TEXAS INSTRUMENTS
Data sheet acquired from Harris Semiconductor
SCHS115A – Revised November 1999

CD4093B Types

CMOS Quad 2-Input NAND Schmitt Triggers

High-Voltage Types (20 Volt Rating)

■ CD4093B consists of four Schmitt-trigger circuits. Each circuit functions as a two-input NAND gate with Schmitt-trigger action on both inputs. The gate switches at different points for positive- and negative-going signals. The difference between the positive voltage (V_P) and the negative voltage (V_N) is defined as hysteresis voltage (V_H) (see Fig. 2).

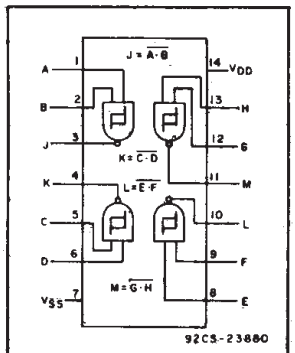
The CD4093 types are supplied in a 14-lead hermetic dual-in-line ceramic package (F suffix), 14-lead dual-in-line plastic package (E suffix), 14-lead dual-in-line plastic small-outline package (M), and in chip form (H suffix). Add the suffix 96 to the M package for tape and reel.

Features:

- Schmitt-trigger action on each input with no external components
- Hysteresis voltage typically 0.9 V at V_{DD} = 5 V and 2.3 V at V_{DD} = 10 V
- Noise immunity greater than 50%
- No limit on input rise and fall times
- Standardized, symmetrical output characteristics
- 100% tested for quiescent current at 20 V
- Maximum input current of 1 μA at 18 V over full package-temperature range, 100 nA at 18 V and 25°C
- 5-V, 10-V, and 15-V parametric ratings
- Meets all requirements of JEDEC **Standard No. 13B,** "Standard Specifications for Description of 'B' Series CMOS Devices"

Applications:

- Wave and pulse shapers
- High-noise-environment systems
- Monostable multivibrators
- Astable multivibrators
- NAND logic



FUNCTIONAL DIAGRAM

RECOMMENDED OPERATING CONDITIONS

For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges.

CHARACTERISTIC	MIN.	MAX.	UNITS
Supply Voltage Range (T_A = Full Package Temp. Range)	3	18	V

MAXIMUM RATINGS, ***Absolute-Maximum Values:***

DC SUPPLY-VOLTAGE RANGE, (V_{DD})
Voltages referenced to V_{SS} Terminal) ..... -0.5V to +20V
INPUT VOLTAGE RANGE, ALL INPUTS ..... -0.5V to V_{DD} +0.5V
DC INPUT CURRENT, ANY ONE INPUT ..... ±10mA
PACKAGE THERMAL IMPEDANCE, θ_{JA} (See Note 1):
E package ..... 80°C/W
M package ..... 86°C/W
DEVICE DISSIPATION PER OUTPUT TRANSISTOR
FOR T_A = FULL PACKAGE-TEMPERATURE RANGE (All Package Types) 100mW
OPERATING-TEMPERATURE RANGE (T_A) ..... -55°C to +125°C
STORAGE TEMPERATURE RANGE (T_{stg}) ..... -65°C to +150°C
LEAD TEMPERATURE (DURING SOLDERING):
At distance 1/16 ± 1/32 inch (1.59 ± 0.79mm) from case for 10s max ..... +265°C

NOTE 1: Package thermal impedance is calculated in accordance with JESD 51.

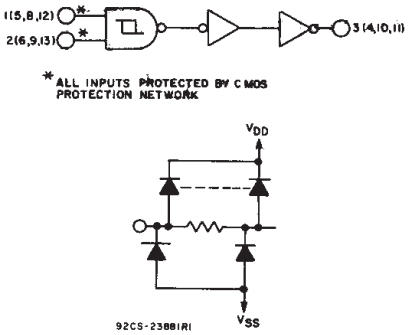
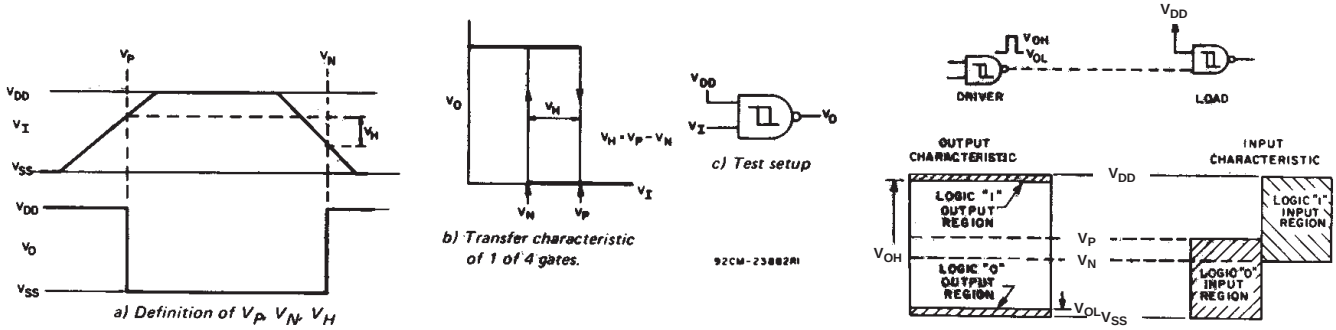


Fig. 1 – Logic diagram – 1 of 4 Schmitt triggers.



a) Definition of V_P, V_N, V_H

b) Transfer characteristic of 1 of 4 gates.

c) Test setup

Fig. 2 – Hysteresis definition, characteristic, and test setup.

