

# 4-Bit 24 Mb/s Dual-Supply Level Translator

## NLSX4378A

The NLSX4378A is a 4-bit configurable dual-supply bidirectional auto sensing translator that does not require a directional control pin. The  $V_{CC}$  I/O and  $V_L$  I/O ports are designed to track two different power supply rails,  $V_{CC}$  and  $V_L$  respectively. The  $V_{CC}$  and  $V_L$  supply rails are configurable from 1.65 V to 5.5 V. This allows voltage logic signals on the  $V_L$  side to be translated into lower, higher or equal value voltage logic signals on the  $V_{CC}$  side, and vice-versa.

The NLSX4378A translator has open-drain outputs with integrated 10 k $\Omega$  pullup resistors on the I/O lines. The integrated pullup resistors are used to pullup the I/O lines to either  $V_L$  or  $V_{CC}$ . The NLSX4378A is an excellent match for open-drain applications such as the I<sup>2</sup>C communication bus.

### Features

- $V_L$  can be Less than, Greater than or Equal to  $V_{CC}$
- Wide  $V_{CC}$  Operating Range: 1.65 V to 5.5 V  
Wide  $V_L$  Operating Range: 1.65 V to 5.5 V
- High-Speed with 24 Mb/s Guaranteed Data Rate
- Low Bit-to-Bit Skew
- Enable Input is Overvoltage Tolerant (OVT) to 5.5 V
- Nonpreferential Powerup Sequencing
- Integrated 10 k $\Omega$  Pullup Resistors
- ESD Protection: >7 kV HBM for all pins
- Small Space Saving Package – 2.02 x 1.54 mm  $\mu$ Bump12
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

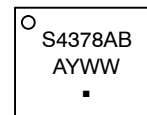
### Typical Applications

- I<sup>2</sup>C, SMBus, PMBus
- Low Voltage ASIC Level Translation
- Mobile Phones, PDAs, Cameras



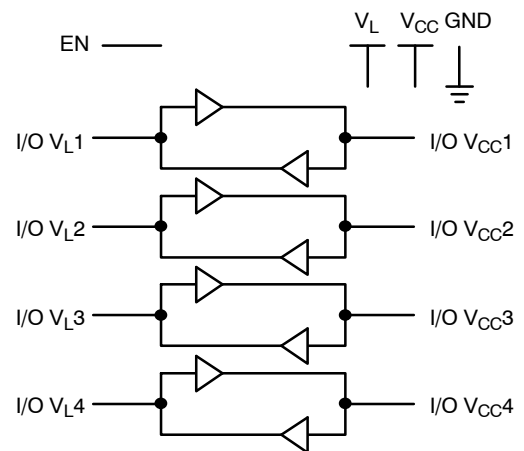
$\mu$ Bump12  
FC SUFFIX  
CASE 499AU

### MARKING DIAGRAM



- A = Assembly Location
- Y = Year
- WW = Work Week
- = Pb-Free Package

### LOGIC DIAGRAM



### ORDERING INFORMATION

See detailed ordering and shipping information on page 8 of this data sheet.

# NLSX4378A

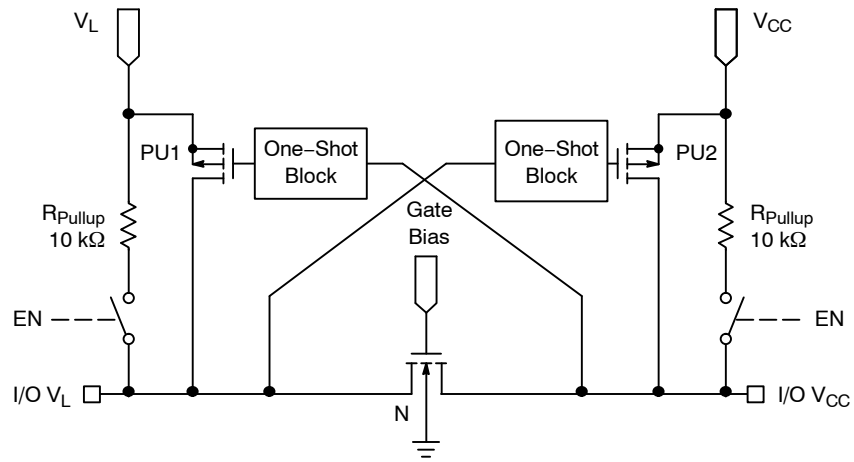


Figure 1. Block Diagram (1 I/O Line)

