

# MC14513B

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

### CMOS MSI (Low-Power Complementary MOS)

The MC14513B 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 has output drive capability. Lamp test (LT), blanking (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. The Ripple Blanking Input (RBI) and Ripple Blanking Output (RBO) can be used to suppress either leading or trailing zeroes. 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 Binary Input
- Blanking Input
- Lamp Test Provision
- Readout Blanking on all Illegal Input Combinations
- Lamp Intensity Modulation Capability
- Time Share (Multiplexing) Capability
- Adds Ripple Blanking In, Ripple Blanking Out to MC14511B
- Supply Voltage Range = 3.0 V to 18 V
- Capable of Driving Two Low-Power TTL Loads, One Low-Power Schottky TTL Load to Two HTL Loads Over the Rated Temperature Range
- These Devices are Pb-Free and are RoHS Compliant

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

Parameter	Symbol	Value	Unit
DC Supply Voltage Range	$V_{DD}$	-0.5 to +18.0	V
Input Voltage Range, All Inputs	$V_{in}$	-0.5 to $V_{DD} + 0.5$	V
DC Current Drain per Input Pin	I	10	mA
Power Dissipation per Package (Note 1)	$P_D$	500	mW
Operating Temperature Range	$T_A$	-55 to +125	°C
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Maximum Continuous Output Drive Current (Source) per Output	$I_{OHmax}$	25	mA
Maximum Continuous Output Power (Source) per Output (Note 2)	$P_{OHmax}$	50	mW

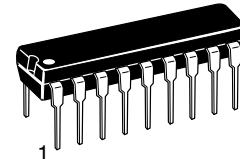
Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Temperature Derating: Plastic "P and D/DW"  
Packages: - 7.0 mW/°C From 65°C To 125°C
2.  $P_{OHmax} = I_{OH} (V_{DD} - V_{OH})$



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PDIP-18  
P SUFFIX  
CASE 707

#### MARKING DIAGRAM



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

#### ORDERING INFORMATION

Device	Package	Shipping
MC14513BCPG	PDIP-18 (Pb-Free)	20 Units/Rail

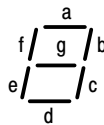
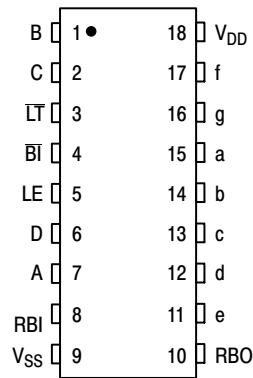
This device contains protection circuitry to protect the inputs against damage due to high static voltages or electric fields. However, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high-impedance circuit. A destructive high 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).

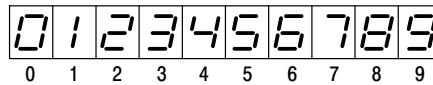
Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ).

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## PIN ASSIGNMENT



## DISPLAY



## TRUTH TABLE

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

X = Don't Care

†RBO = RBI ( $\overline{D} \overline{C} \overline{B} \overline{A}$ ), indicated by other rows of table

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

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## ELECTRICAL CHARACTERISTICS (Voltages Referenced to $V_{SS}$ )

