

## CMOS QUAD LOW-TO-HIGH VOLTAGE SHIFTER

Check for Samples: [CD40109B-Q1](#)

### FEATURES

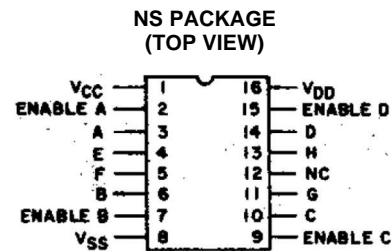
- Qualified for Automotive Applications
- Independent of Power Supply Sequence Considerations
  - $V_{CC}$  Can Exceed  $V_{DD}$
  - Input Signals can Exceed Both  $V_{CC}$  and  $V_{DD}$
- Up and Down Level-Shifting Capability
- Three-State Outputs With Separate Enable Controls
- Standardized Symmetrical Output Characteristics
- 100% Tested for Quiescent Current at 20 V
- Maximum Input Current:
  - 1  $\mu$ A at 18 V Over Full Package-Temperature Range
  - 100 nA at 18 V and 25°C
- Noise Margin (Full Package-Temperature Range):
  - 1 V at  $V_{CC} = 5$  V,  $V_{DD} = 10$  V
  - 2 V at  $V_{CC} = 10$  V,  $V_{DD} = 15$  V
- 5-V, 10-V, and 15-V Parametric Ratings
- Meets All Requirements of JEDEC Tentative Standard No. 13B, "Standard specifications for

### Description of 'B' Series CMOS Devices"

- Latch-Up Performance Meets 50 mA per JESD 78, Class I

### APPLICATIONS

- High-or-Low Level-Shifting With Three-State Outputs for Unidirectional or Bidirectional Bussing
- Isolation of Logic Subsystem Using Separate Power Supplies from Supply Sequencing, Supply Loss, and Supply Regulation Considerations



### DESCRIPTION

CD40109B contains four low-to-high-voltage level-shifting circuits. Each circuit will shift a low-voltage digital-logic input signal (A, B, C, D) with logical 1 =  $V_{CC}$  and logical 0 =  $V_{SS}$  to a high-voltage output signal (E, F, G, H) with logical 1 =  $V_{DD}$  and logical 0 =  $V_{SS}$ .

The RCA-CD40109, unlike other low-to-high level-shifting circuits, does not require the presence of the high-voltage supply ( $V_{DD}$ ) before the application of either the low-voltage supply ( $V_{CC}$ ) or the input signals. There are no restrictions on the sequence of application of  $V_{DD}$ ,  $V_{CC}$ , or the input signals. In addition, with one exception there are no restrictions on the relative magnitudes of the supply voltages or input signals within the device maximum ratings, provided that the input signal swings between  $V_{SS}$  and at least 0.7  $V_{CC}$ ;  $V_{CC}$  may exceed  $V_{DD}$ , and input signals may exceed  $V_{CC}$  and  $V_{DD}$ . When operated in the mode  $V_{CC} > V_{DD}$ , the CD40109 will operate as a high-to-low level-shifter.

The CD40109 also features individual three-state output capability. A low level on any of the separately enabled three-state output controls produces a high-impedance state in the corresponding output.

### ORDERING INFORMATION<sup>(1)</sup>

$T_A$	PACKAGE <sup>(2)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	SOIC – NS	Reel of 2000	CD40109BQNSRQ1	CD40109BQ

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).
- (2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

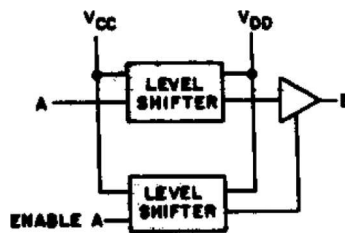
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

