

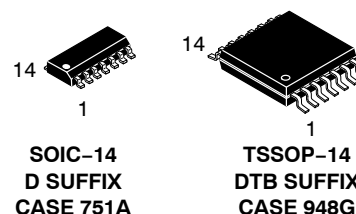
# Single Supply Quad Operational Amplifiers

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

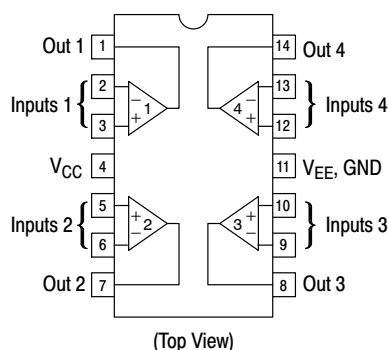
The LM324 series are low-cost, quad operational amplifiers with true differential inputs. They have several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier can operate at supply voltages as low as 3.0 V or as high as 32 V with quiescent 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 Single Supply Split Supplies	V <sub>CC</sub> V <sub>CC</sub> , V <sub>EE</sub>	32 ±16	Vdc
Input Differential Voltage Range (Note 1)	V <sub>IDR</sub>	±32	Vdc
Input Common Mode Voltage Range	V <sub>ICR</sub>	–0.3 to 32	Vdc
Output Short Circuit Duration	t <sub>SC</sub>	Continuous	
Junction Temperature	T <sub>J</sub>	150	°C
Thermal Resistance, Junction–to–Air (Note 2) Case 646 Case 751A Case 948G	R <sub>θJA</sub>	118 156 190	°C/W
Storage Temperature Range	T <sub>stg</sub>	–65 to +150	°C
Operating Ambient Temperature Range LM224 LM324, LM324A, LM324E LM2902, LM2902E LM2902V, NCV2902 (Note 3)	T <sub>A</sub>	–25 to +85 0 to +70 –40 to +105 –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) 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 ( $V_{CC} = 5.0\text{ V}$ , $V_{EE} = \text{GND}$ , $T_A = 25^\circ\text{C}$ , 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 $V_{CC} = 5.0\text{ V}$ to $30\text{ V}$ $V_{ICR} = 0\text{ V}$ to $V_{CC} - 1.7\text{ V}$ , $V_O = 1.4\text{ V}$ , $R_S = 0\ \Omega$ $T_A = 25^\circ\text{C}$ $T_A = T_{\text{high}}$ (Note 4) $T_A = T_{\text{low}}$ (Note 4)	$V_{IO}$	–	2.0	5.0	–	2.0	3.0	–	2.0	7.0	–	2.0	7.0	–	2.0	7.0	mV
Average Temperature Coefficient of Input Offset Voltage $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Notes 4 and 6)	$\Delta V_{IO}/\Delta T$	–	7.0	–	–	7.0	30	–	7.0	–	–	7.0	–	–	7.0	–	$\mu\text{V}/^\circ\text{C}$
Input Offset Current $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 4)	$I_{IO}$	–	3.0	30	–	5.0	30	–	5.0	50	–	5.0	50	–	5.0	50	nA
Average Temperature Coefficient of Input Offset Current $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Notes 4 and 6)	$\Delta I_{IO}/\Delta T$	–	10	–	–	10	300	–	10	–	–	10	–	–	10	–	$\text{pA}/^\circ\text{C}$
Input Bias Current $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 4)	$I_{IB}$	–	–90	–150	–	–45	–100	–	–90	–250	–	–90	–250	–	–90	–250	nA
Input Common Mode Voltage Range (Note 5) $V_{CC} = 30\text{ V}$ $T_A = +25^\circ\text{C}$ $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 4)	$V_{ICR}$	0	–	28.3	0	–	28.3	0	–	28.3	0	–	28.3	0	–	28.3	V
Differential Input Voltage Range	$V_{IDR}$	–	–	$V_{CC}$	–	–	$V_{CC}$	–	–	$V_{CC}$	–	–	$V_{CC}$	–	–	$V_{CC}$	V
Large Signal Open Loop Voltage Gain $R_L = 2.0\text{ k}\Omega$ , $V_{CC} = 15\text{ V}$ , for Large $V_O$ Swing $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 4)	$A_{VOL}$	50	100	–	25	100	–	25	100	–	25	100	–	25	100	–	V/mV
Channel Separation $10\text{ kHz} \leq f \leq 20\text{ kHz}$ , Input Referenced	CS	–	–120	–	–	–120	–	–	–120	–	–	–120	–	–	–120	–	dB
Common Mode Rejection, $R_S \leq 10\text{ k}\Omega$	CMR	70	85	–	65	70	–	65	70	–	50	70	–	50	70	–	dB
Power Supply Rejection	PSR	65	100	–	65	100	–	65	100	–	50	100	–	50	100	–	dB

