

# MC74VHCT138A

## 3-to-8 Line Decoder

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 ( $\overline{Y0}$  –  $\overline{Y7}$ ) will go Low. When enable input E3 is held Low or either  $\overline{E2}$  or  $\overline{E1}$  is held High, decoding function is inhibited and all outputs go high. E3,  $\overline{E2}$ , and  $\overline{E1}$  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

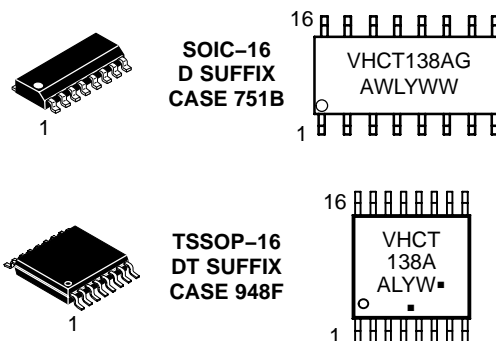
- High Speed:  $t_{PD} = 7.6$  ns (Typ) at  $V_{CC} = 5.0$  V
- Low Power Dissipation:  $I_{CC} = 4$   $\mu$ A (Max) at  $T_A = 25^\circ$ C
- TTL-Compatible Inputs:  $V_{IL} = 0.8$  V;  $V_{IH} = 2.0$  V
- Power Down Protection Provided on Inputs and Outputs
- Balanced Propagation Delays
- Designed for 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
- Pb-Free Packages are Available\*



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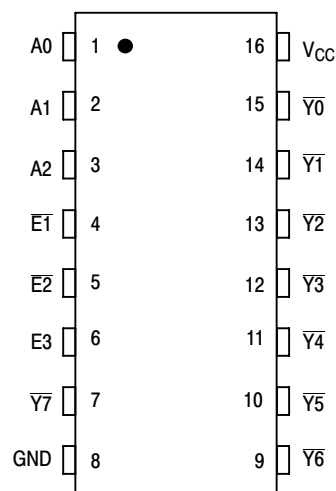
<http://onsemi.com>

### MARKING DIAGRAMS



A = Assembly Location  
 WL, L = Wafer Lot  
 Y = Year  
 WW, W = Work Week  
 G or  $\blacksquare$  = 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 5 of this data sheet.