Characteristic	Symbol	$V_{DD}$ Vdc	- 55°C		25°C			125°C		Unit
			Min	Max	Min	Typ (Note 3)	Max	Min	Max	
Output Voltage — Segment Outputs “0” Level $V_{in} = V_{DD}$ or 0  “1” Level $V_{in} = 0$ or $V_{DD}$	$V_{OL}$	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	
	$V_{OH}$	5.0	4.1	–	4.1	5.0	–	4.1	–	Vdc
		10	9.1	–	9.1	10	–	9.1	–	
		15	14.1	–	14.1	15	–	14.1	–	
Output Voltage — RBO Output “0” Level $V_{in} = V_{DD}$ or 0  “1” Level $V_{in} = 0$ or $V_{DD}$	$V_{OL}$	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	
	$V_{OH}$	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 (Note 3) “0” Level ( $V_O = 3.8$ or $0.5$ Vdc) ( $V_O = 8.8$ or $1.0$ Vdc) ( $V_O = 13.8$ or $1.5$ Vdc)  “1” Level ( $V_O = 0.5$ or $3.8$ Vdc) ( $V_O = 1.0$ or $8.8$ Vdc) ( $V_O = 1.5$ or $13.8$ Vdc)	$V_{IL}$	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	
	$V_{IH}$	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 — Segments Source ( $I_{OH} = 0$ mA) ( $I_{OH} = 5.0$ mA) ( $I_{OH} = 10$ mA) ( $I_{OH} = 15$ mA) ( $I_{OH} = 20$ mA) ( $I_{OH} = 25$ mA)  ( $I_{OH} = 0$ mA) ( $I_{OH} = 5.0$ mA) ( $I_{OH} = 10$ mA) ( $I_{OH} = 15$ mA) ( $I_{OH} = 20$ mA) ( $I_{OH} = 25$ mA)  ( $I_{OH} = 0$ mA) ( $I_{OH} = 5.0$ mA) ( $I_{OH} = 10$ mA) ( $I_{OH} = 15$ mA) ( $I_{OH} = 20$ mA) ( $I_{OH} = 25$ mA)	$V_{OH}$	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	–	–	–	
	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	–		
		–	–	–	8.75	–	–	–		
	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	–		
		–	–	–	13.80	–	–	–		

3. Noise immunity specified for worst-case input combination.  
 Noise Margin for both “1” and “0” level = 1.0 Vdc min @  $V_{DD} = 5.0$  Vdc  
 2.0 Vdc min @  $V_{DD} = 10$  Vdc  
 2.5 Vdc min @  $V_{DD} = 15$  Vdc

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## ELECTRICAL CHARACTERISTICS (continued) (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 Drive Current — RBO Output (V <sub>OH</sub> = 2.5 V) Source (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) Sink (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	I <sub>OH</sub>	5.0	-0.40	-	-0.32	-0.64	-	-0.22	-	mAdc
		10	-0.21	-	-0.17	-0.34	-	-0.12	-	
		15	-0.81	-	-0.66	-1.30	-	-0.46	-	
	I <sub>OL</sub>	5.0	0.18	-	0.15	0.29	-	0.10	-	mAdc
		10	0.47	-	0.38	0.75	-	0.26	-	
		15	1.80	-	1.50	2.90	-	1.0	-	
Output Drive Current — Segments (V <sub>OL</sub> = 0.4 V) Sink (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 (Note 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>							

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<sub>T</sub>(C<sub>L</sub>) = I<sub>T</sub>(50 pF) + 3.5 × 10<sup>-3</sup> (C<sub>L</sub> - 50) V<sub>DD</sub>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.

Input LE and RBI 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<sub>L</sub> loads.

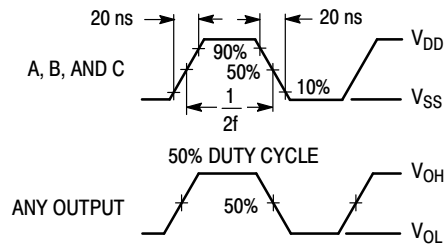


Figure 1. Dynamic Power Dissipation Signal Waveforms

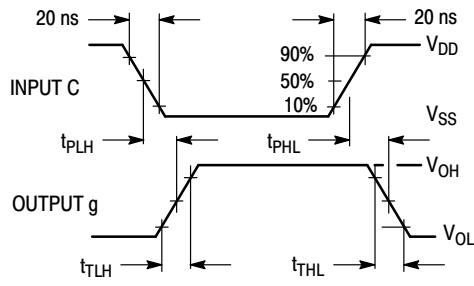
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## SWITCHING CHARACTERISTICS (Note 7) ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

