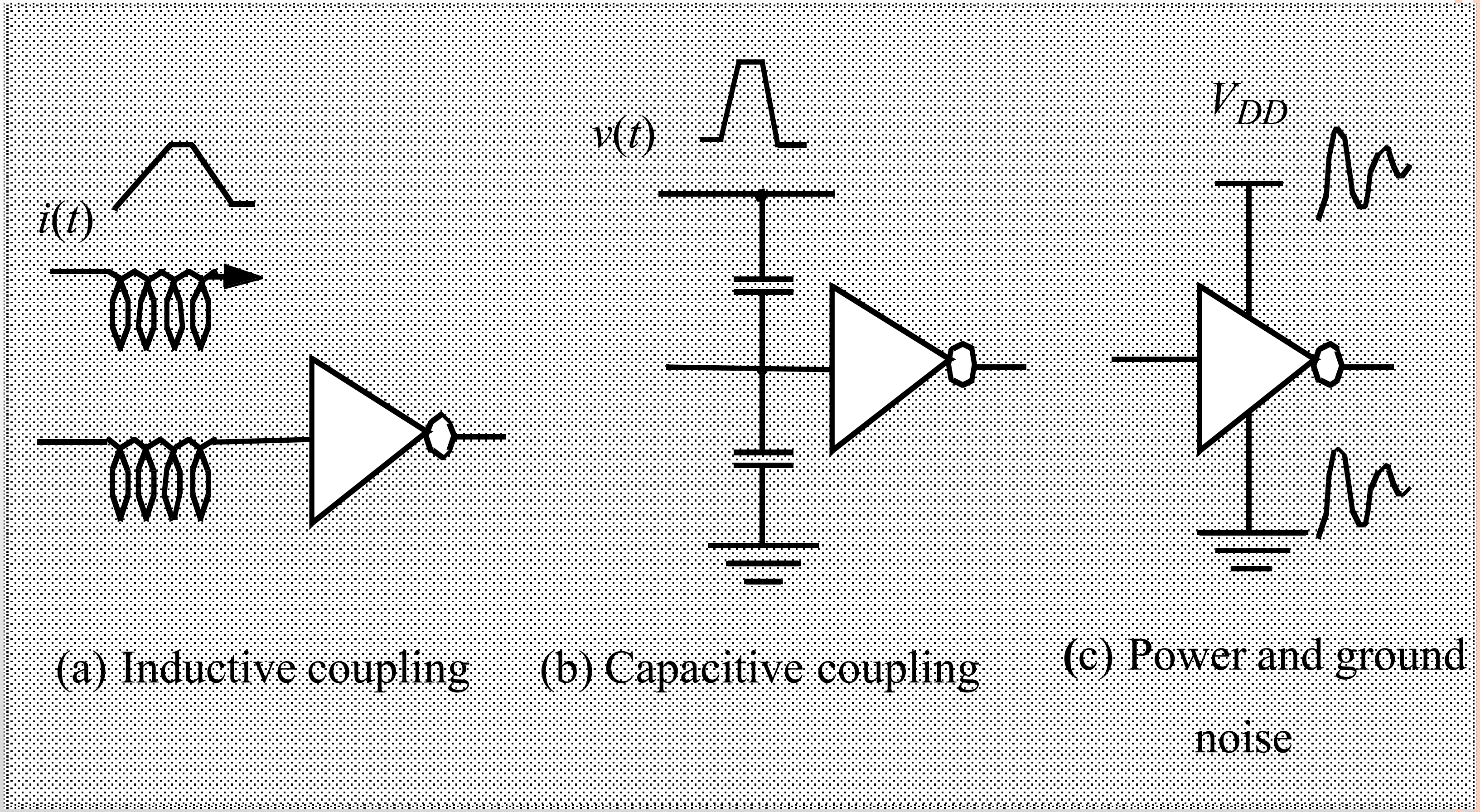
INVERSOR CMOS CARACTERÍSTICA DE CARGA



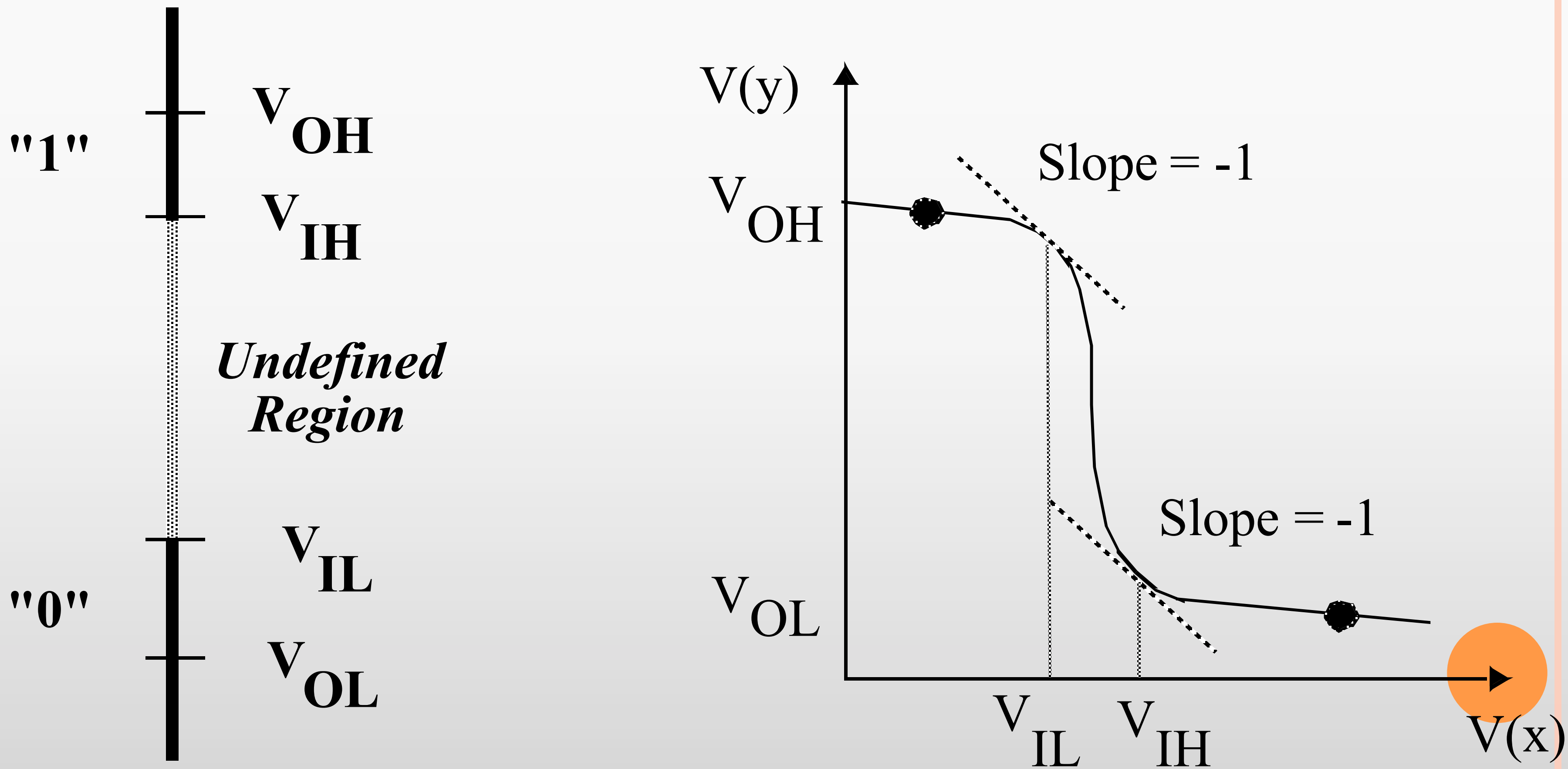
Operacion DC: Transferencia de Voltaje



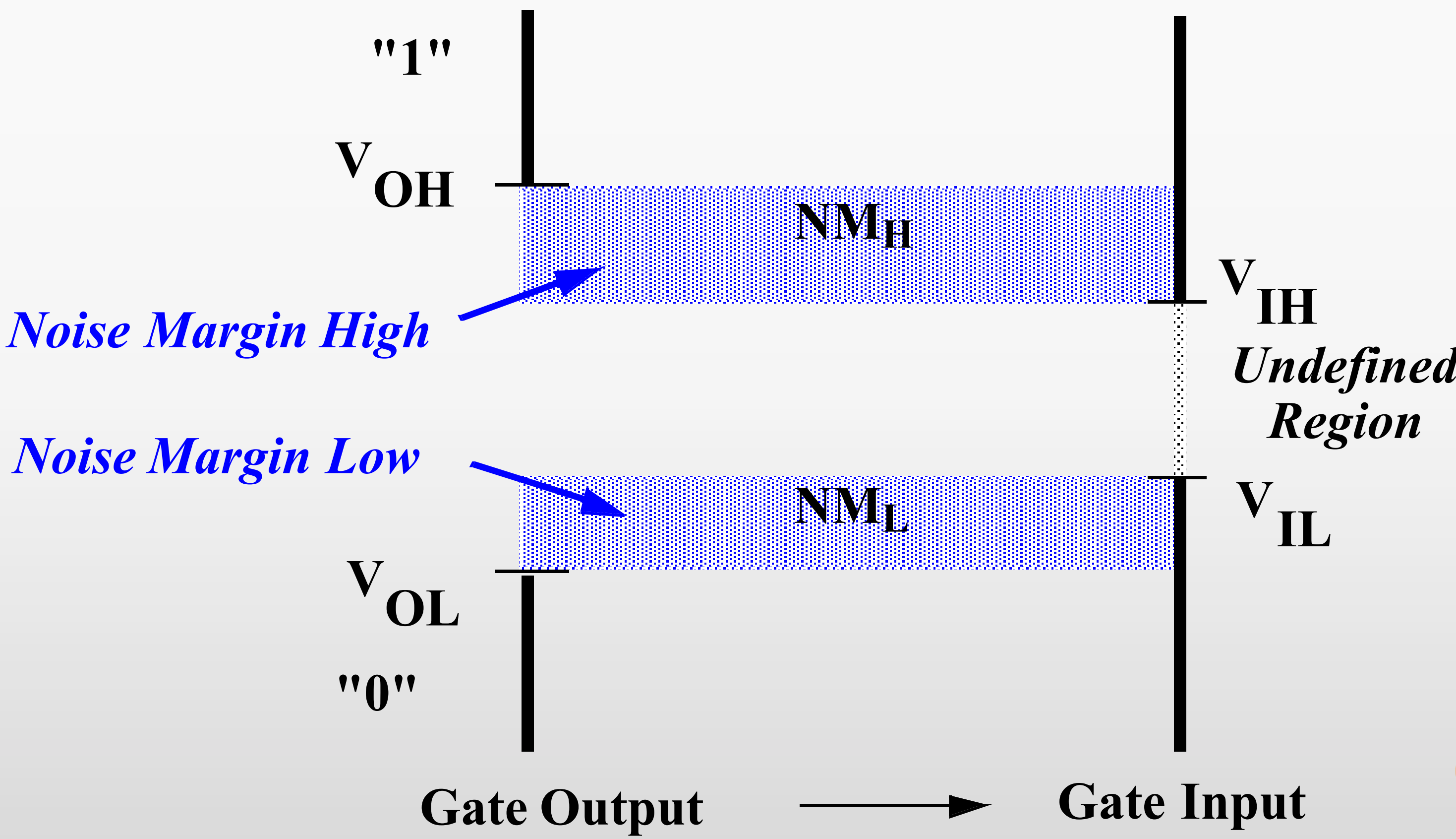
Ruido en Circuitos Digitales



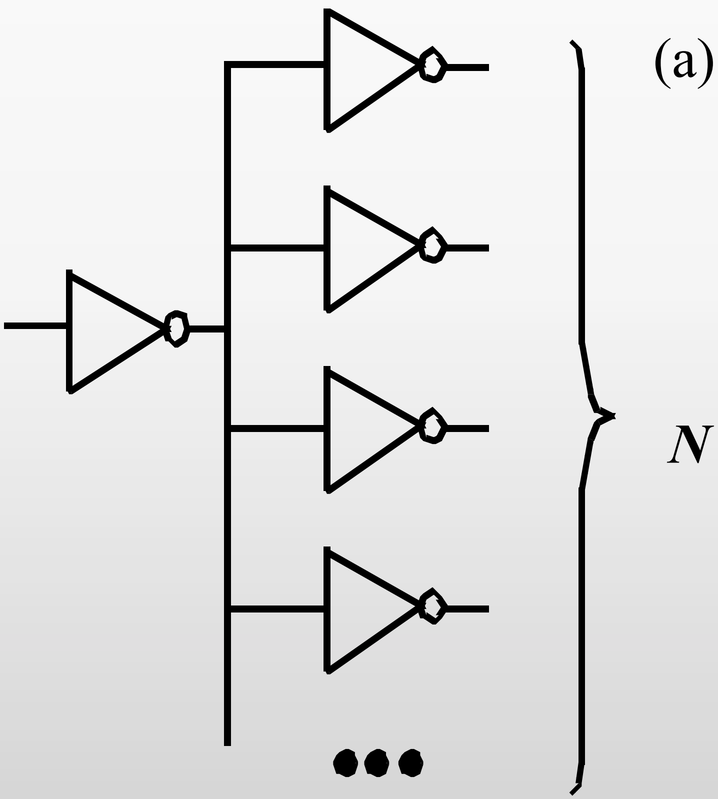
Niveles de las señales digitales



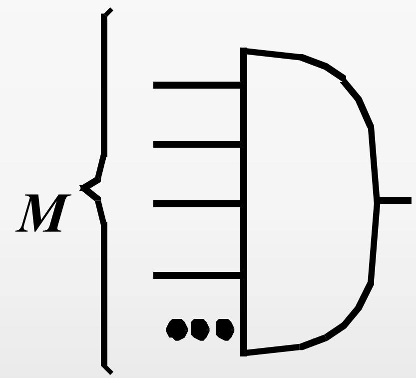
MARGEN DE RUIDO



Fan-in y Fan-out

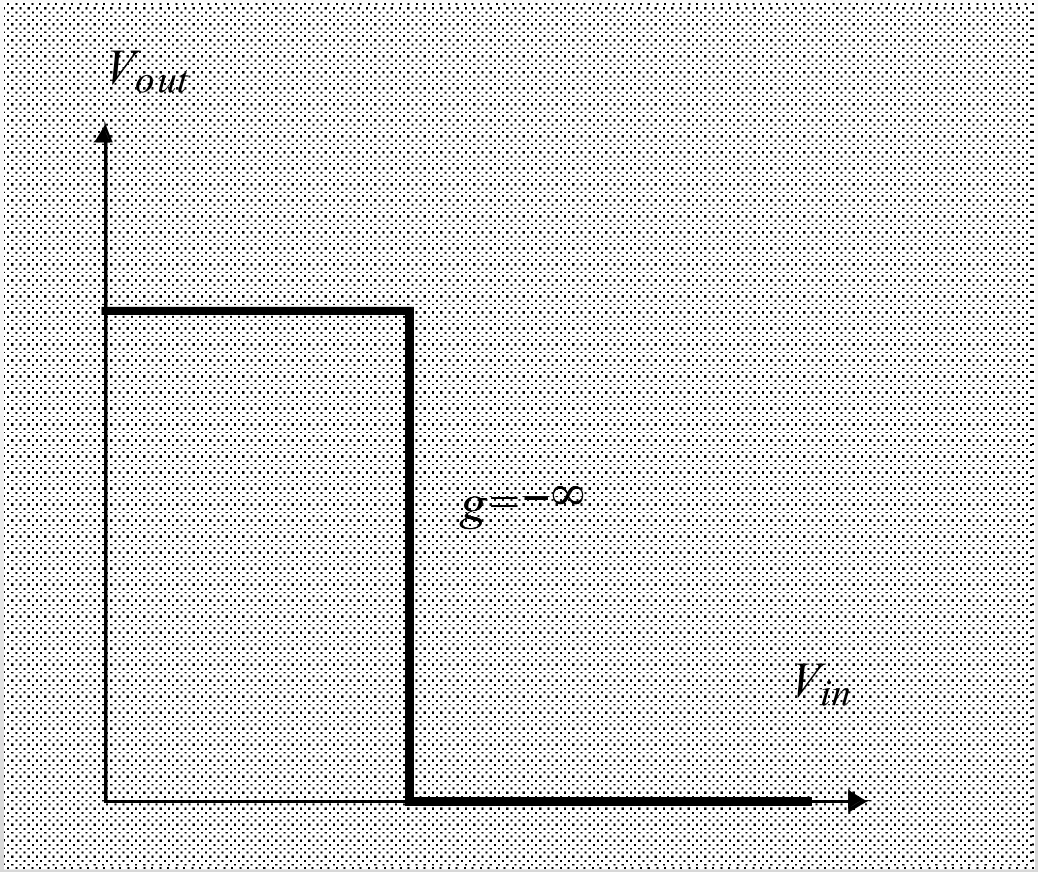


(a) Fan-out *N*



(b) Fan-in *M*

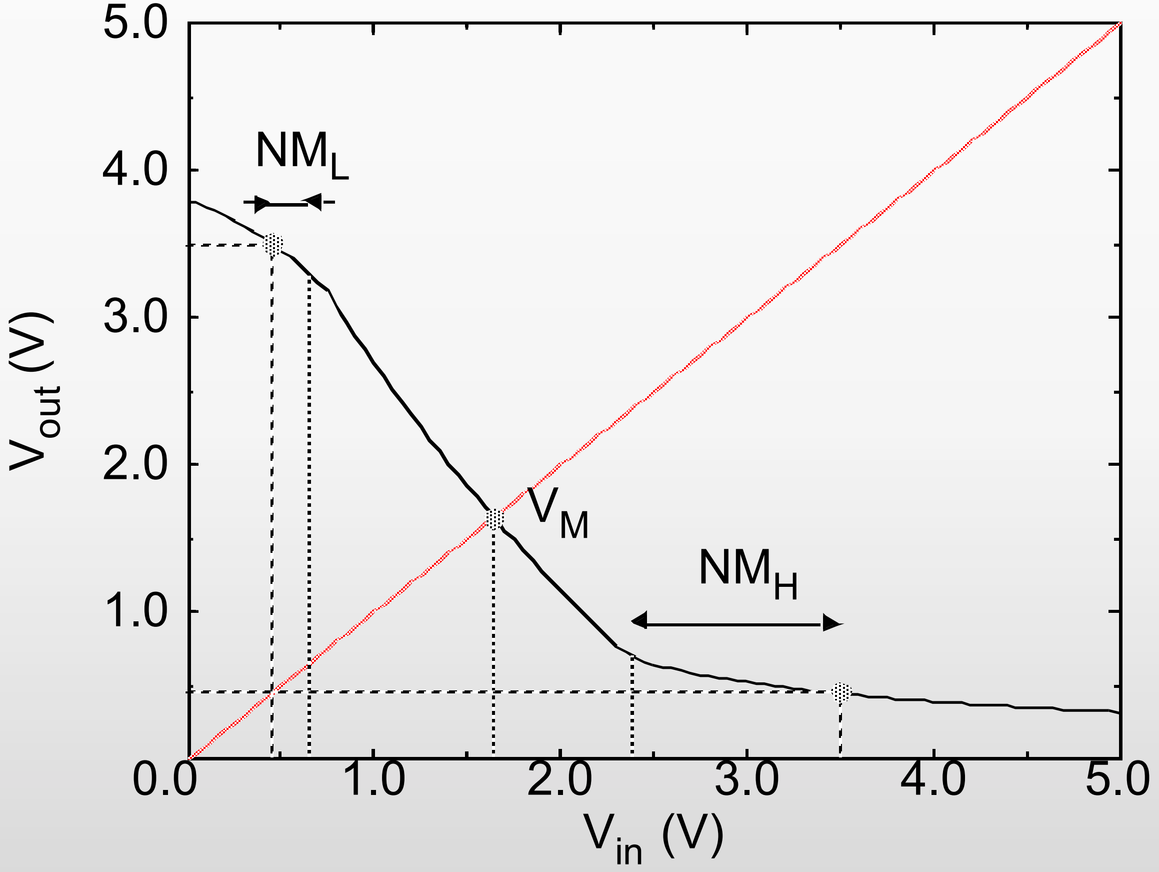
Compuerta Ideal



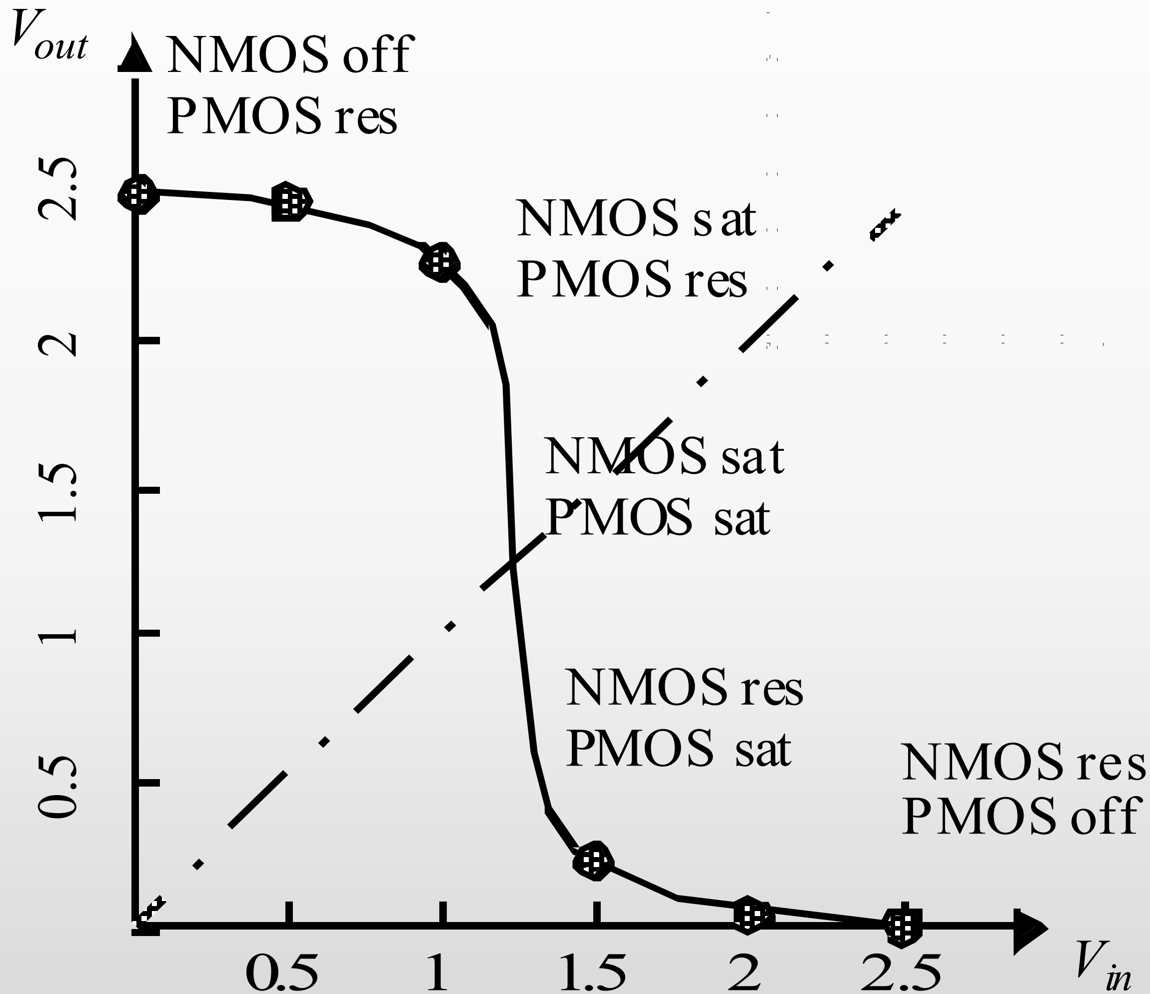