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

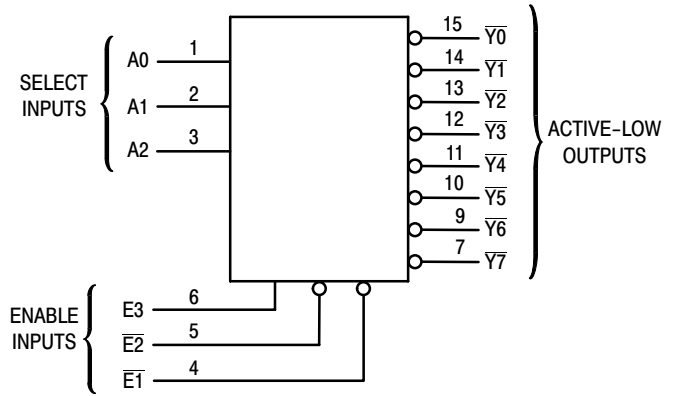
# MC74VHCT138A

**FUNCTION TABLE**

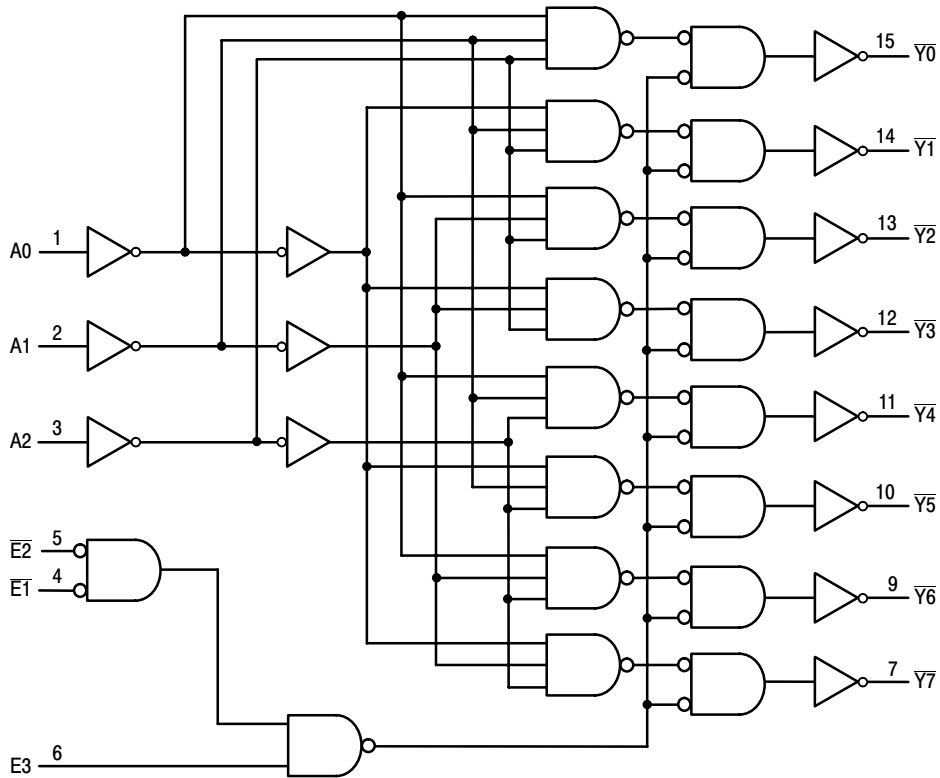
| Inputs |                 |                 |    |    |    | Outputs |    |    |    |    |    |    |    |
|--------|-----------------|-----------------|----|----|----|---------|----|----|----|----|----|----|----|
| E3     | $\overline{E2}$ | $\overline{E1}$ | A2 | A1 | A0 | Y0      | Y1 | Y2 | Y3 | 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  | L  | H  | H  | H  | H  | H  |
| H      | L               | L               | H  | L  | H  | H       | H  | H  | H  | L  | H  | H  | H  |
| H      | L               | L               | H  | H  | L  | H       | H  | H  | H  | H  | L  | H  | H  |
| H      | L               | L               | H  | H  | H  | H       | H  | H  | H  | H  | H  | L  | H  |

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

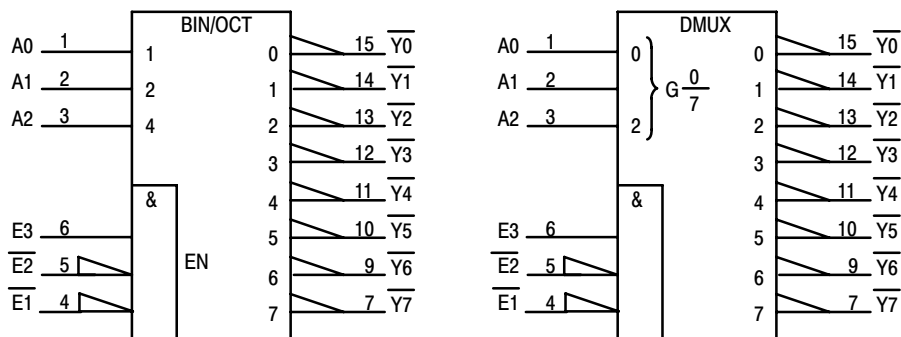
**LOGIC DIAGRAM**



**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<br>$V_{CC} = 0$<br>High or Low State              | - 0.5 to + 7.0<br>- 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,<br>SOIC Packages†<br>TSSOP Package† | 500<br>450                                | mW          |
| $T_{stg}$ | Storage Temperature   | - 65 to + 150                             | $^{\circ}C$ |

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.

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/ $^{\circ}C$  from 65 $^{\circ}$  to 125 $^{\circ}C$   
TSSOP Package: - 6.1 mW/ $^{\circ}C$  from 65 $^{\circ}$  to 125 $^{\circ}C$

## 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<br>$V_{CC} = 0$<br>High or Low State | 0<br>0 | 5.5<br>$V_{CC}$ | V           |
| $T_A$      | Operating Temperature                                  | - 55   | + 125           | $^{\circ}C$ |
| $t_r, t_f$ | Input Rise and Fall Time<br>$V_{CC} = 5.0V \pm 0.5V$   | 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 $^{\circ}C$ | 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         |

