# TXS0104 4-Bit Bidirectional Voltage-Level Translator for Open-Drain and Push-Pull Applications

## 1 Features

- No direction-control signal needed
- Maximum data rates:
  - 50Mbps (push pull)
  - 2Mbps (open drain)
- Available in the Texas Instruments NanoFree™ package
- 1.1V to 3.6V on A port and 1.65V to 5.5V on B port
- No power-supply sequencing required – either VCCA or VCCB can be ramped first
- VCCA can be >, =, < VCCB
- Latch-up performance exceeds 100mA per JESD 78, class II
- ESD protection exceeds JESD 22:
  - A port:
    - 2000V Human-Body Model (A114-B)
    - 200V Machine Model (A115-A)
    - 1000V Charged-Device Model (C101)
  - B port:
    - 4kV Human-Body Model (A114-B)
    - 200V Machine Model (A115-A)
    - 1000V Charged-Device Model (C101)

## 2 Applications

- Handset
- Smartphone
- Tablet
- Desktop PC

## 3 Description

This 4-bit non-inverting translator uses two separate configurable power-supply rails. The A port is designed to track $V_{CCA}$. $V_{CCA}$ accepts any supply voltage from 1.1V to 3.6V. The B port is designed to track $V_{CCB}$. $V_{CCB}$ accepts any supply voltage from 1.65V to 5.5V. This allows for low-voltage bidirectional translation between any of the 1.1V, 1.8V, 2.V, 3.3V, and 5V voltage nodes.

When the output-enable (OE) input is low, all outputs are placed in the high-impedance state.

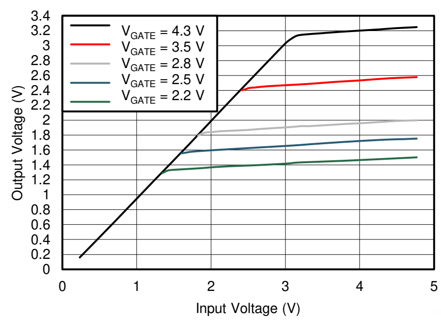
The TXS0104 is designed so that the OE input circuit is supplied by $V_{CCA}$.

For the high-impedance state during power up or power down, tie OE to GND through a pull-down resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

**Package Information**

| PART NUMBER | PACKAGE(1) | PACKAGE SIZE(2) |
|---|---|---|
| TXS0104 | YCJ (DSBGA, 14) | 1.4mm × 1.05mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.
(2) The package size (length × width) is a nominal value and includes pins, where applicable




**Transfer Characteristics of an N-Channel Transistor**

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# 4 Pin Configuration and Functions

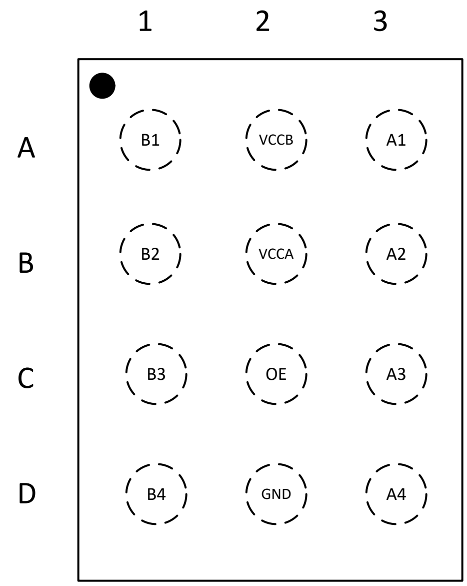



**Figure 4-1. YCJ Package, 12-Pin DSBGA (Top View)**

**Table 4-1. Pin Functions: DSBGA**

| PIN | | TYPE | DESCRIPTION |
|---|---|---|---|
| NO. | NAME | | |
| A3 | A1 | I/O | Input/output A1. Referenced to $V_{CCA}$. |
| B3 | A2 | I/O | Input/output A2. Referenced to $V_{CCA}$. |
| C3 | A3 | I/O | Input/output A3. Referenced to $V_{CCA}$. |
| D3 | A4 | I/O | Input/output A4. Referenced to $V_{CCA}$. |
| A1 | B1 | I/O | Input/output B1. Referenced to $V_{CCB}$. |
| B1 | B2 | I/O | Input/output B2. Referenced to $V_{CCB}$. |
| C1 | B3 | I/O | Input/output B3. Referenced to $V_{CCB}$. |
| D1 | B4 | I/O | Input/output B4. Referenced to $V_{CCB}$. |
| D2 | GND | — | Ground |
| C2 | OE | I | 3-state output-mode enable. Pull OE low to place all outputs in 3-state mode. Referenced to $V_{CCA}$. |
| B2 | $V_{CCA}$ | — | A-port supply voltage. 1.1V ≤ $V_{CCA}$ ≤ 3.6V and $V_{CCA}$ ≤ $V_{CCB}$. |
| A2 | $V_{CCB}$ | — | B-port supply voltage. 1.65V ≤ $V_{CCB}$ ≤ 5.5V. |

# 5 Specifications

## 5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1]

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $V_{CCA}$ | Supply voltage A | | –0.5 | 4.6 | V |
| $V_{CCB}$ | Supply voltage B | | –0.5 | 6.5 | V |
| $V_I$ | Input Voltage[2] | I/O Ports (A Port) | –0.5 | 4.6 | V |
| | | I/O Ports (B Port) | –0.5 | 6.5 | |
| $V_I$ | Input Voltage[2] | OE | –0.5 | 6.5 | V |
| $V_O$ | Voltage applied to any output in the high-impedance or power-off state[2] | A Port | –0.5 | 4.6 | V |
| | | B Port | –0.5 | 6.5 | |
| $V_O$ | Voltage applied to any output in the high or low state[2] [3] | A Port | –0.5 | $V_{CCA}$ + 0.5 | V |
| | | B Port | –0.5 | $V_{CCB}$ + 0.5 | |
| $I_{IK}$ | Input clamp current | $V_I < 0$ | –50 | | mA |
| $I_{OK}$ | Output clamp current | $V_O < 0$ | –50 | | mA |
| $I_O$ | Continuous output current | | –50 | 50 | mA |
| | Continuous current through $V_{CC}$ or GND | | –100 | 100 | mA |
| $T_j$ | Junction Temperature | | | 150 | °C |
| $T_{stg}$ | Storage temperature | | –65 | 150 | °C |

(1) Stresses beyond those listed under *Section 5.1* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Section 5.3* Exposure beyond the limits listed in *Section 5.3* may affect device reliability.
(2) The input voltage and output negative-voltage ratings may be exceeded if the input and output current ratings are observed.
(3) The output positive-voltage rating may be exceeded up to 6.5V maximum if the output current rating is observed.

## 5.2 ESD Ratings

| | | | | VALUE | UNIT |
|---|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 | A Port | ±2000 | V |
| | | | B Port | ±4000 | |
| | | Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002 | A Port | ±1000 | |
| | | | B Port | ±1000 | |

## 5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted) (1) (2) (3)

| | | | $V_{CCA}$ | $V_{CCB}$ | MIN | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{CCA}$ | Supply voltage A | | | | 1.1 | 3.6 | V |
| $V_{CCB}$ | Supply voltage B | | | | 1.65 | 5.5 | V |
| OS | One-Shot Activation Threshold | A-port I/O's | 1.1V to 3.6V | 1.65V to 5.5V | $V_{CCI}$ x 0.30 | | V |
| | | B-port I/O's | 1.1V to 3.6V | 1.65V to 5.5V | $V_{CCI}$ x 0.30 | | |
| Δt/Δv | Input transition rise and fall time | Push-Pull Driving | 1.1V to 3.6V | 1.65V to 5.5V | | 10 | ns/V |
| $T_A$ | Operating free-air temperature | | | | –40 | 125 | °C |

(1) $V_{CCI}$ is the $V_{CC}$ associated with the input port.
(2) $V_{CCO}$ is the $V_{CC}$ associated with the output port.
(3) All control inputs and data I/Os of this device have weak pulldowns to make sure the line is not floating when undefined external to the device. The input leakage from these weak pulldowns is defined by the $I_I$ specification indicated under *Section 5.5*.

## 5.4 Thermal Information

| THERMAL METRIC(1) | | TXS0204 YCJ (DSBGA) 12 PINS | UNIT |
|---|---|---|---|
| $R_{θJA}$ | Junction-to-ambient thermal resistance | 102.7 | °C/W |
| $R_{θJC(top)}$ | Junction-to-case (top) thermal resistance | 0.7 | °C/W |
| $R_{θJB}$ | Junction-to-board thermal resistance | 26.1 | °C/W |
| $Y_{JT}$ | Junction-to-top characterization parameter | 0.4 | °C/W |
| $Y_{JB}$ | Junction-to-board characterization parameter | 26.1 | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application note.

## 5.5 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted). Please see Figure 6-4

| | | Test Condition | | $V_{CCA}$ | $V_{CCB}$ | MIN | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{OH}$ | High-Level Output Voltage | $V_{IH}$ = 0.67V | A | 1.1V to 1.3V | 1.65V to 1.9V | $V_{CCA}$ x 0.7 | | V |
| | | $V_{IH}$ = 0.72V | | 1.1V to 1.3V | 2.25V to 2.75V | $V_{CCA}$ x 0.7 | | V |
| | | $V_{IH}$ = 0.75V | | 1.1V to 1.3V | 3V to 3.6V | $V_{CCA}$ x 0.7 | | V |
| | | $V_{IH}$ = 0.67V | B | 1.1V to 1.3V | 1.65V to 1.9V | $V_{CCB}$ x 0.7 | | V |
| | | $V_{IH}$ = 0.73 | | 1.1V to 1.3V | 2.25V to 2.75V | $V_{CCB}$ x 0.7 | | V |
| | | $V_{IH}$ = 0.76 | | 1.1V to 1.3V | 3V to 3.6V | $V_{CCB}$ x 0.7 | | V |
| $V_{OH}$ | High-Level Output Voltage | $I_{OH}$ = -20µA, $V_{IB}$ > $V_{CCB}$ - 0.4V | A | 1.1V to 3.6V | 1.65V to 5.5V | $V_{CCA}$ x 0.75 | | V |
| | | $I_{OH}$ = -20µA, $V_{IA}$ > $V_{CCA}$ - 0.4V | B | 1.1V to 3.6V | 1.65V to 5.5V | $V_{CCB}$ x 0.75 | | V |
| $V_{OL}$ | Low-Level Output Voltage | VIL = 0.1V with external 4.7kΩ pull-up resistor | A | 1.1V to 1.3V | 1.65V to 1.9V | | 0.112 | V |
| | | | | 1.1V to 1.3V | 2.25V to 2.75V | | 0.12 | V |
| | | | | 1.1V to 1.3V | 3to 3.6V | | 0.11 | V |
| | | | B | 1.1V to 1.3V | 1.65V to 1.9V | | 0.12 | V |
| | | | | 1.1V to 1.3V | 2.25V to 2.75V | | 0.125 | V |
| | | | | 1.1V to 1.3V | 3to 3.6V | | 0.13 | V |
| | | VIL = 0.2V with external 4.7kΩ pull-up resistor | A | 1.1V to 1.3V | 1.65V to 1.9V | | 0.215 | V |
| | | | | 1.1V to 1.3V | 2.25V to 2.75V | | 0.212 | V |
| | | | | 1.1V to 1.3V | 3to 3.6V | | 0.215 | V |
| | | | B | 1.1V to 1.3V | 1.65V to 1.9V | | 0.23 | V |
| | | | | 1.1V to 1.3V | 2.25V to 2.75V | | 0.23 | V |
| | | | | 1.1V to 1.3V | 3to 3.6V | | 0.24 | V |
| | | VIL = 0.3V with external 4.7kΩ pull-up resistor | A | 1.1V to 1.3V | 1.65V to 1.9V | | 0.34 | V |
| | | | | 1.1V to 1.3V | 2.25V to 2.75V | | 0.316 | V |
| | | | | 1.1V to 1.3V | 3to 3.6V | | 0.34 | V |
| | | | B | 1.1V to 1.3V | 1.65V to 1.9V | | 0.4 | V |
| | | | | 1.1V to 1.3V | 2.25V to 2.75V | | 0.34 | V |
| | | | | 1.1V to 1.3V | 3to 3.6V | | 0.35 | V |
| $V_{OL}$ | Low-Level Output Voltage | $I_{OL}$ = 1mA, $V_{IB}$ ≤ 0.15V | A | 1.1V to 3.6V | 1.65V to 5.5V | | 0.4 | V |
| | | $I_{OL}$ = 1mA, $V_{IA}$ ≤ 0.15V | B | 1.1V to 3.6V | 1.65V to 5.5V | | 0.4 | V |

