

# BCD-to-Seven Segment Latch/Decoder/Driver

## MC14511B

The MC14511B BCD-to-seven segment latch/decoder/driver is constructed with complementary MOS (CMOS) enhancement mode devices and NPN bipolar output drivers in a single monolithic structure. The circuit provides the functions of a 4-bit storage latch, an 8421 BCD-to-seven segment decoder, and an output drive capability. Lamp test ( $\overline{LT}$ ), blanking ( $\overline{BI}$ ), and latch enable (LE) inputs are used to test the display, to turn-off or pulse modulate the brightness of the display, and to store a BCD code, respectively. It can be used with seven-segment light-emitting diodes (LED), incandescent, fluorescent, gas discharge, or liquid crystal readouts either directly or indirectly.

Applications include instrument (e.g., counter, DVM, etc.) display driver, computer/calculator display driver, cockpit display driver, and various clock, watch, and timer uses.

### Features

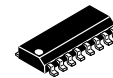
- Low Logic Circuit Power Dissipation
- High-Current Sourcing Outputs (Up to 25 mA)
- Latch Storage of Code
- Blanking Input
- Lamp Test Provision
- Readout Blanking on all Illegal Input Combinations
- Lamp Intensity Modulation Capability
- Time Share (Multiplexing) Facility
- Supply Voltage Range = 3.0 V to 18 V
- Capable of Driving Two Low-power TTL Loads, One Low-power Schottky TTL Load, or Two HTL Loads Over the Rated Temperature Range
- Chip Complexity: 216 FETs or 54 Equivalent Gates
- Triple Diode Protection on all Inputs
- NLV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These Devices are Pb-Free and are RoHS Compliant

### MAXIMUM RATINGS (Voltages Referenced to $V_{SS}$ ) (Note 1)

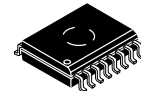
Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage Range	-0.5 to +18.0	V
$V_{in}$	Input Voltage Range, All Inputs	-0.5 to $V_{DD} + 0.5$	V
I	DC Current Drain per Input Pin	10	mA
$P_D$	Power Dissipation, per Package (Note 2)	500	mW
$T_A$	Operating Temperature Range	-55 to +125	°C
$T_{stg}$	Storage Temperature Range	-65 to +150	°C
$I_{OHmax}$	Maximum Output Drive Current (Source) per Output	25	mA
$P_{OHmax}$	Maximum Continuous Output Power (Source) per Output (Note 3)	50	mA

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Maximum Ratings are those values beyond which damage to the device may occur.
2. Temperature Derating: "D/DW" Packages: -7.0 mW/°C From 65°C to 125°C
3.  $P_{OHmax} = I_{OH} (V_{DD} - V_{OH})$

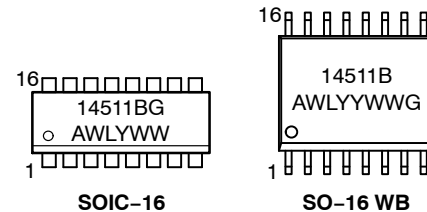


SOIC-16  
D SUFFIX  
CASE 751B



SO-16 WB  
DW SUFFIX  
CASE 751G

### MARKING DIAGRAMS



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

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 7 of this data sheet.

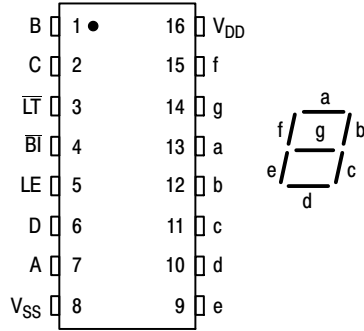
# MC14511B

This device contains protection circuitry to protect the inputs against damage due to high static voltages or electric fields. However, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high-impedance circuit. A destructive high current mode may occur if  $V_{in}$  and  $V_{out}$  are not constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

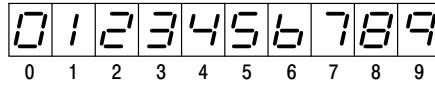
Due to the sourcing capability of this circuit, damage can occur to the device if  $V_{DD}$  is applied, and the outputs are shorted to  $V_{SS}$  and are at a logical 1 (See Maximum Ratings).