**TRUTH TABLE<sup>(1)</sup>**

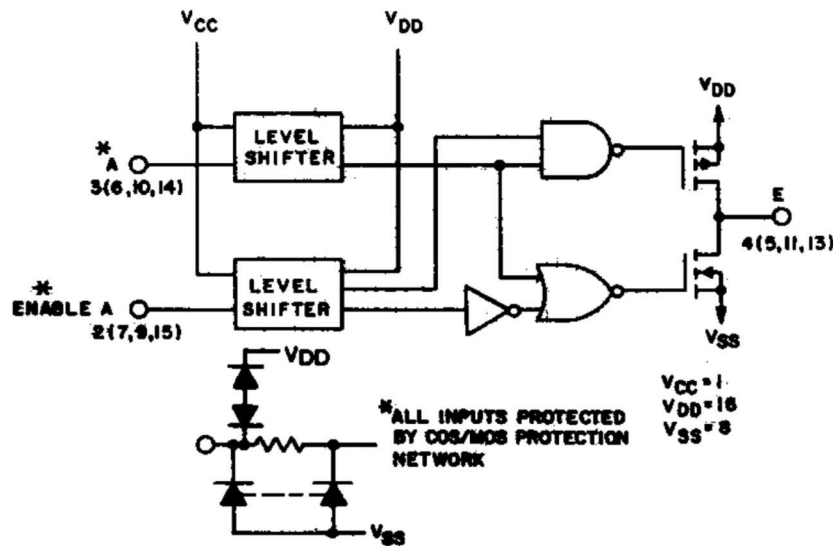
INPUTS		OUTPUTS
A, B, C, D	ENABLE A, B, C, D	E, F, G, H
0	1	0
1	1	1
X	0	Z

(1) 0 =  $V_{SS}$ , 1 =  $V_{CC}$  at inputs and  $V_{DD}$  at outputs, X = Don't care, Z = High impedance

**Functional Diagram (1 of 4 Units)**



**Logic Diagram (1 of 4 Units)**



**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

over operating free-air temperature range (unless otherwise noted)

			VALUE	UNIT
V <sub>DD</sub>	DC supply voltage range	Voltages referenced to V <sub>SS</sub> terminal	–0.5 to +20	V
	Output voltage range	All outputs	–0.5 to V <sub>DD</sub> + 0.5	V
	DC input current	Any one input	±10	mA
P <sub>D</sub>	Power dissipation per package	T <sub>A</sub> = –40°C to + 100°C	500	mW
		T <sub>A</sub> = 100°C to + 125°C	Derate linearly at 12 mW/°C to 200 mW	
	Device dissipation per output transistor (for T <sub>A</sub> = full package-temperature range, all package types)		100	mW
T <sub>A</sub>	Operating-temperature range		–40 to +125	°C
T <sub>stg</sub>	Storage temperature range		–65 to +150	°C
	Latch-Up Performance per JESD 78, Class I		50	mA

(1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

**RECOMMENDED OPERATING CONDITIONS**

		MIN	MAX	UNIT
V <sub>DD</sub>	Supply-voltage range (for T <sub>A</sub> = full package-temperature range)	3	18	V