## 5.6 Electrical Characteristics (Cont.)

over operating free-air temperature range (unless otherwise noted)(1) (2)

| PARAMETER | | TEST CONDITIONS | $V_{CCA}$ | $V_{CCB}$ | Operating free-air temperature ($T_A$) | | | | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 25°C | | | –40°C to 85°C | | | –40°C to 125°C | | | |
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $I_I$ | Input leakage current | OE: $V_I = V_{CC}$ or GND | 1.1V to 3.6V | 1.65V to 5.5V | -2 | | 2 | -2 | | 2 | -2 | | 2 | µA |
| $I_{OZ}$ | High-impedance state output current | A or B Port: $V_I = V_{CCI}$ or GND $V_O = V_{CCO}$ or GND OE = GND | 1.1V to 3.6V | 1.65V to 5.5V | –1 | | 1 | –2 | | 2 | –3 | | 3 | µA |
| $I_{CCA}$ | $V_{CCA}$ supply current | $V_I = V_{CCI}$ or GND $I_O = 0$ | 1.1V to 3.6V | 1.65V to 5.5V | | | 2.4 | | | 3.3 | | | 6.2 | µA |
| | | | 3.6V | 0V | | | 2.2 | | | 2.2 | | | 2.2 | |
| | | | 0V | 5.5V | –3 | | | –3 | | | –3 | | | |
| $I_{CCB}$ | $V_{CCB}$ supply current | $V_I = V_{CCI}$ or GND $I_O = 0$ | 1.1V to 3.6V | 1.65V to 5.5V | | | 12 | | | 12 | | | 21 | µA |
| | | | 3.6V | 0V | -1 | | | –1 | | | –1 | | | |
| | | | 0V | 5.5V | | | 5 | | | 5 | | | 8 | |
| $I_{CCA} + I_{CCB}$ | Combined supply current | $V_I = V_{CCI}$ or GND $I_O = 0$ | 1.1V to 3.6V | 1.65V to 5.5V | | | 14.4 | | | 14.4 | | | 25 | µA |
| $C_i$ | Control Input Capacitance | $V_I$ = 3.3V or GND | 3.3V | 3.3V | | | 6 | | | 6 | | | 6 | pF |
| $C_{io}$ | Data I/O Capacitance | OE = GND, $V_O$ = 1.65V DC +1MHz -16dBm sine wave | 3.3V | 3.3V | | 5 | 6.5 | | 12 | 16.5 | | 12 | 16.5 | pF |

(1) $V_{CCI}$ is the $V_{CC}$ associated with the input port
(2) $V_{CCO}$ is the $V_{CC}$ associated with the output port

## 5.7 Switching Characteristics, $V_{CCA} = 1.2 \pm 0.1V$

| PARAMETER | | FROM | TO | Test Conditions | | B-Port Supply Voltage ($V_{CCB}$) | | | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1.8 ± 0.15V | | 2.5 ± 0.2V | | 3.3 ± 0.3V | | 5.0 ± 0.5V | | |
| | | | | | | MIN | MAX | MIN | MAX | MIN | MAX | MIN | MAX | |
| $t_{PHL}$ | Propagation Delay (Hight-to-Low) | A | B | Push-Pull | -40°C to 85°C | | 6.4 | | 6.8 | | 7.7 | | 11.1 | ns |
| | | | | | -40°C to 125°C | | 6.7 | | 7.3 | | 8.3 | | 9.8 | |
| | | | | Open-Drain | -40°C to 85°C | | 6.8 | | 7.8 | | 9.3 | | 11.9 | |
| | | | | | -40°C to 125°C | | 7.2 | | 8.4 | | 10 | | 12.7 | |
| $t_{PLH}$ | Propagation Delay (Low-to-High) | | | Push-Pull | -40°C to 85°C | | 20.4 | | 20.9 | | 43.1 | | 100.1 | |
| | | | | | -40°C to 125°C | | 16 | | 13.8 | | 15.3 | | 29.5 | |
| | | | | Open-Drain | -40°C to 85°C | | 92.7 | | 91.5 | | 110.2 | | 241 | |
| | | | | | -40°C to 125°C | | 58.7 | | 53.1 | | 49 | | 55.2 | |

| PARAMETER | | FROM | TO | Test Conditions | | B-Port Supply Voltage ($V_{CCB}$) | | | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1.8 ± 0.15V | | 2.5 ± 0.2V | | 3.3 ± 0.3V | | 5.0 ± 0.5V | | |
| | | | | | | MIN | MAX | MIN | MAX | MIN | MAX | MIN | MAX | |
| $t_{PHL}$ | Propagation Delay (Hight-to-Low) | B | A | Push-Pull | -40°C to 85°C | | 3.8 | | 3.7 | | 4.1 | | 5.3 | ns |
| | | | | | -40°C to 125°C | | 3.9 | | 3.9 | | 4.3 | | 5.5 | |
| | | | | Open-Drain | -40°C to 85°C | | 3.9 | | 4.1 | | 4.7 | | 6 | |
| | | | | | -40°C to 125°C | | 4.1 | | 4.3 | | 4.9 | | 6.2 | |
| $t_{PLH}$ | Propagation Delay (Low-to-High) | | | Push-Pull | -40°C to 85°C | | 10.7 | | 0.5 | | 0.1 | | 0.5 | |
| | | | | | -40°C to 125°C | | 1.4 | | 0.6 | | 0.2 | | 0.5 | |
| | | | | Open-Drain | -40°C to 85°C | | 0.6 | | 0.5 | | 0.5 | | 0.5 | |
| | | | | | -40°C to 125°C | | 0.6 | | 0.5 | | 0.5 | | 0.5 | |
| $t_{en}$ | Enable Time | OE | A or B | | -40°C to 85°C | | 350 | | 216.9 | | 165.9 | | 260 | ns |
| | | | | | -40°C to 125°C | | 260 | | 179.5 | | 142.5 | | 107 | |
| $t_{dis}$ | Disable Time | OE | A or B | | -40°C to 85°C | | 300 | | 300 | | 300 | | 260 | |
| | | | | | -40°C to 125°C | | 260 | | 200 | | 250 | | 250 | |
| $t_{rA}$ | Ouput Rise Time | B | A | Push-Pull | -40°C to 85°C | | 32 | | 24.8 | | 22.5 | | 22 | ns |
| | | | | | -40°C to 125°C | | 22.7 | | 18.4 | | 16.3 | | 14.2 | |
| | | | | Open-Drain | -40°C to 85°C | | 295.9 | | 243.4 | | 226 | | 200.8 | |
| | | | | | -40°C to 125°C | | 221.5 | | 173.3 | | 145.9 | | 119.4 | |
| $t_{rB}$ | Ouput Rise Time | A | B | Push-Pull | -40°C to 85°C | | 23.5 | | 22.8 | | 44.1 | | 28 | ns |
| | | | | | -40°C to 125°C | | 20.6 | | 16.8 | | 15.9 | | 22.1 | |
| | | | | Open-Drain | -40°C to 85°C | | 164.2 | | 143.7 | | 128.8 | | 280.1 | |
| | | | | | -40°C to 125°C | | 148.1 | | 108.4 | | 81.6 | | 55.5 | |
| $t_{fA}$ | Output Fall Time | B | A | Push-Pull | -40°C to 85°C | | 5.2 | | 4.4 | | 4.3 | | 6.7 | ns |
| | | | | | -40°C to 125°C | | 5.6 | | 4.8 | | 4.7 | | 5 | |
| | | | | Open-Drain | -40°C to 85°C | | 5.7 | | 5 | | 5.3 | | 5.9 | |
| | | | | | -40°C to 125°C | | 6.1 | | 5.5 | | 5.8 | | 6.4 | |
| $t_{fB}$ | Output Fall Time | A | B | Push-Pull | -40°C to 85°C | | 11.2 | | 12 | | 14 | | 14 | ns |
| | | | | | -40°C to 125°C | | 12 | | 13.1 | | 15.2 | | 19.9 | |
| | | | | Open-Drain | -40°C to 85°C | | 12.2 | | 14.1 | | 17.6 | | 24.9 | |
| | | | | | -40°C to 125°C | | 13.2 | | 15.4 | | 19.1 | | 26.7 | |

