

# NLSV4T244

## Non-Inverting Level Translator, Dual-Supply, 4-Bit

The NLSV4T244 is a 4-bit configurable dual-supply voltage level translator. The input  $A_n$  and output  $B_n$  ports are designed to track two different power supply rails,  $V_{CCA}$  and  $V_{CCB}$  respectively. Both supply rails are configurable from 0.9 V to 4.5 V allowing universal low-voltage translation from the input  $A_n$  to the output  $B_n$  port.

### Features

- Wide  $V_{CCA}$  and  $V_{CCB}$  Operating Range: 0.9 V to 4.5 V
- High-Speed w/ Balanced Propagation Delay
- Inputs and Outputs have OVT Protection to 4.5 V
- Non-preferential  $V_{CCA}$  and  $V_{CCB}$  Sequencing
- Outputs at 3-State until Active  $V_{CC}$  is Reached
- Power-Off Protection
- Outputs Switch to 3-State with  $V_{CCB}$  at GND
- Ultra-Small Packaging: 1.7 mm x 2.0 mm UQFN12
- NLVSV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These are Pb-Free Devices

### Typical Applications

- Mobile Phones, PDAs, Other Portable Devices

### Important Information

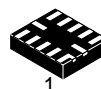
- ESD Protection for All Pins:  
HBM (Human Body Model) > 1500 V



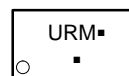
ON Semiconductor®

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

### MARKING DIAGRAMS

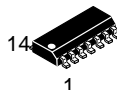


UQFN12  
MU SUFFIX  
CASE 523AE

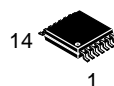
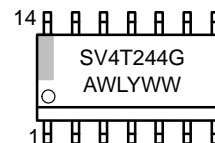


UR = Specific Device Code  
M = Date Code  
▪ = Pb-Free Package

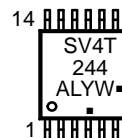
(Note: Microdot may be in either location)



SOIC-14  
D SUFFIX  
CASE 751A



TSSOP-14  
DT SUFFIX  
CASE 948G



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

(Note: Microdot may be in either location)

### ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

NLSV4T244

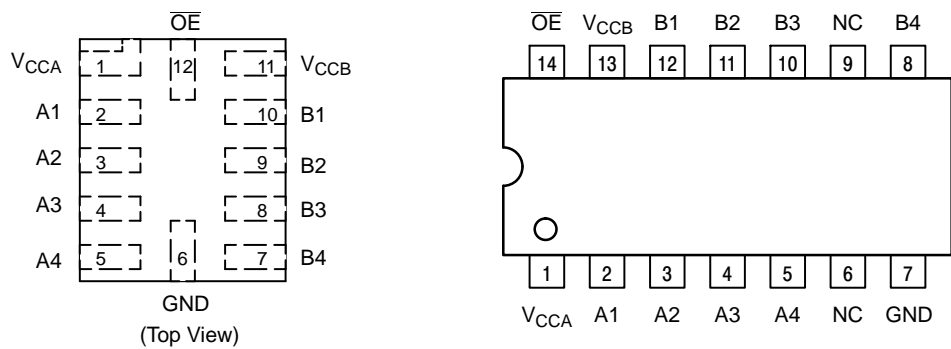


Figure 1. Pin Assignments

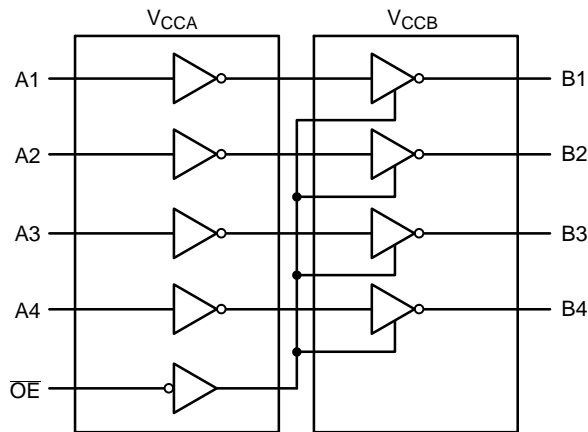


Figure 2. Logic Diagram

PIN ASSIGNMENT

PIN	FUNCTION
VCCA	Input Port DC Power Supply
VCCB	Output Port DC Power Supply
GND	Ground
A <sub>n</sub>	Input Port
B <sub>n</sub>	Output Port
OE	Output Enable