**STATIC ELECTRICAL CHARACTERISTICS**

PARAMETER	CONDITIONS			LIMITS AT INDICATED TEMPERATURES (°C)						UNIT
	V <sub>O</sub> (V)	V <sub>IN</sub> (V)	V <sub>DD</sub> (V)	–40	+85	+125	+25			
							MIN	TYP	MAX	
I <sub>DD</sub> Max	Quiescent device current	0, 5	5	1	30	30	0.02			μA
		0, 10	10	2	60	60	0.02			
		0, 15	15	4	120	120	0.02			
		0, 20	20	20	600	600	0.04			
I <sub>OL</sub> Min	Output low (sink) current	0.4	0, 5	5	0.61	0.42	0.36	0.51	1	mA
		0.5	0, 10	10	1.5	1.1	0.9	1.3	2.6	
		1.5	0, 15	15	4	2.8	2.4	3.4	6.8	
I <sub>OH</sub> Min	Output high (source) current	4.6	0, 5	5	–0.61	–0.42	–0.36	–0.51	–1	mA
		2.5	0, 5	5	–1.8	–1.3	–1.15	–1.6	–3.2	
		9.5	0, 10	10	–1.5	–1.1	–0.9	–1.3	–2.6	
		13.5	0, 15	15	–4	–2.8	–2.4	–3.4	–6.8	
V <sub>OL</sub> Max	Output voltage: low-level	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		
V <sub>OH</sub> Min	Output voltage: high-level	0, 5	5	4.95			4.95	5	V	
		0, 10	10	9.95			9.95	10		
		0, 15	15	14.95			14.95	15		
I <sub>IN</sub> Max	Input current	0, 18	18	±0.1	±1	±1	±10 <sup>–5</sup>		±0.1	μA
I <sub>OUT</sub> Max		0, 18	18	±0.4	±12	±12	±10 <sup>–4</sup>		±0.4	μA
V <sub>IL</sub> Max	Input low voltage	1, 9	5	10	1.5			1.5		V
		1.5, 13.5	10	15	3			3		
V <sub>IH</sub> Min	Input high voltage	1, 9	5	10	3.5			3.5		V
		1.5, 13.5	10	15	7			7		

**DYNAMIC ELECTRICAL CHARACTERISTICS**
 $T_A = 25^\circ\text{C}$ , Input  $t_r/t_f = 20\text{ ns}$ ,  $C_L = 50\text{ pF}$ ,  $R_L = 200\text{ k}\Omega$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	SHIFTING MODE	$V_{CC}$ (V)	$V_{DD}$ (V)	MIN	MAX	UNIT
$t_{PHL}$	Propagation delay time, high-to-low level, data input to output	L – H	5	10	300	600	ns
			5	15	220	440	
			10	15	180	360	
		H – L	10	5	250	500	
			15	5	250	500	
$t_{PLH}$	Propagation delay time, low-to-high level, data input to output	L – H	5	10	130	260	ns
			5	15	120	240	
			10	15	70	140	
		H – L	10	5	230	460	
			15	5	230	460	
			15	10	80	160	
$t_{PHZ}$	Propagation delay time, 3-state disable, delay, output high to high impedance	L – H	5	10	60	120	ns
			5	15	75	150	
			10	15	35	70	
		H – L	10	5	200	400	
			15	5	200	400	
$t_{PLZ}$	Propagation delay time, 3-state disable, delay, output low to high impedance	L – H	5	10	370	740	ns
			5	15	300	600	
			10	15	250	500	
		H – L	10	5	250	500	
			15	10	130	260	
$t_{PZH}$	Propagation delay time, 3-state disable, delay, output high impedance to high	L – H	5	10	320	640	ns
			5	15	230	460	
			10	15	180	360	
		H – L	10	5	300	600	
			15	5	300	600	
$t_{PZL}$	Propagation delay time, 3-state disable, delay, output high impedance to low	L – H	5	10	100	200	ns
			5	15	80	160	
			10	15	40	80	
		H – L	10	5	200	400	
			15	5	200	400	
$t_{THL}, t_{TLH}$	Transition time	L – H	5	10	50	100	ns
			5	15	40	80	
			10	15	40	80	
		H – L	10	5	100	200	
			15	5	100	200	
$C_i$	Input capacitance		Any input		5	7.5	pF

