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 ($\overline{LT}$), 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. 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.

- 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.

MC14513B

L SUFFIX
CERAMIC
CASE 726

P SUFFIX
PLASTIC
CASE 707

ORDERING INFORMATION

MC14XXXBCP   Plastic
MC14XXXBCL   Ceramic

$T_A = -55°$ to $125°C$ for all packages.

PIN ASSIGNMENT

B	1 •	18	V_{DD}
C	2	17	f
$\overline{LT}$	3	16	g
$\overline{BI}$	4	15	a
LE	5	14	b
D	6	13	c
A	7	12	d
RBI	8	11	e
V_{SS}	9	10	RBO

```
    a
  f | g | b
    | g |
  e |   | c
    d
```

DISPLAY

```
0 1 2 3 4 5 6 7 8 9
0 1 2 3 4 5 6 7 8 9
```

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 Continuous Output Drive Current (Source) per Output	I_{OHmax}	25	mA
Maximum Continuous Output Power (Source) per Output ‡	P_{OHmax}	50	mW

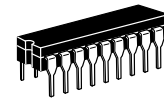‡$P_{OHmax} = I_{OH} (V_{DD} - V_{OH})$
* Maximum Ratings are those values beyond which damage to the device may occur.
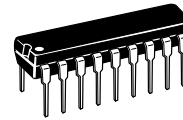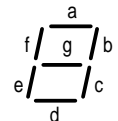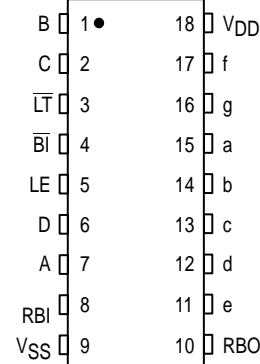†Temperature Derating:
    Plastic "P and D/DW" Packages: -7.0 mW/°C From 65°C To 125°C
    Ceramic "L" Packages: -12 mW/°C From 100°C To 125°C

TRUTH TABLE

Inputs									Outputs							
RBI	LE	$\overline{BI}$	$\overline{LT}$	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	1	1	0	0	1	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	0	1	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	0	1	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 ($\overline{D}\,\overline{C}\,B\,\overline{A}$), indicated by other rows of table
*Depends upon the BCD code previously applied when LE = 0.

MOTOROLA

ELECTRICAL CHARACTERISTICS (Voltages Referenced to V_{SS})

Characteristic	Symbol	V_{DD} Vdc	−55°C Min	−55°C Max	25°C Min	25°C Typ #	25°C Max	125°C Min	125°C Max	Unit
Output Voltage — Segment Outputs "0" Level	V_{OL}									Vdc
V_{in} = V_{DD} or 0		5.0	—	0.05	—	0	0.05	—	0.05	
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
"1" Level	V_{OH}	5.0	4.1	—	4.1	5.0	—	4.1	—	Vdc
V_{in} = 0 or V_{DD}		10	9.1	—	9.1	10	—	9.1	—	
		15	14.1	—	14.1	15	—	14.1	—	
Output Voltage — RBO Output "0" Level	V_{OL}									Vdc
V_{in} = V_{DD} or 0		5.0	—	0.05	—	0	0.05	—	0.05	
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
"1" Level	V_{OH}	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
V_{in} = 0 or V_{DD}		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage # "0" Level	V_{IL}									Vdc
(V_O = 3.8 or 0.5 Vdc)		5.0	—	1.5	—	2.25	1.5	—	1.5	
(V_O = 8.8 or 1.0 Vdc)		10	—	3.0	—	4.50	3.0	—	3.0	
(V_O = 13.8 or 1.5 Vdc)		15	—	4.0	—	6.75	4.0	—	4.0	
(V_O = 0.5 or 3.8 Vdc) "1" Level	V_{IH}	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
(V_O = 1.0 or 8.8 Vdc)		10	7.0	—	7.0	5.50	—	7.0	—	
(V_O = 1.5 or 13.8 Vdc)		15	11	—	11	8.25	—	11	—	
Output Drive Voltage — Segments (I_{OH} = 0 mA) Source	V_{OH}	5.0	4.1	—	4.1	4.57	—	4.1	—	Vdc
(I_{OH} = 5.0 mA)			—	—	—	4.24	—	—	—	
(I_{OH} = 10 mA)			3.9	—	3.9	4.12	—	3.5	—	
(I_{OH} = 15 mA)			—	—	—	3.94	—	—	—	
(I_{OH} = 20 mA)			3.4	—	3.4	3.70	—	3.0	—	
(I_{OH} = 25 mA)			—	—	—	3.54	—	—	—	
(I_{OH} = 0 mA)		10	9.1	—	9.1	9.58	—	9.1	—	Vdc
(I_{OH} = 5.0 mA)			—	—	—	9.26	—	—	—	
(I_{OH} = 10 mA)			9.0	—	9.0	9.17	—	8.6	—	
(I_{OH} = 15 mA)			—	—	—	9.04	—	—	—	
(I_{OH} = 20 mA)			8.6	—	8.6	8.90	—	8.2	—	
(I_{OH} = 25 mA)			—	—	—	8.75	—	—	—	
(I_{OH} = 0 mA)		15	14.1	—	14.1	14.59	—	14.1	—	Vdc
(I_{OH} = 5.0 mA)			—	—	—	14.27	—	—	—	
(I_{OH} = 10 mA)			14	—	14	14.18	—	13.6	—	
(I_{OH} = 15 mA)			—	—	—	14.07	—	—	—	
(I_{OH} = 20 mA)			13.6	—	13.6	13.95	—	13.2	—	
(I_{OH} = 25 mA)			—	—	—	13.80	—	—	—	