$R_i = \infty$

$R_o = 0$

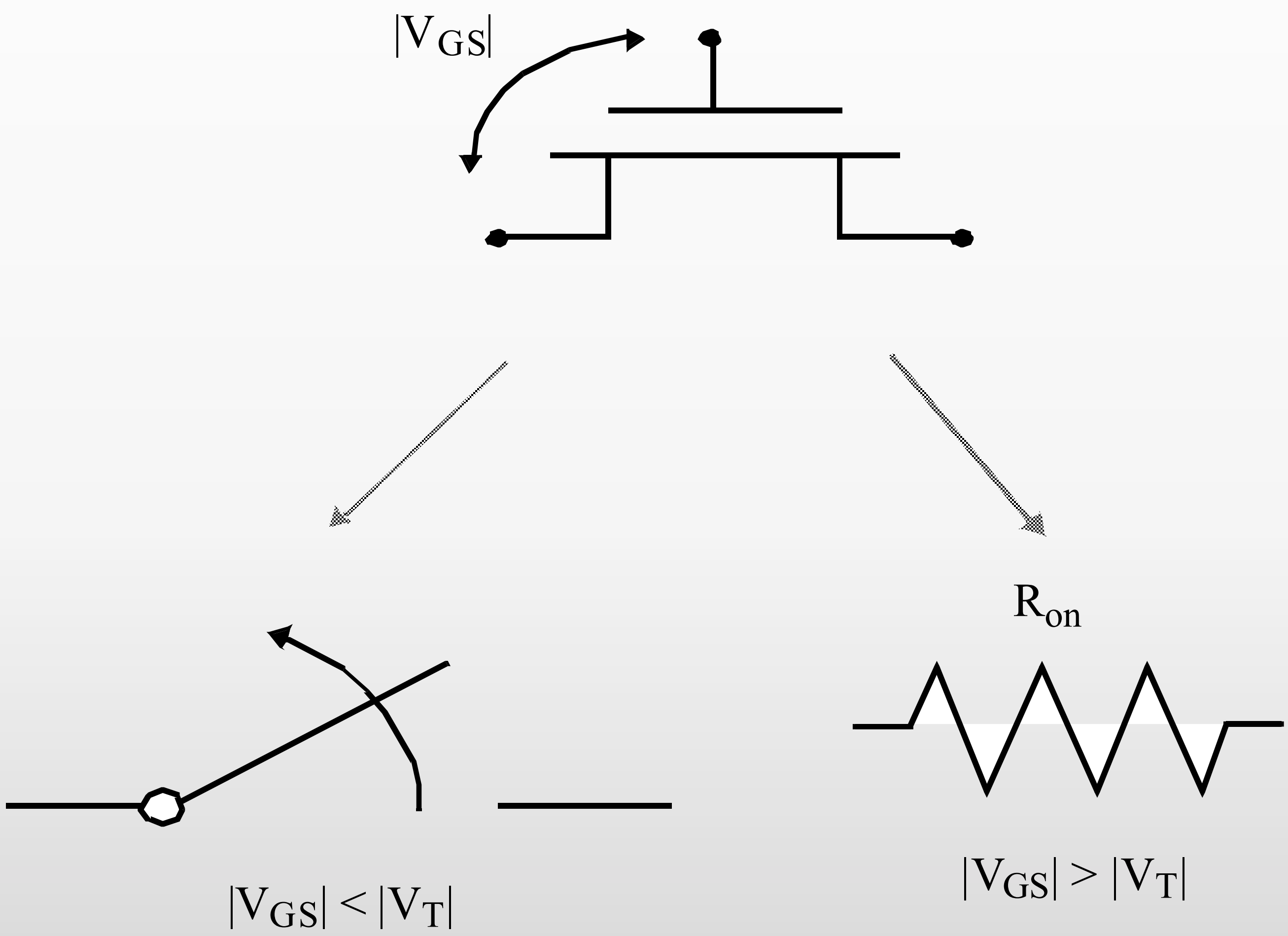
Característica Real del Inversor



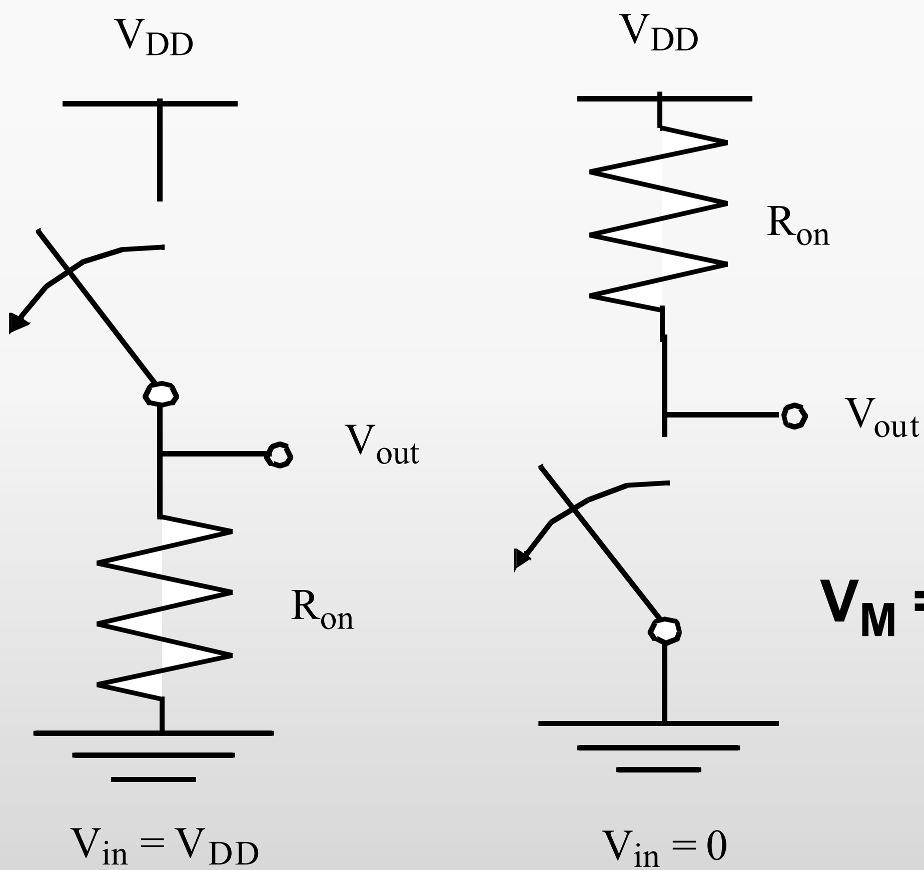
INVERSOR CMOS VTC



Modelo de Conmutación del Transistor MOS



Inversor CMOS: Estado Estacionario

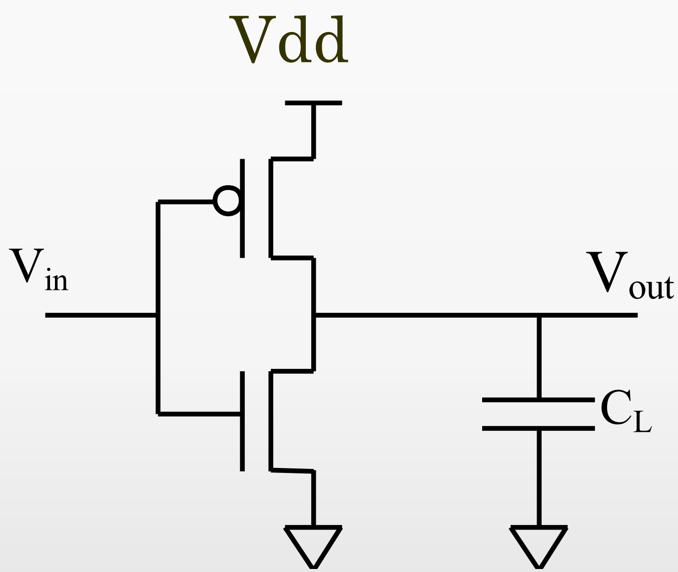


$$V_{OH} = V_{DD}$$

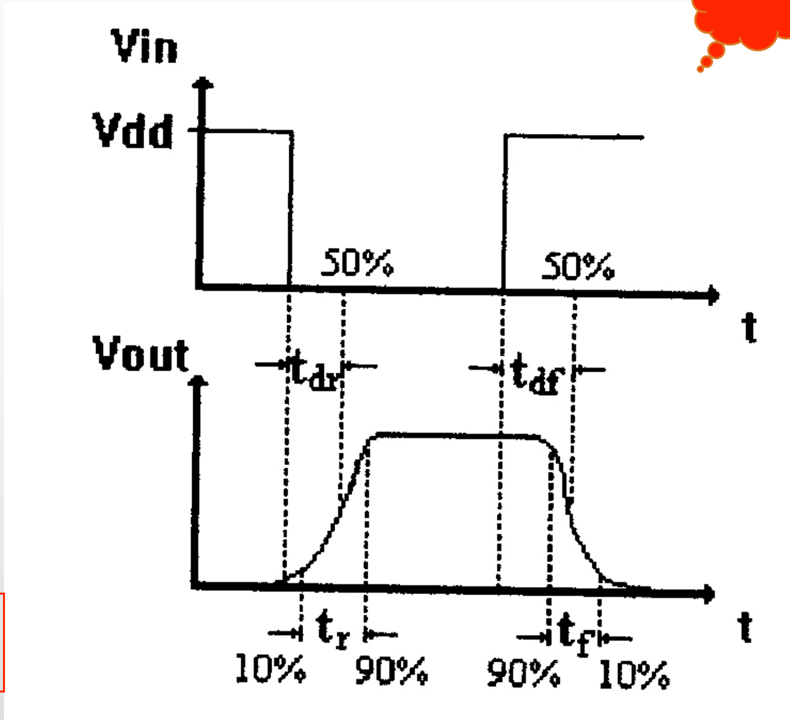
$$V_{OL} = 0$$

$$V_M = f(R_{onn}, R_{onp})$$

Tiempos de Respuesta CMOS

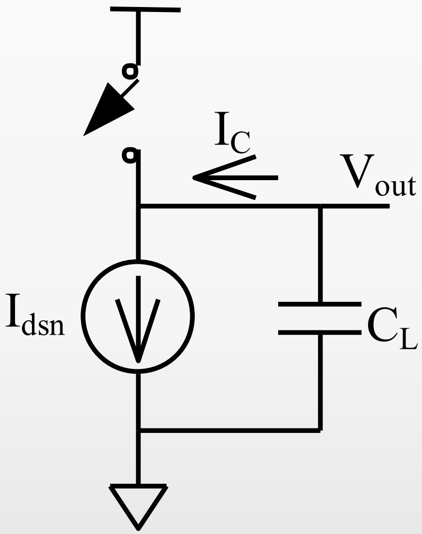


NEGADOR BASICO

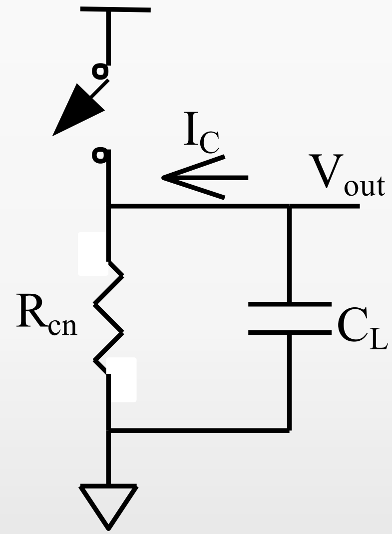


