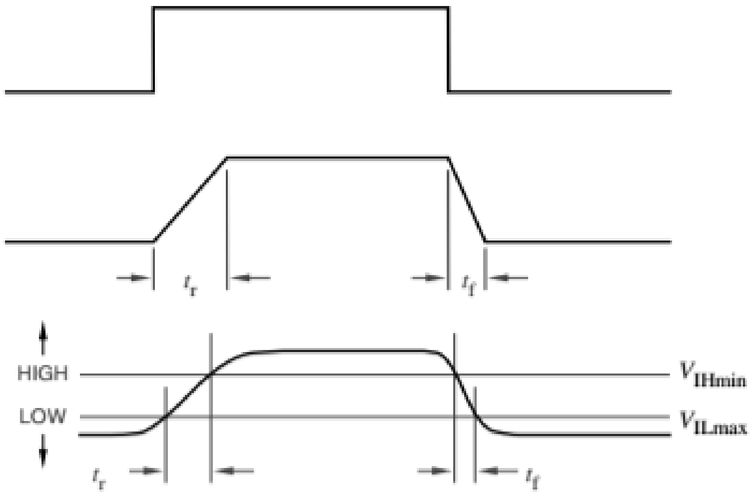
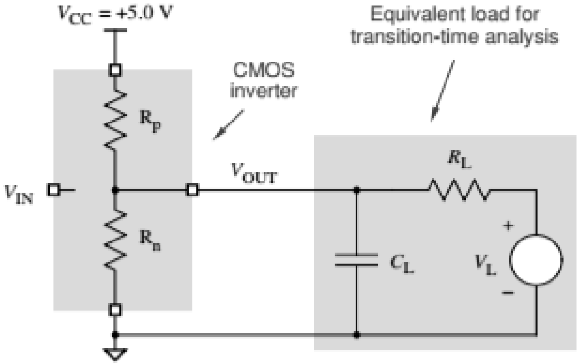
Electrónica III

