

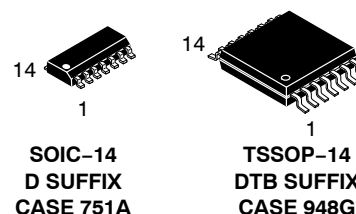
# Single Supply Quad Operational Amplifiers

## LM324, LM324A, LM324E, LM224, LM2902, LM2902E, LM2902V, NCV2902

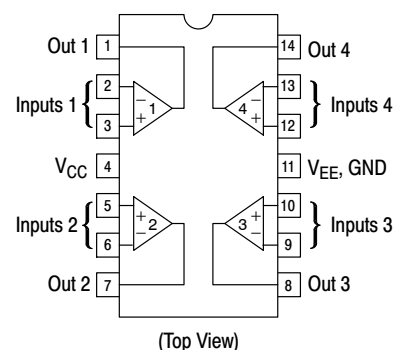
The LM324 series are low-cost, quad operational amplifiers with true differential inputs. They have several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier can operate at supply voltages as low as 3.0 V or as high as 32 V with quiescent currents about one-fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

### Features

- Short Circuited Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V
- Low Input Bias Currents: 100 nA Maximum (LM324A)
- Four Amplifiers Per Package
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Industry Standard Pinouts
- ESD Clamps on the Inputs Increase Ruggedness 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



### PIN CONNECTIONS



### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

### DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 11 of this data sheet.

# LM324, LM324A, LM324E, LM224, LM2902, LM2902E, LM2902V, NCV2902

## MAXIMUM RATINGS (T<sub>A</sub> = +25°C, unless otherwise noted.)

| Rating                                                                                                                | Symbol                                               | Value                                                | Unit            |
|-----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------|-----------------|
| Power Supply Voltages<br>Single Supply<br>Split Supplies                                                              | V <sub>CC</sub><br>V <sub>CC</sub> , V <sub>EE</sub> | 32<br>±16                                            | V <sub>dc</sub> |
| Input Differential Voltage Range (Note 1)                                                                             | V <sub>IDR</sub>                                     | ±32                                                  | V <sub>dc</sub> |
| Input Common Mode Voltage Range                                                                                       | V <sub>ICR</sub>                                     | –0.3 to 32                                           | V <sub>dc</sub> |
| Output Short Circuit Duration                                                                                         | t <sub>SC</sub>                                      | Continuous                                           |                 |
| Junction Temperature                                                                                                  | T <sub>J</sub>                                       | 150                                                  | °C              |
| Thermal Resistance, Junction–to–Air (Note 2)<br>Case 646<br>Case 751A<br>Case 948G                                    | R <sub>θJA</sub>                                     | 118<br>156<br>190                                    | °C/W            |
| Storage Temperature Range                                                                                             | T <sub>stg</sub>                                     | –65 to +150                                          | °C              |
| Operating Ambient Temperature Range<br>LM224<br>LM324, LM324A, LM324E<br>LM2902, LM2902E<br>LM2902V, NCV2902 (Note 3) | T <sub>A</sub>                                       | –25 to +85<br>0 to +70<br>–40 to +105<br>–40 to +125 | °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. Split Power Supplies.
2. All R<sub>θJA</sub> measurements made on evaluation board with 1 oz. copper traces of minimum pad size. All device outputs were active.
3. NCV2902 is qualified for automotive use.

## ESD RATINGS

| Rating                                                                                     | HBM  | MM  | Unit |
|--------------------------------------------------------------------------------------------|------|-----|------|
| ESD Protection at any Pin (Human Body Model – HBM, Machine Model – MM)<br>NCV2902 (Note 3) | 2000 | 200 | V    |
| LM324E, LM2902E                                                                            | 2000 | 200 | V    |
| LM324DG/DR2G, LM2902DG/DR2G                                                                | 200  | 100 | V    |
| All Other Devices                                                                          | 2000 | 200 | V    |

# LM324, LM324A, LM324E, LM224, LM2902, LM2902E, LM2902V, NCV2902

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

| Characteristics                                                                                                                                                                                                                                                                        | Symbol               | LM224 |      |                 | LM324A |      |                 | LM324, LM324E |      |                 | LM2902, LM2902E |      |                 | LM2902V/NCV2902 |      |                 | Unit  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------|------|-----------------|--------|------|-----------------|---------------|------|-----------------|-----------------|------|-----------------|-----------------|------|-----------------|-------|
|                                                                                                                                                                                                                                                                                        |                      | Min   | Typ  | Max             | Min    | Typ  | Max             | Min           | Typ  | Max             | Min             | Typ  | Max             | Min             | Typ  | Max             |       |
| Input Offset Voltage<br>V <sub>CC</sub> = 5.0 V to 30 V<br>V <sub>ICR</sub> = 0 V to<br>V <sub>CC</sub> - 1.7 V,<br>V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 0 Ω<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>high</sub> (Note 4)<br>T <sub>A</sub> = T <sub>low</sub> (Note 4) | V <sub>IO</sub>      | –     | 2.0  | 5.0             | –      | 2.0  | 3.0             | –             | 2.0  | 7.0             | –               | 2.0  | 7.0             | –               | 2.0  | 7.0             | mV    |
| Average Temperature<br>Coefficient of Input<br>Offset Voltage<br>T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub><br>(Notes 4 and 6)                                                                                                                                             | ΔV <sub>IO</sub> /ΔT | –     | 7.0  | –               | –      | 7.0  | 30              | –             | 7.0  | –               | –               | 7.0  | –               | –               | 7.0  | –               | μV/°C |
| Input Offset Current<br>T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub><br>(Note 4)                                                                                                                                                                                             | I <sub>IO</sub>      | –     | 3.0  | 30              | –      | 5.0  | 30              | –             | 5.0  | 50              | –               | 5.0  | 50              | –               | 5.0  | 50              | nA    |
| Average Temperature<br>Coefficient of Input<br>Offset Current<br>T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub><br>(Notes 4 and 6)                                                                                                                                             | ΔI <sub>IO</sub> /ΔT | –     | 10   | –               | –      | 10   | 300             | –             | 10   | –               | –               | 10   | –               | –               | 10   | –               | pA/°C |
| Input Bias Current<br>T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub><br>(Note 4)                                                                                                                                                                                               | I <sub>IB</sub>      | –     | –90  | –150            | –      | –45  | –100            | –             | –90  | –250            | –               | –90  | –250            | –               | –90  | –250            | nA    |
| Input Common Mode<br>Voltage Range<br>(Note 5)<br>V <sub>CC</sub> = 30 V<br>T <sub>A</sub> = +25°C<br>T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub><br>(Note 4)                                                                                                               | V <sub>ICR</sub>     | 0     | –    | 28.3            | 0      | –    | 28.3            | 0             | –    | 28.3            | 0               | –    | 28.3            | 0               | –    | 28.3            | V     |
| Differential Input<br>Voltage Range                                                                                                                                                                                                                                                    | V <sub>IDR</sub>     | –     | –    | V <sub>CC</sub> | –      | –    | V <sub>CC</sub> | –             | –    | V <sub>CC</sub> | –               | –    | V <sub>CC</sub> | –               | –    | V <sub>CC</sub> | V     |
| Large Signal Open<br>Loop Voltage Gain<br>R <sub>L</sub> = 2.0 kΩ,<br>V <sub>CC</sub> = 15 V,<br>for Large V <sub>O</sub> Swing<br>T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub><br>(Note 4)                                                                                  | A <sub>VOL</sub>     | 50    | 100  | –               | 25     | 100  | –               | 25            | 100  | –               | 25              | 100  | –               | 25              | 100  | –               | V/mV  |
| Channel Separation<br>10 kHz ≤ f ≤ 20 kHz,<br>Input Referenced                                                                                                                                                                                                                         | CS                   | –     | –120 | –               | –      | –120 | –               | –             | –120 | –               | –               | –120 | –               | –               | –120 | –               | dB    |
| Common Mode<br>Rejection,<br>R <sub>S</sub> ≤ 10 kΩ                                                                                                                                                                                                                                    | CMR                  | 70    | 85   | –               | 65     | 70   | –               | 65            | 70   | –               | 50              | 70   | –               | 50              | 70   | –               | dB    |
| Power Supply<br>Rejection                                                                                                                                                                                                                                                              | PSR                  | 65    | 100  | –               | 65     | 100  | –               | 65            | 100  | –               | 50              | 100  | –               | 50              | 100  | –               | dB    |

