

# NLSX4401

## 1-Bit 20 Mb/s Dual-Supply Level Translator

The NLSX4401 is a 1-bit configurable dual-supply bidirectional auto sensing translator that does not require a directional control pin. The I/O  $V_{CC}$  and I/O  $V_L$  ports are designed to track two different power supply rails,  $V_{CC}$  and  $V_L$  respectively. Both the  $V_{CC}$  and  $V_L$  supply rails are configurable from 1.5 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 NLSX4401 translator has integrated 10 k $\Omega$  pull-up resistors on the I/O lines. The integrated pull-up resistors are used to pull up the I/O lines to either  $V_L$  or  $V_{CC}$ . The NLSX4401 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: 1.5 V to 5.5 V  
Wide  $V_L$  Operating Range: 1.5 V to 5.5 V
- High Speed with 24 Mb/s Guaranteed Data Rate
- Low Bit-to-Bit Skew
- Enable Input and I/O Pins are Overvoltage Tolerant (OVT) to 5.5 V
- Non-preferential Powerup Sequencing
- Power-Off Protection
- Integrated 10 k $\Omega$  Pull-up Resistors
- Small Space Saving Package:  
1.45 mm x 1.0 mm UDFN6 Package
- These Devices are Pb-Free and are RoHS Compliant

### Typical Applications

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

### Important Information

- ESD Protection for All Pins
  - Human Body Model (HBM) > 5000 V



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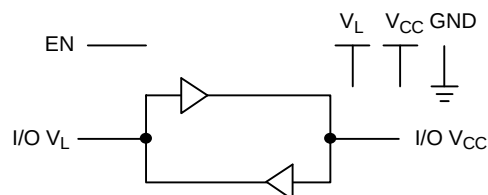
UDFN6  
1.45 x 1.0  
CASE 517AQ

### MARKING DIAGRAM



Y = Specific Device Code  
(Rotated 270° clockwise)  
M = Date Code

### LOGIC DIAGRAM



### ORDERING INFORMATION

| Device         | Package            | Shipping <sup>†</sup> |
|----------------|--------------------|-----------------------|
| NLSX4401MU1TCG | UDFN6<br>(Pb-Free) | 3000 / Tape<br>& Reel |

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

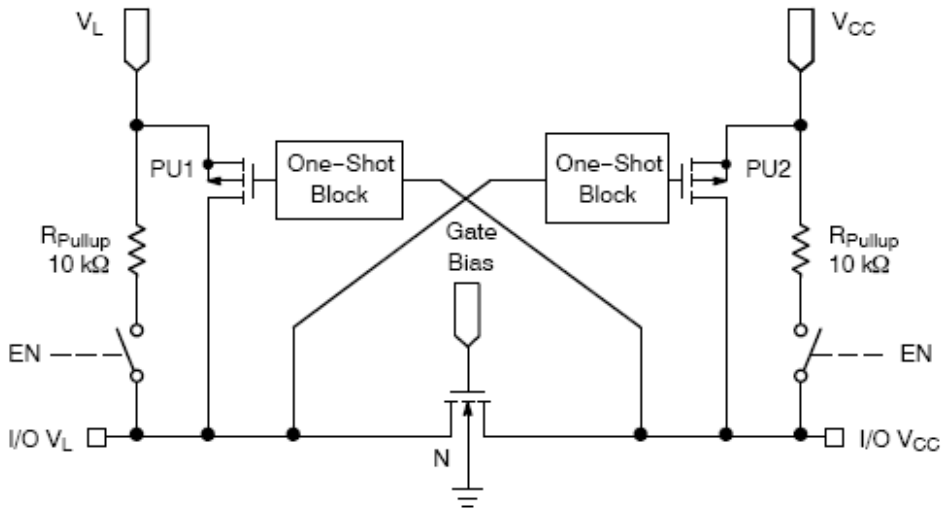


Figure 1. Block Diagram (1 I/O Line)

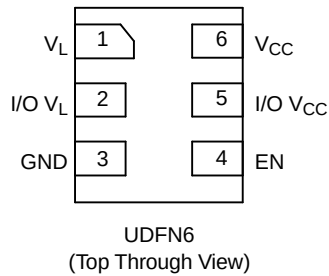


Figure 2. Pinout Diagram

PIN ASSIGNMENT

| Pins                | Description                                 |
|---------------------|---------------------------------------------|
| V <sub>CC</sub>     | V <sub>CC</sub> Supply Voltage              |
| V <sub>L</sub>      | V <sub>L</sub> Supply Voltage               |
| GND                 | Ground                                      |
| EN                  | Output Enable, Referenced to V <sub>L</sub> |
| I/O V <sub>CC</sub> | I/O Port, Referenced to V <sub>CC</sub>     |
| I/O 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 |

