National Semiconductor

CD4093BM/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 3.0 V to 15 V
- 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) $T_A = 25°C$

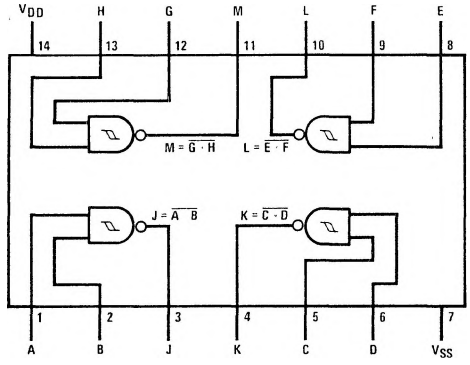
Typical	$V_{DD} = 5.0\,V$	$V_H = 1.5\,V$
	$V_{DD} = 10\,V$	$V_H = 2.2\,V$
	$V_{DD} = 15\,V$	$V_H = 2.7\,V$
Guaranteed		$V_H = 0.1\,V_{DD}$

Applications

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

Connection Diagram

Dual-In-Line Package



Absolute Maximum Ratings

(Notes 1 and 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
Package Dissipation (P_D)	500 mW
Lead Temperature (Soldering, 10 seconds) (T_L)	300°C

Recommended Operating Conditions

(Note 2)

V_{DD} dc Supply Voltage	3 to 15 V_{DC}
V_{IN} Input Voltage	0 to V_{DD} V_{DC}
T_A Operating Temperature Range	
CD4093BM	−55°C to +125°C
CD4093BC	−40°C to +85°C

DC Electrical Characteristics CD4093BM (Note 2)

PARAMETER		CONDITIONS	−55°C		25°C			125°C		UNITS
			MIN	MAX	MIN	TYP	MAX	MIN	MAX	
I_{DD}	Quiescent Device Current	V_{DD} = 5V		0.25			0.25		7.5	μA
		V_{DD} = 10V		0.5			0.5		15.0	μA
		V_{DD} = 15V		1.0			1.0		30.0	μA
V_{OL}	Low Level Output Voltage	V_{IN} = V_{DD}, $\|I_O\| < 1\mu A$								
		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}, $\|I_O\| < 1\mu A$								
		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	$\|I_O\| < 1\mu A$								
	(Any Input)	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	$\|I_O\| < 1\mu A$								
	(Any Input)	V_{DD} = 5V, V_O = 0.5V	2.75	3.65	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 ($V_{T+} - V_{T-}$)	V_{DD} = 5V	0.5	2.35	0.5	1.5	2.0	0.35	2.0	V
	(Any Input)	V_{DD} = 10V	1.0	4.30	1.0	2.2	4.0	0.70	4.0	V
		V_{DD} = 15V	1.5	6.30	1.5	2.7	6.0	1.20	6.0	V
I_{OL}	Low Level Output Current	V_{IN} = V_{DD}								
		V_{DD} = 5V, V_O = 0.4V	0.64		0.51	0.88		0.36		mA
		V_{DD} = 10V, V_O = 0.5V	1.6		1.3	2.25		0.9		mA
		V_{DD} = 15V, V_O = 1.5V	4.2		3.4	8.8		2.4		mA
I_{OH}	High Level Output Current	V_{IN} = V_{SS}								
		V_{DD} = 5V, V_O = 4.6V	−0.64		0.51	−0.88		−0.36		mA
		V_{DD} = 10V, V_O = 9.5V	−1.6		−1.3	−2.25		−0.9		mA
		V_{DD} = 15V, V_O = 13.5V	−4.2		−3.4	−8.8		−2.4		mA
I_{IN}	Input Current	V_{DD} = 15V, V_{IN} = 0V		−0.1		-10^{-5}	−0.1		−1.0	μA
		V_{DD} = 15V, V_{IN} = 15V		0.1		10^{-5}	0.1		1.0	μA

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 CD4093BC (Note 2)

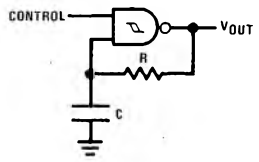
PARAMETER		CONDITIONS	−40°C		25°C			+85°C		UNITS
			MIN	MAX	MIN	TYP	MAX	MIN	MAX	
I_{DD}	Quiescent Device Current	V_{DD} = 5V		1.0			1.0		7.5	μA
		V_{DD} = 10V		2.0			2.0		15.0	μA
		V_{DD} = 15V		4.0			4.0		30.0	μA
V_{OL}	Low Level Output Voltage	V_{IN} = V_{DD}, $\|I_O\| < 1\mu A$								
		V_{DD} = 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}, $\|I_O\| < 1\mu A$								
		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	$\|I_O\| < 1\mu A$								
	(Any Input)	V_{DD} = 5V, V_O = 4.5V	1.3	2.25	1.5	1.8	2.25	1.5	2.30	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	$\|I_O\| < 1\mu A$								
	(Any Input)	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 ($V_{T+} - V_{T-}$)	V_{DD} = 5V	0.5	2.35	0.5	1.5	2.0	0.35	2.0	V
	(Any Input)	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	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	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		−8.0	−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