Fig. 3 – Input and output characteristics.

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STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS			LIMITS AT INDICATED TEMPERATURES (°C)							UNITS
	V_O (V)	V_{IN} (V)	V_{DD} (V)	−55	−40	+85	+125	+25 MIN.	+25 TYP.	+25 MAX.	
Quiescent Device Current, I_{DD} Max.	–	0,5	5	1	1	30	30	–	0.02	1	μA
	–	0,10	10	2	2	60	60	–	0.02	2	
	–	0,15	15	4	4	120	120	–	0.02	4	
	–	0,20	20	20	20	600	600	–	0.04	20	
Positive Trigger Threshold Voltage V_P Min.	–	a	5	2.2	2.2	2.2	2.2	2.2	2.9	–	V
	–	a	10	4.6	4.6	4.6	4.6	4.6	5.9	–	
	–	a	15	6.8	6.8	6.8	6.8	6.8	8.8	–	
	–	b	5	2.6	2.6	2.6	2.6	2.6	3.3	–	
	–	b	10	5.6	5.6	5.6	5.6	5.6	7	–	
	–	b	15	6.3	6.3	6.3	6.3	6.3	9.4	–	
V_P Max.	–	a	5	3.6	3.6	3.6	3.6	–	2.9	3.6	V
	–	a	10	7.1	7.1	7.1	7.1	–	5.9	7.1	
	–	a	15	10.8	10.8	10.8	10.8	–	8.8	10.8	
	–	b	5	4	4	4	4	–	3.3	4	
	–	b	10	8.2	8.2	8.2	8.2	–	7	8.2	
	–	b	15	12.7	12.7	12.7	12.7	–	9.4	12.7	
Negative Trigger Threshold Voltage V_N Min.	–	a	5	0.9	0.9	0.9	0.9	0.9	1.9	–	V
	–	a	10	2.5	2.5	2.5	2.5	2.5	3.9	–	
	–	a	15	4	4	4	4	4	5.8	–	
	–	b	5	1.4	1.4	1.4	1.4	1.4	2.3	–	
	–	b	10	3.4	3.4	3.4	3.4	3.4	5.1	–	
	–	b	15	4.8	4.8	4.8	4.8	4.8	7.3	–	
V_N Max.	–	a	5	2.8	2.8	2.8	2.8	–	1.9	2.8	V
	–	a	10	5.2	5.2	5.2	5.2	–	3.9	5.2	
	–	a	15	7.4	7.4	7.4	7.4	–	5.8	7.4	
	–	b	5	3.2	3.2	3.2	3.2	–	2.3	3.2	
	–	b	10	6.6	6.6	6.6	6.6	–	5.1	6.6	
	–	b	15	9.6	9.6	9.6	9.6	–	7.3	9.6	
Hysteresis Voltage V_H Min.	–	a	5	0.3	0.3	0.3	0.3	0.3	0.9	–	V
	–	a	10	1.2	1.2	1.2	1.2	1.2	2.3	–	
	–	a	15	1.6	1.6	1.6	1.6	1.6	3.5	–	
	–	b	5	0.3	0.3	0.3	0.3	0.3	0.9	–	
	–	b	10	1.2	1.2	1.2	1.2	1.2	2.3	–	
	–	b	15	1.6	1.6	1.6	1.6	1.6	3.5	–	
V_H Max.	–	a	5	1.6	1.6	1.6	1.6	–	0.9	1.6	V
	–	a	10	3.4	3.4	3.4	3.4	–	2.3	3.4	
	–	a	15	5	5	5	5	–	3.5	5	
	–	b	5	1.6	1.6	1.6	1.6	–	0.9	1.6	
	–	b	10	3.4	3.4	3.4	3.4	–	2.3	3.4	
	–	b	15	5	5	5	5	–	3.5	5	

[a] Input on terminals 1,5,8,12 or 2,6,9,13; other inputs to V_{DD}.

[b] Input on terminals 1 and 2, 5 and 6,8 and 9, or 12 and 13; other inputs to V_{DD}.