4. LM224:  $T_{\text{low}} = -25^\circ\text{C}$ ,  $T_{\text{high}} = +85^\circ\text{C}$   
 LM324/LM324A/LM324E:  $T_{\text{low}} = 0^\circ\text{C}$ ,  $T_{\text{high}} = +70^\circ\text{C}$   
 LM2902/LM2902E:  $T_{\text{low}} = -40^\circ\text{C}$ ,  $T_{\text{high}} = +105^\circ\text{C}$   
 LM2902V & NCV2902:  $T_{\text{low}} = -40^\circ\text{C}$ ,  $T_{\text{high}} = +125^\circ\text{C}$   
 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  $0.3\text{ V}$ . The upper end of the common mode voltage range is  $V_{CC} - 1.7\text{ V}$ , but either or both inputs can go to  $+32\text{ V}$  without damage, independent of the magnitude of  $V_{CC}$ .
6. Guaranteed by design.

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

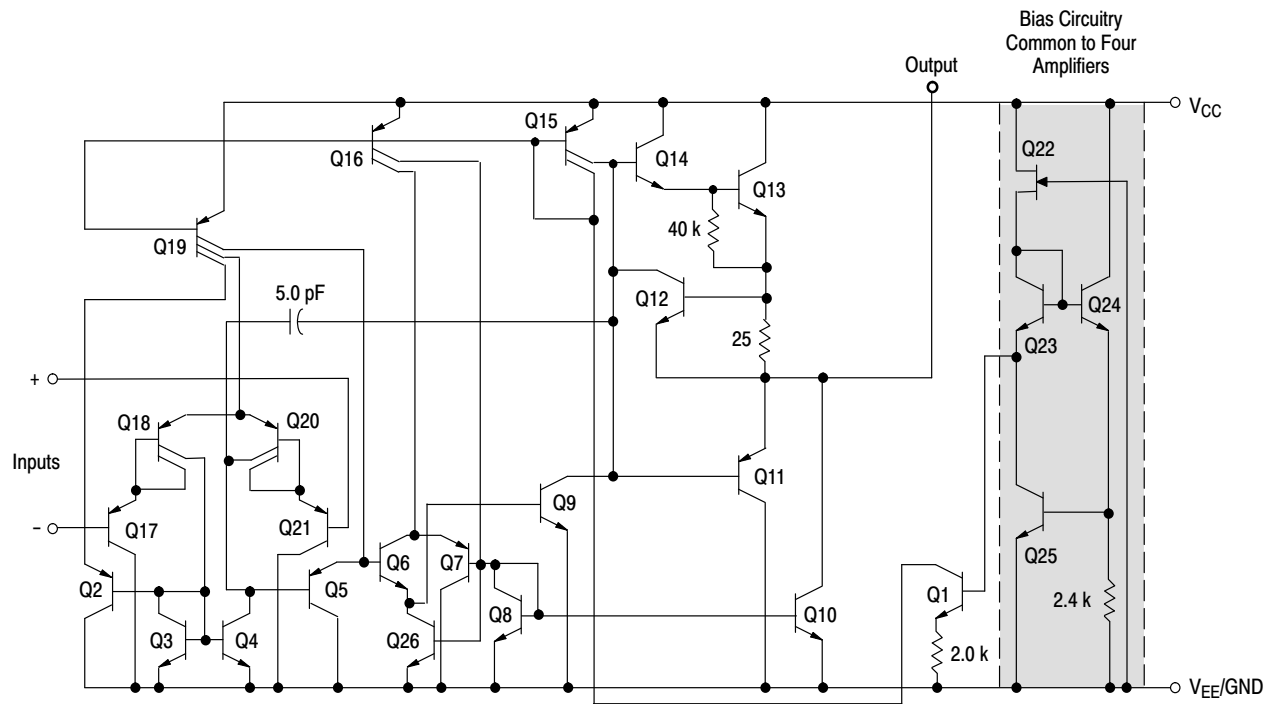
## ELECTRICAL CHARACTERISTICS ( $V_{CC} = 5.0\text{ V}$ , $V_{EE} = \text{GND}$ , $T_A = 25^\circ\text{C}$ , unless otherwise noted.)