## MAXIMUM RATINGS

| Symbol              | Parameter                                                                   | Value        | Condition            | Unit |
|---------------------|-----------------------------------------------------------------------------|--------------|----------------------|------|
| V <sub>CC</sub>     | High-side DC Supply Voltage                                                 | −0.5 to +7.0 |                      | V    |
| V <sub>L</sub>      | High-side DC Supply Voltage                                                 | −0.5 to +7.0 |                      | V    |
| I/O V <sub>CC</sub> | V <sub>CC</sub> –Referenced DC Input/Output Voltage                         | −0.5 to +7.0 |                      | V    |
| I/O V <sub>L</sub>  | V <sub>L</sub> –Referenced DC Input/Output Voltage                          | −0.5 to +7.0 |                      | V    |
| V <sub>EN</sub>     | Enable Control Pin DC Input Voltage                                         | −0.5 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)  | ±50          | Continuous           | mA   |
| I <sub>I/OK</sub>   | Input/Output Clamping Current (I/O V <sub>L</sub> and I/O V <sub>CC</sub> ) | −50          | V <sub>I/O</sub> < 0 | mA   |
| T <sub>STG</sub>    | 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 <sub>CC</sub>     | High-side Positive DC Supply Voltage                                                     | 1.5 | 5.5      | V    |
| V <sub>L</sub>      | High-side Positive DC Supply Voltage                                                     | 1.5 | 5.5      | V    |
| V <sub>EN</sub>     | Enable Control Pin Voltage                                                               | GND | 5.5      | V    |
| V <sub>IO_VCC</sub> | I/O Pin Voltage (Side referred to V <sub>CC</sub> )                                      | GND | 5.5      | V    |
| V <sub>IO_VL</sub>  | I/O Pin Voltage (Side referred to V <sub>L</sub> )                                       | GND | 5.5      | V    |
| Δt/ΔV               | Input Transition Rise and Fall Rate<br>A– or B–Ports, Push–Pull Driving<br>Control Input |     | 10<br>10 | ns/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.

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## DC ELECTRICAL CHARACTERISTICS ( $V_L = 1.5\text{ V}$ to $5.5\text{ V}$ and $V_{CC} = 1.5\text{ V}$ to $5.5\text{ V}$ , unless otherwise specified) (Note 1)

| Symbol       | Parameter                                 | Test Conditions (Note 2)                                               | -55°C to +125°C |     |              | Unit             |
|--------------|-------------------------------------------|------------------------------------------------------------------------|-----------------|-----|--------------|------------------|
|              |                                           |                                                                        | Min             | Typ | Max          |                  |
| $V_{IHC}$    | I/O $V_{CC}$ Input HIGH Voltage           |                                                                        | $V_{CC} - 0.4$  | –   | –            | V                |
| $V_{ILC}$    | I/O $V_{CC}$ Input LOW Voltage            |                                                                        | –               | –   | 0.15         | V                |
| $V_{IHL}$    | I/O $V_L$ Input HIGH Voltage              |                                                                        | $V_L - 0.4$     | –   | –            | V                |
| $V_{ILL}$    | I/O $V_L$ Input LOW Voltage               |                                                                        | –               | –   | 0.15         | V                |
| $V_{IH}$     | Control Pin Input HIGH Voltage            |                                                                        | $0.65 * V_L$    | –   | –            | V                |
| $V_{IL}$     | Control Pin Input LOW Voltage             |                                                                        | –               | –   | $0.35 * V_L$ | V                |
| $V_{OHC}$    | I/O $V_{CC}$ Output HIGH Voltage          | I/O $V_{CC}$ source current = 20 $\mu\text{A}$                         | $2/3 * V_{CC}$  | –   | –            | V                |
| $V_{OLC}$    | I/O $V_{CC}$ Output LOW Voltage           | I/O $V_{CC}$ sink current = 1 mA                                       | –               | –   | 0.4          | V                |
| $V_{OHL}$    | I/O $V_L$ Output HIGH Voltage             | I/O $V_L$ source current = 20 $\mu\text{A}$                            | $2/3 * V_L$     | –   | –            | V                |
| $V_{OLL}$    | I/O $V_L$ Output LOW Voltage              | I/O $V_L$ sink current = 1 mA                                          | –               | –   | 0.4          | V                |
| $I_{QVCC}$   | $V_{CC}$ Supply Current<br>Supply Current | I/O $V_{CC}$ and I/O $V_L$ unconnected, $V_{EN} = V_L$                 | –               | 0.5 | 2.0          | $\mu\text{A}$    |
|              |                                           | $V_L = 5.5\text{ V}$ , $V_{CC} = 0\text{ V}$                           | –               | –   | 1.0          |                  |
|              |                                           | $V_L = 0\text{ V}$ , $V_{CC} = 5.5\text{ V}$                           | –               | –   | –1.0         |                  |
| $I_{QVL}$    | $V_L$ Supply Current<br>Supply Current    | I/O $V_{CC}$ and I/O $V_L$ unconnected, $V_{EN} = V_L$                 | –               | 0.3 | 1.5          | $\mu\text{A}$    |
|              |                                           | $V_L = 5.5\text{ V}$ , $V_{CC} = 0\text{ V}$                           | –               | –   | –1.0         |                  |
|              |                                           | $V_L = 0\text{ V}$ , $V_{CC} = 5.5\text{ V}$                           | –               | –   | 1.0          |                  |
| $I_{TS-VCC}$ | $V_{CC}$ Tristate Output Mode             | I/O $V_{CC}$ and I/O $V_L$ unconnected, $V_{EN} = \text{GND}$          | –               | 0.1 | 1.0          | $\mu\text{A}$    |
| $I_{TS-VL}$  | $V_L$ Tristate Output Mode Supply Current | I/O $V_{CC}$ and I/O $V_L$ unconnected, $V_{EN} = \text{GND}$          | –               | 0.1 | 1.0          | $\mu\text{A}$    |
| $I_I$        | Enable Pin Input Leakage Current          |                                                                        | –               | –   | 1.0          | $\mu\text{A}$    |
| $I_{OFF}$    | I/O Power-Off Leakage Current             | I/O $V_{CC}$ Port, $V_{CC} = 0\text{ V}$ , $V_L = 0$ to $5.5\text{ V}$ | –               | –   | 1.0          | $\mu\text{A}$    |
|              |                                           | I/O $V_L$ Port, $V_{CC} = 0$ to $5.5\text{ V}$ , $V_L = 0\text{ V}$    | –               | –   | 1.0          |                  |
| $I_{OZ}$     | I/O Tristate Output Mode Leakage Current  |                                                                        | –               | 0.1 | 1.0          | $\mu\text{A}$    |
| $R_{PU}$     | Pull-Up Resistors<br>I/O $V_L$ and $V_C$  |                                                                        | –               | 10  | –            | $\text{k}\Omega$ |

