MOTOROLA

MC14511B

CMOS MSI

(LOW-POWER COMPLEMENTARY MOS)

BCD-TO-SEVEN SEGMENT LATCH/DECODER/DRIVER

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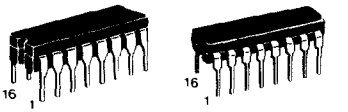
The MC14511B BCD-to-seven segment latch/decoder/driver is constructed with complementary MOS (CMOS) enhancement mode devices and NPN bipolar output drivers in a single monolithic structure. The circuit provides the functions of a 4-bit storage latch, an 8421 BCD-to-seven segment decoder, and an output 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



L SUFFIX
CERAMIC PACKAGE
CASE 620

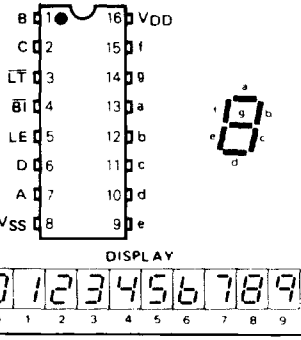
P SUFFIX
PLASTIC PACKAGE
CASE 648

ORDERING INFORMATION

A Series: −55°C to +125°C
MC14XXXBAL (Ceramic Package Only)

C Series: −40°C to +85°C
MC14XXXBCP (Plastic Package)
MC14XXXBCL (Ceramic Package)

PIN ASSIGNMENT



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 — AL Device CL/CP Device	T_A	-55 to +125 -40 to +85	°C
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

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

This device contains 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 $V_{SS} \leq (V_{in}$ 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}).

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	0	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	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

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ELECTRICAL CHARACTERISTICS (Voltages Referenced to V_{SS})

Characteristic	Symbol	V_{DD} Vdc	T_{low}* Min	T_{low}* Max	25°C Min	25°C Typ	25°C Max	T_{high}* Min	T_{high}* Max	Unit
Output Voltage "0" Level	V_{OL}	5.0	–	0.05	–	0	0.05	–	0.05	V
V_{in} = V_{DD} or 0		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	4.57	–	4.1	–	V
V_{in} = 0 or V_{DD}		10	9.1	–	9.1	9.58	–	9.1	–	
		15	14.1	–	14.1	14.59	–	14.1	–	
Input Voltage# "0" Level	V_{IL}									V
(V_O = 3.8 or 0.5 V)		5.0	–	1.5		2.25	1.5	–	1.5	
(V_O = 8.8 or 1.0 V)		10	–	3.0	–	4.50	3.0	–	3.0	
(V_O = 13.8 or 1.5 V)		15	–	4.0	–	6.75	4.0	–	4.0	
"1" Level	V_{IH}									V
(V_O = 0.5 or 3.8 V)		5.0	3.5	–	3.5	2.75	–	3.5	–	
(V_O = 1.0 or 8.8 V)		10	7.0	–	7.0	5.50	–	7.0	–	
(V_O = 1.5 or 13.8 V)		15	11.0	–	11.0	8.25	–	11.0	–	
Output Drive Voltage (AL Device)	V_{OH}									V
(I_{OH} = 0 mA) Source		5.0	4.10	–	4.10	4.57	–	4.1		
(I_{OH} = 5.0 mA)			–	–	–	4.24	–	–	–	
(I_{OH} = 10 mA)			3.90	–	3.90	4.12	–	3.5	–	
(I_{OH} = 15 mA)			–	–	–	3.94	–	–	–	
(I_{OH} = 20 mA)			3.40	–	3.40	3.70	–	3.0	–	
(I_{OH} = 25 mA)			–	–	–	3.54	–	–	–	
(I_{OH} = 0 mA)		10	9.10	–	9.10	9.53	–	9.1	–	V
(I_{OH} = 5.0 mA)			–	–	–	9.26	–	–	–	
(I_{OH} = 10 mA)			9.00	–	9.00	9.17	–	8.6	–	
(I_{OH} = 15 mA)			–	–	–	9.04	–	–	–	
(I_{OH} = 20 mA)			8.60	–	8.60	8.90	–	8.2	–	
(I_{OH} = 25 mA)			–	–	–	8.70	–	–	–	
(I_{OH} = 0 mA)		15	14.1	–	14.1	14.59	–	14.1	–	V
(I_{OH} = 5.0 mA)			–	–	–	14.27	–	–	–	
(I_{OH} = 10 mA)			14.0	–	14.0	14.13	–	13.6	–	
(I_{OH} = 15 mA)			–	–	–	14.07	–	–	–	
(I_{OH} = 20 mA)			13.6	–	13.6	13.95	–	13.2	–	
(I_{OH} = 25 mA)			–	–	–	13.70	–	–	–	
Output Drive Voltage (CL/CP Device)	V_{OH}									V
(I_{OH} = 0 mA) Source		5.0	4.10	–	4.10	4.57	–	4.1	–	
(I_{OH} = 5.0 mA)			–	–	–	4.24	–	–	–	
(I_{OH} = 10 mA)			3.60	–	3.60	4.12	–	3.3	–	
(I_{OH} = 15 mA)			–	–	–	3.94	–	–	–	
(I_{OH} = 20 mA)			2.80	–	2.80	3.75	–	2.5	–	
(I_{OH} = 25 mA)			–	–	–	3.54	–	–	–	
(I_{OH} = 0 mA)		10	9.10	–	9.10	9.58	–	9.1	–	V
(I_{OH} = 5.0 mA)			–	–	–	9.26	–	–	–	
(I_{OH} = 10 mA)			8.75	–	8.75	9.17	–	8.45	–	
(I_{OH} = 15 mA)			–	–	–	9.04	–	–	–	
(I_{OH} = 20 mA)			8.10	–	8.10	8.90	–	7.8	–	
(I_{OH} = 25 mA)			–	–	–	8.75	–	–	–	
(I_{OH} = 0 mA)		15	14.1	–	14.1	14.59	–	14.1	–	V
(I_{OH} = 5.0 mA)			–	–	–	14.27	–	–	–	
(I_{OH} = 10 mA)			13.75	–	13.75	14.18	–	13.45	–	
(I_{OH} = 15 mA)			–	–	–	14.07	–	–	–	
(I_{OH} = 20 mA)			13.1	–	13.1	13.95	–	12.8	–	
(I_{OH} = 25 mA)			–	–	–	13.80	–	–	–	
Output Drive Current (AL Device)	I_{OL}									mA
(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	–	
Output Drive Current (CL/CP Device)	I_{OL}									mA
(V_{OL} = 0.4 V) Sink		5.0	0.52	–	0.44	0.88	–	0.36	–	
(V_{OL} = 0.5 V)		10	1.3	–	1.1	2.25	–	0.9	–	
(V_{OL} = 1.5 V)		15	3.6	–	3.0	8.8	–	2.4	–	

