

# 3-to-8 Line Decoder

## MC74VHCT138A

The MC74VHCT138A is an advanced high speed CMOS 3-to-8 decoder fabricated with silicon gate CMOS technology. It achieves high speed operation similar to equivalent Bipolar Schottky TTL while maintaining CMOS low power dissipation.

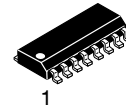
When the device is enabled, three Binary Select inputs (A0 – A2) determine which one of the outputs ( $\overline{Y}0$  –  $\overline{Y}7$ ) will go Low. When enable input E3 is held Low or either  $\overline{E}2$  or  $\overline{E}1$  is held High, decoding function is inhibited and all outputs go high. E3,  $\overline{E}2$ , and  $\overline{E}1$  inputs are provided to ease cascade connection and for use as an address decoder for memory systems.

The VHCT inputs are compatible with TTL levels. This device can be used as a level converter for interfacing 3.3 V to 5.0 V, because they have full 5.0 V CMOS level output swings.

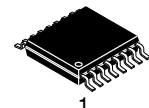
The VHCT138A input structures provide protection when voltages between 0 V and 5.5 V are applied, regardless of the supply voltage. The output structures also provide protection when  $V_{CC} = 0$  V. These input and output structures help prevent device destruction caused by supply voltage – input/output voltage mismatch, battery backup, hot insertion, etc.

### Features

- High Speed:  $t_{PD} = 7.6$  ns (Typ) at  $V_{CC} = 5.0$  V
- Low Power Dissipation:  $I_{CC} = 4$   $\mu$ A (Max) at  $T_A = 25^\circ\text{C}$
- TTL-Compatible Inputs:  $V_{IL} = 0.8$  V;  $V_{IH} = 2.0$  V
- Power Down Protection Provided on Inputs and Outputs
- Balanced Propagation Delays
- Designed for 4.5 V to 5.5 V Operating Range
- Pin and Function Compatible with Other Standard Logic Families
- Latchup Performance Exceeds 300 mA
- ESD Performance:
  - Human Body Model > 2000 V;
  - Machine Model > 200 V
- Chip Complexity: 122 FETs or 30.5 Equivalent Gates
- These Devices are Pb-Free and are RoHS Compliant

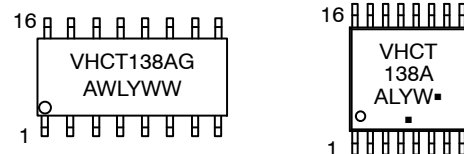


SOIC-16  
D SUFFIX  
CASE 751B



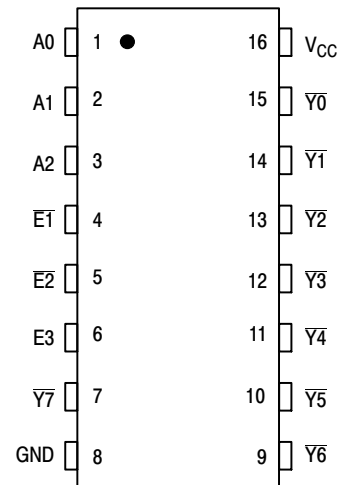
TSSOP-16  
DT SUFFIX  
CASE 948F

### MARKING DIAGRAM



A = Assembly Location  
 WL, L = Wafer Lot  
 Y = Year  
 WW, W = Work Week  
 G or ■ = Pb-Free Package  
 (Note: Microdot may be in either location)

### PIN ASSIGNMENT



### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 6 of this data sheet.

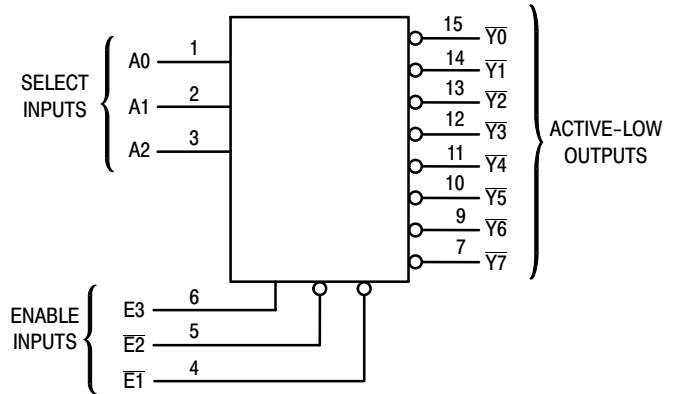
# MC74VHCT138A

FUNCTION TABLE

Inputs						Outputs							
E3	E2	E1	A2	A1	A0	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	X	H	X	X	X	H	H	H	H	H	H	H	H
X	H	X	X	X	X	H	H	H	H	H	H	H	H
L	X	X	X	X	X	H	H	H	H	H	H	H	H
H	L	L	L	L	L	L	H	H	H	H	H	H	H
H	L	L	L	L	H	H	L	H	H	H	H	H	H
H	L	L	L	H	L	H	H	L	H	H	H	H	H
H	L	L	L	H	H	H	H	H	L	H	H	H	H
H	L	L	H	L	L	H	H	H	H	L	H	H	H
H	L	L	H	L	H	H	H	H	H	H	L	H	H
H	L	L	H	H	L	H	H	H	H	H	H	L	H
H	L	L	H	H	H	H	H	H	H	H	H	H	L