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  $V_L = +1.8\text{ V}$ ,  $V_{CC} = +3.3\text{ V}$  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.

# NLSX4401

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

(I/O test circuit of Figures 3 and 4,  $C_{LOAD} = 15 \text{ pF}$ , driver output impedance  $\leq 50 \Omega$ ,  $R_{LOAD} = 1 \text{ M}\Omega$ )

| Symbol | Parameter | Test Conditions | -40°C to +85°C<br>(Notes 3 & 4) |     |     | Unit |
|--------|-----------|-----------------|---------------------------------|-----|-----|------|
|        |           |                 | Min                             | Typ | Max |      |

### $V_L = 1.5 \text{ V}$ , $V_{CC} = 1.5 \text{ V}$

|                |                                                               |  |    |    |     |      |
|----------------|---------------------------------------------------------------|--|----|----|-----|------|
| $t_{RVCC}$     | I/O $V_{CC}$ Rise Time                                        |  |    | 9  | 32  | ns   |
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                        |  |    | 11 | 20  | ns   |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                           |  |    | 20 | 30  | ns   |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                           |  |    | 10 | 13  | ns   |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |    | 7  | 16  | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |    | 12 | 15  | ns   |
| $t_{EN}$       | Enable Time                                                   |  |    |    | 50  | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |    |    | 300 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |    |    | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 15 |    |     | Mbps |

### $V_L = 1.5 \text{ V}$ , $V_{CC} = 5.5 \text{ V}$

|                |                                                               |  |    |    |     |      |
|----------------|---------------------------------------------------------------|--|----|----|-----|------|
| $t_{RVCC}$     | I/O $V_{CC}$ Rise Time                                        |  |    | 9  | 12  | ns   |
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                        |  |    | 17 | 30  | ns   |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                           |  |    | 2  | 4   | ns   |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                           |  |    | 3  | 7   | ns   |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |    | 14 | 24  | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |    | 3  | 5   | ns   |
| $t_{EN}$       | Enable Time                                                   |  |    |    | 40  | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |    |    | 250 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |    |    | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 20 |    |     | Mbps |

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

|                |                                                               |  |    |    |     |      |
|----------------|---------------------------------------------------------------|--|----|----|-----|------|
| $t_{RVCC}$     | I/O $V_{CC}$ Rise Time                                        |  |    | 11 | 18  | ns   |
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                        |  |    | 10 | 15  | ns   |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                           |  |    | 12 | 15  | ns   |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                           |  |    | 5  | 8   | ns   |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |    | 7  | 10  | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |    | 5  | 9   | ns   |
| $t_{EN}$       | Enable Time                                                   |  |    |    | 50  | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |    |    | 300 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |    |    | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 20 |    |     | Mbps |

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

|            |                        |  |  |   |    |    |
|------------|------------------------|--|--|---|----|----|
| $t_{RVCC}$ | I/O $V_{CC}$ Rise Time |  |  | 8 | 12 | ns |
|------------|------------------------|--|--|---|----|----|

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.

3. Typical values are for the specified  $V_L$  and  $V_{CC}$  at  $T_A = +25^\circ\text{C}$ . All units are production tested at  $T_A = +25^\circ\text{C}$ .

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

5. Skew is the variation of propagation delay between output signals and applies only to output signals on the same port (I/O\_VLn or I/O\_VCCn) and switching with the same polarity (LOW-to-HIGH or HIGH-to-LOW). Skew is defined by applying a single input to the two input channels and measuring the difference in propagation delays between the output channels.