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

## PIN ASSIGNMENT



## DISPLAY



## TRUTH TABLE

Inputs							Outputs							
LE	BI	LT	D	C	B	A	a	b	c	d	e	f	g	Display
X	X	0	X	X	X	X	1	1	1	1	1	1	1	8
X	0	1	X	X	X	X	0	0	0	0	0	0	0	Blank
0	1	1	0	0	0	0	1	1	1	1	1	1	0	0
0	1	1	0	0	0	1	0	1	1	0	0	0	0	1
0	1	1	0	0	1	0	1	1	0	1	1	0	1	2
0	1	1	0	0	1	1	1	1	1	1	0	0	1	3
0	1	1	0	1	0	0	0	1	1	0	0	1	1	4
0	1	1	0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	1	1	0	0	0	1	1	1	1	1	6
0	1	1	0	1	1	1	1	1	1	0	0	0	0	7
0	1	1	1	0	0	0	1	1	1	1	1	1	1	8
0	1	1	1	0	0	1	1	1	1	0	0	1	1	9
0	1	1	1	0	1	0	0	0	0	0	0	0	0	Blank
0	1	1	1	0	1	1	0	0	0	0	0	0	0	Blank
0	1	1	1	1	0	0	0	0	0	0	0	0	0	Blank
0	1	1	1	1	1	0	0	0	0	0	0	0	0	Blank
0	1	1	1	1	1	1	0	0	0	0	0	0	0	Blank
1	1	1	X	X	X	X	*							*

X = Don't Care

\*Depends upon the BCD code previously applied when LE = 0

# MC14511B

## 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 4)	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level 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>	"1" Level V <sub>OH</sub>	5.0	4.1	-	4.1	4.57	-	4.1	-	Vdc	
		10	9.1	-	9.1	9.58	-	9.1	-		
		15	14.1	-	14.1	14.59	-	14.1	-		
Input Voltage # (V <sub>O</sub> = 3.8 or 0.5 Vdc) (V <sub>O</sub> = 8.8 or 1.0 Vdc) (V <sub>O</sub> = 13.8 or 1.5 Vdc)	"0" Level 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 3.8 Vdc) (V <sub>O</sub> = 1.0 or 8.8 Vdc) (V <sub>O</sub> = 1.5 or 13.8 Vdc)	"1" Level 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 Voltage Source (I <sub>OH</sub> = 0 mA) (I <sub>OH</sub> = 5.0 mA) (I <sub>OH</sub> = 10 mA) (I <sub>OH</sub> = 15 mA) (I <sub>OH</sub> = 20 mA) (I <sub>OH</sub> = 25 mA)	V <sub>OH</sub>	5.0	4.1	-	4.1	4.57	-	4.1	-	Vdc	
			-	-	-	4.24	-	-	-		
			3.9	-	3.9	4.12	-	3.5	-		
		10	9.1	-	9.1	9.58	-	9.1	-	Vdc	
			-	-	-	9.26	-	-	-		
			9.0	-	9.0	9.17	-	8.6	-		
		15	14.1	-	14.1	14.59	-	14.1	-	Vdc	
			-	-	-	14.27	-	-	-		
			14	-	14	14.18	-	13.6	-		
		(I <sub>OH</sub> = 0 mA) (I <sub>OH</sub> = 5.0 mA) (I <sub>OH</sub> = 10 mA) (I <sub>OH</sub> = 15 mA) (I <sub>OH</sub> = 20 mA) (I <sub>OH</sub> = 25 mA)	15	14.1	-	14.1	14.59	-	14.1	-	Vdc
				-	-	-	14.27	-	-	-	
				14	-	14	14.18	-	13.6	-	
Output Drive Current Sink (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	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	C <sub>in</sub>	-	-	-	-	5.0	7.5	-	-	pF	
Quiescent Current (Per Package) V <sub>in</sub> = 0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	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 (Notes 5 & 6) (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.9 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (3.8 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (5.7 μA/kHz) f + I <sub>DD</sub>								