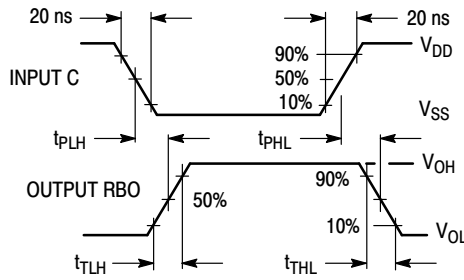
Characteristic	Symbol	$V_{DD}$ Vdc	All Types			Unit
			Min	Typ	Max	
Output Rise Time — Segment Outputs	$t_{TLH}$	5.0 10 15	— — —	40 30 25	80 60 50	ns
Output Rise Time — RBO Output	$t_{TLH}$	5.0 10 15	— — —	480 240 190	960 480 380	ns
Output Fall Time — Segment Outputs (Note 7) $t_{THL} = (1.5 \text{ ns/pF}) C_L + 50 \text{ ns}$ $t_{THL} = (0.75 \text{ ns/pF}) C_L + 37.5 \text{ ns}$ $t_{THL} = (0.55 \text{ ns/pF}) C_L + 37.5 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	125 75 65	250 150 130	ns
Output Fall Time — RBO Outputs $t_{THL} = (3.25 \text{ ns/pF}) C_L + 107.5 \text{ ns}$ $t_{THL} = (1.35 \text{ ns/pF}) C_L + 67.5 \text{ ns}$ $t_{THL} = (0.95 \text{ ns/pF}) C_L + 62.5 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	270 135 110	540 270 220	ns
Propagation Delay Time — A, B, C, D Inputs (Note 7) $t_{PLH} = (0.40 \text{ ns/pF}) C_L + 620 \text{ ns}$ $t_{PLH} = (0.25 \text{ ns/pF}) C_L + 237.5 \text{ ns}$ $t_{PLH} = (0.20 \text{ ns/pF}) C_L + 165 \text{ ns}$ $t_{PHL} = (1.3 \text{ ns/pF}) C_L + 655 \text{ ns}$ $t_{PHL} = (0.60 \text{ ns/pF}) C_L + 260 \text{ ns}$ $t_{PHL} = (0.35 \text{ ns/pF}) C_L + 182.5 \text{ ns}$	$t_{PLH}$	5.0 10 15	— — —	640 250 175	1280 500 350	ns
	$t_{PHL}$	5.0 10 15	— — —	720 290 200	1440 580 400	ns
Propagation Delay Time — RBI and $\overline{BI}$ Inputs (Note 7) $t_{PLH} = (1.05 \text{ ns/pF}) C_L + 547.5 \text{ ns}$ $t_{PLH} = (0.45 \text{ ns/pF}) C_L + 177.5 \text{ ns}$ $t_{PLH} = (0.30 \text{ ns/pF}) C_L + 135 \text{ ns}$ $t_{PHL} = (0.85 \text{ ns/pF}) C_L + 442.5 \text{ ns}$ $t_{PHL} = (0.45 \text{ ns/pF}) C_L + 177.5 \text{ ns}$ $t_{PHL} = (0.35 \text{ ns/pF}) C_L + 142.5 \text{ ns}$	$t_{PLH}$	5.0 10 15	— — —	600 200 150	750 300 220	ns
	$t_{PHL}$	5.0 10 15	— — —	485 200 160	970 400 320	ns
Propagation Delay Time — $\overline{LT}$ Input (Note 7) $t_{PLH} = (0.45 \text{ ns/pF}) C_L + 290.5 \text{ ns}$ $t_{PLH} = (0.25 \text{ ns/pF}) C_L + 112.5 \text{ ns}$ $t_{PLH} = (0.20 \text{ ns/pF}) C_L + 80 \text{ ns}$ $t_{PHL} = (1.3 \text{ ns/pF}) C_L + 248 \text{ ns}$ $t_{PHL} = (0.45 \text{ ns/pF}) C_L + 102.5 \text{ ns}$ $t_{PHL} = (0.35 \text{ ns/pF}) C_L + 72.5 \text{ ns}$	$t_{PLH}$	5.0 10 15	— — —	313 125 90	625 250 180	ns
	$t_{PHL}$	5.0 10 15	— — —	313 125 90	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	$t_{WL(LE)}$	5.0 10 15	520 220 130	260 110 65	— — —	ns