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## TIMING CHARACTERISTICS – RAIL-TO-RAIL DRIVING CONFIGURATIONS (continued)

(I/O test circuit of Figures 3 and 4,  $C_{LOAD} = 15 \text{ pF}$ , driver output impedance  $\leq 50 \Omega$ ,  $R_{LOAD} = 1 \text{ M}\Omega$ )

| Symbol | Parameter | Test Conditions | –40°C to +85°C<br>(Notes 3 & 4) |     |     | Unit |
|--------|-----------|-----------------|---------------------------------|-----|-----|------|
|        |           |                 | Min                             | Typ | Max |      |

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

|                |                                                               |  |    |   |     |      |
|----------------|---------------------------------------------------------------|--|----|---|-----|------|
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                        |  |    | 8 | 12  | ns   |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                           |  |    | 7 | 10  | ns   |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                           |  |    | 5 | 7   | ns   |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |    | 7 | 10  | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |    | 5 | 8   | ns   |
| $t_{EN}$       | Enable Time                                                   |  |    |   | 40  | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |    |   | 225 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |    |   | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 24 |   |     | Mbps |

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

|                |                                                               |  |    |    |     |      |
|----------------|---------------------------------------------------------------|--|----|----|-----|------|
| $t_{RVCC}$     | I/O $V_{CC}$ Rise Time                                        |  |    | 13 | 20  | ns   |
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                        |  |    | 7  | 10  | ns   |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                           |  |    | 8  | 13  | ns   |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                           |  |    | 9  | 15  | ns   |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |    | 6  | 9   | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |    | 7  | 12  | ns   |
| $t_{EN}$       | Enable Time                                                   |  |    |    | 60  | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |    |    | 250 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |    |    | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 24 |    |     | Mbps |

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

|                |                                                               |  |    |   |     |      |
|----------------|---------------------------------------------------------------|--|----|---|-----|------|
| $t_{RVCC}$     | I/O $V_{CC}$ Rise Time                                        |  |    | 9 | 12  | ns   |
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                        |  |    | 6 | 9   | ns   |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                           |  |    | 6 | 12  | ns   |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                           |  |    | 7 | 12  | ns   |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |    | 5 | 7   | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |    | 6 | 9   | ns   |
| $t_{EN}$       | Enable Time                                                   |  |    |   | 50  | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |    |   | 250 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |    |   | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 24 |   |     | Mbps |

**$V_L = 5.5 \text{ V}$ ,  $V_{CC} = 1.5 \text{ V}$**

|            |                        |  |  |    |    |    |
|------------|------------------------|--|--|----|----|----|
| $t_{RVCC}$ | I/O $V_{CC}$ Rise Time |  |  | 13 | 20 | ns |
| $t_{FVCC}$ | I/O $V_{CC}$ Fall Time |  |  | 6  | 9  | ns |

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.

3. Typical values are for the specified  $V_L$  and  $V_{CC}$  at  $T_A = +25^\circ\text{C}$ . All units are production tested at  $T_A = +25^\circ\text{C}$ .

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

5. Skew is the variation of propagation delay between output signals and applies only to output signals on the same port (I/O\_VLn or I/O\_VCCn) and switching with the same polarity (LOW-to-HIGH or HIGH-to-LOW). Skew is defined by applying a single input to the two input channels and measuring the difference in propagation delays between the output channels.

# NLSX4401

## TIMING CHARACTERISTICS – RAIL-TO-RAIL DRIVING CONFIGURATIONS (continued)

(I/O test circuit of Figures 3 and 4,  $C_{LOAD} = 15 \text{ pF}$ , driver output impedance  $\leq 50 \Omega$ ,  $R_{LOAD} = 1 \text{ M}\Omega$ )

| Symbol                                          | Parameter                                                                            | Test Conditions | –40°C to +85°C<br>(Notes 3 & 4) |     |     | Unit |
|-------------------------------------------------|--------------------------------------------------------------------------------------|-----------------|---------------------------------|-----|-----|------|
|                                                 |                                                                                      |                 | Min                             | Typ | Max |      |
| V <sub>L</sub> = 5.5 V, V <sub>CC</sub> = 1.5 V |                                                                                      |                 |                                 |     |     |      |
| t <sub>RVL</sub>                                | I/O V <sub>L</sub> Rise Time                                                         |                 |                                 | 8   | 10  | ns   |
| t <sub>FVL</sub>                                | I/O V <sub>L</sub> Fall Time                                                         |                 |                                 | 20  | 27  | ns   |
| t <sub>PDVL–VCC</sub>                           | Propagation Delay (Driving I/O V <sub>L</sub> , V <sub>L</sub> to V <sub>CC</sub> )  |                 |                                 | 5   | 8   | ns   |
| t <sub>PDVCC–VL</sub>                           | Propagation Delay (Driving I/O V <sub>CC</sub> , V <sub>CC</sub> to V <sub>L</sub> ) |                 |                                 | 14  | 24  | ns   |
| t <sub>EN</sub>                                 | Enable Time                                                                          |                 |                                 |     |     | ns   |
| t <sub>DIS</sub>                                | Disable Time                                                                         |                 |                                 |     |     | ns   |
| t <sub>PPSKEW</sub>                             | Part-to-Part Skew                                                                    |                 |                                 |     | 2   | ns   |
| MDR                                             | Maximum Data Rate                                                                    |                 | 20                              |     |     | Mbps |

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

|                |                                                               |  |    |   |     |      |
|----------------|---------------------------------------------------------------|--|----|---|-----|------|
| $t_{RVCC}$     | I/O $V_{CC}$ Rise Time                                        |  |    | 5 | 7   | ns   |
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                        |  |    | 6 | 8   | ns   |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                           |  |    | 5 | 7   | ns   |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                           |  |    | 4 | 7   | ns   |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |    | 4 | 6   | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |    | 4 | 6   | ns   |
| $t_{EN}$       | Enable Time                                                   |  |    |   | 30  | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |    |   | 225 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |    |   | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 24 |   |     | Mbps |

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.