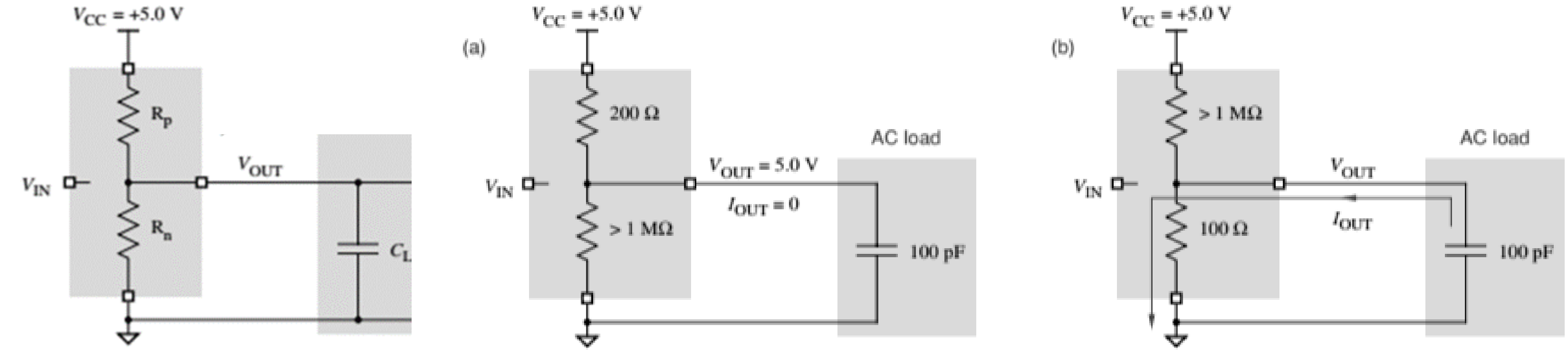
Curso 2021

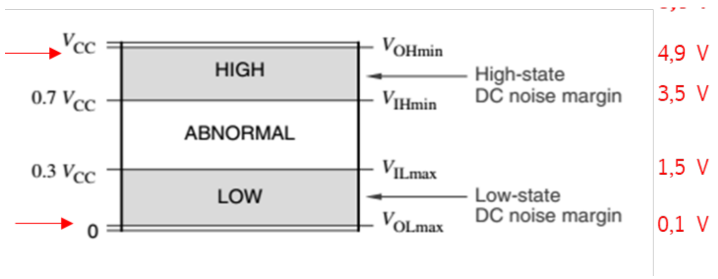
Comportamiento Dinámico

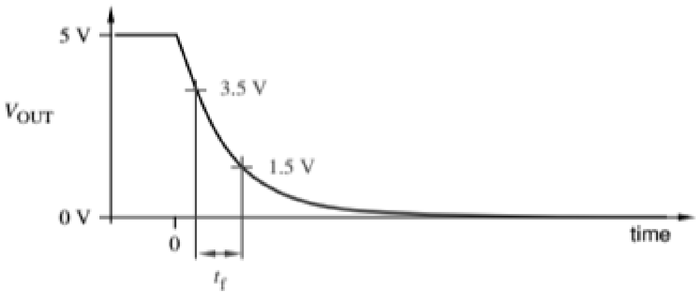
Rise and Fall time









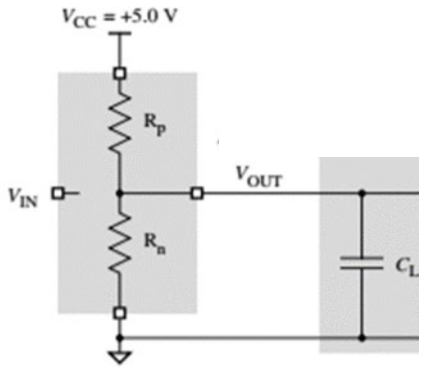


$$V_{OUT} = V_{CC} \cdot e^{-t/(R_n C_L)}$$
$$= 5.0 \cdot e^{-t/(100 \cdot 100 \cdot 10^{-12})} \text{ V}$$
$$= 5.0 \cdot e^{-t/(10 \cdot 10^{-9})} \text{ V}$$

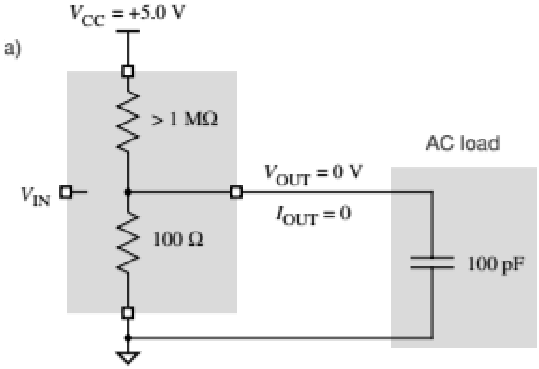
$$t = -R_n C_L \cdot \ln \frac{V_{OUT}}{V_{CC}} = -10 \cdot 10^{-9} \cdot \ln \frac{V_{OUT}}{5.0}$$
$$t_{3.5} = 3.57 \text{ ns}$$
$$t_{1.5} = 12.04 \text{ ns}$$

$t_f = t_{1,5} - t_{3,5}$ = 12,04 ns – 3,57 ns = 8,47 ns

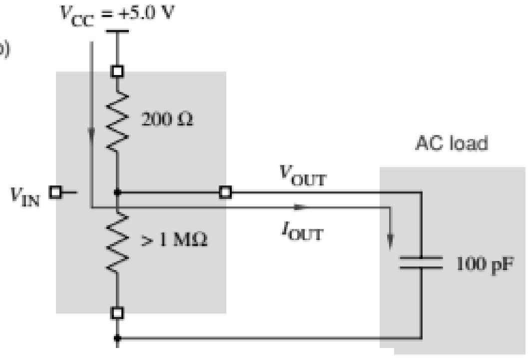
$R_n \times C_L$ = 100 x 100 x 10^{-12} = 10 x 10^{-9} = 10 ns

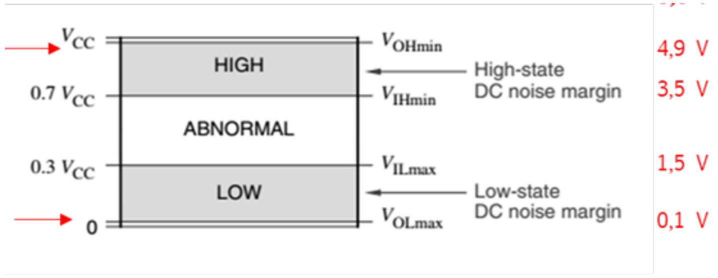


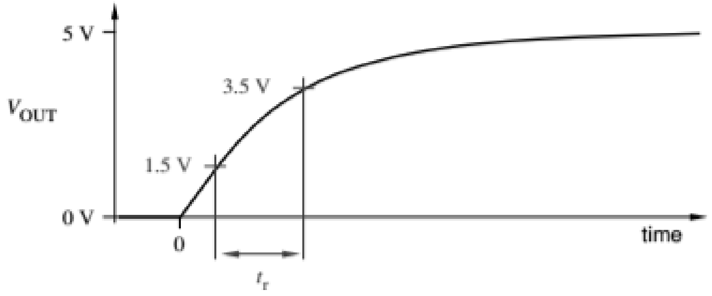
a)



(b)







$$V_{OUT} = V_{CC} \cdot (1 - e^{-t/(R_p C_L)})$$
$$= 5.0 \cdot (1 - e^{-t/(200 \cdot 100 \cdot 10^{-12})}) \text{ V}$$
$$= 5.0 \cdot (1 - e^{-t/(20 \cdot 10^{-9})}) \text{ V}$$

