

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

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.

- 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

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

Rating	Symbol	Value	Unit
DC Supply Voltage	$V_{DD}$	- 0.5 to + 18	V
Input Voltage, All Inputs	$V_{in}$	- 0.5 to $V_{DD} + 0.5$	V
DC Current Drain per Input Pin	I	10	mA
Operating Temperature Range	$T_A$	- 55 to + 125	°C
Power Dissipation per Package†	$P_D$	500	mW
Storage Temperature Range	$T_{stg}$	- 65 to + 150	°C
Maximum Output Drive Current (Source) per Output	$I_{OHmax}$	25	mA
Maximum Continuous Output Power (Source) per Output ‡	$P_{OHmax}$	50	mW

‡ $P_{OHmax} = I_{OH} (V_{DD} - V_{OH})$

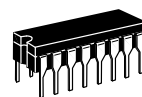
\* Maximum Ratings are those values beyond which damage to the device may occur.

† Temperature Derating:

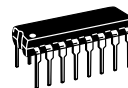
Plastic "P and D/DW" Packages: - 7.0 mW/°C From 65°C To 125°C

Ceramic "L" Packages: - 12 mW/°C From 100°C To 125°C

## MC14511B



**L SUFFIX**  
CERAMIC  
CASE 620



**P SUFFIX**  
PLASTIC  
CASE 648



**D SUFFIX**  
SOIC  
CASE 751B



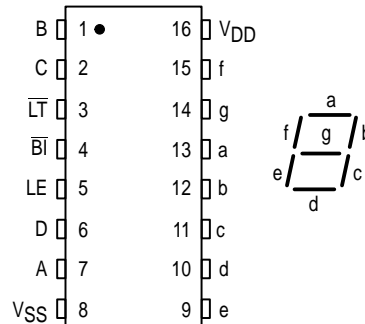
**DW SUFFIX**  
SOIC  
CASE 751G

### ORDERING INFORMATION

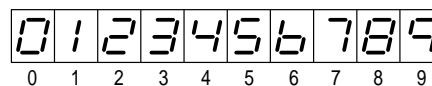
MC14XXXBCP	Plastic
MC14XXXBCL	Ceramic
MC14XXXBDW	SOIC
MC14XXXBD	SOIC

$T_A = -55^\circ$  to  $125^\circ\text{C}$  for all packages.

### 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 1	1	1	1	1	1	0	0	2
0	1	1	0 0 1 0	0	1	1	1	1	0	0	3
0	1	1	0 1 0 0	0	1	1	0	0	0	1	4
0	1	1	0 1 0 1	1	0	1	1	1	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	0	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 0 1	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

**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 #	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		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.1	—	4.1	4.57	—	4.1		—
			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		
	"1" Level (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)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5		—
			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	—		
			—	—	—	3.94	—	—	—		
			3.4	—	3.4	3.70	—	3.0	—		
			—	—	—	3.54	—	—	—		
	V <sub>OH</sub>	10	9.1	—	9.1	9.58	—	9.1	—	Vdc	
			—	—	—	9.26	—	—	—		
			9.0	—	9.0	9.17	—	8.6	—		
			—	—	—	9.04	—	—	—		
			8.6	—	8.6	8.90	—	8.2	—		
			—	—	—	8.70	—	—	—		
V <sub>OH</sub>	15	14.1	—	14.1	14.59	—	14.1	—	Vdc		
		—	—	—	14.27	—	—	—			
		14	—	14	14.18	—	13.6	—			
		—	—	—	14.07	—	—	—			
		13.6	—	13.6	13.95	—	13.2	—			
		—	—	—	13.70	—	—	—			
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**† (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> I <sub>T</sub> = (3.8 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (5.7 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10									
		15									

#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

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

†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.

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

Characteristic	Symbol	V <sub>DD</sub> 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

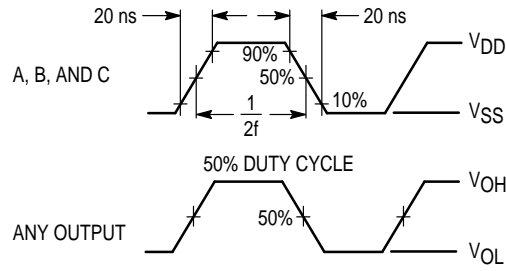
\* The formulas given are for the typical characteristics only.

