

# NTS0104

Dual supply translating transceiver; open drain; auto direction sensing

Rev. 3 — 3 January 2012

Product data sheet

## 1. General description

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The NTS0104 is a 4-bit, dual supply translating transceiver with auto direction sensing, that enables bidirectional voltage level translation. It features two 4-bit input-output ports (An and Bn), one output enable input (OE) and two supply pins ( $V_{CC(A)}$  and  $V_{CC(B)}$ ).  $V_{CC(A)}$  can be supplied at any voltage between 1.65 V and 3.6 V and  $V_{CC(B)}$  can be supplied at any voltage between 2.3 V and 5.5 V, making the device suitable for translating between any of the voltage nodes (1.8 V, 2.5 V, 3.3 V and 5.0 V). Pins An and OE are referenced to  $V_{CC(A)}$  and pins Bn are referenced to  $V_{CC(B)}$ . A LOW level at pin OE causes the outputs to assume a high-impedance OFF-state. This device is fully specified for partial power-down applications using  $I_{OFF}$ . The  $I_{OFF}$  circuitry disables the output, preventing the damaging backflow current through the device when it is powered down.

## 2. Features and benefits

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- Wide supply voltage range:
  - ◆  $V_{CC(A)}$ : 1.65 V to 3.6 V and  $V_{CC(B)}$ : 2.3 V to 5.5 V
- Maximum data rates:
  - ◆ Push-pull: 50 Mbps
- $I_{OFF}$  circuitry provides partial Power-down mode operation
- Inputs accept voltages up to 5.5 V
- ESD protection:
  - ◆ HBM JESD22-A114E Class 2 exceeds 2500 V for A port
  - ◆ HBM JESD22-A114E Class 3B exceeds 8000 V for B port
  - ◆ MM JESD22-A115-A exceeds 200 V
  - ◆ CDM JESD22-C101E exceeds 1500 V (For NTS0104UK 1000 V)
  - ◆ IEC61000-4-2 contact discharge exceeds 8000 V for B port
- Latch-up performance exceeds 100 mA per JESD 78B Class II
- Multiple package options
- Specified from  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  and  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$

## 3. Applications

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- I<sup>2</sup>C/SMBus
- UART
- GPIO



## 4. Ordering information

Table 1. Ordering information

| Type number | Package           |          |  |           |
|-------------|-------------------|----------|--|-----------|
|             | Temperature range | Name     | Description  | Version   |
| NTS0104PW   | -40 °C to +125 °C | TSSOP14  | plastic thin shrink small outline package; 14 leads; body width 4.4 mm   | SOT402-1  |
| NTS0104BQ   | -40 °C to +125 °C | DHVQFN14 | plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 14 terminals; body 2.5 × 3 × 0.85 mm | SOT762-1  |
| NTS0104GU12 | -40 °C to +125 °C | XQFN12   | plastic, extremely thin quad flat package; no leads; 12 terminals; body 1.70 × 2.0 × 0.50 mm                                 | SOT1174-1 |
| NTS0104UK   | -40 °C to +125 °C | WLCSP12  | wafer level chip scale package; 12 balls; 1.2 x 1.6 x 0.56 mm  | NTS0104UK |

## 5. Marking

Table 2. Marking

| Type number | Marking code |
|-------------|--------------|
| NTS0104PW   | NTS0104      |
| NTS0104BQ   | S0104        |
| NTS0104GU12 | s4           |
| NTS0104UK   | s04          |

### 6. Functional diagram

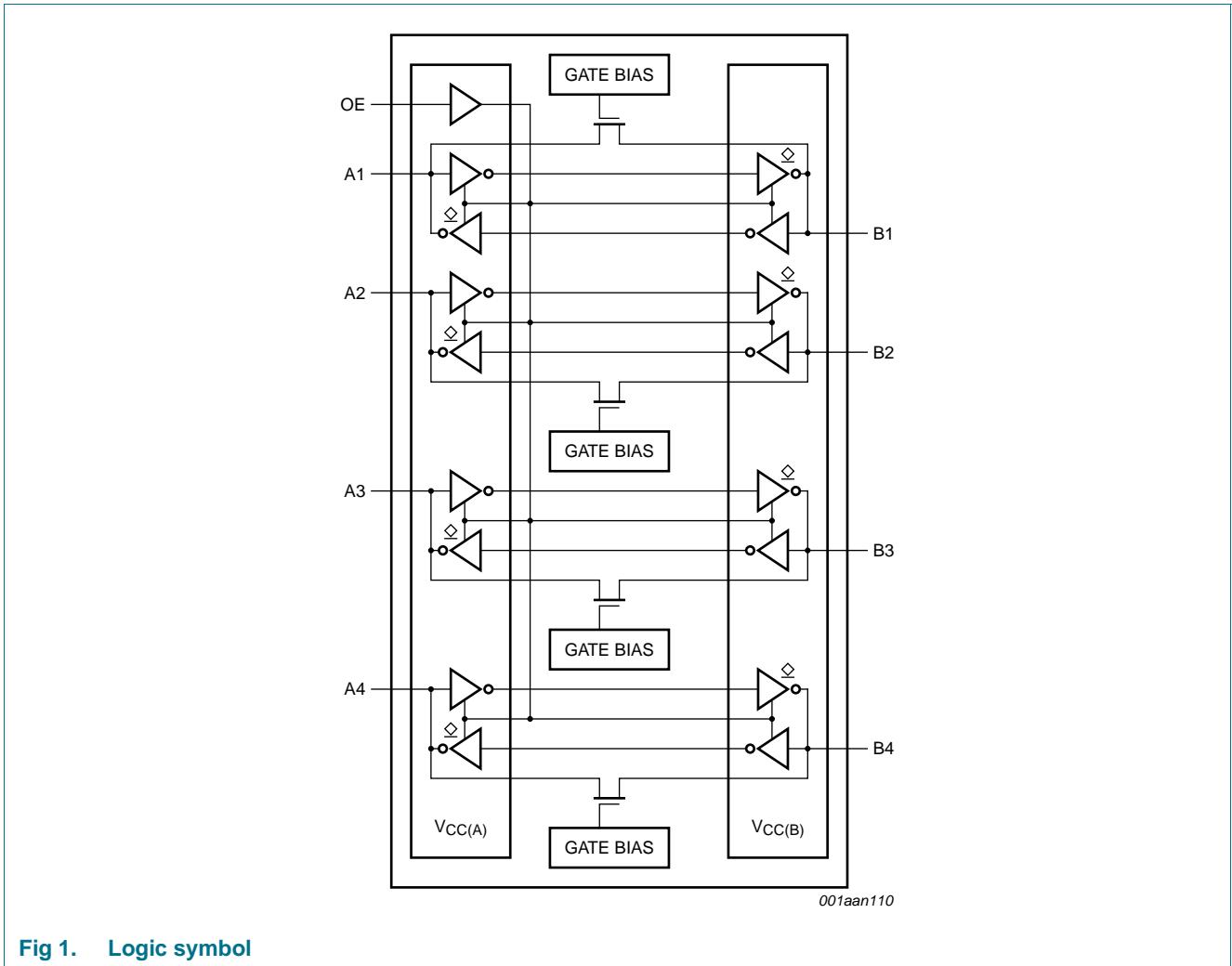
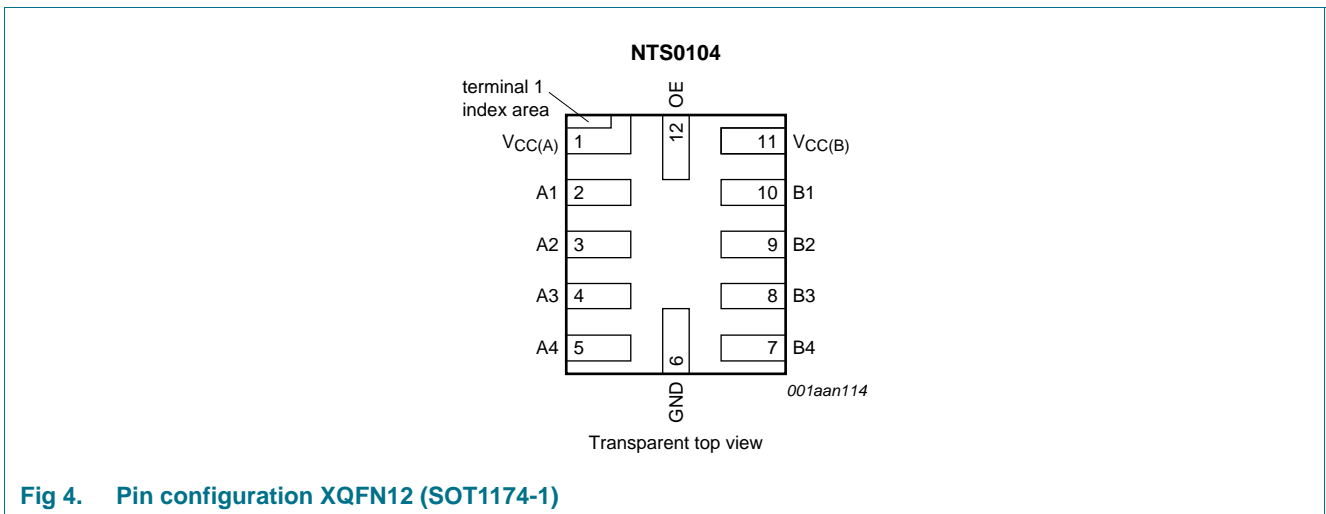
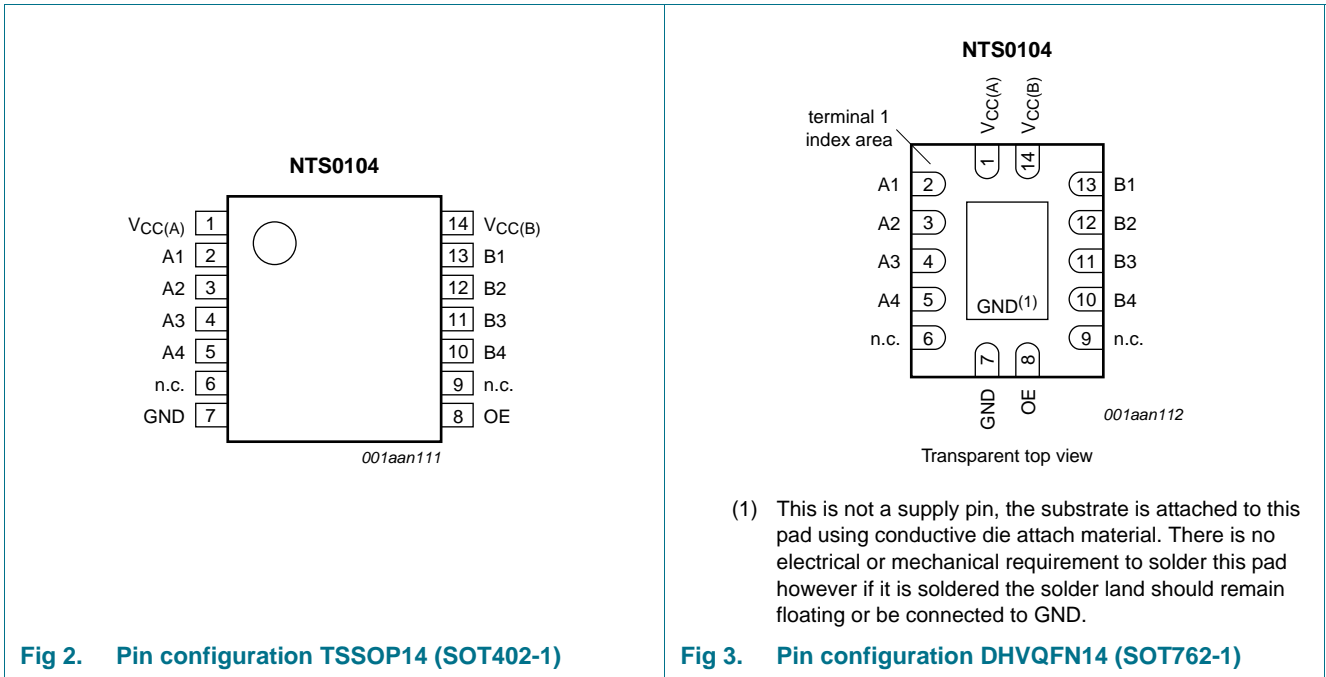
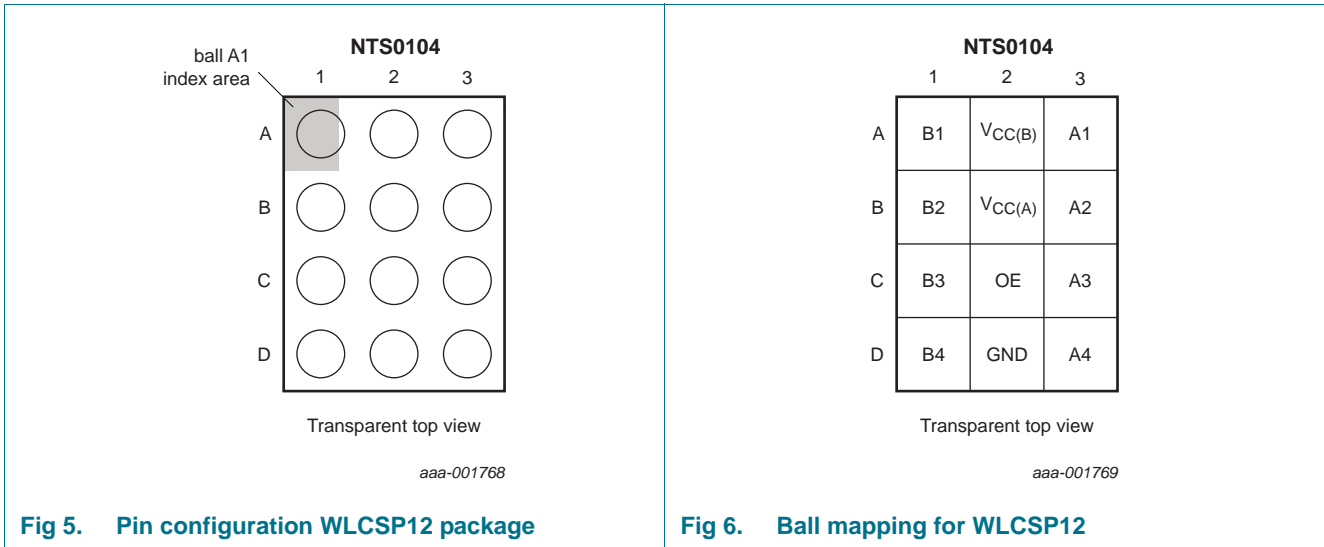