4. LM224: T<sub>low</sub> = –25°C, T<sub>high</sub> = +85°C  
 LM324/LM324A/LM324E: T<sub>low</sub> = 0°C, T<sub>high</sub> = +70°C  
 LM2902/LM2902E: T<sub>low</sub> = –40°C, T<sub>high</sub> = +105°C  
 LM2902V & NCV2902: T<sub>low</sub> = –40°C, T<sub>high</sub> = +125°C  
 NCV2902 is qualified for automotive use.

5. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V<sub>CC</sub> – 1.7 V, but either or both inputs can go to +32 V without damage, independent of the magnitude of V<sub>CC</sub>.
6. Guaranteed by design.

# LM324, LM324A, LM324E, LM224, LM2902, LM2902E, LM2902V, NCV2902

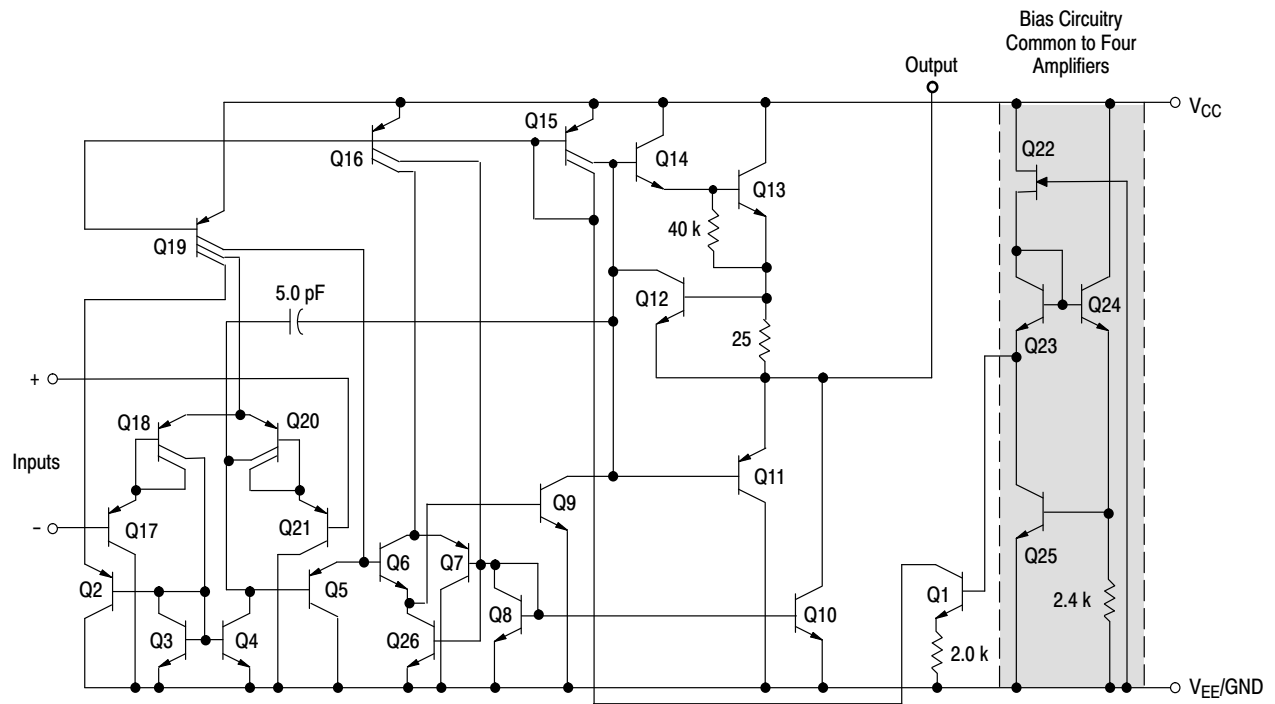
## ELECTRICAL CHARACTERISTICS (V<sub>CC</sub> = 5.0 V, V<sub>EE</sub> = GND, T<sub>A</sub> = 25°C, unless otherwise noted.)