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  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

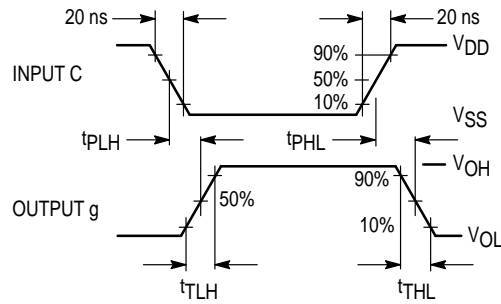
Due to the sourcing capability of this circuit, damage can occur to the device if  $V_{DD}$  is applied, and the outputs are shorted to  $V_{SS}$  and are at a logical 1 (See Maximum Ratings).

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

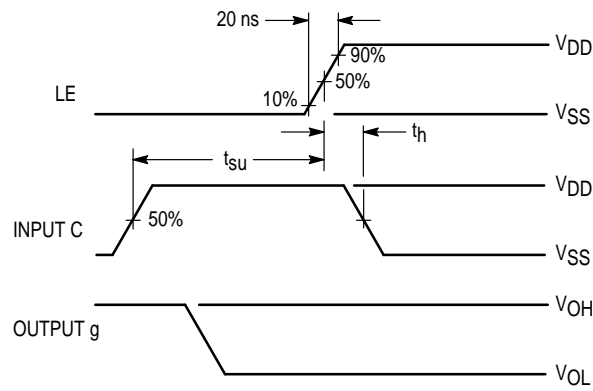
Input LE low, and Inputs D,  $\overline{B}$ I and  $\overline{L}$ T high.  
 f in respect to a system clock.  
 All outputs connected to respective  $C_L$  loads.



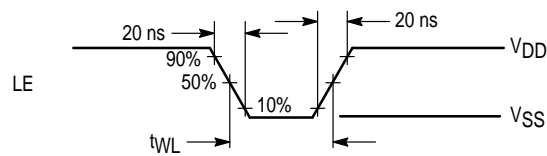
**Figure 1. Dynamic Power Dissipation Signal Waveforms**



**(a) Inputs D and LE low, and Inputs A, B,  $\overline{B}$ I and  $\overline{L}$ T high.**



**(b) Input D low, Inputs A, B,  $\overline{B}$ I and  $\overline{L}$ T high.**

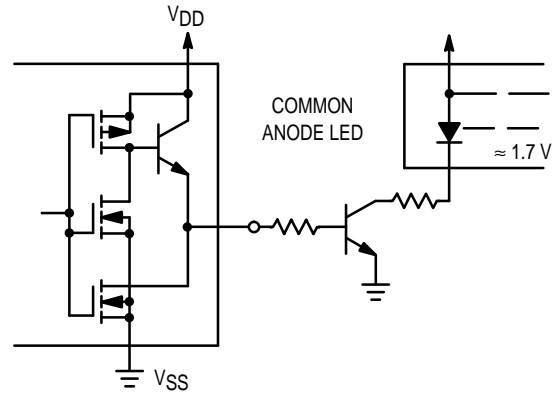
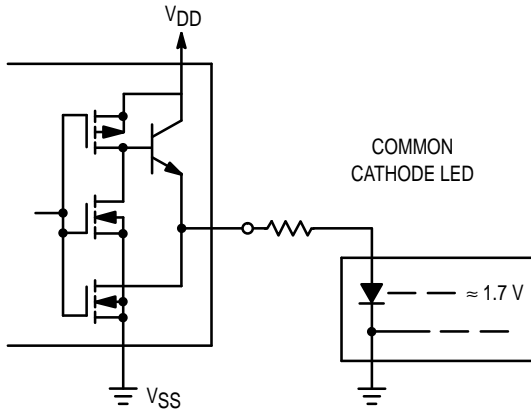