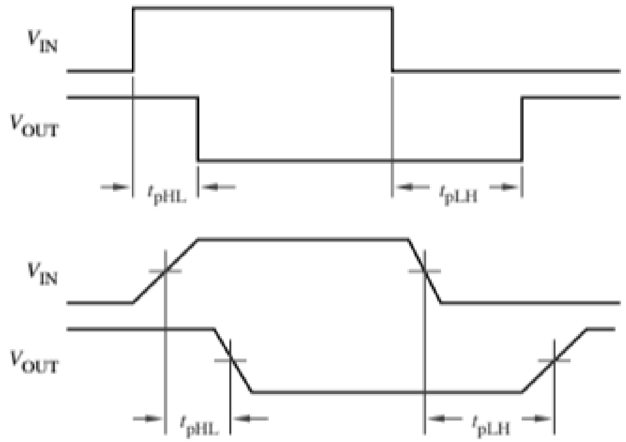
$$t = -RC \cdot \ln \frac{V_{CC} - V_{OUT}}{V_{CC}}$$
$$= -20 \cdot 10^{-9} \cdot \ln \frac{5.0 - V_{OUT}}{5.0}$$

$$t_{1.5} = 7.13 \text{ ns}$$
$$t_{3.5} = 24.08 \text{ ns}$$

$T_r = t_{3,5} - t_{1,5} = 24{,}08 \text{ ns} - 7{,}13 \text{ ns} = 16{,}95 \text{ ns}$

$R_p \times C_L = 200 \times 100 \times 10^{-12} = 20 \times 10^{-9}$ ns

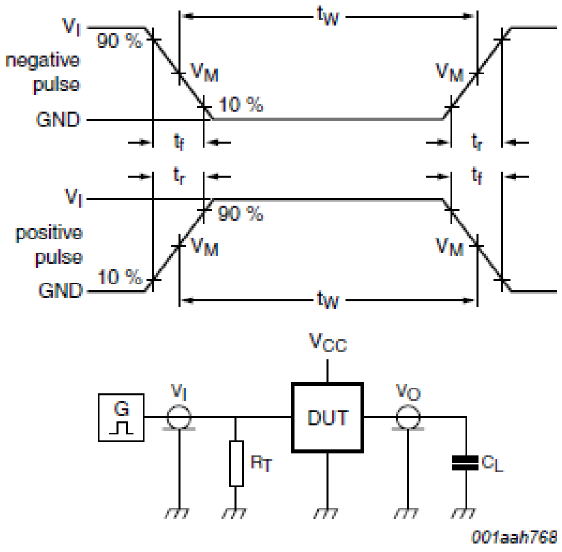
Propagation time



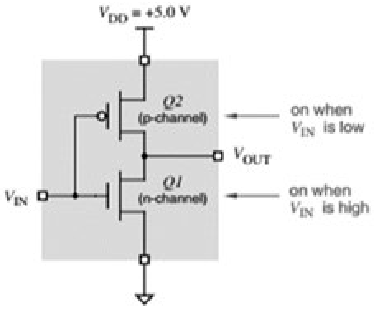
AC CHARACTERISTICS (C_L = 50 pF, Input t_r = t_f = 6 ns)

Symbol	Parameter	V_{CC} (V)	Guaranteed Limit -55 to 25°C	≤85°C	≤125°C	Unit
t_{PLH}, t_{PHL}	Maximum Propagation Delay, Input A or B to Output Y (Figures 1 and 2)	2.0 3.0 4.5 6.0	75 30 15 13	95 40 19 16	110 55 22 19	ns
t_{TLH}, t_{THL}	Maximum Output Transition Time, Any Output (Figures 1 and 2)	2.0 3.0 4.5 6.0	75 27 15 13	95 32 19 16	110 36 22 19	ns
C_{in}	Maximum Input Capacitance		10	10	10	pF

NOTE: For propagation delays with loads other than 50 pF, and information on typical parametric values, see Chapter 2 of the ON Semiconductor High- Speed CMOS Data Book (DL129/D).



Potencia Consumida



C_{pd}	Power dissipation capacitance per gate	No load, T_A = 25°C	20	pF

$$\mathbf{P_{TG} = C_{PD} \cdot V^2_{CC} \cdot f}$$

Potencia Interna

$$f = 1\ \text{MHz}$$

$$V_{CC} = 5\ \text{V}$$

$$C_{PD} = 20\ \text{pF}$$

$$P_{TG} = 20\ \text{pF} \cdot 5^2 \cdot 1\ \text{MHz} = 0{,}5\ \text{mW}$$

$$\mathbf{P_{LG} = C_L \cdot V^2_{CC} \cdot f}$$

Potencia en la carga

$$P_{DG} = P_{TG} + P_{LG} = C_{PD} \cdot V^2_{CC} \cdot f + C_L \cdot V^2_{CC} \cdot f$$

$$\mathbf{P_{DG} = P_{TG} + P_{LG} = (C_{PD} + C_L) \cdot V^2_{CC} \cdot f}$$

Potencia Total x Gate

$$C_L = 10\ \text{pF}$$

$$P_{DG} = P_{TG} + P_{LG} = (20\ \text{pF} + 10\ \text{pF}) \cdot 5^2 \cdot 1\ \text{MHz} = 0{,}75\ \text{mW}$$

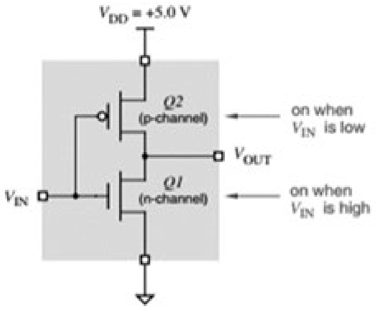
$$\mathbf{P_{integrado} = P_{DG} \cdot 4} = 0{,}75\ \text{mW} \cdot 4 = 3\ \text{mW}$$

