

# LM339, LM339E, LM239, LM2901, LM2901E, LM2901V, NCV2901, MC3302

## Single Supply Quad Comparators

These comparators are designed for use in level detection, low-level sensing and memory applications in consumer, automotive, and industrial electronic applications.

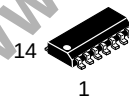
### Features

- Single Supply Operation: 3.0 V to 36 V
- Split Supply Operation:  $\pm 1.5$  V to  $\pm 18$  V
- Low Input Bias Current: 25 nA (Typ)
- Low Input Offset Current:  $\pm 5.0$  nA (Typ)
- Low Input Offset Voltage
- Input Common Mode Voltage Range to GND
- Low Output Saturation Voltage: 130 mV (Typ) @ 4.0 mA
- TTL and CMOS Compatible
- ESD Clamps on the Inputs Increase Reliability without Affecting Device Operation
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

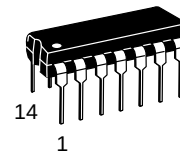


ON Semiconductor®

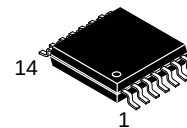
[www.onsemi.com](http://www.onsemi.com)



SOIC-14  
D SUFFIX  
CASE 751A

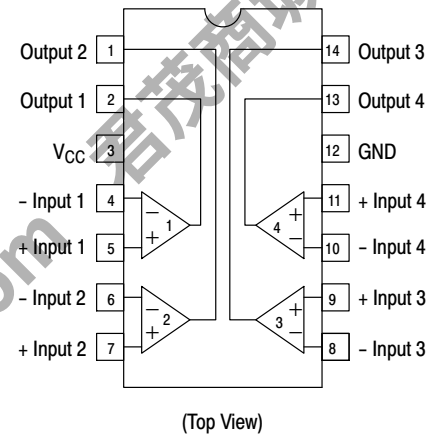


PDIP-14  
N, P SUFFIX  
CASE 646



TSSOP-14  
DTB SUFFIX  
CASE 948G

### PIN CONNECTIONS



(Top View)

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 7 of this data sheet.

### DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 8 of this data sheet.

# MAXIMUM RATINGS

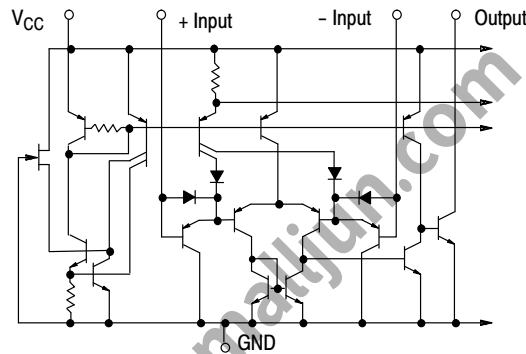
| Rating                                                                                                         | Symbol                     | Value                                                              | Unit                      |
|----------------------------------------------------------------------------------------------------------------|----------------------------|--------------------------------------------------------------------|---------------------------|
| Power Supply Voltage<br>LM239/LM339, E/LM2901, E, V<br>MC3302                                                  | $V_{CC}$                   | +36 or $\pm 18$<br>+30 or $\pm 15$                                 | Vdc                       |
| Input Differential Voltage Range<br>LM239/LM339, E/LM2901, E, V<br>MC3302                                      | $V_{IDR}$                  | 36<br>30                                                           | Vdc                       |
| Input Common Mode Voltage Range                                                                                | $V_{ICMR}$                 | -0.3 to $V_{CC}$                                                   | Vdc                       |
| Output Short Circuit to Ground (Note 1)                                                                        | $I_{SC}$                   | Continuous                                                         |                           |
| Power Dissipation @ $T_A = 25^\circ\text{C}$<br>Plastic Package<br>Derate above $25^\circ\text{C}$             | $P_D$<br>$1/R_{\theta JA}$ | 1.0<br>8.0                                                         | W<br>mW/ $^\circ\text{C}$ |
| Junction Temperature                                                                                           | $T_J$                      | 150                                                                | $^\circ\text{C}$          |
| Operating Ambient Temperature Range<br>LM239<br>MC3302<br>LM2901, LM2901E<br>LM2901V, NCV2901<br>LM339, LM339E | $T_A$                      | -25 to +85<br>-40 to +85<br>-40 to +105<br>-40 to +125<br>0 to +70 | $^\circ\text{C}$          |
| Storage Temperature Range                                                                                      | $T_{stg}$                  | -65 to +150                                                        | $^\circ\text{C}$          |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. The maximum output current may be as high as 20 mA, independent of the magnitude of  $V_{CC}$ . Output short circuits to  $V_{CC}$  can cause excessive heating and eventual destruction.