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 $V_{CC} = 5.0\text{ V}$ , $R_L = 2.0\text{ k}\Omega$ , $T_A = 25^\circ\text{C}$ $V_{CC} = 30\text{ V}$ $R_L = 2.0\text{ k}\Omega$ ( $T_A = T_{\text{high}}$ to $T_{\text{low}}$ ) (Note 7) $V_{CC} = 30\text{ V}$ $R_L = 10\text{ k}\Omega$ ( $T_A = T_{\text{high}}$ to $T_{\text{low}}$ ) (Note 7)	$V_{OH}$	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, $V_{CC} = 5.0\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 7)	$V_{OL}$	–	5.0	20	–	5.0	20	–	5.0	20	–	5.0	100	–	5.0	100	mV
Output Source Current ( $V_{ID} = +1.0\text{ V}$ , $V_{CC} = 15\text{ V}$ ) $T_A = 25^\circ\text{C}$ $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 7)	$I_{O+}$	20 10	40 20	– –	20 10	40 20	– –	20 10	40 20	– –	20 10	40 20	– –	20 10	40 20	– –	mA
Output Sink Current ( $V_{ID} = -1.0\text{ V}$ , $V_{CC} = 15\text{ V}$ ) $T_A = 25^\circ\text{C}$ $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 7) ( $V_{ID} = -1.0\text{ V}$ , $V_O = 200\text{ mV}$ , $T_A = 25^\circ\text{C}$ )	$I_{O-}$	10 5.0 12	20 8.0 50	– – –	10 5.0 12	20 8.0 50	– – –	10 5.0 12	20 8.0 50	– – –	10 5.0 –	20 8.0 –	– – –	10 5.0 –	20 8.0 –	– – –	mA  $\mu\text{A}$
Output Short Circuit to Ground (Note 8)	$I_{SC}$	–	40	60	–	40	60	–	40	60	–	40	60	–	40	60	mA
Power Supply Current ( $T_A = T_{\text{high}}$ to $T_{\text{low}}$ ) (Note 7) $V_{CC} = 30\text{ V}$ $V_O = 0\text{ V}$ , $R_L = \infty$ $V_{CC} = 5.0\text{ V}$ , $V_O = 0\text{ V}$ , $R_L = \infty$	$I_{CC}$	– –	– –	3.0 1.2	– –	1.4 0.7	3.0 1.2	– –	– –	3.0 1.2	– –	– –	3.0 1.2	– –	– –	3.0 1.2	mA

7. LM224:  $T_{\text{low}} = -25^\circ\text{C}$ ,  $T_{\text{high}} = +85^\circ\text{C}$   
 LM324/LM324A/LM324E:  $T_{\text{low}} = 0^\circ\text{C}$ ,  $T_{\text{high}} = +70^\circ\text{C}$   
 LM2902/LM2902E:  $T_{\text{low}} = -40^\circ\text{C}$ ,  $T_{\text{high}} = +105^\circ\text{C}$   
 LM2902V & NCV2902:  $T_{\text{low}} = -40^\circ\text{C}$ ,  $T_{\text{high}} = +125^\circ\text{C}$   
*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  $V_{CC} - 1.7\text{ V}$ , but either or both inputs can go to +32 V without damage, independent of the magnitude of  $V_{CC}$ .

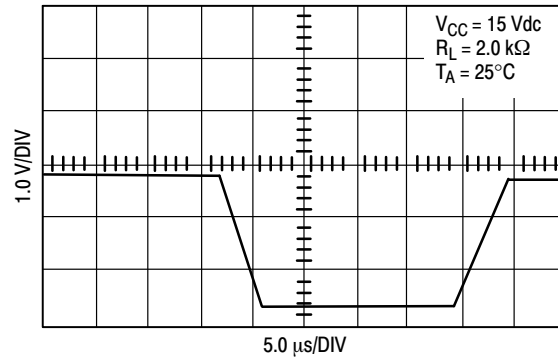
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.



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

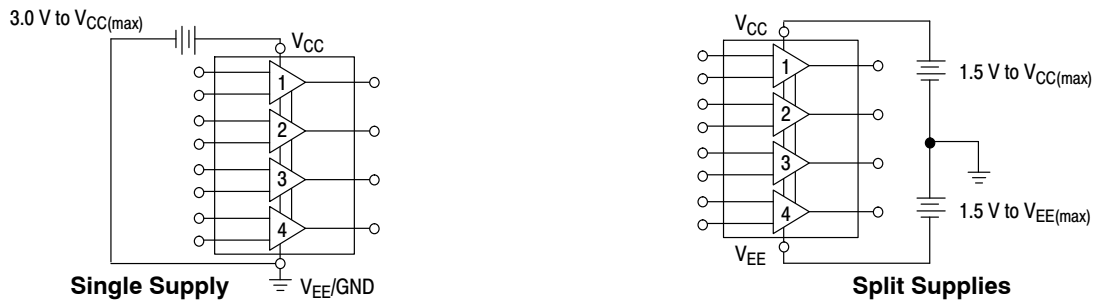
## CIRCUIT DESCRIPTION

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.