TRUTH TABLE

Inputs		Outputs
OE	A <sub>n</sub>	B <sub>n</sub>
L	L	L
L	H	H
H	X	3-State

ORDERING INFORMATION

Device	Package	Shipping †
NLSV4T244MUTAG	UQFN12 (Pb-Free)	3000 / Tape and Reel
NLVS4T244MUTAG*		
NLSV4T244DR2G	SOIC-14 (Pb-Free)	2500 / Tape and Reel
NLSV4T244DTR2G	TSSOP-14 (Pb-Free)	2500 / Tape and Reel

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

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

# NLSV4T244

## MAXIMUM RATINGS

Symbol	Rating	Value	Condition	Unit
$V_{CCA}, V_{CCB}$	DC Supply Voltage	-0.5 to +5.5		V
$V_I$	DC Input Voltage $A_n$	-0.5 to +5.5		V
$V_C$	Control Input $\overline{OE}$	-0.5 to +5.5		V
$V_O$	DC Output Voltage (Power Down) $B_n$	-0.5 to +5.5	$V_{CCA} = V_{CCB} = 0$	V
	(Active Mode) $B_n$	-0.5 to +5.5		V
	(Tri-State Mode) $B_n$	-0.5 to +5.5		V
$I_{IK}$	DC Input Diode Current	-20	$V_I < \text{GND}$	mA
$I_{OK}$	DC Output Diode Current	-50	$V_O < \text{GND}$	mA
$I_O$	DC Output Source/Sink Current	$\pm 50$		mA
$I_{CCA}, I_{CCB}$	DC Supply Current Per Supply Pin	$\pm 100$		mA
$I_{GND}$	DC Ground Current per Ground Pin	$\pm 100$		mA
$T_{STG}$	Storage Temperature	-65 to +150		°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.

## RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min	Max	Unit
$V_{CCA}, V_{CCB}$	Positive DC Supply Voltage	0.9	4.5	V
$V_I$	Bus Input Voltage	GND	4.5	V
$V_C$	Control Input $\overline{OE}$	GND	4.5	V
$V_{IO}$	Bus Output Voltage (Power Down Mode) $B_n$	GND	4.5	V
	(Active Mode) $B_n$	GND	$V_{CCB}$	V
	(Tri-State Mode) $B_n$	GND	4.5	V
$T_A$	Operating Temperature Range	-40	+105	°C
$\Delta t / \Delta V$	Input Transition Rise or Rate $V_I$ , from 30% to 70% of $V_{CC}$ ; $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$	0	10	nS