# ESD RATINGS

| Rating                                                                 | HBM  | MM  | Unit |
|------------------------------------------------------------------------|------|-----|------|
| ESD Protection at any Pin (Human Body Model – HBM, Machine Model – MM) |      |     |      |
| NCV2901                                                                | 2000 | 200 | V    |
| LM339E, LM2901E                                                        | 1500 | 200 | V    |
| LM339DG/DR2G, LM2901DG/DR2G                                            | 250  | 100 | V    |
| All Other Devices                                                      | 1500 | 200 | V    |



NOTE: Diagram shown is for 1 comparator.

Figure 1. Circuit Schematic

# LM339, LM339E, LM239, LM2901, LM2901E, LM2901V, NCV2901, MC3302

## ELECTRICAL CHARACTERISTICS (V<sub>CC</sub> = +5.0 Vdc, T<sub>A</sub> = +25°C, unless otherwise noted)

| Characteristic                                                                                                                                       | Symbol            | LM239/339/339E |            |                       | LM2901/2901E/2901V<br>/NCV2901 |            |                       | MC3302 |            |                       | Unit |
|------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------|------------|-----------------------|--------------------------------|------------|-----------------------|--------|------------|-----------------------|------|
|                                                                                                                                                      |                   | Min            | Typ        | Max                   | Min                            | Typ        | Max                   | Min    | Typ        | Max                   |      |
| Input Offset Voltage (Note 3)                                                                                                                        | V <sub>IO</sub>   | –              | ±2.0       | ±5.0                  | –                              | ±2.0       | ±7.0                  | –      | ±3.0       | ±20                   | mVdc |
| Input Bias Current (Notes 3, 4)<br>(Output in Analog Range)                                                                                          | I <sub>IB</sub>   | –              | 25         | 250                   | –                              | 25         | 250                   | –      | 25         | 500                   | nA   |
| Input Offset Current (Note 3)                                                                                                                        | I <sub>IO</sub>   | –              | ±5.0       | ±50                   | –                              | ±5.0       | ±50                   | –      | ±3.0       | ±100                  | nA   |
| Input Common Mode Voltage Range                                                                                                                      | V <sub>ICMR</sub> | 0              | –          | V <sub>CC</sub> – 1.5 | 0                              | –          | V <sub>CC</sub> – 1.5 | 0      | –          | V <sub>CC</sub> – 1.5 | V    |
| Supply Current<br>R <sub>L</sub> = ∞ (For All Comparators)<br>R <sub>L</sub> = ∞, V <sub>CC</sub> = 30 Vdc                                           | I <sub>CC</sub>   | –              | 0.8<br>1.0 | 2.0<br>2.5            | –                              | 0.8<br>1.0 | 2.0<br>2.5            | –      | 0.8<br>1.0 | 2.0<br>2.5            | mA   |
| Voltage Gain<br>R <sub>L</sub> ≥ 15 kΩ, V <sub>CC</sub> = 15 Vdc                                                                                     | A <sub>VOL</sub>  | 50             | 200        | –                     | 25                             | 100        | –                     | 25     | 100        | –                     | V/mV |
| Large Signal Response Time<br>V <sub>I</sub> = TTL Logic Swing,<br>V <sub>ref</sub> = 1.4 Vdc, V <sub>RL</sub> = 5.0 Vdc,<br>R <sub>L</sub> = 5.1 kΩ | –                 | –              | 300        | –                     | –                              | 300        | –                     | –      | 300        | –                     | ns   |
| Response Time (Note 5)<br>V <sub>RL</sub> = 5.0 Vdc, R <sub>L</sub> = 5.1 kΩ                                                                         | –                 | –              | 1.3        | –                     | –                              | 1.3        | –                     | –      | 1.3        | –                     | μs   |
| Output Sink Current<br>V <sub>I</sub> (–) ≥ +1.0 Vdc, V <sub>I</sub> (+) = 0,<br>V <sub>O</sub> ≤ 1.5 Vdc                                            | I <sub>Sink</sub> | 6.0            | 16         | –                     | 6.0                            | 16         | –                     | 6.0    | 16         | –                     | mA   |
| Saturation Voltage<br>V <sub>I</sub> (–) ≥ +1.0 Vdc, V <sub>I</sub> (+) = 0,<br>I <sub>Sink</sub> ≤ 4.0 mA                                           | V <sub>sat</sub>  | –              | 130        | 400                   | –                              | 130        | 400                   | –      | 130        | 500                   | mV   |
| Output Leakage Current<br>V <sub>I</sub> (+) ≥ +1.0 Vdc, V <sub>I</sub> (–) = 0,<br>V <sub>O</sub> = +5.0 Vdc                                        | I <sub>OL</sub>   | –              | 0.1        | –                     | –                              | 0.1        | –                     | –      | 0.1        | –                     | nA   |

