

TXU0104-Q1 Automotive 4-Bit Fixed Direction Voltage-Level Translator with Schmitt-Trigger Inputs and 3-State Outputs

1 Features

- AEC-Q100 qualified for automotive applications
- Available in wetttable flank QFN (WBQA) package
- Fully configurable dual-rail design allows each port to operate from 1.1 V to 5.5 V
- Up to 200 Mbps support for 3.3 V to 5.0 V
- Schmitt-trigger inputs allows for slow and noisy inputs
- [Inputs with integrated static pull-down resistors](#) prevent channels from floating
- High drive strength (up to 12 mA at 5 V)
- Low power consumption
 - 3 μ A maximum (25°C)
 - 6 μ A maximum (–40°C to 125°C)
- [V_{CC} isolation and V_{CC} disconnect \(I_{off-float}\)](#) feature
 - If either V_{CC} input is <100 mV or disconnected, all outputs are disabled and become high-impedance
- I_{off} supports partial-power-down mode operation
- [Control logic \(OE\) with V_{CC\(MIN\)} circuitry](#) allows for control from either A or B port
- Pinout compatible with TXB family level shifters
- Available in other variants that support common applications: [TXU0204-Q1](#), [TXU0304-Q1](#)
- Operating temperature from –40°C to +125°C
- Latch-up performance exceeds 100 mA per JESD 78, class II
- ESD protection exceeds JESD 22
 - 2500-V human-body model
 - 1500-V charged-device model

2 Applications

- [Eliminate slow or noisy input signals](#)
- [Driving indicator LEDs or buzzers](#)
- [Debouncing a mechanical switch](#)
- General purpose I/O level shifting
- Push-pull level shifting (UART, SPI, JTAG, and so forth)

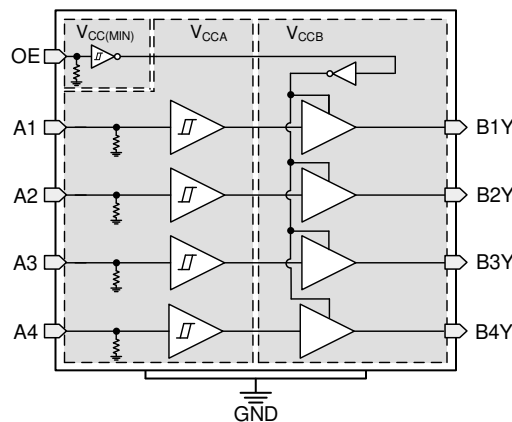
3 Description

TXU0104-Q1 is a 4-bit, dual-supply noninverting fixed direction voltage level translation device. Ax pins are referenced to V_{CCA} logic level, OE pin can be referenced to either V_{CCA} or V_{CCB} logic levels, and Bx pins are referenced to V_{CCB} logic levels. The A port is able to accept input voltages ranging from 1.1 V to 5.5 V, while the B port can also accept input voltages from 1.1 V to 5.5 V. Fixed direction data transmission can occur from A to B or B to A when OE is set to high in reference to either supply. When OE is set to low, all output pins are in the high-impedance state. See [Device Functional Modes](#) for a summary of the operation of the control logic.

Device Information⁽¹⁾

| DEVICE NUMBER | PACKAGE | BODY SIZE (NOM) |
|----------------|------------|-------------------|
| TXU0104-Q1WBQA | VQFN (14) | 3.00 mm × 2.50 mm |
| TXU0104-Q1PW | TSSOP (14) | 5.00 mm × 4.40 mm |

- (1) For all available packages, see the orderable addendum at the end of the data sheet.



TXU0104-Q1 Functional Block Diagram



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4 Revision History

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

| Changes from Revision A (May 2021) to Revision B (March 2022) | Page |
|--|-------------|
| • Added WBQA package and supporting information..... | 1 |

| Changes from Revision * (April 2021) to Revision A (May 2021) | Page |
|---|-------------|
| • Changed the status of the data sheet from: <i>advanced information</i> to: <i>production data</i> | 1 |

5 Related Products

[TXU0x04-Q1 Automotive 4-Bit Unidirectional Voltage-Level Translators](#)

TXU0x04-Q1 are 4-bit, dual-supply noninverting fixed direction voltage level translators. These devices are compatible to the TXB0104-Q1 with the same pinout allowing for a drop in replacement. The OE pin can be referenced to either V_{CCA} or V_{CCB} logic levels allowing for one of the TXU0x04-Q1 devices to be used for fixed direction, high drive applications which the TXB0104-Q1 is not recommended to support.

[TXU0204-Q1](#)

TXU0204-Q1 is a 4-bit, dual-supply noninverting fixed direction voltage level translators with 2 channels in the opposing direction commonly used for GPIO, UART, and JTAG translation.

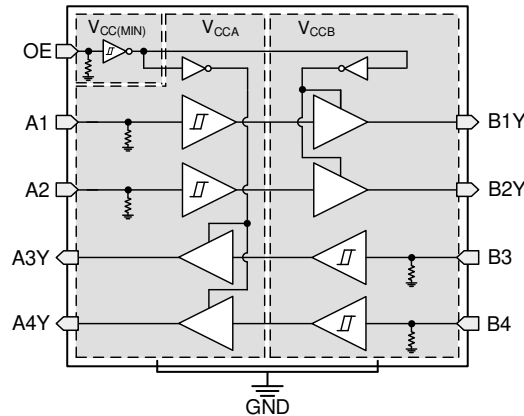


Figure 5-1. TXU0204-Q1 Functional Block Diagram

[TXU0304-Q1](#)

TXU0304-Q1 is a 4-bit, dual-supply noninverting fixed direction voltage level translators with 1 channel in the opposing direction commonly used for GPIO, SPI, and I2S translation.

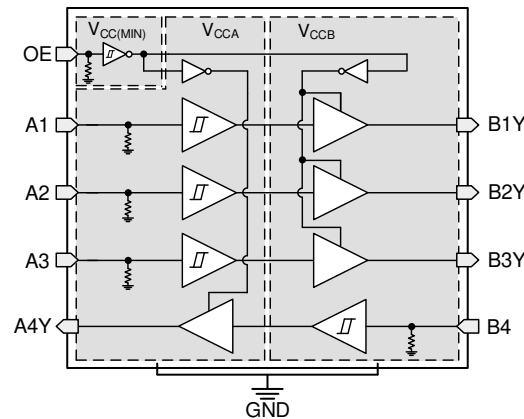


Figure 5-2. TXU0304-Q1 Functional Block Diagram

6 Pin Configuration and Functions—TXU0104-Q1

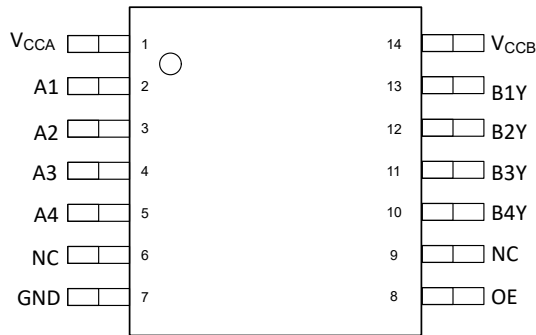


Figure 6-1. PW Package, 14-Pin TSSOP Transparent (Top View)

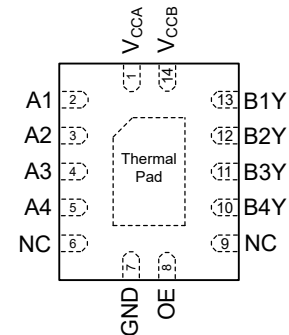


Figure 6-2. WBQA Package, 14-Pin VQFN Transparent (Top View)

Table 6-1. TXU0104-Q1 Pin Functions

| PIN | | TYPE ⁽¹⁾ | DESCRIPTION |
|-------------|----------|---------------------|---|
| NAME | PW, WBQA | | |
| A1 | 2 | I | Input A1. Referenced to V_{CCA} . |
| A2 | 3 | I | Input A2. Referenced to V_{CCA} . |
| A3 | 4 | I | Input A3. Referenced to V_{CCA} . |
| A4 | 5 | I | Input A4. Referenced to V_{CCA} . |
| B1Y | 13 | O | Output B1. Referenced to V_{CCB} . |
| B2Y | 12 | O | Output B2. Referenced to V_{CCB} . |
| B3Y | 11 | O | Output B3. Referenced to V_{CCB} . |
| B4Y | 10 | O | Output B4. Referenced to V_{CCB} . |
| GND | 7 | — | Ground |
| OE | 8 | I | Output Enable. Pull to GND to place all outputs in high-impedance mode. Pull to V_{CCA} or V_{CCB} to enable all outputs. |
| NC | 6, 9 | — | No internal connection. |
| V_{CCA} | 1 | — | A-port supply voltage. $1.1\text{ V} \leq V_{CCA} \leq 5.5\text{ V}$ |
| V_{CCB} | 14 | — | B-port supply voltage. $1.1\text{ V} \leq V_{CCB} \leq 5.5\text{ V}$ |
| Thermal Pad | | — | Thermal pad. May be left floating or grounded (recommended for best thermal and mechanical integrity). |

(1) I = input, O = output

7 Specifications

7.1 Absolute Maximum Ratings

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

| | | | MIN | MAX | UNIT |
|------------------|---|--------------------|------|------------------------|------|
| V _{CCA} | Supply voltage A | | -0.5 | 6.5 | V |
| V _{CCB} | Supply voltage B | | -0.5 | 6.5 | V |
| V _I | Input Voltage ⁽²⁾ | I/O Ports (A Port) | -0.5 | 6.5 | V |
| | | I/O Ports (B Port) | -0.5 | 6.5 | |
| | | OE | -0.5 | 6.5 | |
| V _O | Voltage applied to any output in the high-impedance or power-off state ⁽²⁾ | A Port | -0.5 | 6.5 | 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 | -20 | | mA |
| I _{OK} | Output clamp current | V _O < 0 | -20 | | mA |
| I _O | Continuous output current | | -25 | 25 | mA |
| | Continuous current through V _{CC} or GND | | -100 | 100 | |
| T _J | Junction Temperature | | | 150 | °C |
| T _{stg} | Storage temperature | | -65 | 150 | °C |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* 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 *Recommended Operating Conditions*. Exposure beyond the limits listed in *Recommended Operating Conditions* 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 6.5 V maximum if the output current rating is observed.