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

# NLSV4T244

## DC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Test Conditions	V <sub>CCA</sub> (V)	V <sub>CCB</sub> (V)	-40°C to +85°C		Unit
					Min	Max	
V <sub>IH</sub>	Input HIGH Voltage (An, OE)		3.6 – 4.5	0.9 – 4.5	2.2	–	V
			2.7 – 3.6		2.0	–	
			2.3 – 2.7		1.6	–	
			1.4 – 2.3		0.65 * V <sub>CCA</sub>	–	
			0.9 – 1.4		0.9 * V <sub>CCA</sub>	–	
V <sub>IL</sub>	Input LOW Voltage (An, OE)		3.6 – 4.5	0.9 – 4.5	–	0.8	V
			2.7 – 3.6		–	0.8	
			2.3 – 2.7		–	0.7	
			1.4 – 2.3		–	0.35 * V <sub>CCA</sub>	
			0.9 – 1.4		–	0.1 * V <sub>CCA</sub>	
V <sub>OH</sub>	Output HIGH Voltage	I <sub>OH</sub> = –100 µA; V <sub>I</sub> = V <sub>IH</sub>	0.9 – 4.5	0.9 – 4.5	V <sub>CCB</sub> – 0.2	–	V
		I <sub>OH</sub> = –0.5 mA; V <sub>I</sub> = V <sub>IH</sub>	0.9	0.9	0.75 * V <sub>CCB</sub>	–	
		I <sub>OH</sub> = –2 mA; V <sub>I</sub> = V <sub>IH</sub>	1.4	1.4	1.05	–	
		I <sub>OH</sub> = –6 mA; V <sub>I</sub> = V <sub>IH</sub>	1.65	1.65	1.25	–	
		I <sub>OH</sub> = –12 mA; V <sub>I</sub> = V <sub>IH</sub>	2.3	2.3	2.0	–	
			2.7	2.7	2.2	–	
		I <sub>OH</sub> = –18 mA; V <sub>I</sub> = V <sub>IH</sub>	2.3	2.3	1.7	–	
			3.0	3.0	2.4	–	
V <sub>OL</sub>	Output LOW Voltage	I <sub>OL</sub> = –24 mA; V <sub>I</sub> = V <sub>IH</sub>	3.0	3.0	2.2	–	V
		I <sub>OL</sub> = 100 µA; V <sub>I</sub> = V <sub>IL</sub>	0.9 – 4.5	0.9 – 4.5	–	0.2	
		I <sub>OL</sub> = 0.5 mA; V <sub>I</sub> = V <sub>IL</sub>	1.1	1.1	–	0.3	
		I <sub>OL</sub> = 2 mA; V <sub>I</sub> = V <sub>IL</sub>	1.4	1.4	–	0.35	
		I <sub>OL</sub> = 6 mA; V <sub>I</sub> = V <sub>IL</sub>	1.65	1.65	–	0.3	
		I <sub>OL</sub> = 12 mA; V <sub>I</sub> = V <sub>IL</sub>	2.3	2.3	–	0.4	
			2.7	2.7	–	0.4	
		I <sub>OL</sub> = 18 mA; V <sub>I</sub> = V <sub>IL</sub>	2.3	2.3	–	0.6	
			3.0	3.0	–	0.45	
I <sub>OFF</sub>	Power-Off Leakage Current	OE = 0 V	0	0.9 – 4.5	–1.0	1.0	µA
			0.9 – 4.5	0	–1.0	1.0	
I <sub>CCA</sub>	Quiescent Supply Current	V <sub>I</sub> = V <sub>CCA</sub> or GND; I <sub>O</sub> = 0, V <sub>CCA</sub> = V <sub>CCB</sub>	0.9 – 4.5	0.9 – 4.5	–	2.0	µA
I <sub>CCB</sub>	Quiescent Supply Current	V <sub>I</sub> = V <sub>CCA</sub> or GND; I <sub>O</sub> = 0, V <sub>CCA</sub> = V <sub>CCB</sub>	0.9 – 4.5	0.9 – 4.5	–	2.0	µA
I <sub>CCA</sub> + I <sub>CCB</sub>	Quiescent Supply Current	V <sub>I</sub> = V <sub>CCA</sub> or GND; I <sub>O</sub> = 0, V <sub>CCA</sub> = V <sub>CCB</sub>	0.9 – 4.5	0.9 – 4.5	–	4.0	µA
ΔI <sub>CCA</sub>	Increase in I <sub>CC</sub> per Input Voltage, Other Inputs at V <sub>CCA</sub> or GND	V <sub>I</sub> = V <sub>CCA</sub> – 0.6 V; V <sub>I</sub> = V <sub>CCA</sub> or GND	4.5 3.6	4.5 3.6	–	10 5.0	µA
ΔI <sub>CCB</sub>	Increase in I <sub>CC</sub> per Input Voltage, Other Inputs at V <sub>CCA</sub> or GND	V <sub>I</sub> = V <sub>CCA</sub> – 0.6 V; V <sub>I</sub> = V <sub>CCA</sub> or GND	4.5 3.6	4.5 3.6	–	10 5.0	µA
I <sub>OZ</sub>	I/O Tri-State Output Leakage Current	T <sub>A</sub> = 25°C, OE = V <sub>CCA</sub>	0.9 – 4.5	0.9 – 4.5	–1.0	1.0	µA