| Characteristics                                                                                                                                                                                                                                                                                                                                                   | Symbol           | LM224           |                 |             | LM324A          |                 |             | LM324, LM324E   |                 |             | LM2902, LM2902E |                |             | LM2902V/NCV2902 |                |             | Unit         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------|-----------------|-------------|-----------------|-----------------|-------------|-----------------|-----------------|-------------|-----------------|----------------|-------------|-----------------|----------------|-------------|--------------|
|                                                                                                                                                                                                                                                                                                                                                                   |                  | Min             | Typ             | Max         | Min             | Typ             | Max         | Min             | Typ             | Max         | Min             | Typ            | Max         | Min             | Typ            | Max         |              |
| Output Voltage – High Limit<br>V <sub>CC</sub> = 5.0 V, R <sub>L</sub> = 2.0 kΩ, T <sub>A</sub> = 25°C<br>V <sub>CC</sub> = 30 V<br>R <sub>L</sub> = 2.0 kΩ<br>(T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> )<br>(Note 7)<br>V <sub>CC</sub> = 30 V<br>R <sub>L</sub> = 10 kΩ<br>(T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> )<br>(Note 7) | V <sub>OH</sub>  | 3.3             | 3.5             | –           | 3.3             | 3.5             | –           | 3.3             | 3.5             | –           | 3.3             | 3.5            | –           | 3.3             | 3.5            | –           | V            |
| Output Voltage – Low Limit,<br>V <sub>CC</sub> = 5.0 V,<br>R <sub>L</sub> = 10 kΩ,<br>T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub><br>(Note 7)                                                                                                                                                                                                          | V <sub>OL</sub>  | –               | 5.0             | 20          | –               | 5.0             | 20          | –               | 5.0             | 20          | –               | 5.0            | 100         | –               | 5.0            | 100         | mV           |
| Output Source Current<br>(V <sub>ID</sub> = +1.0 V,<br>V <sub>CC</sub> = 15 V)<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub><br>(Note 7)                                                                                                                                                                                     | I <sub>O</sub> + | 20<br>10        | 40<br>20        | –<br>–      | 20<br>10        | 40<br>20        | –<br>–      | 20<br>10        | 40<br>20        | –<br>–      | 20<br>10        | 40<br>20       | –<br>–      | 20<br>10        | 40<br>20       | –<br>–      | mA           |
| Output Sink Current<br>(V <sub>ID</sub> = –1.0 V,<br>V <sub>CC</sub> = 15 V)<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub><br>(Note 7)<br>(V <sub>ID</sub> = –1.0 V,<br>V <sub>O</sub> = 200 mV,<br>T <sub>A</sub> = 25°C)                                                                                                   | I <sub>O</sub> – | 10<br>5.0<br>12 | 20<br>8.0<br>50 | –<br>–<br>– | 10<br>5.0<br>12 | 20<br>8.0<br>50 | –<br>–<br>– | 10<br>5.0<br>12 | 20<br>8.0<br>50 | –<br>–<br>– | 10<br>5.0<br>–  | 20<br>8.0<br>– | –<br>–<br>– | 10<br>5.0<br>–  | 20<br>8.0<br>– | –<br>–<br>– | mA<br><br>μA |
| Output Short Circuit to Ground<br>(Note 8)                                                                                                                                                                                                                                                                                                                        | I <sub>SC</sub>  | –               | 40              | 60          | –               | 40              | 60          | –               | 40              | 60          | –               | 40             | 60          | –               | 40             | 60          | mA           |
| Power Supply Current<br>(T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> )<br>(Note 7)<br>V <sub>CC</sub> = 30 V<br>V <sub>O</sub> = 0 V, R <sub>L</sub> = ∞<br>V <sub>CC</sub> = 5.0 V,<br>V <sub>O</sub> = 0 V, R <sub>L</sub> = ∞                                                                                                                       | I <sub>CC</sub>  | –<br>–          | –<br>–          | 3.0<br>1.2  | –<br>–          | 1.4<br>0.7      | 3.0<br>1.2  | –<br>–          | –<br>–          | 3.0<br>1.2  | –<br>–          | –<br>–         | 3.0<br>1.2  | –<br>–          | –<br>–         | 3.0<br>1.2  | mA           |

7. LM224: T<sub>low</sub> = –25°C, T<sub>high</sub> = +85°C  
 LM324/LM324A/LM324E: T<sub>low</sub> = 0°C, T<sub>high</sub> = +70°C  
 LM2902/LM2902E: T<sub>low</sub> = –40°C, T<sub>high</sub> = +105°C  
 LM2902V & NCV2902: T<sub>low</sub> = –40°C, T<sub>high</sub> = +125°C  
 NCV2902 is qualified for automotive use.

8. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V<sub>CC</sub> – 1.7 V, but either or both inputs can go to +32 V without damage, independent of the magnitude of V<sub>CC</sub>.

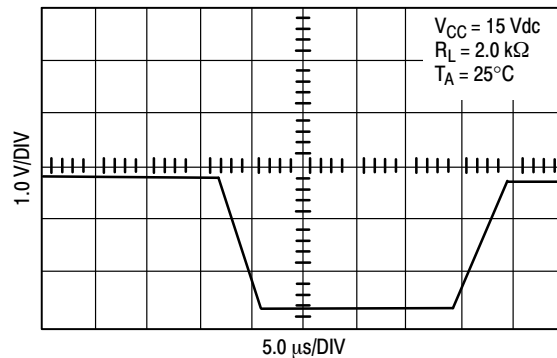
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.



**Figure 1. Representative Circuit Diagram**  
(One-Fourth of Circuit Shown)

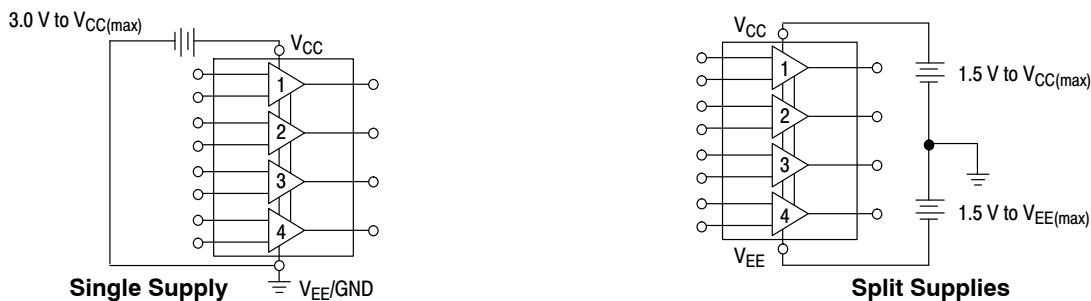
## CIRCUIT DESCRIPTION

The LM324 series is made using four internally compensated, two-stage operational amplifiers. The first stage of each consists of differential input devices Q20 and Q18 with input buffer transistors Q21 and Q17 and the differential to single ended converter Q3 and Q4. The first stage performs not only the first stage gain function but also performs the level shifting and transconductance reduction functions. By reducing the transconductance, a smaller compensation capacitor (only 5.0 pF) can be employed, thus saving chip area. The transconductance reduction is accomplished by splitting the collectors of Q20 and Q18. Another feature of this input stage is that the input common mode range can include the negative supply or ground, in single supply operation, without saturating either the input devices or the differential to single-ended converter. The second stage consists of a standard current source load amplifier stage.

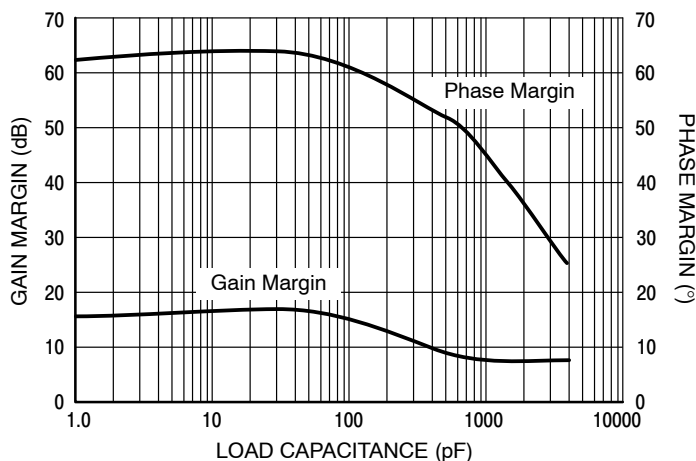


**Figure 2. Large Signal Voltage Follower Response**

Each amplifier is biased from an internal-voltage regulator which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.