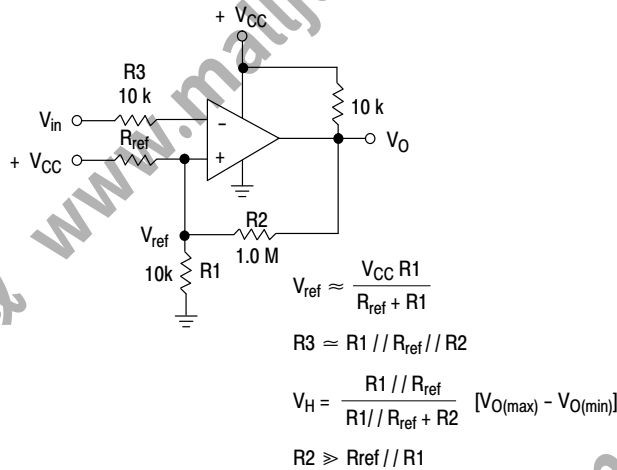
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

- (LM239) T<sub>low</sub> = –25°C, T<sub>high</sub> = +85°C  
(LM339, LM339E) T<sub>low</sub> = 0°C, T<sub>high</sub> = +70°C  
(MC3302) T<sub>low</sub> = –40°C, T<sub>high</sub> = +85°C  
(LM2901), LM2901E T<sub>low</sub> = –40°C, T<sub>high</sub> = +105°C  
(LM2901V & NCV2901) T<sub>low</sub> = –40°C, T<sub>high</sub> = +125°C  
NCV2901 is qualified for automotive use.
- At the output switch point, V<sub>O</sub> = 1.4 Vdc, R<sub>S</sub> ≤ 100 Ω 5.0 Vdc ≤ V<sub>CC</sub> ≤ 30 Vdc, with the inputs over the full common mode range (0 Vdc to V<sub>CC</sub> – 1.5 Vdc).
- The bias current flows out of the inputs due to the PNP input stage. This current is virtually constant, independent of the output state.
- The response time specified is for a 100 mV input step with 5.0 mV overdrive. For larger signals, 300 ns is typical.

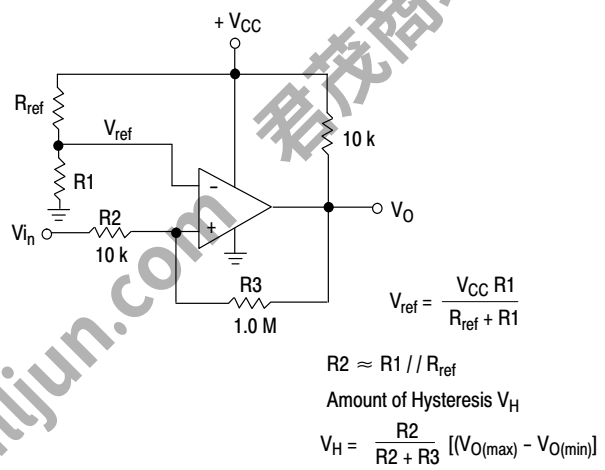
**PERFORMANCE CHARACTERISTICS** ( $V_{CC} = +5.0$  Vdc,  $T_A = T_{low}$  to  $T_{high}$  [Note 6])

| Characteristic                                                                         | Symbol     | LM239/339/339E |     |                | LM2901/2901E/2901V<br>/NCV2901 |     |                | MC3302 |     |                | Unit    |
|----------------------------------------------------------------------------------------|------------|----------------|-----|----------------|--------------------------------|-----|----------------|--------|-----|----------------|---------|
|                                                                                        |            | Min            | Typ | Max            | Min                            | Typ | Max            | Min    | Typ | Max            |         |
| Input Offset Voltage (Note 7)                                                          | $V_{IO}$   | –              | –   | $\pm 9.0$      | –                              | –   | $\pm 15$       | –      | –   | $\pm 40$       | mVdc    |
| Input Bias Current (Notes 7, 8)<br>(Output in Analog Range)                            | $I_{IB}$   | –              | –   | 400            | –                              | –   | 500            | –      | –   | 1000           | nA      |
| Input Offset Current (Note 7)                                                          | $I_{IO}$   | –              | –   | $\pm 150$      | –                              | –   | $\pm 200$      | –      | –   | $\pm 300$      | nA      |
| Input Common Mode Voltage Range                                                        | $V_{ICMR}$ | 0              | –   | $V_{CC} - 2.0$ | 0                              | –   | $V_{CC} - 2.0$ | 0      | –   | $V_{CC} - 2.0$ | V       |
| Saturation Voltage<br>$V_I(-) \geq +1.0$ Vdc, $V_I(+) = 0$ ,<br>$I_{sink} \leq 4.0$ mA | $V_{sat}$  | –              | –   | 700            | –                              | –   | 700            | –      | –   | 700            | mV      |
| Output Leakage Current<br>$V_I(+) \geq +1.0$ Vdc, $V_I(-) = 0$ ,<br>$V_O = 30$ Vdc     | $I_{OL}$   | –              | –   | 1.0            | –                              | –   | 1.0            | –      | –   | 1.0            | $\mu$ A |
| Differential Input Voltage<br>All $V_I \geq 0$ Vdc                                     | $V_{ID}$   | –              | –   | $V_{CC}$       | –                              | –   | $V_{CC}$       | –      | –   | $V_{CC}$       | Vdc     |

