

# MC14028B

## BCD-To-Decimal Decoder Binary-To-Octal Decoder

The MC14028B decoder is constructed so that an 8421 BCD code on the four inputs provides a decimal (one-of-ten) decoded output, while a 3-bit binary input provides a decoded octal (one-of-eight) code output with D forced to a logic "0". Expanded decoding such as binary-to-hexadecimal (one-of-sixteen), etc., can be achieved by using other MC14028B devices. The part is useful for code conversion, address decoding, memory selection control, demultiplexing, or readout decoding.

### Features

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range
- Positive Logic Design
- Low Outputs on All Illegal Input Combinations
- Similar to CD4028B
- These Devices are Pb-Free and are RoHS Compliant
- NLV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable

### MAXIMUM RATINGS (Voltages Referenced to $V_{SS}$ )

Parameter	Symbol	Value	Unit
DC Supply Voltage Range	$V_{DD}$	-0.5 to +18.0	V
Input or Output Voltage Range (DC or Transient)	$V_{in}, V_{out}$	-0.5 to $V_{DD}$ + 0.5	V
Input or Output Current (DC or Transient) per Pin	$I_{in}, I_{out}$	±10	mA
Power Dissipation per Package (Note 1)	$P_D$	500	mW
Ambient Temperature Range	$T_A$	-55 to +125	°C
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Lead Temperature (8-Second Soldering)	$T_L$	260	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

#### 1. Temperature Derating: Plastic "P" and D/DW"

Packages: - 7.0 mW/°C From 65°C To 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

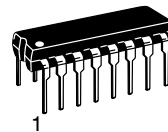
Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.



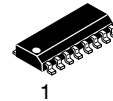
ON Semiconductor®

<http://onsemi.com>

### MARKING DIAGRAMS



PDIIP-16  
P SUFFIX  
CASE 648



SOIC-16  
D SUFFIX  
CASE 751B



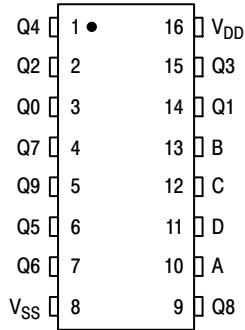
A = Assembly Location  
WL = Wafer Lot  
YY, Y = Year  
WW = Work Week  
G = Pb-Free Package

### ORDERING INFORMATION

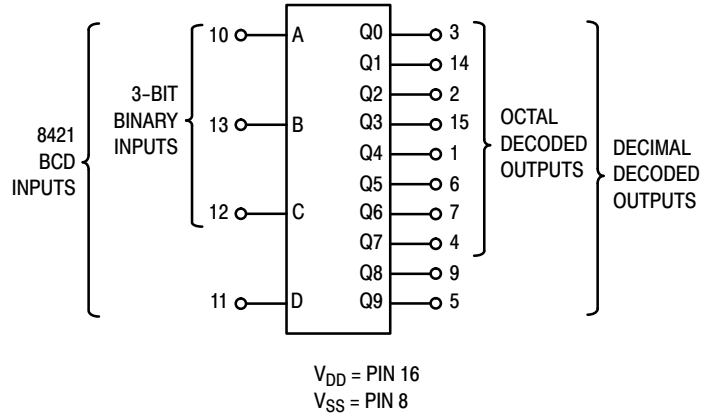
See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

# MC14028B

## PIN ASSIGNMENT



## BLOCK DIAGRAM



## TRUTH TABLE

D	C	B	A	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0
0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0	0	0	1	0
0	0	1	0	0	0	0	0	0	0	0	1	0	0
0	0	1	1	0	0	0	0	0	0	1	0	0	0
0	1	0	0	0	0	0	0	0	1	0	0	0	0
0	1	0	1	0	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	0	1	0	0	0	0	0	0
0	1	1	1	0	0	1	0	0	0	0	0	0	0
1	0	0	0	0	1	0	0	0	0	0	0	0	0
1	0	0	1	1	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	1	0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0	0	0	0

## ORDERING INFORMATION

Device	Package	Shipping†
MC14028BCPG	PDIP-16 (Pb-Free)	25 Units / Rail
MC14028BDG	SOIC-16 (Pb-Free)	48 Units / Rail
MC14028BDR2G	SOIC-16 (Pb-Free)	2500 / Tape & Reel
NLV14028BDR2G*		

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

\*NLV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable.