**Figure 3.**



**Figure 4. Gain and Phase Margin**

# LM324, LM324A, LM324E, LM224, LM2902, LM2902E, LM2902V, NCV2902

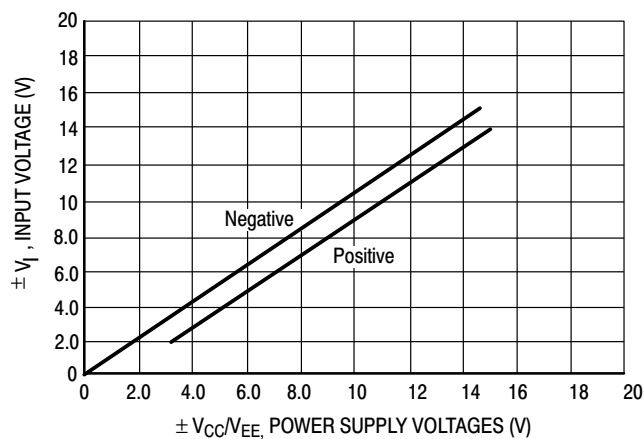


Figure 5. Input Voltage Range

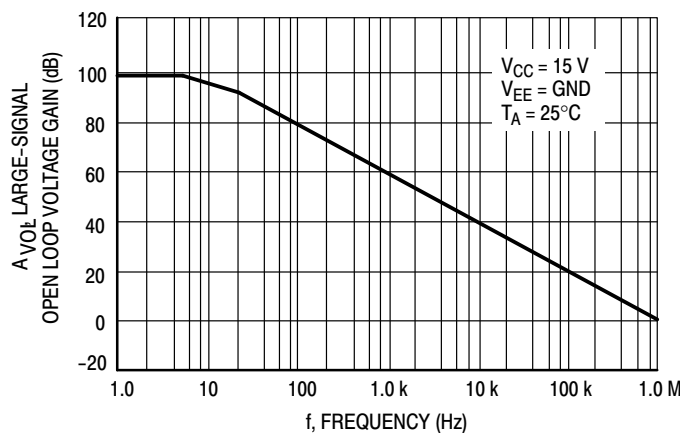


Figure 6. Open Loop Frequency

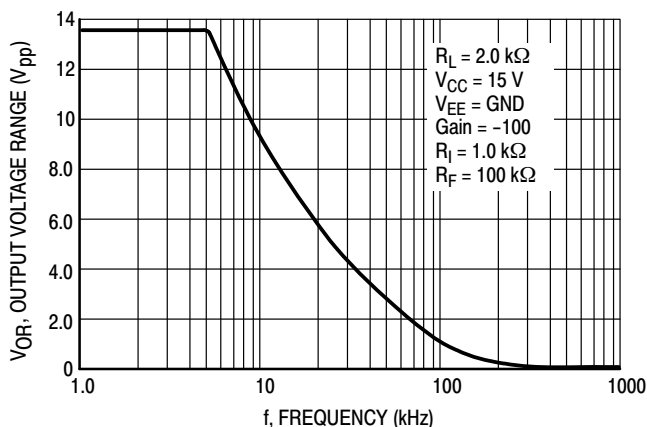


Figure 7. Large-Signal Frequency Response

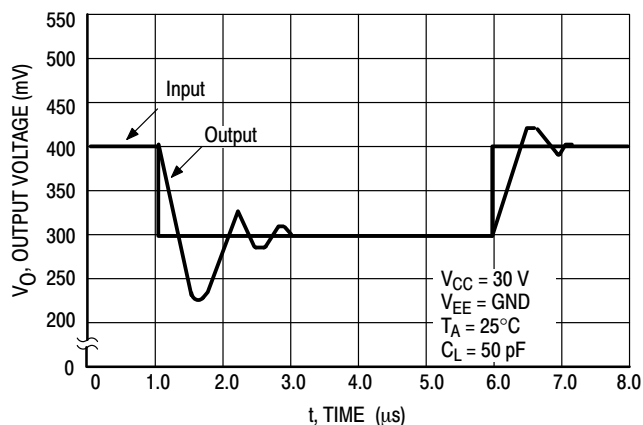


Figure 8. Small-Signal Voltage Follower Pulse Response (Noninverting)