7.2 ESD Ratings

| | | | VALUE | UNIT |
|--------------------|-------------------------|---|-------|------|
| V _(ESD) | Electrostatic discharge | Human body model (HBM), per AEC Q100-002 ⁽¹⁾ | ±2500 | V |
| | | Charged device model (CDM), per AEC Q100-011 | ±1500 | |

- (1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification

7.3 Recommended Operating Conditions

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

| | | MIN | MAX | UNIT | |
|------------------|--------------------------------|---------------------------|------|------------------|---|
| V _{CCA} | Supply voltage A | 1.08 | 5.5 | V | |
| V _{CCB} | Supply voltage B | 1.08 | 5.5 | V | |
| I _{OH} | High-level output current | V _{CCO} = 1.1 V | -1.5 | mA | |
| | | V _{CCO} = 1.4 V | -3 | | |
| | | V _{CCO} = 1.65 V | -4.5 | | |
| | | V _{CCO} = 2.3 V | -8 | | |
| | | V _{CCO} = 3 V | -10 | | |
| | | V _{CCO} = 4.5 V | -12 | | |
| I _{OL} | Low-level output current | V _{CCO} = 1.1 V | 1.5 | mA | |
| | | V _{CCO} = 1.4 V | 3 | | |
| | | V _{CCO} = 1.65 V | 4.5 | | |
| | | V _{CCO} = 2.3 V | 8 | | |
| | | V _{CCO} = 3 V | 10 | | |
| | | V _{CCO} = 4.5 V | 12 | | |
| V _I | Input voltage ⁽³⁾ | 0 | 5.5 | V | |
| V _O | Output voltage | Active State | 0 | V _{CCO} | V |
| | | Tri-State | 0 | 5.5 | |
| 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 ensure 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 [Electrical Characteristics](#).

7.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | TXU0104 | | | | UNIT |
|-------------------------------|--|------------|------------|------------|-------------|------|
| | | PW (TSSOP) | BQA (WQFN) | RUT (UQFN) | DTR (X2SON) | |
| | | 14 PINS | 14 PINS | 12 PINS | 12 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance | 135.8 | 87.2 | 171.9 | 176.6 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 65.0 | 90.0 | 100.4 | 84.1 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 78.8 | 56.0 | 97.1 | 99.1 | °C/W |
| Y _{JT} | Junction-to-top characterization parameter | 15.6 | 9.8 | 10.9 | 2.6 | °C/W |
| Y _{JB} | Junction-to-board characterization parameter | 78.2 | 56.0 | 95.5 | 98.9 | °C/W |
| R _{θJC(bottom)} | Junction-to-case (bottom) thermal resistance | N/A | 33.0 | N/A | N/A | °C/W |

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

7.5 Electrical Characteristics

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 |
| V _{T+} | Positive-going input-threshold voltage | Data Inputs (Ax, Bx) (Referenced to V _{CCI}) | 1.1 V | 1.1 V | | 0.44 | 0.88 | 0.44 | 0.88 | V | |
| | | | 1.4 V | 1.4 V | | 0.60 | 0.98 | 0.60 | 0.98 | | |
| | | | 1.65 V | 1.65 V | | 0.76 | 1.13 | 0.76 | 1.13 | | |
| | | | 2.3 V | 2.3 V | | 1.08 | 1.56 | 1.08 | 1.56 | | |
| | | | 3 V | 3 V | | 1.48 | 1.92 | 1.48 | 1.92 | | |
| | | | 4.5 V | 4.5 V | | 2.19 | 2.74 | 2.19 | 2.74 | | |
| | | | 5.5 V | 5.5 V | | 2.65 | 3.33 | 2.65 | 3.33 | | |
| | | OE (Referenced to V _{CCA} or V _{CCB}) | 1.1 V | 1.1 V | | 0.44 | 0.88 | 0.44 | 0.88 | V | |
| | | | 1.4 V | 1.4 V | | 0.60 | 0.98 | 0.60 | 0.98 | | |
| | | | 1.65 V | 1.65 V | | 0.76 | 1.13 | 0.76 | 1.13 | | |
| | | | 2.3 V | 2.3 V | | 1.08 | 1.56 | 1.08 | 1.56 | | |
| | | | 3 V | 3 V | | 1.48 | 1.92 | 1.48 | 1.92 | | |
| | | | 4.5 V | 4.5 V | | 2.19 | 2.74 | 2.19 | 2.74 | | |
| | | | 5.5 V | 5.5 V | | 2.65 | 3.33 | 2.65 | 3.33 | | |
| V _{T-} | Negative-going input-threshold voltage | Data Inputs (Ax, Bx) (Referenced to V _{CCI}) | 1.1 V | 1.1 V | | 0.17 | 0.48 | 0.17 | 0.48 | V | |
| | | | 1.4 V | 1.4 V | | 0.28 | 0.59 | 0.28 | 0.59 | | |
| | | | 1.65 V | 1.65 V | | 0.35 | 0.69 | 0.35 | 0.69 | | |
| | | | 2.3 V | 2.3 V | | 0.56 | 0.97 | 0.56 | 0.97 | | |
| | | | 3 V | 3 V | | 0.89 | 1.5 | 0.89 | 1.5 | | |
| | | | 4.5 V | 4.5 V | | 1.51 | 1.97 | 1.51 | 1.97 | | |
| | | | 5.5 V | 5.5 V | | 1.88 | 2.4 | 1.88 | 2.4 | | |
| | | OE (Referenced to V _{CCA} or V _{CCB}) | 1.1 V | 1.1 V | | 0.17 | 0.48 | 0.17 | 0.48 | V | |
| | | | 1.4 V | 1.4 V | | 0.28 | 0.59 | 0.28 | 0.59 | | |
| | | | 1.65 V | 1.65 V | | 0.35 | 0.69 | 0.35 | 0.69 | | |
| | | | 2.3 V | 2.3 V | | 0.56 | 0.97 | 0.56 | 0.97 | | |
| | | | 3 V | 3 V | | 0.89 | 1.5 | 0.89 | 1.5 | | |
| | | | 4.5 V | 4.5 V | | 1.51 | 1.97 | 1.51 | 1.97 | | |
| | | | 5.5 V | 5.5 V | | 1.88 | 2.46 | 1.88 | 2.46 | | |
| ΔV _T | Input-threshold hysteresis (V _{T+} – V _{T-}) | Data Inputs (Ax, Bx) (Referenced to V _{CCI}) | 1.1 V | 1.1 V | | 0.2 | 0.4 | 0.2 | 0.4 | V | |
| | | | 1.4 V | 1.4 V | | 0.25 | 0.5 | 0.25 | 0.5 | | |
| | | | 1.65 V | 1.65 V | | 0.3 | 0.55 | 0.3 | 0.55 | | |
| | | | 2.3 V | 2.3 V | | 0.38 | 0.65 | 0.38 | 0.65 | | |
| | | | 3 V | 3 V | | 0.46 | 0.72 | 0.46 | 0.72 | | |
| | | | 4.5 V | 4.5 V | | 0.58 | 0.93 | 0.58 | 0.93 | | |
| | | | 5.5 V | 5.5 V | | 0.69 | 1.06 | 0.69 | 1.06 | | |
| | | OE (Referenced to V _{CCA} or V _{CCB}) | 1.1 V | 1.1 V | | 0.15 | 0.41 | 0.15 | 0.41 | V | |
| | | | 1.4 V | 1.4 V | | 0.2 | 0.5 | 0.2 | 0.5 | | |
| | | | 1.65 V | 1.65 V | | 0.23 | 0.55 | 0.23 | 0.55 | | |
| | | | 2.3 V | 2.3 V | | 0.32 | 0.65 | 0.32 | 0.65 | | |
| | | | 3 V | 3 V | | 0.39 | 0.72 | 0.39 | 0.72 | | |
| | | | 4.5 V | 4.5 V | | 0.57 | 0.97 | 0.57 | 0.97 | | |
| | | | 5.5 V | 5.5 V | | 0.69 | 1.18 | 0.69 | 1.18 | | |