## 5.8 Switching Characteristics, $V_{CCA}$ = 1.5 ± 0.1V

| PARAMETER | | FROM | TO | Test Conditions | | B-Port Supply Voltage ($V_{CCB}$) | | | | | | | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1.8 ± 0.15V | | | 2.5 ± 0.2V | | | 3.3 ± 0.3V | | | 5.0 ± 0.5V | | | |
| | | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $t_{PHL}$ | Propagation Delay (Hight-to-Low) | A | B | Push-Pull | -40°C to 85°C | | | 3.9 | | | 3.7 | | | 4.2 | | | 5.2 | ns |
| | | | | | -40°C to 125°C | | | 4 | | | 3.9 | | | 4.5 | | | 5.6 | |
| | | | | Open-Drain | -40°C to 85°C | | | 3.9 | | | 4 | | | 4.7 | | | 6 | |
| | | | | | -40°C to 125°C | | | 4 | | | 4.3 | | | 5 | | | 6.4 | |
| $t_{PLH}$ | Propagation Delay (Low-to-High) | | | Push-Pull | -40°C to 85°C | | | 8.9 | | | 6.5 | | | 5.8 | | | 5.7 | |
| | | | | | -40°C to 125°C | | | 9.1 | | | 6.8 | | | 6.2 | | | 6 | |
| | | | | Open-Drain | -40°C to 85°C | | | 22.2 | | | 24.4 | | | 22.8 | | | 18.8 | |
| | | | | | -40°C to 125°C | | | 12.5 | | | 10.7 | | | 10.5 | | | 10.4 | |
| $t_{PHL}$ | Propagation Delay (Hight-to-Low) | B | A | Push-Pull | -40°C to 85°C | | | 2.9 | | | 2.8 | | | 3.2 | | | 4.2 | ns |
| | | | | | -40°C to 125°C | | | 3 | | | 2.9 | | | 3.3 | | | 4.3 | |
| | | | | Open-Drain | -40°C to 85°C | | | 2.9 | | | 2.9 | | | 3.4 | | | 4.5 | |
| | | | | | -40°C to 125°C | | | 3 | | | 3.1 | | | 3.5 | | | 4.7 | |
| $t_{PLH}$ | Propagation Delay (Low-to-High) | | | Push-Pull | -40°C to 85°C | | | 8.2 | | | 1 | | | 1 | | | 1 | |
| | | | | | -40°C to 125°C | | | 1.8 | | | 1 | | | 0.3 | | | 1 | |
| | | | | Open-Drain | -40°C to 85°C | | | 1.5 | | | 1 | | | 1 | | | 1 | |
| | | | | | -40°C to 125°C | | | 4 | | | 1 | | | 1 | | | 1 | |
| $t_{en}$ | Enable Time | OE | A or B | | -40°C to 85°C | | | 250 | | | 150 | | | 150 | | | 100 | ns |
| | | | | | -40°C to 125°C | | | 250 | | | 200 | | | 200 | | | 100 | |
| $t_{dis}$ | Disable Time | OE | A or B | | -40°C to 85°C | | | 250 | | | 200 | | | 250 | | | 200 | |
| | | | | | -40°C to 125°C | | | 250 | | | 200 | | | 250 | | | 160 | |
| $t_{rA}$ | Ouput Rise Time | B | A | Push-Pull | -40°C to 85°C | | | 12.2 | | | 9 | | | 7.3 | | | 6.7 | ns |
| | | | | | -40°C to 125°C | | | 12.5 | | | 9.5 | | | 7.9 | | | 7 | |
| | | | | Open-Drain | -40°C to 85°C | | | 190 | | | 141.5 | | | 112.5 | | | 81.5 | |
| | | | | | -40°C to 125°C | | | 166.3 | | | 130 | | | 102.1 | | | 73.7 | |
| $t_{rB}$ | Ouput Rise Time | A | B | Push-Pull | -40°C to 85°C | | | 13.7 | | | 10.2 | | | 8.9 | | | 7.8 | ns |
| | | | | | -40°C to 125°C | | | 14.3 | | | 10.8 | | | 9.4 | | | 8.2 | |
| | | | | Open-Drain | -40°C to 85°C | | | 145.5 | | | 115.1 | | | 85.7 | | | 47.5 | |
| | | | | | -40°C to 125°C | | | 150 | | | 110 | | | 79 | | | 43.1 | |
| $t_{fA}$ | Output Fall Time | B | A | Push-Pull | -40°C to 85°C | | | 3.8 | | | 3 | | | 2.9 | | | 3.1 | ns |
| | | | | | -40°C to 125°C | | | 4 | | | 3.3 | | | 3.2 | | | 3.4 | |
| | | | | Open-Drain | -40°C to 85°C | | | 3.9 | | | 3.2 | | | 3.2 | | | 3.5 | |
| | | | | | -40°C to 125°C | | | 4.1 | | | 3.5 | | | 3.5 | | | 3.8 | |

| PARAMETER | | FROM | TO | Test Conditions | | B-Port Supply Voltage ($V_{CCB}$) | | | | | | | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1.8 ± 0.15V | | | 2.5 ± 0.2V | | | 3.3 ± 0.3V | | | 5.0 ± 0.5V | | | |
| | | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $t_{fB}$ | Output Fall Time | A | B | Push-Pull | -40°C to 85°C | | | 6.7 | | | 6.3 | | | 7.1 | | | 9.3 | ns |
| | | | | | -40°C to 125°C | | | 7 | | | 6.9 | | | 7.8 | | | 10 | |
| | | | | Open-Drain | -40°C to 85°C | | | 6.8 | | | 6.8 | | | 8 | | | 10.7 | |
| | | | | | -40°C to 125°C | | | 7.2 | | | 7.5 | | | 8.8 | | | 11.5 | |

## 5.9 Switching Characteristics, $V_{CCA}$ = 1.8 ± 0.15V

| PARAMETER | | FROM | TO | Test Conditions | | B-Port Supply Voltage ($V_{CCB}$) | | | | | | | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1.8 ± 0.15V | | | 2.5 ± 0.2V | | | 3.3 ± 0.3V | | | 5.0 ± 0.5V | | | |
| | | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $t_{PHL}$ | Propagation Delay (Hight-to-Low) | A | B | Push-Pull | -40°C to 85°C | | | 4.6 | | | 4.6 | | | 4.7 | | | 5.8 | ns |
| $t_{PHL}$ | | A | B | Push-Pull | -40°C to 125°C | | | 6 | | | 6 | | | 5.8 | | | 5.8 | |
| $t_{PHL}$ | | A | B | Open-Drain | -40°C to 85°C | | | 8.8 | | | 8.8 | | | 9.6 | | | 10 | |
| $t_{PHL}$ | | A | B | Open-Drain | -40°C to 125°C | | | 8.8 | | | 8.8 | | | 9.6 | | | 10 | |
| $t_{PLH}$ | Propagation Delay (Low-to-High) | A | B | Push-Pull | -40°C to 85°C | | | 7.8 | | | 6.8 | | | 6.8 | | | 7 | ns |
| $t_{PLH}$ | | A | B | Push-Pull | -40°C to 125°C | | | 8 | | | 7.7 | | | 6.8 | | | 7 | |
| $t_{PLH}$ | | A | B | Open-Drain | -40°C to 85°C | | | 260 | | | 260 | | | 208 | | | 198 | |
| $t_{PLH}$ | | A | B | Open-Drain | -40°C to 125°C | | | 50 | | | 50 | | | 26 | | | 33 | |
| $t_{PHL}$ | Propagation Delay (Hight-to-Low) | B | A | Push-Pull | -40°C to 85°C | | | 4.4 | | | 4.4 | | | 4.5 | | | 4.7 | ns |
| $t_{PHL}$ | | B | A | Push-Pull | -40°C to 125°C | | | 4.4 | | | 4.4 | | | 4.5 | | | 4.7 | |
| $t_{PHL}$ | | B | A | Open-Drain | -40°C to 85°C | | | 5.3 | | | 5.3 | | | 4.4 | | | 4.1 | |
| $t_{PHL}$ | | B | A | Open-Drain | -40°C to 125°C | | | 5.3 | | | 5.3 | | | 4.4 | | | 4.5 | |
| $t_{PLH}$ | Propagation Delay (Low-to-High) | B | A | Push-Pull | -40°C to 85°C | | | 7.4 | | | 5.3 | | | 4.5 | | | 4.7 | ns |
| $t_{PLH}$ | | B | A | Push-Pull | -40°C to 125°C | | | 5.3 | | | 5.3 | | | 4.5 | | | 4.7 | |
| $t_{PLH}$ | | B | A | Open-Drain | -40°C to 85°C | | | 175 | | | 175 | | | 140 | | | 102 | |
| $t_{PLH}$ | | B | A | Open-Drain | -40°C to 125°C | | | 36 | | | 36 | | | 16 | | | 20 | |
| $t_{en}$ | Enable Time | OE | A or B | | -40°C to 85°C | | | 250 | | | 200 | | | 200 | | | 200 | ns |
| | | | | | -40°C to 125°C | | | 200 | | | 200 | | | 200 | | | 200 | |
| $t_{dis}$ | Disable Time | OE | A or B | | -40°C to 85°C | | | 250 | | | 200 | | | 200 | | | 200 | ns |
| | | | | | -40°C to 125°C | | | 250 | | | 200 | | | 250 | | | 200 | |
| $t_{rA}$ | Ouput Rise Time | B | A | Push-Pull | -40°C to 85°C | | | 11.1 | | | 9.5 | | | 9.3 | | | 7.6 | ns |
| | | B | A | Push-Pull | -40°C to 125°C | | | 11.4 | | | 9.5 | | | 9.3 | | | 15 | |
| | | B | A | Open-Drain | -40°C to 85°C | | | 165 | | | 165 | | | 132 | | | 95 | |
| | | B | A | Open-Drain | -40°C to 125°C | | | 199 | | | 199 | | | 150 | | | 109 | |
| | Ouput Rise Time | A | B | Push-Pull | -40°C to 85°C | | | 12.8 | | | 10.8 | | | 9.1 | | | 7.6 | ns |
| | | A | B | Push-Pull | -40°C to 125°C | | | 13.3 | | | 10.8 | | | 9.1 | | | 7.6 | |
| | | A | B | Open-Drain | -40°C to 85°C | | | 152 | | | 145 | | | 106 | | | 58 | |
| | | A | B | Open-Drain | -40°C to 125°C | | | 186 | | | 186 | | | 112 | | | 58 | |

| PARAMETER | | FROM | TO | Test Conditions | | B-Port Supply Voltage ($V_{CCB}$) 1.8 ± 0.15V | | | 2.5 ± 0.2V | | | 3.3 ± 0.3V | | | 5.0 ± 0.5V | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $t_{fA}$ | Output Fall Time | B | A | Push-Pull | -40°C to 85°C | | | 5.9 | | | 5.9 | | | 6 | | | 13.3 | ns |
| | | B | A | Push-Pull | -40°C to 125°C | | | 5.9 | | | 5.9 | | | 6 | | | 13.3 | |
| | | B | A | Open-Drain | -40°C to 85°C | | | 6.9 | | | 6.9 | | | 6.4 | | | 6.1 | |
| | | B | A | Open-Drain | -40°C to 125°C | | | 6.9 | | | 6.9 | | | 6.4 | | | 6.1 | |
| | Output Fall Time | A | B | Push-Pull | -40°C to 85°C | | | 7.6 | | | 7.6 | | | 7.5 | | | 8.8 | ns |
| | | A | B | Push-Pull | -40°C to 125°C | | | 7.6 | | | 7.6 | | | 7.5 | | | 8.8 | |
| | | A | B | Open-Drain | -40°C to 85°C | | | 13.8 | | | 13.8 | | | 16.2 | | | 16.2 | |
| | | A | B | Open-Drain | -40°C to 125°C | | | 13.8 | | | 13.8 | | | 16.2 | | | 16.2 | |