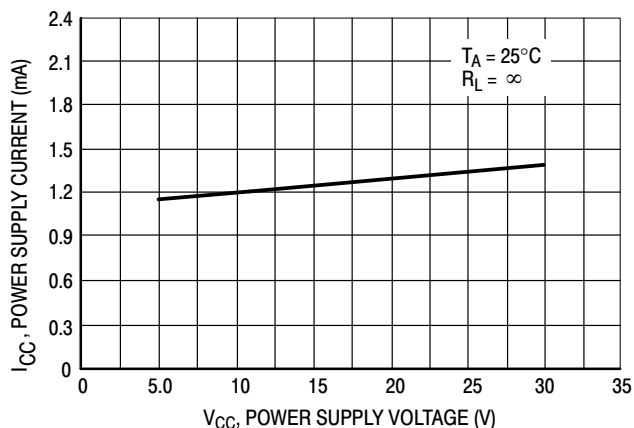


Figure 9. Power Supply Current versus Power Supply Voltage

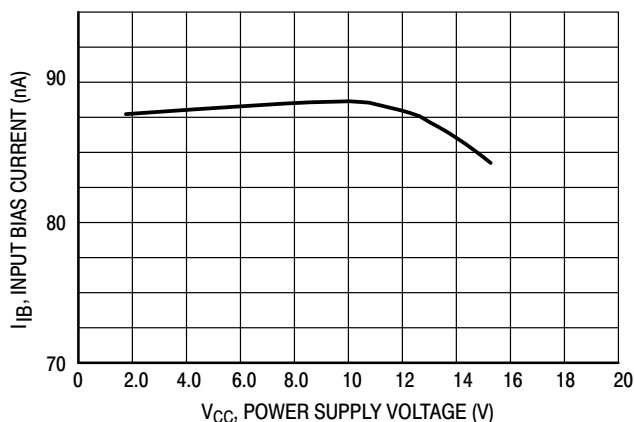


Figure 10. Input Bias Current versus Power Supply Voltage

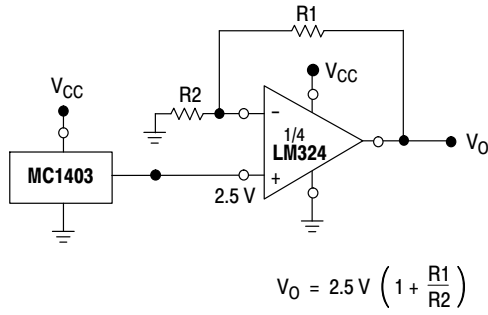


Figure 11. Voltage Reference

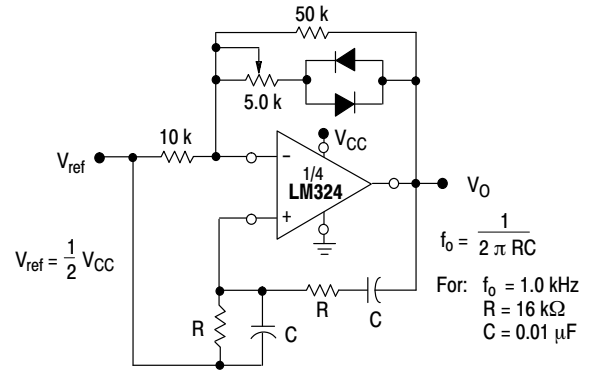


Figure 12. Wien Bridge Oscillator

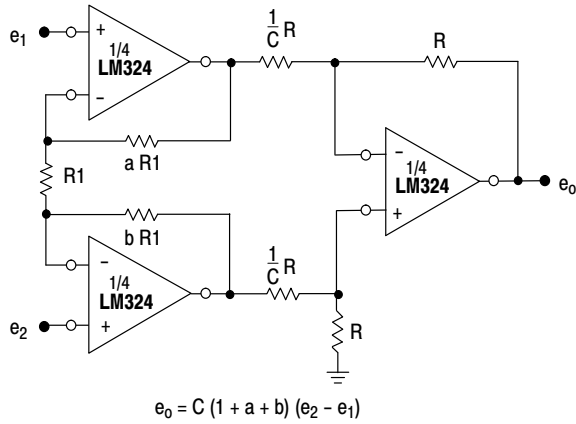


Figure 13. High Impedance Differential Amplifier

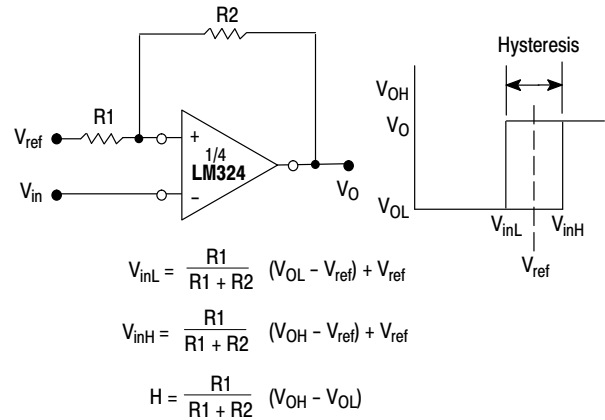


Figure 14. Comparator with Hysteresis

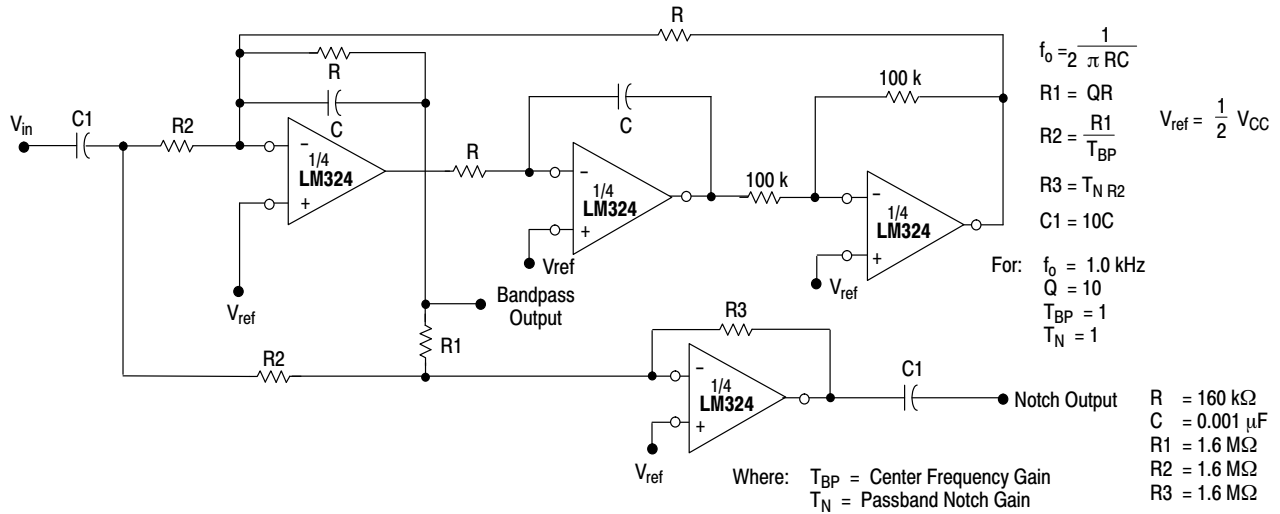


Figure 15. Bi-Quad Filter

# LM324, LM324A, LM324E, LM224, LM2902, LM2902E, LM2902V, NCV2902

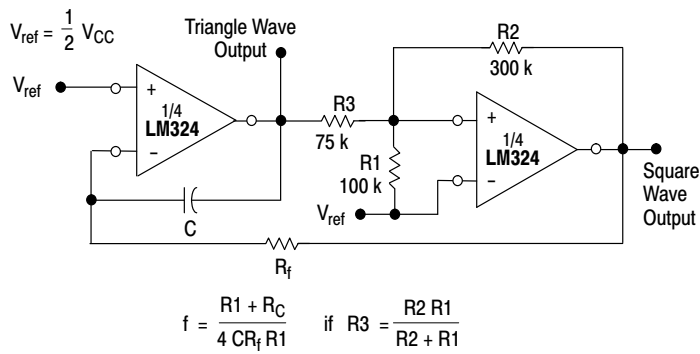


Figure 16. Function Generator

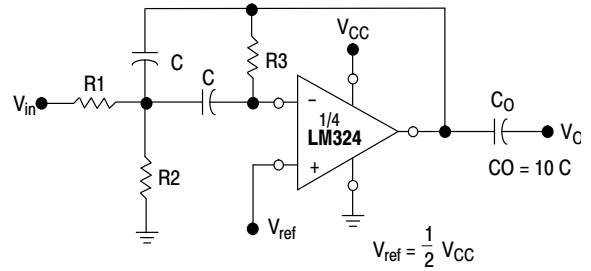


Figure 17. Multiple Feedback Bandpass Filter

Given:  $f_0$  = center frequency

$A(f_0)$  = gain at center frequency

Choose value  $f_0$ ,  $C$

$$\text{Then: } R3 = \frac{Q}{\pi f_0 C}$$

$$R1 = \frac{R3}{2 A(f_0)}$$

$$R2 = \frac{R1 R3}{4 Q^2 R1 - R3}$$

For less than 10% error from operational amplifier,  $\frac{Q_0 f_0}{BW} < 0.1$

where  $f_0$  and  $BW$  are expressed in Hz.