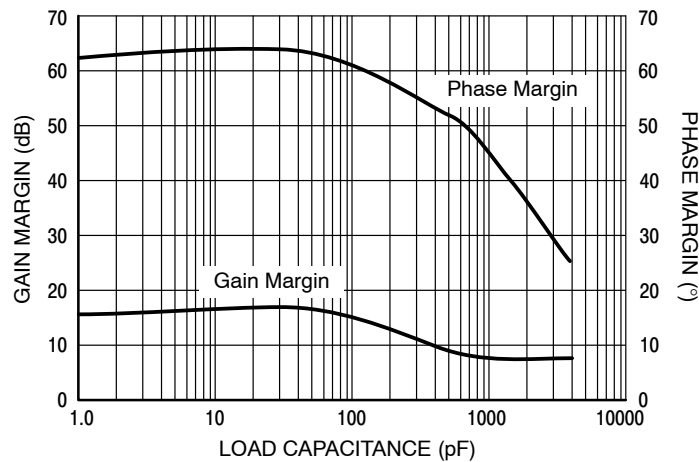


**Figure 2. Large Signal Voltage Follower Response**

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

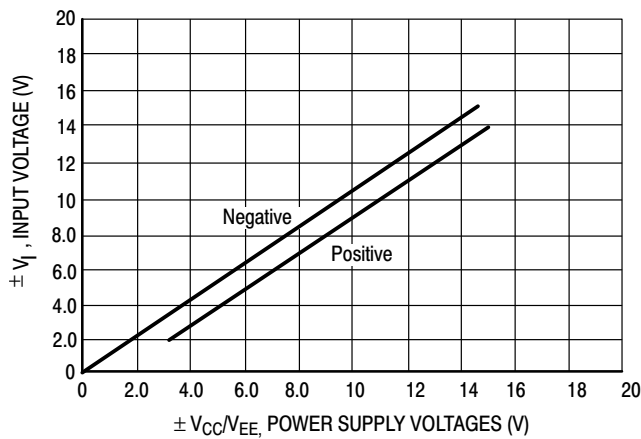


Figure 5. Input Voltage Range

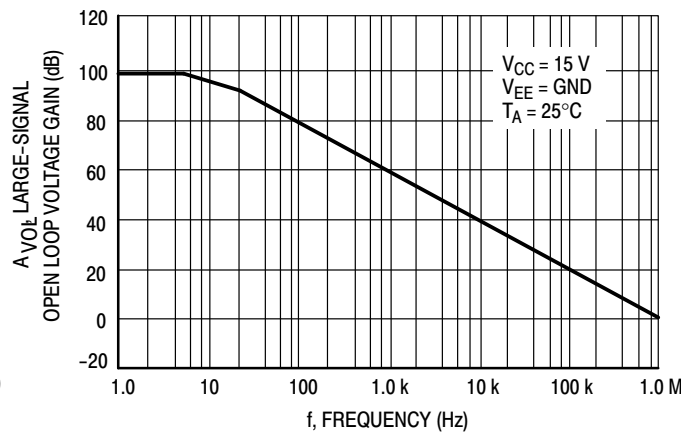


Figure 6. Open Loop Frequency

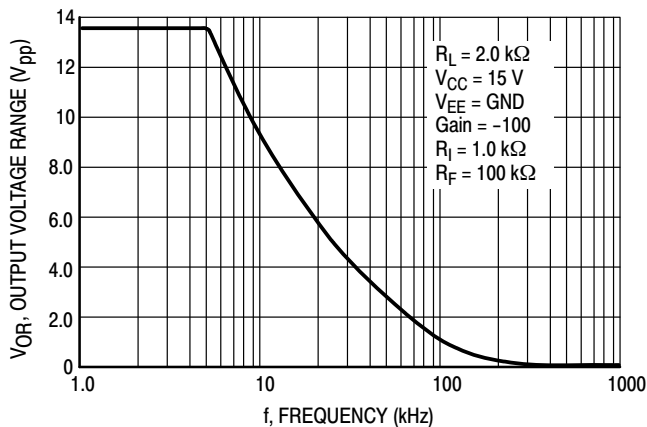


Figure 7. Large-Signal Frequency Response

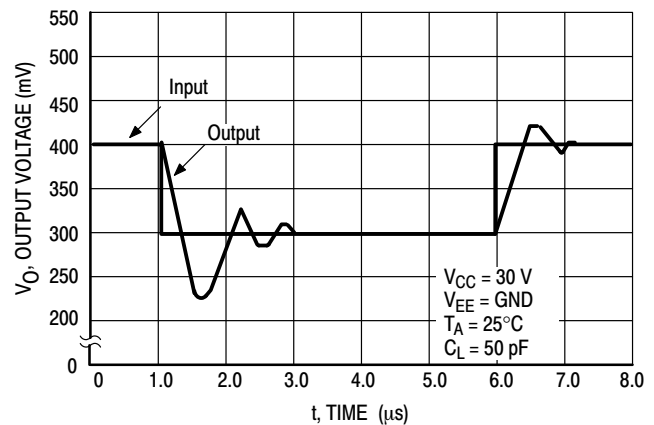


Figure 8. Small-Signal Voltage Follower Pulse Response (Noninverting)