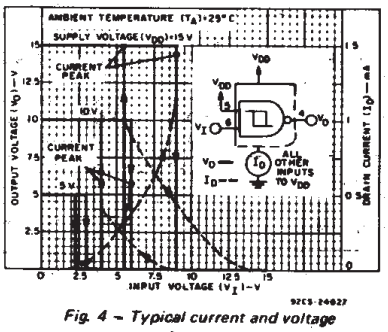


Fig. 4 – Typical current and voltage transfer characteristics.

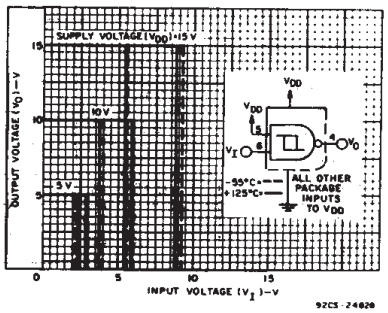


Fig. 5 – Typical voltage transfer characteristics as a function of temperature.

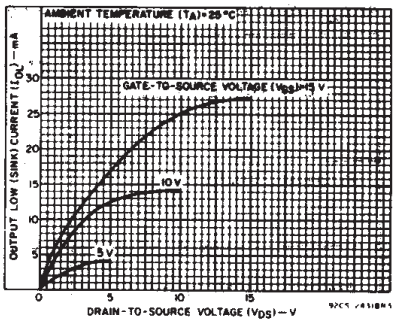


Fig. 6 – Typical output low (sink) current characteristics.

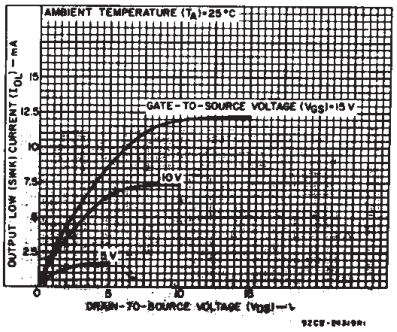


Fig 7 – Minimum output low (sink) current characteristics.

STATIC ELECTRICAL CHARACTERISTICS (CONT'D)

CHARACTERISTIC	CONDITIONS			LIMITS AT INDICATED TEMPERATURES (°C)							UNITS
	V_O (V)	V_{IN} (V)	V_{DD} (V)	−55	−40	+85	+125	+25 MIN.	+25 TYP.	+25 MAX.	
Output Low (Sink) Current, I_{OL} Min.	0.4	0,5	5	0.64	0.61	0.42	0.36	0.51	1	–	mA
	0.5	0,10	10	1.6	1.5	1.1	0.9	1.3	2.6	–	
	1.5	0,15	15	4.2	4	2.8	2.4	3.4	6.8	–	
Output High (Source) Current, I_{OH} Min.	4.6	0,5	5	−0.64	−0.61	−0.42	−0.36	−0.51	−1	–	
	2.5	0,5	5	−2	−1.8	−1.3	−1.15	−1.6	−3.2	–	
	9.5	0,10	10	−1.6	−1.5	−1.1	−0.9	−1.3	−2.6	–	
	13.5	0,15	15	−4.2	−4	−2.8	−2.4	−3.4	−6.8	–	
Output Voltage Low-Level, V_{OL} Max.	–	0,5	5	0.05				–	0	0.05	V
	–	0,10	10	0.05				–	0	0.05	
	–	0,15	15	0.05				–	0	0.05	
Output Voltage High-Level, V_{OH} Min.	–	0,5	5	4.95				4.95	5	–	
	–	0,10	10	9.95				9.95	10	–	
	–	0,15	15	14.95				14.95		–	
Input Current, I_{IN} Max.	–	0,18	18	±0.1	±0.1	±1	±1	–	$\pm 10^{-5}$	±0.1	μA

DYNAMIC ELECTRICAL CHARACTERISTICS

At $T_A = 25°C$; Input t_r, $t_f = 20$ ns, $C_L = 50$ pF, $R_L = 200k\Omega$

CHARACTERISTIC	TEST CONDITIONS	V_{DD} VOLTS	LIMITS TYP.	LIMITS MAX.	UNITS
Propagation Delay Time: t_{PHL}, t_{PLH}		5	190	380	ns
		10	90	180	
		15	65	130	
Transition Time, t_{THL}, t_{TLH}		5	100	200	ns
		10	50	100	
		15	40	80	
Input Capacitance, C_{IN}	Any Input		5	7.5	pF

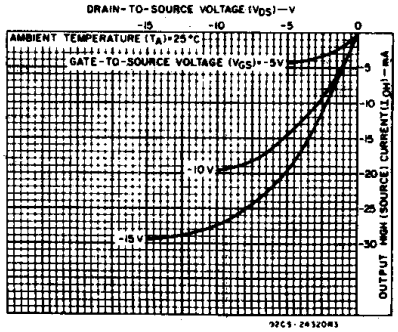


Fig. 8 – Typical output high (source) current characteristics.