Potencia Total x Integrado

I_{CC}	DC Supply Current, V_{CC} and GND Pins	±50	mA
P_D	Power Dissipation in Still Air, SOIC Package† TSSOP Package†	500 450	mW

Potencia Consumida

C_{pd}	Power dissipation capacitance per gate	No load, $T_A = 25°C$	20	pF



$$P_{TG} = C_{PD} \,.\, V^2_{CC} \,.\, f$$

$$f = 1 \text{ MHz}$$

$$V_{CC} = 3{,}3 \text{ V}$$

$$C_{PD} = 20 \text{ pF}$$

$$P_{TG} = 20 \text{ pF} \,.\, 3{,}3^2 \,.\, 1 \text{ MHz} = 0{,}21 \text{ mW}$$

$$P_{LG} = C_L \,.\, V^2_{CC} \,.\, f$$

$$P_{DG} = P_{TG} + P_{LG} = C_{PD} \,.\, V^2_{CC} \,.\, f + C_L \,.\, V^2_{CC} \,.\, f$$

$$P_{DG} = P_{TG} + P_{LG} = (C_{PD} + C_L) \,.\, V^2_{CC} \,.\, f$$

$$C_L = 10 \text{ pF}$$

$$P_{DG} = P_{TG} + P_{LG} = (20 \text{ pF} + 10 \text{ pF}) \,.\, 3{,}3^2 \,.\, 1 \text{ MHz} = 0{,}33 \text{ mW}$$

$$P_{CHIP} = P_{DG} \,.\, 4 = 0{,}33 \text{ mW} \,.\, 4 = 1{,}3 \text{ mW}$$

$$P_{TG} = C_{PD} \,.\, V^2_{CC} \,.\, f$$

$$f = 1 \text{ MHz}$$

$$V_{CC} = 1{,}8 \text{ V}$$

$$C_{PD} = 20 \text{ pF}$$

$$P_{TG} = 20 \text{ pF} \,.\, 1{,}8^2 \,.\, 1 \text{ MHz} = 0{,}06 \text{ mW}$$

$$P_{LG} = C_L \,.\, V^2_{CC} \,.\, f$$

$$P_{DG} = P_{TG} + P_{LG} = C_{PD} \,.\, V^2_{CC} \,.\, f + C_L \,.\, V^2_{CC} \,.\, f$$

$$P_{DG} = P_{TG} + P_{LG} = (C_{PD} + C_L) \,.\, V^2_{CC} \,.\, f$$

$$C_L = 10 \text{ pF}$$

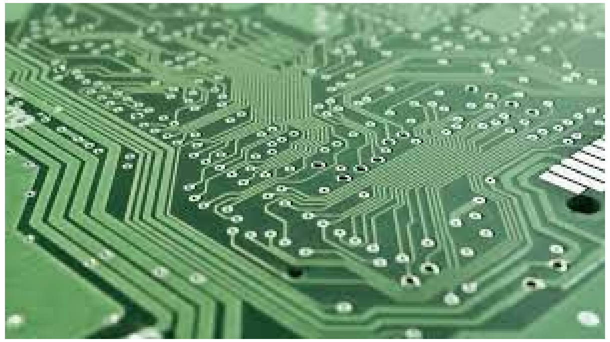
$$P_{DG} = P_{TG} + P_{LG} = (20 \text{ pF} + 10 \text{ pF}) \,.\, 1{,}8^2 \,.\, 1 \text{ MHz} = 0{,}097 \text{ mW}$$

$$P_{CHIP} = P_{DG} \,.\, 4 = 0{,}097 \text{ mW} \,.\, 4 = 0{,}4 \text{ mW}$$

I_{CC}	DC Supply Current, V_{CC} and GND Pins	±50	mA
P_D	Power Dissipation in Still Air, SOIC Package† / TSSOP Package†	500 / 450	mW

ITBA

Consideraciones en Conmutación



Características de una pista de Circuito Impreso
Inductancia = 10 nH por pulgada
Resistencia = 10 mΩ por pulgada
Capacidad = 1 pF por pulgada

Capacidad de Entrada por Pin : Cin = 10 pf

Frecuencia de Operación : Giga Hertz
Tensión de Operación: 5 Volt – 3,3 Volt – 1,8 Volt

		6.0	13	16	19	
C_{in}	Maximum Input Capacitance		10	10	10	pF

$$V = L \cdot \frac{dI}{dt}$$

$$\left(\frac{dI}{dt}\right)_{\text{Max-resistor}} = \frac{\Delta V}{T_t} \cdot \frac{1}{R}$$

R : Resistencia de Carga

ΔV = Tensión de conmutación

T_t : Tiempo de Transición (t_r o t_f , el menor de ambos)

Symbol	Parameter	Vcc (V)	Guaranteed Limit -55 to 25°C	≤85°C	≤125°C	Unit
t_{TLH}, t_{THL}	Maximum Output Transition Time, Any Output (Figures 1 and 2)	2.0	75	95	110	ns
		3.0	27	32	36	
		4.5	15	19	22	
		6.0	13	16	19	

$$\left(\frac{dI}{dt}\right)_{\text{Max-resistor}} = \frac{\Delta V}{T_t} \cdot \frac{1}{R}$$