## 5.10 Switching Characteristics, $V_{CCA}$ = 2.5 ± 0.2V

| PARAMETER | | FROM | TO | Test Conditions | | B-Port Supply Voltage ($V_{CCB}$) 1.8 ± 0.15V | | | 2.5 ± 0.2V | | | 3.3 ± 0.3V | | | 5.0 ± 0.5V | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $t_{PHL}$ | Propagation Delay (Hight-to-Low) | A | B | Push-Pull | -40°C to 85°C | | | 3.2 | | | 3.2 | | | 3.3 | | | 3.4 | ns |
| | | | | | -40°C to 125°C | | | 3.2 | | | 3.2 | | | 3.3 | | | 3.4 | |
| | | | | Open-Drain | -40°C to 85°C | | | 6.3 | | | 6.3 | | | 6 | | | 5.8 | |
| | | | | | -40°C to 125°C | | | 6.3 | | | 6.3 | | | 6 | | | 5.8 | |
| $t_{PLH}$ | Propagation Delay (Low-to-High) | | | Push-Pull | -40°C to 85°C | | | 3.5 | | | 3.5 | | | 4.1 | | | 4.4 | |
| | | | | | -40°C to 125°C | | | 3.8 | | | 3.8 | | | 4.1 | | | 4.4 | |
| | | | | Open-Drain | -40°C to 85°C | | | 250 | | | 250 | | | 206 | | | 190 | |
| | | | | | -40°C to 125°C | | | 3.5 | | | 3.5 | | | 4.1 | | | 4.4 | |
| $t_{PHL}$ | Propagation Delay (Hight-to-Low) | B | A | Push-Pull | -40°C to 85°C | | | 3 | | | 3 | | | 3.6 | | | 4.3 | ns |
| | | | | | -40°C to 125°C | | | 3 | | | 3 | | | 3.6 | | | 4.3 | |
| | | | | Open-Drain | -40°C to 85°C | | | 4.7 | | | 4.7 | | | 4.2 | | | 4 | |
| | | | | | -40°C to 125°C | | | 4.7 | | | 4.7 | | | 4.2 | | | 4 | |
| $t_{PLH}$ | Propagation Delay (Low-to-High) | | | Push-Pull | -40°C to 85°C | | | 8.4 | | | 2.5 | | | 1.6 | | | 0.7 | |
| | | | | | -40°C to 125°C | | | 8.7 | | | 2.5 | | | 1.6 | | | 0.7 | |
| | | | | Open-Drain | -40°C to 85°C | | | 170 | | | 170 | | | 140 | | | 103 | |
| | | | | | -40°C to 125°C | | | 29.9 | | | 2.5 | | | 1.6 | | | 1 | |
| $t_{en}$ | Enable Time | OE | A or B | | -40°C to 85°C | | | 200 | | | 200 | | | 200 | | | 200 | ns |
| | | | | | -40°C to 125°C | | | 200 | | | 200 | | | 200 | | | 200 | |
| $t_{dis}$ | Disable Time | OE | A or B | | -40°C to 85°C | | | 200 | | | 200 | | | 200 | | | 200 | |
| | | | | | -40°C to 125°C | | | 250 | | | 200 | | | 200 | | | 200 | |
| $t_{rA}$ | Ouput Rise Time | B | A | Push-Pull | -40°C to 85°C | | | 10.3 | | | 7.4 | | | 6.6 | | | 5.6 | ns |
| | | | | | -40°C to 125°C | | | 10.6 | | | 7.4 | | | 6.6 | | | 5.6 | |
| | | | | Open-Drain | -40°C to 85°C | | | 153 | | | 149 | | | 121 | | | 89 | |
| | | | | | -40°C to 125°C | | | 180 | | | 180 | | | 150 | | | 105 | |

| PARAMETER | | FROM | TO | Test Conditions | | B-Port Supply Voltage ($V_{CCB}$) | | | | | | | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1.8 ± 0.15V | | | 2.5 ± 0.2V | | | 3.3 ± 0.3V | | | 5.0 ± 0.5V | | | |
| | | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $t_{rB}$ | Ouput Rise Time | A | B | Push-Pull | -40°C to 85°C | | | 11.4 | | | 8.3 | | | 7.2 | | | 6.1 | ns |
| | | | | | -40°C to 125°C | | | 11.9 | | | 8.8 | | | 7.6 | | | 6.6 | |
| | | | | Open-Drain | -40°C to 85°C | | | 155 | | | 151 | | | 112 | | | 64 | |
| | | | | | -40°C to 125°C | | | 170 | | | 170 | | | 120 | | | 64 | |
| $t_{fA}$ | Output Fall Time | B | A | Push-Pull | -40°C to 85°C | | | 5.7 | | | 5.7 | | | 5.5 | | | 5.3 | ns |
| | | | | | -40°C to 125°C | | | 5.7 | | | 5.7 | | | 5.5 | | | 5.3 | |
| | | | | Open-Drain | -40°C to 85°C | | | 6.9 | | | 6.9 | | | 6.2 | | | 5.8 | |
| | | | | | -40°C to 125°C | | | 5.8 | | | 5.8 | | | 5.8 | | | 5.8 | |
| $t_{fB}$ | Output Fall Time | A | B | Push-Pull | -40°C to 85°C | | | 7.8 | | | 7.8 | | | 6.7 | | | 6.6 | ns |
| | | | | | -40°C to 125°C | | | 7.8 | | | 7.8 | | | 6.7 | | | 6.6 | |
| | | | | Open-Drain | -40°C to 85°C | | | 8.8 | | | 8.8 | | | 9.4 | | | 10.4 | |
| | | | | | -40°C to 125°C | | | 8.8 | | | 8.8 | | | 9.4 | | | 10.4 | |

## 5.11 Switching Characteristics, $V_{CCA}$ = 3.3 ± 0.3V

| PARAMETER | | FROM | TO | Test Conditions | | B-Port Supply Voltage ($V_{CCB}$) | | | | | | | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1.8 ± 0.15V | | | 2.5 ± 0.2V | | | 3.3 ± 0.3V | | | 5.0 ± 0.5V | | | |
| | | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $t_{PHL}$ | Propagation Delay (Hight-to-Low) | A | B | Push-Pull | -40°C to 85°C | | | 3.5 | | | 2.8 | | | 2.4 | | | 3.1 | ns |
| | | | | | -40°C to 125°C | | | 3.5 | | | 2.8 | | | 2.4 | | | 3.1 | |
| | | | | Open-Drain | -40°C to 85°C | | | 4.2 | | | 4.2 | | | 4.2 | | | 4.6 | |
| | | | | | -40°C to 125°C | | | 4.2 | | | 4.2 | | | 4.2 | | | 4.6 | |
| $t_{PLH}$ | Propagation Delay (Low-to-High) | | | Push-Pull | -40°C to 85°C | | | 4.2 | | | 4.2 | | | 4.2 | | | 4.4 | |
| | | | | | -40°C to 125°C | | | 4.2 | | | 4.2 | | | 4.2 | | | 4.4 | |
| | | | | Open-Drain | -40°C to 85°C | | | 4.2 | | | 4.2 | | | 204 | | | 165 | |
| | | | | | -40°C to 125°C | | | 4.2 | | | 4.2 | | | 4.2 | | | 4.4 | |
| $t_{PHL}$ | Propagation Delay (Hight-to-Low) | B | A | Push-Pull | -40°C to 85°C | | | 2.9 | | | 2.5 | | | 2.5 | | | 3.3 | ns |
| | | | | | -40°C to 125°C | | | 2.9 | | | 2.5 | | | 2.5 | | | 3.3 | |
| | | | | Open-Drain | -40°C to 85°C | | | 124 | | | 124 | | | 124 | | | 97 | |
| | | | | | -40°C to 125°C | | | 124 | | | 124 | | | 124 | | | 97 | |
| $t_{PLH}$ | Propagation Delay (Low-to-High) | | | Push-Pull | -40°C to 85°C | | | 10 | | | 5 | | | 2.5 | | | 2.6 | |
| | | | | | -40°C to 125°C | | | 10 | | | 5 | | | 2.5 | | | 2.6 | |
| | | | | Open-Drain | -40°C to 85°C | | | 27.5 | | | 15 | | | 139 | | | 105 | |
| | | | | | -40°C to 125°C | | | 27.5 | | | 15 | | | 2.5 | | | 3.3 | |
| $t_{en}$ | Enable Time | OE | A or B | | -40°C to 85°C | | | 200 | | | 200 | | | 200 | | | 200 | ns |
| | | | | | -40°C to 125°C | | | 200 | | | 200 | | | 200 | | | 200 | |
| $t_{dis}$ | Disable Time | OE | A or B | | -40°C to 85°C | | | 250 | | | 200 | | | 250 | | | 200 | |
| | | | | | -40°C to 125°C | | | 250 | | | 200 | | | 250 | | | 200 | |

| PARAMETER | | FROM | TO | Test Conditions | | B-Port Supply Voltage ($V_{CCB}$) | | | | | | | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1.8 ± 0.15V | | | 2.5 ± 0.2V | | | 3.3 ± 0.3V | | | 5.0 ± 0.5V | | | |
| | | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $t_{rA}$ | Ouput Rise Time | B | A | Push-Pull | -40°C to 85°C | | | 11.6 | | | 6.9 | | | 5.6 | | | 4.8 | ns |
| | | | | | -40°C to 125°C | | | 11.6 | | | 6.9 | | | 5.8 | | | 5 | |
| | | | | Open-Drain | -40°C to 85°C | | | 140 | | | 140 | | | 116 | | | 85 | |
| | | | | | -40°C to 125°C | | | 140 | | | 140 | | | 140 | | | 102 | |
| $t_{rB}$ | Ouput Rise Time | A | B | Push-Pull | -40°C to 85°C | | | 11.3 | | | 8.1 | | | 6.4 | | | 7.4 | ns |
| | | | | | -40°C to 125°C | | | 11.3 | | | 8.1 | | | 6.8 | | | 7.4 | |
| | | | | Open-Drain | -40°C to 85°C | | | 135 | | | 130 | | | 116 | | | 116 | |
| | | | | | -40°C to 125°C | | | 135 | | | 130 | | | 130 | | | 75 | |
| $t_{fA}$ | Output Fall Time | B | A | Push-Pull | -40°C to 85°C | | | 5.4 | | | 5.4 | | | 5.4 | | | 5 | ns |
| | | | | | -40°C to 125°C | | | 5.4 | | | 5.4 | | | 5.4 | | | 5 | |
| | | | | Open-Drain | -40°C to 85°C | | | 6.1 | | | 6.1 | | | 6.1 | | | 5.7 | |
| | | | | | -40°C to 125°C | | | 6.1 | | | 6.1 | | | 6.1 | | | 5.7 | |
| $t_{fB}$ | Output Fall Time | A | B | Push-Pull | -40°C to 85°C | | | 7.4 | | | 7.4 | | | 7.4 | | | 7.6 | ns |
| | | | | | -40°C to 125°C | | | 7.4 | | | 7.4 | | | 7.4 | | | 7.6 | |
| | | | | Open-Drain | -40°C to 85°C | | | 7.6 | | | 7.6 | | | 7.6 | | | 8.3 | |
| | | | | | -40°C to 125°C | | | 7.6 | | | 7.6 | | | 7.6 | | | 8.3 | |