If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

# LM324, LM324A, LM324E, LM224, LM2902, LM2902E, LM2902V, NCV2902

## ORDERING INFORMATION

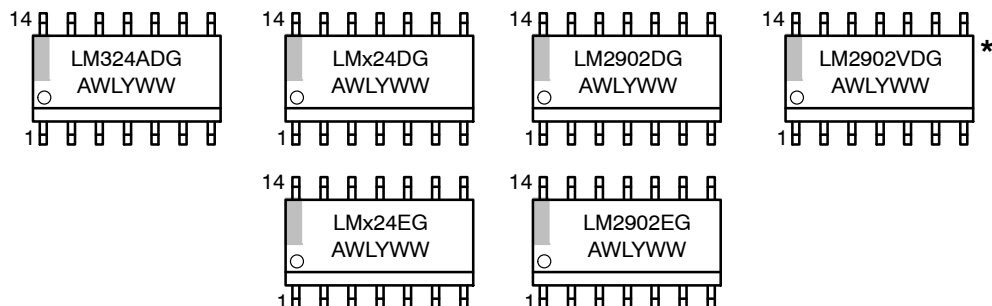
| Device         | Operating Temperature Range | Package            | Shipping <sup>†</sup> |
|----------------|-----------------------------|--------------------|-----------------------|
| LM224DR2G      | -25°C to +85°C              | SOIC-14 (Pb-Free)  | 2500/Tape & Reel      |
| LM224DTBR2G    |                             | TSSOP-14 (Pb-Free) | 2500/Tape & Reel      |
| LM324DR2G      | 0°C to +70°C                | SOIC-14 (Pb-Free)  | 2500/Tape & Reel      |
| LM324EDR2G     |                             | SOIC-14 (Pb-Free)  | 2500/Tape & Reel      |
| LM324DTBR2G    |                             | TSSOP-14 (Pb-Free) | 2500/Tape & Reel      |
| LM324ADR2G     |                             | SOIC-14 (Pb-Free)  | 2500/Tape & Reel      |
| LM324ADTBR2G   |                             | TSSOP-14 (Pb-Free) | 2500/Tape & Reel      |
| LM2902DR2G     | -40°C to +105°C             | SOIC-14 (Pb-Free)  | 2500/Tape & Reel      |
| LM2902EDR2G    |                             | SOIC-14 (Pb-Free)  | 2500/Tape & Reel      |
| LM2902DTBR2G   |                             | TSSOP-14 (Pb-Free) | 2500/Tape & Reel      |
| LM2902VDR2G    | -40°C to +125°C             | SOIC-14 (Pb-Free)  | 2500/Tape & Reel      |
| LM2902VDTBR2G  |                             | TSSOP-14 (Pb-Free) | 2500/Tape & Reel      |
| NCV2902DR2G*   |                             | SOIC-14 (Pb-Free)  | 2500/Tape & Reel      |
| NCV2902DTBR2G* |                             | TSSOP-14 (Pb-Free) |                       |

<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.

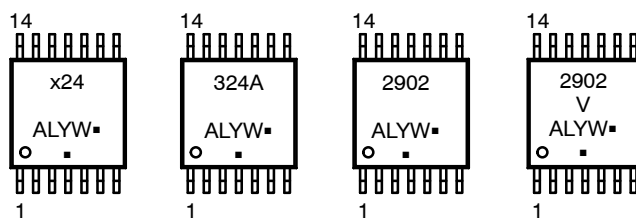
\*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable.

# MARKING DIAGRAMS

## SOIC-14 D SUFFIX CASE 751A



## TSSOP-14 DTB SUFFIX CASE 948G



x = 2 or 3  
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)

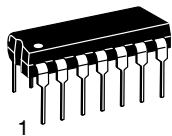
\*This marking diagram also applies to NCV2902.

# MECHANICAL CASE OUTLINE

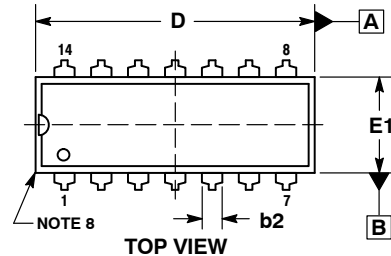
## PACKAGE DIMENSIONS

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ON



SCALE 1:1



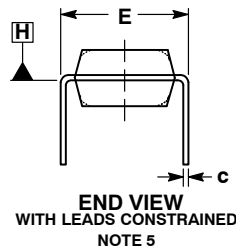
TOP VIEW

PDIP-14  
CASE 646-06  
ISSUE S

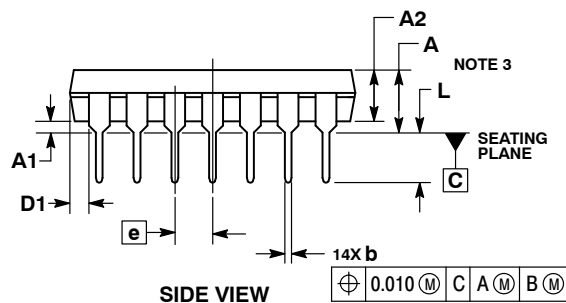
DATE 22 APR 2015

### NOTES:

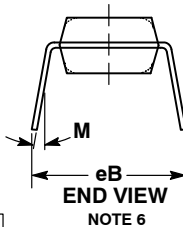
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSIONS A, A1 AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3.
4. DIMENSIONS D, D1 AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE NOT TO EXCEED 0.10 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).



END VIEW  
WITH LEADS CONSTRAINED  
NOTE 5



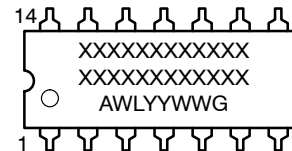
SIDE VIEW



END VIEW  
NOTE 6

| 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°   |

### GENERIC MARKING DIAGRAM\*



XXXXX = Specific Device Code  
A = Assembly Location  
WL = Wafer Lot  
YY = Year  
WW = Work Week  
G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking.  
Pb-Free indicator, "G" or microdot "▪", may or may not be present.