$R = 1\ K\Omega$

$\Delta V = 5$ Volt

$T_t = 15$ ns

$= 5\ V / (15\ ns\ .\ 1\ K\Omega) = 3{,}3\ .\ 10^5\ A/s$

Si lo aplico a mi fórmula

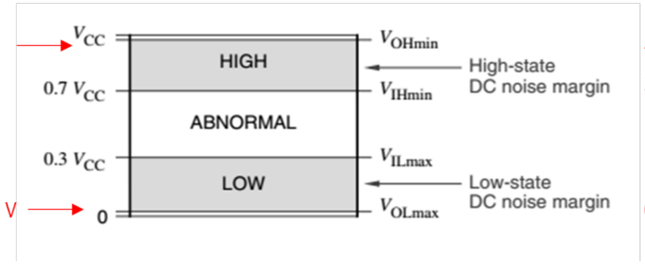
$$V = L \cdot \frac{dI}{dt}$$

$V = 10\ .\ 10^{-9}\ .\ 3{,}3\ .\ 10^5 = 3{,}3$ mV

	5,0 V	3,3 V
NMH =	1,4 V	0,9 V
NML =	1,4 V	0,9 V

Vcc – 0,1 V

GND + 0,1 V



	5,0 V	3,3 V
V_{OHmin}	4,9 V	3,2 V
V_{IHmin}	3,5 V	2,3 V
V_{ILmax}	1,5 V	1 V
V_{OLmax}	0,1 V	0,1 V

Que pasa si

$R = 250\ \Omega$

$\Delta V = 5$ Volt

$T_t = 1$ ns

$= 5\ V / (1\ ns\ .\ 250\ \Omega) = 20\ .\ 10^6\ A/s$

V = $10\ .\ 10^{-9} \times 20\ .\ 10^6 =$ **200 mV**

Supongamos que trabajamos en 3,3 Volt

$R = 250\ \Omega$

$\Delta V = 3{,}3$ Volt

$T_t = 1$ ns

$= 3{,}3\ V / (1\ ns\ .\ 250\ \Omega) = 13{,}2\ .\ 10^6\ A/s$

V = $10\ .\ 10^{-9} \times 13{,}2\ .\ 10^6 =$ **132 mV**

Finalmente en 1,8 Volt

$R = 250\ \Omega$

$\Delta V = 1{,}8$ Volt

$T_t = 1$ ns

$= 1{,}8\ V / (1\ ns\ .\ 250\ \Omega) = 7{,}2\ .\ 10^6\ A/s$

V = $10\ .\ 10^{-9} \times 7{,}2\ .\ 10^6 =$ **72 mV**

Ground Bounce

$$\left(\frac{dI}{dt}\right)_{\text{Max-capacitor}} = \frac{1.52\Delta V}{T_t^2}\cdot C$$

A modo de ejemplo:

C = 50 pF

ΔV = 5 Volt

T_t = 5 ns

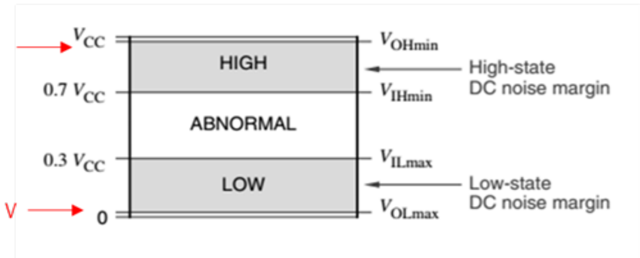
= (1,52 . 5 V / (5 ns)^2) . 50 pF = 1,52 . 10^7 A/s

V = 10 . 10^{-9} x (1,52 . 10^7) = **152 mV**

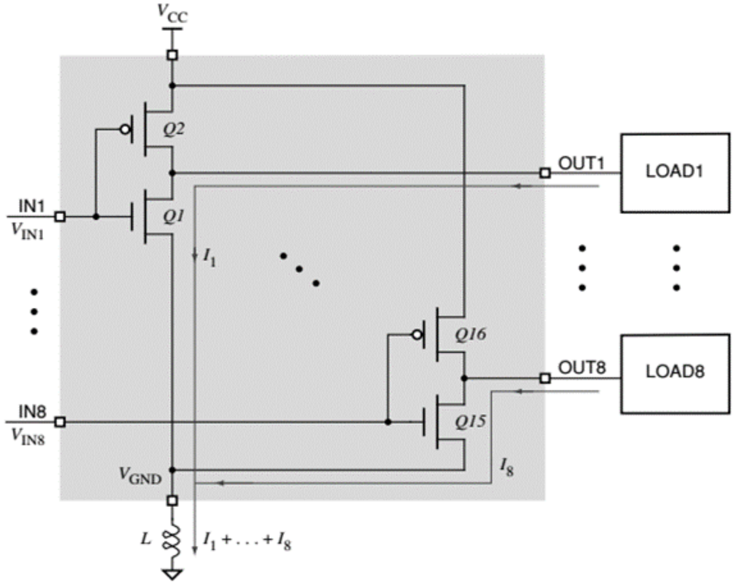
	5,0 V	3,3 V
NMH =	1,4 V	0,9 V
NML =	1,4 V	0,9 V