6. (LM239)  $T_{low} = -25^\circ\text{C}$ ,  $T_{high} = +85^\circ\text{C}$   
 (LM339, LM339E)  $T_{low} = 0^\circ\text{C}$ ,  $T_{high} = +70^\circ\text{C}$   
 (MC3302)  $T_{low} = -40^\circ\text{C}$ ,  $T_{high} = +85^\circ\text{C}$   
 (LM2901, LM2901E)  $T_{low} = -40^\circ\text{C}$ ,  $T_{high} = +105^\circ\text{C}$   
 (LM2901V & NCV2901)  $T_{low} = -40^\circ\text{C}$ ,  $T_{high} = +125^\circ\text{C}$   
 NCV2901 is qualified for automotive use.
7. At the output switch point,  $V_O \approx 1.4$  Vdc,  $R_S \leq 100 \Omega$ ,  $5.0$  Vdc  $\leq V_{CC} \leq 30$  Vdc, with the inputs over the full common mode range (0 Vdc to  $V_{CC} - 1.5$  Vdc).
8. The bias current flows out of the inputs due to the PNP input stage. This current is virtually constant, independent of the output state.
9. The response time specified is for a 100 mV input step with 5.0 mV overdrive. For larger signals, 300 ns is typical.



**Figure 2. Inverting Comparator with Hysteresis**



**Figure 3. Noninverting Comparator with Hysteresis**

### Typical Characteristics

( $V_{CC} = 15\text{ Vdc}$ ,  $T_A = +25^\circ\text{C}$  (each comparator) unless otherwise noted.)

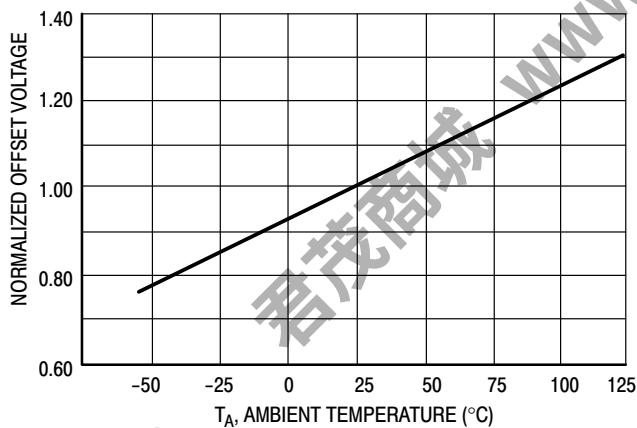


Figure 4. Normalized Input Offset Voltage

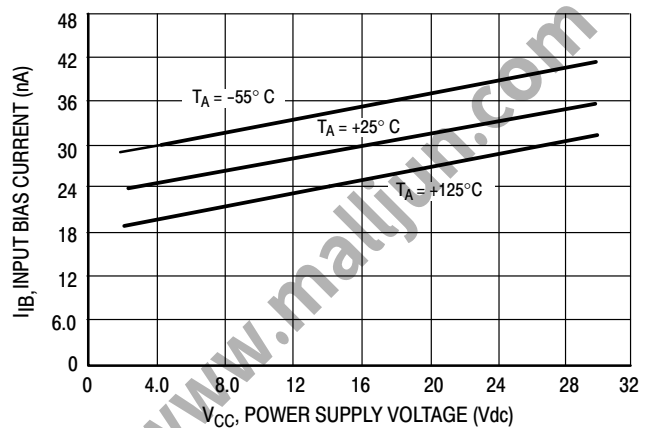


Figure 5. Input Bias Current

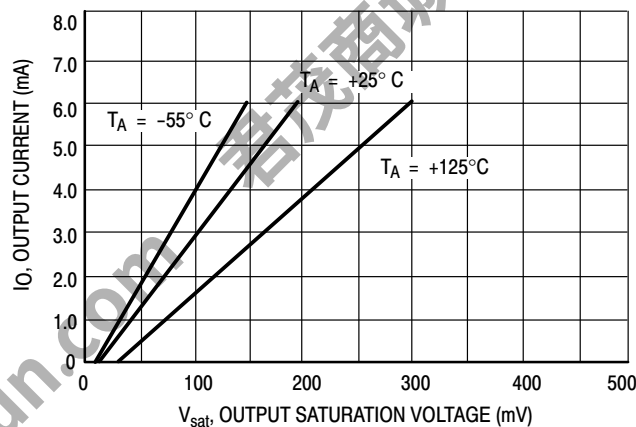
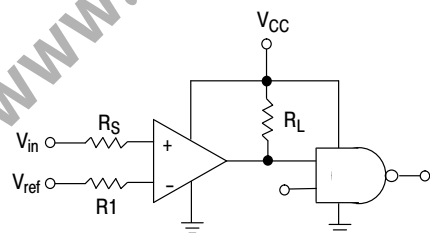