## 5.12 Switching Characteristics: $T_{sk}$, $T_{MAX}$

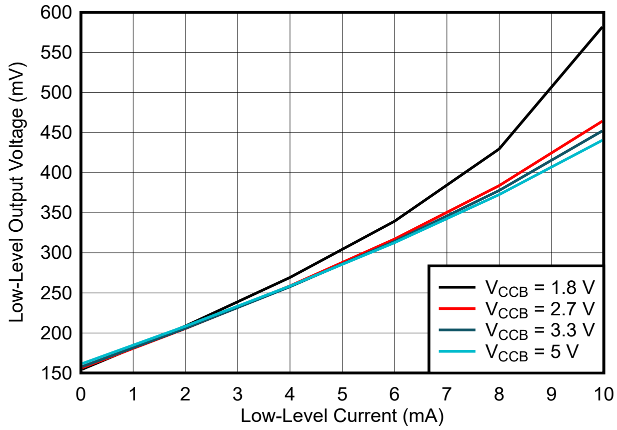
over operating free-air temperature range (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | | $V_{CCA}$ | $V_{CCB}$ | Operating free-air temperature ($T_A$) -40°C to 125°C MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| TMAX - Maximum Data Rate | 50% Duty Cycle InputOne channel switching | Push-Pull Driving | 1.2V ± 0.1V | 1.8 ± 0.15V | | | 24 | Mbps |
| | | | | 2.5V ± 0.2V | | | 24 | |
| | | | | 3.3V ± 0.3V | | | 24 | |
| | | | | 5V ± 0.5V | | | 24 | |
| | | | 1.5V ± 0.1V | 1.8 ± 0.15V | | | 24 | |
| | | | | 2.5V ± 0.2V | | | 24 | |
| | | | | 3.3V ± 0.3V | | | 24 | |
| | | | | 5V ± 0.5V | | | 24 | |
| | | | 1.8 ± 0.15V | 1.8 ± 0.15V | | | 50 | |
| | | | | 2.5V ± 0.2V | | | 50 | |
| | | | | 3.3V ± 0.3V | | | 50 | |
| | | | | 5V ± 0.5V | | | 50 | |
| | | | 2.5V ± 0.2V | 1.8 ± 0.15V | | | 50 | |
| | | | | 2.5V ± 0.2V | | | 50 | |
| | | | | 3.3V ± 0.3V | | | 50 | |
| | | | | 5V ± 0.5V | | | 50 | |
| | | | 3.3V ± 0.3V | 1.8 ± 0.15V | | | 50 | |
| | | | | 2.5V ± 0.2V | | | 50 | |
| | | | | 3.3V ± 0.3V | | | 50 | |
| | | | | 5V ± 0.5V | | | 50 | |

over operating free-air temperature range (unless otherwise noted)

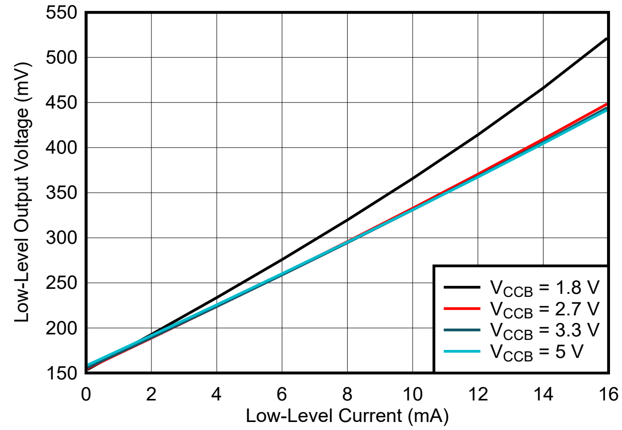
| PARAMETER | TEST CONDITIONS | | $V_{CCA}$ | $V_{CCB}$ | Operating free-air temperature ($T_A$) -40°C to 125°C MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| TMAX - Maximum Data Rate | 50% Duty Cycle InputOne channel switching | Open-Drain Driving | 1.2V ± 0.1V | 1.8 ± 0.15V | | | 1 | Mbps |
| | | | | 2.5V ± 0.2V | | | 1 | |
| | | | | 3.3V ± 0.3V | | | 1 | |
| | | | | 5V ± 0.5V | | | 1 | |
| | | | 1.5V ± 0.1V | 1.8 ± 0.15V | | | 2 | |
| | | | | 2.5V ± 0.2V | | | 2 | |
| | | | | 3.3V ± 0.3V | | | 2 | |
| | | | | 5V ± 0.5V | | | 2 | |
| | | | 1.8 ± 0.15V | 1.8 ± 0.15V | | | 2 | |
| | | | | 2.5V ± 0.2V | | | 2 | |
| | | | | 3.3V ± 0.3V | | | 2 | |
| | | | | 5V ± 0.5V | | | 2 | |
| | | | 2.5V ± 0.2V | 1.8 ± 0.15V | | | 2 | |
| | | | | 2.5V ± 0.2V | | | 2 | |
| | | | | 3.3V ± 0.3V | | | 2 | |
| | | | | 5V ± 0.5V | | | 2 | |
| | | | 3.3V ± 0.3V | 1.8 ± 0.15V | | | 2 | |
| | | | | 2.5V ± 0.2V | | | 2 | |
| | | | | 3.3V ± 0.3V | | | 2 | |
| | | | | 5V ± 0.5V | | | 2 | |
| $t_w$ | Pulse Duration, Data Inputs | Push-Pull Driving | 1.2V ± 0.1V to 3.3V ± 0.3V | 1.8V ± 0.15V to 5.5V ± 0.5V | 41 | | | ns |
| | | Open-Drain Driving | 1.2V ± 0.1V to 3.3V ± 0.3V | 1.8V ± 0.15V to 5.5V ± 0.5V | 500 | | | |
| $t_{sk}$ - Output skew | Skew between any two outputs of the same package switching in the same direction | Push-Pull Driving | 1.2V ± 0.1V to 3.3V ± 0.3V | 1.8V ± 0.15V to 5.5V ± 0.5V | | | 1 | ns |
| | | Open-Drain Driving | 1.2V ± 0.1V to 3.3V ± 0.3V | 1.8V ± 0.15V to 5.5V ± 0.5V | | | 1 | |

## 5.13 Typical Characteristics



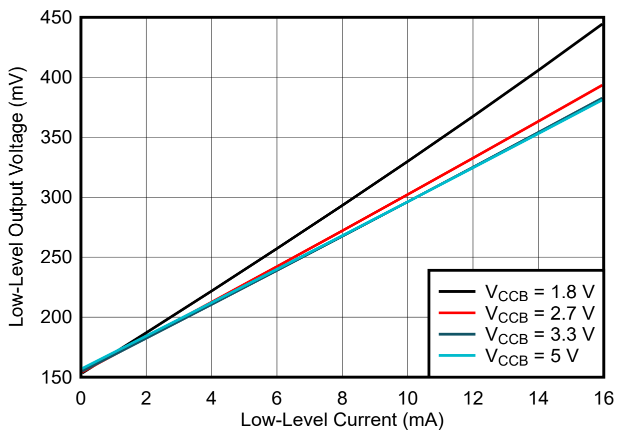

$V_{CCA}$ = 1.2V $V_{IL(A)}$ = 150mV

**Figure 5-1. Low-Level Output Voltage ($V_{OL(Ax)}$) vs Low-Level Current ($I_{OL(Ax)}$)**



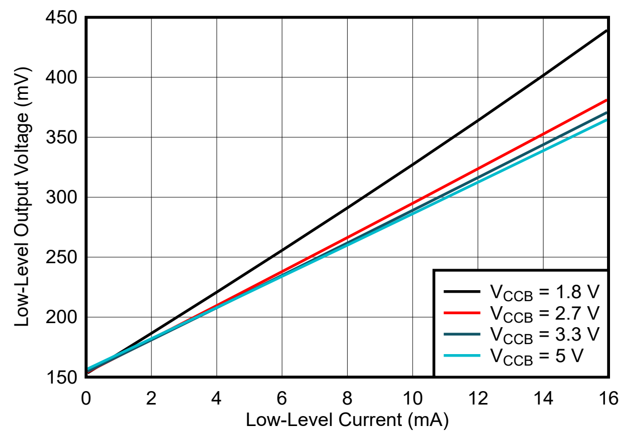

$V_{CCA}$ = 1.8V $V_{IL(A)}$ = 150mV

**Figure 5-2. Low-Level Output Voltage ($V_{OL(Ax)}$) vs Low-Level Current ($I_{OL(Ax)}$)**




$V_{CCA}$ = 2.7V $V_{IL(A)}$ = 150mV

**Figure 5-3. Low-Level Output Voltage ($V_{OL(Ax)}$) vs Low-Level Current ($I_{OL(Ax)}$)**




$V_{CCA}$ = 3.3V $V_{IL(A)}$ = 150mV

**Figure 5-4. Low-Level Output Voltage ($V_{OL(Ax)}$) vs Low-Level Current ($I_{OL(Ax)}$)**

# 6 Parameter Measurement Information

## 6.1 Load Circuits

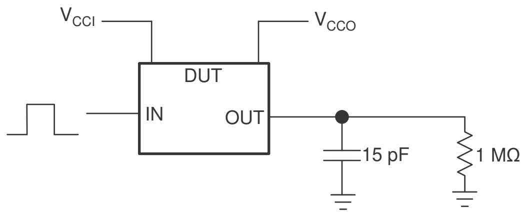



**Figure 6-1. Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement Using a Push-Pull Driver**

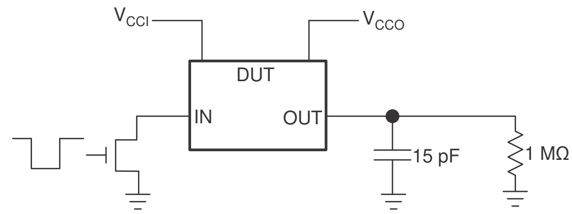
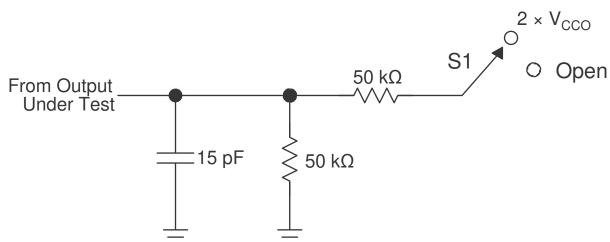


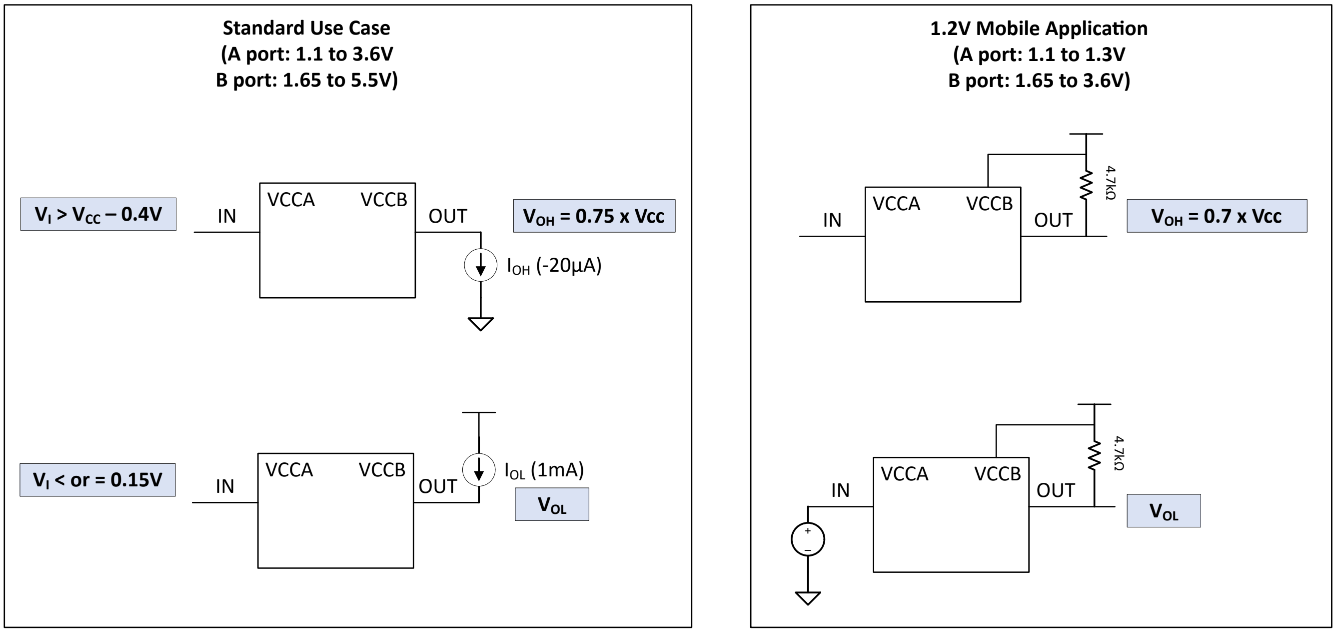

**Figure 6-2. Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement Using an Open-Drain Driver**




| TEST | S1 |
|---|---|
| $t_{PZL}$ / $t_{PLZ}$ ($t_{dis}$) | 2 × $V_{CCO}$ |
| $t_{PHZ}$ / $t_{PZH}$ ($t_{en}$) | Open |