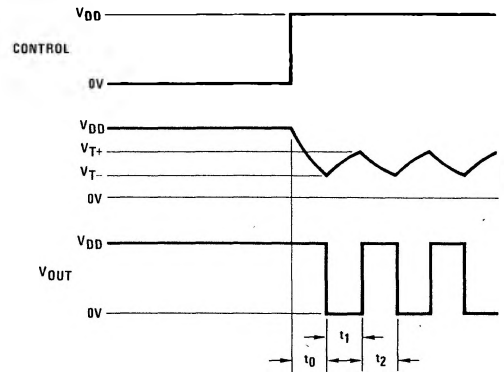
AC Electrical Characteristics T_A = 25°C, C_L = 50 pF, R_L = 200k, Input t_r, t_f = 20 ns, unless otherwise specified.

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
t_{PHL}, t_{PLH}	Propagation Delay Time	V_{DD} = 5V		300	600	ns
		V_{DD} = 10V		120	300	ns
		V_{DD} = 15V		80	240	ns
t_{THL}, t_{TLH}	Transition Time	V_{DD} = 5V		90	200	ns
		V_{DD} = 10V		50	100	ns
		V_{DD} = 15V		40	80	ns
C_{IN}	Average Input Capacitance			5.0	7.5	pF
C_{PD}	Power Dissipation Capacitance			24		pF

Typical Applications

Gated Oscillator





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

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

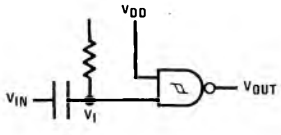
$t_1 = RC \ln [(V_{DD} - V_{T-})/(V_{DD} + V_{T+})]$

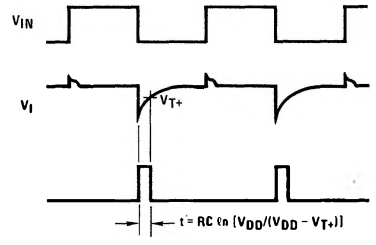
$t_2 = RC \ln [V_{T+}/V_{T-}]$

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

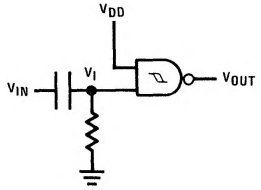
Gated One-Shot

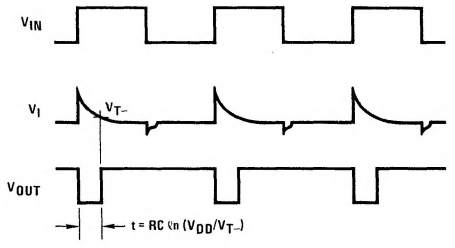
(a) Negative-Edge Triggered





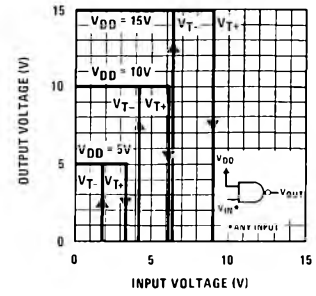
(b) Positive-Edge Triggered



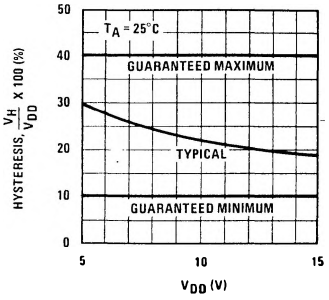


Typical Performance Characteristics

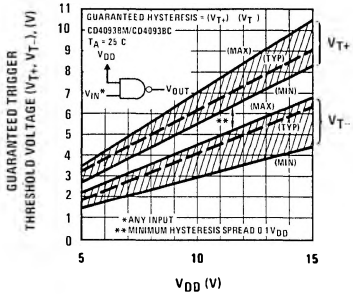
Typical Transfer Characteristics



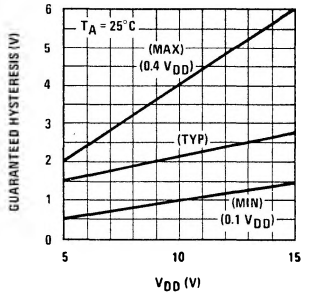
Guaranteed Hysteresis vs V_{DD}



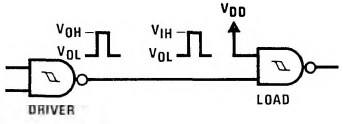
Guaranteed Trigger Threshold Voltage vs V_{DD}

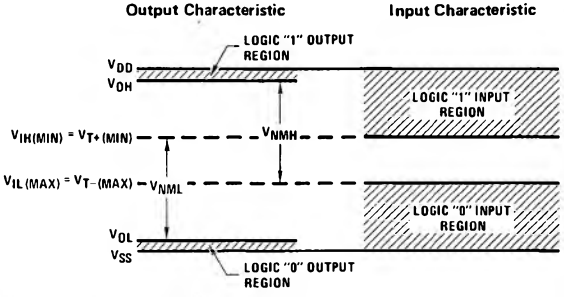


Guaranteed Hysteresis vs V_{DD}



Input and Output Characteristics





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

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

AC Test Circuits and Switching Time Waveforms