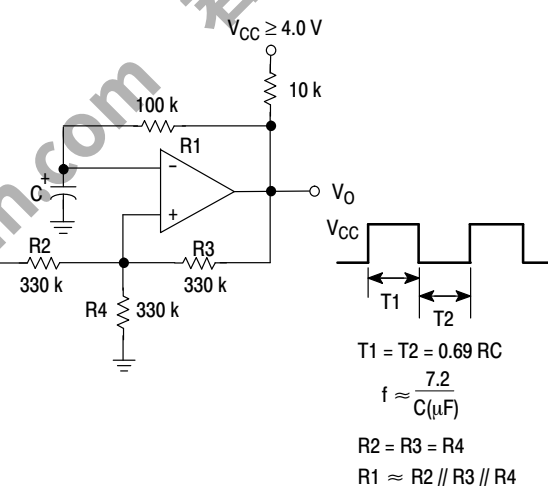
Figure 6. Output Sink Current versus Output Saturation Voltage



$R_S$  = Source Resistance  
 $R_1 \approx R_S$

| Logic | Device      | $V_{CC}$ (V) | $R_L$ k $\Omega$ |
|-------|-------------|--------------|------------------|
| CMOS  | 1/4 MC14001 | +15          | 100              |
| TTL   | 1/4 MC7400  | +5.0         | 10               |

Figure 7. Driving Logic



$T_1 = T_2 = 0.69 RC$   
 $f \approx \frac{7.2}{C(\mu\text{F})}$   
 $R_2 = R_3 = R_4$   
 $R_1 \approx R_2 \parallel R_3 \parallel R_4$

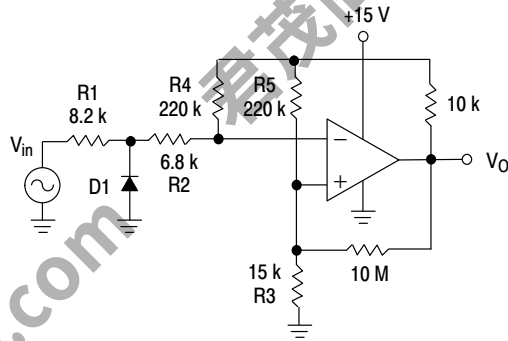
Figure 8. Squarewave Oscillator

## APPLICATIONS INFORMATION

These quad comparators feature high gain, wide bandwidth characteristics. This gives the device oscillation tendencies if the outputs are capacitively coupled to the inputs via stray capacitance. This oscillation manifests itself during output transitions ( $V_{OL}$  to  $V_{OH}$ ). To alleviate this situation input resistors  $< 10\text{ k}\Omega$  should be used. The

addition of positive feedback ( $< 10\text{ mV}$ ) is also recommended. It is good design practice to ground all unused input pins.

Differential input voltages may be larger than supply voltages without damaging the comparator's inputs. Voltages more negative than  $-300\text{ mV}$  should not be used.



D1 prevents input from going negative by more than  $0.6\text{ V}$ .

$$R1 + R2 = R3$$

$$R3 \leq \frac{R5}{10} \text{ for small error in zero crossing}$$

Figure 9. Zero Crossing Detector (Single Supply)

$$V_{in(min)} \approx 0.4\text{ V peak for } 1\% \text{ phase distortion } (\Delta\theta).$$

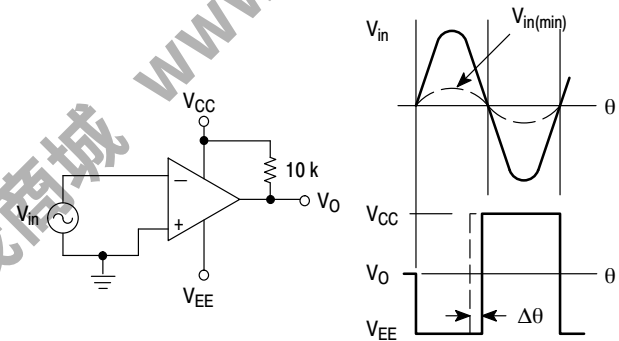


Figure 10. Zero Crossing Detector (Split Supplies)