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

4. Noise immunity specified for worst-case input combination.

Noise Margin for both "1" and "0" level =

1.0 Vdc min @ V<sub>DD</sub> = 5.0 Vdc

2.0 Vdc min @ V<sub>DD</sub> = 10 Vdc

2.5 Vdc min @ V<sub>DD</sub> = 15 Vdc

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

6. To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + 3.5 \times 10^{-3} (C_L - 50) V_{DD} f$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V<sub>DD</sub> in Vdc, and f in kHz is input frequency.

# MC14511B

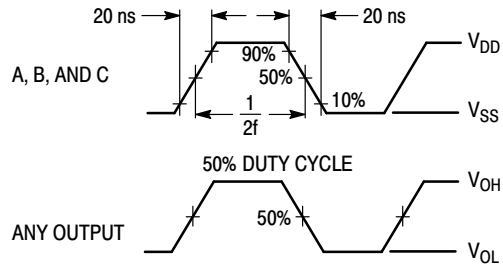
## SWITCHING CHARACTERISTICS (Note 7) ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$ Vdc	Min	Typ	Max	Unit
Output Rise Time $t_{TLH} = (0.40 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{TLH} = (0.25 \text{ ns/pF}) C_L + 17.5 \text{ ns}$ $t_{TLH} = (0.20 \text{ ns/pF}) C_L + 15 \text{ ns}$	$t_{TLH}$	5.0 10 15	– – –	40 30 25	80 60 50	ns
Output Fall Time $t_{THL} = (1.5 \text{ ns/pF}) C_L + 50 \text{ ns}$ $t_{THL} = (0.75 \text{ ns/pF}) C_L + 37.5 \text{ ns}$ $t_{THL} = (0.55 \text{ ns/pF}) C_L + 37.5 \text{ ns}$	$t_{THL}$	5.0 10 15	– – –	125 75 65	250 150 130	ns
Data Propagation Delay Time $t_{PLH} = (0.40 \text{ ns/pF}) C_L + 620 \text{ ns}$ $t_{PLH} = (0.25 \text{ ns/pF}) C_L + 237.5 \text{ ns}$ $t_{PLH} = (0.20 \text{ ns/pF}) C_L + 165 \text{ ns}$ $t_{PHL} = (1.3 \text{ ns/pF}) C_L + 655 \text{ ns}$ $t_{PHL} = (0.60 \text{ ns/pF}) C_L + 260 \text{ ns}$ $t_{PHL} = (0.35 \text{ ns/pF}) C_L + 182.5 \text{ ns}$	$t_{PLH}$    $t_{PHL}$	5.0 10 15  5.0 10 15	– – –  – – –	640 250 175  720 290 200	1280 500 350  1440 580 400	ns
Blank Propagation Delay Time $t_{PLH} = (0.30 \text{ ns/pF}) C_L + 585 \text{ ns}$ $t_{PLH} = (0.25 \text{ ns/pF}) C_L + 187.5 \text{ ns}$ $t_{PLH} = (0.15 \text{ ns/pF}) C_L + 142.5 \text{ ns}$ $t_{PHL} = (0.85 \text{ ns/pF}) C_L + 442.5 \text{ ns}$ $t_{PHL} = (0.45 \text{ ns/pF}) C_L + 177.5 \text{ ns}$ $t_{PHL} = (0.35 \text{ ns/pF}) C_L + 142.5 \text{ ns}$	$t_{PLH}$    $t_{PHL}$	5.0 10 15  5.0 10 15	– – –  – – –	600 200 150  485 200 160	750 300 220  970 400 320	ns
Lamp Test Propagation Delay Time $t_{PLH} = (0.45 \text{ ns/pF}) C_L + 290.5 \text{ ns}$ $t_{PLH} = (0.25 \text{ ns/pF}) C_L + 112.5 \text{ ns}$ $t_{PLH} = (0.20 \text{ ns/pF}) C_L + 80 \text{ ns}$ $t_{PHL} = (1.3 \text{ ns/pF}) C_L + 248 \text{ ns}$ $t_{PHL} = (0.45 \text{ ns/pF}) C_L + 102.5 \text{ ns}$ $t_{PHL} = (0.35 \text{ ns/pF}) C_L + 72.5 \text{ ns}$	$t_{PLH}$    $t_{PHL}$	5.0 10 15  5.0 10 15	– – –  – – –	313 125 90  313 125 90	625 250 180  625 250 180	ns
Setup Time	$t_{su}$	5.0 10 15	100 40 30	– – –	– – –	ns
Hold Time	$t_h$	5.0 10 15	60 40 30	– – –	– – –	ns
Latch Enable Pulse Width	$t_{WL}$	5.0 10 15	520 220 130	260 110 65	– – –	ns