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.

# NLSV4T244

## TOTAL STATIC POWER CONSUMPTION ( $I_{CCA} + I_{CCB}$ )

V <sub>CCA</sub> (V)	-40°C to +85°C										Unit
	V <sub>CCB</sub> (V)										
	4.5		3.3		2.8		1.8		0.9		
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
4.5		2		2		2		2		< 1.5	μA
3.3		2		2		2		2		< 1.5	μA
2.8		< 2		< 1		< 1		< 0.5		< 0.5	μA
1.8		< 1		< 1		< 0.5		< 0.5		< 0.5	μA
0.9		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	μA

NOTE: Connect ground before applying supply voltage  $V_{CCA}$  or  $V_{CCB}$ . This device is designed with the feature that the power-up sequence of  $V_{CCA}$  and  $V_{CCB}$  will not damage the IC.

## AC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	V <sub>CCA</sub> (V)	-40°C to +85°C										Unit
			V <sub>CCB</sub> (V)										
			4.5		3.3		2.8		1.8		1.2		
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
t <sub>PLH</sub> , t <sub>PHL</sub> (Note 1)	Propagation Delay, A <sub>n</sub> to B <sub>n</sub>	4.5		1.6		1.8		2.0		2.1		2.3	nS
		3.3		1.7		1.9		2.1		2.3		2.6	
		2.8		1.9		2.1		2.3		2.5		2.8	
		1.8		2.1		2.4		2.5		2.7		3.0	
		1.2		2.4		2.7		2.8		3.0		3.3	
t <sub>PZH</sub> , t <sub>PZL</sub> (Note 1)	Output Enable, OE to B <sub>n</sub>	4.5		2.6		3.8		4.0		4.1		4.3	nS
		3.3		3.7		3.9		4.1		4.3		4.6	
		2.5		3.9		4.1		4.3		4.5		4.8	
		1.8		4.1		4.4		4.5		4.7		5.0	
		1.2		4.4		4.7		4.8		5.0		5.3	
t <sub>PHZ</sub> , t <sub>PLZ</sub> (Note 1)	Output Disable, OE to B <sub>n</sub>	4.5		2.6		3.8		4.0		4.1		4.3	nS
		3.3		3.7		3.9		4.1		4.3		4.6	
		2.5		3.9		4.1		4.3		4.5		4.8	
		1.8		4.1		4.4		4.5		4.7		5.0	
		1.2		4.4		4.7		4.8		5.0		5.3	
t <sub>OSHL</sub> , t <sub>OSLH</sub> (Note 1)	Output to Output Skew, Time	4.5		0.15		0.15		0.15		0.15		0.15	nS
		3.3		0.15		0.15		0.15		0.15		0.15	
		2.5		0.15		0.15		0.15		0.15		0.15	
		1.8		0.15		0.15		0.15		0.15		0.15	
		1.2		0.15		0.15		0.15		0.15		0.15	