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

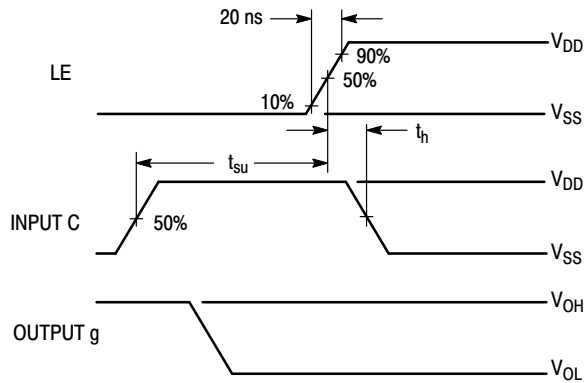
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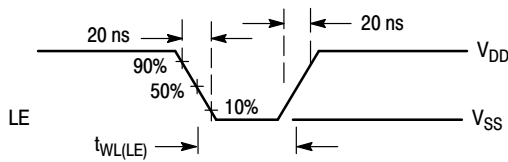
a. Data Propagation Delay: Inputs RBI, D and LE low, and Inputs A, B,  $\overline{BI}$  and  $\overline{LT}$  high.



b. Inputs A, B, D and LE low, and Inputs RBI,  $\overline{BI}$  and  $\overline{LT}$  high.



c. Setup and Hold Times: Input RBI and D low, Inputs A, B,  $\overline{BI}$  and  $\overline{LT}$  high.



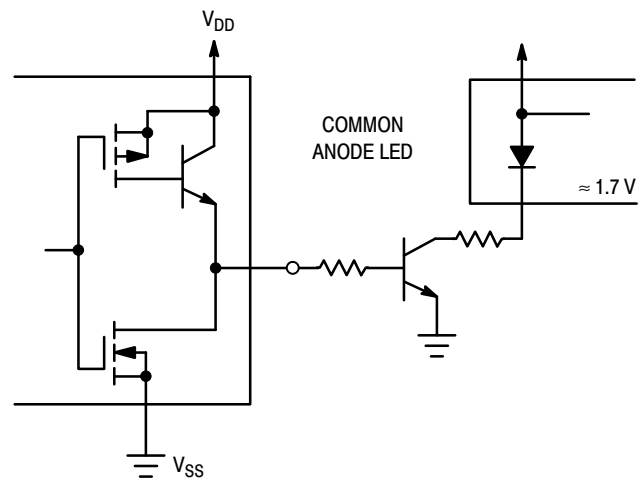
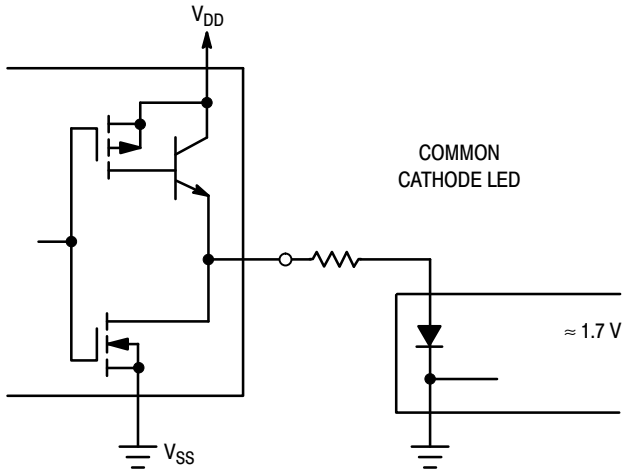
d. Pulse Width: Data DCBA strobed into latches.

Figure 2. Dynamic Signal Waveforms

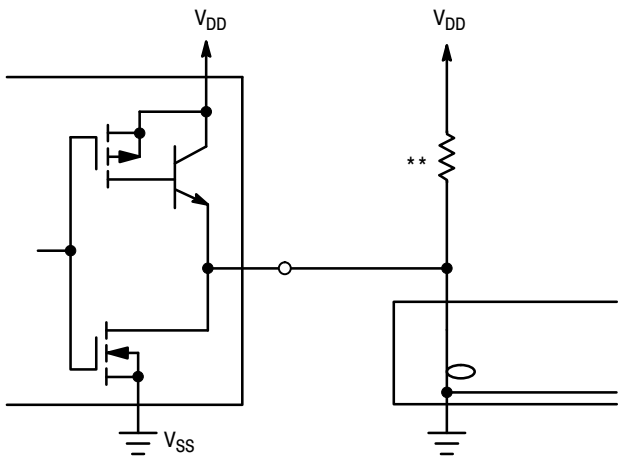
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## CONNECTIONS TO VARIOUS DISPLAY READOUTS