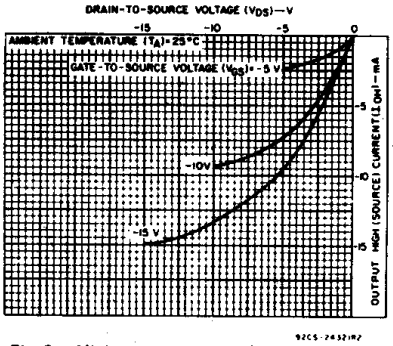


Fig. 9 – Minimum output high (source) current characteristics.

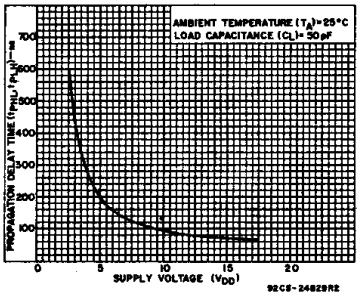


Fig. 10 – Typical propagation delay time vs. supply voltage.

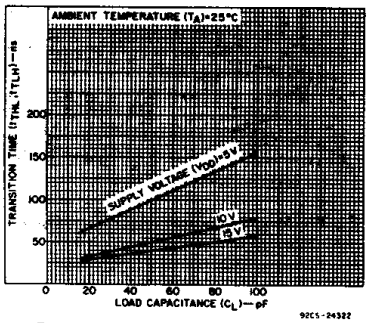


Fig. 11 – Typical transition time vs. load capacitance.

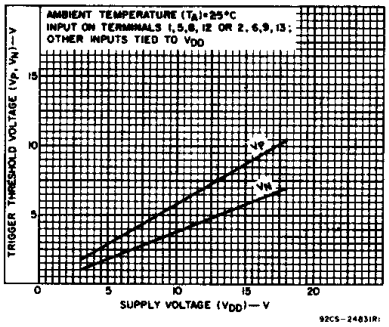


Fig. 12 – Typical trigger threshold voltage vs. V_{DD}

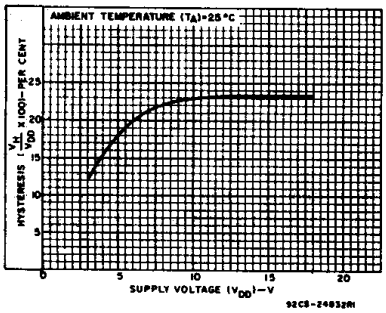


Fig. 13 – Typical per cent hysteresis vs. supply voltage.

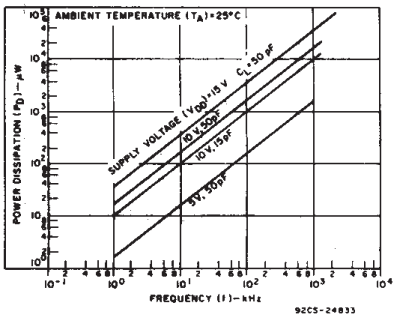


Fig. 14 – Typical power dissipation vs. frequency characteristics.

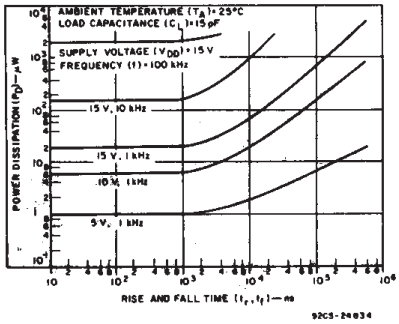


Fig. 15 – Typical power dissipation vs. rise and fall times.

APPLICATIONS

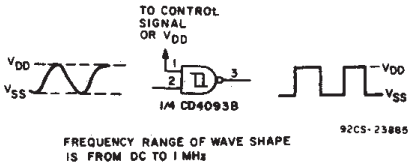


Fig. 16 – Wave shaper.

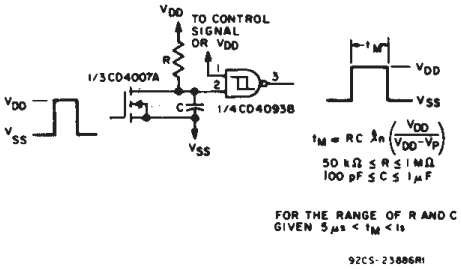


Fig. 17 – Monostable multivibrator.

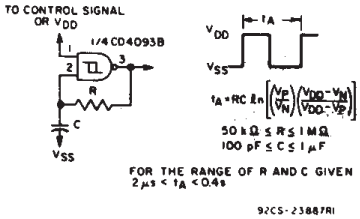


Fig. 18 – Astable multivibrator.

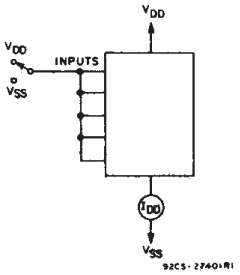


Fig. 19 – Quiescent device current test circuit.