7.5 Electrical Characteristics (continued)

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 | |
| V _{OH} | High-level output voltage ⁽³⁾ | I _{OH} = -0.1 mA | 1.1V – 5.5V | 1.1V – 5.5V | | | | V _{CCO} - 0.1 | | | V _{CCO} - 0.1 | V | |
| | | I _{OH} = -0.5 mA | 1.1 V | 1.1 V | | | | 0.82 | | | 0.82 | | |
| | | I _{OH} = -3 mA | 1.4 V | 1.4 V | | | | 1 | | | 1 | | |
| | | I _{OH} = -4.5 mA | 1.65 V | 1.65 V | | | | 1.2 | | | 1.2 | | |
| | | I _{OH} = -8 mA | 2.3 V | 2.3 V | | | | 1.7 | | | 1.7 | | |
| | | I _{OH} = -10 mA | 3 V | 3 V | | | | 2.2 | | | 2.2 | | |
| | | I _{OH} = -12 mA | 4.5 V | 4.5 V | | | | 3.7 | | | 3.7 | | |
| V _{OL} | Low-level output voltage ⁽⁴⁾ | I _{OL} = 0.1 mA | 1.1V – 5.5V | 1.1V – 5.5V | | | | | 0.1 | | 0.1 | V | |
| | | I _{OL} = 0.5 mA | 1.1 V | 1.1 V | | | | | 0.27 | | 0.27 | | |
| | | I _{OL} = 3 mA | 1.4 V | 1.4 V | | | | | 0.35 | | 0.35 | | |
| | | I _{OL} = 4.5 mA | 1.65 V | 1.65 V | | | | | 0.45 | | 0.45 | | |
| | | I _{OL} = 8 mA | 2.3 V | 2.3 V | | | | | 0.7 | | 0.7 | | |
| | | I _{OL} = 10 mA | 3 V | 3 V | | | | | 0.8 | | 0.8 | | |
| | | I _{OL} = 12 mA | 4.5 V | 4.5 V | | | | | 0.8 | | 0.8 | | |
| I _I | Input leakage current | OE V _I = V _{CC} or GND | 1.1V – 5.5V | 1.1V – 5.5V | -0.1 | 1.5 | -0.1 | 1.5 | -0.1 | 2 | 2 | μA | |
| | | Data Inputs (A _x , B _x) V _I = V _{CC1} or GND | 1.1V – 5.5V | 1.1V – 5.5V | -0.1 | 1.5 | -0.1 | 1.5 | -2 | 2 | 2 | μA | |
| I _{off} | Partial power down current | A Port or B Port V _I or V _O = 0 V - 5.5 V | 0 V | 0 V - 5.5 V | -1.5 | 1.5 | -2 | 2 | -2.5 | 2.5 | 2.5 | μA | |
| | | | 0 V - 5.5 V | 0 V | -1.5 | 1.5 | -2 | 2 | -2.5 | 2.5 | | | |
| I _{off-float} | Floating supply Partial power down current | A Port or B Port V _I or V _O = GND | Floating ⁽⁵⁾ | 0 V - 5.5 V | -1.5 | 1.5 | -2 | 2 | -2.5 | 2.5 | 2.5 | μA | |
| | | | 0 V - 5.5 V | Floating ⁽⁵⁾ | -1.5 | 1.5 | -2 | 2 | -2.5 | 2.5 | | | |
| I _{OZ} | Tri-state output current | A or B Port: V _I = V _{CC1} or GND V _O = V _{CCO} or GND OE = GND | 1.1V – 5.5V | 1.1V – 5.5V | -0.3 | 0.3 | -1 | 1 | -2 | 2 | 2 | μA | |
| I _{CCA} | V _{CCA} supply current | V _I = V _{CC1} or GND I _O = 0 | 1.1V – 5.5V | 1.1V – 5.5V | | 1.5 | | 2.5 | | | 6 | μA | |
| | | | 0 V | 5.5 V | -0.3 | | -1 | | -1 | | | | |
| | | | 5.5 V | 0 V | | 1 | | 1.5 | | | 3 | | |
| I _{CCB} | V _{CCB} supply current | V _I = V _{CC1} or GND I _O = 0 | 1.1V – 5.5V | 1.1V – 5.5V | | 1.5 | | 2.5 | | | 6 | μA | |
| | | | 0 V | 5.5 V | | 1 | | 1.5 | | | 3 | | |
| | | | 5.5 V | 0 V | -0.3 | | -1 | | -1 | | | | |
| I _{CCA} + I _{CCB} | Combined supply current | V _I = V _{CC1} or GND I _O = 0 | 1.1V – 5.5V | 1.1V – 5.5V | | 2.5 | | 3 | | | 6 | μA | |
| | | | Floating ⁽⁵⁾ | 5.5 V | | 1.5 | | 7 | | | 15 | | |
| C _i | Control Input Capacitance | V _I = 3.3 V or GND | 3.3 V | 3.3 V | | 2.75 | | 3 | | 3.5 | pF | | |

7.5 Electrical Characteristics (continued)

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 | | |
| C _{io} | Data I/O Capacitance | OE = GND, V _O = 1.65V DC +1 MHz -16 dBm sine wave | 3.3 V | 3.3 V | 3 | | | 4 | | | 4 | | | 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
- (3) Tested at V_I = V_{T+(MAX)}
- (4) Tested at V_I = V_{T-(MIN)}
- (5) Floating is defined as a node that is both not actively driven by an external device and has leakage not exceeding 10nA

7.6 Switching Characteristics: T_{sk}, T_{MAX}

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

| PARAMETER | TEST CONDITIONS | V _{CCI} | V _{CCO} | Operating free-air temperature (T _A) | | | UNIT | | | | | |
|--------------------------------------|---|------------------|-------------------------------|---|----------------|-----------------|---------------|------|----|--|--|----|
| | | | | -40°C to 125°C | | | | | | | | |
| | | | | MIN | TYP | MAX | | | | | | |
| T _{MAX} - Maximum Data Rate | 50% Duty Cycle Input One channel switching 20% of pulse > 0.7*V _{CCO} 20% of pulse < 0.3*V _{CCO} | Up Translation | 3.0 V - 3.6 V | 4.5 V - 5.5 V | 200 | | | Mbps | | | | |
| | | | 1.65 V - 1.95 V | 4.5 V - 5.5 V | 150 | | | | | | | |
| | | | 1.1 V - 1.3 V | 4.5 V - 5.5 V | 30 | | | | | | | |
| | | | 1.65 V - 1.95 V | 3.0 V - 3.6 V | 100 | | | | | | | |
| | | | 1.1 V - 1.3 V | 3.0 V - 3.6 V | 30 | | | | | | | |
| | | | 1.1 V - 1.3 V | 1.65 V - 1.95 V | 20 | | | | | | | |
| | | Down Translation | 4.5 V - 5.5 V | 3.0 V - 3.6 V | 125 | | | | | | | |
| | | | 4.5 V - 5.5 V | 1.65 V - 1.95 V | 50 | | | | | | | |
| | | | 4.5 V - 5.5 V | 1.1 V - 1.3 V | 10 | | | | | | | |
| | | | 3.0 V - 3.6 V | 1.65 V - 1.95 V | 50 | | | | | | | |
| | | | 3.0 V - 3.6 V | 1.1 V - 1.3 V | 10 | | | | | | | |
| | | | 1.65 V - 1.95 V | 1.1 V - 1.3 V | 10 | | | | | | | |
| | | | t _{sk} - Output skew | Timing skew between any switching outputs on the rising or falling edge | Up Translation | 3.0 V - 3.6 V | 4.5 V - 5.5 V | | 3 | | | ns |
| | | | | | | 1.65 V - 1.95 V | 4.5 V - 5.5 V | | 10 | | | |
| 1.1 V - 1.3 V | 4.5 V - 5.5 V | 42 | | | | | | | | | | |
| 1.65 V - 1.95 V | 3.0 V - 3.6 V | 8 | | | | | | | | | | |
| 1.1 V - 1.3 V | 3.0 V - 3.6 V | 42 | | | | | | | | | | |
| 1.1 V - 1.3 V | 1.65 V - 1.95 V | 45 | | | | | | | | | | |
| Down Translation | 4.5 V - 5.5 V | 3.0 V - 3.6 V | | | 3 | | | | | | | |
| | 4.5 V - 5.5 V | 1.65 V - 1.95 V | | | 10 | | | | | | | |
| | 4.5 V - 5.5 V | 1.1 V - 1.3 V | | | 42 | | | | | | | |
| | 3.0 V - 3.6 V | 1.65 V - 1.95 V | | | 8 | | | | | | | |
| | 3.0 V - 3.6 V | 1.1 V - 1.3 V | | | 42 | | | | | | | |
| | 1.65 V - 1.95 V | 1.1 V - 1.3 V | | | 45 | | | | | | | |

7.7 Switching Characteristics, $V_{CCA} = 1.2 \pm 0.1 \text{ V}$

See [Figure 8-1](#) and [Table 8-1](#) for test circuit and loading. See [Figure 8-2](#), [Figure 8-3](#), and [Figure 8-4](#) for measurement waveforms.

| PARAMETER | FROM | TO | Test Conditions | B-Port Supply Voltage (V_{CCB}) | | | | | | | | | | | | UNIT | | | | | | |
|-----------|-------------------|----|-----------------|-------------------------------------|------|-----|-------------|-----|------|--------------|------|-----|-------------|-----|------|------|-------------|-----|-----|-------------|-----|-----|
| | | | | 1.2 ± 0.1 V | | | 1.5 ± 0.1 V | | | 1.8 ± 0.15 V | | | 2.5 ± 0.2 V | | | | 3.3 ± 0.3 V | | | 5.0 ± 0.5 V | | |
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | | MIN | TYP | MAX | MIN | TYP | MAX |
| t_{pd} | Propagation delay | A | B | -40°C to 85°C | 3.3 | 96 | 0.5 | 43 | 0.5 | 37 | 0.5 | 32 | 0.5 | 30 | 0.5 | 31 | ns | | | | | |
| | | | | -40°C to 125°C | 5.7 | 60 | 3.0 | 39 | 1.4 | 33 | 0.5 | 28 | 0.5 | 27 | 0.5 | 26 | | | | | | |
| | | B | A | -40°C to 85°C | 3.3 | 95 | 1.9 | 80 | 0.5 | 75 | 0.5 | 70 | 0.5 | 69 | 0.5 | 69 | | | | | | |
| | | | | -40°C to 125°C | 5.7 | 60 | 4.1 | 51 | 2.9 | 48 | 1.8 | 45 | 1.5 | 44 | 1.3 | 44 | | | | | | |
| t_{dis} | Disable time | OE | A | -40°C to 85°C | 28.8 | 133 | 28.5 | 130 | 28.4 | 133 | 28.8 | 137 | 28.4 | 143 | 18.7 | 211 | ns | | | | | |
| | | | | -40°C to 125°C | 43.3 | 133 | 43.3 | 130 | 43.7 | 130 | 44.7 | 131 | 45.4 | 134 | 31.8 | 140 | | | | | | |
| | | OE | B | -40°C to 85°C | 32.5 | 150 | 27.6 | 117 | 25.8 | 110 | 22.5 | 104 | 22.1 | 112 | 20.1 | 181 | | | | | | |
| | | | | -40°C to 125°C | 48.3 | 149 | 43.2 | 120 | 40.8 | 113 | 36.8 | 104 | 36.5 | 107 | 33.8 | 111 | | | | | | |
| t_{en} | Enable time | OE | A | -40°C to 85°C | 24.1 | 237 | 22.1 | 229 | 21.4 | 230 | 21.3 | 232 | 21.7 | 235 | 22.7 | 244 | ns | | | | | |
| | | | | -40°C to 125°C | 34.9 | 156 | 33.3 | 167 | 32.0 | 169 | 31.7 | 173 | 32.0 | 177 | 34.2 | 187 | | | | | | |
| | | OE | B | -40°C to 85°C | 21.3 | 237 | 14.3 | 152 | 11.2 | 140 | 8.8 | 130 | 8.2 | 130 | 8.4 | 132 | | | | | | |
| | | | | -40°C to 125°C | 29.8 | 143 | 23.0 | 116 | 18.6 | 107 | 15.4 | 97 | 14.5 | 97 | 14.8 | 103 | | | | | | |