## PIN ASSIGNMENT

Pins	Description
V <sub>CC</sub>	V <sub>CC</sub> Input Voltage
V <sub>L</sub>	V <sub>L</sub> Input Voltage
GND	Ground
EN	Output Enable
I/O V <sub>CCn</sub>	V <sub>CC</sub> I/O Port, Referenced to V <sub>CC</sub>
I/O V <sub>Ln</sub>	V <sub>L</sub> I/O Port, Referenced to V <sub>L</sub>

## FUNCTION TABLE

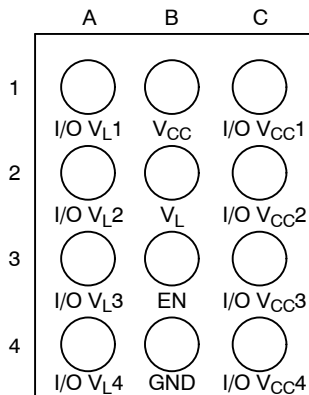
EN	Operating Mode
L	Hi-Z
H	I/O Buses Connected

## PIN LOCATION

Pin	Pin Name
A1	I/O V <sub>L</sub> 1
A2	I/O V <sub>L</sub> 2
A3	I/O V <sub>L</sub> 3
A4	I/O V <sub>L</sub> 4
B1	V <sub>CC</sub>
B2	V <sub>L</sub>
B3	EN
B4	GND
C1	I/O V <sub>CC</sub> 1
C2	I/O V <sub>CC</sub> 2
C3	I/O V <sub>CC</sub> 3
C4	I/O V <sub>CC</sub> 4

## μBump12

(2.02 x 1.54 mm)



(Bottom View)

# NLSX4378A

## MAXIMUM RATINGS

Symbol	Parameter	Condition	Value	Unit
V <sub>CC</sub>	DC Supply Voltage		-0.3 to +7.0	V
V <sub>L</sub>	DC Supply Voltage		-0.3 to +7.0	V
I/O V <sub>CC</sub>	V <sub>CC</sub> -Referenced DC Input/Output Voltage		-0.3 to (V <sub>CC</sub> + 0.3)	V
I/O V <sub>L</sub>	V <sub>L</sub> -Referenced DC Input/Output Voltage		-0.3 to (V <sub>L</sub> + 0.3)	V
V <sub>EN</sub>	Enable Control Pin DC Input Voltage		-0.3 to +7.0	V
I <sub>I/O_SC</sub>	Short-Circuit Duration (I/O V <sub>L</sub> and I/O V <sub>CC</sub> to GND)	Continuous	40	mA
T <sub>STG</sub>	Storage Temperature		-65 to +150	°C
I <sub>LU</sub>	Latch-up Current		100	mA
ESD Rating	Human Body Model Charged Device Model		7000 2000	V

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 <sub>CC</sub>	DC Supply Voltage	1.65	5.5	V
V <sub>L</sub>	DC Supply Voltage	1.65	5.5	V
V <sub>EN</sub>	Enable Control Pin Voltage	GND	5.5	V
V <sub>IO</sub>	I/O Pin Voltage	GND	V <sub>CC</sub> or V <sub>L</sub>	V
T <sub>A</sub>	Operating Temperature Range	-55	+125	°C

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.