3. Typical values are for the specified  $V_L$  and  $V_{CC}$  at  $T_A = +25^\circ\text{C}$ . All units are production tested at  $T_A = +25^\circ\text{C}$ .

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

5. Skew is the variation of propagation delay between output signals and applies only to output signals on the same port (I/O\_VLn or I/O\_VCCn) and switching with the same polarity (LOW-to-HIGH or HIGH-to-LOW). Skew is defined by applying a single input to the two input channels and measuring the difference in propagation delays between the output channels.

## TIMING CHARACTERISTICS – OPEN DRAIN DRIVING CONFIGURATIONS

(I/O test circuit of Figures 5 and 6,  $C_{LOAD} = 15 \text{ pF}$ , driver output impedance  $\leq 50 \Omega$ ,  $R_{LOAD} = 1 \text{ M}\Omega$ )

| Symbol                                          | Parameter                     | Test Conditions | –40°C to +85°C<br>(Notes 6 & 7) |     |     | Unit |
|-------------------------------------------------|-------------------------------|-----------------|---------------------------------|-----|-----|------|
|                                                 |                               |                 | Min                             | Typ | Max |      |
| V <sub>L</sub> = 1.5 V, V <sub>CC</sub> = 1.5 V |                               |                 |                                 |     |     |      |
| t <sub>RVCC</sub>                               | I/O V <sub>CC</sub> Rise Time |                 |                                 | 55  | 70  | ns   |
| t <sub>FVCC</sub>                               | I/O V <sub>CC</sub> Fall Time |                 |                                 | 7   | 14  | ns   |
| t <sub>RVL</sub>                                | I/O V <sub>L</sub> Rise Time  |                 |                                 | 50  | 65  | ns   |
| t <sub>FVL</sub>                                | I/O V <sub>L</sub> Fall Time  |                 |                                 | 7   | 12  | ns   |

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.

6. Typical values are for the specified  $V_L$  and  $V_{CC}$  at  $T_A = +25^\circ\text{C}$ . All units are production tested at  $T_A = +25^\circ\text{C}$ .

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

8. Skew is the variation of propagation delay between output signals and applies only to output signals on the same port (I/O\_VLn or I/O\_VCCn) and switching with the same polarity (LOW-to-HIGH or HIGH-to-LOW). Skew is defined by applying a single input to the two input channels and measuring the difference in propagation delays between the output channels.

# NLSX4401

## TIMING CHARACTERISTICS – OPEN DRAIN DRIVING CONFIGURATIONS (continued)

(I/O test circuit of Figures 5 and 6,  $C_{LOAD} = 15 \text{ pF}$ , driver output impedance  $\leq 50 \Omega$ ,  $R_{LOAD} = 1 \text{ M}\Omega$ )

| Symbol | Parameter | Test Conditions | –40°C to +85°C<br>(Notes 6 & 7) |     |     | Unit |
|--------|-----------|-----------------|---------------------------------|-----|-----|------|
|        |           |                 | Min                             | Typ | Max |      |

### $V_L = 1.5 \text{ V}$ , $V_{CC} = 1.5 \text{ V}$

|                |                                                               |  |   |    |     |      |
|----------------|---------------------------------------------------------------|--|---|----|-----|------|
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |   | 20 | 34  | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |   | 19 | 34  | ns   |
| $t_{EN}$       | Enable Time                                                   |  |   |    | 100 | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |   |    | 300 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |   |    | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 3 |    |     | Mbps |

### $V_L = 1.5 \text{ V}$ , $V_{CC} = 5.5 \text{ V}$

|                |                                                               |  |   |    |     |      |
|----------------|---------------------------------------------------------------|--|---|----|-----|------|
| $t_{RVCC}$     | I/O $V_{CC}$ Rise Time                                        |  |   | 22 | 34  | ns   |
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                        |  |   | 20 | 27  | ns   |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                           |  |   | 43 | 55  | ns   |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                           |  |   | 6  | 12  | ns   |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |   | 13 | 26  | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |   | 19 | 24  | ns   |
| $t_{EN}$       | Enable Time                                                   |  |   |    | 80  | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |   |    | 250 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |   |    | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 3 |    |     | Mbps |