**Figure 6-3. Load Circuit for Enable-Time and Disable-Time Measurement**

1. $t_{PLZ}$ and $t_{PHZ}$ are the same as $t_{dis}$.
2. $t_{PZL}$ and $t_{PZH}$ are the same as $t_{en}$.
3. $V_{CCI}$ is the $V_{CC}$ associated with the input port.
4. $V_{CCO}$ is the $V_{CC}$ associated with the output port.




**Note**

For 1.2V Mobile Application, see VIH and VIL test conditions in Section 5.5

**Figure 6-4. Load Circuit Diagram for VOH and VOL**

## 6.2 Voltage Waveforms

The outputs are measured one at a time, with one transition per measurement. All input pulses are supplied by generators that have the following characteristics:

- PRR ≤ 10MHz
- $Z_O$ = 50Ω
- dv/dt ≥ 1V/ns

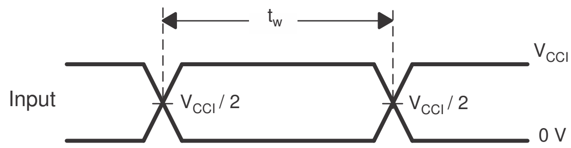



**Figure 6-5. Pulse Duration**

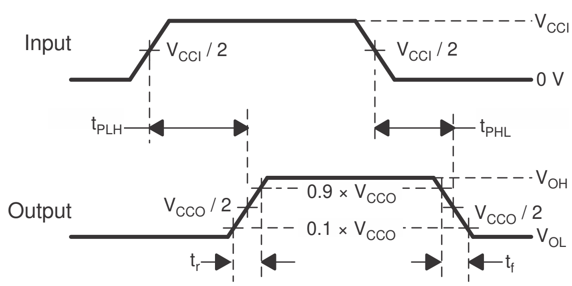
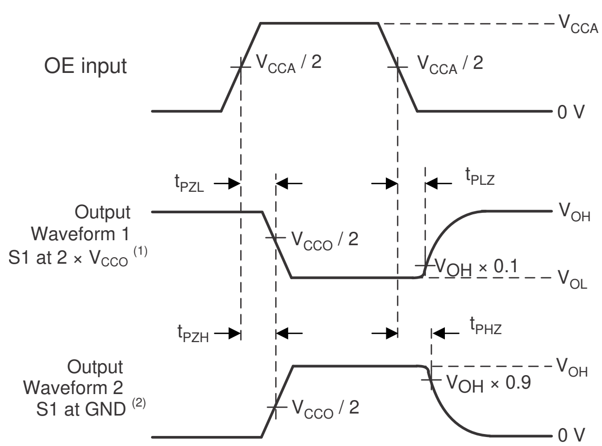



**Figure 6-6. Propagation Delay Times**




A. Waveform 1 is for an output with internal such that the output is high, except when OE is high (see Figure 6-3).

B. Waveform 2 is for an output with conditions such that the output is low, except when OE is high.

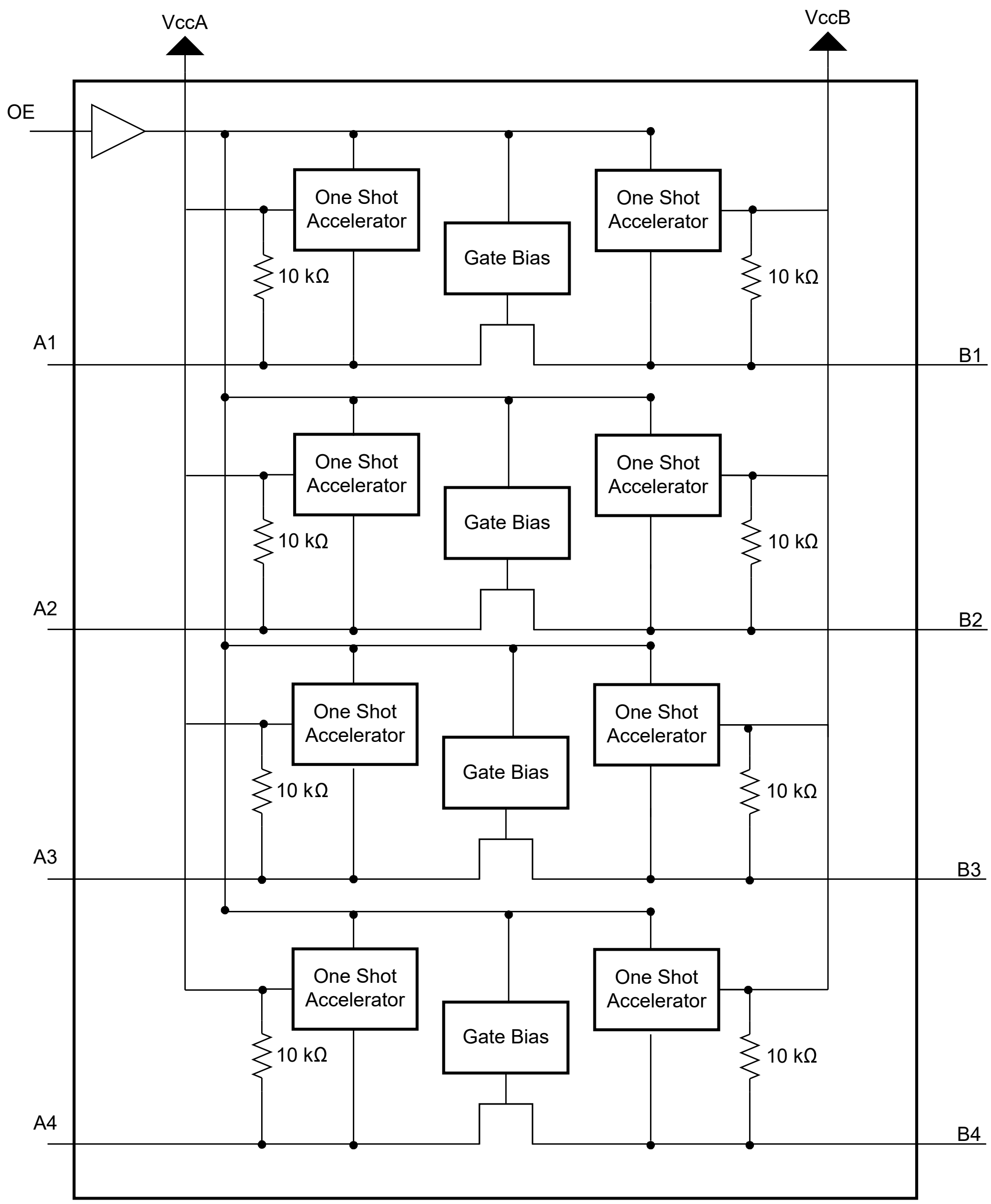
**Figure 6-7. Enable and Disable Times**

# 7 Detailed Description

## 7.1 Overview

The TXS0104 device is a directionless voltage-level translator specifically designed for translating logic voltage levels. The A port is able to accept I/O voltages ranging from 1.1V to 3.6V, while the B port can accept I/O voltages from 1.65V to 5.5V. The device is a pass gate architecture with edge rate accelerators (one shots) to improve the overall data rate. 10kΩ pullup resistors, commonly used in open drain applications, have been conveniently integrated so that an external resistor is not needed. While this device is designed for open drain applications, the device can also translate push-pull CMOS logic outputs.

## 7.2 Functional Block Diagram



## 7.3 Feature Description

### *7.3.1 Architecture*

The TXS0104 architecture (see Figure 7-1) does not require a direction-control signal to control the direction of data flow from A to B or from B to A.

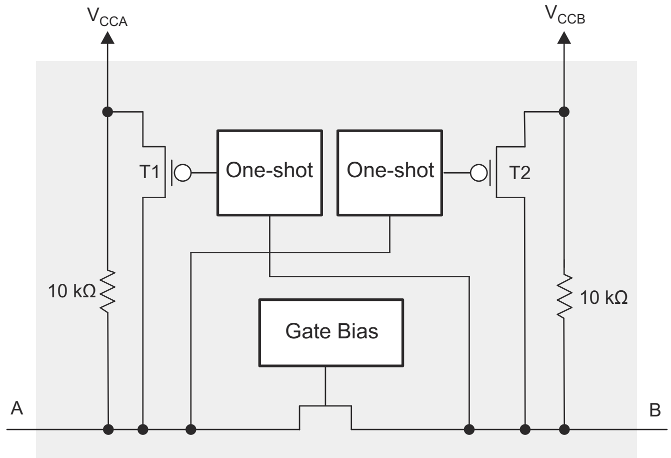



**Figure 7-1. Architecture of a TXS0204 Cell**

Each A-port I/O has an internal 10kΩ pullup resistor to $V_{CCA}$, and each B-port I/O has an internal 10kΩ pullup resistor to $V_{CCB}$. The output one-shots detect rising edges on the A or B ports. During a rising edge, the one-shot turns on the PMOS transistors (T1, T2) for a short duration which speeds up the low-to-high transition.

### *7.3.2 Input Driver Requirements*

The fall time ($t_{fA}$, $t_{fB}$) of a signal depends on the output impedance of the external device driving the data I/Os of the TXS0104 device. Similarly, the $t_{PHL}$ and maximum data rates also depend on the output impedance of the external driver. The values for $t_{fA}$, $t_{fB}$, $t_{PHL}$, and maximum data rates in the data sheet assume that the output impedance of the external driver is less than 50Ω.

### *7.3.3 Power Up*

During operation, confirm that $V_{CCA} \leq V_{CCB}$ at all times. During power-up sequencing, $V_{CCA} \geq V_{CCB}$ does not damage the device, so any power supply can be ramped up first.

### *7.3.4 Enable and Disable*

The TXS0104 device has an OE input that disables the device by setting OE low, which places all I/Os in the high-impedance state. The disable time ($t_{dis}$) indicates the delay between the time when the OE pin goes low and when the outputs actually enter the high-impedance state. The enable time ($t_{en}$) indicates the amount of time the user must allow for the one-shot circuitry to become operational after the OE pin is taken high.