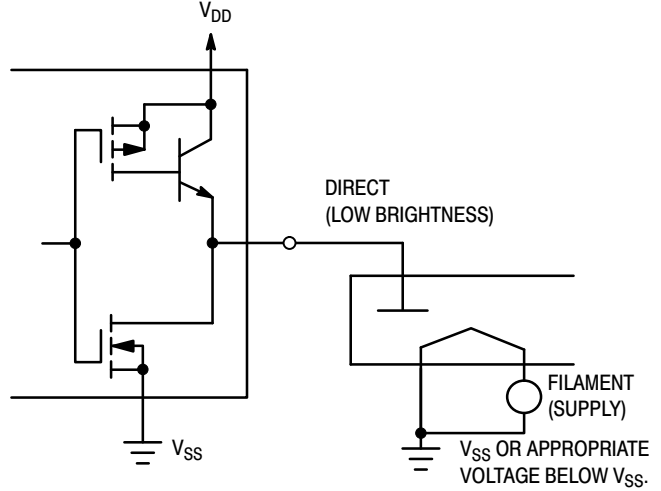
### LIGHT EMITTING DIODE (LED) READOUT



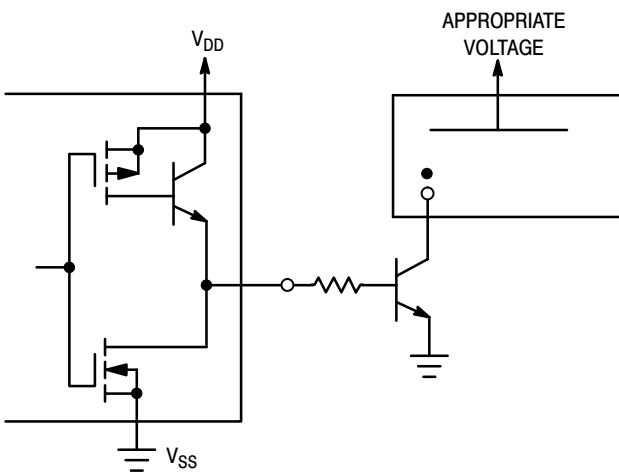
### INCANDESCENT READOUT



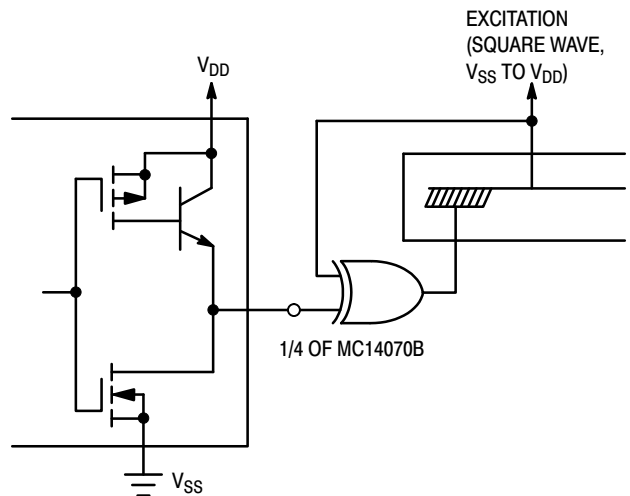
### FLUORESCENT READOUT



### GAS DISCHARGE READOUT



### LIQUID CRYSTAL (LC) READOUT

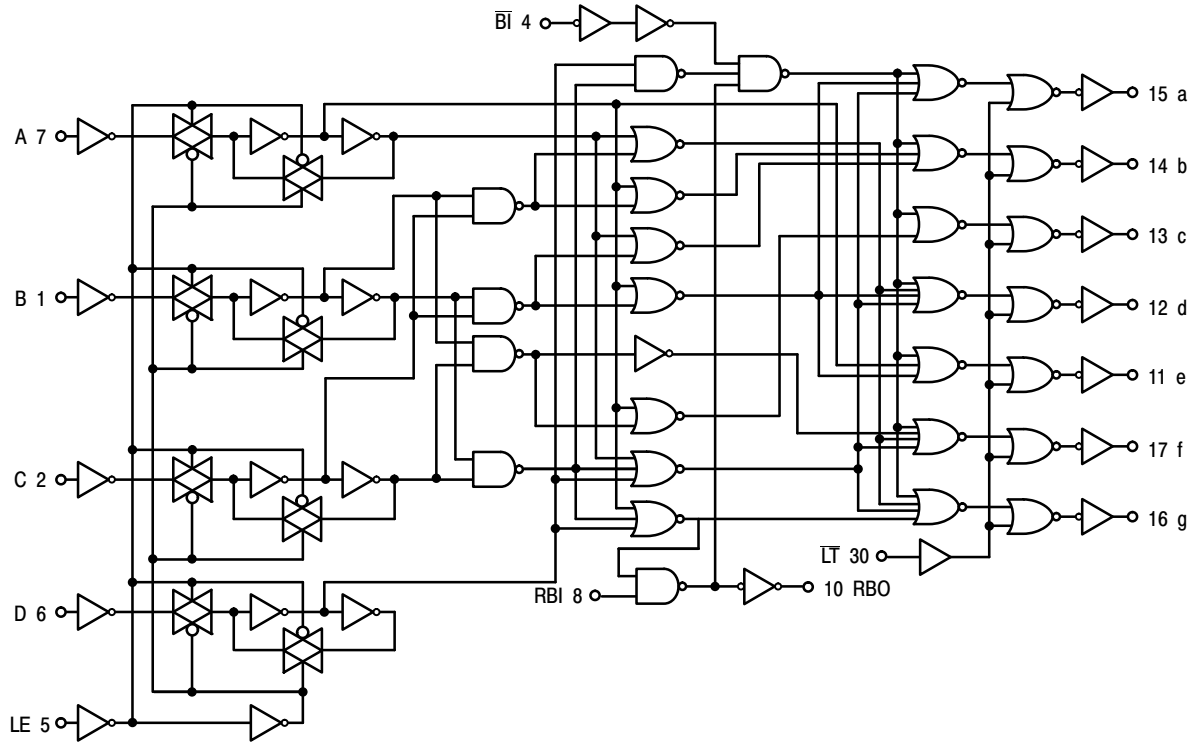


\*\* A filament pre-warm resistor is recommended to reduce filament thermal shock and increase the effective cold resistance of the filament.