7.8 Switching Characteristics, $V_{CCA} = 1.5 \pm 0.1 \text{ V}$

See [Figure 8-1](#) and [Table 8-1](#) for test circuit and loading. See [Figure 8-2](#), [Figure 8-3](#), and [Figure 8-4](#) for measurement waveforms.

| PARAMETER | FROM | TO | Test Conditions | B-Port Supply Voltage (V_{CCB}) | | | | | | | | | | | | UNIT | | | | | | |
|-----------|-------------------|----|-----------------|-------------------------------------|------|-----|-------------|-----|------|--------------|------|-----|-------------|-----|------|------|-------------|-----|-----|-------------|-----|-----|
| | | | | 1.2 ± 0.1 V | | | 1.5 ± 0.1 V | | | 1.8 ± 0.15 V | | | 2.5 ± 0.2 V | | | | 3.3 ± 0.3 V | | | 5.0 ± 0.5 V | | |
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | | MIN | TYP | MAX | MIN | TYP | MAX |
| t_{pd} | Propagation delay | A | B | -40°C to 85°C | 1.9 | 80 | 0.5 | 31 | 0.5 | 25 | 0.5 | 19 | 0.5 | 17 | 0.5 | 15 | ns | | | | | |
| | | | | -40°C to 125°C | 4.1 | 51 | 1.6 | 31 | 0.5 | 25 | 0.5 | 20 | 0.5 | 18 | 0.5 | 16 | | | | | | |
| | | B | A | -40°C to 85°C | 0.5 | 43 | 0.5 | 31 | 0.5 | 28 | 0.5 | 26 | 0.5 | 25 | 0.5 | 24 | | | | | | |
| | | | | -40°C to 125°C | 3.0 | 39 | 1.6 | 31 | 0.5 | 28 | 0.5 | 26 | 0.5 | 25 | 0.5 | 24 | | | | | | |
| t_{dis} | Disable time | OE | A | -40°C to 85°C | 20.0 | 91 | 19.0 | 82 | 18.8 | 81 | 19.2 | 82 | 19.6 | 83 | 12.2 | 87 | ns | | | | | |
| | | | | -40°C to 125°C | 34.9 | 95 | 32.6 | 86 | 32.8 | 85 | 33.4 | 87 | 34.2 | 88 | 24.6 | 92 | | | | | | |
| | | OE | B | -40°C to 85°C | 27.4 | 127 | 21.7 | 91 | 19.9 | 82 | 16.3 | 71 | 15.9 | 71 | 13.7 | 70 | | | | | | |
| | | | | -40°C to 125°C | 44.4 | 130 | 36.7 | 95 | 34.7 | 86 | 30.2 | 75 | 29.8 | 75 | 26.6 | 74 | | | | | | |
| t_{en} | Enable time | OE | A | -40°C to 85°C | 14.9 | 102 | 14.4 | 86 | 13.5 | 88 | 12.7 | 90 | 12.6 | 92 | 13.2 | 97 | ns | | | | | |
| | | | | -40°C to 125°C | 25.5 | 102 | 25.2 | 89 | 24.1 | 91 | 22.8 | 93 | 22.8 | 96 | 23.5 | 100 | | | | | | |
| | | OE | B | -40°C to 85°C | 17.9 | 175 | 12.7 | 80 | 9.1 | 69 | 6.1 | 57 | 4.9 | 53 | 4.5 | 54 | | | | | | |
| | | | | -40°C to 125°C | 26.6 | 135 | 21.0 | 81 | 16.8 | 71 | 12.5 | 60 | 10.8 | 56 | 10.4 | 57 | | | | | | |

7.9 Switching Characteristics, $V_{CCA} = 1.8 \pm 0.15 \text{ V}$

See [Figure 8-1](#) and [Table 8-1](#) for test circuit and loading. See [Figure 8-2](#), [Figure 8-3](#), and [Figure 8-4](#) for measurement waveforms.

| PARAMETER | FROM | TO | Test Conditions | B-Port Supply Voltage (V_{CCB}) | | | | | | | | | | | | UNIT | | | | | | |
|-----------|-------------------|----|-----------------|-------------------------------------|------|-----|-------------|-----|------|--------------|------|-----|-------------|-----|------|------|-------------|-----|-----|-------------|-----|-----|
| | | | | 1.2 ± 0.1 V | | | 1.5 ± 0.1 V | | | 1.8 ± 0.15 V | | | 2.5 ± 0.2 V | | | | 3.3 ± 0.3 V | | | 5.0 ± 0.5 V | | |
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | | MIN | TYP | MAX | MIN | TYP | MAX |
| t_{pd} | Propagation delay | A | B | -40°C to 85°C | 0.5 | 75 | 0.5 | 28 | 0.5 | 22 | 0.5 | 17 | 0.5 | 14 | 0.5 | 12 | ns | | | | | |
| | | | | -40°C to 125°C | 2.9 | 48 | 0.5 | 28 | 0.5 | 23 | 0.5 | 17 | 0.5 | 15 | 0.5 | 13 | | | | | | |
| | | B | A | -40°C to 85°C | 0.5 | 37 | 0.5 | 25 | 0.5 | 22 | 0.5 | 19 | 0.5 | 19 | 0.5 | 18 | | | | | | |
| | | | | -40°C to 125°C | 1.4 | 33 | 0.5 | 25 | 0.5 | 23 | 0.5 | 20 | 0.5 | 19 | 0.5 | 19 | | | | | | |
| t_{dis} | Disable time | OE | A | -40°C to 85°C | 17.2 | 79 | 14.7 | 67 | 14.5 | 65 | 14.3 | 65 | 14.4 | 66 | 8.5 | 68 | ns | | | | | |
| | | | | -40°C to 125°C | 30.9 | 83 | 28.0 | 71 | 26.6 | 69 | 27.5 | 70 | 27.2 | 71 | 20.0 | 73 | | | | | | |
| | | OE | B | -40°C to 85°C | 25.4 | 121 | 18.7 | 81 | 16.5 | 71 | 12.8 | 60 | 12.5 | 58 | 9.8 | 55 | | | | | | |
| | | | | -40°C to 125°C | 41.7 | 123 | 34.0 | 86 | 30.3 | 76 | 26.2 | 64 | 25.3 | 62 | 21.8 | 59 | | | | | | |
| t_{en} | Enable time | OE | A | -40°C to 85°C | 10.9 | 88 | 9.5 | 66 | 9.4 | 63 | 8.6 | 65 | 8.2 | 66 | 8.1 | 69 | ns | | | | | |
| | | | | -40°C to 125°C | 20.3 | 87 | 19.0 | 69 | 18.9 | 67 | 17.6 | 68 | 17.1 | 70 | 17.1 | 73 | | | | | | |
| | | OE | B | -40°C to 85°C | 16.7 | 177 | 10.4 | 75 | 8.1 | 58 | 4.9 | 46 | 3.3 | 42 | 2.2 | 39 | | | | | | |
| | | | | -40°C to 125°C | 25.1 | 135 | 18.7 | 77 | 15.5 | 60 | 11.0 | 49 | 8.7 | 44 | 7.3 | 42 | | | | | | |

7.10 Switching Characteristics, $V_{CCA} = 2.5 \pm 0.2 \text{ V}$

See [Figure 8-1](#) and [Table 8-1](#) for test circuit and loading. See [Figure 8-2](#), [Figure 8-3](#), and [Figure 8-4](#) for measurement waveforms.

| PARAMETER | | FROM | TO | Test Conditions | B-Port Supply Voltage (V_{CCB}) | | | | | | | | | | | | UNIT | | | | | | |
|-----------|-------------------|------|----|-----------------|-------------------------------------|-----|------|-------------|------|-----|--------------|-----|------|-------------|------|-----|------|-------------|-----|-----|-------------|-----|-----|
| | | | | | 1.2 ± 0.1 V | | | 1.5 ± 0.1 V | | | 1.8 ± 0.15 V | | | 2.5 ± 0.2 V | | | | 3.3 ± 0.3 V | | | 5.0 ± 0.5 V | | |
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | | MIN | TYP | MAX | MIN | TYP | MAX |
| t_{pd} | Propagation delay | A | B | -40°C to 85°C | 0.5 | 70 | 0.5 | 26 | 0.5 | 20 | 0.5 | 14 | 0.5 | 12 | 0.5 | 9 | ns | | | | | | |
| | | | | -40°C to 125°C | 1.8 | 45 | 0.5 | 26 | 0.5 | 20 | 0.5 | 14 | 0.5 | 12 | 0.5 | 10 | | | | | | | |
| | | B | A | -40°C to 85°C | 0.5 | 32 | 0.5 | 19 | 0.5 | 17 | 0.5 | 14 | 0.5 | 13 | 0.5 | 13 | | | | | | | |
| | | | | -40°C to 125°C | 0.5 | 28 | 0.5 | 20 | 0.5 | 17 | 0.5 | 14 | 0.5 | 13 | 0.5 | 13 | | | | | | | |
| t_{dis} | Disable time | OE | A | -40°C to 85°C | 12.9 | 65 | 10.5 | 51 | 9.0 | 51 | 8.1 | 43 | 8.4 | 44 | 5.0 | 45 | ns | | | | | | |
| | | | | -40°C to 125°C | 24.9 | 68 | 21.8 | 55 | 19.7 | 50 | 18.2 | 47 | 18.6 | 48 | 15.0 | 49 | | | | | | | |
| | | OE | B | -40°C to 85°C | 23.2 | 112 | 16.5 | 74 | 14.0 | 61 | 9.0 | 46 | 9.1 | 44 | 6.4 | 39 | | | | | | | |
| | | | | -40°C to 125°C | 38.7 | 115 | 30.9 | 79 | 27.1 | 66 | 21.6 | 51 | 20.5 | 48 | 16.8 | 43 | | | | | | | |
| t_{en} | Enable time | OE | A | -40°C to 85°C | 7.9 | 80 | 5.9 | 50 | 5.1 | 44 | 4.7 | 39 | 4.4 | 40 | 3.7 | 41 | ns | | | | | | |
| | | | | -40°C to 125°C | 15.6 | 74 | 13.5 | 53 | 12.4 | 47 | 12.0 | 42 | 11.5 | 43 | 10.8 | 44 | | | | | | | |
| | | OE | B | -40°C to 85°C | 16.3 | 183 | 9.2 | 74 | 6.0 | 54 | 4.0 | 36 | 2.1 | 31 | 0.5 | 27 | | | | | | | |
| | | | | -40°C to 125°C | 24.4 | 139 | 17.2 | 76 | 13.0 | 57 | 9.8 | 38 | 7.1 | 33 | 4.7 | 29 | | | | | | | |