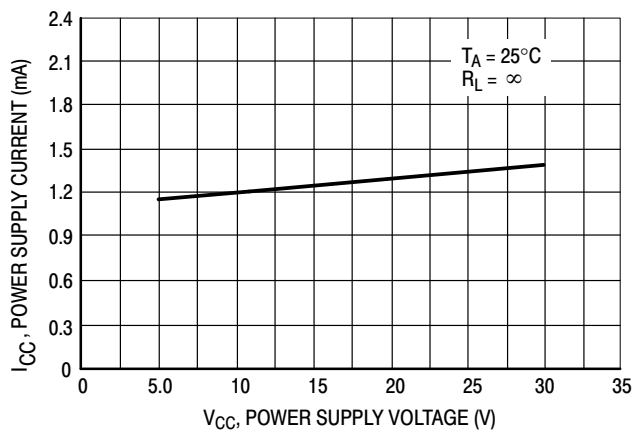


Figure 9. Power Supply Current versus Power Supply Voltage

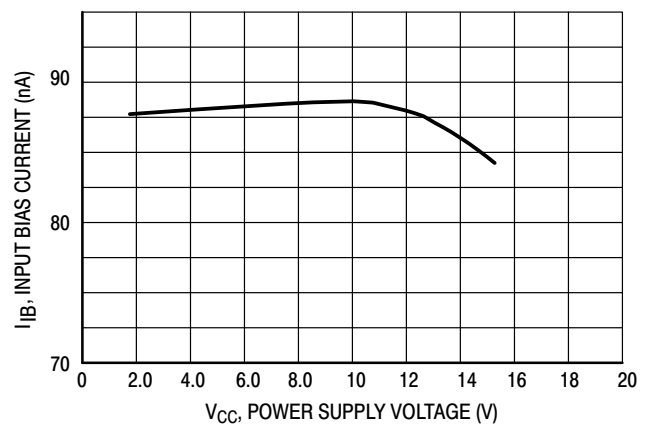


Figure 10. Input Bias Current versus Power Supply Voltage

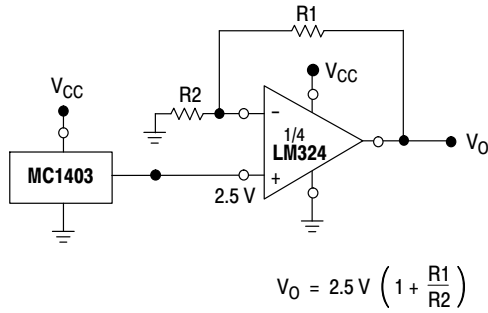


Figure 11. Voltage Reference

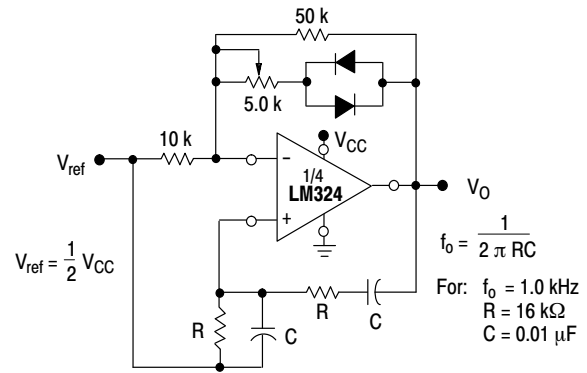


Figure 12. Wien Bridge Oscillator

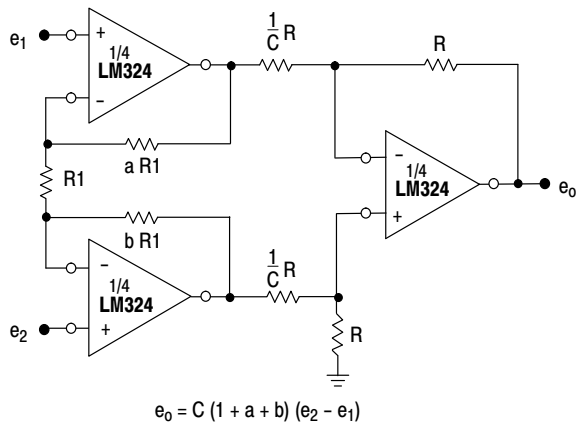


Figure 13. High Impedance Differential Amplifier

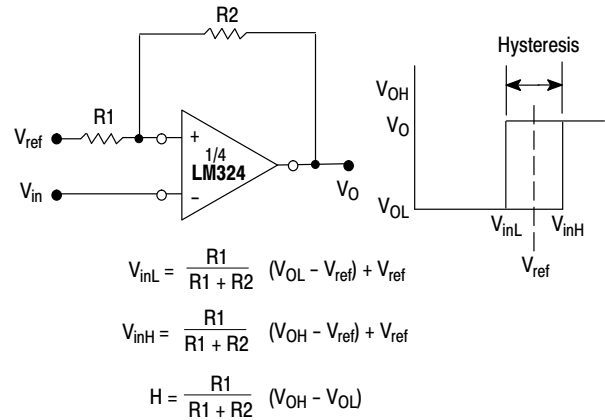


Figure 14. Comparator with Hysteresis

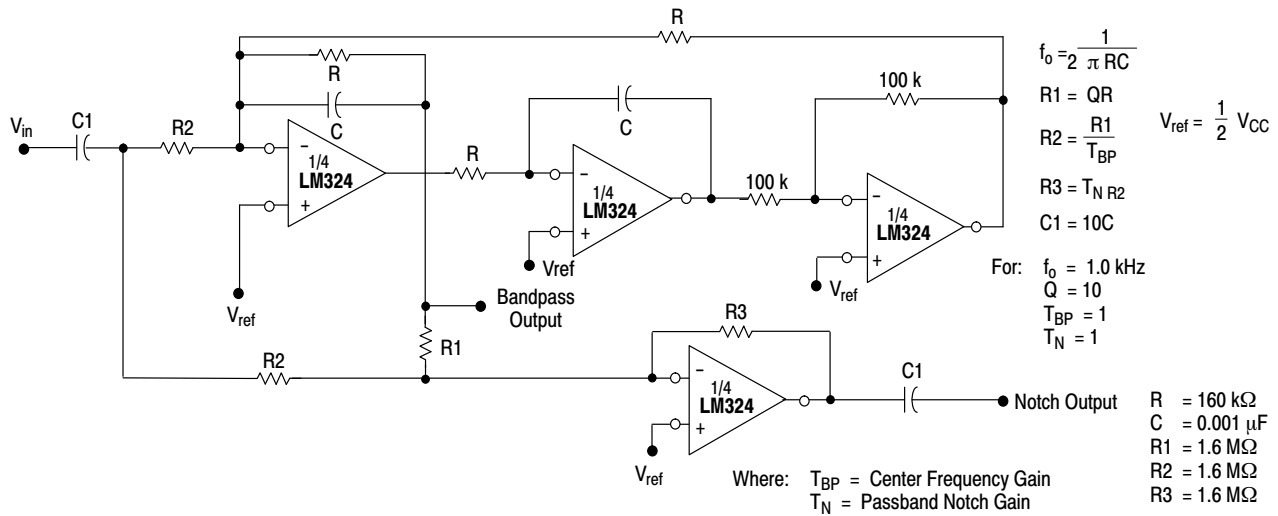


Figure 15. Bi-Quad Filter



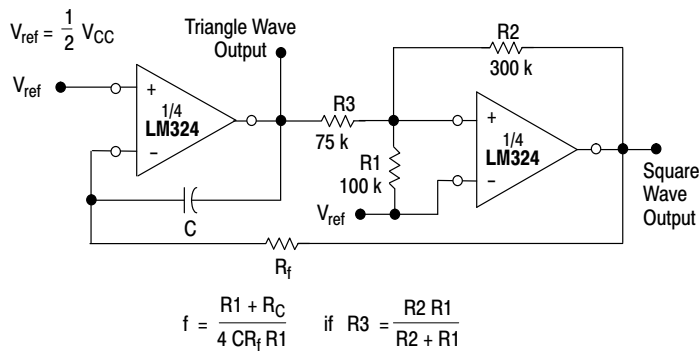