Fig 1. Logic symbol

## 7. Pinning information

### 7.1 Pinning





7.2 Pin description

Table 3. Pin description

| Symbol             | Pin                   |             | Ball           | Description  |
|--------------------|-----------------------|-------------|----------------|--|
|                    | SOT402-1 and SOT762-1 | SOT1174-1   | WLCSP12        |  |
| V <sub>CC(A)</sub> | 1                     | 1           | B2             | supply voltage A   |
| A1, A2, A3, A4     | 2, 3, 4, 5            | 2, 3, 4, 5  | A3, B3, C3, D3 | data input or output (referenced to V <sub>CC(A)</sub> )             |
| n.c.               | 6, 9                  | -           | -              | not connected  |
| GND                | 7                     | 6           | D2             | ground (0 V)   |
| OE                 | 8                     | 12          | C2             | output enable input (active HIGH; referenced to V <sub>CC(A)</sub> ) |
| B4, B3, B2, B1     | 10, 11, 12, 13        | 7, 8, 9, 10 | D1, C1, B1, A1 | data input or output (referenced to V <sub>CC(B)</sub> )             |
| V <sub>CC(B)</sub> | 14                    | 11          | A2             | supply voltage B   |

8. Functional description

Table 4. Function table<sup>[1]</sup>

| Supply voltage               |                    | Input | Input/output    |                 |
|------------------------------|--------------------|-------|-----------------|-----------------|
| V <sub>CC(A)</sub>           | V <sub>CC(B)</sub> | OE    | An              | Bn              |
| 1.65 V to V <sub>CC(B)</sub> | 2.3 V to 5.5 V     | L     | Z               | Z               |
| 1.65 V to V <sub>CC(B)</sub> | 2.3 V to 5.5 V     | H     | input or output | output or input |
| GND <sup>[2]</sup>           | GND <sup>[2]</sup> | X     | Z               | Z               |

[1] H = HIGH voltage level; L = LOW voltage level; X = don't care; Z = high-impedance OFF-state.

[2] When either V<sub>CC(A)</sub> or V<sub>CC(B)</sub> is at GND level, the device goes into power-down mode.

## 9. Limiting values

**Table 5. Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to GND (ground = 0 V).

| Symbol      | Parameter               | Conditions                    | Min    | Max  | Unit            |    |
|-------------|-------------------------|-------------------------------|--------|------|-----------------|----|
| $V_{CC(A)}$ | supply voltage A        |                               | -0.5   | +6.5 | V               |    |
| $V_{CC(B)}$ | supply voltage B        |                               | -0.5   | +6.5 | V               |    |
| $V_I$       | input voltage           | A port and OE input           | [1][2] | -0.5 | +6.5            | V  |
|             |                         | B port                        | [1][2] | -0.5 | +6.5            | V  |
| $V_O$       | output voltage          | Active mode                   | [1][2] |      |                 |    |
|             |                         | A or B port                   |        | -0.5 | $V_{CCO} + 0.5$ | V  |
|             |                         | Power-down or 3-state mode    | [1]    |      |                 |    |
|             |                         | A port                        |        | -0.5 | +4.6            | V  |
|             |                         | B port                        |        | -0.5 | +6.5            | V  |
| $I_{IK}$    | input clamping current  | $V_I < 0$ V                   | -50    | -    | mA              |    |
| $I_{OK}$    | output clamping current | $V_O < 0$ V                   | -50    | -    | mA              |    |
| $I_O$       | output current          | $V_O = 0$ V to $V_{CCO}$      | [2]    | -    | $\pm 50$        | mA |
| $I_{CC}$    | supply current          | $I_{CC(A)}$ or $I_{CC(B)}$    | -      | 100  | mA              |    |
| $I_{GND}$   | ground current          |                               | -100   | -    | mA              |    |
| $T_{stg}$   | storage temperature     |                               | -65    | +150 | °C              |    |
| $P_{tot}$   | total power dissipation | $T_{amb} = -40$ °C to +125 °C | [3]    | -    | 250             | mW |

[1] The minimum input and minimum output voltage ratings may be exceeded if the input and output current ratings are observed.

[2]  $V_{CCO}$  is the supply voltage associated with the output.

[3] For TSSOP14 packages: above 60 °C the value of  $P_{tot}$  derates linearly at 5.5 mW/K.  
For DHVQFN14 packages: above 60 °C the value of  $P_{tot}$  derates linearly at 4.5 mW/K.

## 10. Recommended operating conditions

**Table 6. Recommended operating conditions**[1][2]

| Symbol              | Parameter                           | Conditions   | Min  | Max  | Unit |
|---------------------|-------------------------------------|--|------|------|------|
| $V_{CC(A)}$         | supply voltage A                    |  | 1.65 | 3.6  | V    |
| $V_{CC(B)}$         | supply voltage B                    |  | 2.3  | 5.5  | V    |
| $T_{amb}$           | ambient temperature                 |  | -40  | +125 | °C   |
| $\Delta t/\Delta V$ | input transition rise and fall rate | A or B port; push-pull driving                                 |      |      |      |
|                     |                                     | $V_{CC(A)} = 1.65$ V to 3.6 V;<br>$V_{CC(B)} = 2.3$ V to 5.5 V | -    | 10   | ns/V |
|                     |                                     | OE input   |      |      |      |
|                     |                                     | $V_{CC(A)} = 1.65$ V to 3.6 V;<br>$V_{CC(B)} = 2.3$ V to 5.5 V | -    | 10   | ns/V |

[1] The A and B sides of an unused I/O pair must be held in the same state, both at  $V_{CCI}$  or both at GND.