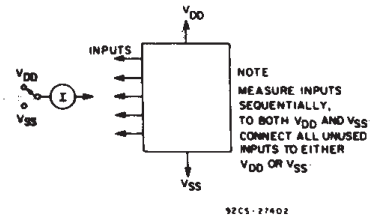
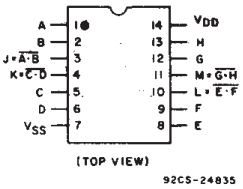


Fig. 20 – Input current test circuit.



TERMINAL ASSIGNMENT

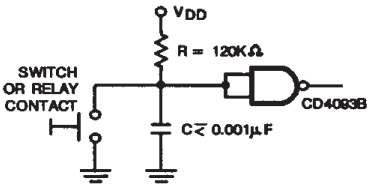


Fig. 21 – Contact Debaucer

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FAIRCHILD SEMICONDUCTOR™

October 1987
Revised January 1999

CD4093BC
Quad 2-Input NAND Schmitt Trigger

General Description

The CD4093B consists of four Schmitt-trigger circuits. Each circuit functions as a 2-input NAND gate with Schmitt-trigger action on both inputs. The gate switches at different points for positive and negative-going signals. The difference between the positive (V_T^+) and the negative voltage (V_T^-) is defined as hysteresis voltage (V_H).

All outputs have equal source and sink currents and conform to standard B-series output drive (see Static Electrical Characteristics).

Features

- Wide supply voltage range: 3.0V to 15V
- Schmitt-trigger on each input with no external components
- Noise immunity greater than 50%
- Equal source and sink currents
- No limit on input rise and fall time
- Standard B-series output drive
- Hysteresis voltage (any input) $T_A = 25°C$

Typical	$V_{DD} = 5.0V$	$V_H = 1.5V$
	$V_{DD} = 10V$	$V_H = 2.2V$
	$V_{DD} = 15V$	$V_H = 2.7V$
Guaranteed		$V_H = 0.1\ V_{DD}$

Applications

- Wave and pulse shapers
- High-noise-environment systems
- Monostable multivibrators
- Astable multivibrators
- NAND logic

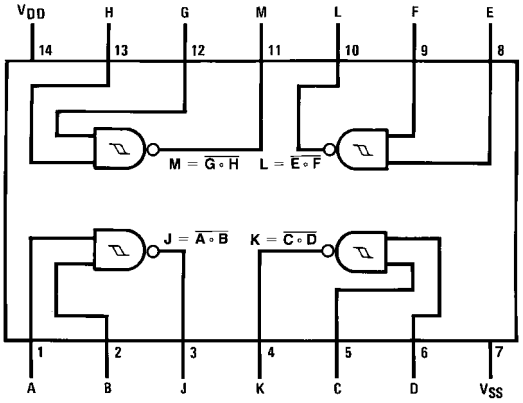
Ordering Code:

Order Number	Package Number	Package Description
CD4093BCM	M14A	14-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-120, 0.150" Narrow Body
CD4093BCN	N14A	14-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide

Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

Connection Diagram

Pin Assignments for SOIC and DIP



Top View

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Absolute Maximum Ratings (Note 1)

(Note 2)

DC Supply Voltage (V_{DD})	–0.5 to +18 V_{DC}
Input Voltage (V_{IN})	–0.5 to V_{DD} +0.5 V_{DC}
Storage Temperature Range (T_S)	–65°C to +150°C
Power Dissipation (P_D)	
Dual-In-Line	700 mW
Small Outline	500 mW
Lead Temperature (T_L)	
(Soldering, 10 seconds)	260°C

Recommended Operating Conditions (Note 2)

DC Supply Voltage (V_{DD})	3 to 15 V_{DC}
Input Voltage (V_{IN})	0 to V_{DD} V_{DC}
Operating Temperature Range (T_A)	–40°C to +85°C

Note 1: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed; they are not meant to imply that the devices should be operated at these limits. The table of "Recommended Operating Conditions" and "Electrical Characteristics" provides conditions for actual device operation.

Note 2: V_{SS} = 0V unless otherwise specified.

DC Electrical Characteristics (Note 2)