(continued)

ELECTRICAL CHARACTERISTICS — continued (Voltages Referenced to V_{SS})

Characteristic	Symbol	V_{DD} Vdc	− 55°C Min	− 55°C Max	25°C Min	25°C Typ #	25°C Max	125°C Min	125°C Max	Unit
Output Drive Current — RBO Output	I_{OH}									mAdc
(V_{OH} = 2.5 V) Source		5.0	− 0.40	—	− 0.32	− 0.64	—	− 0.22	—	
(V_{OH} = 9.5 V)		10	− 0.21	—	− 0.17	− 0.34	—	− 0.12	—	
(V_{OH} = 13.5 V)		15	− 0.81	—	− 0.66	− 1.30	—	− 0.46	—	
(V_{OL} = 0.4 V) Sink	I_{OL}	5.0	0.18	—	0.15	0.29	—	0.10	—	mAdc
(V_{OL} = 0.5 V)		10	0.47	—	0.38	0.75	—	0.26	—	
(V_{OL} = 1.5 V)		15	1.80	—	1.50	2.90	—	1.0	—	
Output Drive Current — Segments	I_{OL}									mAdc
(V_{OL} = 0.4 V) Sink		5.0	0.64	—	0.51	0.88	—	0.36	—	
(V_{OL} = 0.5 V)		10	1.6	—	1.3	2.25	—	0.9	—	
(V_{OL} = 1.5 V)		15	4.2	—	3.4	8.8	—	2.4	—	
Input Current	I_{in}	15	—	± 0.1	—	±0.00001	± 0.1	—	± 1.0	µAdc
Input Capacitance	C_{in}	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current	I_{DD}	5.0	—	5.0	—	0.005	5.0	—	150	µAdc
(Per Package) V_{in} = 0 or V_{DD},		10	—	10	—	0.010	10	—	300	
I_{out} = 0 µA		15	—	20	—	0.015	20	—	600	
Total Supply Current**†	I_T	5.0			I_T = (1.9 µA/kHz) f + I_{DD}					µAdc
(Dynamic plus Quiescent,		10			I_T = (3.8 µA/kHz) f + I_{DD}					
Per Package)		15			I_T = (5.7 µA/kHz) f + I_{DD}					
(C_L = 50 pF on all outputs, all buffers switching)										

#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

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

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

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

where: I_T is in µA (per package), C_L in pF, V_{DD} in Vdc, and f in kHz is input frequency.