[2]  $V_{CC(A)}$  must be less than or equal to  $V_{CC(B)}$ .

## 11. Static characteristics

**Table 7. Typical static characteristics**

At recommended operating conditions; voltages are referenced to GND (ground = 0 V);  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

| Symbol    | Parameter                 | Conditions  | Min | Typ | Max     | Unit          |
|-----------|---------------------------|---|-----|-----|---------|---------------|
| $I_I$     | input leakage current     | OE input; $V_I = 0\text{ V to }3.6\text{ V}$ ; $V_{CC(A)} = 1.65\text{ V to }3.6\text{ V}$ ; $V_{CC(B)} = 2.3\text{ V to }5.5\text{ V}$ | -   | -   | $\pm 1$ | $\mu\text{A}$ |
| $I_{OZ}$  | OFF-state output current  | A or B port; $V_O = 0\text{ V or }V_{CCO}$ ; $V_{CC(A)} = 1.65\text{ V to }3.6\text{ V}$ ; $V_{CC(B)} = 2.3\text{ V to }5.5\text{ V}$   | [1] | -   | $\pm 1$ | $\mu\text{A}$ |
| $I_{OFF}$ | power-off leakage current | A port; $V_I$ or $V_O = 0\text{ V to }3.6\text{ V}$ ; $V_{CC(A)} = 0\text{ V}$ ; $V_{CC(B)} = 0\text{ V to }5.5\text{ V}$               | -   | -   | $\pm 1$ | $\mu\text{A}$ |
|           |                           | B port; $V_I$ or $V_O = 0\text{ V to }5.5\text{ V}$ ; $V_{CC(B)} = 0\text{ V}$ ; $V_{CC(A)} = 0\text{ V to }3.6\text{ V}$               | -   | -   | $\pm 1$ | $\mu\text{A}$ |
| $C_I$     | input capacitance         | OE input; $V_{CC(A)} = 3.3\text{ V}$ ; $V_{CC(B)} = 3.3\text{ V}$   | -   | 2   | -       | pF            |
| $C_{I/O}$ | input/output capacitance  | A port  | -   | 4   | -       | pF            |
|           |                           | B port  | -   | 7   | -       | pF            |
|           |                           | A or B port; $V_{CC(A)} = 3.3\text{ V}$ ; $V_{CC(B)} = 3.3\text{ V}$  | -   | 9   | -       | pF            |

[1]  $V_{CCO}$  is the supply voltage associated with the output.

**Table 8. Typical supply current**

At recommended operating conditions; voltages are referenced to GND (ground = 0 V);  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

| $V_{CC(A)}$ | $V_{CC(B)}$ |             |             |             |             |             | Unit          |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---------------|
|             | 2.5 V       |             | 3.3 V       |             | 5.0 V       |             |               |
|             | $I_{CC(A)}$ | $I_{CC(B)}$ | $I_{CC(A)}$ | $I_{CC(B)}$ | $I_{CC(A)}$ | $I_{CC(B)}$ |               |
| 1.8 V       | 0.1         | 0.5         | 0.1         | 1.5         | 0.1         | 4.6         | $\mu\text{A}$ |
| 2.5 V       | 0.1         | 0.1         | 0.1         | 0.8         | 0.1         | 3.8         | $\mu\text{A}$ |
| 3.3 V       | -           | -           | 0.1         | 0.1         | 0.1         | 2.8         | $\mu\text{A}$ |

**Table 9. Static characteristics**

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

| Symbol   | Parameter                | Conditions  | -40 °C to +85 °C |                 | -40 °C to +125 °C |                 | Unit |   |
|----------|--------------------------|---|------------------|-----------------|-------------------|-----------------|------|---|
|          |                          |   | Min              | Max             | Min               | Max             |      |   |
| $V_{IH}$ | HIGH-level input voltage | A port  |                  |                 |                   |                 |      |   |
|          |                          | $V_{CC(A)} = 1.65\text{ V to }1.95\text{ V}$ ; $V_{CC(B)} = 2.3\text{ V to }5.5\text{ V}$ | [1]              | $V_{CCI} - 0.2$ | -                 | $V_{CCI} - 0.2$ | -    | V |
|          |                          | $V_{CC(A)} = 2.3\text{ V to }3.6\text{ V}$ ; $V_{CC(B)} = 2.3\text{ V to }5.5\text{ V}$   | [1]              | $V_{CCI} - 0.4$ | -                 | $V_{CCI} - 0.4$ | -    | V |
|          |                          | B port  |                  |                 |                   |                 |      |   |
|          |                          | $V_{CC(A)} = 1.65\text{ V to }3.6\text{ V}$ ; $V_{CC(B)} = 2.3\text{ V to }5.5\text{ V}$  | [1]              | $V_{CCI} - 0.4$ | -                 | $V_{CCI} - 0.4$ | -    | V |
|          |                          | OE input  |                  |                 |                   |                 |      |   |
|          |                          | $V_{CC(A)} = 1.65\text{ V to }3.6\text{ V}$ ; $V_{CC(B)} = 2.3\text{ V to }5.5\text{ V}$  |                  | $0.65V_{CC(A)}$ | -                 | $0.65V_{CC(A)}$ | -    | V |

**Table 9. Static characteristics ...continued**

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

| Symbol           | Parameter                 | Conditions   | -40 °C to +85 °C         |                        | -40 °C to +125 °C    |                        | Unit   |
|------------------|---------------------------|--|--------------------------|------------------------|----------------------|------------------------|--------|
|                  |                           |  | Min                      | Max                    | Min                  | Max                    |        |
| V <sub>IL</sub>  | LOW-level input voltage   | A or B port<br>V <sub>CC(A)</sub> = 1.65 V to 3.6 V;<br>V <sub>CC(B)</sub> = 2.3 V to 5.5 V  | -                        | 0.15                   | -                    | 0.15                   | V      |
|                  |                           | OE input<br>V <sub>CC(A)</sub> = 1.65 V to 3.6 V;<br>V <sub>CC(B)</sub> = 2.3 V to 5.5 V   | -                        | 0.35V <sub>CC(A)</sub> | -                    | 0.35V <sub>CC(A)</sub> | V      |
| V <sub>OH</sub>  | HIGH-level output voltage | A or B port; I <sub>O</sub> = -20 μA<br>V <sub>CC(A)</sub> = 1.65 V to 3.6 V;<br>V <sub>CC(B)</sub> = 2.3 V to 5.5 V                           | [2] 0.67V <sub>CCO</sub> | -                      | 0.67V <sub>CCO</sub> | -                      | V      |
| V <sub>OL</sub>  | LOW-level output voltage  | A or B port; I <sub>O</sub> = 1 mA<br>V <sub>I</sub> ≤ 0.15 V;<br>V <sub>CC(A)</sub> = 1.65 V to 3.6 V;<br>V <sub>CC(B)</sub> = 2.3 V to 5.5 V | [2]                      | -                      | 0.4                  | -                      | 0.4 V  |
| I <sub>I</sub>   | input leakage current     | OE input; V <sub>I</sub> = 0 V to 3.6 V;<br>V <sub>CC(A)</sub> = 1.65 V to 3.6 V;<br>V <sub>CC(B)</sub> = 2.3 V to 5.5 V                       | -                        | ±2                     | -                    | ±12                    | μA     |
| I <sub>OZ</sub>  | OFF-state output current  | A or B port; V <sub>O</sub> = 0 V or V <sub>CCO</sub> ;<br>V <sub>CC(A)</sub> = 1.65 V to 3.6 V;<br>V <sub>CC(B)</sub> = 2.3 V to 5.5 V        | [2]                      | -                      | ±2                   | -                      | ±12 μA |
| I <sub>OFF</sub> | power-off leakage current | A port; V <sub>I</sub> or V <sub>O</sub> = 0 V to 3.6 V;<br>V <sub>CC(A)</sub> = 0 V; V <sub>CC(B)</sub> = 0 V to 5.5 V                        | -                        | ±2                     | -                    | ±12                    | μA     |
|                  |                           | B port; V <sub>I</sub> or V <sub>O</sub> = 0 V to 3.6 V;<br>V <sub>CC(B)</sub> = 0 V; V <sub>CC(A)</sub> = 0 V to 3.6 V                        | -                        | ±2                     | -                    | ±12                    | μA     |
| I <sub>CC</sub>  | supply current            | V <sub>I</sub> = 0 V or V <sub>CCI</sub> ; I <sub>O</sub> = 0 A  | [1]                      |                        |                      |                        |        |
|                  |                           | I <sub>CC(A)</sub><br>V <sub>CC(A)</sub> = 1.65 V to 3.6 V;<br>V <sub>CC(B)</sub> = 2.3 V to 5.5 V   | -                        | 2.4                    | -                    | 15                     | μA     |
|                  |                           | V <sub>CC(A)</sub> = 3.6 V; V <sub>CC(B)</sub> = 0 V   | -                        | 2.2                    | -                    | 15                     | μA     |
|                  |                           | V <sub>CC(A)</sub> = 0 V; V <sub>CC(B)</sub> = 5.5 V   | -                        | -1                     | -                    | -8                     | μA     |
|                  |                           | I <sub>CC(B)</sub><br>V <sub>CC(A)</sub> = 1.65 V to 3.6 V;<br>V <sub>CC(B)</sub> = 2.3 V to 5.5 V   | -                        | 12                     | -                    | 30                     | μA     |
|                  |                           | V <sub>CC(A)</sub> = 3.6 V; V <sub>CC(B)</sub> = 0 V   | -                        | -1                     | -                    | -5                     | μA     |
|                  |                           | V <sub>CC(A)</sub> = 0 V; V <sub>CC(B)</sub> = 5.5 V   | -                        | 1                      | -                    | 6                      | μA     |
|                  |                           | I <sub>CC(A)</sub> + I <sub>CC(B)</sub><br>V <sub>CC(A)</sub> = 1.65 V to 3.6 V;<br>V <sub>CC(B)</sub> = 2.3 V to 5.5 V                        | -                        | 14.4                   | -                    | 45                     | μA     |

[1] V<sub>CCI</sub> is the supply voltage associated with the input.