# NLSX4378A

## DC ELECTRICAL CHARACTERISTICS ( $V_{CC} = 1.65\text{ V to }5.5\text{ V}$ and $V_L = 1.65\text{ V to }5.5\text{ V}$ , unless otherwise specified)

Symbol	Parameter	Test Conditions	-40°C to +85°C			-55°C to +125°C		Unit
			Min	Typ (Notes 1, 2)	Max	Min	Max	
$V_{IHC}$	I/O $V_{CC}$ Input HIGH Voltage		$V_{CC} - 0.4$	-	-	$V_{CC} - 0.4$	-	V
$V_{ILC}$	I/O $V_{CC}$ Input LOW Voltage		-	-	0.15	-	0.15	V
$V_{IHL}$	I/O $V_L$ Input HIGH Voltage		$V_L - 0.4$	-	-	$V_L - 0.4$	-	V
$V_{ILL}$	I/O $V_L$ Input LOW Voltage		-	-	0.15	-	0.15	V
$V_{IH}$	Control Pin Input HIGH Voltage		$0.65 * V_L$	-	-	$0.65 * V_L$	-	V
$V_{IL}$	Control Pin Input LOW Voltage		-	-	$0.35 * V_L$	-	$0.35 * V_L$	V
$V_{OHC}$	I/O $V_{CC}$ Output HIGH Voltage	I/O $V_{CC}$ Source Current = 20 $\mu$ A	$0.8 * V_{CC}$	-	-	$0.8 * V_{CC}$	-	V
$V_{OLC}$	I/O $V_{CC}$ Output LOW Voltage	I/O $V_{CC}$ Sink Current = 1.0 mA, I/O $V_L \leq 0.15\text{ V}$	-	-	0.4	-	0.4	V
$V_{OHL}$	I/O $V_L$ Output HIGH Voltage	I/O $V_L$ Source Current = 20 $\mu$ A	$0.8 * V_L$	-	-	$0.8 * V_L$	-	V
$V_{OLL}$	I/O $V_L$ Output LOW Voltage	I/O $V_L$ Sink Current = 1.0 mA, I/O $V_{CC} \leq 0.15\text{ V}$	-	-	0.4	-	0.4	V
$I_{QVCC}$	$V_{CC}$ Supply Current	I/O $V_{CC}$ and I/O $V_L$ Unconnected, $V_{EN} = V_L$	-	0.5	2.0	-	3.0	$\mu$ A
$I_{QVL}$	$V_L$ Supply Current	I/O $V_{CC}$ and I/O $V_L$ Unconnected, $V_{EN} = V_L$	-	0.3	1.0	-	3.0	$\mu$ A
$I_{TS-VCC}$	$V_{CC}$ Tristate Output Mode Supply Current	I/O $V_{CC}$ and I/O $V_L$ Unconnected, $V_{EN} = \text{GND}$	-	0.1	1.0	-	1.5	$\mu$ A
$I_{TS-VL}$	$V_L$ Tristate Output Mode Supply Current	I/O $V_{CC}$ and I/O $V_L$ Unconnected, $V_{EN} = \text{GND}$	-	0.1	1.0	-	1.5	$\mu$ A
$I_{OZ}$	I/O Tristate Output Mode Leakage Current	$T_A = +25^\circ\text{C}$	-	0.1	1.0	-	1.0	$\mu$ A
$R_{PU}$	Pullup Resistor I/O $V_L$ and $V_{CC}$	$T_A = +25^\circ\text{C}$	-	10	-	-	-	k $\Omega$

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.

1. Typical values are for  $V_{CC} = +2.8\text{ V}$ ,  $V_L = +1.8\text{ V}$  and  $T_A = +25^\circ\text{C}$ .

2. All units are production tested at  $T_A = +25^\circ\text{C}$ . Limits over the operating temperature range are guaranteed by design.