Input LE and RBI 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.
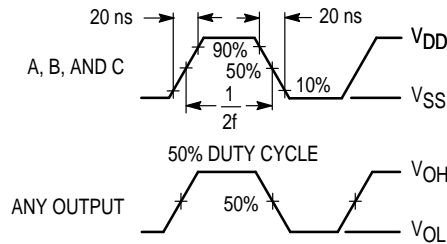
**Figure 1. Dynamic Power Dissipation Signal Waveforms**

SWITCHING CHARACTERISTICS* (C_L = 50 pF, T_A = 25°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* t_{THL} = (1.5 ns/pF) C_L + 50 ns t_{THL} = (0.75 ns/pF) C_L + 37.5 ns t_{THL} = (0.55 ns/pF) C_L + 37.5 ns	t_{THL}	5.0 10 15	— — —	125 75 65	250 150 130	ns
Output Fall Time — RBO Outputs t_{THL} = (3.25 ns/pF) C_L + 107.5 ns t_{THL} = (1.35 ns/pF) C_L + 67.5 ns t_{THL} = (0.95 ns/pF) C_L + 62.5 ns	t_{THL}	5.0 10 15	— — —	270 135 110	540 270 220	ns
Propagation Delay Time — A, B, C, D Inputs* t_{PLH} = (0.40 ns/pF) C_L + 620 ns t_{PLH} = (0.25 ns/pF) C_L + 237.5 ns t_{PLH} = (0.20 ns/pF) C_L + 165 ns	t_{PLH}	5.0 10 15	— — —	640 250 175	1280 500 350	ns
t_{PHL} = (1.3 ns/pF) C_L + 655 ns t_{PHL} = (0.60 ns/pF) C_L + 260 ns t_{PHL} = (0.35 ns/pF) C_L + 182.5 ns	t_{PHL}	5.0 10 15	— — —	720 290 200	1440 580 400	ns
Propagation Delay Time — RBI and $\overline{BI}$ Inputs* t_{PLH} = (1.05 ns/pF) C_L + 547.5 ns t_{PLH} = (0.45 ns/pF) C_L + 177.5 ns t_{PLH} = (0.30 ns/pF) C_L + 135 ns	t_{PLH}	5.0 10 15	— — —	600 200 150	750 300 220	ns
t_{PHL} = (0.85 ns/pF) C_L + 442.5 ns t_{PHL} = (0.45 ns/pF) C_L + 177.5 ns t_{PHL} = (0.35 ns/pF) C_L + 142.5 ns	t_{PHL}	5.0 10 15	— — —	485 200 160	970 400 320	ns
Propagation Delay Time — $\overline{LT}$ Input* t_{PLH} = (0.45 ns/pF) C_L + 290.5 ns t_{PLH} = (0.25 ns/pF) C_L + 112.5 ns t_{PLH} = (0.20 ns/pF) C_L + 80 ns	t_{PLH}	5.0 10 15	— — —	313 125 90	625 250 180	ns
t_{PHL} = (1.3 ns/pF) C_L + 248 ns t_{PHL} = (0.45 ns/pF) C_L + 102.5 ns t_{PHL} = (0.35 ns/pF) C_L + 72.5 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