### $V_L = 1.8 \text{ V}$ , $V_{CC} = 3.3 \text{ V}$

|                |                                                               |  |   |    |     |      |
|----------------|---------------------------------------------------------------|--|---|----|-----|------|
| $t_{RVCC}$     | I/O $V_{CC}$ Rise Time                                        |  |   | 34 | 40  | ns   |
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                        |  |   | 1  | 15  | ns   |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                           |  |   | 40 | 48  | ns   |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                           |  |   | 1  | 2   | ns   |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |   | 9  | 15  | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |   | 6  | 11  | ns   |
| $t_{EN}$       | Enable Time                                                   |  |   |    | 70  | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |   |    | 300 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |   |    | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 7 |    |     | Mbps |

### $V_L = 5.5 \text{ V}$ , $V_{CC} = 1.5 \text{ V}$

|                |                                                            |  |  |    |    |    |
|----------------|------------------------------------------------------------|--|--|----|----|----|
| $t_{RVCC}$     | I/O $V_{CC}$ Rise Time                                     |  |  | 44 | 52 | ns |
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                     |  |  | 1  | 2  | ns |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                        |  |  | 7  | 30 | ns |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                        |  |  | 17 | 23 | ns |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ ) |  |  | 10 | 17 | ns |

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.

6. Typical values are for the specified  $V_L$  and  $V_{CC}$  at  $T_A = +25^\circ\text{C}$ . All units are production tested at  $T_A = +25^\circ\text{C}$ .

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

8. Skew is the variation of propagation delay between output signals and applies only to output signals on the same port (I/O\_VLn or I/O\_VCCn) and switching with the same polarity (LOW-to-HIGH or HIGH-to-LOW). Skew is defined by applying a single input to the two input channels and measuring the difference in propagation delays between the output channels.



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## TIMING CHARACTERISTICS – OPEN DRAIN DRIVING CONFIGURATIONS (continued)

(I/O test circuit of Figures 5 and 6,  $C_{LOAD} = 15 \text{ pF}$ , driver output impedance  $\leq 50 \Omega$ ,  $R_{LOAD} = 1 \text{ M}\Omega$ )

| Symbol | Parameter | Test Conditions | –40°C to +85°C<br>(Notes 6 & 7) |     |     | Unit |
|--------|-----------|-----------------|---------------------------------|-----|-----|------|
|        |           |                 | Min                             | Typ | Max |      |

$V_L = 5.5 \text{ V}$ ,  $V_{CC} = 1.5 \text{ V}$

|                |                                                               |  |   |    |     |      |
|----------------|---------------------------------------------------------------|--|---|----|-----|------|
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |   | 12 | 24  | ns   |
| $t_{EN}$       | Enable Time                                                   |  |   |    | 100 | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |   |    | 300 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |   |    | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 3 |    |     | Mbps |

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

|                |                                                               |  |   |    |     |      |
|----------------|---------------------------------------------------------------|--|---|----|-----|------|
| $t_{RVCC}$     | I/O $V_{CC}$ Rise Time                                        |  |   | 42 | 50  | ns   |
| $t_{FVCC}$     | I/O $V_{CC}$ Fall Time                                        |  |   | 2  | 3   | ns   |
| $t_{RVL}$      | I/O $V_L$ Rise Time                                           |  |   | 44 | 48  | ns   |
| $t_{FVL}$      | I/O $V_L$ Fall Time                                           |  |   | 2  | 3   | ns   |
| $t_{PDVL-VCC}$ | Propagation Delay (Driving I/O $V_L$ , $V_L$ to $V_{CC}$ )    |  |   | 4  | 6   | ns   |
| $t_{PDVCC-VL}$ | Propagation Delay (Driving I/O $V_{CC}$ , $V_{CC}$ to $V_L$ ) |  |   | 6  | 9   | ns   |
| $t_{EN}$       | Enable Time                                                   |  |   |    | 60  | ns   |
| $t_{DIS}$      | Disable Time                                                  |  |   |    | 225 | ns   |
| $t_{PPSKEW}$   | Part-to-Part Skew                                             |  |   |    | 2   | ns   |
| MDR            | Maximum Data Rate                                             |  | 7 |    |     | Mbps |

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.

6. Typical values are for the specified  $V_L$  and  $V_{CC}$  at  $T_A = +25^\circ\text{C}$ . All units are production tested at  $T_A = +25^\circ\text{C}$ .

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

8. Skew is the variation of propagation delay between output signals and applies only to output signals on the same port (I/O\_VLn or I/O\_VCCn) and switching with the same polarity (LOW-to-HIGH or HIGH-to-LOW). Skew is defined by applying a single input to the two input channels and measuring the difference in propagation delays between the output channels.