Vcc – 0,1 V

GND + 0,1 V



5,0 V	3,3 V
4,9 V	3,2 V
3,5 V	2,3 V
1,5 V	1 V
0,1 V	0,1 V



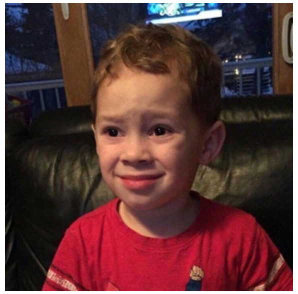
C = 50 pF

ΔV = 5 Volt

T_t = 5 ns

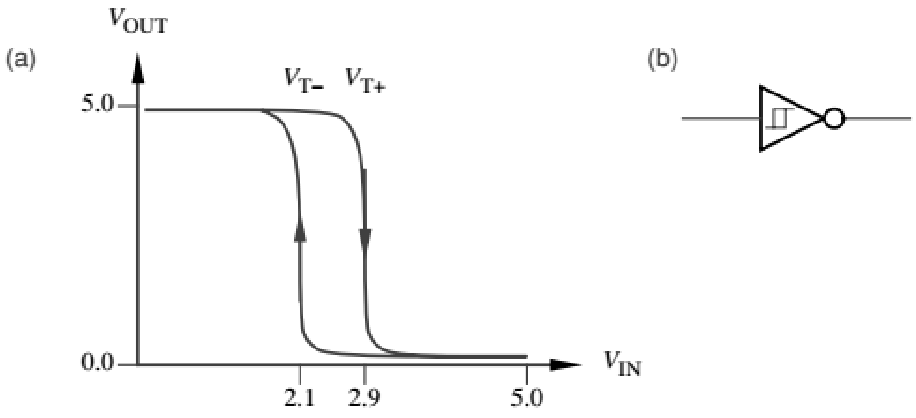
= (1,52 . 5 V / (5 ns)^2) . 50 pF = 1,52 . 10^7 A/s

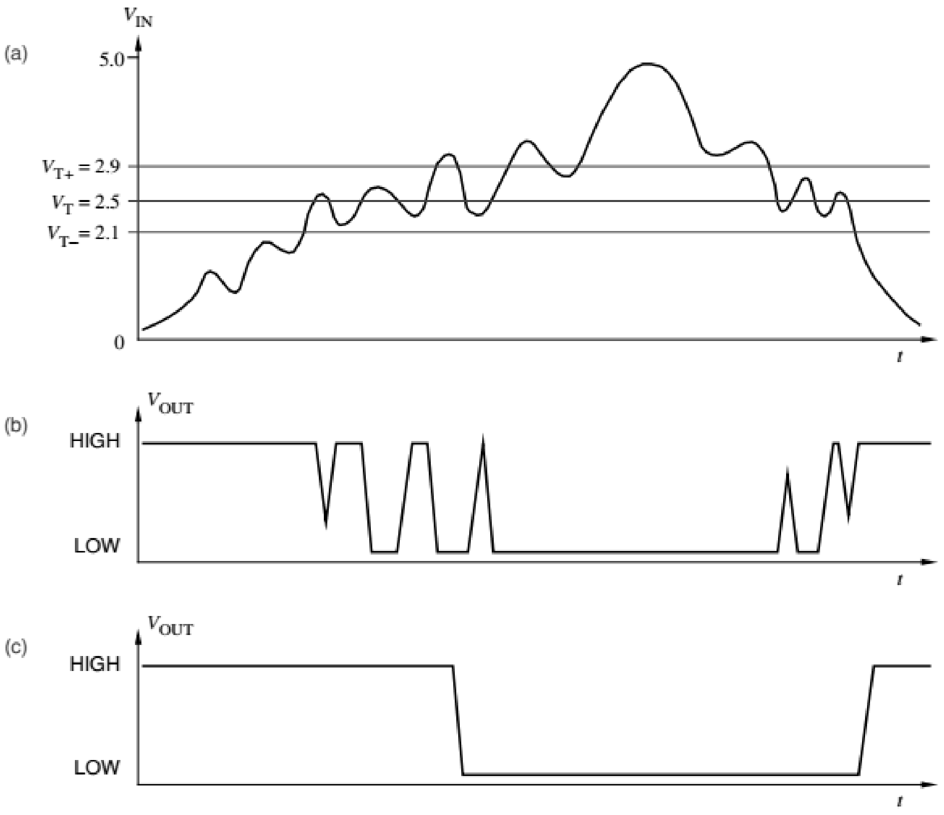
V = 10 . 10^{-9} x 8 x (1,52 . 10^7) = **1,216 V**