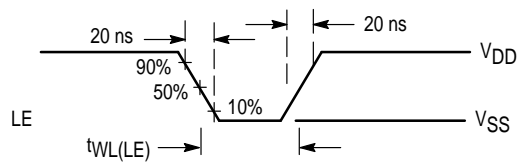* The formulas given are for the typical characteristics only.
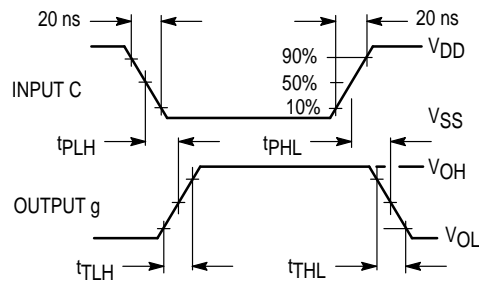
a. Data Propagation Delay: Inputs RBI, D and LE low, and Inputs A, B, $\overline{BI}$ and $\overline{LT}$ high.
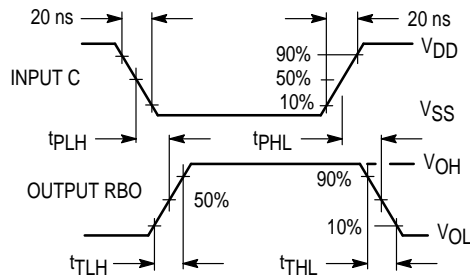
b. Inputs A, B, D and LE low, and Inputs RBI, $\overline{BI}$ and $\overline{LT}$ high.
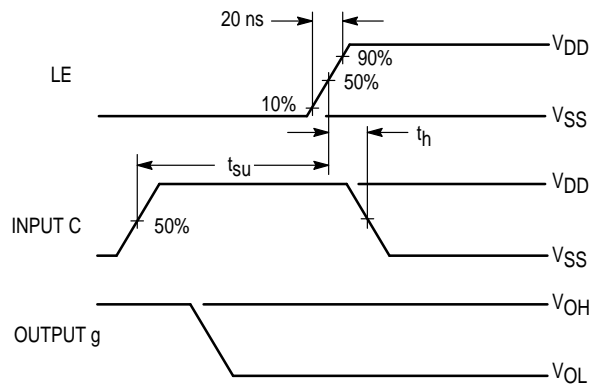
c. Setup and Hold Times: Input RBI and D low, Inputs A, B, $\overline{BI}$ and $\overline{LT}$ high.
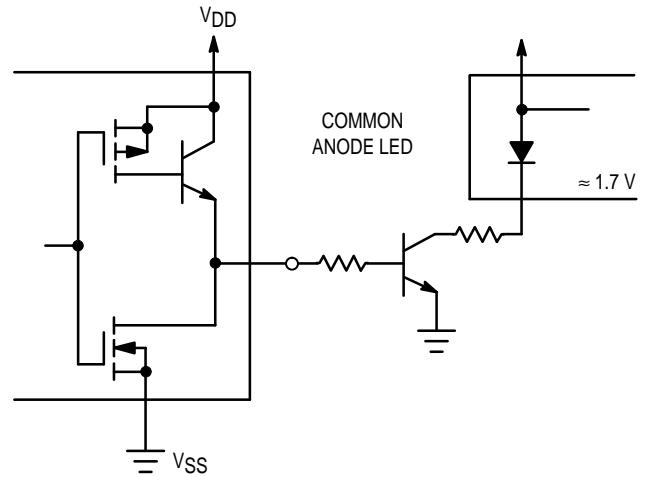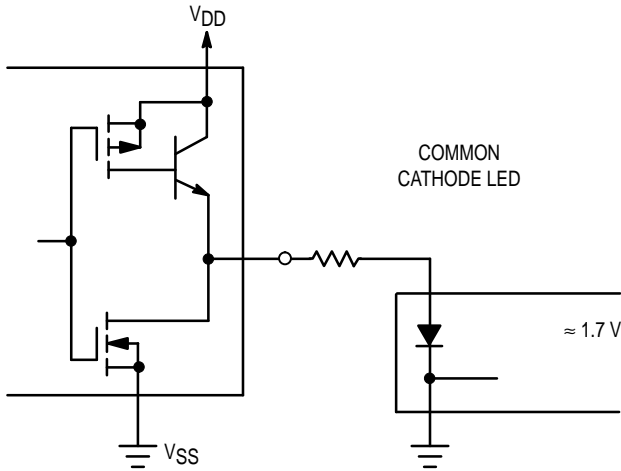

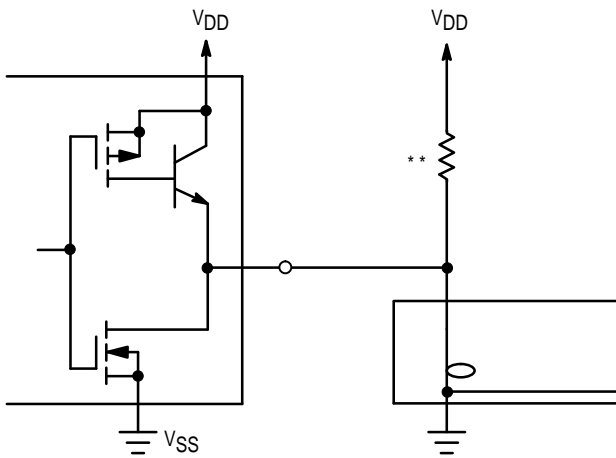
d. Pulse Width: Data DCBA strobed into latches.