### *7.3.5 Pullup and Pulldown Resistors on I/O Lines*

Each A-port I/O has an internal 10kΩ pullup resistor to $V_{CCA}$, and each B-port I/O has an internal 10-kΩ pullup resistor to $V_{CCB}$. If a smaller value of pullup resistor is required, an external resistor must be added from the I/O to $V_{CCA}$ or $V_{CCB}$ (in parallel with the internal 10-kΩ resistors).

## 7.4 Device Functional Modes

The TXS0104 device has two functional modes, enabled and disabled. To disable the device set the OE input low, which places all I/Os in a high impedance state. Setting the OE input high will enable the device.

# 8 Application and Implementation

**Note**

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

## 8.1 Application Information

The TXS0104 device can be used in level-translation applications for interfacing devices or systems operating at different interface voltages with one another. The TXS0104 device is an excellent choice for applications where an open-drain driver is connected to the data I/Os. The TXS0104 device can also be used in applications where a push-pull driver is connected to the data I/Os, but the TXB0104 device can be a better option for such push-pull applications.

## 8.2 Typical Application

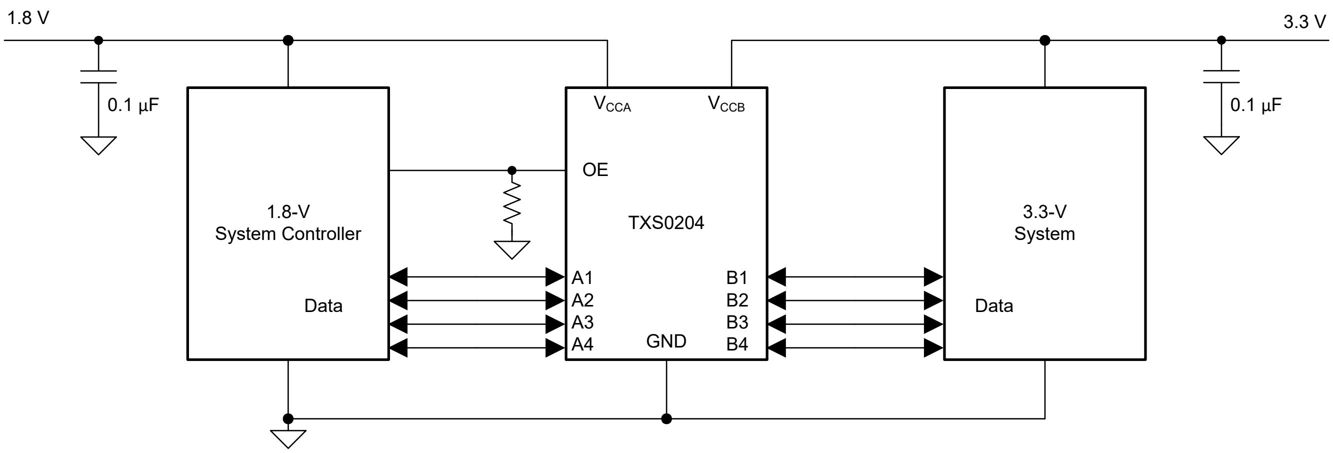



**Figure 8-1. Application Schematic**

### *8.2.1 Design Requirements*

For this design example, use the parameters listed in Table 8-1.

**Table 8-1. Design Parameters**

| DESIGN PARAMETER | EXAMPLE VALUE |
|---|---|
| Input voltage range | 1.1 to 3.6V |
| Output voltage range | 1.65 to 5.5V |

### 8.2.2 Detailed Design Procedure

To begin the design process, determine the following:

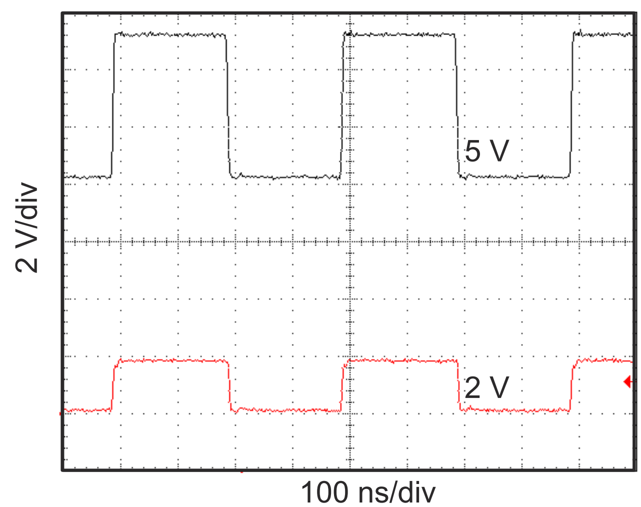
- Input voltage range
  - Use the supply voltage of the device that is driving the TXS0104 device to determine the input voltage range. For a valid logic high the value must exceed the $V_{IH}$ of the input port. For a valid logic low the value must be less than the $V_{IL}$ of the input port.
- Output voltage range
  - Use the supply voltage of the device that the TXS0104 device is driving to determine the output voltage range.
  - The TXS0104 device has 10-kΩ internal pullup resistors. External pullup resistors can be added to reduce the total RC of a signal trace if necessary.
- An external pull down resistor decreases the output $V_{OH}$ and $V_{OL}$. Use Equation 1 to calculate the $V_{OH}$ as a result of an external pull down resistor.

$$V_{OH} = V_{CCx} \times R_{PD} / (R_{PD} + 10\,k\Omega) \quad (1)$$

where

$V_{CCx}$ is the supply voltage on either $V_{CCA}$ or $V_{CCB}$
$R_{PD}$ is the value of the external pull down resistor

### 8.2.3 Application Curve




$V_{CCA}$ = 1.8V $V_{CCB}$ = 5V

**Figure 8-2. Level-Translation of a 2.5MHz Signal**

## 8.3 Power Supply Recommendations

The TXS0104 device uses two separate configurable power-supply rails, $V_{CCA}$ and $V_{CCB}$. $V_{CCB}$ accepts any supply voltage from 1.65V to 5.5V and $V_{CCA}$ accepts any supply voltage from 1.1V to 3.6V as long as Vs is less than or equal to $V_{CCB}$. The A port and B port are designed to track $V_{CCA}$ and $V_{CCB}$ respectively allowing for low-voltage bidirectional translation between any of the 1.8V, 2.5V, 3.3V, and 5V voltage nodes.

The TXS0104 device does not require power sequencing between $V_{CCA}$ and $V_{CCB}$ during power-up so the power-supply rails can be ramped in any order. A $V_{CCA}$ value greater than or equal to $V_{CCB}$ ($V_{CCA} \geq V_{CCB}$) does not damage the device.

The output-enable (OE) input circuit is designed so that it is supplied by $V_{CCA}$ and when the (OE) input is low, all outputs are placed in the high-impedance state. For the high-impedance state of the outputs during power up or power down, the OE input pin must be tied to GND through a pulldown resistor and must not be enabled until $V_{CCA}$ and $V_{CCB}$ are fully ramped and stable. The minimum value of the pulldown resistor to ground is determined by the current-sourcing capability of the driver.

## 8.4 Layout

### *8.4.1 Layout Guidelines*

For device reliability, following common printed-circuit board layout guidelines is recommended.

- Bypass capacitors should be used on power supplies.
- Short trace lengths should be used to avoid excessive loading.
- PCB signal trace-lengths must be kept short enough so that the round-trip delay of any reflection is less than the one shot duration, approximately 30ns, and encounters low impedance at the source driver.
- Placing pads on the signal paths for loading capacitors or pullup resistors to help adjust rise and fall times of signals depending on the system requirements

### *8.4.2 Layout Example*

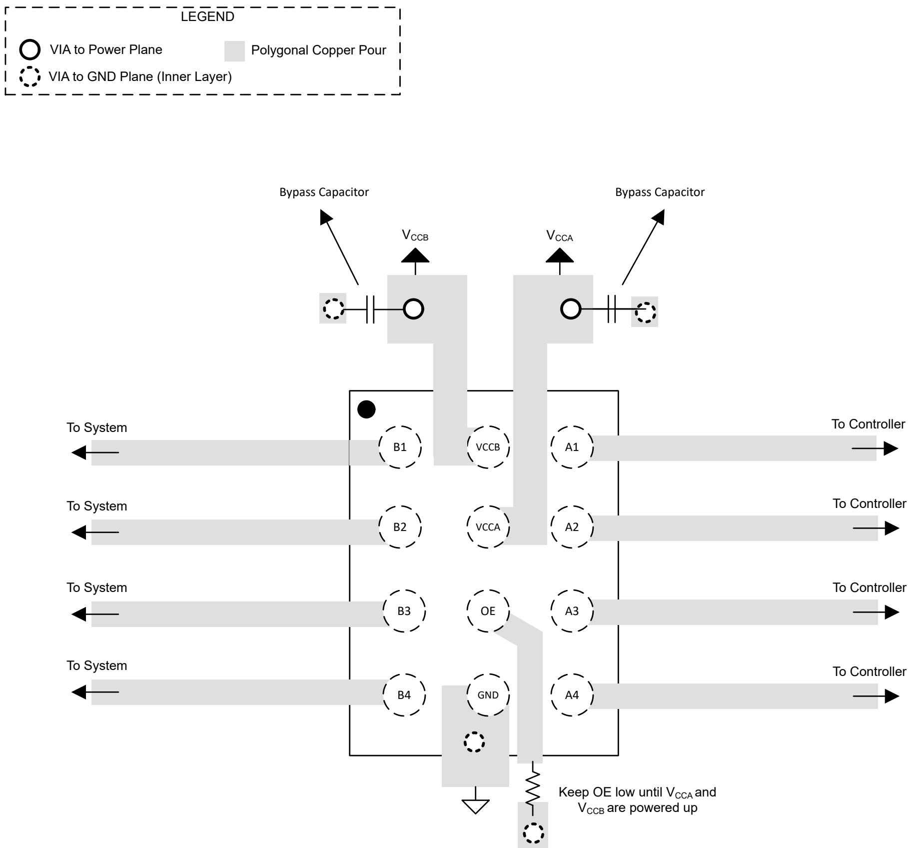



**Figure 8-3. TXS0104 Layout Example**

# 9 Device and Documentation Support

## 9.1 Documentation Support

### *9.1.1 Related Documentation*

For related documentation, see the following:

- Texas Instruments, *Effects of External Pullup and Pulldown Resistors on TXS and TXB Devices* application report
- Texas Instruments, *Basics of Voltage Translation* application report
- Texas Instruments, *A Guide to Voltage Translation With TXS-Type Translators* application report

## 9.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

## 9.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

## 9.4 Trademarks

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## 9.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## 9.6 Glossary

TI Glossary  This glossary lists and explains terms, acronyms, and definitions.