7.11 Switching Characteristics, $V_{CCA} = 3.3 \pm 0.3 \text{ V}$

See [Figure 8-1](#) and [Table 8-1](#) for test circuit and loading. See [Figure 8-2](#), [Figure 8-3](#), and [Figure 8-4](#) for measurement waveforms.

| PARAMETER | | FROM | TO | Test Conditions | B-Port Supply Voltage (V_{CCB}) | | | | | | | | | | | | UNIT | | | | | | |
|-----------|-------------------|------|----|-----------------|-------------------------------------|-----|------|-------------------------|------|-----|--------------------------|-----|------|-------------------------|------|-----|------|-------------------------|-----|-----|-------------------------|-----|-----|
| | | | | | $1.2 \pm 0.1 \text{ V}$ | | | $1.5 \pm 0.1 \text{ V}$ | | | $1.8 \pm 0.15 \text{ V}$ | | | $2.5 \pm 0.2 \text{ V}$ | | | | $3.3 \pm 0.3 \text{ V}$ | | | $5.0 \pm 0.5 \text{ V}$ | | |
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | | MIN | TYP | MAX | MIN | TYP | MAX |
| t_{pd} | Propagation delay | A | B | -40°C to 85°C | 0.5 | 69 | 0.5 | 25 | 0.5 | 19 | 0.5 | 13 | 0.5 | 11 | 0.5 | 8 | ns | | | | | | |
| | | | | -40°C to 125°C | 1.5 | 44 | 0.5 | 25 | 0.5 | 19 | 0.5 | 13 | 0.5 | 11 | 0.5 | 9 | | | | | | | |
| | | B | A | -40°C to 85°C | 0.5 | 30 | 0.5 | 17 | 0.5 | 14 | 0.5 | 12 | 0.5 | 11 | 0.5 | 10 | | | | | | | |
| | | | | -40°C to 125°C | 0.5 | 27 | 0.5 | 18 | 0.5 | 15 | 0.5 | 12 | 0.5 | 11 | 0.5 | 10 | | | | | | | |
| t_{dis} | Disable time | OE | A | -40°C to 85°C | 12.9 | 62 | 10.1 | 47 | 8.7 | 42 | 6.9 | 39 | 6.6 | 39 | 6.9 | 40 | ns | | | | | | |
| | | | | -40°C to 125°C | 24.0 | 65 | 20.6 | 51 | 18.4 | 46 | 15.7 | 40 | 15.3 | 39 | 15.9 | 40 | | | | | | | |
| | | OE | B | -40°C to 85°C | 22.7 | 109 | 15.7 | 71 | 13.2 | 59 | 8.5 | 42 | 7.6 | 38 | 4.7 | 34 | | | | | | | |
| | | | | -40°C to 125°C | 37.6 | 111 | 29.5 | 75 | 25.4 | 63 | 19.2 | 46 | 18.5 | 42 | 14.2 | 36 | | | | | | | |
| t_{en} | Enable time | OE | A | -40°C to 85°C | 6.6 | 85 | 4.2 | 45 | 3.0 | 37 | 2.4 | 31 | 2.2 | 30 | 1.7 | 30 | ns | | | | | | |
| | | | | -40°C to 125°C | 13.6 | 72 | 10.9 | 47 | 9.3 | 40 | 8.2 | 33 | 8.1 | 32 | 7.5 | 33 | | | | | | | |
| | | OE | B | -40°C to 85°C | 16.3 | 192 | 8.9 | 76 | 5.4 | 55 | 2.6 | 34 | 1.8 | 27 | 0.5 | 22 | | | | | | | |
| | | | | -40°C to 125°C | 24.3 | 144 | 16.7 | 78 | 12.2 | 57 | 8.0 | 36 | 6.6 | 29 | 3.7 | 24 | | | | | | | |

7.12 Switching Characteristics, $V_{CCA} = 5.0 \pm 0.5 \text{ V}$

See [Figure 8-1](#) and [Table 8-1](#) for test circuit and loading. See [Figure 8-2](#), [Figure 8-3](#), and [Figure 8-4](#) for measurement waveforms.

| PARAMETER | FROM | TO | Test Conditions | B-Port Supply Voltage (V_{CCB}) | | | | | | | | | | | | UNIT | | | | | | |
|-----------|-------------------|----|-----------------|-------------------------------------|------|-----|-------------|-----|------|--------------|------|-----|-------------|-----|------|------|-------------|-----|-----|-------------|-----|-----|
| | | | | 1.2 ± 0.1 V | | | 1.5 ± 0.1 V | | | 1.8 ± 0.15 V | | | 2.5 ± 0.2 V | | | | 3.3 ± 0.3 V | | | 5.0 ± 0.5 V | | |
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | | MIN | TYP | MAX | MIN | TYP | MAX |
| t_{pd} | Propagation delay | A | B | -40°C to 85°C | 0.5 | 69 | 0.5 | 24 | 0.5 | 18 | 0.5 | 13 | 0.5 | 10 | 0.5 | 8 | ns | | | | | |
| | | | | -40°C to 125°C | 1.3 | 44 | 0.5 | 24 | 0.5 | 19 | 0.5 | 13 | 0.5 | 11 | 0.5 | 8 | | | | | | |
| | | B | A | -40°C to 85°C | 0.5 | 31 | 0.5 | 15 | 0.5 | 12 | 0.5 | 9 | 0.5 | 8 | 0.5 | 8 | | | | | | |
| | | | | -40°C to 125°C | 0.5 | 26 | 0.5 | 16 | 0.5 | 13 | 0.5 | 10 | 0.5 | 9 | 0.5 | 8 | | | | | | |
| t_{dis} | Disable time | OE | A | -40°C to 85°C | 10.8 | 58 | 7.7 | 42 | 5.9 | 36 | 4.2 | 31 | 3.4 | 30 | 2.8 | 26 | ns | | | | | |
| | | | | -40°C to 125°C | 20.8 | 61 | 17.0 | 46 | 14.5 | 40 | 11.8 | 33 | 10.4 | 31 | 9.6 | 29 | | | | | | |
| | | OE | B | -40°C to 85°C | 9.7 | 109 | 5.9 | 69 | 13.2 | 56 | 8.4 | 40 | 6.9 | 36 | 3.7 | 29 | | | | | | |
| | | | | -40°C to 125°C | 37.4 | 111 | 29.2 | 73 | 24.6 | 60 | 18.1 | 43 | 16.4 | 39 | 12.2 | 31 | | | | | | |
| t_{en} | Enable time | OE | A | -40°C to 85°C | 6.0 | 102 | 2.8 | 44 | 1.2 | 33 | 0.5 | 25 | 0.5 | 22 | 0.5 | 21 | ns | | | | | |
| | | | | -40°C to 125°C | 12.4 | 81 | 8.8 | 46 | 6.5 | 36 | 4.7 | 27 | 4.2 | 24 | 4.4 | 23 | | | | | | |
| | | OE | B | -40°C to 85°C | 16.7 | 212 | 8.8 | 82 | 4.8 | 58 | 1.6 | 35 | 0.5 | 26 | 0.5 | 19 | | | | | | |
| | | | | -40°C to 125°C | 24.8 | 158 | 16.7 | 83 | 11.7 | 60 | 6.9 | 37 | 4.7 | 28 | 3.5 | 21 | | | | | | |

7.13 Operating Characteristics

$T_A = 25^\circ\text{C}$ ⁽¹⁾

| PARAMETER | | Test Conditions | Supply Voltage ($V_{CCB} = V_{CCA}$) | | | | | | UNIT |
|--------------------------|--------------------------|--|--|------------|-------------|------------|------------|------------|------|
| | | | 1.2 ± 0.1V | 1.5 ± 0.1V | 1.8 ± 0.15V | 2.5 ± 0.2V | 3.3 ± 0.3V | 5.0 ± 0.5V | |
| | | | TYP | TYP | TYP | TYP | TYP | TYP | |
| C_{pdA} ⁽²⁾ | A to B: outputs enabled | A Port CL = 0, RL = Open f = 10 MHz $t_{rise} = t_{fall} = 1\text{ ns}$ | 2 | 2 | 2 | 2 | 2 | 3 | pF |
| | A to B: outputs disabled | | 2 | 2 | 2 | 2 | 2 | 3 | |
| | B to A: outputs enabled | | 12 | 12 | 12 | 13 | 13 | 16 | |
| | B to A: outputs disabled | | 2 | 2 | 2 | 2 | 2 | 3 | |
| C_{pdB} ⁽³⁾ | A to B: outputs enabled | B Port CL = 0, RL = Open f = 10 MHz $t_{rise} = t_{fall} = 1\text{ ns}$ | 12 | 12 | 12 | 13 | 13 | 16 | pF |
| | A to B: outputs disabled | | 2 | 2 | 2 | 2 | 2 | 3 | |
| | B to A: outputs enabled | | 2 | 2 | 2 | 2 | 2 | 3 | |
| | B to A: outputs disabled | | 2 | 2 | 2 | 2 | 2 | 3 | |

- (1) See the [CMOS Power Consumption and \$C_{pd}\$ Calculation](#) application report for additional information about how power dissipation capacitance affects power consumption.
- (2) A-Port power dissipation capacitance per transceiver.
- (3) B-Port power dissipation capacitance per transceiver.