Figure 2. Dynamic Signal Waveforms
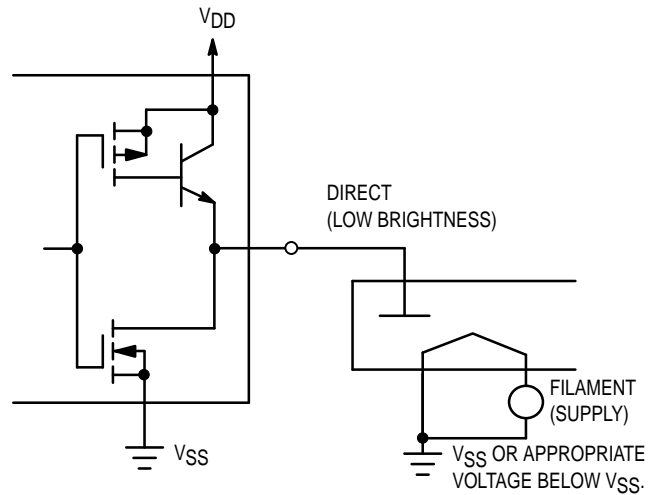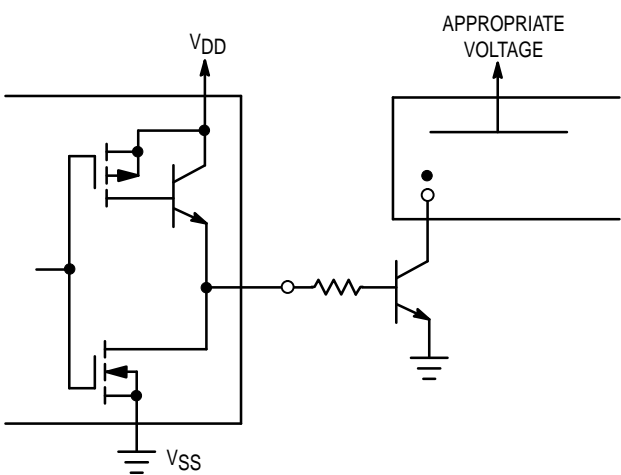
CONNECTIONS TO VARIOUS DISPLAY READOUTS

LIGHT EMITTING DIODE (LED) READOUT

COMMON
CATHODE LED

≈ 1.7 V

V_{DD}

V_{SS}

COMMON
ANODE LED

≈ 1.7 V

V_{DD}

V_{SS}

INCANDESCENT READOUT

V_{DD}

V_{DD}

**

V_{SS}

FLUORESCENT READOUT

V_{DD}

DIRECT
(LOW BRIGHTNESS)

FILAMENT
(SUPPLY)

V_{SS} OR APPROPRIATE
VOLTAGE BELOW V_{SS}.

V_{SS}

GAS DISCHARGE READOUT

APPROPRIATE
VOLTAGE

V_{DD}

V_{SS}

LIQUID CRYSTAL (LC) READOUT

EXCITATION
(SQUARE WAVE,
V_{SS} TO V_{DD})

V_{DD}

1/4 OF MC14070B

V_{SS}
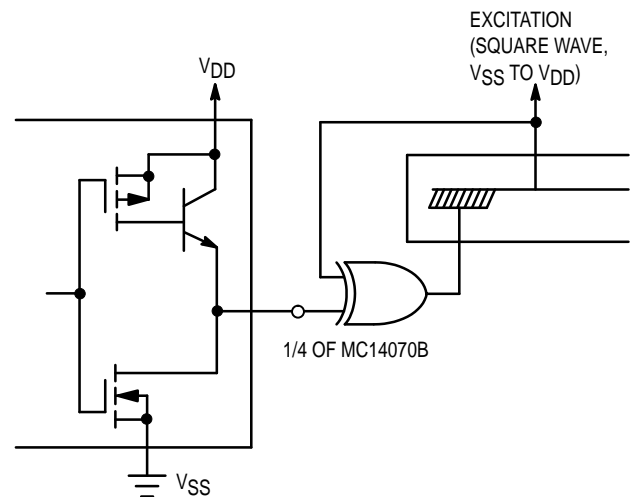
** A filament pre–warm resistor is recommended to reduce
filament thermal shock and increase the effective cold
resistance of the filament.