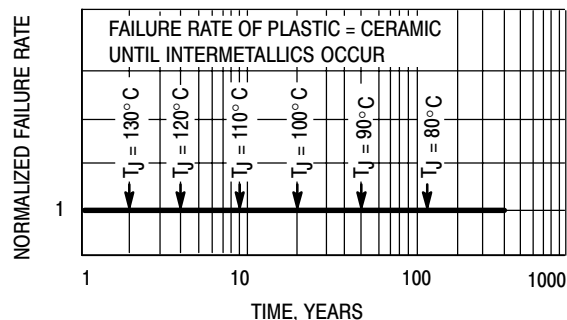


Figure 1. Failure Rate vs. Time Junction Temperature

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## DC ELECTRICAL CHARACTERISTICS

| Symbol             | Parameter   | Test Conditions  | V <sub>CC</sub><br>(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<br>4.5<br>5.5      | 1.4<br>2.0<br>2.0     |            |                    | 1.4<br>2.0<br>2.0     |                    | 1.4<br>2.0<br>2.0      |                    | V    |
| V <sub>IL</sub>    | Maximum Low-Level Input Voltage   |  | 3.0<br>4.5<br>5.5      |                       |            | 0.53<br>0.8<br>0.8 |                       | 0.53<br>0.8<br>0.8 |                        | 0.53<br>0.8<br>0.8 | V    |
| V <sub>OH</sub>    | Minimum High-Level Output Voltage<br>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><br>I <sub>OH</sub> = -50 μA                           | 3.0<br>4.5             | 2.9<br>4.4            | 3.0<br>4.5 |                    | 2.9<br>4.4            |                    | 2.9<br>4.4             |                    | V    |
|                    |   | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>I <sub>OH</sub> = -4 mA<br>I <sub>OH</sub> = -8 mA | 3.0<br>4.5             | 2.58<br>3.94          |            |                    | 2.48<br>3.80          |                    | 2.34<br>3.66           |                    | V    |
| V <sub>OL</sub>    | Maximum Low-Level Output Voltage<br>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><br>I <sub>OL</sub> = 50 μA                            | 3.0<br>4.5             |                       | 0.0<br>0.0 | 0.1<br>0.1         |                       | 0.1<br>0.1         |                        | 0.1<br>0.1         | V    |
|                    |   | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>I <sub>OL</sub> = 4 mA<br>I <sub>OL</sub> = 8 mA   | 3.0<br>4.5             |                       |            | 0.36<br>0.36       |                       | 0.44<br>0.44       |                        | 0.52<br>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>CC(T)</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> ,<br>t <sub>PHL</sub> | Maximum Propagation Delay,<br>Input A to Y        | V <sub>CC</sub> = 3.3 ± 0.3V    C <sub>L</sub> = 15pF<br>C <sub>L</sub> = 50pF |                       | 9.5<br>10.8 | 14.5<br>15.5 | 1.0<br>1.0            | 16.0<br>17.0 | 1.0<br>1.0             | 16.0<br>17.0 | ns   |
|  |   | V <sub>CC</sub> = 5.0 ± 0.5V    C <sub>L</sub> = 15pF<br>C <sub>L</sub> = 50pF |                       | 7.6<br>8.1  | 10.4<br>11.4 | 1.0<br>1.0            | 12.0<br>13.0 | 1.0<br>1.0             | 12.0<br>13.0 |      |
| t <sub>PLH</sub> ,<br>t <sub>PHL</sub> | Maximum Propagation Delay,<br>Input E3 to Y       | V <sub>CC</sub> = 3.3 ± 0.3V    C <sub>L</sub> = 15pF<br>C <sub>L</sub> = 50pF |                       | 9.7<br>9.5  | 13.0<br>14.0 | 1.0<br>1.0            | 14.5<br>15.5 | 1.0<br>1.0             | 14.5<br>15.5 | ns   |
|  |   | V <sub>CC</sub> = 5.0 ± 0.5V    C <sub>L</sub> = 15pF<br>C <sub>L</sub> = 50pF |                       | 6.6<br>7.1  | 9.1<br>10.1  | 1.0<br>1.0            | 10.5<br>11.5 | 1.0<br>1.0             | 10.5<br>11.5 |      |
| t <sub>PLH</sub> ,<br>t <sub>PHL</sub> | Maximum Propagation Delay,<br>Input E1 or E2 to Y | V <sub>CC</sub> = 3.3 ± 0.3V    C <sub>L</sub> = 15pF<br>C <sub>L</sub> = 50pF |                       | 10.1<br>9.9 | 14.0<br>15.0 | 1.0<br>1.0            | 15.5<br>16.5 | 1.0<br>1.0             | 15.5<br>16.5 | ns   |
|  |   | V <sub>CC</sub> = 5.0 ± 0.5V    C <sub>L</sub> = 15pF<br>C <sub>L</sub> = 50pF |                       | 7.0<br>7.5  | 9.6<br>10.6  | 1.0<br>1.0            | 11.0<br>12.0 | 1.0<br>1.0             | 11.0<br>12.0 |      |
| C <sub>IN</sub>                        | Maximum Input Capacitance                         |  |                       | 4           | 10           |                       | 10           |                        | 10           | pF   |
| C <sub>PD</sub>                        | Power Dissipation Capacitance (Note 1)            | <b>Typical @ 25°C, V<sub>CC</sub> = 5.0V</b>                                   |                       |             |              |                       |              |                        |              | 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>.