(Continued)

ELECTRICAL CHARACTERISTICS (Continued)

Characteristic	Symbol	V_{DD} Vdc	T_{low}* Min	T_{low}* Max	25°C Min	25°C Typ	25°C Max	T_{high}* Min	T_{high}* Max	Unit
Input Current (AL Device)	I_{in}	15	–	±0.1	–	±0.00001	±0.1	–	±1.0	μA
Input Current (CL/CP Device)	I_{in}	15	–	±0.3	–	±0.00001	±0.3	–	±1.0	μA
Input Capacitance	C_{in}	–	–	–	–	5.0	7.5	–	–	pF
Quiescent Current (AL Device) (Per Package) V_{in}=0 or V_{DD}, I_{out} = 0 μA	I_{DD}	5.0 10 15	– – –	5.0 10 20	– – –	0.005 0.010 0.015	5.0 10 20	– – –	150 300 600	μA
Quiescent Current (CL/CP Device) (Per Package) V_{in}=0 or V_{DD}, I_{out} = 0 μA	I_{DD}	5.0 10 15	– – –	20 40 80	– – –	0.005 0.010 0.015	20 40 80	– – –	150 300 600	μA
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C_L = 50 pF on all outputs, all buffers switching)	I_T	5.0 10 15	I_T = (1.9 μA/kHz) f + I_{DD} I_T = (3.8 μA/kHz) f + I_{DD} I_T = (5.7 μA/kHz) f + I_{DD}							μA

*T_{low} = -55°C for AL Device, -40°C for CL/CP Device.
T_{high} = +125°C for AL Device, +85°C for CL/CP Device.
#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

†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.

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

SWITCHING CHARACTERISTICS* (C_L = 50 pF, T_A = 25°C)

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

*The formulas given are for the typical characteristics only.