# NLSX4378A

## TIMING CHARACTERISTICS – RAIL-TO-RAIL DRIVING CONFIGURATIONS

(I/O test circuit of Figures 2 and 3,  $C_{LOAD} = 15 \text{ pF}$ , driver output impedance  $\leq 50 \Omega$ ,  $R_{LOAD} = 1 \text{ M}\Omega$ )

Symbol	Parameter	Test Conditions	-40°C to +85°C (Note 3)			-55°C to +125°C (Note 3)		Unit
			Min	Typ	Max	Min	Max	

**$V_L = 1.65 \text{ V}$ ,  $V_{CC} = 5.5 \text{ V}$**

$t_{RVCC}$	I/O $V_{CC}$ Risetime				15		15	ns
$t_{FVCC}$	I/O $V_{CC}$ Falltime				30		30	ns
$t_{RVL}$	I/O $V_L$ Risetime				30		30	ns
$t_{FVL}$	I/O $V_L$ Falltime				10		10	ns
$t_{PDVL-VCC}$	Propagation Delay (Driving I/O $V_L$ )				20		20	ns
$t_{PDVCC-VL}$	Propagation Delay (Driving I/O $V_{CC}$ )				20		20	ns
$t_{SKEW}$	Channel-to-Channel Skew				5		5	nS
MDR	Maximum Data Rate		24				24	Mb/s

**$V_L = 1.8 \text{ V}$ ,  $V_{CC} = 2.8 \text{ V}$**

$t_{RVCC}$	I/O $V_{CC}$ Risetime				15		15	ns
$t_{FVCC}$	I/O $V_{CC}$ Falltime				15		15	ns
$t_{RVL}$	I/O $V_L$ Risetime				25		25	ns
$t_{FVL}$	I/O $V_L$ Falltime				10		10	ns
$t_{PDVL-VCC}$	Propagation Delay (Driving I/O $V_L$ )				15		15	ns
$t_{PDVCC-VL}$	Propagation Delay (Driving I/O $V_{CC}$ )				15		15	ns
$t_{SKEW}$	Channel-to-Channel Skew				5		5	nS
MDR	Maximum Data Rate		24				24	Mb/s

**$V_L = 2.5 \text{ V}$ ,  $V_{CC} = 3.6 \text{ V}$**

$t_{RVCC}$	I/O $V_{CC}$ Risetime				15		15	ns
$t_{FVCC}$	I/O $V_{CC}$ Falltime				10		10	ns
$t_{RVL}$	I/O $V_L$ Risetime				15		15	ns
$t_{FVL}$	I/O $V_L$ Falltime				10		10	ns
$t_{PDVL-VCC}$	Propagation Delay (Driving I/O $V_L$ )				15		15	ns
$t_{PDVCC-VL}$	Propagation Delay (Driving I/O $V_{CC}$ )				15		15	ns
$t_{SKEW}$	Channel-to-Channel Skew				5		5	nS
MDR	Maximum Data Rate		24				24	Mb/s

**$V_L = 2.8 \text{ V}$ ,  $V_{CC} = 1.8 \text{ V}$**

$t_{RVCC}$	I/O $V_{CC}$ Risetime				25		25	ns
$t_{FVCC}$	I/O $V_{CC}$ Falltime				10		10	ns
$t_{RVL}$	I/O $V_L$ Risetime				15		15	ns
$t_{FVL}$	I/O $V_L$ Falltime				15		15	ns
$t_{PDVL-VCC}$	Propagation Delay (Driving I/O $V_L$ )				15		15	ns
$t_{PDVCC-VL}$	Propagation Delay (Driving I/O $V_{CC}$ )				15		15	ns
$t_{SKEW}$	Channel-to-Channel Skew				5		5	nS
MDR	Maximum Data Rate		24				24	Mb/s

3. Limits over the operating temperature range are guaranteed by design.

# NLSX4378A

## TIMING CHARACTERISTICS – RAIL-TO-RAIL DRIVING CONFIGURATIONS

(I/O test circuit of Figures 2 and 3,  $C_{LOAD} = 15 \text{ pF}$ , driver output impedance  $\leq 50 \Omega$ ,  $R_{LOAD} = 1 \text{ M}\Omega$ )