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## SWITCHING WAVEFORMS

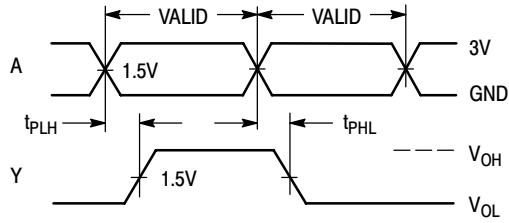


Figure 2.

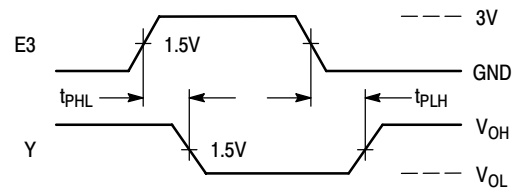


Figure 3.

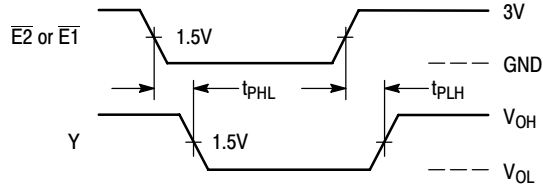
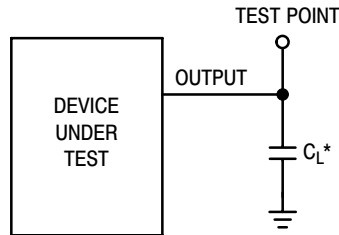


Figure 4.



\*Includes all probe and jig capacitance

Figure 5. Test Circuit

### ORDERING INFORMATION

| Device           | Package              | Shipping†        |
|------------------|----------------------|------------------|
| MC74VHCT138ADR2  | SOIC-16              | 2500 Tape & Reel |
| MC74VHCT138ADR2G | SOIC-16<br>(Pb-Free) | 2500 Tape & Reel |
| MC74VHCT138ADTR2 | TSSOP-16*            | 2500 Tape & Reel |
| MC74VHCT138ADTRG | TSSOP-16*            | 2500 Tape & Reel |

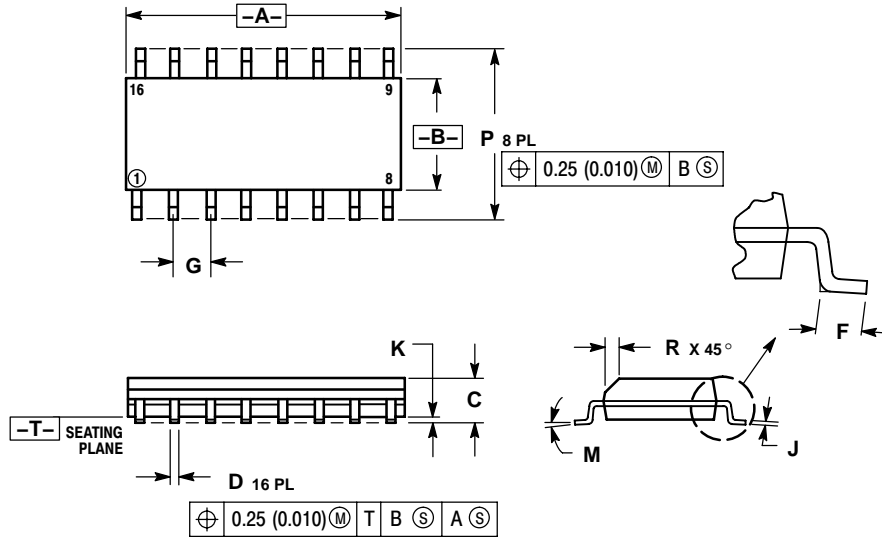
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

\*This package is inherently Pb-Free.