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

LOGIC DIAGRAM
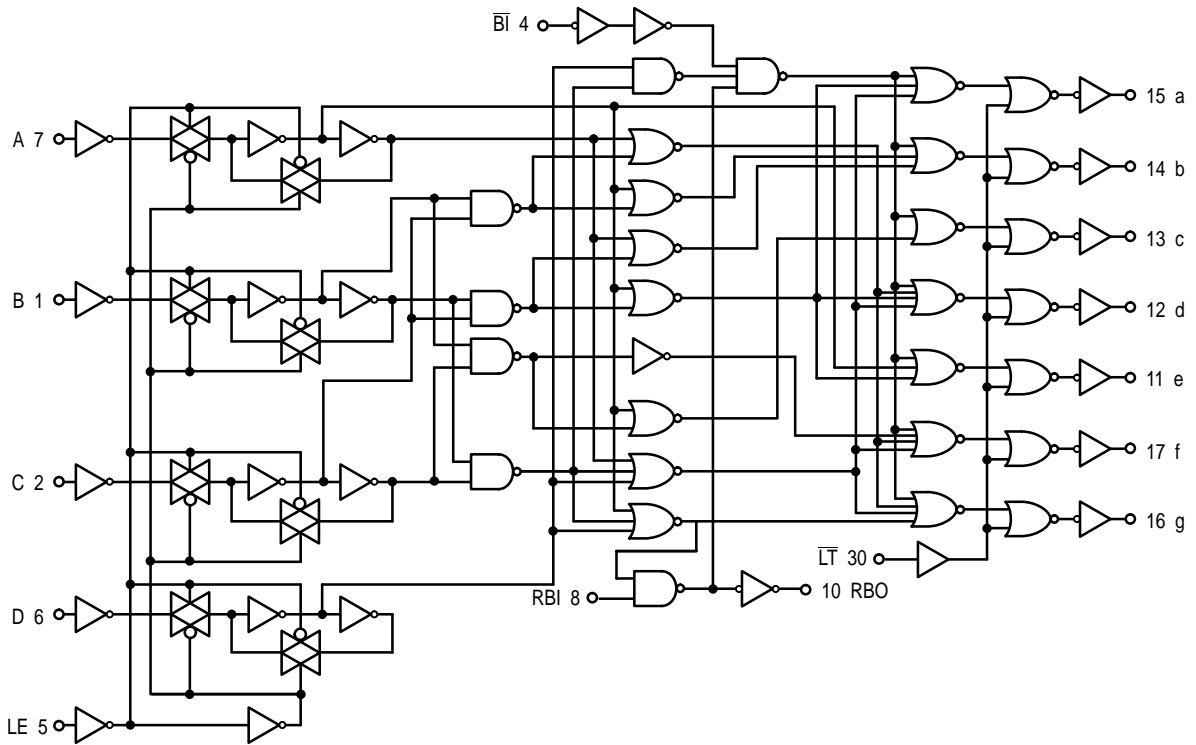
TYPICAL APPLICATIONS FOR RIPPLE BLANKING

LEADING EDGE ZERO SUPPRESSION

DISPLAYS

TRAILING EDGE ZERO SUPPRESSION
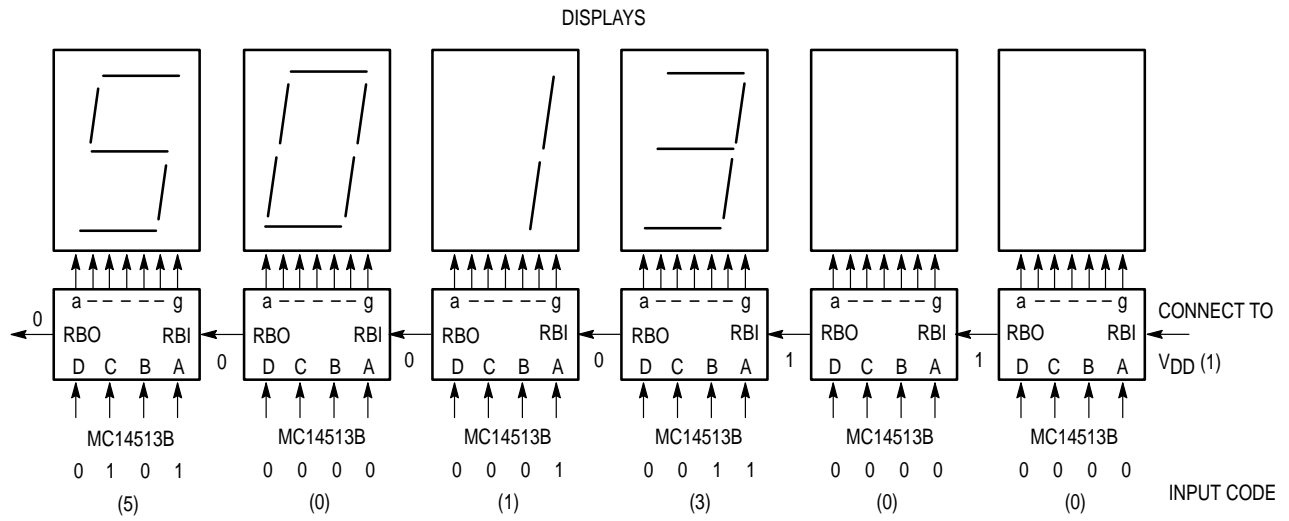
DISPLAYS

L SUFFIX
CERAMIC DIP PACKAGE
CASE 726–04
ISSUE G

**OPTIONAL LEAD
CONFIGURATION (1, 9, 10, 18)**
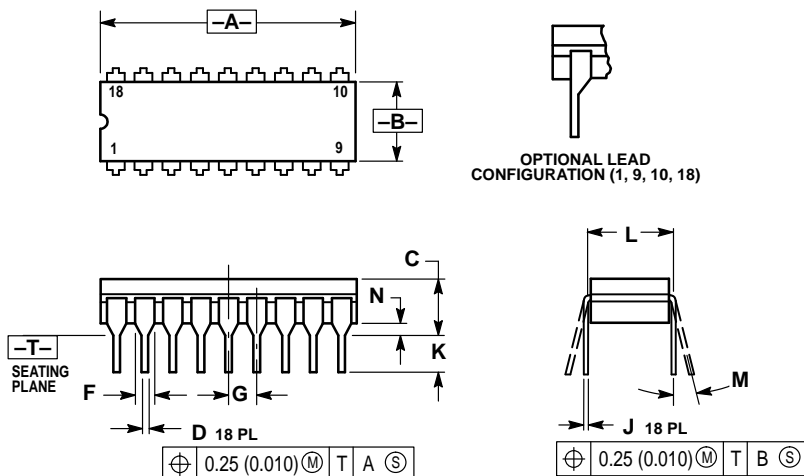
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
4. DIMENSION F FOR FULL LEADS. HALF LEADS OPTIONAL AT LEAD POSITIONS 1, 9, 10, AND 18.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.880	0.910	22.35	23.11
B	0.240	0.295	6.10	7.49
C	—	0.200	—	5.08
D	0.015	0.021	0.38	0.53