TYPICAL CHARACTERISTICS

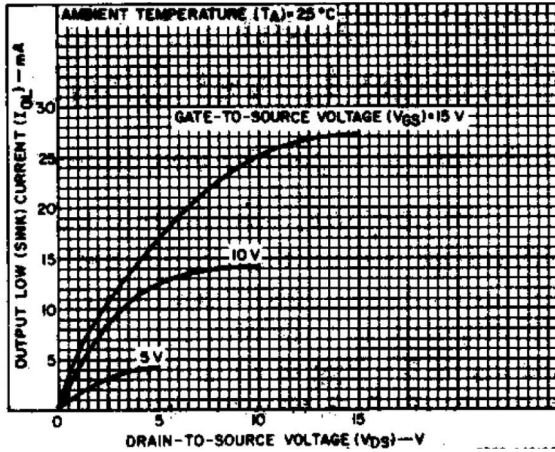


Figure 1. Typical Output Low (Sink) Current Characteristics

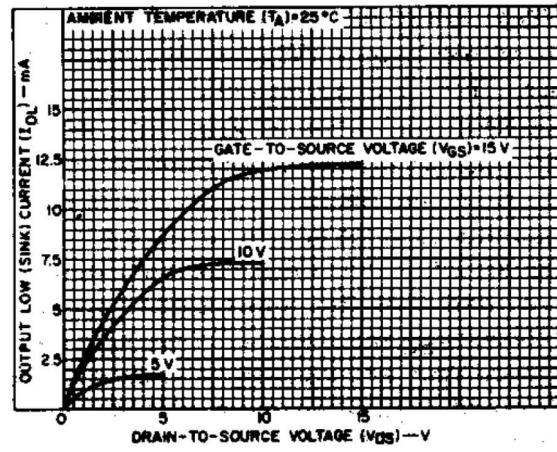


Figure 2. Minimum Output Low (Sink) Current Characteristics

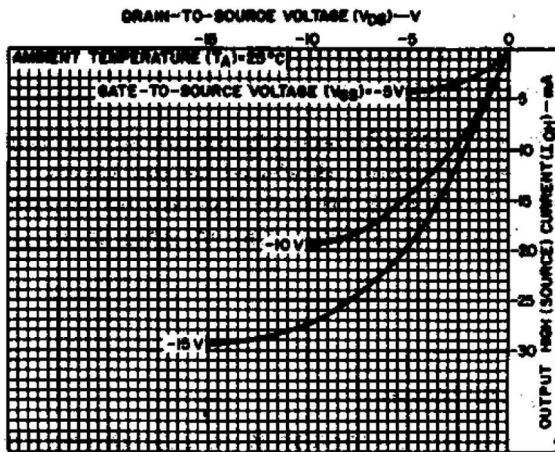


Figure 3. Typical Output High (Source) Current Characteristics

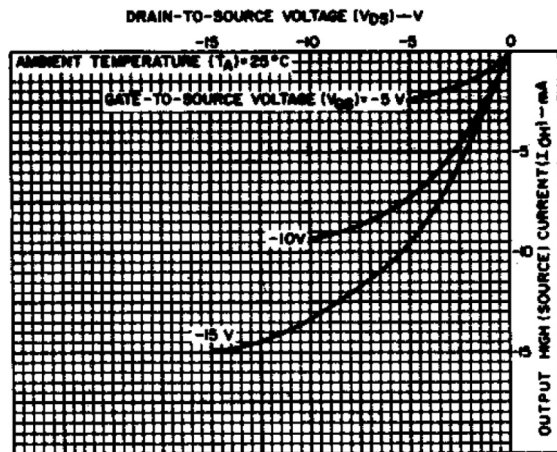


Figure 4. Minimum Output High (Source) Current Characteristics