[2] V<sub>CCO</sub> is the supply voltage associated with the output.



## 12. Dynamic characteristics

**Table 10. Dynamic characteristics for temperature range  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ <sup>[1]</sup>**

Voltages are referenced to GND (ground = 0 V); for test circuit see [Figure 9](#); for wave forms see [Figure 7](#) and [Figure 8](#).

| Symbol   | Parameter                          | Conditions                               | $V_{CC(B)}$                     |      |                                 |     |                                 |      | Unit |
|--|------------------------------------|--|---------------------------------|------|---------------------------------|-----|---------------------------------|------|------|
|  |                                    |  | $2.5\text{ V} \pm 0.2\text{ V}$ |      | $3.3\text{ V} \pm 0.3\text{ V}$ |     | $5.0\text{ V} \pm 0.5\text{ V}$ |      |      |
|  |                                    |  | Min                             | Max  | Min                             | Max | Min                             | Max  |      |
| <b><math>V_{CC(A)} = 1.8\text{ V} \pm 0.15\text{ V}</math></b> |                                    |  |                                 |      |                                 |     |                                 |      |      |
| $t_{PHL}$  | HIGH to LOW propagation delay      | A to B                                   | -                               | 4.6  | -                               | 4.7 | -                               | 5.8  | ns   |
| $t_{PLH}$  | LOW to HIGH propagation delay      | A to B                                   | -                               | 6.8  | -                               | 6.8 | -                               | 7.0  | ns   |
| $t_{PHL}$  | HIGH to LOW propagation delay      | B to A                                   | -                               | 4.4  | -                               | 4.5 | -                               | 4.7  | ns   |
| $t_{PLH}$  | LOW to HIGH propagation delay      | B to A                                   | -                               | 5.3  | -                               | 4.5 | -                               | 0.5  | ns   |
| $t_{en}$   | enable time                        | OE to A; B                               | -                               | 200  | -                               | 200 | -                               | 200  | ns   |
| $t_{dis}$  | disable time                       | OE to A; no external load <sup>[2]</sup> | -                               | 35   | -                               | 35  | -                               | 35   | ns   |
|  |                                    | OE to B; no external load <sup>[2]</sup> | -                               | 35   | -                               | 35  | -                               | 35   | ns   |
|  |                                    | OE to A                                  | -                               | 230  | -                               | 230 | -                               | 230  | ns   |
|  |                                    | OE to B                                  | -                               | 200  | -                               | 200 | -                               | 200  | ns   |
| $t_{TLH}$  | LOW to HIGH output transition time | A port                                   | 3.2                             | 9.5  | 2.3                             | 9.3 | 1.8                             | 7.6  | ns   |
|  |                                    | B port                                   | 3.3                             | 10.8 | 2.7                             | 9.1 | 2.7                             | 7.6  | ns   |
| $t_{THL}$  | HIGH to LOW output transition time | A port                                   | 2.0                             | 5.9  | 1.9                             | 6.0 | 1.7                             | 13.3 | ns   |
|  |                                    | B port                                   | 2.9                             | 7.6  | 2.8                             | 7.5 | 2.8                             | 10.0 | ns   |
| $t_{sk(o)}$  | output skew time                   | between channels <sup>[3]</sup>          | -                               | 0.7  | -                               | 0.7 | -                               | 0.7  | ns   |
| $t_W$  | pulse width                        | data inputs                              | 20                              | -    | 20                              | -   | 20                              | -    | ns   |
| $f_{data}$   | data rate                          |  | -                               | 50   | -                               | 50  | -                               | 50   | Mbps |
| <b><math>V_{CC(A)} = 2.5\text{ V} \pm 0.2\text{ V}</math></b>  |                                    |  |                                 |      |                                 |     |                                 |      |      |
| $t_{PHL}$  | HIGH to LOW propagation delay      | A to B                                   | -                               | 3.2  | -                               | 3.3 | -                               | 3.4  | ns   |
| $t_{PLH}$  | LOW to HIGH propagation delay      | A to B                                   | -                               | 3.5  | -                               | 4.1 | -                               | 4.4  | ns   |
| $t_{PHL}$  | HIGH to LOW propagation delay      | B to A                                   | -                               | 3.0  | -                               | 3.6 | -                               | 4.3  | ns   |
| $t_{PLH}$  | LOW to HIGH propagation delay      | B to A                                   | -                               | 2.5  | -                               | 1.6 | -                               | 0.7  | ns   |
| $t_{en}$   | enable time                        | OE to A; B                               | -                               | 200  | -                               | 200 | -                               | 200  | ns   |
| $t_{dis}$  | disable time                       | OE to A; no external load <sup>[2]</sup> | -                               | 35   | -                               | 35  | -                               | 35   | ns   |
|  |                                    | OE to B; no external load <sup>[2]</sup> | -                               | 35   | -                               | 35  | -                               | 35   | ns   |
|  |                                    | OE to A                                  | -                               | 200  | -                               | 200 | -                               | 200  | ns   |
|  |                                    | OE to B                                  | -                               | 200  | -                               | 200 | -                               | 200  | ns   |
| $t_{TLH}$  | LOW to HIGH output transition time | A port                                   | 2.8                             | 7.4  | 2.6                             | 6.6 | 1.8                             | 6.2  | ns   |
|  |                                    | B port                                   | 3.2                             | 8.3  | 2.9                             | 7.9 | 2.4                             | 6.8  | ns   |

**Table 10. Dynamic characteristics for temperature range –40 °C to +85 °C<sup>[1]</sup>**

*Voltages are referenced to GND (ground = 0 V); for test circuit see [Figure 9](#); for wave forms see [Figure 7](#) and [Figure 8](#).*

| Symbol                                   | Parameter                          | Conditions                               | V <sub>CC(B)</sub> |     |               |     |               |     | Unit |
|--|------------------------------------|--|--------------------|-----|---------------|-----|---------------|-----|------|
|  |                                    |  | 2.5 V ± 0.2 V      |     | 3.3 V ± 0.3 V |     | 5.0 V ± 0.5 V |     |      |
|  |                                    |  | Min                | Max | Min           | Max | Min           | Max |      |
| t <sub>THL</sub>                         | HIGH to LOW output transition time | A port                                   | 1.9                | 5.7 | 1.9           | 5.5 | 1.8           | 5.3 | ns   |
|  |                                    | B port                                   | 2.2                | 7.8 | 2.4           | 6.7 | 2.6           | 6.6 | ns   |
| t <sub>sk(o)</sub>                       | output skew time                   | between channels <sup>[3]</sup>          | -                  | 0.7 | -             | 0.7 | -             | 0.7 | ns   |
| t <sub>W</sub>                           | pulse width                        | data inputs                              | 20                 | -   | 20            | -   | 20            | -   | ns   |
| f <sub>data</sub>                        | data rate                          |  | -                  | 50  | -             | 50  | -             | 50  | Mbps |
| <b>V<sub>CC(A)</sub> = 3.3 V ± 0.3 V</b> |                                    |  |                    |     |               |     |               |     |      |
| t <sub>PHL</sub>                         | HIGH to LOW propagation delay      | A to B                                   | -                  | -   | -             | 2.4 | -             | 3.1 | ns   |
| t <sub>PLH</sub>                         | LOW to HIGH propagation delay      | A to B                                   | -                  | -   | -             | 4.2 | -             | 4.4 | ns   |
| t <sub>PHL</sub>                         | HIGH to LOW propagation delay      | B to A                                   | -                  | -   | -             | 2.5 | -             | 3.3 | ns   |
| t <sub>PLH</sub>                         | LOW to HIGH propagation delay      | B to A                                   | -                  | -   | -             | 2.5 | -             | 2.6 | ns   |
| t <sub>en</sub>                          | enable time                        | OE to A; B                               | -                  | -   | -             | 200 | -             | 200 | ns   |
| t <sub>dis</sub>                         | disable time                       | OE to A; no external load <sup>[2]</sup> | -                  | -   | -             | 35  | -             | 35  | ns   |
|  |                                    | OE to B; no external load <sup>[2]</sup> | -                  | -   | -             | 35  | -             | 35  | ns   |
|  |                                    | OE to A                                  | -                  | -   | -             | 260 | -             | 260 | ns   |
|  |                                    | OE to B                                  | -                  | -   | -             | 200 | -             | 200 | ns   |
| t <sub>TLH</sub>                         | LOW to HIGH output transition time | A port                                   | -                  | -   | 2.3           | 5.6 | 1.9           | 5.9 | ns   |
|  |                                    | B port                                   | -                  | -   | 2.5           | 6.4 | 2.1           | 7.4 | ns   |
| t <sub>THL</sub>                         | HIGH to LOW output transition time | A port                                   | -                  | -   | 2.0           | 5.4 | 1.9           | 5.0 | ns   |
|  |                                    | B port                                   | -                  | -   | 2.3           | 7.4 | 2.4           | 7.6 | ns   |
| t <sub>sk(o)</sub>                       | output skew time                   | between channels <sup>[3]</sup>          | -                  | -   | -             | 0.7 | -             | 0.7 | ns   |
| t <sub>W</sub>                           | pulse width                        | data inputs                              | -                  | -   | 20            | -   | 20            | -   | ns   |
| f <sub>data</sub>                        | data rate                          |  | -                  | -   | -             | 50  | -             | 50  | Mbps |

[1] t<sub>en</sub> is the same as t<sub>pZL</sub> and t<sub>pZH</sub>.

t<sub>dis</sub> is the same as t<sub>pLZ</sub> and t<sub>pHZ</sub>.

[2] Delay between OE going LOW and when the outputs are actually disabled.

[3] Skew between any two outputs of the same package switching in the same direction.