Circuitos Especiales

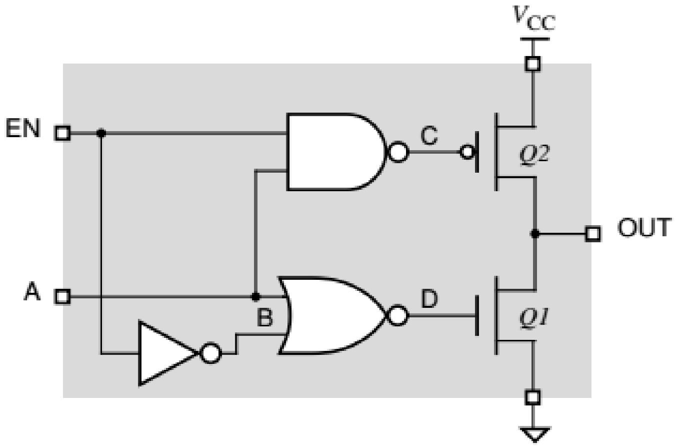
Schmitt Trigger





Three State

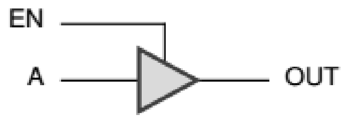
(a)



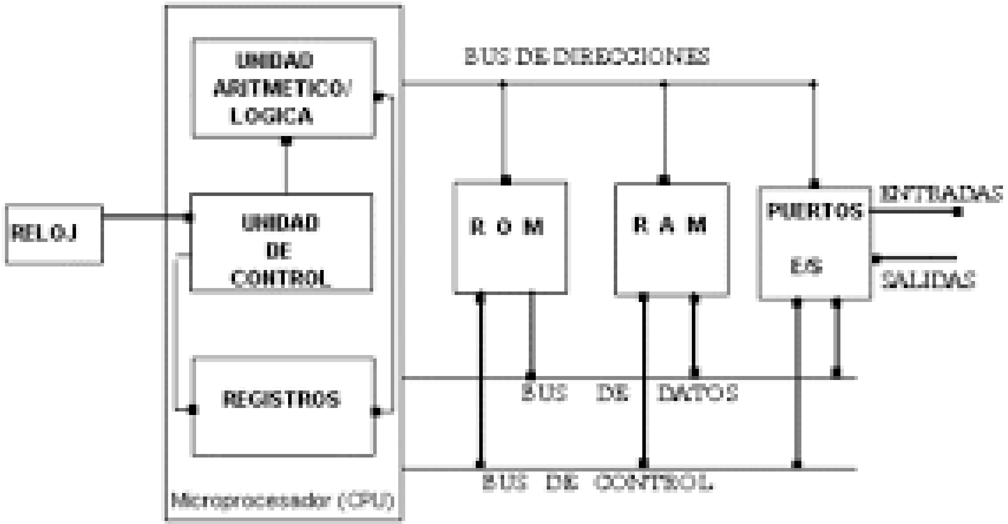
(b)

EN	A	B	C	D	*Q1*	*Q2*	OUT
L	L	H	H	L	off	off	Hi-Z
L	H	H	H	L	off	off	Hi-Z
H	L	L	H	H	on	off	L
H	H	L	L	L	off	on	H

(c)



Three State



UNIDAD
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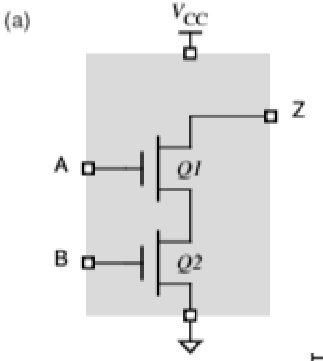
LOGICA
BUS DE DIRECCIONES
RELOJ
UNIDAD
DE
CONTROL
R O M
R A M
PUERTOS
E/S
ENTRADAS
SALIDAS
REGISTROS
BUS DE DATOS
BUS DE CONTROL
Microprocesador (CPU)

Open Drain

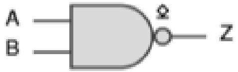
(a)

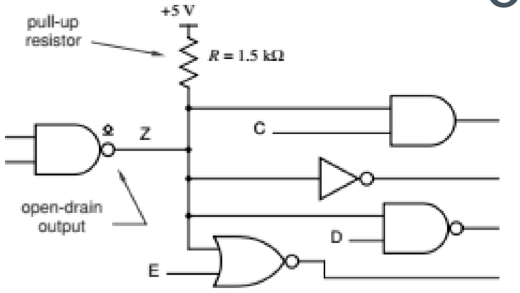


(b)

A	B	Q1	Q2	Z
L	L	off	off	open
L	H	off	on	open
H	L	on	off	open
H	H	on	on	L

(c)





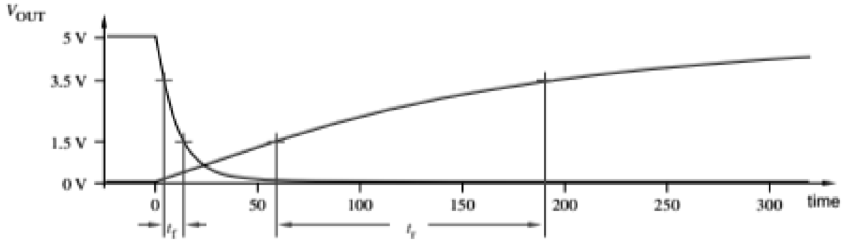
V_{OH}	Minimum High-Level Output Voltage	$V_{in} = V_{IH}$ or V_{IL} $\lvert I_{out}\rvert \le 20\mu A$	2.0 4.5 6.0	1.9 4.4 5.9	1.9 4.4 5.9	1.9 4.4 5.9	V
		$V_{in} = V_{IH}$ or V_{IL} $\lvert I_{out}\rvert \le 2.4mA$ $\lvert I_{out}\rvert \le 4.0mA$ $\lvert I_{out}\rvert \le 5.2mA$	3.0 4.5 6.0	2.48 3.98 5.48	2.34 3.84 5.34	2.20 3.70 5.20	