**(c) Data DCBA strobed into latches.**

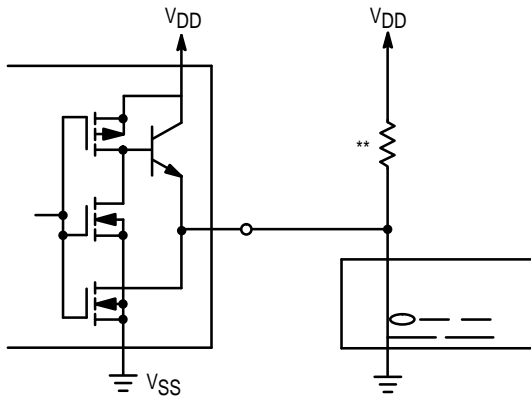
**Figure 2. Dynamic Signal Waveforms**

## CONNECTIONS TO VARIOUS DISPLAY READOUTS

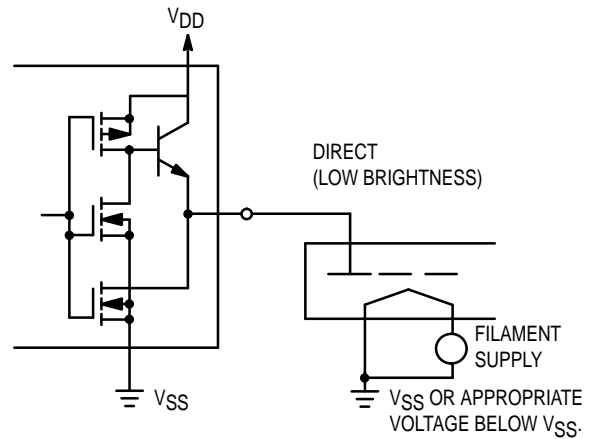
### LIGHT EMITTING DIODE (LED) READOUT



### INCANDESCENT READOUT

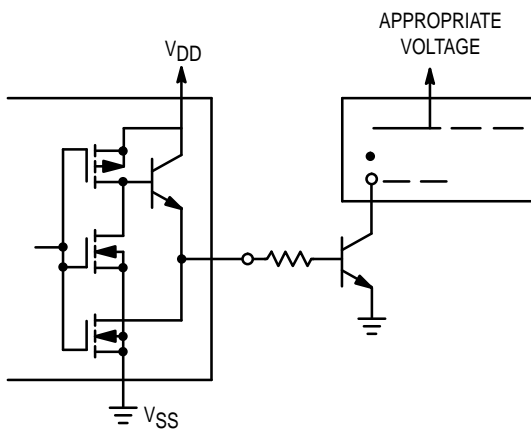


### FLUORESCENT READOUT

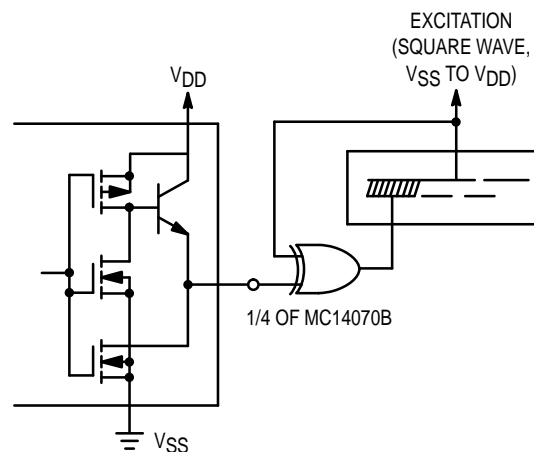


(CAUTION: Maximum working voltage = 18.0 V)