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FIGURE 1 – DYNAMIC POWER DISSIPATION SIGNAL WAVEFORMS

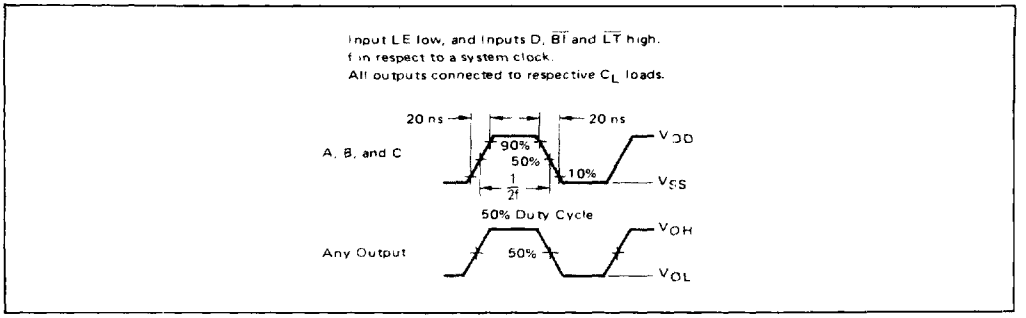
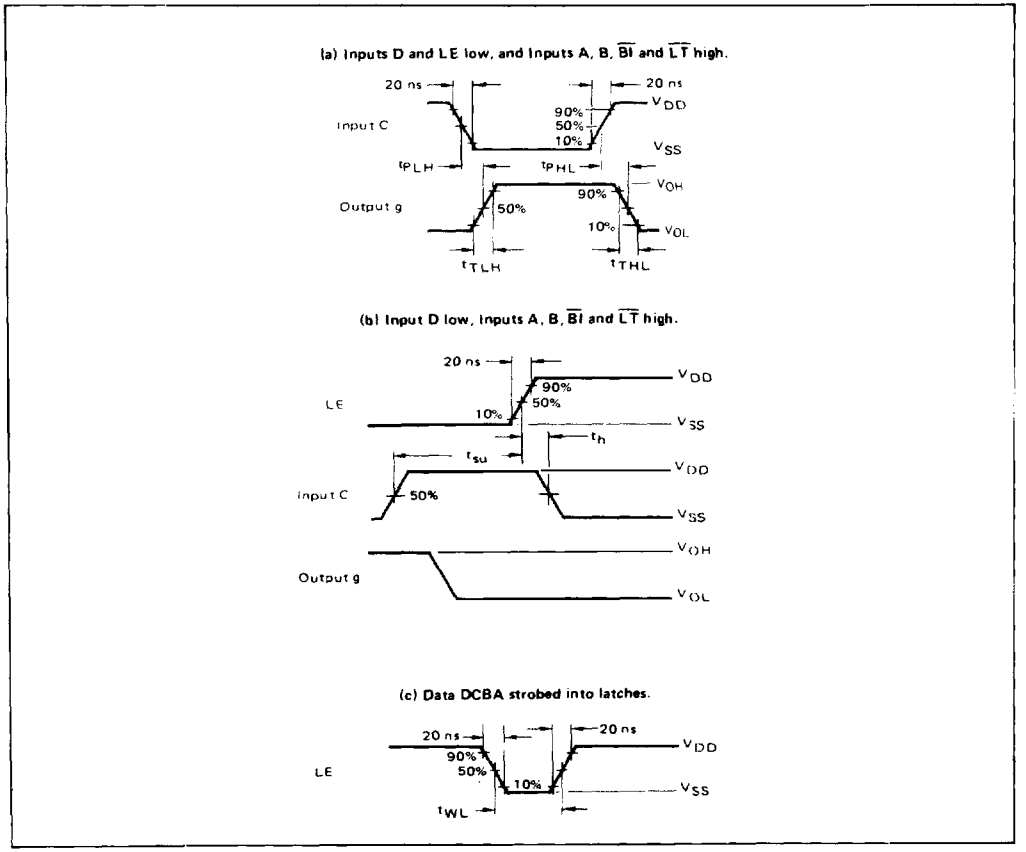


FIGURE 2 – DYNAMIC SIGNAL WAVEFORMS



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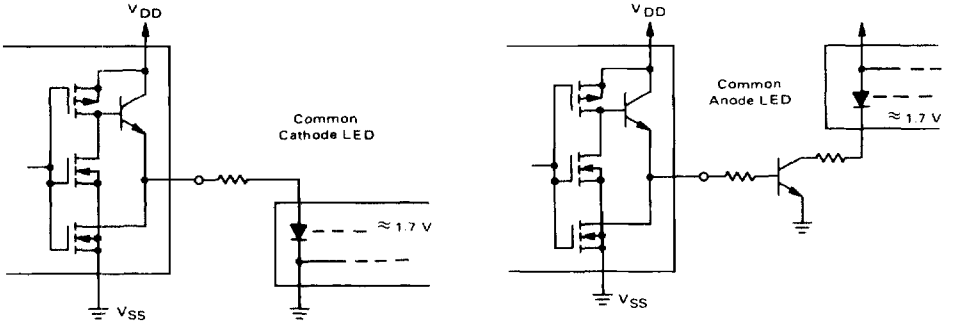
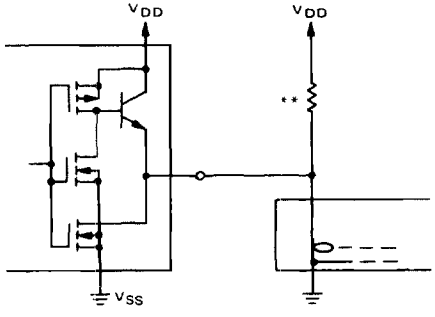
CONNECTIONS TO VARIOUS DISPLAY READOUTS