Circuitos Equivalentes

TIEMPO DE BAJADA



$V_{out} \geq V_{DD} - V_{tn}$



$0 \leq V_{out} \leq V_{DD} - V_{tn}$

T_F --> Tiempo de Bajada

En Zona de Saturación

$$C_L \frac{dV_{out}}{dt} + \frac{\beta_n}{2}(V_{DD} - V_{tn})^2 = 0$$

$$I_{ds} = \beta \frac{(V_{gs} - V_t)^2}{2}, \qquad 0 < V_{gs} - V_t < V_{ds}$$

$t_f = t_{f1} + t_{f2}$

$$t_{f1} = -2 \frac{C_L}{\beta_n (V_{DD} - V_{tn})^2} \int_{0.9\,V_{DD}}^{V_{DD} - V_{tn}} (dV_{out})$$

$$\boxed{t_{f1} = \frac{2\,C_L\,(V_{tn} - 0.1\,V_{DD})}{\beta_n (V_{DD} - V_{tn})^2}}$$

T_F --> Tiempo de Bajada(1)

En Zona Lineal

$$C_L \frac{dV_{out}}{dt} + \beta_n \left[(V_{DD} - V_{tn}) \,.\, V_{out} - \frac{V_{out}^2}{2} \right] = 0$$

$$I_{ds} = \beta \,.\, \left[(V_{gs} - V_t) \cdot V_{ds} - \frac{V_{ds}^2}{2} \right], \qquad 0 < V_{ds} < V_{gs} - V_t$$

$$t_{f2} = - \frac{C_L}{\beta_n (V_{DD} - V_{tn})} \cdot \int_{V_{DD} - V_{tn}}^{0.1\, V_{DD}} \left(\frac{dV_{out}}{\frac{V_{out}^2}{2 (V_{DD} - V_{tn})} - V_{out}} \right) \qquad t_{f2} = \frac{C_L}{\beta_n (V_{DD} - V_{tn})} \cdot \ln\left(\frac{19\, V_{DD} - 20\, V_{tn}}{V_{DD}} \right)$$