# NLSX4401

## TEST SETUP

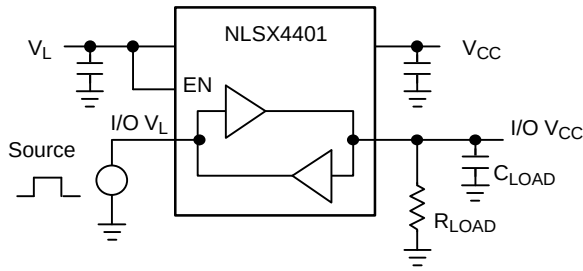


Figure 3. Rail-to-Rail Driving I/O  $V_L$

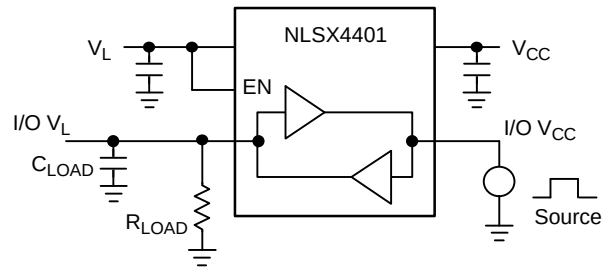


Figure 4. Rail-to-Rail Driving I/O  $V_{CC}$

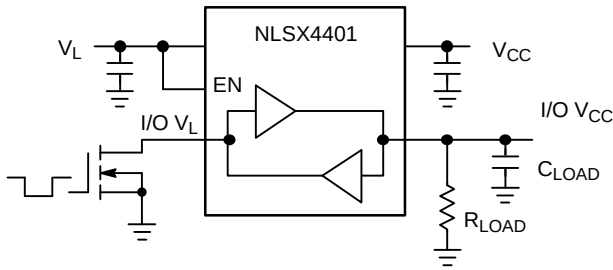


Figure 5. Open-Drain Driving I/O  $V_L$

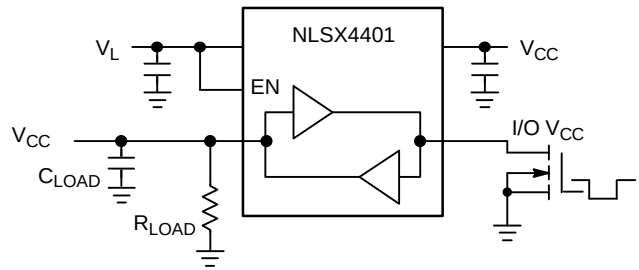


Figure 6. Open-Drain Driving I/O  $V_{CC}$

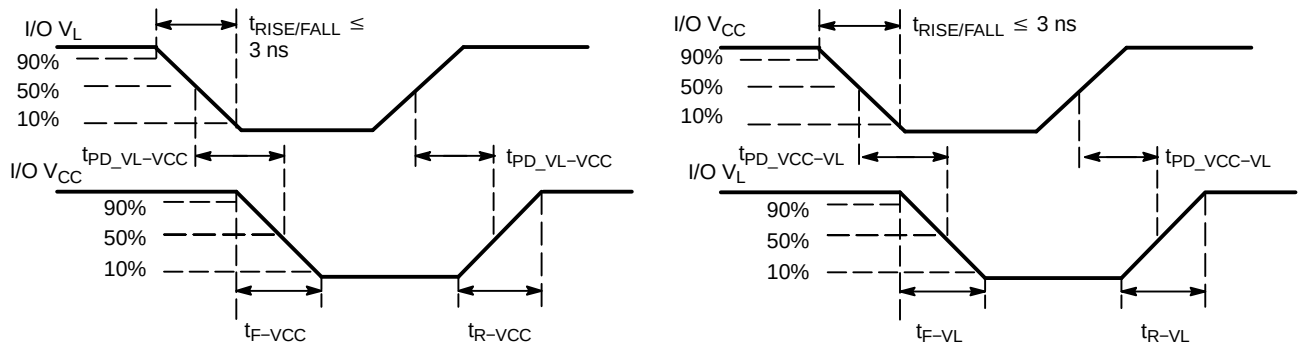
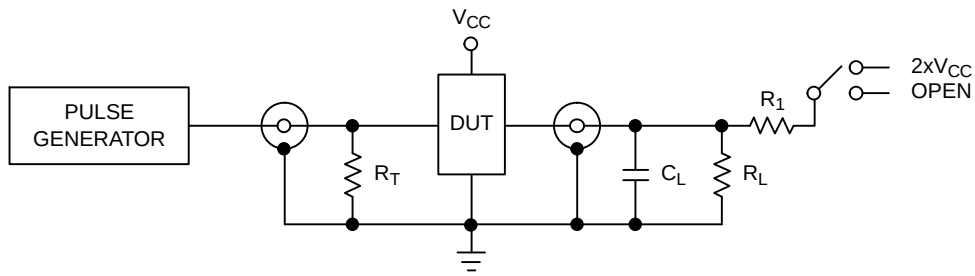