1. Propagation delays defined per Figure 3.

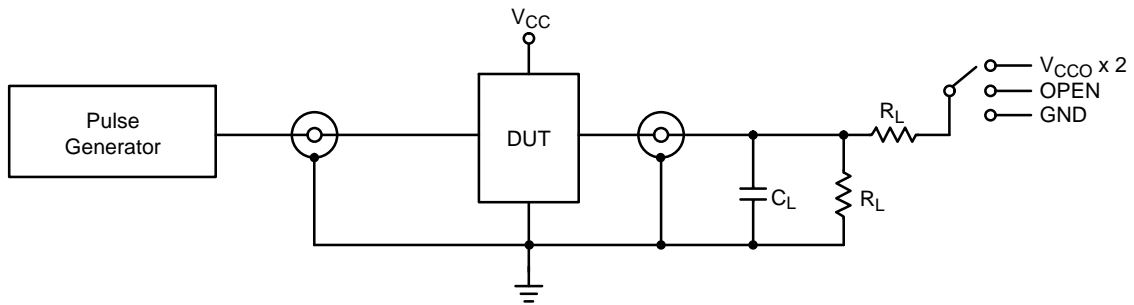
## CAPACITANCE

Symbol	Parameter	Test Conditions	Typ (Note 2)	Unit
$C_{IN}$	Control Pin Input Capacitance	$V_{CCA} = V_{CCB} = 3.3$ V, $V_I = 0$ V or $V_{CCA/B}$	3.5	pF
$C_{I/O}$	I/O Pin Input Capacitance	$V_{CCA} = V_{CCB} = 3.3$ V, $V_I = 0$ V or $V_{CCA/B}$	5.0	pF
$C_{PD}$	Power Dissipation Capacitance	$V_{CCA} = V_{CCB} = 3.3$ V, $V_I = 0$ V or $V_{CCA}$ , $f = 10$ MHz	20	pF

2. Typical values are at  $T_A = +25^\circ\text{C}$ .

3.  $C_{PD}$  is defined as the value of the IC's equivalent capacitance from which the operating current can be calculated from:  
 $I_{CC(\text{operating})} \cong C_{PD} \times V_{CC} \times f_{IN} \times N_{SW}$  where  $I_{CC} = I_{CCA} + I_{CCB}$  and  $N_{SW}$  = total number of outputs switching.

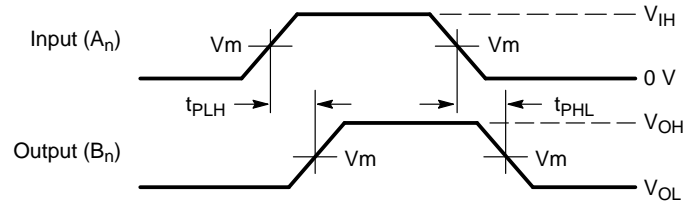
# NLSV4T244



**Figure 3. AC (Propagation Delay) Test Circuit**

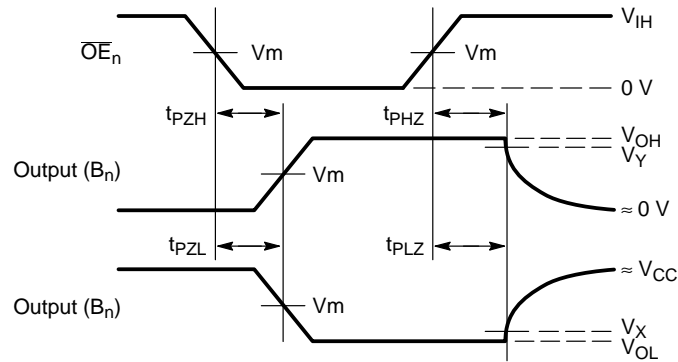
Test	Switch
$t_{PLH}$ , $t_{PHL}$	OPEN
$t_{PLZ}$ , $t_{PZL}$	$V_{CCO} \times 2$
$t_{PHZ}$ , $t_{PZH}$	GND

$C_L = 15 \text{ pF}$  or equivalent (includes probe and jig capacitance)  
 $R_L = 2 \text{ k}\Omega$  or equivalent  
 $Z_{OUT}$  of pulse generator =  $50 \Omega$