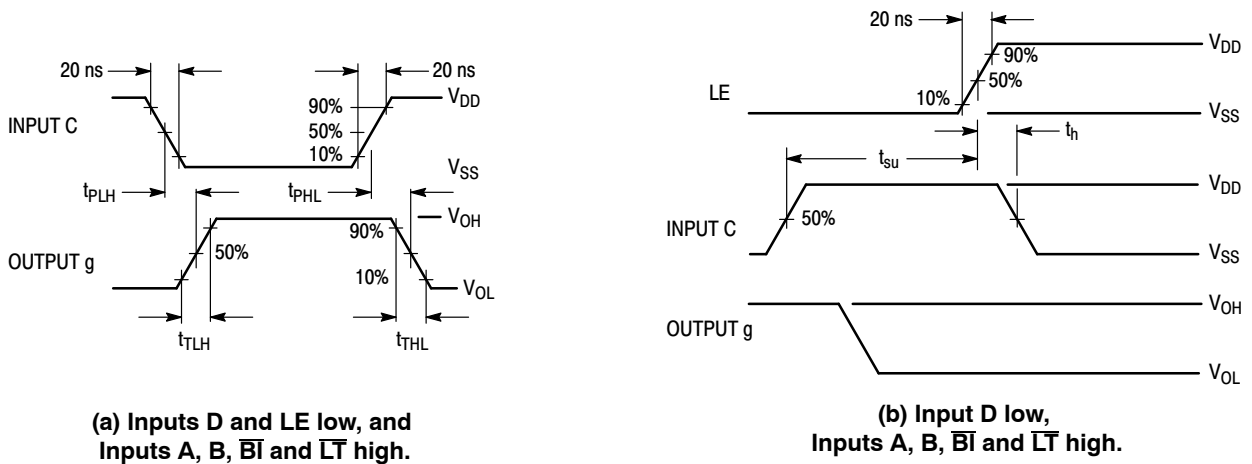
7. The formulas given are for the typical characteristics only.

# MC14511B

Input LE low, and Inputs D,  $\overline{BI}$  and  $\overline{LT}$  high.  
 $f$  in respect to a system clock.  
 All outputs connected to respective  $C_L$  loads.