# LM339, LM339E, LM239, LM2901, LM2901E, LM2901V, NCV2901, MC3302

## ORDERING INFORMATION

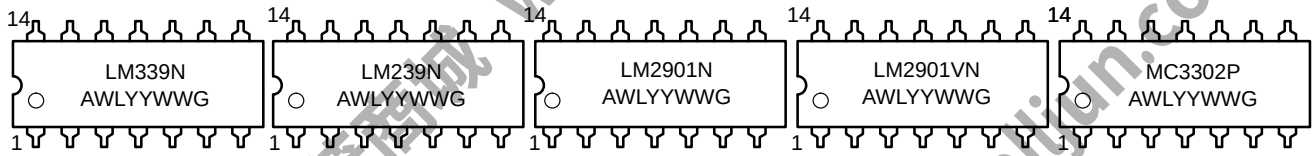
| Device         | Package            | Shipping†          |
|----------------|--------------------|--------------------|
| LM239DG        | SOIC-14 (Pb-Free)  | 55 Units/Tube      |
| LM239DR2G      | SOIC-14 (Pb-Free)  | 2500 / Tape & Reel |
| LM239DTBR2G    | TSSOP-14 (Pb-Free) | 2500 / Tape & Reel |
| LM239NG        | PDIP-14 (Pb-Free)  | 25 Units/Rail      |
| LM339DG        | SOIC-14 (Pb-Free)  | 55 Units/Tube      |
| LM339DR2G      | SOIC-14 (Pb-Free)  | 2500 / Tape & Reel |
| LM339EDR2G     | SOIC-14 (Pb-Free)  | 2500 / Tape & Reel |
| LM339DTBR2G    | TSSOP-14 (Pb-Free) | 2500 / Tape & Reel |
| LM339NG        | PDIP-14 (Pb-Free)  | 25 Units/Rail      |
| LM2901DG       | SOIC-14 (Pb-Free)  | 55 Units/Rail      |
| LM2901DR2G     | SOIC-14 (Pb-Free)  | 2500 / Tape & Reel |
| LM2901EDR2G    | SOIC-14 (Pb-Free)  | 2500 / Tape & Reel |
| LM2901DTBR2G   | TSSOP-14 (Pb-Free) | 2500 / Tape & Reel |
| LM2901NG       | PDIP-14 (Pb-Free)  | 25 Units/Rail      |
| LM2901VDG      | SOIC-14 (Pb-Free)  | 55 Units/Tube      |
| LM2901VDR2G    | SOIC-14 (Pb-Free)  | 2500 / Tape & Reel |
| LM2901VDTBR2G  | TSSOP-14 (Pb-Free) | 2500 / Tape & Reel |
| LM2901VNG      | PDIP-14 (Pb-Free)  | 25 Units/Rail      |
| NCV2901DR2G*   | SOIC-14 (Pb-Free)  | 2500 / Tape & Reel |
| NCV2901DTBR2G* | TSSOP-14 (Pb-Free) | 2500 / Tape & Reel |
| NCV2901CTR*    | Bare Die           | 6000 / Tape & Reel |
| MC3302DG       | SOIC-14 (Pb-Free)  | 55 Units/Tube      |
| MC3302DR2G     | SOIC-14 (Pb-Free)  | 2500 / Tape & Reel |
| MC3302DTBR2G   | TSSOP-14 (Pb-Free) | 2500 / Tape & Reel |
| MC3302PG       | PDIP-14 (Pb-Free)  | 25 Units/Rail      |

†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.

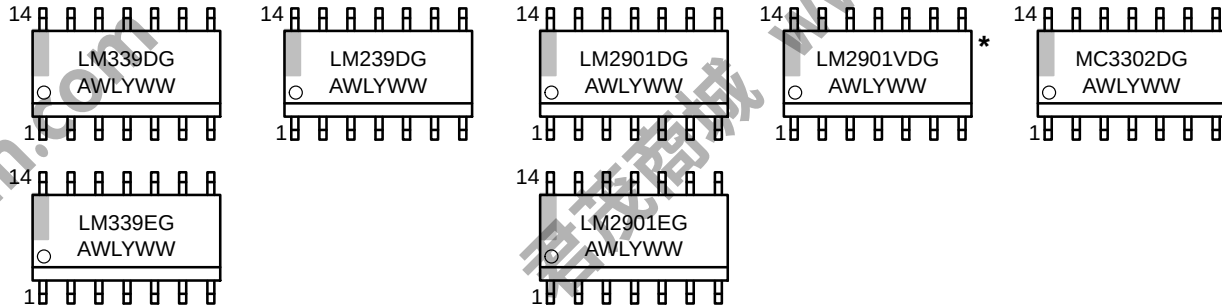
\*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements, AEC-Q100 Qualified and PPAP Capable.