Symbol	Parameter	Conditions	–40°C		+25°C			+85°C		Units
			Min	Max	Min	Typ	Max	Min	Max	
I_{DD}	Quiescent Device Current	V_{DD} = 5V		1.0			1.0		7.5	µA
		V_{DD} = 10V		2.0			2.0		15.0	µA
		V_{DD} = 15V		4.0			4.0		30.0	µA
V_{OL}	LOW Level Output Voltage	$V_{IN} = V_{DD}$, $\|I_O\| < 1$ µA								
		V_{DD} = 5V		0.05		0	0.05		0.05	V
		V_{DD} = 10V		0.05		0	0.05		0.05	V
		V_{DD} = 15V		0.05		0	0.05		0.05	V
V_{OH}	HIGH Level Output Voltage	$V_{IN} = V_{SS}$, $\|I_O\| < 1$ µA								
		V_{DD} = 5V	4.95		4.95	5		4.95		V
		V_{DD} = 10V	9.95		9.95	10		9.95		V
		V_{DD} = 15V	14.95		14.95	15		14.95		V
V_{T-}	Negative-Going Threshold Voltage (Any Input)	$\|I_O\| < 1$ µA								
		V_{DD} = 5V, V_O = 4.5V	1.3	2.25	1.5	1.8	2.25	1.5	2.3	V
		V_{DD} = 10V, V_O = 9V	2.85	4.5	3.0	4.1	4.5	3.0	4.65	V
		V_{DD} = 15V, V_O = 13.5V	4.35	6.75	4.5	6.3	6.75	4.5	6.9	V
V_{T+}	Positive-Going Threshold Voltage (Any Input)	$\|I_O\| < 1$ µA								
		V_{DD} = 5V, V_O = 0.5V	2.75	3.6	2.75	3.3	3.5	2.65	3.5	V
		V_{DD} = 10V, V_O = 1V	5.5	7.15	5.5	6.2	7.0	5.35	7.0	V
		V_{DD} = 15V, V_O = 1.5V	8.25	10.65	8.25	9.0	10.5	8.1	10.5	V
V_H	Hysteresis ($V_{T+} - V_{T-}$) (Any Input)	V_{DD} = 5V	0.5	2.35	0.5	1.5	2.0	0.35	2.0	V
		V_{DD} = 10V	1.0	4.3	1.0	2.2	4.0	0.70	4.0	V
		V_{DD} = 15V	1.5	6.3	1.5	2.7	6.0	1.20	6.0	V
I_{OL}	LOW Level Output Current (Note 3)	$V_{IN} = V_{DD}$								
		V_{DD} = 5V, V_O = 0.4V	0.52		0.44	0.88		0.36		mA
		V_{DD} = 10V, V_O = 0.5V	1.3		1.1	2.25		0.9		mA
		V_{DD} = 15V, V_O = 1.5V	3.6		3.0	8.8		2.4		mA
I_{OH}	HIGH Level Output Current (Note 3)	$V_{IN} = V_{SS}$								
		V_{DD} = 5V, V_O = 4.6V	–0.52		0.44	–0.88		–0.36		mA
		V_{DD} = 10V, V_O = 9.5V	–1.3		–1.1	–2.25		–0.9		mA
		V_{DD} = 15V, V_O = 13.5V	–3.6		–3.0	–8.8		–2.4		mA
I_{IN}	Input Current	V_{DD} = 15V, V_{IN} = 0V		–0.3		-10^{-5}	–0.3		–1.0	µA
		V_{DD} = 15V, V_{IN} = 15V		0.3		10^{-5}	0.3		1.0	µA

Note 3: I_{OH} and I_{OL} are tested one output at a time.

AC Electrical Characteristics (Note 4)

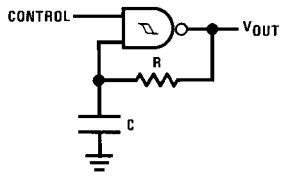
$T_A = 25°C$, $C_L = 50$ pF, $R_L = 200k$, Input t_r, $t_f = 20$ ns, unless otherwise specified

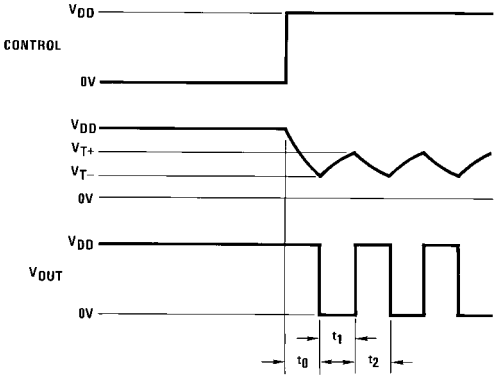
Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{PHL}, t_{PLH}	Propagation Delay Time	$V_{DD} = 5V$		300	450	ns
		$V_{DD} = 10V$		120	210	ns
		$V_{DD} = 15V$		80	160	ns
t_{THL}, t_{TLH}	Transition Time	$V_{DD} = 5V$		90	145	ns
		$V_{DD} = 10V$		50	75	ns
		$V_{DD} = 15V$		40	60	ns
C_{IN}	Input Capacitance	(Any Input)		5.0	7.5	pF
C_{PD}	Power Dissipation Capacitance	(Per Gate)		24		pF

Note 4: AC Parameters are guaranteed by DC correlated testing.