Figure 16. Function Generator

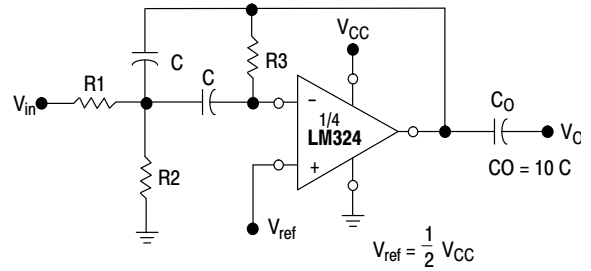


Figure 17. Multiple Feedback Bandpass Filter

Given:  $f_0$  = center frequency

$A(f_0)$  = gain at center frequency

Choose value  $f_0$ ,  $C$

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

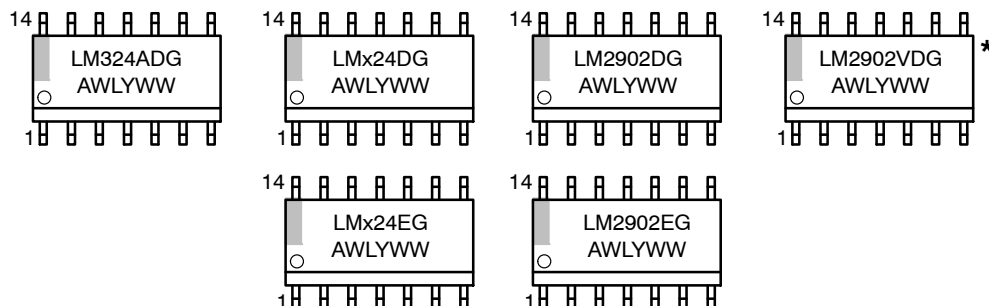
Device	Operating Temperature Range	Package	Shipping <sup>†</sup>
LM224DR2G	-25°C to +85°C	SOIC-14 (Pb-Free)	2500/Tape & Reel
LM224DTBR2G		TSSOP-14 (Pb-Free)	2500/Tape & Reel
LM324DR2G	0°C to +70°C	SOIC-14 (Pb-Free)	2500/Tape & Reel
LM324EDR2G		SOIC-14 (Pb-Free)	2500/Tape & Reel
LM324DTBR2G		TSSOP-14 (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.