Figure 7. Definition of Timing Specification Parameters

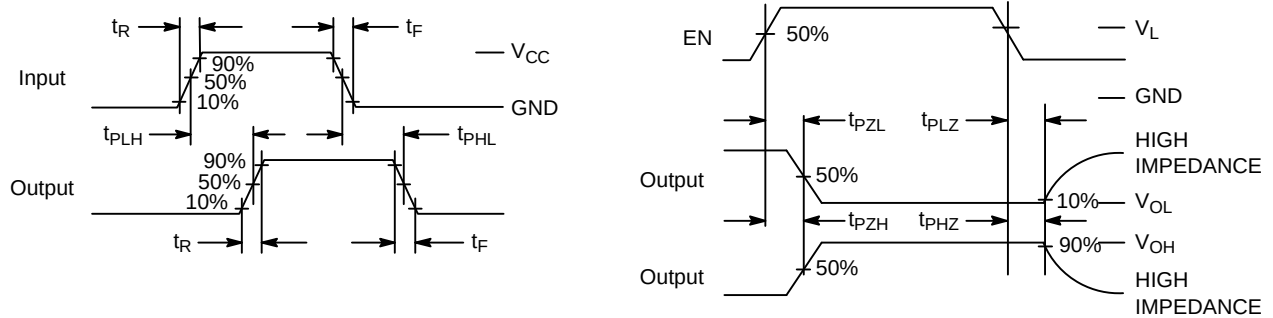
# NLSX4401



| Test                  | Switch            |
|-----------------------|-------------------|
| $t_{PZH}$ , $t_{PHZ}$ | Open              |
| $t_{PZL}$ , $t_{PLZ}$ | $2 \times V_{CC}$ |

$C_L = 15 \text{ pF}$  or equivalent (Includes jig and probe capacitance)  
 $R_L = R_1 = 50 \text{ k}\Omega$  or equivalent  
 $R_T = Z_{OUT}$  of pulse generator (typically  $50 \Omega$ )

**Figure 8. Test Circuit for Enable/Disable Time Measurement**



**Figure 9. Timing Definitions for Propagation Delays and Enable/Disable Measurement**

## APPLICATIONS INFORMATION

**Level Translator Architecture**

The NLSX4401 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 I/O  $V_L$  to the I/O  $V_{CC}$  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 I/O  $V_{CC}$  to I/O  $V_L$  translation shifts input signals with a logic level compatible to  $V_{CC}$  to an output signal matched to  $V_L$ .

The NLSX4401 consists of two 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 or falling input signals. In addition, the one shots decrease the rise and fall time of the output signal for high-to-low and low-to-high transitions.

Each input/output channel has an internal 10 k $\Omega$  pull-up. 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 ( $t_{PHL}$  /  $t_{PLH}$ ), skew ( $t_{PSKEW}$ ) 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 k $\Omega$ .

**Enable Input (EN)**

The NLSX4401 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  $V_{CCA}$  and  $V_{CCB}$  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.

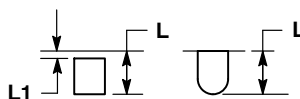
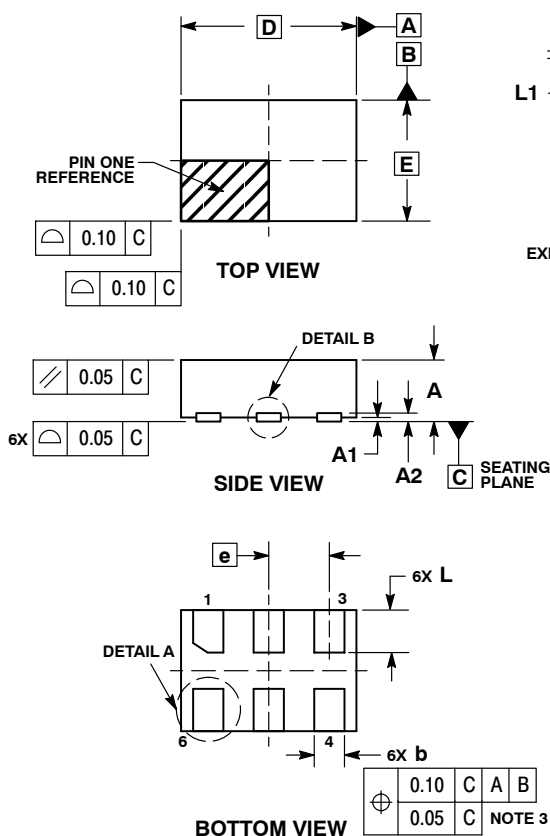
# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



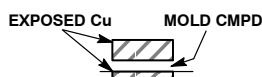
SCALE 4:1

UDFN6, 1.45x1.0, 0.5P  
CASE 517AQ  
ISSUE O

DATE 15 MAY 2008



**DETAIL A**  
OPTIONAL  
CONSTRUCTIONS



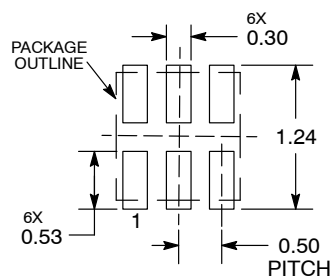
**DETAIL B**  
OPTIONAL  
CONSTRUCTIONS

## 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 THE TERMINAL TIP.

| MILLIMETERS |      |      |
|-------------|------|------|
| DIM         | MIN  | MAX  |
| A           | 0.45 | 0.55 |
| A1          | 0.00 | 0.05 |
| A2          | 0.07 | REF  |
| b           | 0.20 | 0.30 |
| D           | 1.45 | BSC  |
| E           | 1.00 | BSC  |
| e           | 0.50 | BSC  |
| L           | 0.30 | 0.40 |
| L1          | —    | 0.15 |

## MOUNTING 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\*



X = Specific Device Code  
M = Date Code

\*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.

|                         |                              |                                                                                                                                                                                     |
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