Symbol	Parameter	Test Conditions	-40°C to +85°C (Note 3)			-55°C to +125°C (Note 3)		Unit
			Min	Typ	Max	Min	Max	
<b><math>V_L = 3.6 \text{ V}</math>, <math>V_{CC} = 2.5 \text{ V}</math></b>								
$t_{RVCC}$	I/O $V_{CC}$ Risettime				15		15	ns
$t_{FVCC}$	I/O $V_{CC}$ Falltime				10		10	ns
$t_{RVL}$	I/O $V_L$ Risettime				15		15	ns
$t_{FVL}$	I/O $V_L$ Falltime				10		10	ns
$t_{PDVL-VCC}$	Propagation Delay (Driving I/O $V_L$ )				15		15	ns
$t_{PDVCC-VL}$	Propagation Delay (Driving I/O $V_{CC}$ )				15		15	ns
$t_{SKEW}$	Channel-to-Channel Skew				5		5	nS
MDR	Maximum Data Rate		24				24	Mb/s

**$V_L = 5.5 \text{ V}$ ,  $V_{CC} = 1.65 \text{ V}$**

$t_{RVCC}$	I/O $V_{CC}$ Risettime				30		30	ns
$t_{FVCC}$	I/O $V_{CC}$ Falltime				10		10	ns
$t_{RVL}$	I/O $V_L$ Risettime				15		15	ns
$t_{FVL}$	I/O $V_L$ Falltime				30		30	ns
$t_{PDVL-VCC}$	Propagation Delay (Driving I/O $V_L$ )				20		20	ns
$t_{PDVCC-VL}$	Propagation Delay (Driving I/O $V_{CC}$ )				20		20	ns
$t_{SKEW}$	Channel-to-Channel Skew				5		5	nS
MDR	Maximum Data Rate		24				24	Mb/s

3. Limits over the operating temperature range are guaranteed by design.

## TIMING CHARACTERISTICS – OPEN DRAIN DRIVING CONFIGURATIONS

(I/O test circuit of Figures 4 and 5,  $C_{LOAD} = 15 \text{ pF}$ , driver output impedance  $\leq 50 \Omega$ ,  $R_{LOAD} = 1 \text{ M}\Omega$ )

Symbol	Parameter	Test Conditions	-40°C to +85°C (Note 4)			-55°C to +125°C (Note 4)		Unit
			Min	Typ	Max	Min	Max	
<b><math>+1.65 \leq V_L</math>, <math>V_{CC} \leq +5.5 \text{ V}</math></b>								
$t_{RVCC}$	I/O $V_{CC}$ Risettime				400		400	ns
$t_{FVCC}$	I/O $V_{CC}$ Falltime				50		50	ns
$t_{RVL}$	I/O $V_L$ Risettime				400		400	ns
$t_{FVL}$	I/O $V_L$ Falltime				60		60	ns
$t_{PDVL-VCC}$	Propagation Delay (Driving I/O $V_L$ )				1000		1000	ns
$t_{PDVCC-VL}$	Propagation Delay (Driving I/O $V_{CC}$ )				1000		1000	ns
$t_{SKEW}$	Channel-to-Channel Skew				50		50	nS
MDR	Maximum Data Rate		2				2	Mb/s