# MC74VHCT138A

## PACKAGE DIMENSIONS

SOIC-16  
D SUFFIX  
CASE 751B-05  
ISSUE J



### NOTES:

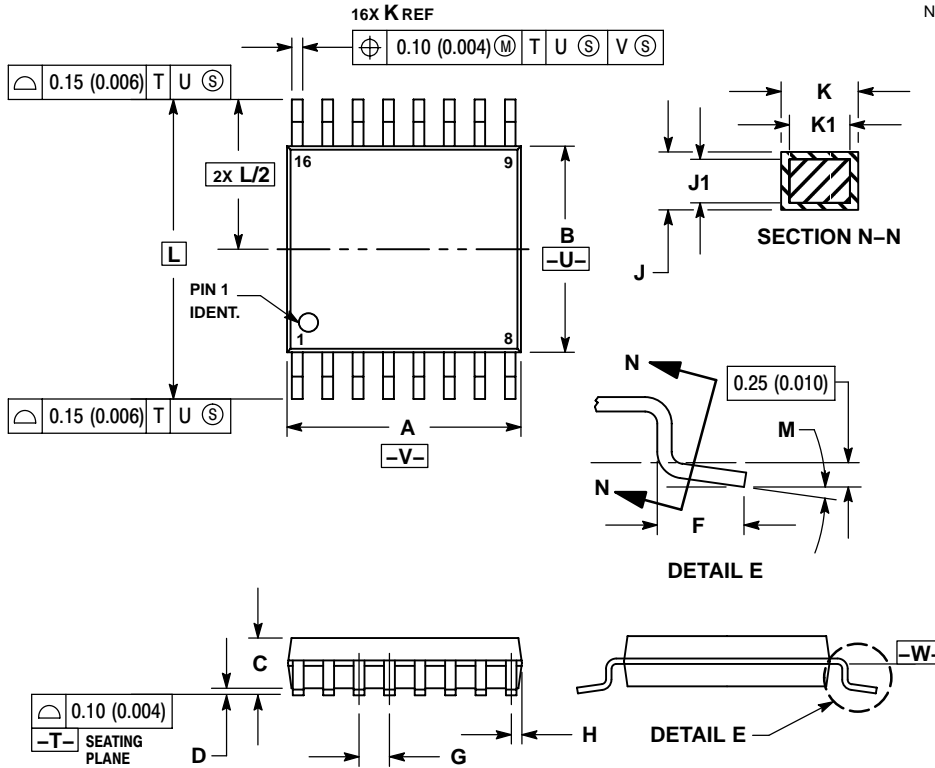
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL 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 |

# MC74VHCT138A

## PACKAGE DIMENSIONS

TSSOP-16  
DT SUFFIX  
CASE 948F-01  
ISSUE A



### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 4.90        | 5.10 | 0.193     | 0.200 |
| B   | 4.30        | 4.50 | 0.169     | 0.177 |
| C   | ---         | 1.20 | ---       | 0.047 |
| D   | 0.05        | 0.15 | 0.002     | 0.006 |
| F   | 0.50        | 0.75 | 0.020     | 0.030 |
| G   | 0.65 BSC    |      | 0.026 BSC |       |
| H   | 0.18        | 0.28 | 0.007     | 0.011 |
| J   | 0.09        | 0.20 | 0.004     | 0.008 |
| J1  | 0.09        | 0.16 | 0.004     | 0.006 |
| K   | 0.19        | 0.30 | 0.007     | 0.012 |
| K1  | 0.19        | 0.25 | 0.007     | 0.010 |
| L   | 6.40 BSC    |      | 0.252 BSC |       |
| M   | 0°          | 8°   | 0°        | 8°    |

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MC74VHCT138A/D