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

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## LOGIC DIAGRAM

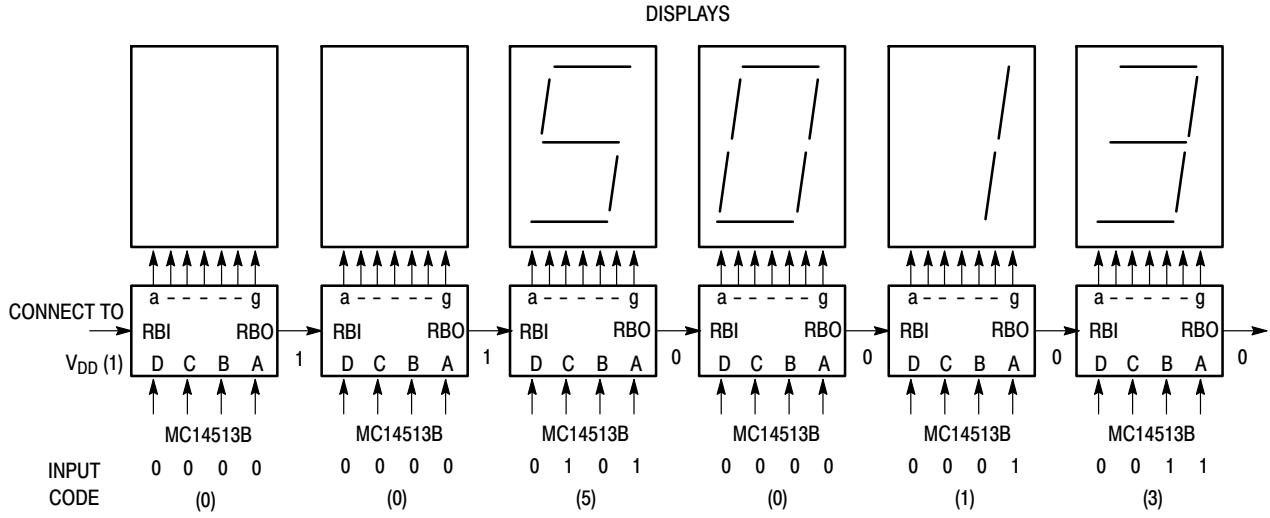




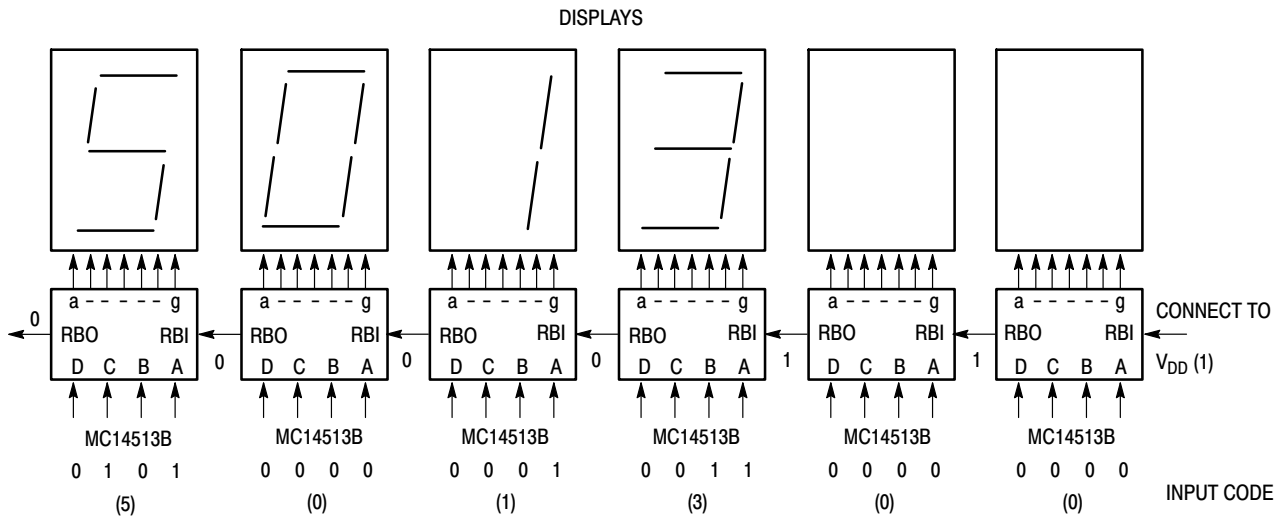
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## TYPICAL APPLICATIONS FOR RIPPLE BLANKING

### LEADING EDGE ZERO SUPPRESSION



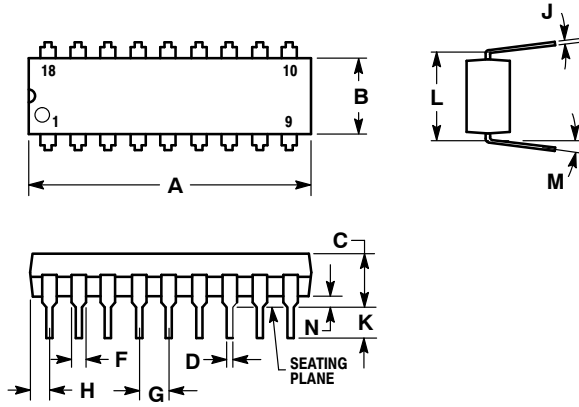
### TRAILING EDGE ZERO SUPPRESSION



# MC14513B

## PACKAGE DIMENSIONS

PDIP-18  
CASE 707-02  
ISSUE D



### NOTES:

1. POSITIONAL TOLERANCE OF LEADS (D), SHALL BE WITHIN 0.25 mm (0.010) AT MAXIMUM MATERIAL CONDITION, IN RELATION TO SEATING PLANE AND EACH OTHER.
2. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION B DOES NOT INCLUDE MOLD FLASH.
4. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.875	0.915	22.22	23.24
B	0.240	0.260	6.10	6.60
C	0.140	0.180	3.56	4.57
D	0.014	0.022	0.36	0.56
F	0.050	0.070	1.27	1.78
G	0.100 BSC		2.54 BSC	
H	0.040	0.060	1.02	1.52
J	0.008	0.012	0.20	0.30
K	0.115	0.135	2.92	3.43
L	0.300 BSC		7.62 BSC	
M	0° 15°		0° 15°	
N	0.020	0.040	0.51	1.02

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