4. Limits over the operating temperature range are guaranteed by design.

# NLSX4378A

## TEST SETUPS

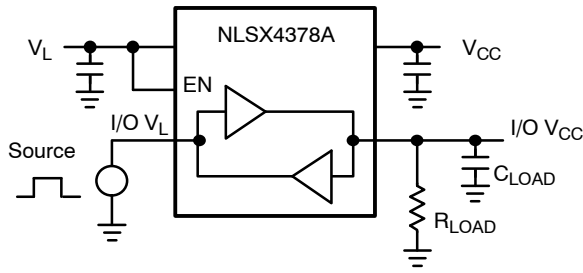


Figure 2. Rail-to-Rail Driving I/O  $V_L$

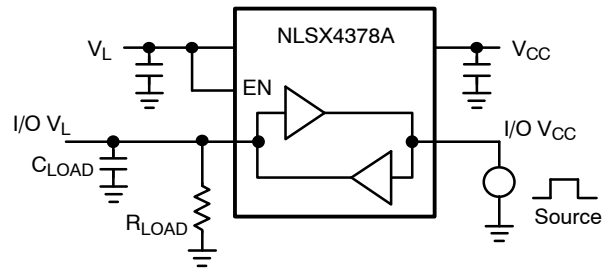


Figure 3. Rail-to-Rail Driving I/O  $V_{CC}$

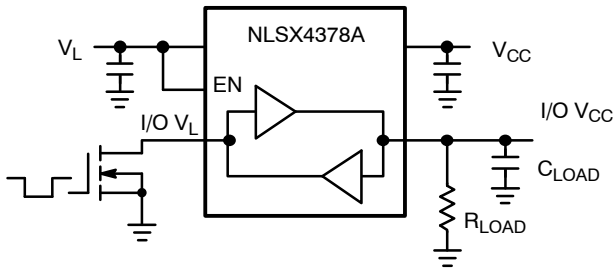


Figure 4. Open-Drain Driving I/O  $V_L$

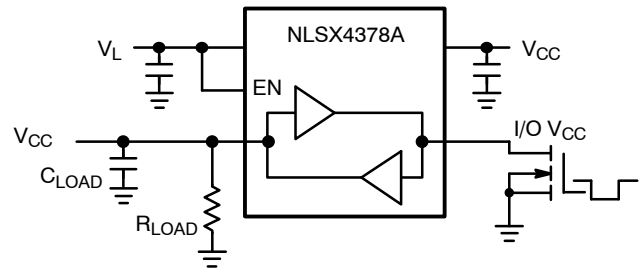


Figure 5. Open-Drain Driving I/O  $V_{CC}$

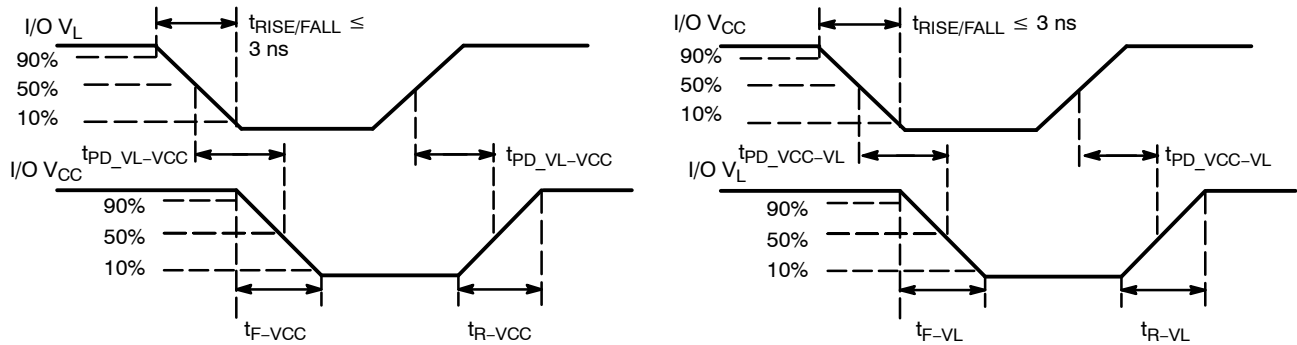


Figure 6. Definition of Timing Specification Parameters

# NLSX4378A

## APPLICATIONS INFORMATION

### Level Translator Architecture

The NLSX4378A auto sense translator provides bi-directional voltage level shifting to transfer data in multiple supply voltage systems. This device has two supply voltages,  $V_L$  and  $V_{CC}$ , which set the logic levels on the input and output sides of the translator. When used to transfer data from the  $V_L$  to the  $V_{CC}$  ports, input signals referenced to the  $V_L$  supply are translated to output signals with a logic level matched to  $V_{CC}$ . In a similar manner, the  $V_{CC}$  to  $V_L$  translation shifts input signals with a logic level compatible to  $V_{CC}$  to an output signal matched to  $V_L$ .

The NLSX4378A consists of four bi-directional channels that independently determine the direction of the data flow without requiring a directional pin. The one-shot circuits are used to detect the rising input signals. In addition, the one shots decrease the rise time of the output signal for low-to-high transitions.

Each input/output pin has an internal 10 k $\Omega$  pull-up resistor. The magnitude of the pull-up resistors can be reduced by connecting external resistors in parallel to the internal 10 k $\Omega$  resistors.