7.14 Typical Characteristics

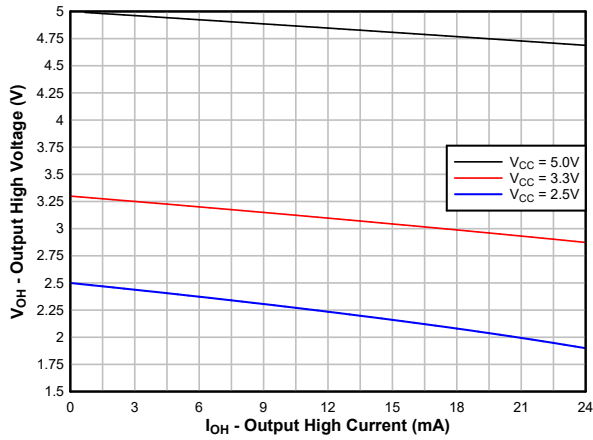


Figure 7-1. Typical ($T_A=25^\circ\text{C}$) Output High Voltage (V_{OH}) vs Source Current (I_{OH})

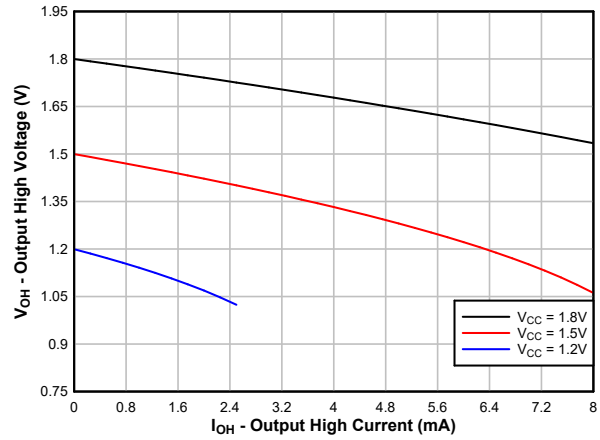


Figure 7-2. Typical ($T_A=25^\circ\text{C}$) Output High Voltage (V_{OH}) vs Source Current (I_{OH})

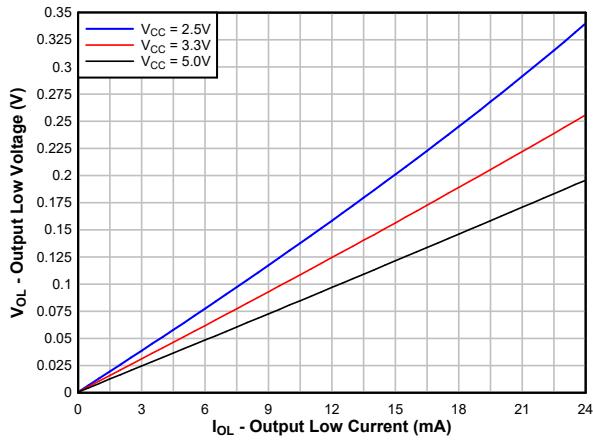


Figure 7-3. Typical ($T_A=25^\circ\text{C}$) Output Low Voltage (V_{OL}) vs Sink Current (I_{OL})

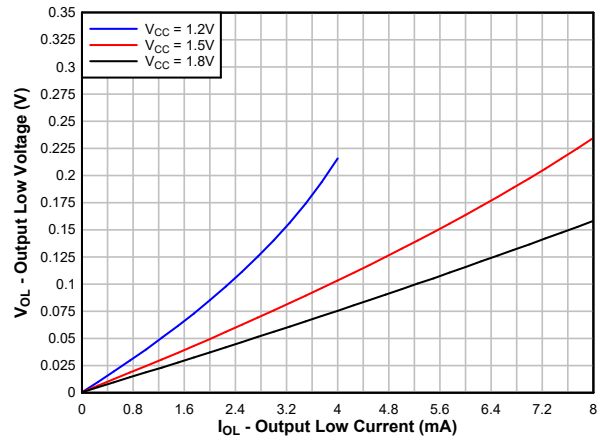


Figure 7-4. Typical ($T_A=25^\circ\text{C}$) Output Low Voltage (V_{OL}) vs Sink Current (I_{OL})

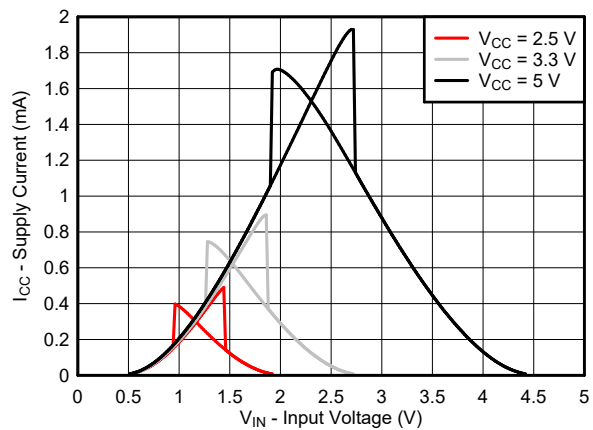


Figure 7-5. Typical ($T_A=25^\circ\text{C}$) Supply Current (I_{CC}) vs Input Voltage (V_{IN})

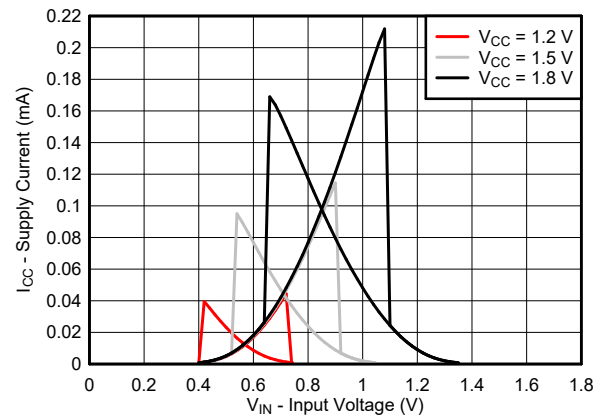


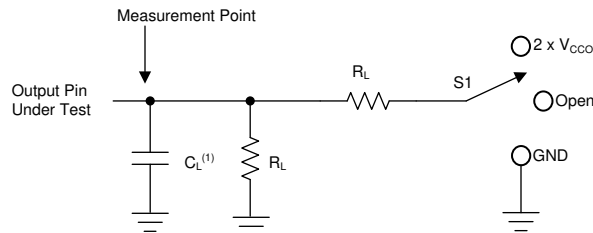
Figure 7-6. Typical ($T_A=25^\circ\text{C}$) Supply Current (I_{CC}) vs Input Voltage (V_{IN})

8 Parameter Measurement Information

8.1 Load Circuit and Voltage Waveforms

Unless otherwise noted, generators supply all input pulses that have the following characteristics:

- $f = 1 \text{ MHz}$
- $Z_O = 50 \Omega$
- $\Delta t/\Delta V \leq 1 \text{ ns/V}$

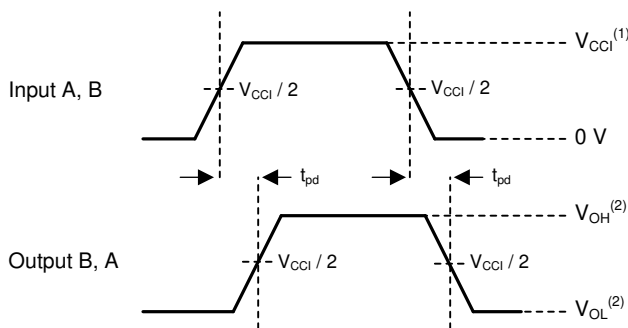


A. C_L includes probe and jig capacitance.

Figure 8-1. Load Circuit

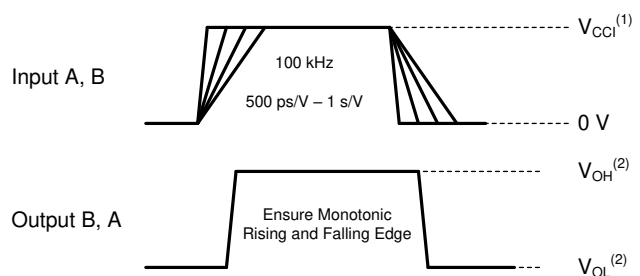
Table 8-1. Load Circuit Conditions

| Parameter | V_{CCO} | R_L | C_L | S_1 | V_{TP} |
|---|----------------|---------------|-------|--------------------|----------|
| t_{pd} Propagation (delay) time | 1.1 V – 5.5 V | 10 k Ω | 5 pF | Open | N/A |
| t_{en}, t_{dis} Enable time, disable time | 1.1 V – 1.6 V | 10 k Ω | 5 pF | $2 \times V_{CCO}$ | 0.1 V |
| | 1.65 V – 2.7 V | 10 k Ω | 5 pF | $2 \times V_{CCO}$ | 0.15 V |
| | 3.0 V – 5.5 V | 10 k Ω | 5 pF | $2 \times V_{CCO}$ | 0.3 V |
| t_{en}, t_{dis} Enable time, disable time | 1.1 V – 1.6 V | 10 k Ω | 5 pF | GND | 0.1 V |
| | 1.65 V – 2.7 V | 10 k Ω | 5 pF | GND | 0.15 V |
| | 3.0 V – 5.5 V | 10 k Ω | 5 pF | GND | 0.3 V |