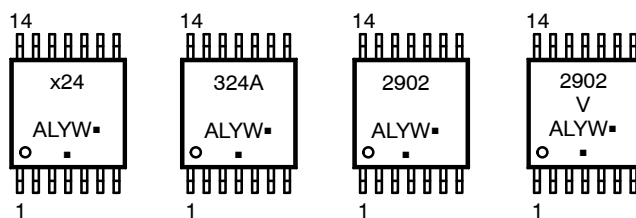
\*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable.

# MARKING DIAGRAMS

## SOIC-14 D SUFFIX CASE 751A



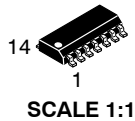
## TSSOP-14 DTB SUFFIX CASE 948G



x = 2 or 3  
A = Assembly Location  
WL, L = Wafer Lot  
YY, Y = Year  
WW, W = Work Week  
G or ■ = Pb-Free Package

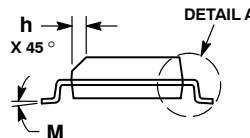
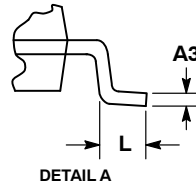
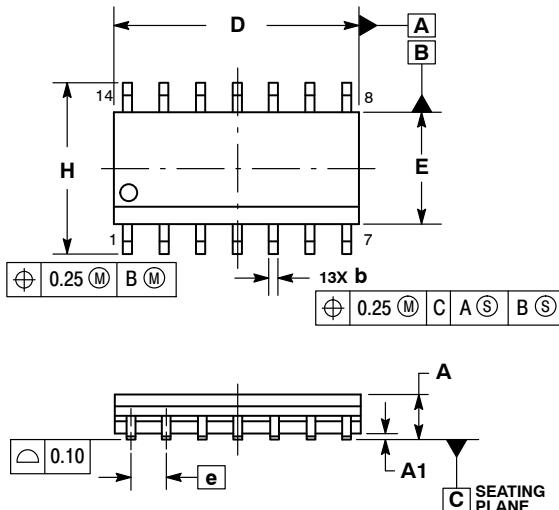
(Note: Microdot may be in either location)

\*This marking diagram also applies to NCV2902.



SOIC-14 NB  
CASE 751A-03  
ISSUE L

DATE 03 FEB 2016

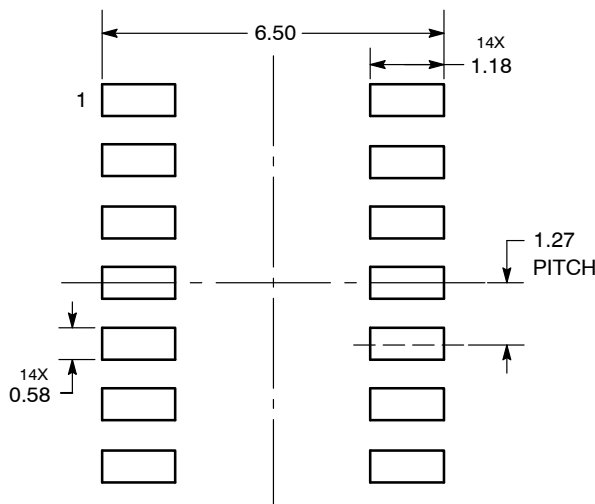


NOTES:

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°

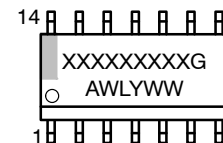
SOLDERING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

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

GENERIC  
MARKING DIAGRAM\*



XXXXXX = Specific Device Code  
A = Assembly Location  
WL = Wafer Lot  
Y = 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. Some products may not follow the Generic Marking.

STYLES ON PAGE 2

DOCUMENT NUMBER:	98ASB42565B	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.
DESCRIPTION:	SOIC-14 NB	PAGE 1 OF 2

onsemi and onsemi are trademarks of Semiconductor Components Industries, LLC dba onsemi or its subsidiaries in the United States and/or other countries. onsemi reserves the right to make changes without further notice to any products herein. onsemi makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does onsemi assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. onsemi does not convey any license under its patent rights nor the rights of others.

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

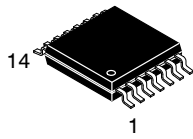
STYLE 6:  
PIN 1. CATHODE  
2. CATHODE  
3. CATHODE  
4. CATHODE  
5. CATHODE  
6. CATHODE  
7. CATHODE  
8. ANODE  
9. ANODE  
10. ANODE  
11. ANODE  
12. ANODE  
13. ANODE  
14. ANODE