### Input Driver Requirements

The rise ( $t_R$ ) and fall ( $t_F$ ) timing parameters of the open drain outputs depend on the magnitude of the pull-up resistors. In addition, the propagation times ( $t_{PD}$ ), skew ( $t_{SKEW}$ ) and maximum data rate depend on the impedance of the device that is connected to the translator. The timing

parameters listed in the data sheet assume that the output impedance of the drivers connected to the translator is less than 50  $\Omega$ .

### Enable Input (EN)

The NLSX4378A has an Enable pin (EN) that provides tri-state operation at the I/O pins. Driving the Enable pin to a low logic level minimizes the power consumption of the device and drives the I/O  $V_{CC}$  and I/O  $V_L$  pins to a high impedance state. Normal translation operation occurs when the EN pin is equal to a logic high signal. The EN pin is referenced to the  $V_L$  supply and has Overvoltage Tolerant (OVT) protection.

### Power Supply Guidelines

During normal operation, supply voltage  $V_L$  can be greater than, less than or equal to  $V_{CC}$ . The sequencing of the power supplies will not damage the device during the power up operation.

For optimal performance, 0.01  $\mu$ F to 0.1  $\mu$ F decoupling capacitors should be used on the  $V_L$  and  $V_{CC}$  power supply pins. Ceramic capacitors are a good design choice to filter and bypass any noise signals on the voltage lines to the ground plane of the PCB. The noise immunity will be maximized by placing the capacitors as close as possible to the supply and ground pins, along with minimizing the PCB connection traces.

## ORDERING INFORMATION

Device	Package	Shipping <sup>†</sup>
NLSX4378ABFCT1G	$\mu$ Bump12 (Backside Laminate Coating) (Pb-Free)	3000 / Tape & Reel

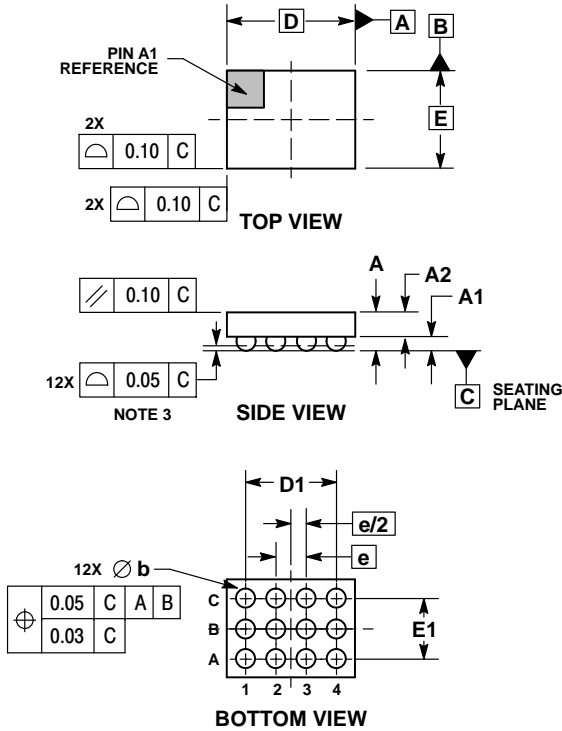
<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.



**12 PIN FLIP-CHIP, 2.02x1.54, 0.5P**  
CASE 499AU  
ISSUE O

DATE 19 MAR 2007

SCALE 4:1



NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. COPLANARITY APPLIES TO SPHERICAL CROWNS OF SOLDER BALLS.

DIM	MILLIMETERS	
	MIN	MAX
A	---	0.66
A1	0.21	0.27
A2	0.33	0.39
b	0.29	0.34
D	2.02 BSC	
D1	1.50 BSC	
E	1.54 BSC	
E1	1.00 BSC	
e	0.50 BSC	

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<b>DESCRIPTION:</b>	<b>12 PIN FLIP-CHIP, 2.02 X 1.54, 0.5P</b>	<b>PAGE 1 OF 1</b>

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