MARKING DIAGRAMS

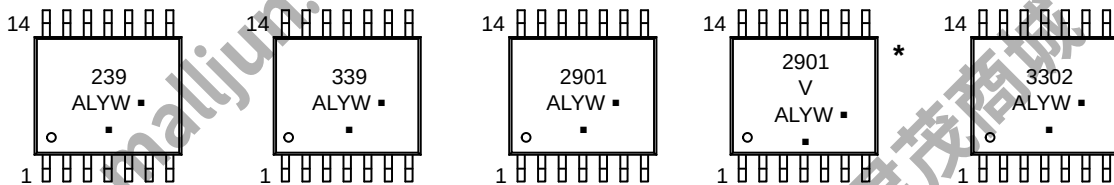
PDIP-14  
N, P SUFFIX  
CASE 646



SOIC-14  
D SUFFIX  
CASE 751A



TSSOP-14  
DTB SUFFIX  
CASE 948G



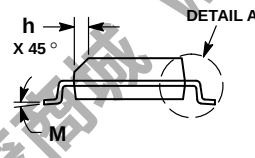
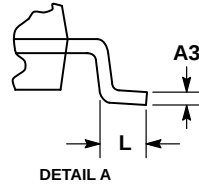
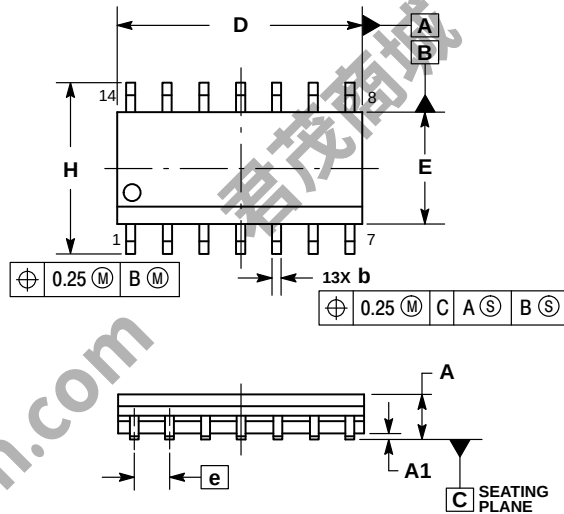
A = Assembly Location  
WL, L = Wafer Lot  
YY, Y = Year  
WW, W = Work Week  
G or ■ = Pb-Free Package

(Note: Microdot may be in either location)

\*This marking diagram also applies to NCV2901.



## PACKAGE DIMENSIONS

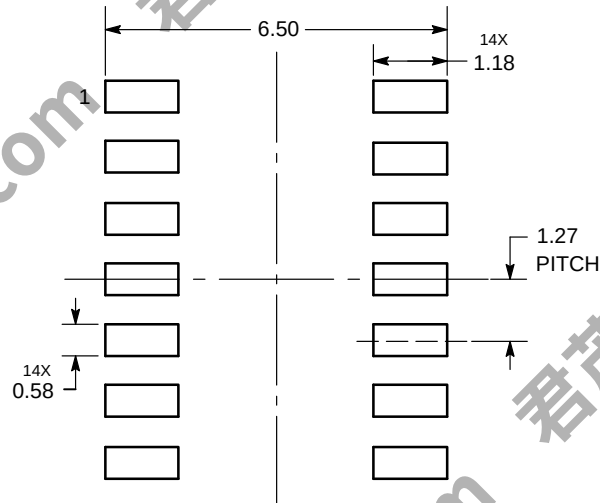
SOIC-14  
CASE 751A-03  
ISSUE K

## NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.13 TOTAL IN EXCESS OF AT MAXIMUM MATERIAL CONDITION.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD PROTRUSIONS.
5. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.

| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 1.35        | 1.75 | 0.054     | 0.068 |
| A1  | 0.10        | 0.25 | 0.004     | 0.010 |
| A3  | 0.19        | 0.25 | 0.008     | 0.010 |
| b   | 0.35        | 0.49 | 0.014     | 0.019 |
| D   | 8.55        | 8.75 | 0.337     | 0.344 |
| E   | 3.80        | 4.00 | 0.150     | 0.157 |
| e   | 1.27 BSC    |      | 0.050 BSC |       |
| H   | 5.80        | 6.20 | 0.228     | 0.244 |
| h   | 0.25        | 0.50 | 0.010     | 0.019 |
| L   | 0.40        | 1.25 | 0.016     | 0.049 |
| M   | 0°          | 7°   | 0°        | 7°    |

## SOLDERING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

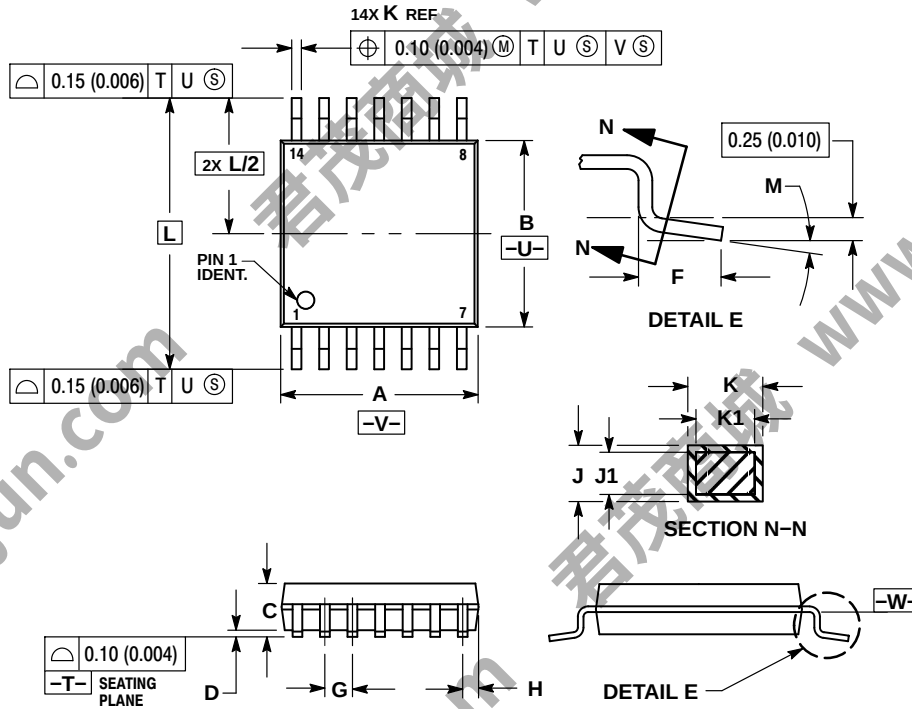
\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