## Dual supply translating transceiver; open drain; auto direction sensing

**Table 11. Dynamic characteristics for temperature range  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$ <sup>[1]</sup>**Voltages are referenced to GND (ground = 0 V); for test circuit see [Figure 9](#); for wave forms see [Figure 7](#) and [Figure 8](#).

| Symbol   | Parameter                          | Conditions                               | $V_{CC(B)}$                     |      |                                 |      |                                 |      | Unit |
|--|------------------------------------|--|---------------------------------|------|---------------------------------|------|---------------------------------|------|------|
|  |                                    |  | $2.5\text{ V} \pm 0.2\text{ V}$ |      | $3.3\text{ V} \pm 0.3\text{ V}$ |      | $5.0\text{ V} \pm 0.5\text{ V}$ |      |      |
|  |                                    |  | Min                             | Max  | Min                             | Max  | Min                             | Max  |      |
| <b><math>V_{CC(A)} = 1.8\text{ V} \pm 0.15\text{ V}</math></b> |                                    |  |                                 |      |                                 |      |                                 |      |      |
| $t_{PHL}$  | HIGH to LOW propagation delay      | A to B                                   | -                               | 5.8  | -                               | 5.9  | -                               | 7.3  | ns   |
| $t_{PLH}$  | LOW to HIGH propagation delay      | A to B                                   | -                               | 8.5  | -                               | 8.5  | -                               | 8.8  | ns   |
| $t_{PHL}$  | HIGH to LOW propagation delay      | B to A                                   | -                               | 5.5  | -                               | 5.7  | -                               | 5.9  | ns   |
| $t_{PLH}$  | LOW to HIGH propagation delay      | B to A                                   | -                               | 6.7  | -                               | 5.7  | -                               | 0.7  | ns   |
| $t_{en}$   | enable time                        | OE to A; B                               | -                               | 200  | -                               | 200  | -                               | 200  | ns   |
| $t_{dis}$  | disable time                       | OE to A; no external load <sup>[2]</sup> | -                               | 45   | -                               | 45   | -                               | 45   | ns   |
|  |                                    | OE to B; no external load <sup>[2]</sup> | -                               | 45   | -                               | 45   | -                               | 45   | ns   |
|  |                                    | OE to A                                  | -                               | 250  | -                               | 250  | -                               | 250  | ns   |
|  |                                    | OE to B                                  | -                               | 220  | -                               | 220  | -                               | 220  | ns   |
| $t_{TLH}$  | LOW to HIGH output transition time | A port                                   | 3.2                             | 11.9 | 2.3                             | 11.7 | 1.8                             | 9.5  | ns   |
|  |                                    | B port                                   | 3.3                             | 13.5 | 2.7                             | 11.4 | 2.7                             | 9.5  | ns   |
| $t_{THL}$  | HIGH to LOW output transition time | A port                                   | 2.0                             | 7.4  | 1.9                             | 7.5  | 1.7                             | 16.7 | ns   |
|  |                                    | B port                                   | 2.9                             | 9.5  | 2.8                             | 9.4  | 2.8                             | 12.5 | ns   |
| $t_{sk(o)}$  | output skew time                   | between channels <sup>[3]</sup>          | -                               | 0.8  | -                               | 0.8  | -                               | 0.8  | ns   |
| $t_W$  | pulse width                        | data inputs                              | 20                              | -    | 20                              | -    | 20                              | -    | ns   |
| $f_{data}$   | data rate                          |  | -                               | 50   | -                               | 50   | -                               | 50   | Mbps |
| <b><math>V_{CC(A)} = 2.5\text{ V} \pm 0.2\text{ V}</math></b>  |                                    |  |                                 |      |                                 |      |                                 |      |      |
| $t_{PHL}$  | HIGH to LOW propagation delay      | A to B                                   | -                               | 4.0  | -                               | 4.2  | -                               | 4.3  | ns   |
| $t_{PLH}$  | LOW to HIGH propagation delay      | A to B                                   | -                               | 4.4  | -                               | 5.2  | -                               | 5.5  | ns   |
| $t_{PHL}$  | HIGH to LOW propagation delay      | B to A                                   | -                               | 3.8  | -                               | 4.5  | -                               | 5.4  | ns   |
| $t_{PLH}$  | LOW to HIGH propagation delay      | B to A                                   | -                               | 3.2  | -                               | 2.0  | -                               | 0.9  | ns   |
| $t_{en}$   | enable time                        | OE to A; B                               | -                               | 200  | -                               | 200  | -                               | 200  | ns   |
| $t_{dis}$  | disable time                       | OE to A; no external load <sup>[2]</sup> | -                               | 45   | -                               | 45   | -                               | 45   | ns   |
|  |                                    | OE to B; no external load <sup>[2]</sup> | -                               | 45   | -                               | 45   | -                               | 45   | ns   |
|  |                                    | OE to A                                  | -                               | 220  | -                               | 220  | -                               | 220  | ns   |
|  |                                    | OE to B                                  | -                               | 220  | -                               | 220  | -                               | 220  | ns   |
| $t_{TLH}$  | LOW to HIGH output transition time | A port                                   | 2.8                             | 9.3  | 2.6                             | 8.3  | 1.8                             | 7.8  | ns   |
|  |                                    | B port                                   | 3.2                             | 10.4 | 2.9                             | 9.7  | 2.4                             | 8.3  | ns   |

**Table 11. Dynamic characteristics for temperature range  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$ <sup>[1]</sup> ...continued**  
 Voltages are referenced to GND (ground = 0 V); for test circuit see [Figure 9](#); for wave forms see [Figure 7](#) and [Figure 8](#).

| Symbol  | Parameter                          | Conditions                               | $V_{CC(B)}$                     |     |                                 |     |                                 |     | Unit |
|---|------------------------------------|--|---------------------------------|-----|---------------------------------|-----|---------------------------------|-----|------|
|   |                                    |  | $2.5\text{ V} \pm 0.2\text{ V}$ |     | $3.3\text{ V} \pm 0.3\text{ V}$ |     | $5.0\text{ V} \pm 0.5\text{ V}$ |     |      |
|   |                                    |  | Min                             | Max | Min                             | Max | Min                             | Max |      |
| $t_{THL}$   | HIGH to LOW output transition time | A port                                   | 1.9                             | 7.2 | 1.9                             | 6.9 | 1.8                             | 6.7 | ns   |
|   |                                    | B port                                   | 2.2                             | 9.8 | 2.4                             | 8.4 | 2.6                             | 8.3 | ns   |
| $t_{sk(o)}$   | output skew time                   | between channels <sup>[3]</sup>          | -                               | 0.8 | -                               | 0.8 | -                               | 0.8 | ns   |
| $t_W$   | pulse width                        | data inputs                              | 20                              | -   | 20                              | -   | 20                              | -   | ns   |
| $f_{data}$  | data rate                          |  | -                               | 50  | -                               | 50  | -                               | 50  | Mbps |
| <b><math>V_{CC(A)} = 3.3\text{ V} \pm 0.3\text{ V}</math></b> |                                    |  |                                 |     |                                 |     |                                 |     |      |
| $t_{PHL}$   | HIGH to LOW propagation delay      | A to B                                   | -                               | -   | -                               | 3.0 | -                               | 3.9 | ns   |
| $t_{PLH}$   | LOW to HIGH propagation delay      | A to B                                   | -                               | -   | -                               | 5.3 | -                               | 5.5 | ns   |
| $t_{PHL}$   | HIGH to LOW propagation delay      | B to A                                   | -                               | -   | -                               | 3.2 | -                               | 4.2 | ns   |
| $t_{PLH}$   | LOW to HIGH propagation delay      | B to A                                   | -                               | -   | -                               | 3.2 | -                               | 3.3 | ns   |
| $t_{en}$  | enable time                        | OE to A; B                               | -                               | -   | -                               | 200 | -                               | 200 | ns   |
| $t_{dis}$   | disable time                       | OE to A; no external load <sup>[2]</sup> | -                               | -   | -                               | 45  | -                               | 45  | ns   |
|   |                                    | OE to B; no external load <sup>[2]</sup> | -                               | -   | -                               | 45  | -                               | 45  | ns   |
|   |                                    | OE to A                                  | -                               | -   | -                               | 280 | -                               | 280 | ns   |
|   |                                    | OE to B                                  | -                               | -   | -                               | 220 | -                               | 220 | ns   |
| $t_{TLH}$   | LOW to HIGH output transition time | A port                                   | -                               | -   | 2.3                             | 7.0 | 1.9                             | 7.4 | ns   |
|   |                                    | B port                                   | -                               | -   | 2.5                             | 8.0 | 2.1                             | 9.3 | ns   |
| $t_{THL}$   | HIGH to LOW output transition time | A port                                   | -                               | -   | 2.0                             | 6.8 | 1.9                             | 6.3 | ns   |
|   |                                    | B port                                   | -                               | -   | 2.3                             | 9.3 | 2.4                             | 9.5 | ns   |
| $t_{sk(o)}$   | output skew time                   | between channels <sup>[3]</sup>          | -                               | -   | -                               | 0.8 | -                               | 0.8 | ns   |
| $t_W$   | pulse width                        | data inputs                              | -                               | -   | 20                              | -   | 20                              | -   | ns   |
| $f_{data}$  | data rate                          |  | -                               | -   | -                               | 50  | -                               | 50  | Mbps |

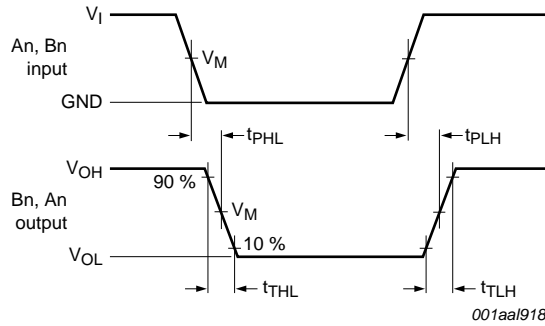
[1]  $t_{en}$  is the same as  $t_{pZL}$  and  $t_{pZH}$ .

$t_{dis}$  is the same as  $t_{pLZ}$  and  $t_{pHZ}$ .

[2] Delay between OE going LOW and when the outputs are actually disabled.

[3] Skew between any two outputs of the same package switching in the same direction.