STYLES ON PAGE 2

|                  |             |                                                                                                                                                                                     |
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PDIP-14  
CASE 646-06  
ISSUE S

DATE 22 APR 2015

STYLE 1:  
PIN 1. COLLECTOR  
2. BASE  
3. EMITTER  
4. NO  
CONNECTION  
5. EMITTER  
6. BASE  
7. COLLECTOR  
8. COLLECTOR  
9. BASE  
10. EMITTER  
11. NO  
CONNECTION  
12. EMITTER  
13. BASE  
14. COLLECTOR

STYLE 2:  
CANCELLED

STYLE 3:  
CANCELLED

STYLE 4:  
PIN 1. DRAIN  
2. SOURCE  
3. GATE  
4. NO  
CONNECTION  
5. GATE  
6. SOURCE  
7. DRAIN  
8. DRAIN  
9. SOURCE  
10. GATE  
11. NO  
CONNECTION  
12. GATE  
13. SOURCE  
14. DRAIN

STYLE 5:  
PIN 1. GATE  
2. DRAIN  
3. SOURCE  
4. NO CONNECTION  
5. SOURCE  
6. DRAIN  
7. GATE  
8. GATE  
9. DRAIN  
10. SOURCE  
11. NO CONNECTION  
12. SOURCE  
13. DRAIN  
14. GATE

STYLE 6:  
PIN 1. COMMON CATHODE  
2. ANODE/CATHODE  
3. ANODE/CATHODE  
4. NO CONNECTION  
5. ANODE/CATHODE  
6. NO CONNECTION  
7. ANODE/CATHODE  
8. ANODE/CATHODE  
9. ANODE/CATHODE  
10. NO CONNECTION  
11. ANODE/CATHODE  
12. ANODE/CATHODE  
13. NO CONNECTION  
14. COMMON ANODE

STYLE 7:  
PIN 1. NO CONNECTION  
2. ANODE  
3. ANODE  
4. NO CONNECTION  
5. ANODE  
6. NO CONNECTION  
7. ANODE  
8. ANODE  
9. ANODE  
10. NO CONNECTION  
11. ANODE  
12. ANODE  
13. NO CONNECTION  
14. COMMON  
CATHODE

STYLE 8:  
PIN 1. NO CONNECTION  
2. CATHODE  
3. CATHODE  
4. NO CONNECTION  
5. CATHODE  
6. NO CONNECTION  
7. CATHODE  
8. CATHODE  
9. CATHODE  
10. NO CONNECTION  
11. CATHODE  
12. CATHODE  
13. NO CONNECTION  
14. COMMON ANODE

STYLE 9:  
PIN 1. COMMON CATHODE  
2. ANODE/CATHODE  
3. ANODE/CATHODE  
4. NO CONNECTION  
5. ANODE/CATHODE  
6. ANODE/CATHODE  
7. COMMON ANODE  
8. COMMON ANODE  
9. ANODE/CATHODE  
10. ANODE/CATHODE  
11. NO CONNECTION  
12. ANODE/CATHODE  
13. ANODE/CATHODE  
14. COMMON CATHODE

STYLE 10:  
PIN 1. COMMON  
CATHODE  
2. ANODE/CATHODE  
3. ANODE/CATHODE  
4. ANODE/CATHODE  
5. ANODE/CATHODE  
6. NO CONNECTION  
7. COMMON ANODE  
8. COMMON  
CATHODE  
9. ANODE/CATHODE  
10. ANODE/CATHODE  
11. ANODE/CATHODE  
12. ANODE/CATHODE  
13. NO CONNECTION  
14. COMMON ANODE

STYLE 11:  
PIN 1. CATHODE  
2. CATHODE  
3. CATHODE  
4. CATHODE  
5. CATHODE  
6. CATHODE  
7. CATHODE  
8. ANODE  
9. ANODE  
10. ANODE  
11. ANODE  
12. ANODE  
13. ANODE  
14. ANODE

STYLE 12:  
PIN 1. COMMON CATHODE  
2. COMMON ANODE  
3. ANODE/CATHODE  
4. ANODE/CATHODE  
5. ANODE/CATHODE  
6. COMMON ANODE  
7. COMMON CATHODE  
8. ANODE/CATHODE  
9. ANODE/CATHODE  
10. ANODE/CATHODE  
11. ANODE/CATHODE  
12. ANODE/CATHODE  
13. ANODE/CATHODE  
14. ANODE/CATHODE

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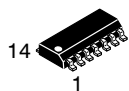
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# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

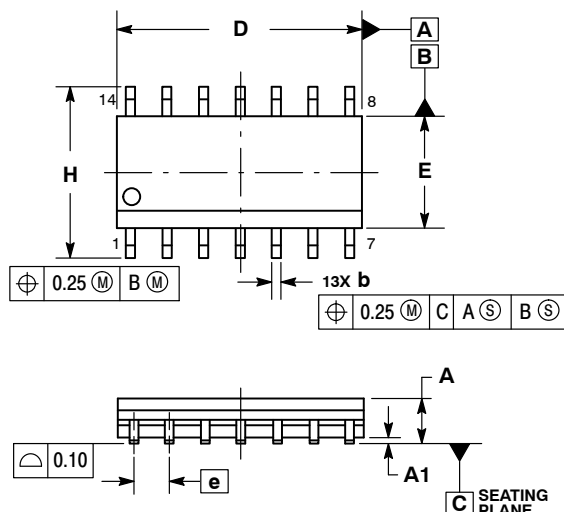
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SCALE 1:1

SOIC-14 NB  
CASE 751A-03  
ISSUE L

DATE 03 FEB 2016

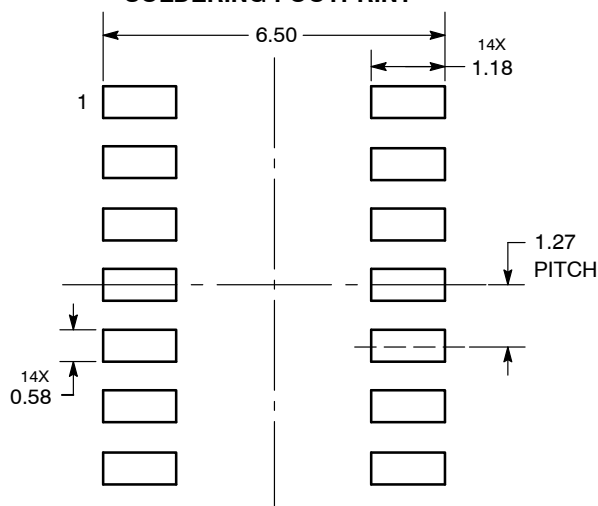


## NOTES:

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°    |

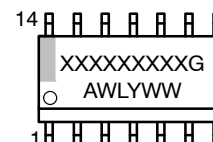
## SOLDERING FOOTPRINT\*



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.

## GENERIC MARKING DIAGRAM\*



\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present.