### GAS DISCHARGE READOUT



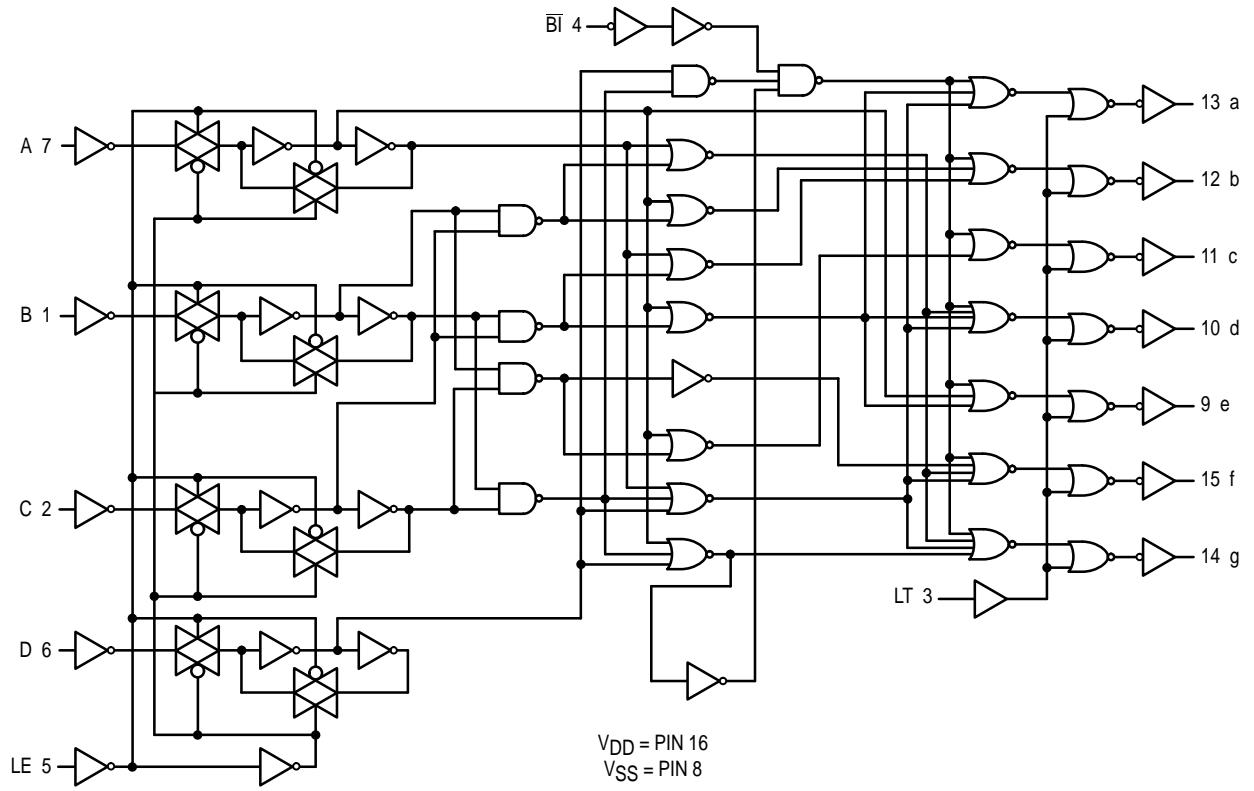
### LIQUID CRYSTAL (LCD) READOUT



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

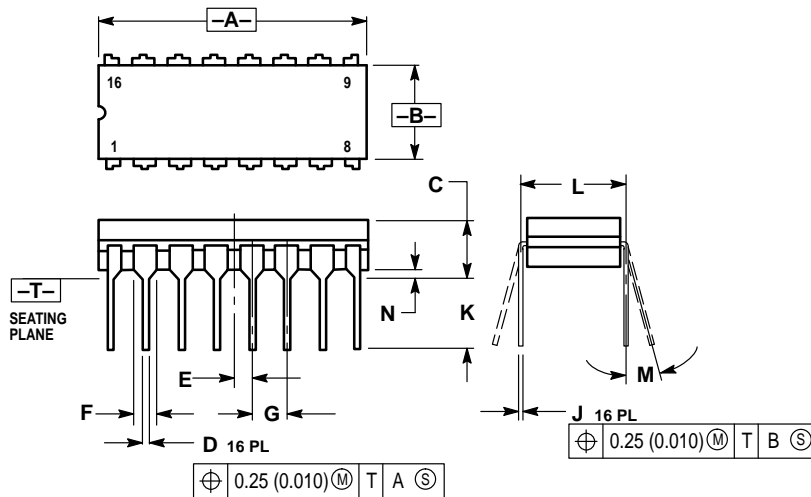
Direct dc drive of LCD's not recommended for life of LCD readouts.