Typical Applications

Gated Oscillator





Assume $t_1 + t_2 >> t_{PHL} + t_{PLH}$ then:

$t_0 = RC\ \ell n\ [V_{DD}/V_{T-}]$

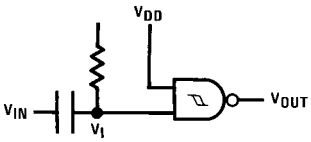
$t_1 = RC\ \ell n\ [(V_{DD} - V_{T-})/(V_{DD} - V_{T+})]$

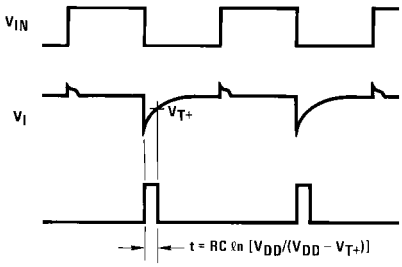
$t_2 = RC\ \ell n\ [V_{T+}/V_{T-}]$

$$f = \frac{1}{t_1 + t_2} = \frac{1}{RC\ \ell n \dfrac{(V_{T+})(V_{DD} - V_{T-})}{(V_{T-})(V_{DD} - V_{T+})}}$$

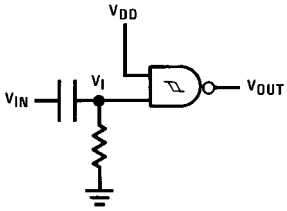
Gated One-Shot

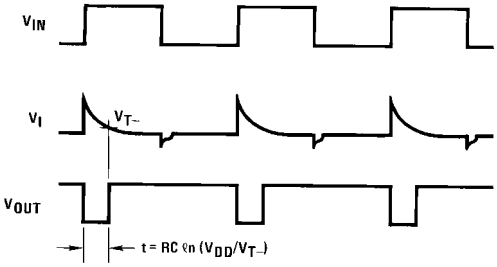
(a) Negative-Edge Triggered





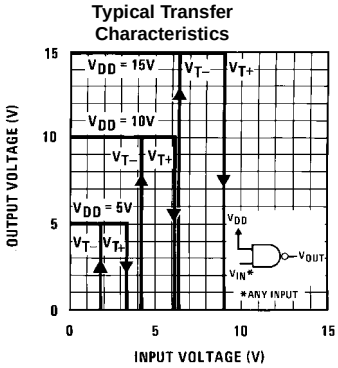
(b) Positive-Edge Triggered



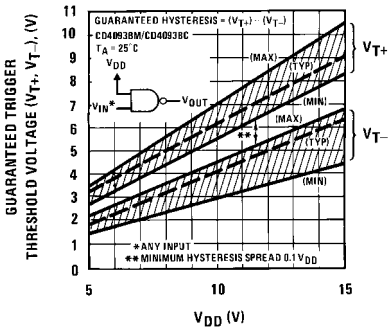


Typical Performance Characteristics

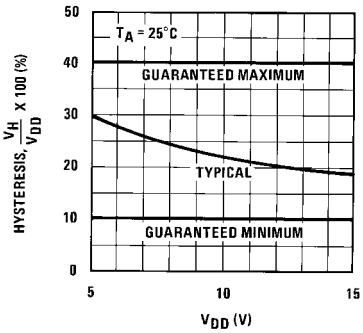
Typical Transfer Characteristics



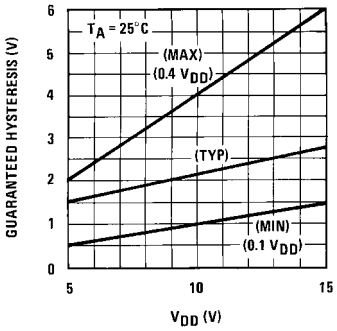
Guaranteed Trigger Threshold Voltage vs V_{DD}



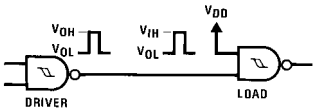
Guaranteed Hysteresis vs V_{DD}



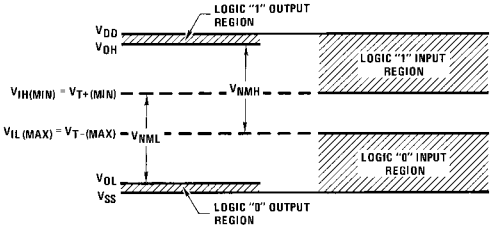
Guaranteed Hysteresis vs V_{DD}



Input and Output Characteristics



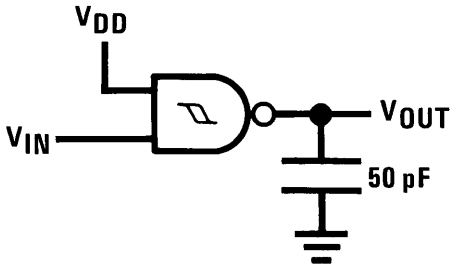
Output Characteristic Input Characteristic