STYLES ON PAGE 2

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**SOIC-14**  
**CASE 751A-03**  
**ISSUE L**

**DATE 03 FEB 2016**

**STYLE 1:**  
PIN 1. COMMON CATHODE  
2. ANODE/CATHODE  
3. ANODE/CATHODE  
4. NO CONNECTION  
5. ANODE/CATHODE  
6. NO CONNECTION  
7. ANODE/CATHODE  
8. ANODE/CATHODE  
9. ANODE/CATHODE  
10. NO CONNECTION  
11. ANODE/CATHODE  
12. ANODE/CATHODE  
13. NO CONNECTION  
14. COMMON ANODE

**STYLE 2:**  
CANCELLED

**STYLE 3:**  
PIN 1. NO CONNECTION  
2. ANODE  
3. ANODE  
4. NO CONNECTION  
5. ANODE  
6. NO CONNECTION  
7. ANODE  
8. ANODE  
9. ANODE  
10. NO CONNECTION  
11. ANODE  
12. ANODE  
13. NO CONNECTION  
14. COMMON CATHODE

**STYLE 4:**  
PIN 1. NO CONNECTION  
2. CATHODE  
3. CATHODE  
4. NO CONNECTION  
5. CATHODE  
6. NO CONNECTION  
7. CATHODE  
8. CATHODE  
9. CATHODE  
10. NO CONNECTION  
11. CATHODE  
12. CATHODE  
13. NO CONNECTION  
14. COMMON ANODE

**STYLE 5:**  
PIN 1. COMMON CATHODE  
2. ANODE/CATHODE  
3. ANODE/CATHODE  
4. ANODE/CATHODE  
5. ANODE/CATHODE  
6. NO CONNECTION  
7. COMMON ANODE  
8. COMMON CATHODE  
9. ANODE/CATHODE  
10. ANODE/CATHODE  
11. ANODE/CATHODE  
12. ANODE/CATHODE  
13. NO CONNECTION  
14. COMMON ANODE

**STYLE 6:**  
PIN 1. CATHODE  
2. CATHODE  
3. CATHODE  
4. CATHODE  
5. CATHODE  
6. CATHODE  
7. CATHODE  
8. ANODE  
9. ANODE  
10. ANODE  
11. ANODE  
12. ANODE  
13. ANODE  
14. ANODE

**STYLE 7:**  
PIN 1. ANODE/CATHODE  
2. COMMON ANODE  
3. COMMON CATHODE  
4. ANODE/CATHODE  
5. ANODE/CATHODE  
6. ANODE/CATHODE  
7. ANODE/CATHODE  
8. ANODE/CATHODE  
9. ANODE/CATHODE  
10. ANODE/CATHODE  
11. COMMON CATHODE  
12. COMMON ANODE  
13. ANODE/CATHODE  
14. ANODE/CATHODE

**STYLE 8:**  
PIN 1. COMMON CATHODE  
2. ANODE/CATHODE  
3. ANODE/CATHODE  
4. NO CONNECTION  
5. ANODE/CATHODE  
6. ANODE/CATHODE  
7. COMMON ANODE  
8. COMMON ANODE  
9. ANODE/CATHODE  
10. ANODE/CATHODE  
11. NO CONNECTION  
12. ANODE/CATHODE  
13. ANODE/CATHODE  
14. COMMON CATHODE

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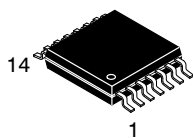
**DESCRIPTION:** SOIC-14 NB

**PAGE 2 OF 2**

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# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

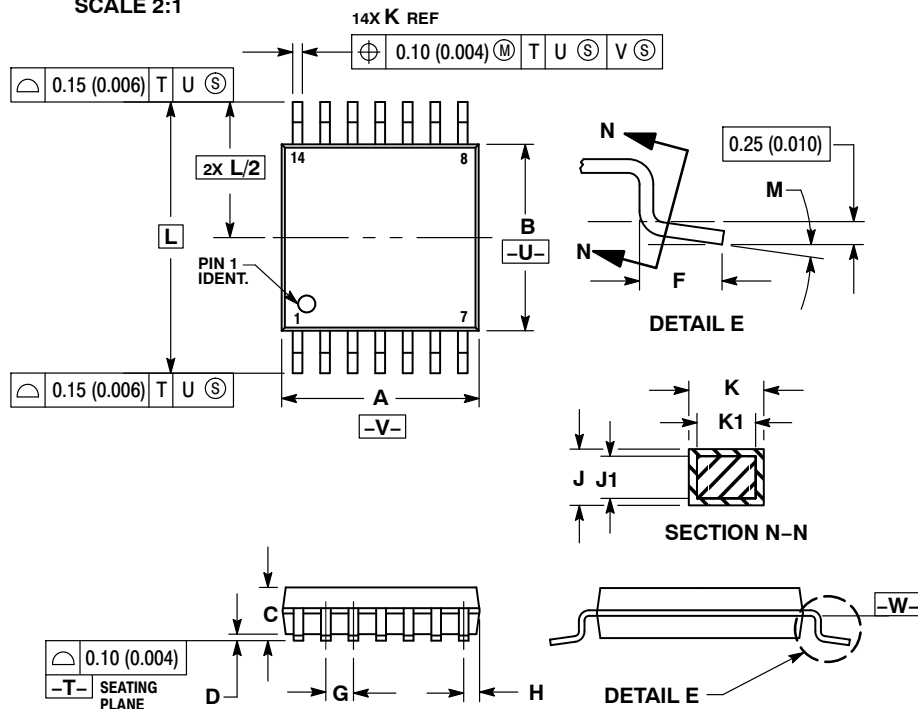
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SCALE 2:1

## TSSOP-14 WB CASE 948G ISSUE C

DATE 17 FEB 2016

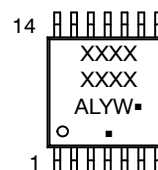


### NOTES:

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°    |

### GENERIC MARKING DIAGRAM\*

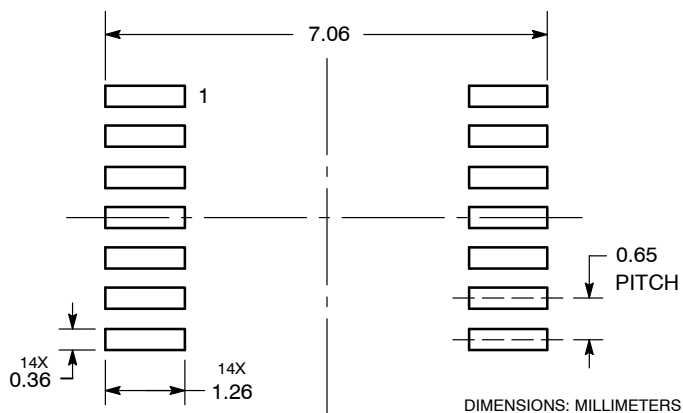


- A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

(Note: Microdot may be in either location)

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present.

### SOLDERING FOOTPRINT



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DESCRIPTION: TSSOP-14 WB

PAGE 1 OF 1

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