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

DOCUMENT NUMBER:	98ASB42565B	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.
DESCRIPTION:	SOIC-14 NB	PAGE 2 OF 2

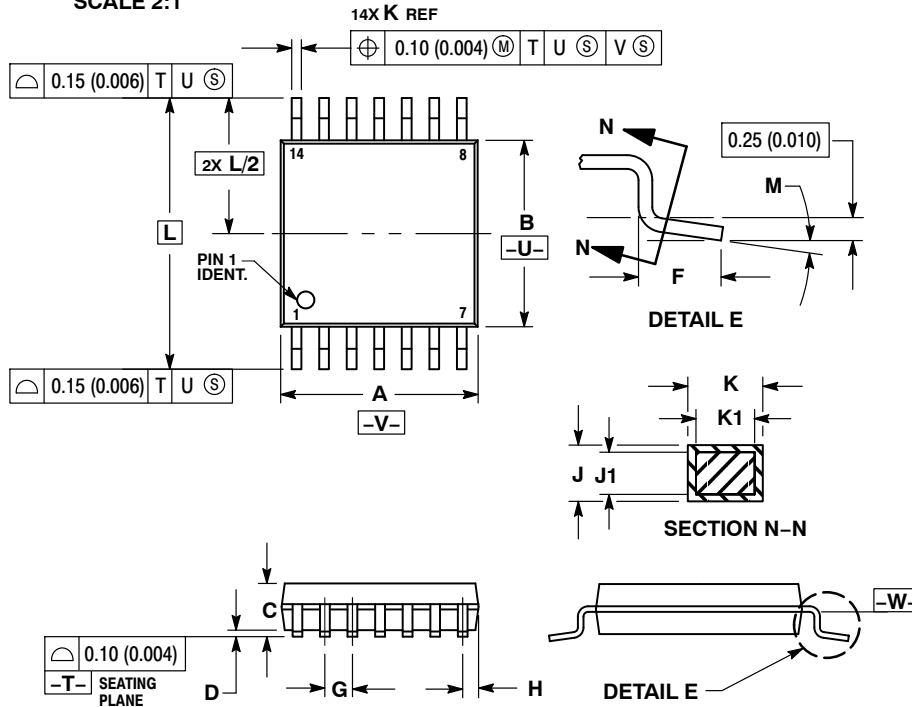
**onsemi** and **onsemi** are trademarks of Semiconductor Components Industries, LLC dba **onsemi** or its subsidiaries in the United States and/or other countries. **onsemi** reserves the right to make changes without further notice to any products herein. **onsemi** makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. **onsemi** does not convey any license under its patent rights nor the rights of others.



TSSOP-14 WB  
CASE 948G  
ISSUE C

DATE 17 FEB 2016

SCALE 2:1

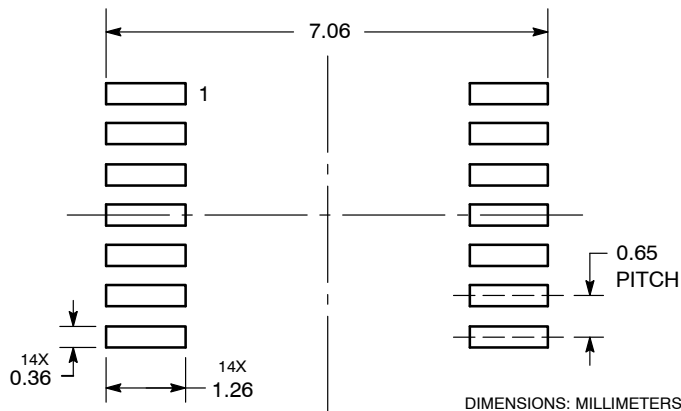


NOTES:

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-.

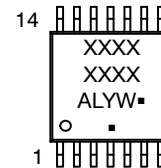
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.90	5.10	0.193	0.200
B	4.30	4.50	0.169	0.177
C	---	1.20	---	0.047
D	0.05	0.15	0.002	0.006
F	0.50	0.75	0.020	0.030
G	0.65 BSC		0.026 BSC	
H	0.50	0.60	0.020	0.024
J	0.09	0.20	0.004	0.008
J1	0.09	0.16	0.004	0.006
K	0.19	0.30	0.007	0.012
K1	0.19	0.25	0.007	0.010
L	6.40 BSC		0.252 BSC	
M	0°	8°	0°	8°

RECOMMENDED  
SOLDERING FOOTPRINT\*



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

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. Some products may not follow the Generic Marking.

DOCUMENT NUMBER:	98ASH70246A	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.
DESCRIPTION:	TSSOP-14 WB	PAGE 1 OF 1

onsemi and onsemi are trademarks of Semiconductor Components Industries, LLC dba onsemi or its subsidiaries in the United States and/or other countries. onsemi reserves the right to make changes without further notice to any products herein. onsemi makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does onsemi assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. onsemi does not convey any license under its patent rights nor the rights of others.

**onsemi**, **Onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## ADDITIONAL INFORMATION

### TECHNICAL PUBLICATIONS:

Technical Library: [www.onsemi.com/design/resources/technical-documentation](http://www.onsemi.com/design/resources/technical-documentation)  
onsemi Website: [www.onsemi.com](http://www.onsemi.com)

### ONLINE SUPPORT: [www.onsemi.com/support](http://www.onsemi.com/support)

For additional information, please contact your local Sales Representative at  
[www.onsemi.com/support/sales](http://www.onsemi.com/support/sales)