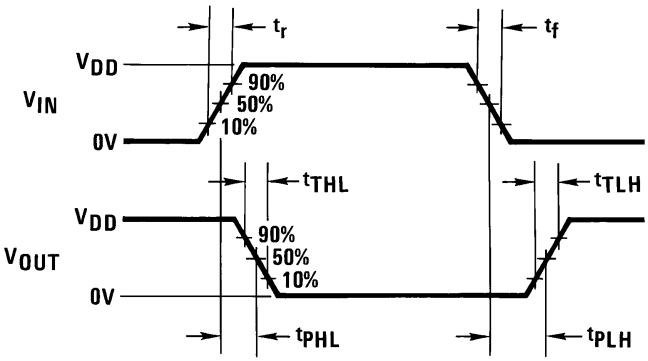


$V_{NML} = V_{IH(MIN)} - V_{OL} \cong V_{IH(MIN)} = V_{T^+(MIN)}$

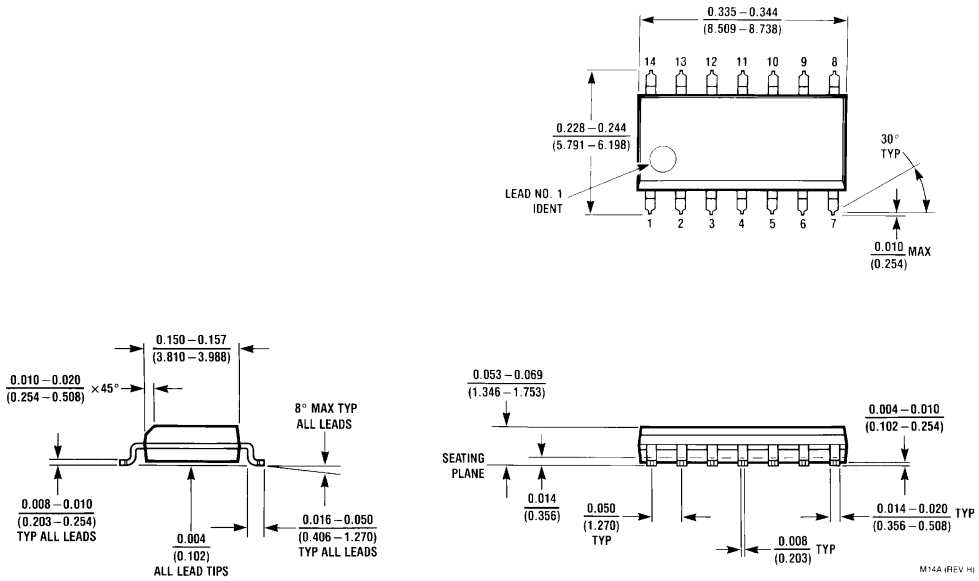
$V_{NMH} = V_{OH} - V_{IL(MAX)} \cong V_{DD} - V_{IL(MAX)} = V_{DD} - V_{T^-(MAX)}$

AC Test Circuits and Switching Time Waveforms



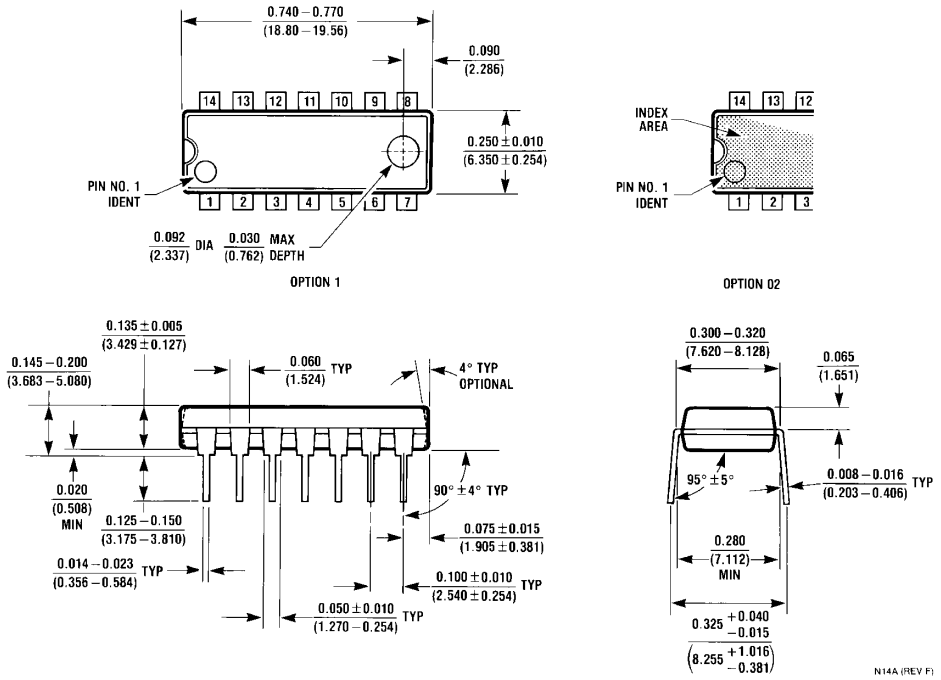


Physical Dimensions inches (millimeters) unless otherwise noted



14-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-120, 0.150" Narrow Body
Package Number M14A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



14-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide
Package Number N14A

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