**Waveform 1 – Propagation Delays**

$t_R = t_F = 2.0 \text{ ns}$ , 10% to 90%;  $f = 1 \text{ MHz}$ ;  $t_W = 500 \text{ ns}$



**Waveform 2 – Output Enable and Disable Times**

$t_R = t_F = 2.0 \text{ ns}$ , 10% to 90%;  $f = 1 \text{ MHz}$ ;  $t_W = 500 \text{ ns}$

**Figure 4. AC (Propagation Delay) Test Circuit Waveforms**

Symbol	$V_{CC}$				
	3.0 V – 4.5 V	2.3 V – 2.7 V	1.65 V – 1.95 V	1.4 V – 1.6 V	0.9 V – 1.3 V
$V_{mA}$	$V_{CCA}/2$	$V_{CCA}/2$	$V_{CCA}/2$	$V_{CCA}/2$	$V_{CCA}/2$
$V_{mB}$	$V_{CCB}/2$	$V_{CCB}/2$	$V_{CCB}/2$	$V_{CCB}/2$	$V_{CCB}/2$
$V_X$	$V_{OL} + 10\% V_{OH}$	$V_{OL} + 10\% V_{OH}$	$V_{OL} + 10\% V_{OH}$	$V_{OL} + 10\% V_{OH}$	$V_{OL} + 10\% V_{OH}$
$V_Y$	$V_{OH} \times 0.9$	$V_{OH} \times 0.9$	$V_{OH} \times 0.9$	$V_{OH} \times 0.9$	$V_{OH} \times 0.9$

# MECHANICAL CASE OUTLINE

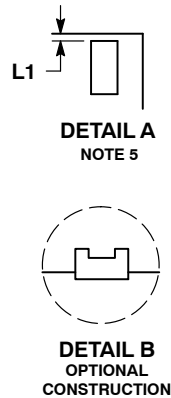
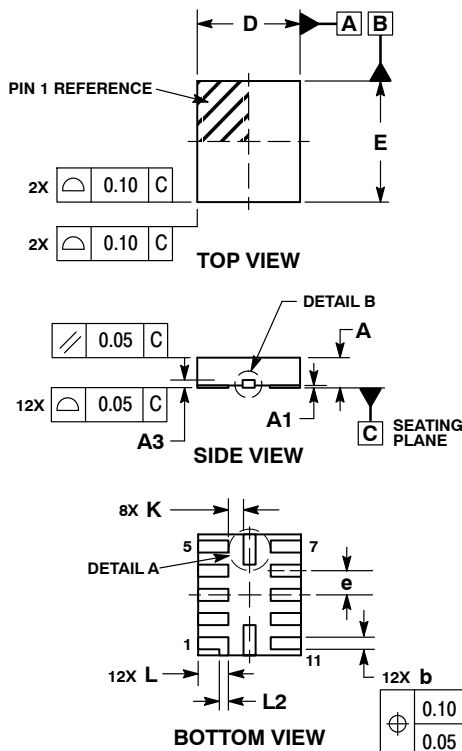
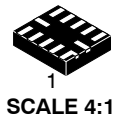
## PACKAGE DIMENSIONS

ON Semiconductor®

ON

UQFN12 1.7x2.0, 0.4P  
CASE 523AE-01  
ISSUE A

DATE 11 JUN 2007

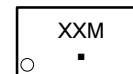


### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 MM FROM TERMINAL TIP.
4. MOLD FLASH ALLOWED ON TERMINALS ALONG EDGE OF PACKAGE. FLASH 0.03 MAX ON BOTTOM SURFACE OF TERMINALS.
5. DETAIL A SHOWS OPTIONAL CONSTRUCTION FOR TERMINALS.