# MC14028B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	- 55°C		25°C			125°C		Unit	
			Min	Max	Min	Typ (Note 2)	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	-	0.05	-	0	0.05	-	0.05	Vdc	
		10	-	0.05	-	0	0.05	-	0.05		
15		-	0.05	-	0	0.05	-	0.05			
V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	-	4.95	5.0	-	4.95	-	Vdc	
		10	9.95	-	9.95	10	-	9.95	-		
		15	14.95	-	14.95	15	-	14.95	-		
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	-	1.5	-	2.25	1.5	-	1.5	Vdc	
		10	-	3.0	-	4.50	3.0	-	3.0		
15		-	4.0	-	6.75	4.0	-	4.0			
(V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	-	3.5	2.75	-	3.5	-	Vdc	
		10	7.0	-	7.0	5.50	-	7.0	-		
		15	11	-	11	8.25	-	11	-		
Output Drive Current (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source  Sink	I <sub>OH</sub>	5.0	-3.0	-	-2.4	-4.2	-	-1.7	-	mAdc
			10	-0.64	-	-0.51	-0.88	-	-0.36	-	
15			-1.6	-	-1.3	-2.25	-	-0.9	-		
15			-4.2	-	-3.4	-8.8	-	-2.4	-		
(V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	-	0.51	0.88	-	0.36	-	mAdc	
		10	1.6	-	1.3	2.25	-	0.9	-		
		15	4.2	-	3.4	8.8	-	2.4	-		
Input Current	I <sub>in</sub>	15	-	± 0.1	-	± 0.00001	± 0.1	-	± 1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	-	-	-	-	5.0	7.5	-	-	pF	
Quiescent Current (Per Package)	I <sub>DD</sub>	5.0	-	5.0	-	0.005	5.0	-	150	μAdc	
		10	-	10	-	0.010	10	-	300		
		15	-	20	-	0.015	20	-	600		
Total Supply Current (Note 3, 4) (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0 10 15	I <sub>T</sub> = (0.3 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (0.6 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (0.9 μA/kHz) f + I <sub>DD</sub>						μAdc		

2. Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

3. The formulas given are for the typical characteristics only at 25°C.

4. To calculate total supply current at loads other than 50 pF: I<sub>T</sub>(C<sub>L</sub>) = I<sub>T</sub>(50 pF) + (C<sub>L</sub> - 50) Vfk where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

## SWITCHING CHARACTERISTICS (Note 5) (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

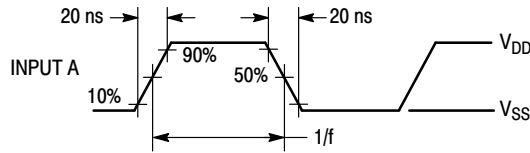
Characteristic	Symbol	V <sub>DD</sub>	Min	Typ (Note 6)	Max	Unit
Output Rise and Fall Time t <sub>TLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	5.0	-	100	200	ns
		10	-	50	100	
		15	-	40	80	
Propagation Delay Time t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 215 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 97 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 65 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	-	300	600	ns
		10	-	130	260	
		15	-	90	180	

5. The formulas given are for the typical characteristics only at 25°C.

6. Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14028B

Inputs B, C, and D switching in respect to a BCD code.



All outputs connected to respective  $C_L$  loads.  $f$  in respect to a system clock.

Inputs A, B, and D low.