$$t_f = t_{f1} + t_{f2}$$

$$\boxed{t_f = 2 \frac{C_L}{\beta_n \,.\, V_{DD} \,.\, (1 - n)} \left[\frac{n - 0.1}{1 - n} + \frac{\ln (19 - 20.n)}{2} \right]}$$

T_F --> Tiempo de Bajada(2)

$$t_f = 2\,\frac{C_L}{\beta_n \,.\, V_{DD} \,.\, (1-n)}\left[\frac{n-0.1}{1-n} + \frac{\ln(19-20.n)}{2}\right]$$

donde

$$n = \frac{V_{tn}}{V_{DD}} \qquad \beta_n = \frac{\varepsilon_{SiO_2} \,.\, \mu_n}{T_{ox}} \cdot \frac{W_n}{L_n}$$

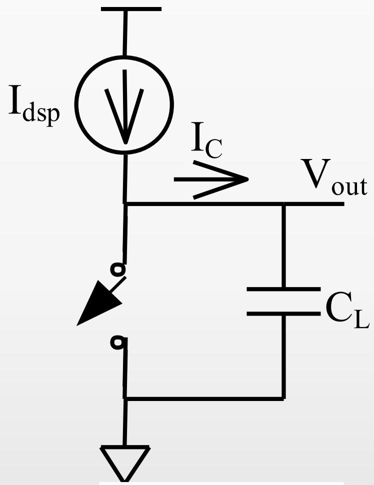
$$t_f \cong k_n \cdot \frac{T_{ox} \,.\, L_n \,.\, C_L}{\varepsilon_{SiO_2} \,.\, \mu_n \,.\, W_n \,.\, V_{DD}}$$