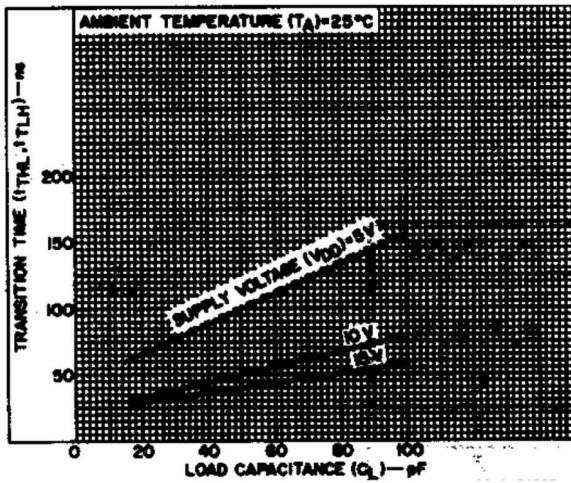


Figure 5. Typical Transition Time as a Function of Load Capacitance

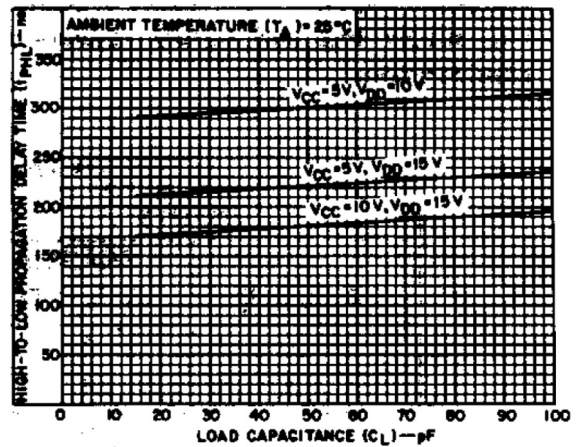


Figure 6. Typical High-to-Low Propagation Delay Time as a Function of Load Capacitance

TYPICAL CHARACTERISTICS (continued)

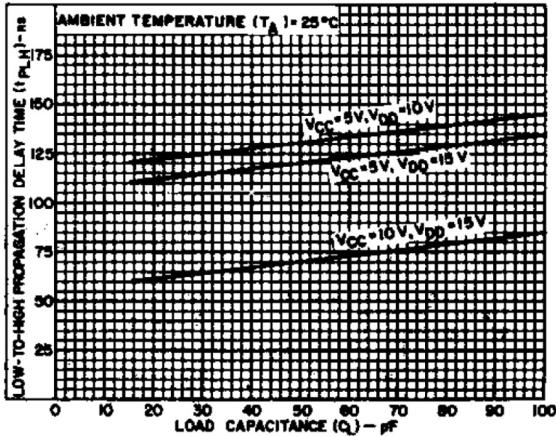


Figure 7. Typical Low-to-High Propagation Delay Time as a Function of Load Capacitance