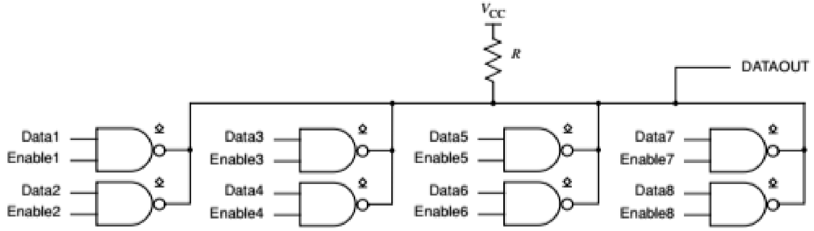
$R_{pull\ up} = V_{cc} / I_{OLmax} = 5\ V / 4\ mA = 1250\ \Omega = 1{,}2\ K\Omega = 1K2$

Si la capacidad de carga es $C_L = 100\ pF$

$t_f = R_n \times C_L = 100\ \Omega \times 100\ pF = 10\ ns$

$t_r = R_{pull\ up} \times C_L = 1{,}\ 2\ K\Omega \times 100\ pF = 120\ ns$





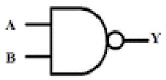
Familias CMOS

Description	Part	Symbol	Condition	Family HC	HCT	AHC	AHCT
Typical propagation delay (ns)	'00	t_{PD}		9	10	3.7	5
	'138			18	20	5.7	7.6
Quiescent power-supply current (μA)	'00	I_{CC}	$V_{in} = 0$ or V_{CC}	2.5	2.5	5.0	5.0
	'138		$V_{in} = 0$ or V_{CC}	40	40	40	40
Quiescent power dissipation (mW)	'00		$V_{in} = 0$ or V_{CC}	0.0125	0.0125	0.025	0.025
	'138		$V_{in} = 0$ or V_{CC}	0.2	0.2	0.2	0.2
Power-dissipation capacitance (pF)	'00	C_{PD}		22	15	2.4	2.6
	'138	C_{PD}		55	51	13	14
Dynamic power dissipation (mW/MHz)	'00			0.55	0.38	0.06	0.065
	'138			1.38	1.28	0.33	0.35
Total power dissipation (mW)	'00		$f = 100$ kHz	0.068	0.050	0.031	0.032
	'00		$f = 1$ MHz	0.56	0.39	0.085	0.09
	'00		$f = 10$ MHz	5.5	3.8	0.63	0.68
	'138		$f = 100$ kHz	0.338	0.328	0.23	0.24
	'138		$f = 1$ MHz	1.58	1.48	0.53	0.55
	'138		$f = 10$ MHz	14.0	13.0	3.45	3.7

Description	Symbol	Condition	Family HC	HCT	AHC	AHCT
LOW-level output current (mA)	I_{OLmaxC}	CMOS load	0.02	0.02	0.05	0.05
	I_{OLmaxT}	TTL load	4.0	4.0	8.0	8.0
LOW-level output voltage (V)	V_{OLmaxC}	$I_{out} \le I_{OLmaxC}$	0.1	0.1	0.1	0.1
	V_{OLmaxT}	$I_{out} \le I_{OLmaxT}$	0.33	0.33	0.44	0.44
HIGH-level output current (mA)	I_{OHmaxC}	CMOS load	–0.02	–0.02	–0.05	–0.05
	I_{OHmaxT}	TTL load	–4.0	–4.0	–8.0	–8.0
HIGH-level output voltage (V)	V_{OHminC}	$\|I_{out}\| \le \|I_{OHmaxC}\|$	4.4	4.4	4.4	4.4
	V_{OHminT}	$\|I_{out}\| \le \|I_{OHmaxT}\|$	3.84	3.84	3.80	3.80

Familias TTL

Description	Symbol	Family 74S	74LS	74AS	74ALS	74F
Maximum propagation delay (ns)		3	9	1.7	4	3
Power consumption per gate (mW)		19	2	8	1.2	4
LOW-level input voltage (V)	V_{ILmax}	0.8	0.8	0.8	0.8	0.8
LOW-level output voltage (V)	V_{OLmax}	0.5	0.5	0.5	0.5	0.5
HIGH-level input voltage (V)	V_{IHmin}	2.0	2.0	2.0	2.0	2.0
HIGH-level output voltage (V)	V_{OHmin}	2.7	2.7	2.7	2.7	2.7
LOW-level input current (mA)	I_{ILmax}	–2.0	–0.4	–0.5	–0.2	–0.6
LOW-level output current (mA)	I_{OLmax}	20	8	20	8	20
HIGH-level input current (μA)	I_{IHmax}	50	20	20	20	20
HIGH-level output current (μA)	I_{OHmax}	–1000	–400	–2000	–400	–1000



Inputs		output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0