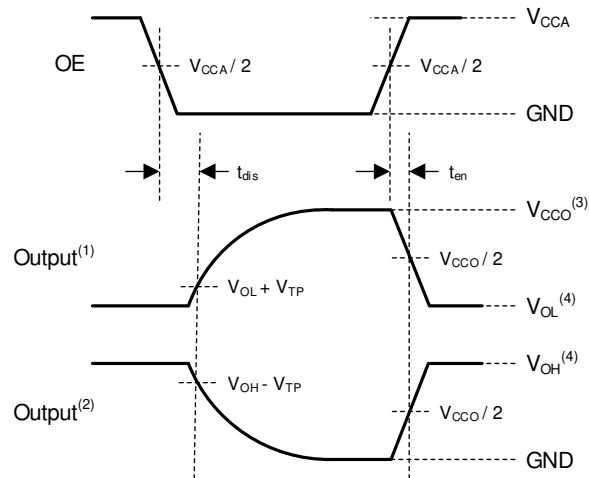
1. V_{CCI} is the supply pin associated with the input port.
2. V_{OH} and V_{OL} are typical output voltage levels that occur with specified R_L , C_L , and S_1

Figure 8-2. Propagation Delay



1. V_{CCI} is the supply pin associated with the input port.
2. V_{OH} and V_{OL} are typical output voltage levels that occur with specified R_L , C_L , and S_1

Figure 8-3. Input Transition Rise and Fall Rate



1. Output waveform on the condition that input is driven to a valid Logic Low.
2. Output waveform on the condition that input is driven to a valid Logic High.
3. V_{CC0} is the supply pin associated with the output port.
4. V_{OH} and V_{OL} are typical output voltage levels with specified R_L, C_L, and S₁.

Figure 8-4. Enable Time And Disable Time

9 Detailed Description

9.1 Overview

The TXU0104-Q1 is a 4-bit translating transceiver that uses two individually configurable power-supply rails. The device is operational with V_{CCA} and V_{CCB} supplies as low as 1.1 V and as high as 5.5 V. Additionally, the device can be operated with $V_{CCA} = V_{CCB}$. The A port is designed to track V_{CCA} , and the B port is designed to track V_{CCB} .

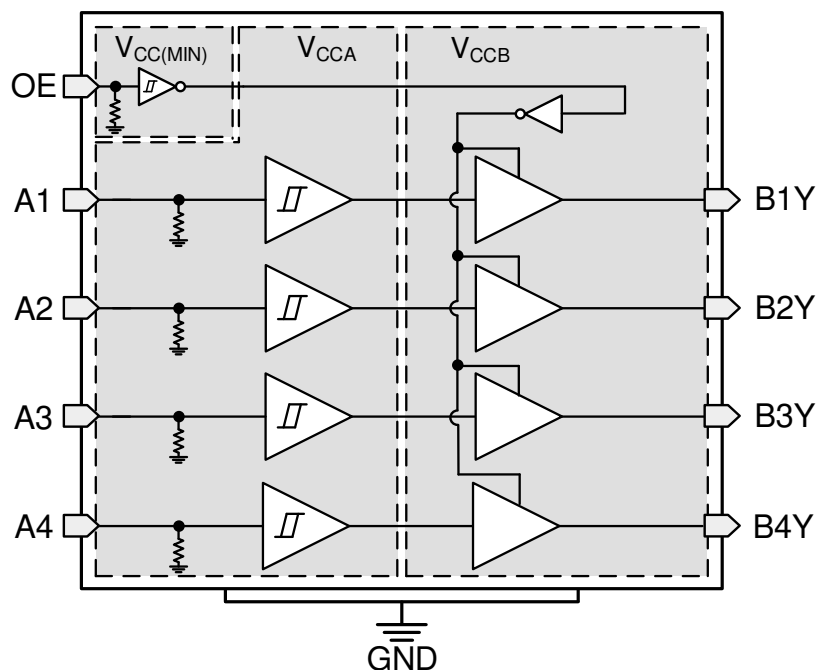
The TXU0104-Q1 device is designed for asynchronous communication between data buses, and transmits data with fixed direction from the A bus to the B bus on some channels and from the B bus to the A bus on the remaining channels. The output-enable input (OE) is used to disable the outputs so the buses are effectively isolated. The output-enable pin of the TXU0104-Q1 (OE) can be referenced to either V_{CCA} or V_{CCB} . The OE pin can be left floating or externally pulled down to ground to ensure the high-impedance state of the level shifter outputs during power up or power down.

This device is fully specified for partial-power-down applications using the I_{off} current. The I_{off} protection circuitry ensures that no excessive current is drawn from or sourced into an input or output while the device is powered down.

The VCC isolation or VCC disconnect feature ensures that if either VCC is less than 100 mV or disconnected with the complementary supply within recommended operating conditions, outputs are disabled and set to the high-impedance state while the supply current is maintained. The I_{off_float} circuitry ensures that no excessive current is drawn from or sourced into an input or output while the supply is floating.

Glitch-free power supply sequencing allows either supply rail to be powered on or off in any order while providing robust power sequencing performance.

9.2 Functional Block Diagram



9.3 Feature Description

9.3.1 CMOS Schmitt-Trigger Inputs with Integrated Pulldowns

Standard CMOS inputs are high impedance and are typically modeled as a resistor in parallel with the input capacitance given in the [Electrical Characteristics](#). The worst case resistance is calculated with the maximum input voltage, given in the [Absolute Maximum Ratings](#), and the maximum input leakage current, given in the [Electrical Characteristics](#), using ohm's law ($R = V \div I$).

The Schmitt-trigger input architecture provides hysteresis as defined by ΔV_T in the [Electrical Characteristics](#), which makes this device extremely tolerant to slow or noisy inputs. Driving the inputs slowly will increase dynamic current consumption of the device. See [Understanding Schmitt Triggers](#) for additional information regarding Schmitt-trigger inputs.

9.3.1.1 Inputs with Integrated Static Pull-Down Resistors

This device has 5 M Ω typical integrated weak pull-downs for each input. This feature allows all inputs to be left floating without the concern for unstable outputs or increased current consumption. This also helps to reduce external component count for applications where not all channels are used or need to be fixed low. If an external pull-up is required, it should be no larger than 1 M Ω to avoid contention with the 5 M Ω internal pull-down.

9.3.2 Control Logic (OE) with $V_{CC(MIN)}$ Circuitry

The output-enable input (OE) is used to disable the outputs so the buses are effectively isolated. The output-enable pin of the TXU0x04-Q1 has $V_{CC(MIN)}$ circuitry, which allows the OE pin to operate with the lower supply voltage. The [Over-Voltage Tolerant Inputs](#) feature allows the OE pin to operate with the higher supply voltage. This combination means that the enable pin can be referenced to either V_{CCA} or V_{CCB} supply. Multiple permutations of each device are possible since the controller can be placed on either the A or B port and can still control the enable pin.

9.3.3 Balanced High-Drive CMOS Push-Pull Outputs

A balanced output allows the device to sink and source similar currents. The high drive capability of this device creates fast edges into light loads, so routing and load conditions should be considered to prevent ringing. Additionally, the outputs of this device are capable of driving larger currents than the device can sustain without being damaged. [Absolute Maximum Ratings](#) defines the electrical and thermal limits that must be followed at all times.

9.3.4 Partial Power Down (I_{off})

The inputs and outputs for this device enter a high-impedance state when the device is powered down, inhibiting current backflow into the device. The I_{off} in the [Electrical Characteristics](#) specifies the maximum leakage into or out of any input or output pin on the device.

9.3.5 VCC Isolation and V_{CC} Disconnect

The outputs for this device are disabled and enter a high-impedance state when either supply is <100 mV or left floating (disconnected), with the complementary supply within recommended operating conditions. It is recommended that the inputs are kept low before floating (disconnecting) either supply.

The $I_{CCX(floating)}$ in the [Electrical Characteristics](#) specifies the maximum supply current. The $I_{off(float)}$ in the [Electrical Characteristics](#) specifies the maximum leakage into or out of any input or output pin on the device.

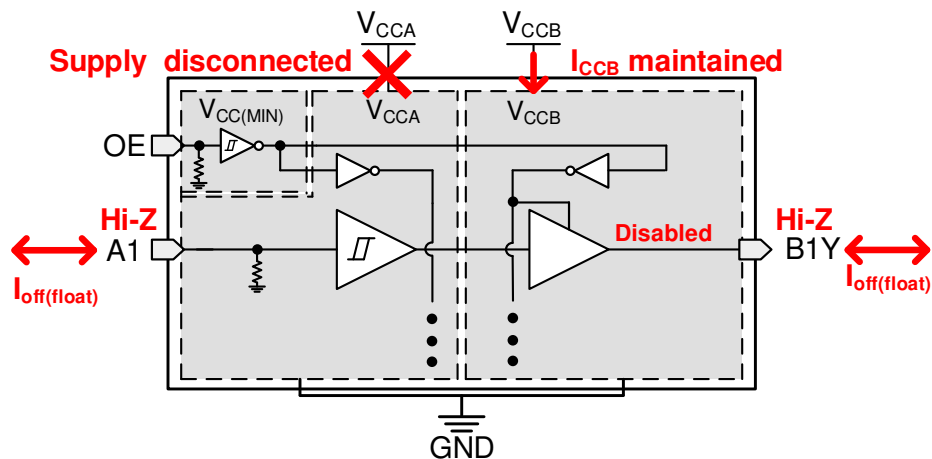


Figure 9-1. V_{CC} Disconnect Feature

9.3.6 Over-Voltage Tolerant Inputs

Input signals to this device can be driven above the supply voltage so long as they remain below the maximum input voltage value specified in the [Recommended Operating Conditions](#).