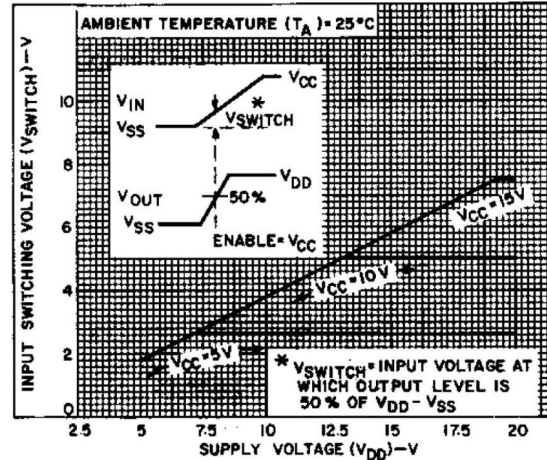


Figure 8. Typical Input Switching as a Function of High-Level Supply Voltage

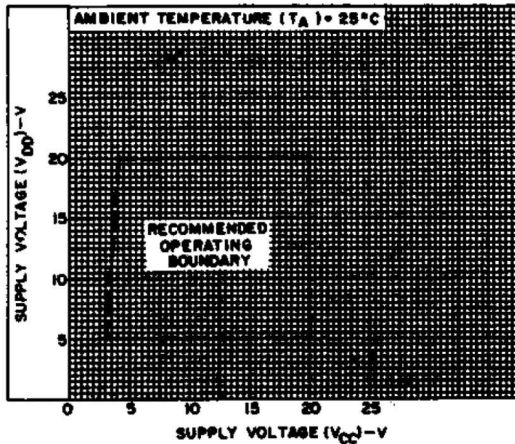


Figure 9. High-Level Supply Voltage vs Low-Level Supply Voltage

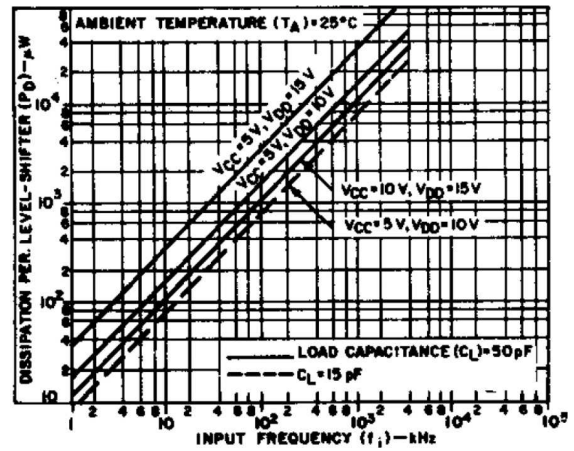


Figure 10. Typical Dynamic Power Dissipation as a Function of Input Frequency

PARAMETER MEASUREMENT INFORMATION

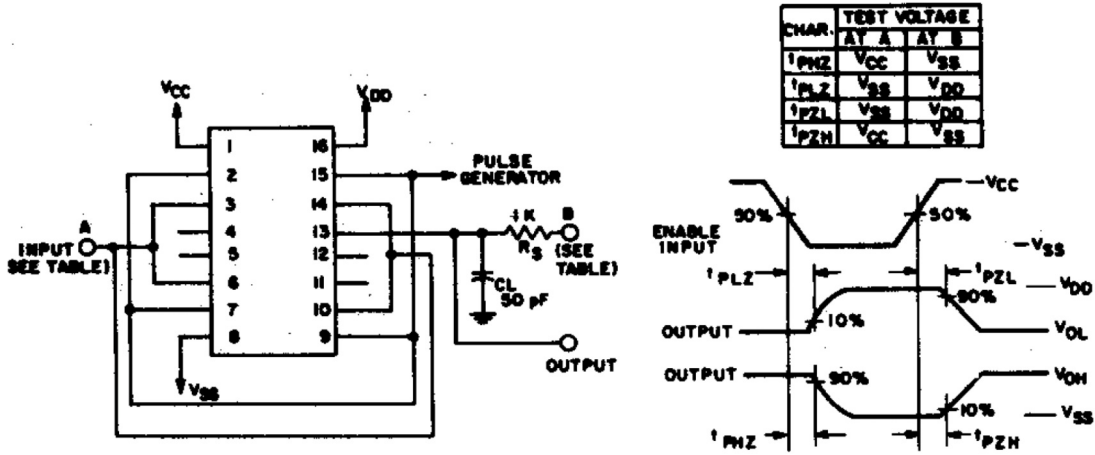


Figure 11. Output Enable Delay Times Test Circuit and Waveforms

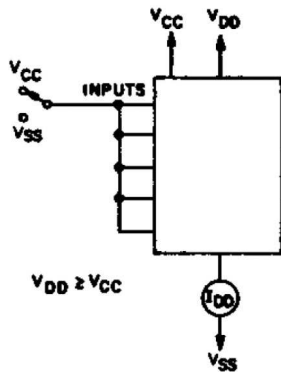


Figure 12. Quiescent Device Current Test Circuit

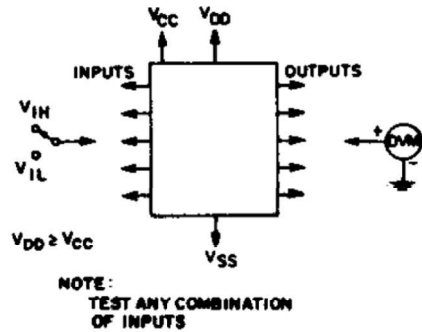


Figure 13. Input Voltage Test Circuit

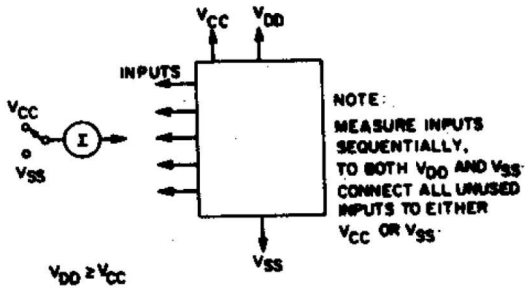


Figure 14. Input Current Test Circuit

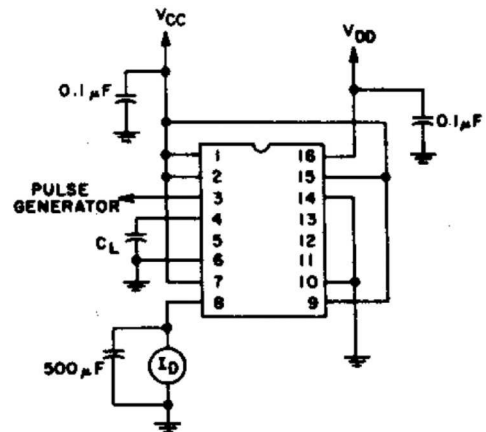
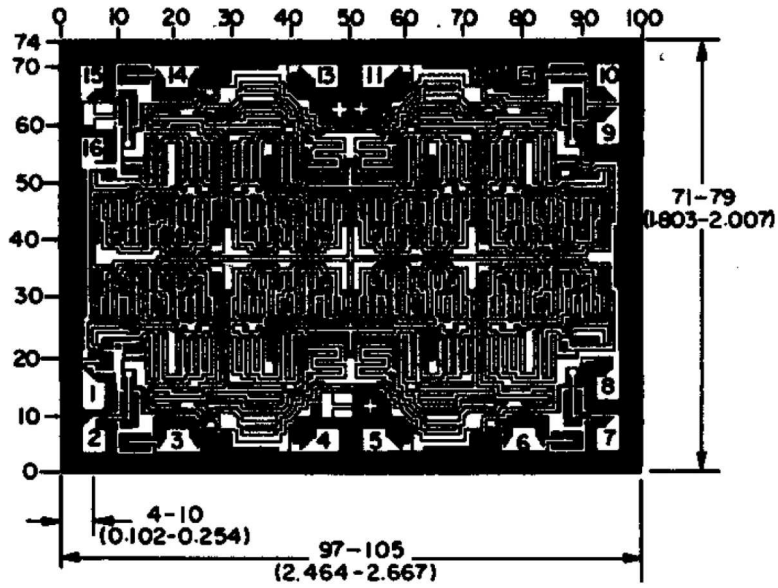


Figure 15. Dynamic Power Dissipation Test Circuit



Note: Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated. Grid graduations are in mils ( $10^{-3}$  inch).

**Figure 16. Dimensions and Pad Layout**



**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
CD40109BQNSRQ1	ACTIVE	SOP	NS	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	CD40109BQ	Samples

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSELETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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**OTHER QUALIFIED VERSIONS OF CD40109B-Q1 :**

- Catalog : [CD40109B](#)
- Military : [CD40109B-MIL](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
CD40109BQNSRQ1	SOP	NS	16	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CD40109BQNSRQ1	SOP	NS	16	2000	356.0	356.0	35.0

# MECHANICAL DATA

NS (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.



# PACKAGE OUTLINE

## NS0016A

### SOP - 2.00 mm max height

SOP



4220735/A 12/2021

#### NOTES:

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm, per side.

# EXAMPLE BOARD LAYOUT

NS0016A

SOP - 2.00 mm max height

SOP



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NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

NS0016A

SOP - 2.00 mm max height

SOP



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:7X

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NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.



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