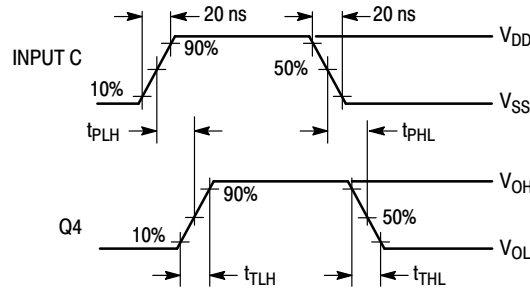
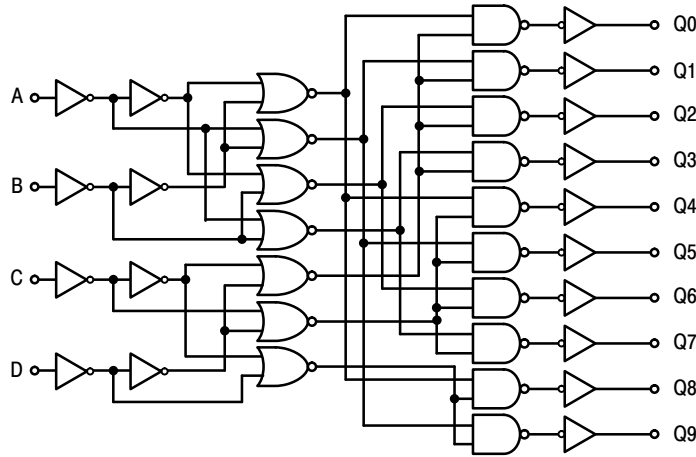


Figure 1. Dynamic Signal Waveforms



LOGIC DIAGRAM

## APPLICATIONS INFORMATION

Expanded decoding can be performed by using the MC14028B and other CMOS Integrated Circuits. The circuit in Figure 2 converts any 4-bit code to a decimal or hexadecimal code. The accompanying table shows the input binary combinations, the associated “output numbers” that go “high” when selected, and the “redefined output numbers” needed for the proper code. For example: For the combination DCBA = 0111 the output number 7 is redefined for the 4-bit binary, 4-bit gray, excess-3, or excess-3 gray codes as 7, 5, 4, or 2, respectively. Figure 3 shows a 6-bit binary 1-of-64 decoder using nine MC14028B circuits and two MC14069UB inverters.

The MC14028B can be used in decimal digit displays, such as, neon readouts or incandescent projection indicators as shown in Figure 4.

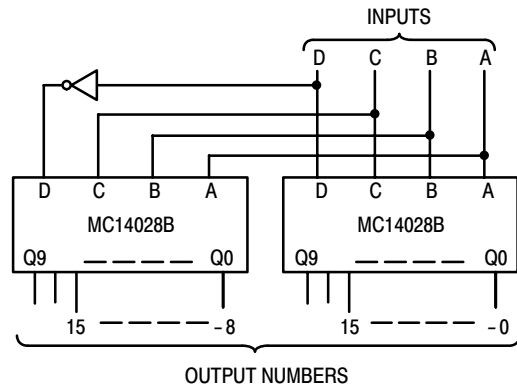


Figure 2. Code Conversion Circuit and Truth Table

# MC14028B

Inputs																			Code and Redefined Output Numbers						
																			Hexadecimal			Decimal			
D	C	B	A	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	4-Bit Binary	4-Bit Gray	Excess-3	Excess-3 Gray	Aiken	4221
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0		0	0	
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1		1	1	
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	3	0	2	2	
0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	2	0	3		
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	4	7	1	4	4	
0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5	6	2		3	
0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	4	3	1	4	
0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	7	5	4	2		
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	8	15	5		5	
1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	9	14	6		6	
1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	10	12	7	9		
1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	11	13	8		5	
1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	12	8	9	5	6	
1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	13	9		6	7	
1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	11	8	8	8	
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	10	7	9	9	