# LOGIC DIAGRAM



## OUTLINE DIMENSIONS

### L SUFFIX CERAMIC DIP PACKAGE CASE 620-10 ISSUE V

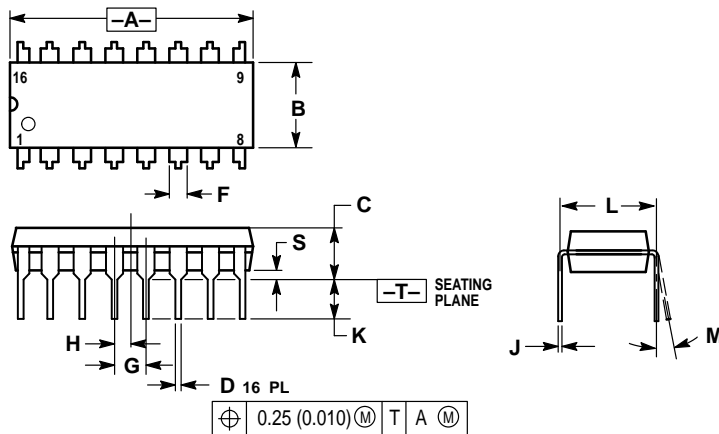


**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
4. DIMENSION F MAY NARROW TO 0.76 (0.030) WHERE THE LEAD ENTERS THE CERAMIC BODY.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.750	0.785	19.05	19.93
B	0.240	0.295	6.10	7.49
C	—	0.200	—	5.08
D	0.015	0.020	0.39	0.50
E	0.050 BSC		1.27 BSC	
F	0.055	0.065	1.40	1.65
G	0.100 BSC		2.54 BSC	
H	0.008	0.015	0.21	0.38
K	0.125	0.170	3.18	4.31
L	0.300 BSC		7.62 BSC	
M	0°	15°	0°	15°
N	0.020	0.040	0.51	1.01

### P SUFFIX PLASTIC DIP PACKAGE CASE 648-08 ISSUE R



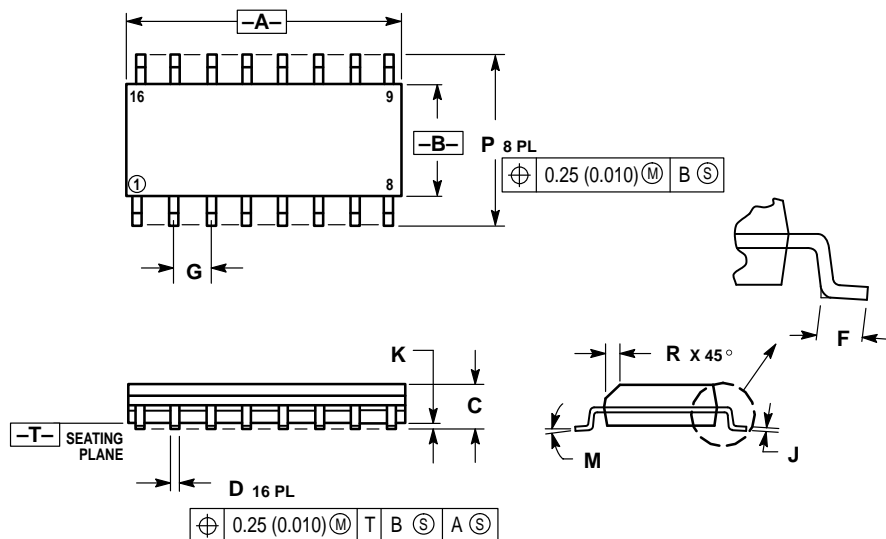
**NOTES:**

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

## OUTLINE DIMENSIONS

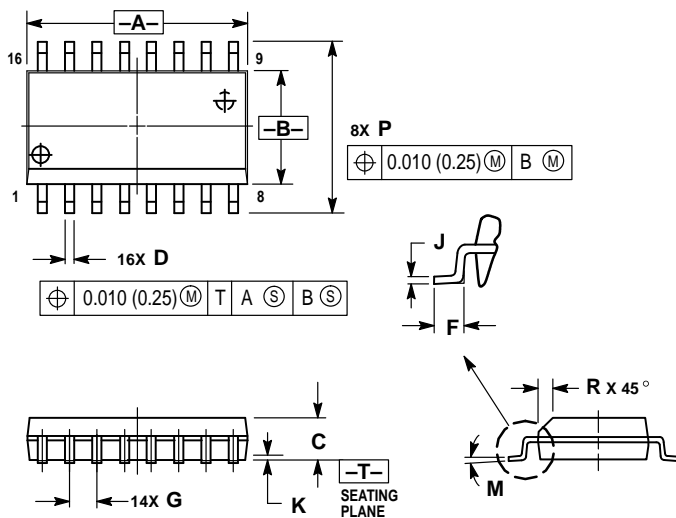
### D SUFFIX PLASTIC SOIC PACKAGE CASE 751B-05 ISSUE J



- 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


### DW SUFFIX PLASTIC SOIC PACKAGE CASE 751G-02 ISSUE A



- 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 0.13 (0.005) TOTAL IN EXCESS OF D DIMENSION AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.15	10.45	0.400	0.411
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.50	0.90	0.020	0.035
G	1.27 BSC		0.050 BSC	
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.05	10.55	0.395	0.415
R	0.25	0.75	0.010	0.029



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