$$t_f \cong k_n' \cdot \frac{L_n \,.\, C_L}{W_n}$$

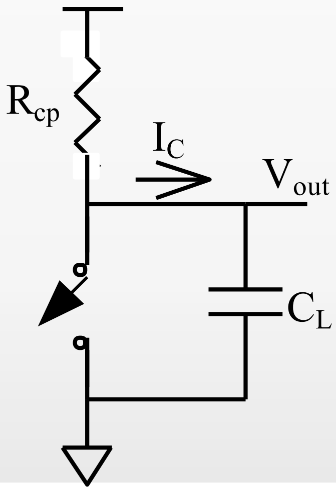
Tecnología específica

Circuitos Equivalentes

TIEMPO DE SUBIDA



$V_{out} \leq |V_{tp}|$



$|V_{tp}| \leq V_{out} \leq V_{DD}$

T_R --> Tiempo de Subida

$$t_r = 2\,\frac{C_L}{\beta_p \,.\, V_{DD} \,.\, (1-p)}\left[\frac{p-0.1}{1-p} + \frac{\ln(19 - 20.p)}{2}\right]$$

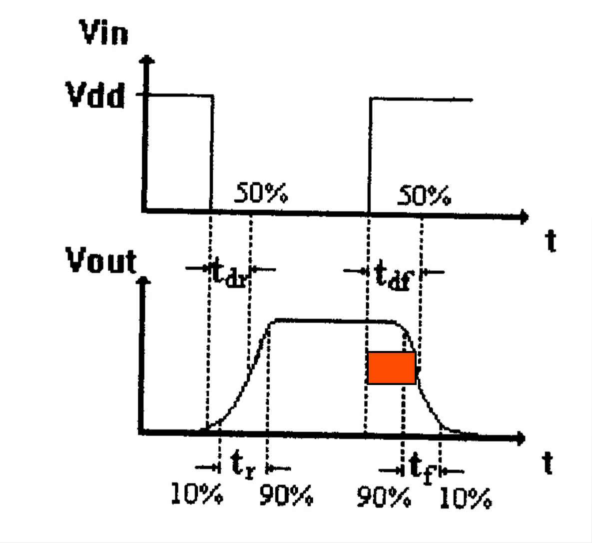
donde $p = \dfrac{|V_{tp}|}{V_{DD}}$ $\qquad \beta_p = \dfrac{\varepsilon_{SiO_2} \,.\, \mu_p}{T_{ox}} \cdot \dfrac{W_p}{L_p}$