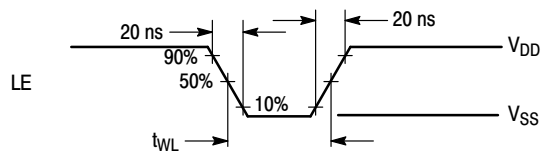


**Figure 1. Dynamic Power Dissipation Signal Waveforms**



**(a) Inputs D and LE low, and Inputs A, B,  $\overline{BI}$  and  $\overline{LT}$  high.**

**(b) Input D low, Inputs A, B,  $\overline{BI}$  and  $\overline{LT}$  high.**



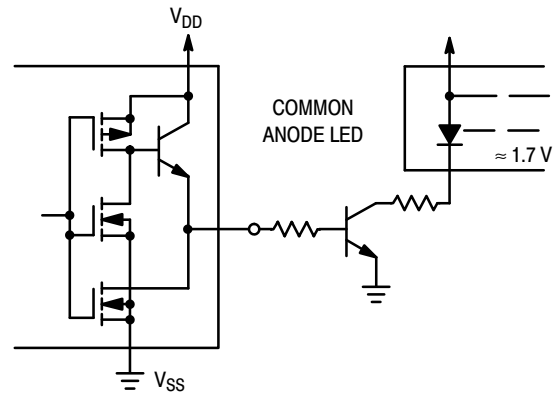
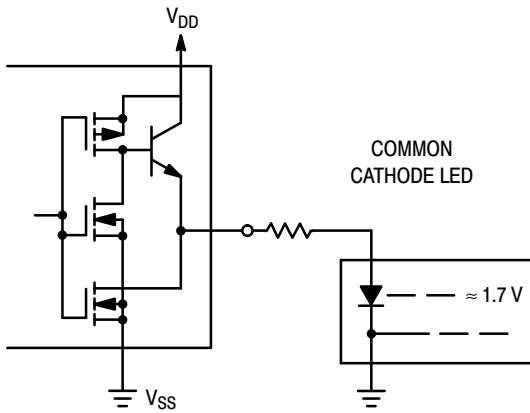
**(c) Data DCBA strobed into latches.**