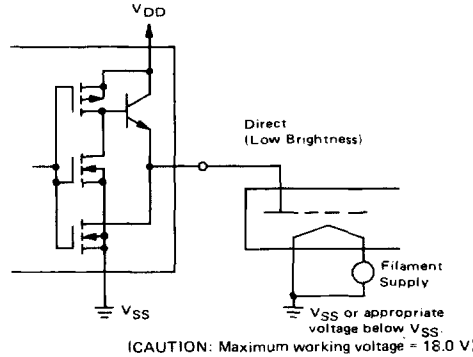
LIGHT EMITTING DIODE (LED) READOUT



INCANDESCENT READOUT

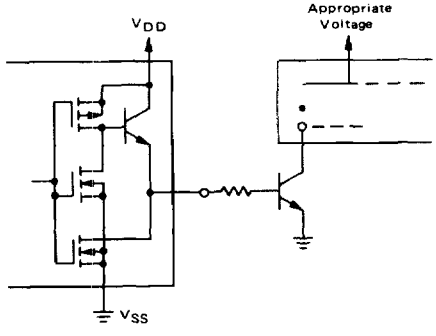


FLUORESCENT READOUT

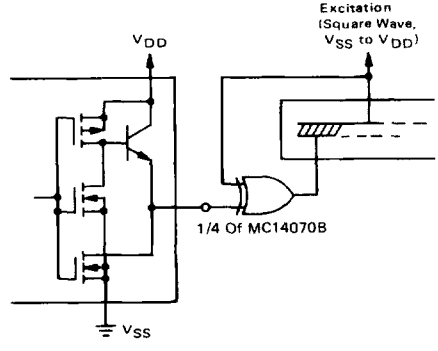


(CAUTION: Maximum working voltage = 18.0 V)

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.

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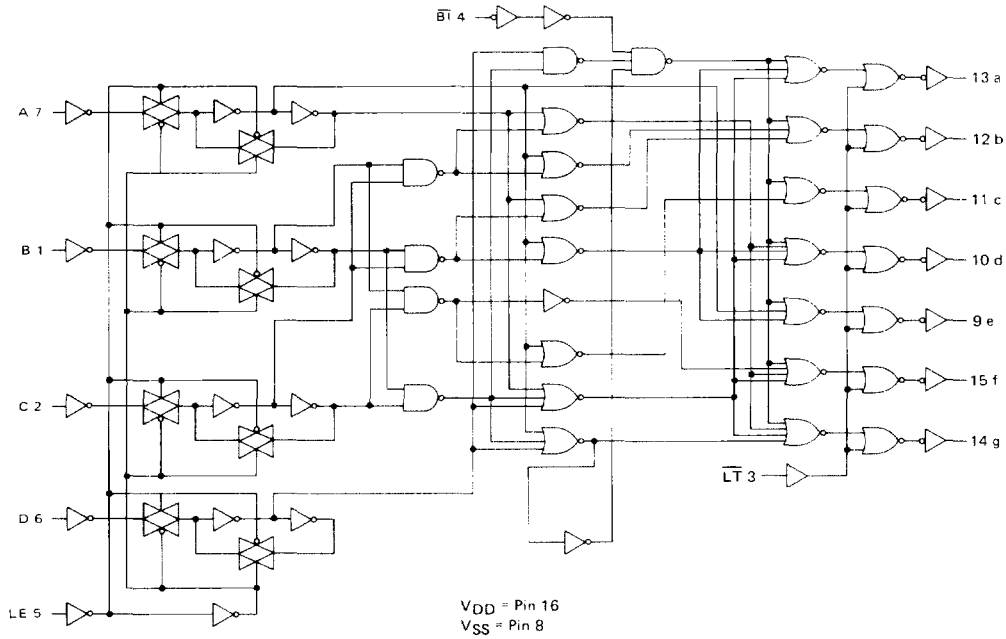
LOGIC DIAGRAM



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