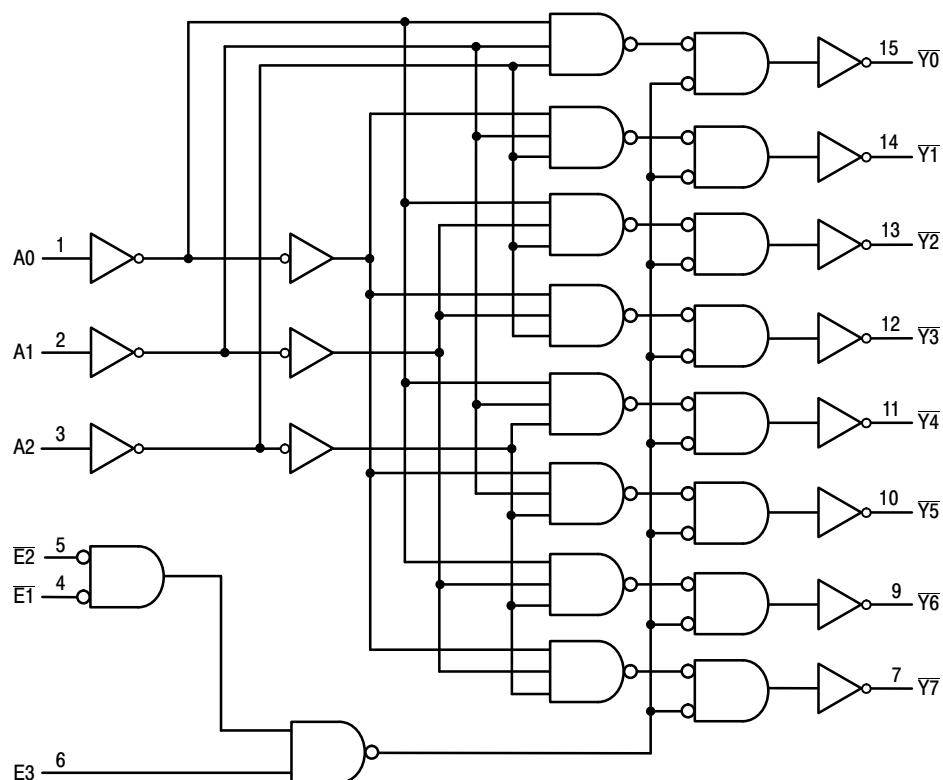
H = high level (steady state); L = low level (steady state);  
X = don't care

LOGIC DIAGRAM

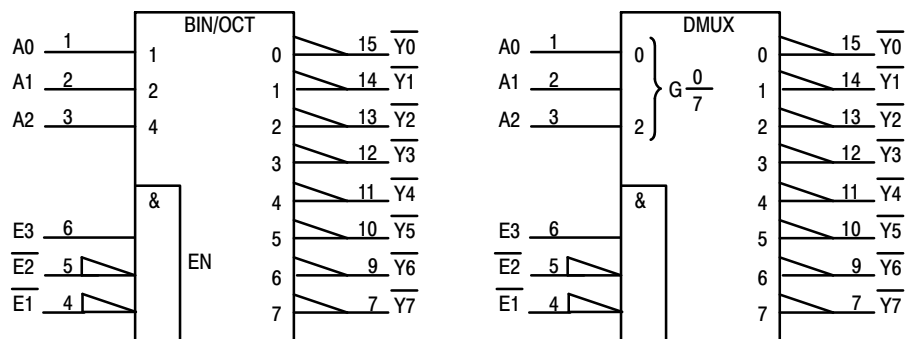


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### EXPANDED LOGIC DIAGRAM



### IEC LOGIC DIAGRAM



# MC74VHCT138A

## MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
$V_{CC}$	DC Supply Voltage	– 0.5 to + 7.0	V
$V_{in}$	DC Input Voltage	– 0.5 to + 7.0	V
$V_{out}$	DC Output Voltage $V_{CC} = 0$ High or Low State	– 0.5 to + 7.0 – 0.5 to $V_{CC} + 0.5$	V
$I_{IK}$	Input Diode Current	– 20	mA
$I_{OK}$	Output Diode Current ( $V_{OUT} < GND$ ; $V_{OUT} > V_{CC}$ )	$\pm 20$	mA
$I_{out}$	DC Output Current, per Pin	$\pm 25$	mA
$I_{CC}$	DC Supply Current, $V_{CC}$ and GND Pins	$\pm 75$	mA
$P_D$	Power Dissipation in Still Air, SOIC Packages† TSSOP Package†	500 450	mW
$T_{stg}$	Storage Temperature	– 65 to + 150	°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