**Figure 2. Dynamic Signal Waveforms**

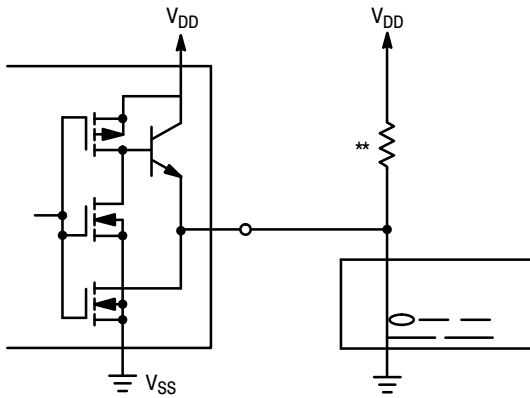
# MC14511B

## CONNECTIONS TO VARIOUS DISPLAY READOUTS

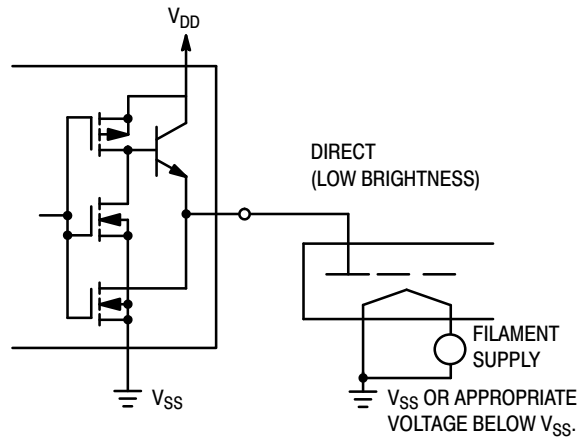
### LIGHT EMITTING DIODE (LED) READOUT



### INCANDESCENT READOUT

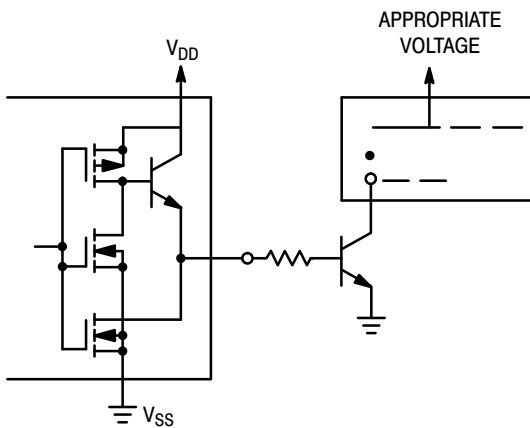


### FLUORESCENT READOUT

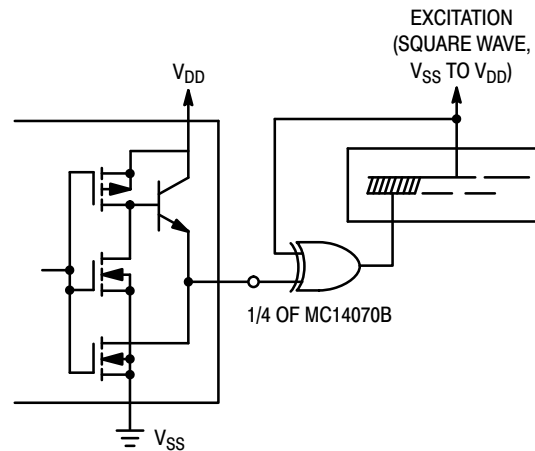


(CAUTION: Maximum working voltage = 18.0 V)