$$\boxed{t_r \cong k_p \cdot \frac{T_{ox} \,.\, L_p \,.\, C_L}{\varepsilon_{SiO_2} \,.\, \mu_p \,.\, W_p \,.\, V_{DD}}}$$

$$\boxed{t_r \cong k_p' \cdot \frac{L_p \,.\, C_L}{W_p}}$$

Tecnología específica

T_{DF}--> Tiempo de Retardo de Bajada



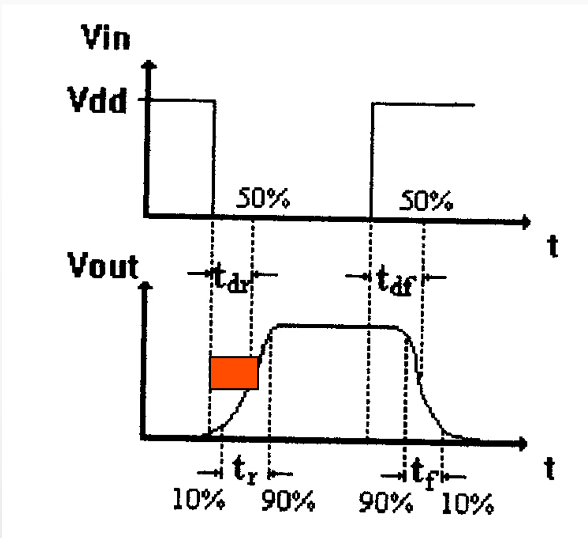
$$t_{df} = \frac{C_L}{\beta_n \, . \, V_{DD} \, . \, (1-n)} \left[\frac{2.n}{1-n} + \ln(3 - 4.n) \right]$$

$$t_{df} \cong c_n \cdot \frac{T_{ox} \, . \, L_n \, . \, C_L}{\varepsilon_{SiO_2} . \, \mu_n \, . \, W_n . \, V_{DD}}$$

Tecnología específica

$$\boxed{t_{df} \cong c_n' \cdot \frac{L_n \, . \, C_L}{W_n \, . \, V_{DD}}}$$

T_{DR}--> Tiempo de Retardo de Subida



Tecnología específica

$$t_{dr} = \frac{C_L}{\beta_p \,.\, V_{DD} \,.\, (1+p)} \left[\frac{-2.p}{1+p} + \ln(3+4.p) \right]$$

$$t_{dr} \cong c_p \cdot \frac{T_{ox} \,.\, L_p \,.\, C_L}{\varepsilon_{SiO_2} \,.\, \mu_p \,.\, W_p \,.\, V_{DD}}$$

$$\boxed{t_{dr} \cong c_p' \cdot \frac{L_p \,.\, C_L}{W_p \,.\, V_{DD}}}$$

DISIPACION DE POTENCIA

i_s : Corriente de saturación inversa

V : Voltaje del diodo

q : Carga del electrón

k : Constante de Boltzman

T^o : Temperatura [^{o}K]

$$i_0 = i_s \left(e^{\frac{q \,.\, V}{k \,.\, T^o}} - 1\right)$$

POTENCIA ESTATICA

$$\boxed{Ps = \sum_{1}^{n} \text{corriente de fuga} \times \text{voltaje de alimentación}}$$

n : Número de dispositivos

POTENCIA DINAMICA

$$P_d = \frac{1}{t_p}\left(\int_0^{tp/2} i_n(t) \,.\, V_{out}(t) \,.\, dt + \int_{tp/2}^{tp} i_p(t) \,.\, (V_{DD} - V_{out}(t)) \,.\, dt \right)$$

i_n : Corriente transitoria del dispositivo n

i_p : Corriente transitoria del dispositivo p

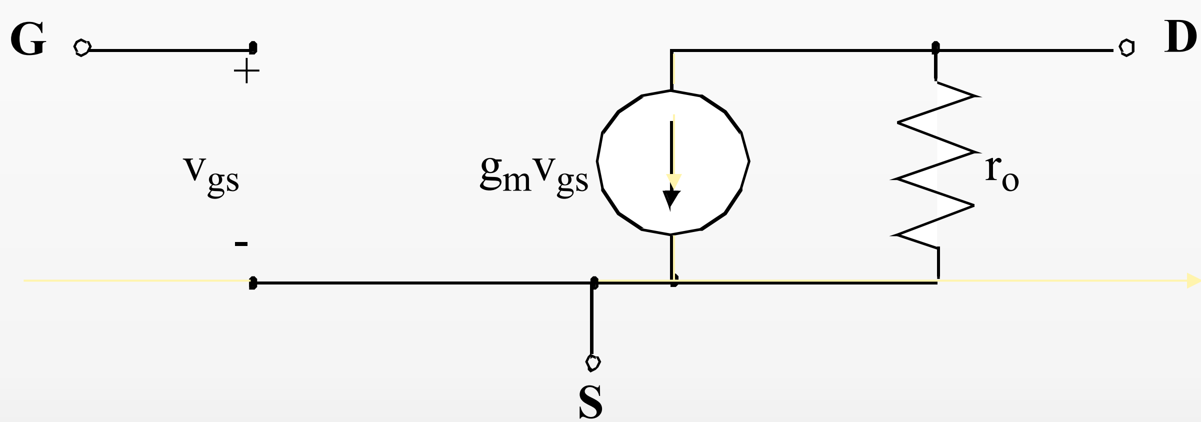
$$i_n(t) = C_L \frac{dV_{out}}{dt} \qquad i_p(t) = C_L \frac{d(V_{DD} - V_{out})}{dt}$$

$$P_d = \frac{C_L \,.\, V_{DD}^2}{t_p}$$

$$\boxed{P_d = C_L \,.\, V_{DD}^2 \,.\, f_p}$$

$$P_d = \frac{C_L}{t_p}\left(\int_0^{V_{DD}} V_{out} \,.\, dV_{out} + \int_{tV_{DD}}^{0} (V_{DD} - V_{out}) \,.\, d(V_{DD} - V_{out}) \right)$$

Modelo Pequeña Señal MOSFET

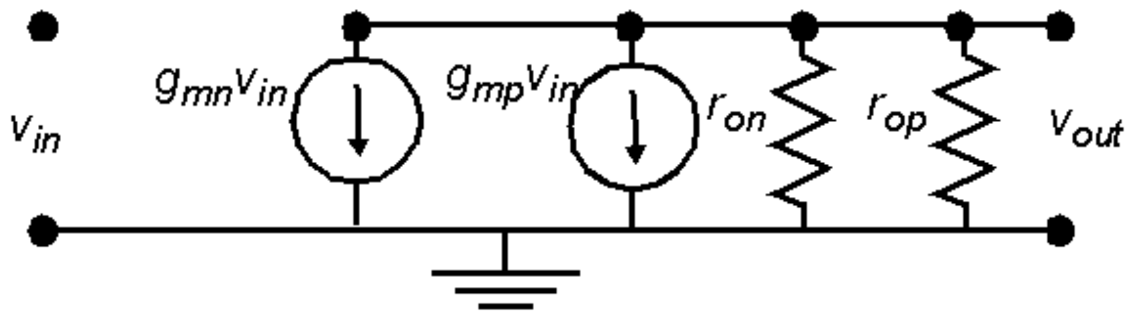


	g_m	r_o
linear	kV_{DS}	$[k(V_{GS}-V_T-V_{DS})]^{-1}$
saturation	$k(V_{GS}-V_T)$	$1/\lambda I_D$