†Derating – SOIC Packages: – 7 mW/°C from 65° to 125°C  
TSSOP Package: – 6.1 mW/°C from 65° to 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $GND \leq (V_{in} \text{ or } V_{out}) \leq V_{CC}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either GND or  $V_{CC}$ ). Unused outputs must be left open.

## RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min	Max	Unit
$V_{CC}$	DC Supply Voltage	3.0	5.5	V
$V_{in}$	DC Input Voltage	0	5.5	V
$V_{out}$	DC Output Voltage $V_{CC} = 0$ High or Low State	0 0	5.5 $V_{CC}$	V
$T_A$	Operating Temperature	– 55	+ 125	°C
$t_r, t_f$	Input Rise and Fall Time $V_{CC} = 5.0V \pm 0.5V$	0	20	ns/V

The  $\theta_{JA}$  of the package is equal to 1/Derating. Higher junction temperatures may affect the expected lifetime of the device per the table and figure below.

## DEVICE JUNCTION TEMPERATURE VERSUS TIME TO 0.1% BOND FAILURES

Junction Temperature °C	Time, Hours	Time, Years
80	1,032,200	117.8
90	419,300	47.9
100	178,700	20.4
110	79,600	9.4
120	37,000	4.2
130	17,800	2.0
140	8,900	1.0

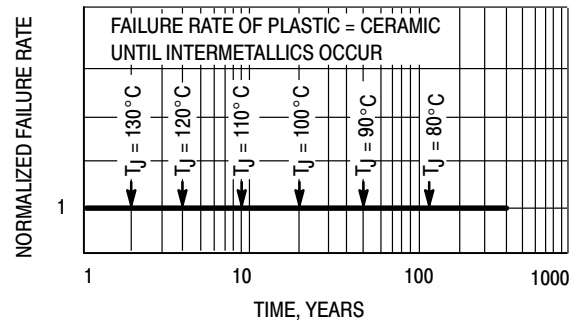


Figure 1. Failure Rate vs. Time Junction Temperature

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## DC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Test Conditions	V <sub>CC</sub> (V)	T <sub>A</sub> = 25°C			T <sub>A</sub> ≤ 85°C		T <sub>A</sub> ≤ 125°C		Unit
				Min	Typ	Max	Min	Max	Min	Max	
V <sub>IH</sub>	Minimum High-Level Input Voltage		3.0 4.5 5.5	1.4 2.0 2.0			1.4 2.0 2.0		1.4 2.0 2.0		V
V <sub>IL</sub>	Maximum Low-Level Input Voltage		3.0 4.5 5.5			0.53 0.8 0.8		0.53 0.8 0.8		0.53 0.8 0.8	V
V <sub>OH</sub>	Minimum High-Level Output Voltage V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> I <sub>OH</sub> = -50 μA	3.0 4.5	2.9 4.4	3.0 4.5		2.9 4.4		2.9 4.4		V
		V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> I <sub>OH</sub> = -4 mA I <sub>OH</sub> = -8 mA	3.0 4.5	2.58 3.94			2.48 3.80		2.34 3.66		V
V <sub>OL</sub>	Maximum Low-Level Output Voltage V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> I <sub>OL</sub> = 50 μA	3.0 4.5		0.0 0.0	0.1 0.1		0.1 0.1		0.1 0.1	V
		V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> I <sub>OL</sub> = 4 mA I <sub>OL</sub> = 8 mA	3.0 4.5			0.36 0.36		0.44 0.44		0.52 0.52	V
I <sub>IN</sub>	Maximum Input Leakage Current	V <sub>IN</sub> = 5.5 V or GND	0 to 5.5			±0.1		±1.0		±1.0	μA
I <sub>CC</sub>	Maximum Quiescent Supply Current	V <sub>IN</sub> = V <sub>CC</sub> or GND	5.5			4.0		40.0		40.0	μA
I <sub>CCT</sub>	Quiescent Supply Current	V <sub>IN</sub> = 3.4 V	5.5			1.35		1.50		1.50	mA
I <sub>OPD</sub>	Output Leakage Current	V <sub>OUT</sub> = 5.5 V	0.0			0.5		5.0		5.0	μA