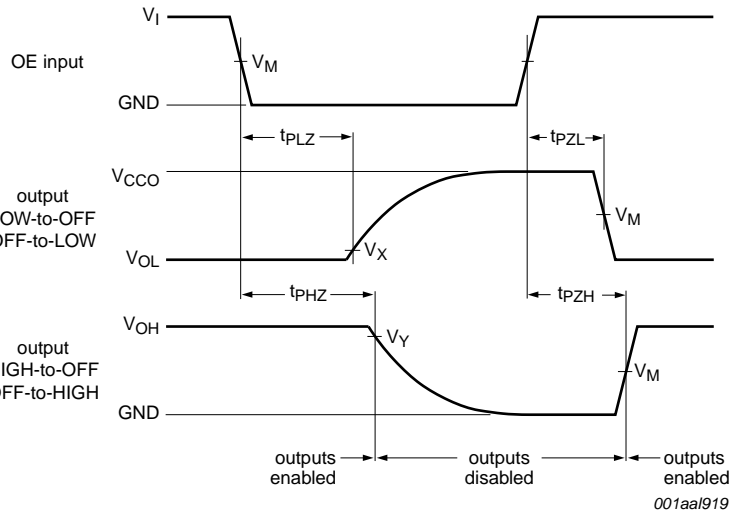
13. Waveforms



Measurement points are given in [Table 12](#).

$V_{OL}$  and  $V_{OH}$  are typical output voltage levels that occur with the output load.

**Fig 7. The data input (An, Bn) to data output (Bn, An) propagation delay times**



Measurement points are given in [Table 12](#).

$V_{OL}$  and  $V_{OH}$  are typical output voltage levels that occur with the output load.

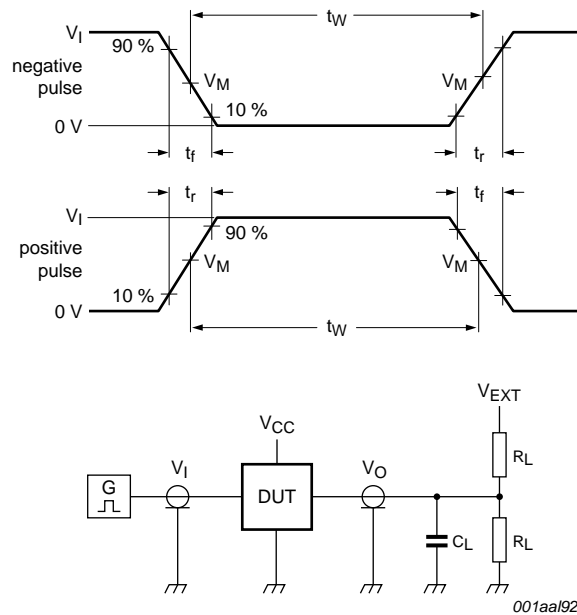
**Fig 8. Enable and disable times**

**Table 12. Measurement points<sup>[1][2]</sup>**

| Supply voltage | Input         | Output        |                   |                   |
|----------------|---------------|---------------|-------------------|-------------------|
| $V_{CCO}$      | $V_M$         | $V_M$         | $V_X$             | $V_Y$             |
| 1.8 V ± 0.15 V | 0.5 $V_{CCI}$ | 0.5 $V_{CCO}$ | $V_{OL} + 0.15$ V | $V_{OH} - 0.15$ V |
| 2.5 V ± 0.2 V  | 0.5 $V_{CCI}$ | 0.5 $V_{CCO}$ | $V_{OL} + 0.15$ V | $V_{OH} - 0.15$ V |
| 3.3 V ± 0.3 V  | 0.5 $V_{CCI}$ | 0.5 $V_{CCO}$ | $V_{OL} + 0.3$ V  | $V_{OH} - 0.3$ V  |
| 5.0 V ± 0.5 V  | 0.5 $V_{CCI}$ | 0.5 $V_{CCO}$ | $V_{OL} + 0.3$ V  | $V_{OH} - 0.3$ V  |

[1]  $V_{CCI}$  is the supply voltage associated with the input.

[2]  $V_{CCO}$  is the supply voltage associated with the output.



Test data is given in [Table 13](#).

All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz; Z<sub>O</sub> = 50 Ω; dV/dt ≥ 1.0 V/ns.

R<sub>L</sub> = Load resistance.

C<sub>L</sub> = Load capacitance including jig and probe capacitance.

V<sub>EXT</sub> = External voltage for measuring switching times.

**Fig 9. Test circuit for measuring switching times**

**Table 13. Test data**

| Supply voltage     |                    | Input                         |            | Load           |                               | V <sub>EXT</sub>                    |                                     |  |
|--------------------|--------------------|-------------------------------|------------|----------------|-------------------------------|-------------------------------------|-------------------------------------|--|
| V <sub>CC(A)</sub> | V <sub>CC(B)</sub> | V <sub>I</sub> <sup>[1]</sup> | Δt/ΔV      | C <sub>L</sub> | R <sub>L</sub> <sup>[2]</sup> | t <sub>PLH</sub> , t <sub>PHL</sub> | t <sub>PZH</sub> , t <sub>PHZ</sub> | t <sub>PZL</sub> , t <sub>PLZ</sub> <sup>[3]</sup> |
| 1.65 V to 3.6 V    | 2.3 V to 5.5 V     | V <sub>CCI</sub>              | ≤ 1.0 ns/V | 15 pF          | 50 kΩ, 1 MΩ                   | open                                | open                                | 2V <sub>CCO</sub>                                  |

[1] V<sub>CCI</sub> is the supply voltage associated with the input.

[2] For measuring data rate, pulse width, propagation delay and output rise and fall measurements, R<sub>L</sub> = 1 MΩ; for measuring enable and disable times, R<sub>L</sub> = 50 kΩ.

[3] V<sub>CCO</sub> is the supply voltage associated with the output.

## 14. Application information

### 14.1 Applications

Voltage level-translation applications. The NTS0104 can be used in point-to-point applications to interface between devices or systems operating at different supply voltages. The device is primarily targeted at I<sup>2</sup>C or 1-wire which use open-drain drivers, it may also be used in applications where push-pull drivers are connected to the ports, however the NTB0104 may be more suitable.

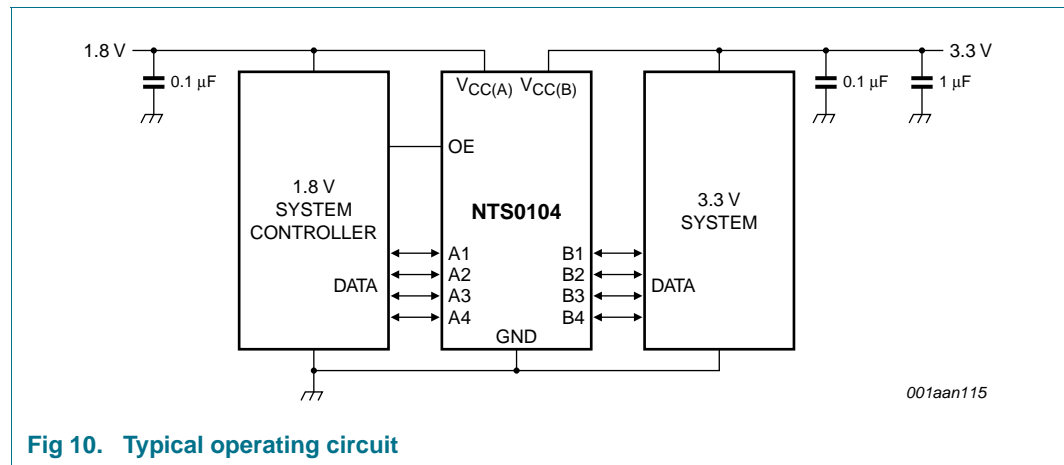


Fig 10. Typical operating circuit

### 14.2 Architecture

The architecture of the NTS0104 is shown in Figure 11. The device does not require an extra input signal to control the direction of data flow from A to B or B to A.

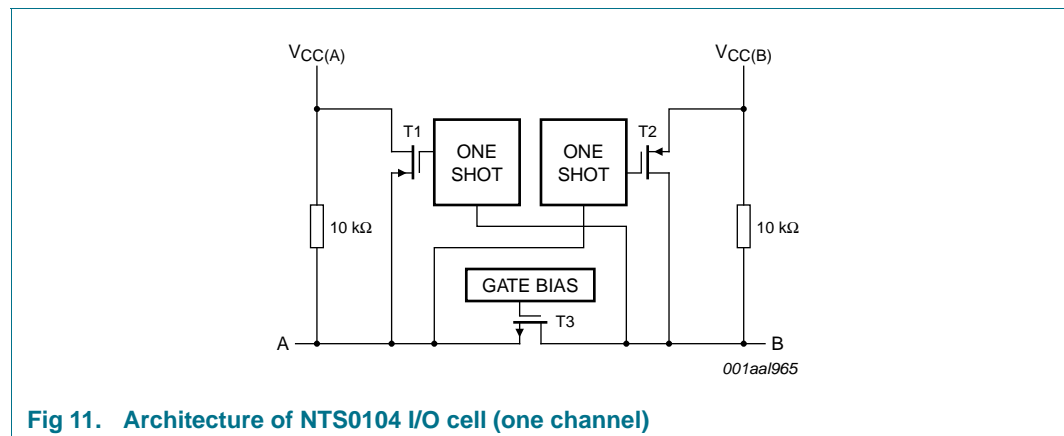


Fig 11. Architecture of NTS0104 I/O cell (one channel)

The NTS0104 is a "switch" type voltage translator, it employs two key circuits to enable voltage translation:

1. A pass-gate transistor (N-channel) that ties the ports together.
2. An output edge-rate accelerator that detects and accelerates rising edges on the I/O pins.

The gate bias voltage of the pass gate transistor (T3) is set at approximately one threshold voltage above the  $V_{CC}$  level of the low-voltage side. During a LOW-to-HIGH transition the output one-shot accelerates the output transition by switching on the PMOS transistors (T1, T2) bypassing the 10 k $\Omega$  pull-up resistors and increasing current drive capability. The one-shot is activated once the input transition reaches approximately  $V_{CC}/2$ ; it is de-activated approximately 50 ns after the output reaches  $V_{CC}/2$ . During the acceleration time the driver output resistance is between approximately 50  $\Omega$  and 70  $\Omega$ . To avoid signal contention and minimize dynamic  $I_{CC}$ , the user should wait for the one-shot circuit to turn-off before applying a signal in the opposite direction. Pull-up resistors are included in the device for DC current sourcing capability.