Determinando V_{IH} y V_{IL}

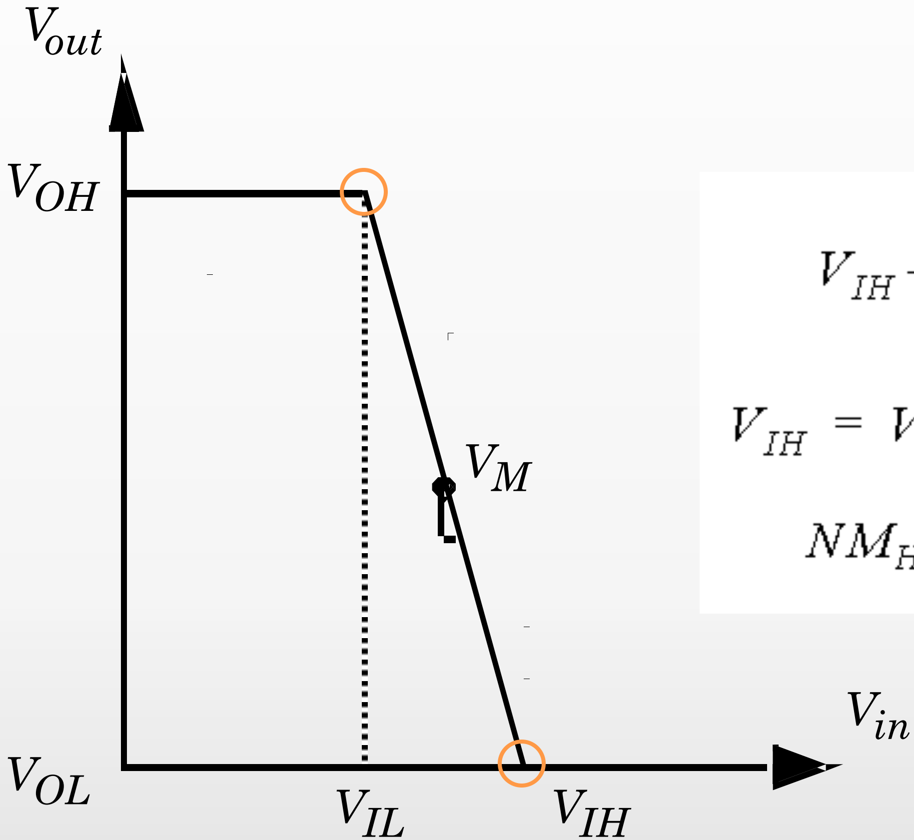
At V_{IH} (V_{IL}): $$\frac{\partial V_{out}}{\partial V_{in}} = -1$$

small-signal model of inverter



$$g = \frac{v_{out}}{v_{in}} = -(g_{mn} + g_{mp}) \times (r_{on} \| r_{op}) = -1$$

MathType 6.7.zip



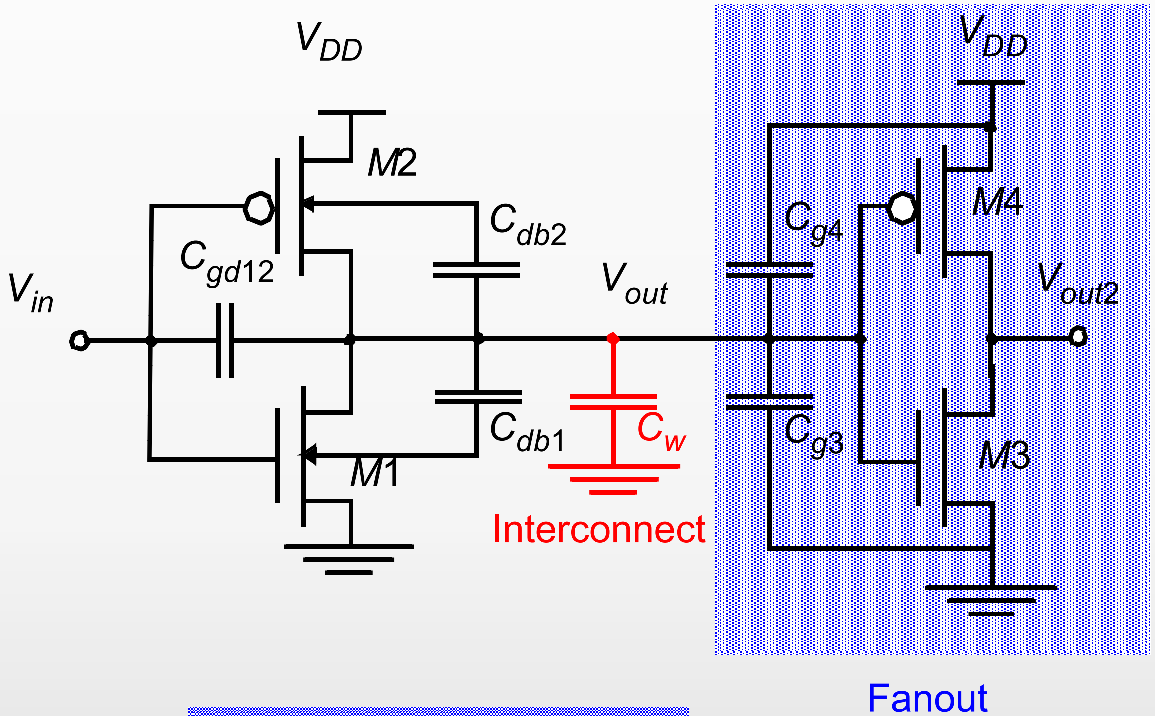
$$V_{IH} - V_{IL} = -\frac{(V_{OH} - V_{OL})}{g} = \frac{-V_{DD}}{g}$$

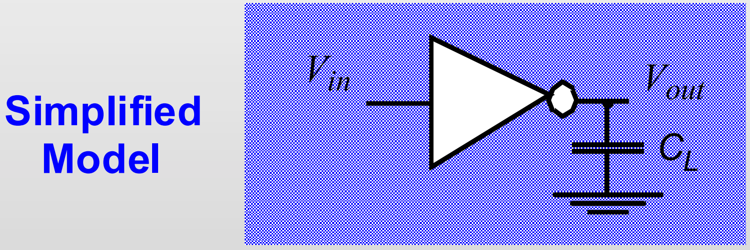
$$V_{IH} = V_M - \frac{V_M}{g} \qquad V_{IL} = V_M + \frac{V_{DD} - V_M}{g}$$

$$NM_H = V_{DD} - V_{IH} \qquad NM_L = V_{IL}$$

Aproximación simplificada

Capacitancias equivalentes





TEMA DE TRABAJO

PROBLEMAS DE CIRCUITOS MICROLECTRONICOS SEDRA/ SMITH :

5.92, 5.93, 5.94, 5.95