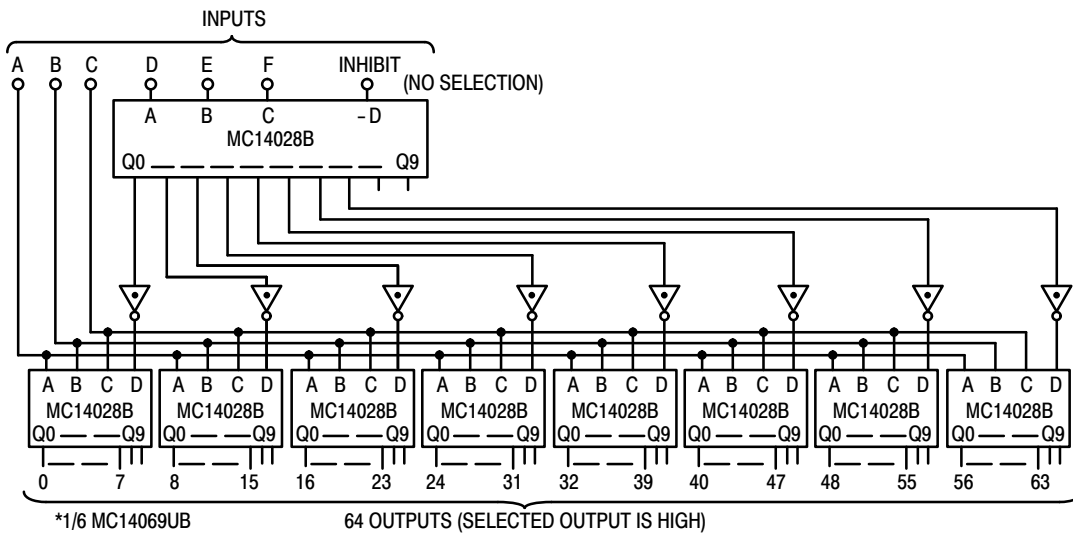


Figure 3. Six-Bit Binary 1-of-64 Decoder

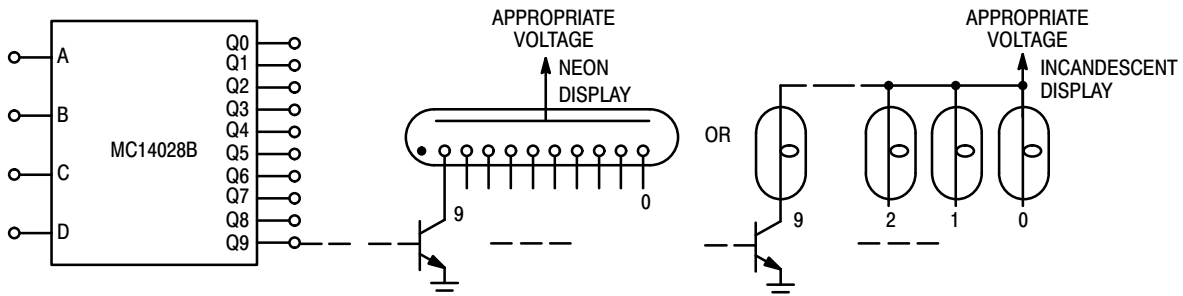
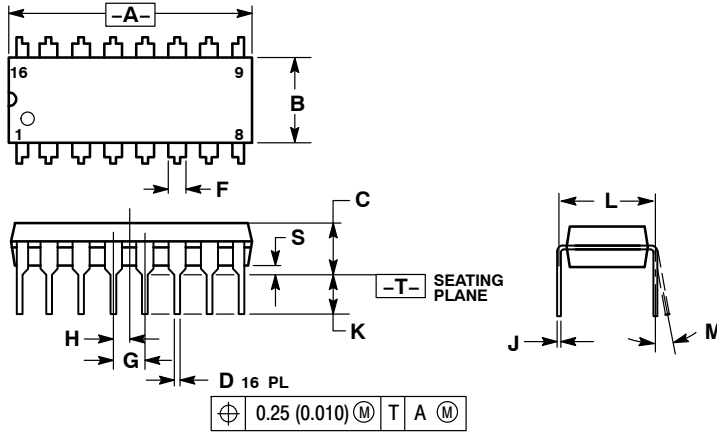