F	0.055	0.070	1.40	1.78
G	0.100 BSC		2.54 BSC	
J	0.008	0.012	0.20	0.30
K	0.125	0.170	3.18	4.32
L	0.300 BSC		7.62 BSC	
M	0°	15°	0°	15°
N	0.020	0.040	0.51	1.02

⊕ | 0.25 (0.010) Ⓜ | T | A Ⓢ

⊕ | 0.25 (0.010) Ⓜ | T | B Ⓢ

D 18 PL

J 18 PL

–T– SEATING PLANE

P SUFFIX
PLASTIC DIP PACKAGE
CASE 707–02
ISSUE C
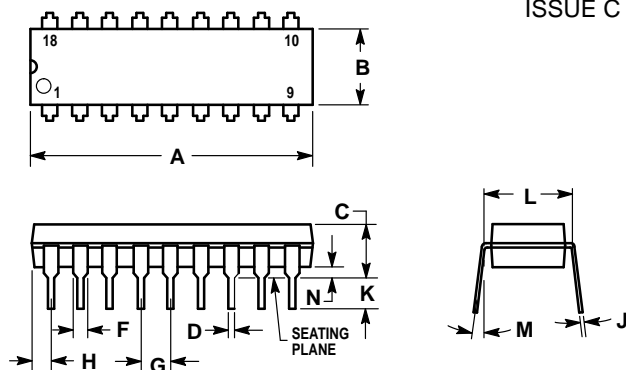
NOTES:
1. POSITIONAL TOLERANCE OF LEADS (D), SHALL BE WITHIN 0.25 (0.010) AT MAXIMUM MATERIAL CONDITION, IN RELATION TO SEATING PLANE AND EACH OTHER.
2. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION B DOES NOT INCLUDE MOLD FLASH.

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

SEATING PLANE

Ⓜ **MOTOROLA**