### 14.3 Input driver requirements

As the NTS0104 is a switch type translator, properties of the input driver directly effect the output signal. The external open-drain or push-pull driver applied to an I/O determines the static current sinking capability of the system; the max data rate, HIGH-to-LOW output transition time ( $t_{THL}$ ) and propagation delay ( $t_{PHL}$ ) are dependent upon the output impedance and edge-rate of the external driver. The limits provided for these parameters in the datasheet assume a driver with output impedance below 50  $\Omega$  is used.

### 14.4 Output load considerations

The maximum lumped capacitive load that can be driven is dependant upon the one-shot pulse duration. In cases with very heavy capacitive loading there is a risk that the output will not reach the positive rail within the one-shot pulse duration.

To avoid excessive capacitive loading and to ensure correct triggering of the one-shot it's recommended to use short trace lengths and low capacitance connectors on NTS0104 PCB layouts. To ensure low impedance termination and avoid output signal oscillations and one-shot re-triggering, the length of the PCB trace should be such that the round trip delay of any reflection is within the one-shot pulse duration (approximately 50 ns).

### 14.5 Power up

During operation  $V_{CC(A)}$  must never be higher than  $V_{CC(B)}$ , however during power-up  $V_{CC(A)} \geq V_{CC(B)}$  does not damage the device, so either power supply can be ramped up first. There is no special power-up sequencing required. The NTS0104 includes circuitry that disables all output ports when either  $V_{CC(A)}$  or  $V_{CC(B)}$  is switched off.

### 14.6 Enable and disable

An output enable input (OE) is used to disable the device. Setting OE = LOW

causes all I/Os to assume the high-impedance OFF-state. The disable time ( $t_{dis}$  with no external load) indicates the delay between when OE goes LOW and when outputs actually become disabled. The enable time ( $t_{en}$ ) indicates the amount of time the user must allow for one one-shot circuitry to become operational after OE is taken HIGH. To ensure the high-impedance OFF-state during power-up or power-down, pin OE should be tied to GND through a pull-down resistor, the minimum value of the resistor is determined by the current-sourcing capability of the driver.



### 14.7 Pull-up or pull-down resistors on I/Os lines

Each A port I/O has an internal 10 k $\Omega$  pull-up resistor to  $V_{CC(A)}$ , and each B port I/O has an internal 10 k $\Omega$  pull-up resistor to  $V_{CC(B)}$ . If a smaller value of pull-up resistor is required, an external resistor must be added parallel to the internal 10 k $\Omega$ , this will effect the  $V_{OL}$  level. When OE goes LOW the internal pull-ups of the NTS0104 are disabled.

15. Package outline

TSSOP14: plastic thin shrink small outline package; 14 leads; body width 4.4 mm

SOT402-1

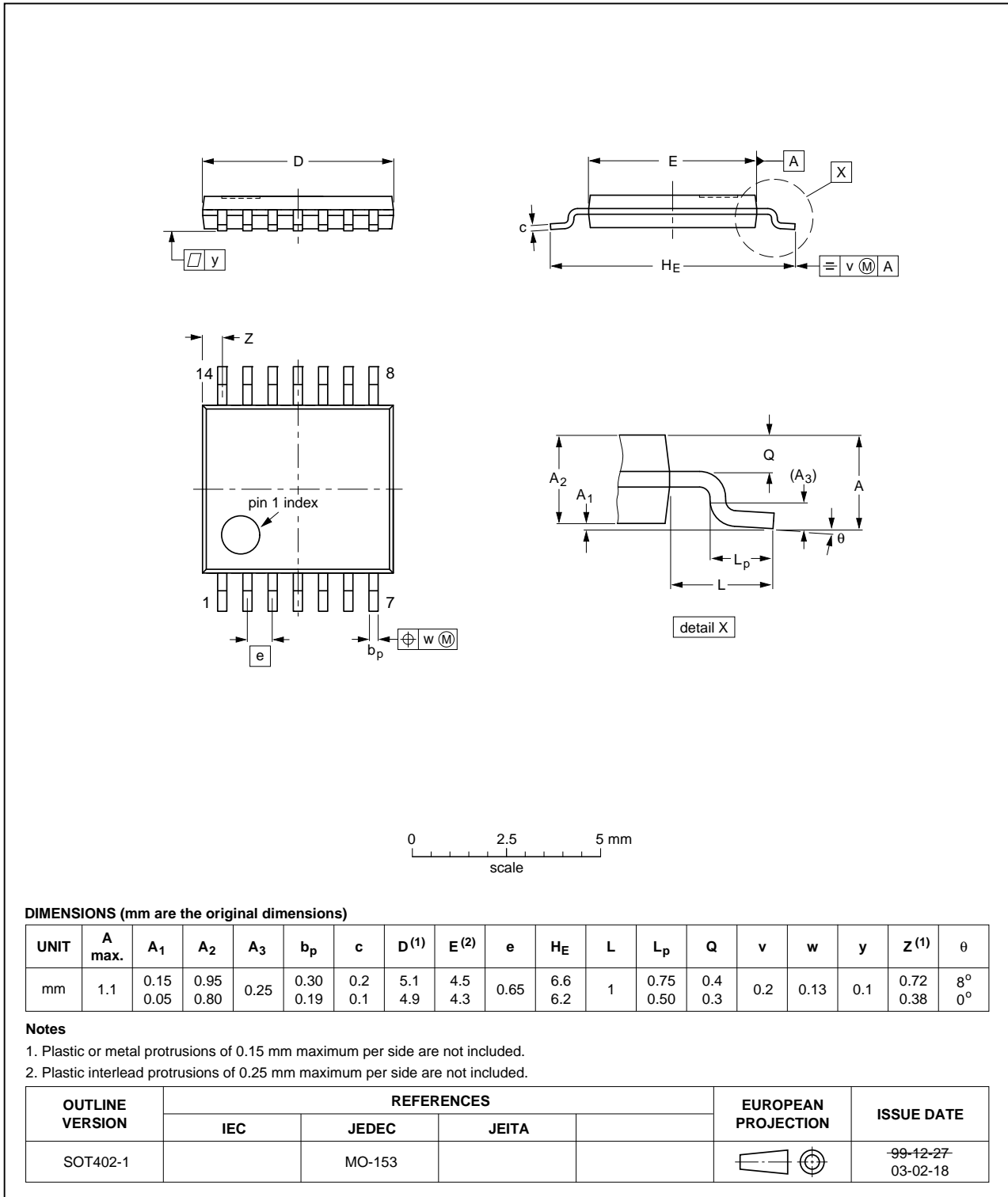


Fig 12. Package outline SOT402-1 (TSSOP14)

DHVQFN14: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 14 terminals; body 2.5 x 3 x 0.85 mm

SOT762-1

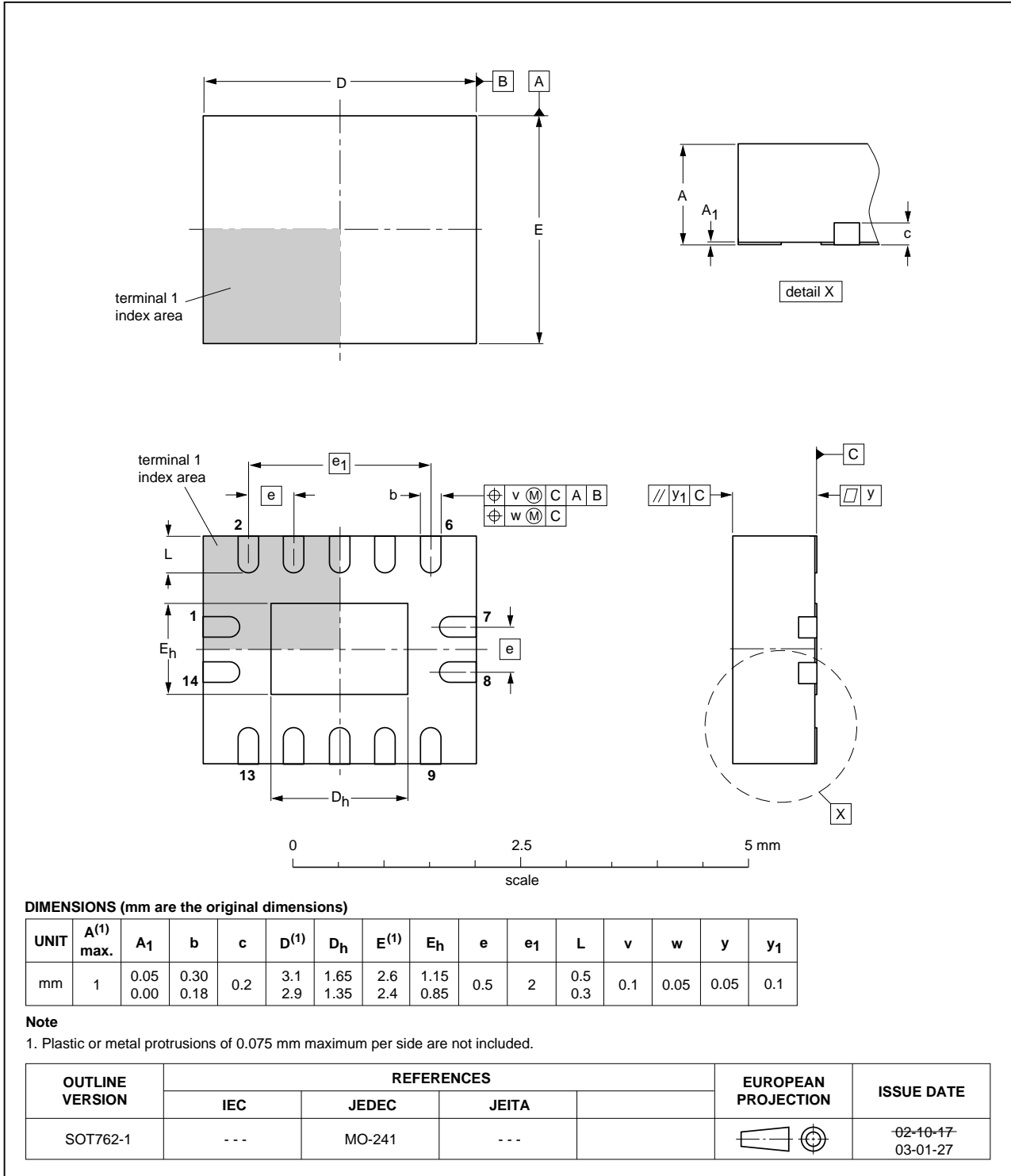


Fig 13. Package outline SOT762-1 (DHVQFN14)