DIM	MILLIMETERS	
	MIN	MAX
A	0.45	0.55
A1	0.00	0.05
A3	0.127 REF	
b	0.15	0.25
D	1.70 BSC	
E	2.00 BSC	
e	0.40 BSC	
K	0.20	----
L	0.45	0.55
L1	0.00	0.03
L2	0.15 REF	

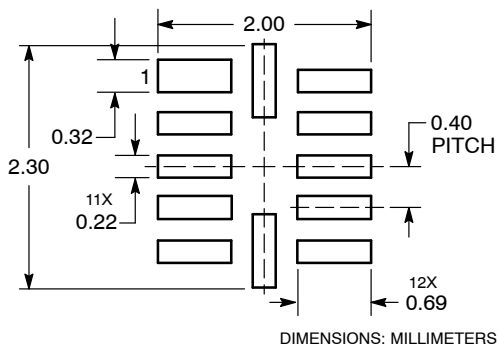
### GENERIC MARKING DIAGRAM\*



XX = Specific Device Code  
M = Date Code  
▪ = 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.

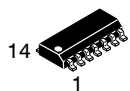
### MOUNTING FOOTPRINT SOLDERMASK DEFINED



DOCUMENT NUMBER:	98AON23418D	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.
DESCRIPTION:	UQFN12 1.7 X 2.0, 0.4P	PAGE 1 OF 1

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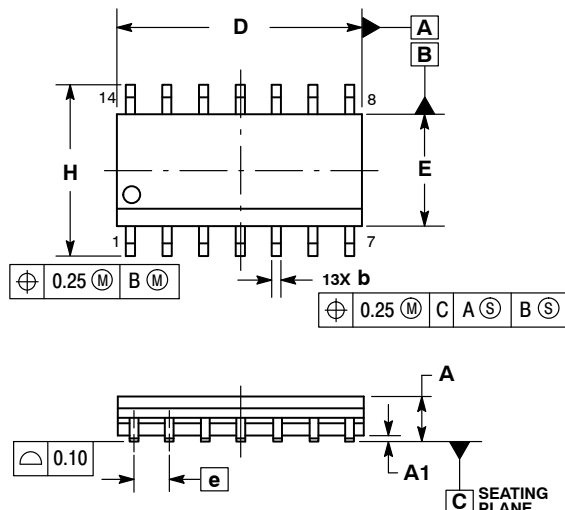
# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



SCALE 1:1

SOIC-14 NB  
CASE 751A-03  
ISSUE L

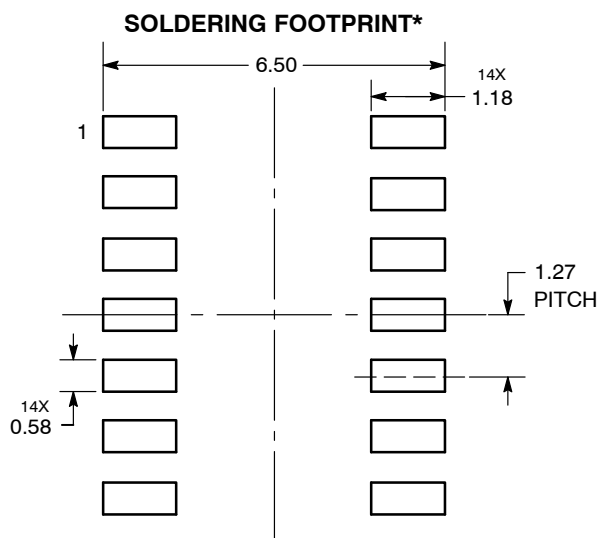
DATE 03 FEB 2016



## 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.

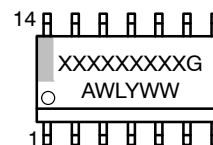
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.054	0.068
A1	0.10	0.25	0.004	0.010
A3	0.19	0.25	0.008	0.010
b	0.35	0.49	0.014	0.019
D	8.55	8.75	0.337	0.344
E	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
h	0.25	0.50	0.010	0.019
L	0.40	1.25	0.016	0.049
M	0°	7°	0°	7°



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\*



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

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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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