## AC ELECTRICAL CHARACTERISTICS (Input t<sub>r</sub> = t<sub>f</sub> = 3.0ns)

Symbol	Parameter	Test Conditions		T <sub>A</sub> = 25°C			T <sub>A</sub> = ≤ 85°C		T <sub>A</sub> ≤ 125°C		Unit
				Min	Typ	Max	Min	Max	Min	Max	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, Input A to Y	V <sub>CC</sub> = 3.3 ± 0.3V	C <sub>L</sub> = 15pF		9.5	14.5	1.0	16.0	1.0	16.0	ns
			C <sub>L</sub> = 50pF		10.8	15.5	1.0	17.0	1.0	17.0	
		V <sub>CC</sub> = 5.0 ± 0.5V	C <sub>L</sub> = 15pF		7.6	10.4	1.0	12.0	1.0	12.0	
			C <sub>L</sub> = 50pF		8.1	11.4	1.0	13.0	1.0	13.0	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, Input E3 to Y	V <sub>CC</sub> = 3.3 ± 0.3V	C <sub>L</sub> = 15pF		9.7	13.0	1.0	14.5	1.0	14.5	ns
			C <sub>L</sub> = 50pF		9.5	14.0	1.0	15.5	1.0	15.5	
		V <sub>CC</sub> = 5.0 ± 0.5V	C <sub>L</sub> = 15pF		6.6	9.1	1.0	10.5	1.0	10.5	
			C <sub>L</sub> = 50pF		7.1	10.1	1.0	11.5	1.0	11.5	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, Input E1 or E2 to Y	V <sub>CC</sub> = 3.3 ± 0.3V	C <sub>L</sub> = 15pF		10.1	14.0	1.0	15.5	1.0	15.5	ns
			C <sub>L</sub> = 50pF		9.9	15.0	1.0	16.5	1.0	16.5	
		V <sub>CC</sub> = 5.0 ± 0.5V	C <sub>L</sub> = 15pF		7.0	9.6	1.0	11.0	1.0	11.0	
			C <sub>L</sub> = 50pF		7.5	10.6	1.0	12.0	1.0	12.0	
C <sub>IN</sub>	Maximum Input Capacitance				4	10		10		10	pF
C <sub>PD</sub>	Power Dissipation Capacitance (Note 1)	Typical @ 25°C, V <sub>CC</sub> = 5.0V									pF
		49									

1. C<sub>PD</sub> is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load. Average operating current can be obtained by the equation: I<sub>CC(OPR)</sub> = C<sub>PD</sub> • V<sub>CC</sub> • f<sub>in</sub> + I<sub>CC</sub>. C<sub>PD</sub> is used to determine the no-load dynamic power consumption; P<sub>D</sub> = C<sub>PD</sub> • V<sub>CC</sub><sup>2</sup> • f<sub>in</sub> + I<sub>CC</sub> • V<sub>CC</sub>.

# MC74VHCT138A

## SWITCHING WAVEFORMS

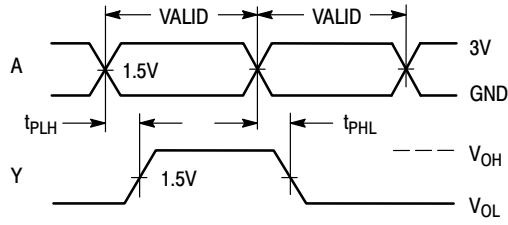


Figure 2.

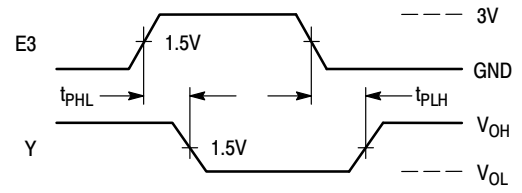


Figure 3.

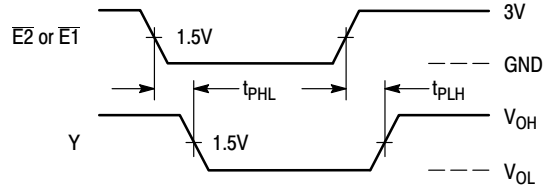
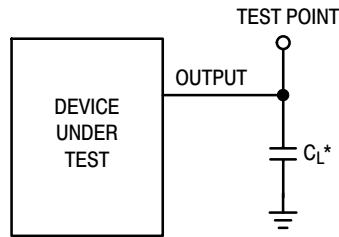


Figure 4.



\*Includes all probe and jig capacitance

Figure 5. Test Circuit

## ORDERING INFORMATION

Device	Package	Shipping <sup>†</sup>
MC74VHCT138ADR2G	SOIC-16 (Pb-Free)	2500 Tape & Reel
MC74VHCT138ADTRG	TSSOP-16*	2500 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](#).

\*This package is inherently Pb-Free.

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