Figure 4. Decimal Digit Display Application

# MC14028B

## PACKAGE DIMENSIONS

PDIP-16  
P SUFFIX  
CASE 648-08  
ISSUE T



**NOTES:**

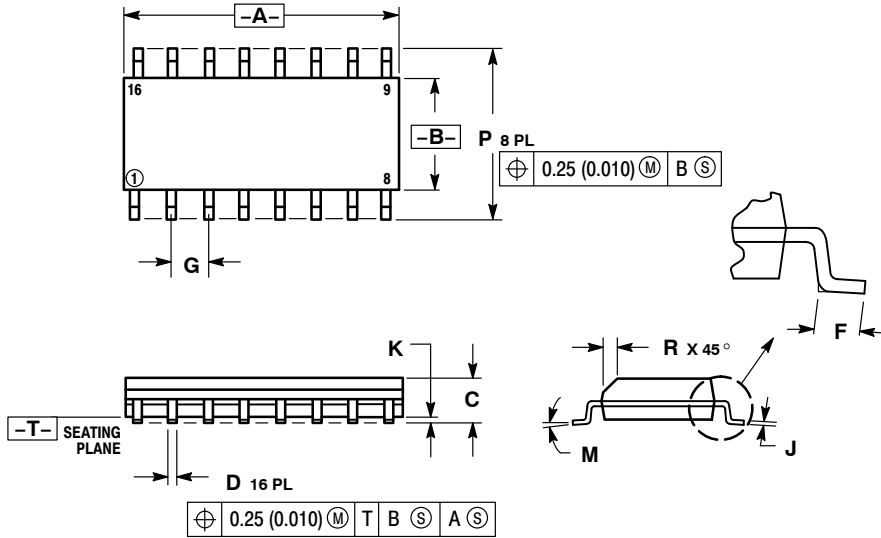
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION B DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.740	0.770	18.80	19.55
B	0.250	0.270	6.35	6.85
C	0.145	0.175	3.69	4.44
D	0.015	0.021	0.39	0.53
F	0.040	0.70	1.02	1.77
G	0.100 BSC		2.54 BSC	
H	0.050 BSC		1.27 BSC	
J	0.008	0.015	0.21	0.38
K	0.110	0.130	2.80	3.30
L	0.295	0.305	7.50	7.74
M	0° 10°		0° 10°	
S	0.020	0.040	0.51	1.01

# MC14028B

## PACKAGE DIMENSIONS

SOIC-16  
D SUFFIX  
CASE 751B-05  
ISSUE K

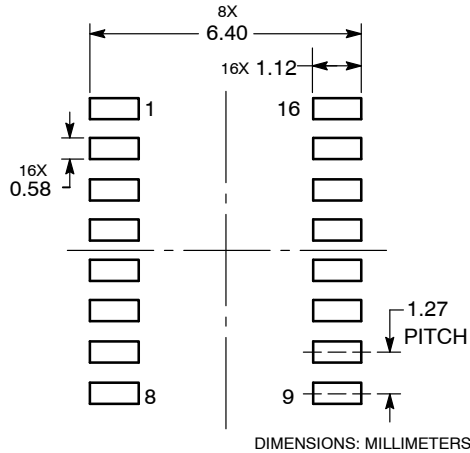


### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.80	10.00	0.386	0.393
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

### SOLDERING FOOTPRINT



ON Semiconductor and are registered trademarks of Semiconductor Components Industries, LLC (SCILLC). SCILLC owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of SCILLC's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. "Typical" parameters which may be provided in SCILLC data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights nor the rights of others. SCILLC products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the SCILLC product could create a situation where personal injury or death may occur. Should Buyer purchase or use SCILLC products for any such unintended or unauthorized application, Buyer shall indemnify and hold SCILLC and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SCILLC was negligent regarding the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

### PUBLICATION ORDERING INFORMATION

#### LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor  
P.O. Box 5163, Denver, Colorado 80217 USA  
Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada  
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada  
Email: [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

N. American Technical Support: 800-282-9855 Toll Free  
USA/Canada  
Europe, Middle East and Africa Technical Support:  
Phone: 421 33 790 2910  
Japan Customer Focus Center  
Phone: 81-3-5817-1050

ON Semiconductor Website: [www.onsemi.com](http://www.onsemi.com)

Order Literature: <http://www.onsemi.com/orderlit>

For additional information, please contact your local Sales Representative