# 10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

**Changes from Revision * (February 2025) to Revision A (January 2026)** **Page**

- First public release of the data sheet....................................................................................................1

| DATE | REVISION | NOTES |
|---|---|---|
| February 2025 | * | Initial Release |

# 11 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| TXS0204YCJR | Active | Production | DSBGA (YCJ) \| 12 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | QF |

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

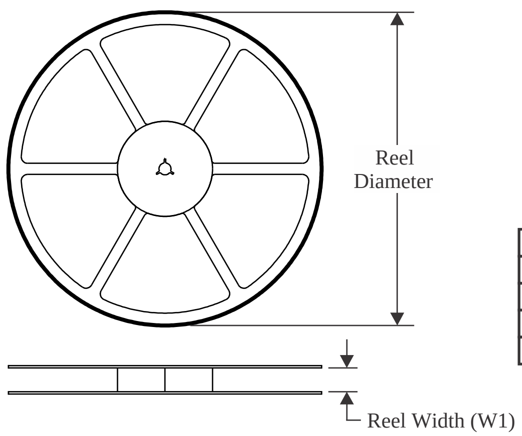
(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

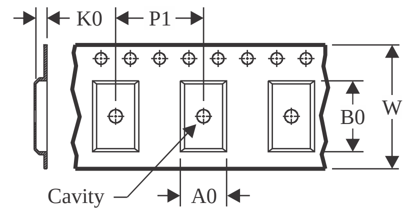
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

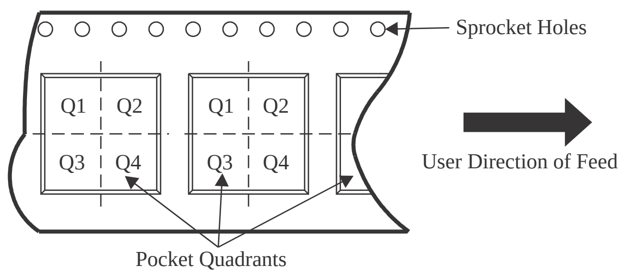
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

## TAPE AND REEL INFORMATION



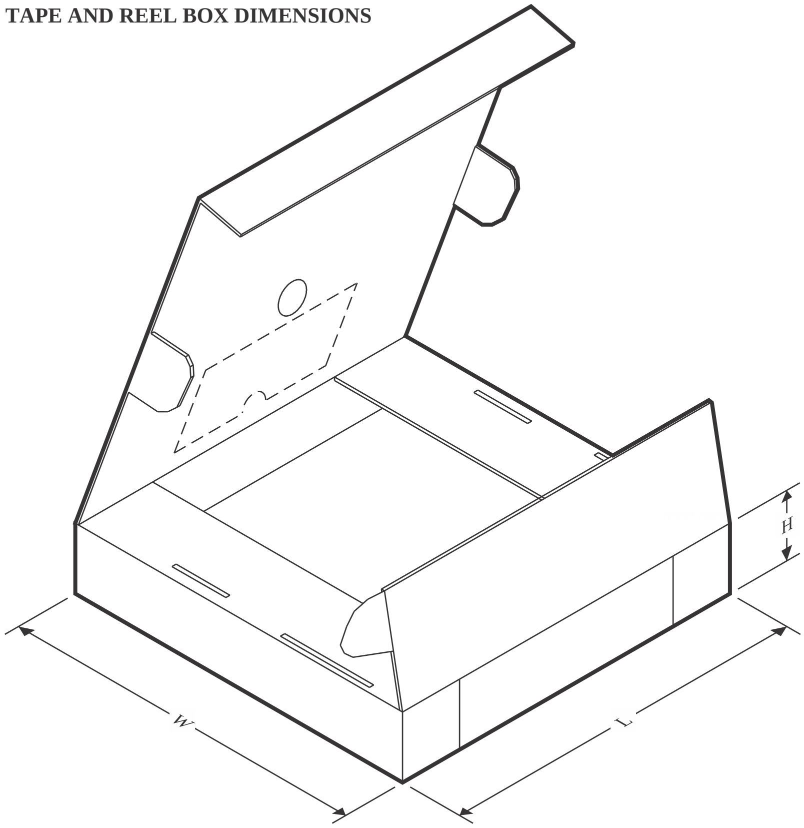

| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |




*All dimensions are nominal

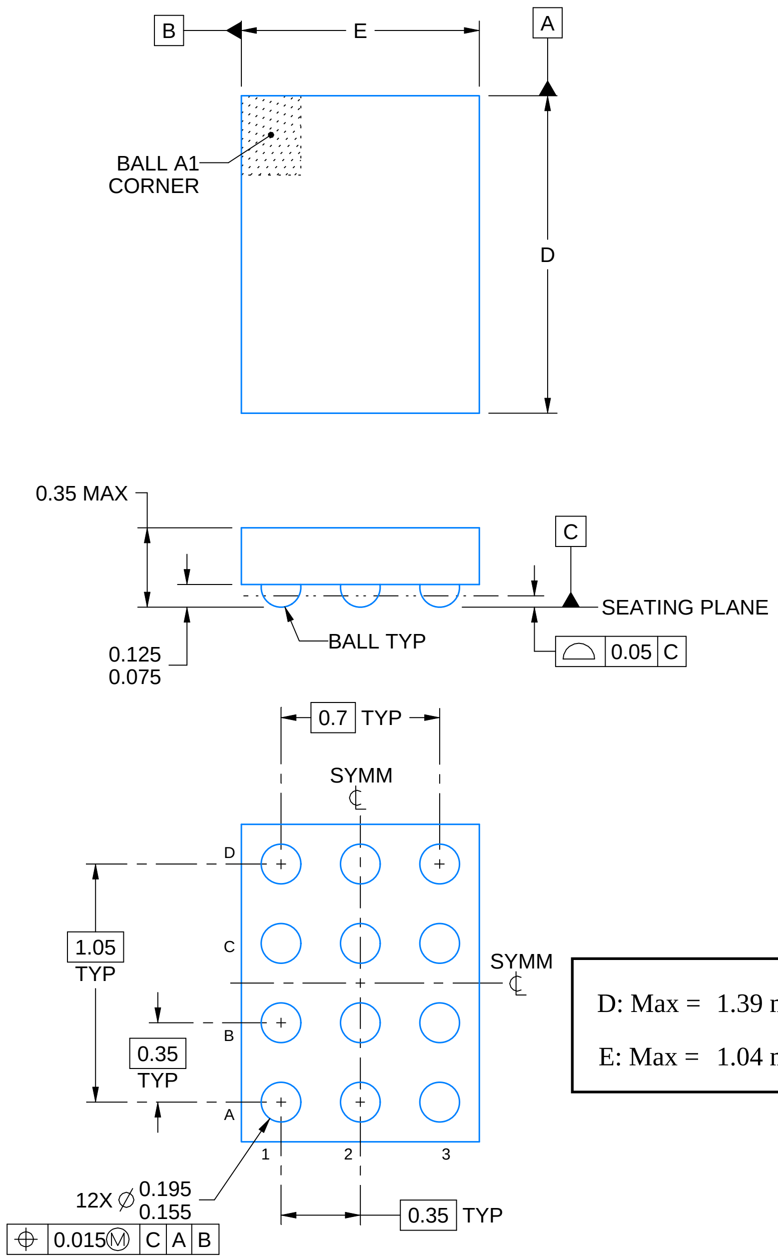
| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TXS0204YCJR | DSBGA | YCJ | 12 | 12000 | 180.0 | 8.4 | 1.12 | 1.62 | 0.42 | 2.0 | 8.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TXS0204YCJR | DSBGA | YCJ | 12 | 12000 | 182.0 | 182.0 | 20.0 |




D: Max = 1.39 mm, Min = 1.33 mm

E: Max = 1.04 mm, Min = 0.98 mm

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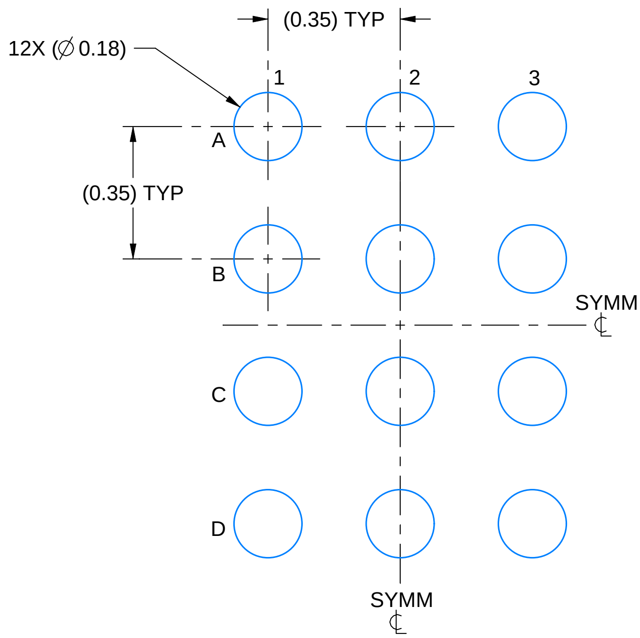
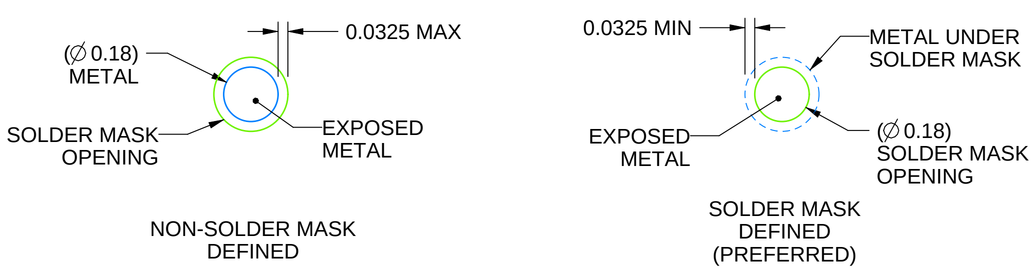
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 50X




SOLDER MASK DETAILS
NOT TO SCALE

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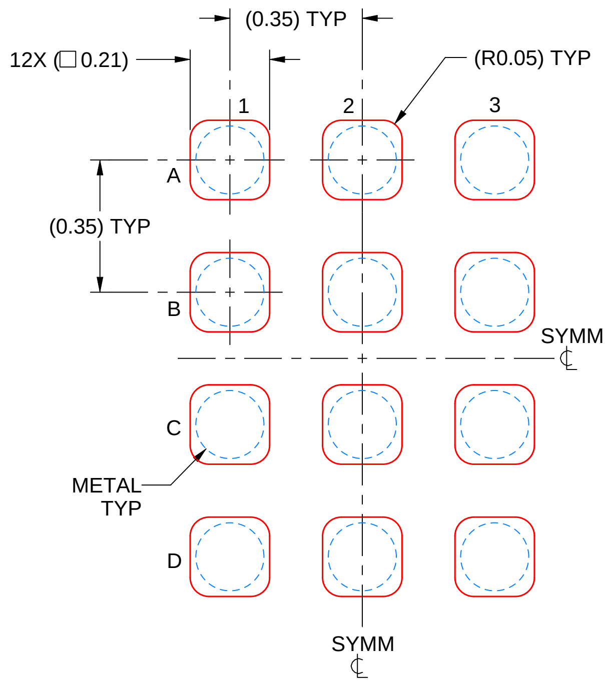
NOTES: (continued)

3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).




SOLDER PASTE EXAMPLE
BASED ON 0.075 mm THICK STENCIL
SCALE: 50X

4224964/A 04/2019

NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

## IMPORTANT NOTICE AND DISCLAIMER