### GAS DISCHARGE READOUT



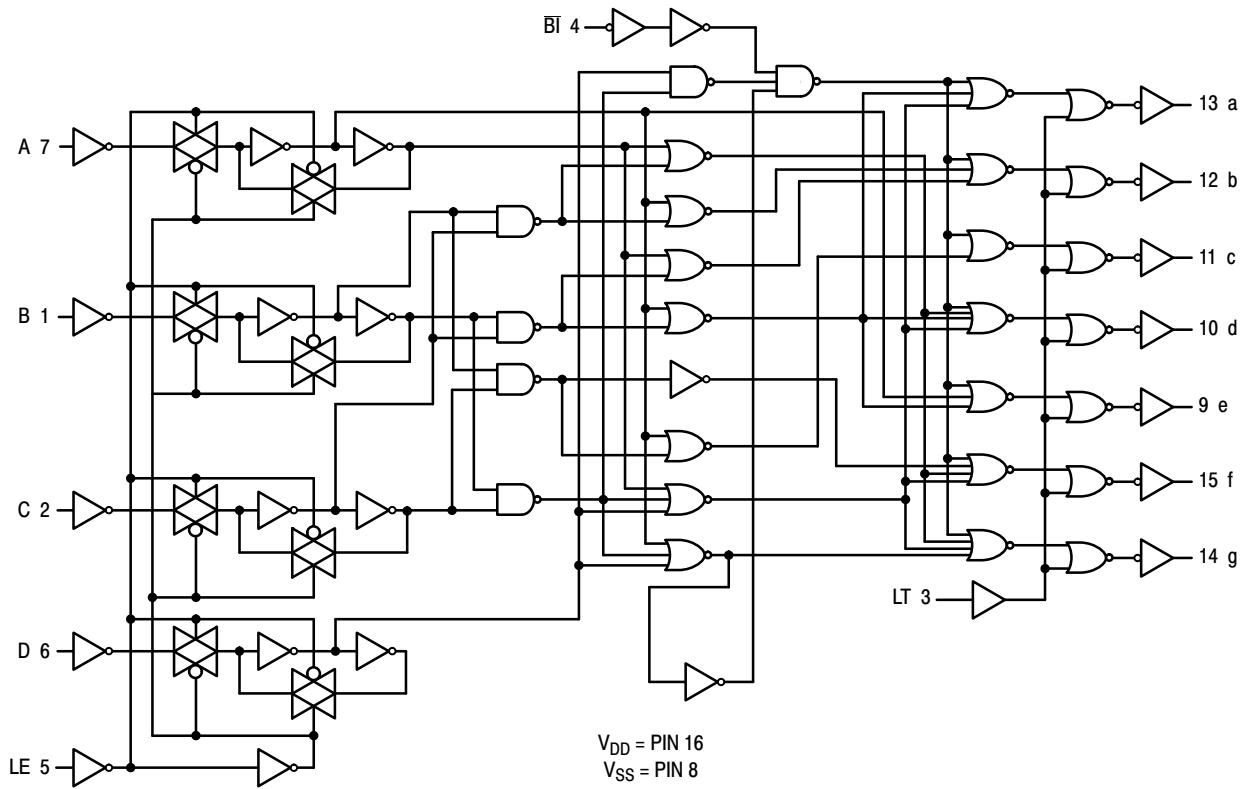
### LIQUID CRYSTAL (LCD) READOUT



\*\*A filament pre-warm resistor is recommended to reduce filament thermal shock and increase the effective cold resistance of the filament.

Direct DC drive of LCD's not recommended for life of LCD readouts.

# MC14511B



**Figure 3. Logic Diagram**

## ORDERING INFORMATION

Device	Package	Shipping <sup>†</sup>
MC14511BDG	SOIC-16 (Pb-Free)	48 Units / Rail
MC14511BDR2G	SOIC-16 (Pb-Free)	2500 / Tape & Reel
MC14511BDWR2G	SO-16 WB (Pb-Free)	1000 / Tape & Reel
NLV14511BDWR2G*	SO-16 WB (Pb-Free)	1000 / Tape & Reel

<sup>†</sup>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.

# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

ON Semiconductor®



SCALE 1:1

## SOIC-16 CASE 751B-05 ISSUE K

DATE 29 DEC 2006



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

- |   |   |   |   |
|---|---|---|---|
| <p>STYLE 1:</p> <p>PIN 1. COLLECTOR<br/>2. BASE<br/>3. EMITTER<br/>4. NO CONNECTION<br/>5. EMITTER<br/>6. BASE<br/>7. COLLECTOR<br/>8. COLLECTOR<br/>9. BASE<br/>10. EMITTER<br/>11. NO CONNECTION<br/>12. EMITTER<br/>13. BASE<br/>14. COLLECTOR<br/>15. EMITTER<br/>16. COLLECTOR</p>                           | <p>STYLE 2:</p> <p>PIN 1. CATHODE<br/>2. ANODE<br/>3. NO CONNECTION<br/>4. CATHODE<br/>5. CATHODE<br/>6. NO CONNECTION<br/>7. ANODE<br/>8. CATHODE<br/>9. CATHODE<br/>10. ANODE<br/>11. NO CONNECTION<br/>12. CATHODE<br/>13. CATHODE<br/>14. NO CONNECTION<br/>15. ANODE<br/>16. CATHODE</p> | <p>STYLE 3:</p> <p>PIN 1. COLLECTOR, DYE #1<br/>2. BASE, #1<br/>3. EMITTER, #1<br/>4. COLLECTOR, #1<br/>5. COLLECTOR, #2<br/>6. BASE, #2<br/>7. EMITTER, #2<br/>8. COLLECTOR, #2<br/>9. COLLECTOR, #3<br/>10. BASE, #3<br/>11. EMITTER, #3<br/>12. COLLECTOR, #3<br/>13. COLLECTOR, #4<br/>14. BASE, #4<br/>15. EMITTER, #4<br/>16. COLLECTOR, #4</p>   | <p>STYLE 4:</p> <p>PIN 1. COLLECTOR, DYE #1<br/>2. COLLECTOR, #1<br/>3. COLLECTOR, #2<br/>4. COLLECTOR, #2<br/>5. COLLECTOR, #3<br/>6. COLLECTOR, #3<br/>7. COLLECTOR, #4<br/>8. COLLECTOR, #4<br/>9. BASE, #4<br/>10. EMITTER, #4<br/>11. BASE, #3<br/>12. EMITTER, #3<br/>13. BASE, #2<br/>14. EMITTER, #2<br/>15. BASE, #1<br/>16. EMITTER, #1</p> |
| <p>STYLE 5:</p> <p>PIN 1. DRAIN, DYE #1<br/>2. DRAIN, #1<br/>3. DRAIN, #2<br/>4. DRAIN, #2<br/>5. DRAIN, #3<br/>6. DRAIN, #3<br/>7. DRAIN, #4<br/>8. DRAIN, #4<br/>9. GATE, #4<br/>10. SOURCE, #4<br/>11. GATE, #3<br/>12. SOURCE, #3<br/>13. GATE, #2<br/>14. SOURCE, #2<br/>15. GATE, #1<br/>16. SOURCE, #1</p> | <p>STYLE 6:</p> <p>PIN 1. CATHODE<br/>2. CATHODE<br/>3. CATHODE<br/>4. CATHODE<br/>5. CATHODE<br/>6. CATHODE<br/>7. CATHODE<br/>8. CATHODE<br/>9. ANODE<br/>10. ANODE<br/>11. ANODE<br/>12. ANODE<br/>13. ANODE<br/>14. ANODE<br/>15. ANODE<br/>16. ANODE</p>                                 | <p>STYLE 7:</p> <p>PIN 1. SOURCE N-CH<br/>2. COMMON DRAIN (OUTPUT)<br/>3. COMMON DRAIN (OUTPUT)<br/>4. GATE P-CH<br/>5. COMMON DRAIN (OUTPUT)<br/>6. COMMON DRAIN (OUTPUT)<br/>7. COMMON DRAIN (OUTPUT)<br/>8. SOURCE P-CH<br/>9. SOURCE P-CH<br/>10. COMMON DRAIN (OUTPUT)<br/>11. COMMON DRAIN (OUTPUT)<br/>12. COMMON DRAIN (OUTPUT)<br/>13. GATE N-CH<br/>14. COMMON DRAIN (OUTPUT)<br/>15. COMMON DRAIN (OUTPUT)<br/>16. SOURCE N-CH</p> |   |

### SOLDERING FOOTPRINT



DIMENSIONS: MILLIMETERS

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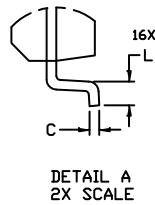
# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



1  
SCALE 1:1

SOIC-16 WB  
CASE 751G  
ISSUE E

DATE 08 OCT 2021



NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.13 TOTAL IN EXCESS OF B DIMENSION AT MAXIMUM MATERIAL CONDITION.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD PROTRUSIONS.
5. MAXIMUM MOLD PROTRUSION OR FLASH TO BE 0.15 PER SIDE.

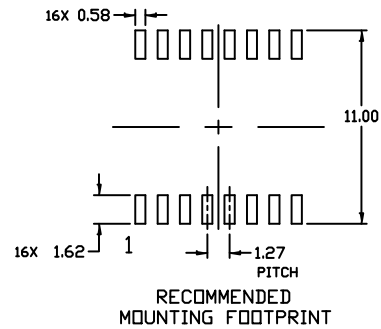
DIM	MILLIMETERS	
	MIN.	MAX.
A	2.35	2.65
A1	0.10	0.25
B	0.35	0.49
C	0.23	0.32
D	10.15	10.45
E	7.40	7.60
e	1.27 BSC	
H	10.05	10.55
h	0.53 REF	
L	0.50	0.90
M	0°	7°

GENERIC MARKING DIAGRAM\*



- XXXXX = Specific Device Code
- A = Assembly Location
- WL = Wafer Lot
- YY = Year
- WW = Work Week
- G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.



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