## PACKAGE DIMENSIONS

## TSSOP-14

CASE 948G

ISSUE B

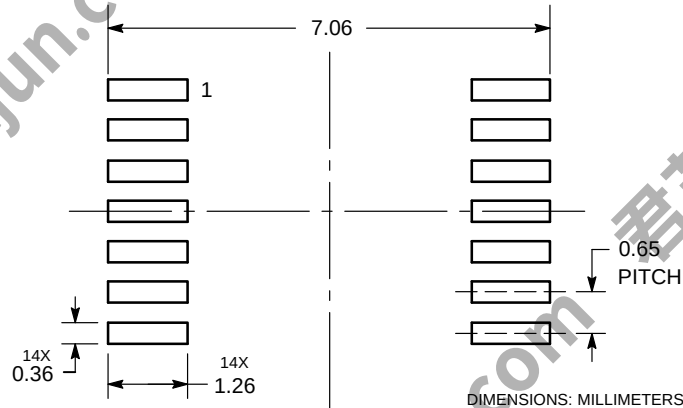


## NOTES:

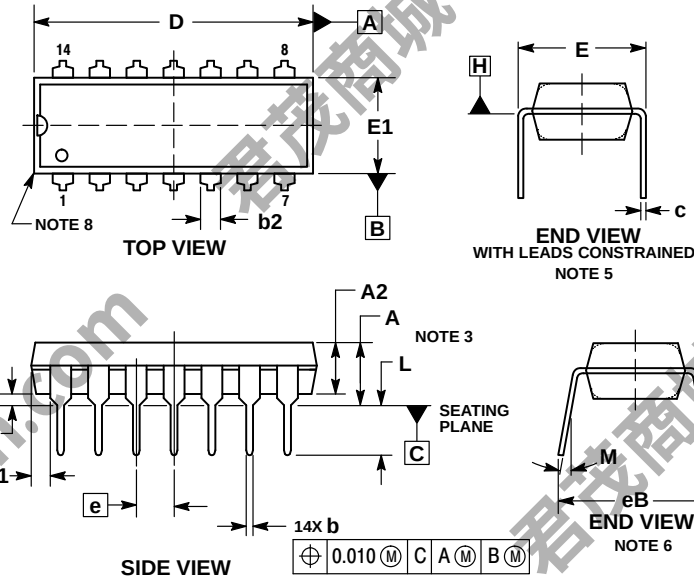
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD 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   | 0.50        | 0.60 | 0.020     | 0.024 |
| 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°    |

## SOLDERING FOOTPRINT



## PACKAGE DIMENSIONS

PDIP-14  
CASE 646-06  
ISSUE S

## NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSIONS A, A1 AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3.
4. DIMENSIONS D, D1 AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE NOT TO EXCEED 0.10 INCH.
5. DIMENSION E IS MEASURED AT A POINT 0.015 BELOW DATUM PLANE H WITH THE LEADS CONSTRAINED PERPENDICULAR TO DATUM C.
6. DIMENSION eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
7. DATUM PLANE H IS COINCIDENT WITH THE BOTTOM OF THE LEADS, WHERE THE LEADS EXIT THE BODY.
8. PACKAGE CONTOUR IS OPTIONAL (ROUNDED OR SQUARE CORNERS).

| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | ---       | 0.210 | ---         | 5.33  |
| A1  | 0.015     | ---   | 0.38        | ---   |
| A2  | 0.115     | 0.195 | 2.92        | 4.95  |
| b   | 0.014     | 0.022 | 0.35        | 0.56  |
| b2  | 0.060 TYP |       | 1.52 TYP    |       |
| C   | 0.008     | 0.014 | 0.20        | 0.36  |
| D   | 0.735     | 0.775 | 18.67       | 19.69 |
| D1  | 0.005     | ---   | 0.13        | ---   |
| E   | 0.300     | 0.325 | 7.62        | 8.26  |
| E1  | 0.240     | 0.280 | 6.10        | 7.11  |
| e   | 0.100 BSC |       | 2.54 BSC    |       |
| eB  | ---       | 0.430 | ---         | 10.92 |
| L   | 0.115     | 0.150 | 2.92        | 3.81  |
| M   | ---       | 10°   | ---         | 10°   |

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