XQFN12: plastic, extremely thin quad flat package; no leads;  
12 terminals; body 1.70 x 2.00 x 0.50 mm

SOT1174-1

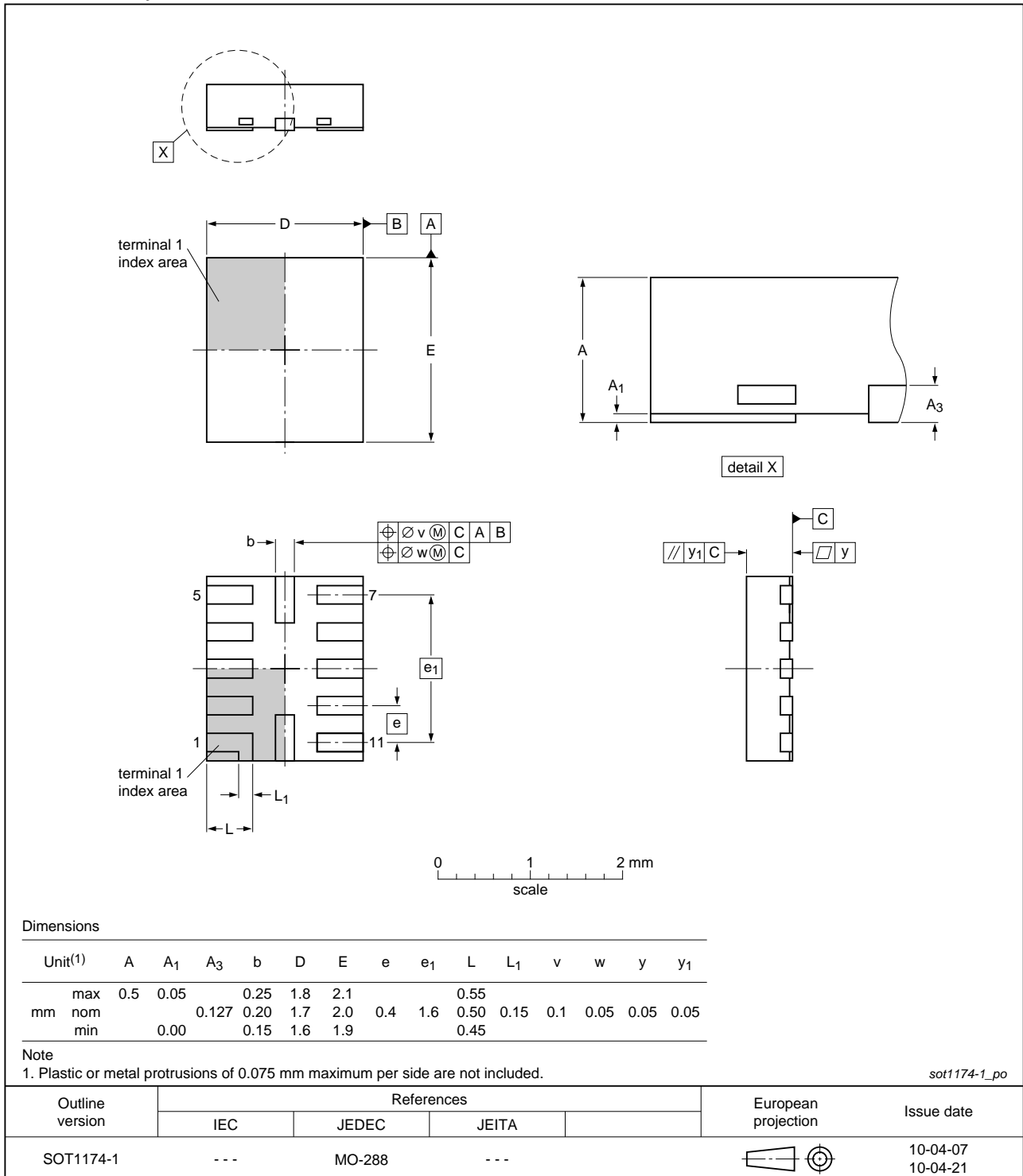


Fig 14. Package outline SOT1174-1 (XQFN12)

WLCSP12: wafer level chip-size package,  
12 bumps; body 1.20 x 1.60 x 0.56 mm. (Backside Coating included)

NTS0104UK

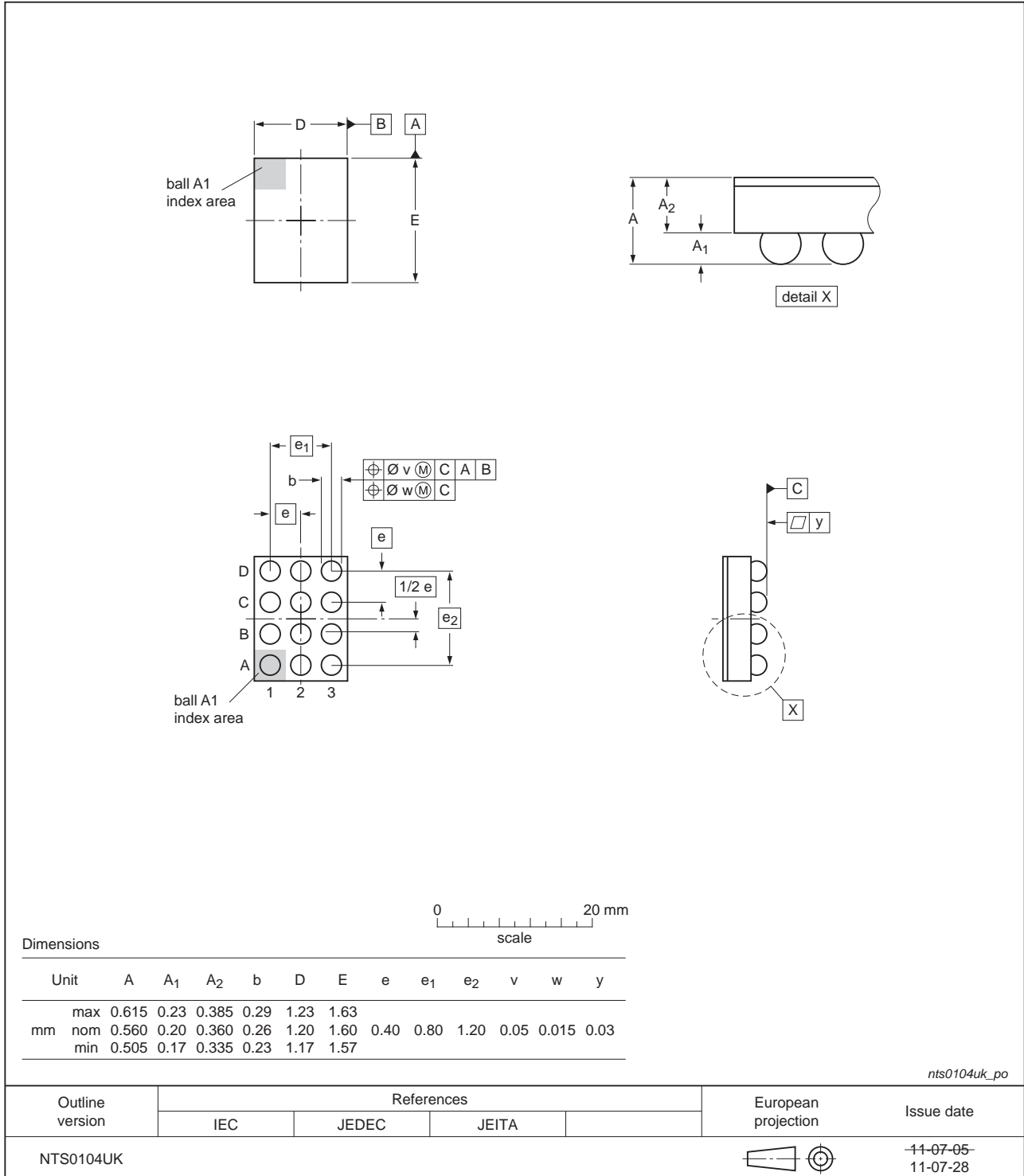


Fig 15. Package outline WLCSP12 package

## 16. Abbreviations

Table 14. Abbreviations

| Acronym          | Description                                 |
|------------------|---|
| CDM              | Charged Device Model                        |
| CMOS             | Complementary Metal Oxide Semiconductor     |
| DUT              | Device Under Test                           |
| ESD              | ElectroStatic Discharge                     |
| GPIO             | General Purpose Input Output                |
| HBM              | Human Body Model                            |
| I <sup>2</sup> C | Inter-Integrated Circuit                    |
| MM               | Machine Model                               |
| SMBus            | System Management Bus                       |
| UART             | Universal Asynchronous Receiver Transmitter |

## 17. Revision history

Table 15. Revision history

| Document ID    | Release date   | Data sheet status  | Change notice | Supersedes  |
|----------------|--|--------------------|---------------|-------------|
| NTS0104 v.3    | 20120103   | Product data sheet | -             | NTS0104 v.2 |
| Modifications: | <ul style="list-style-type: none"><li>• NTS0104UK added.</li><li>• NTS0104D removed.</li></ul> |                    |               |             |
| NTS0104 v.2    | 20110427   | Product data sheet | -             | NTS0104 v.1 |
| NTS0104 v.1    | 20101125   | Product data sheet | -             | -           |

## 18. Legal information

### 18.1 Data sheet status

| Document status <sup>[1][2]</sup> | Product status <sup>[3]</sup> | Definition  |
|-----------------------------------|-------------------------------|---|
| Objective [short] data sheet      | Development                   | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet    | Qualification                 | This document contains data from the preliminary specification.                       |
| Product [short] data sheet        | Production                    | This document contains the product specification.                                     |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

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