9.3.7 Glitch-Free Power Supply Sequencing

Either supply rail may be powered on or off in any order without producing a glitch on the inputs or outputs (that is, where the output erroneously transitions to V_{CC} when it should be held low or vice versa). Glitches of this nature can be misinterpreted by a peripheral as a valid data bit, which could trigger a false device reset of the peripheral, a false device configuration of the peripheral, or even a false data initialization by the peripheral.

9.3.8 Negative Clamping Diodes

Figure 9-2 depicts the inputs and outputs to this device that have negative clamping diodes.

CAUTION

Voltages beyond the values specified in the [Absolute Maximum Ratings](#) table can cause damage to the device. The input negative-voltage and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.

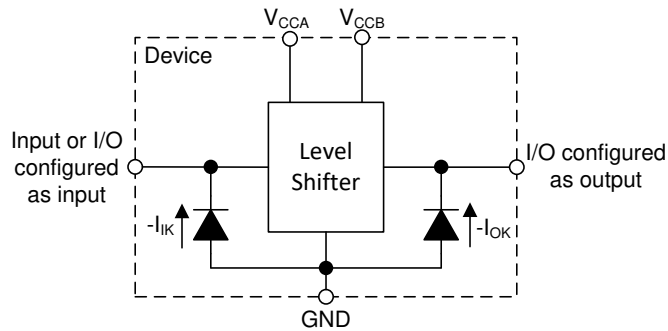


Figure 9-2. Electrical Placement of Clamping Diodes for Each Input and Output

9.3.9 Fully Configurable Dual-Rail Design

The V_{CCA} and V_{CCB} pins can be supplied at any voltage from 1.1 V to 5.5 V, making the device suitable for translating between any of the voltage nodes (1.2 V, 1.5 V, 1.8 V, 3.3 V, and 5.0 V).

9.3.10 Supports High-Speed Translation

The TXU0104-Q1 device can support high data-rate applications. The translated signal data rate can be up to 200 Mbps when the signal is translated from 3.3 V to 5.0 V.

9.3.11 Wettable Flanks

This device includes wettable flanks for at least one package. See the *Features* section on the front page of the data sheet for which packages include this feature.

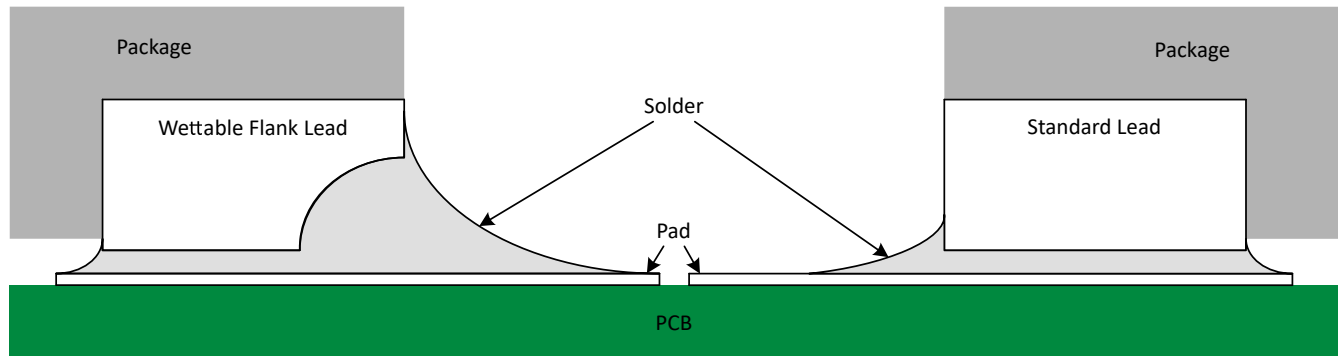


Figure 9-3. Simplified Cutaway View of Wettable-Flank QFN Package and Standard QFN Package After Soldering

Wettable flanks help improve side wetting after soldering, which makes QFN packages easier to inspect with automatic optical inspection (AOI). A wettable flank can be dimpled or step-cut to provide additional surface area for solder adhesion which assists in reliably creating a side fillet as shown in [Figure 9-3](#). Please see the mechanical drawing for additional details.

9.4 Device Functional Modes

Table 9-1. Function Table

| CONTROL INPUTS | Port Status | | OPERATION |
|----------------|-------------|--------|--|
| | Input | Output | |
| H | L | L | Unidirectional non-inverting voltage translation |
| H | H | H | Unidirectional non-inverting voltage translation |
| L | X | Hi-Z | Isolation |

10 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.

10.1 Application Information

The TXU0104-Q1 device can be used in level-translation applications for interfacing devices or systems operating at different interface voltages with one another. The TXU0104-Q1 device is ideal for use in applications where a push-pull driver is connected to the data inputs. The maximum data rate can be up to 200 Mbps when the device translates a signal from 3.3 V to 5.0 V.

10.2 Typical Application

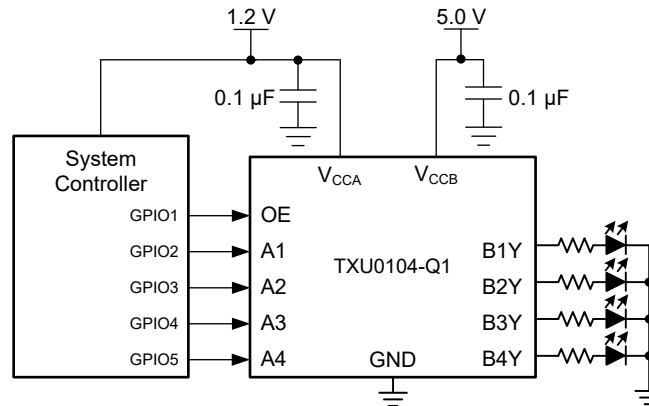


Figure 10-1. TXU0104-Q1 LED Driver Application

10.2.1 Design Requirements

Use the parameters listed in [Table 10-1](#) for this design example.

Table 10-1. Design Parameters

| DESIGN PARAMETERS | EXAMPLE VALUES |
|----------------------|----------------|
| Input voltage range | 1.1 V to 5.5 V |
| Output voltage range | 1.1 V to 5.5 V |

10.2.2 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 TXU0104-Q1 device to determine the input voltage range. For a valid logic-high, the value must exceed the positive-going input-threshold voltage (V_{T+}) of the input port. For a valid logic low the value must be less than the negative-going input-threshold voltage (V_{T-}) of the input port.
- Output voltage range
 - Use the supply voltage of the device that the TXU0104-Q1 device is driving to determine the output voltage range.

10.2.3 Application Curve

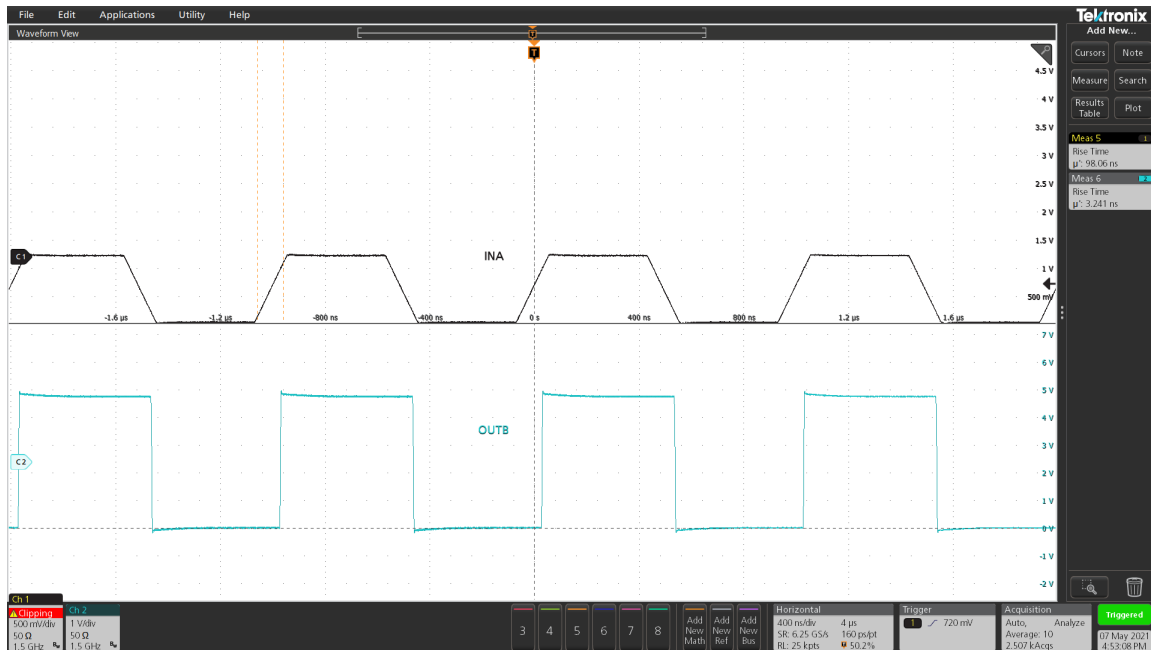


Figure 10-2. Up Translation at 1 MHz (1.2 V to 5 V)

11 Power Supply Recommendations

Always apply a ground reference to the GND pins first. This device is designed for glitch free power sequencing without any supply sequencing requirements such as ramp order or ramp rate.

[Glitch-Free Power Supply Sequencing](#) describes how this device was designed with various power supply sequencing methods in mind to help prevent unintended triggering of downstream devices.

12 Layout

12.1 Layout Guidelines

To ensure reliability of the device, it is recommended to follow common printed-circuit board layout guidelines:

- Use bypass capacitors on the power supply pins and place them as close to the device as possible. A 0.1 μF capacitor is recommended, but transient performance can be improved by having 1 μF and 0.1 μF capacitors in parallel as bypass capacitors.
- The high drive capability of this device creates fast edges into light loads, so routing and load conditions should be considered to prevent ringing.

12.2 Layout Example

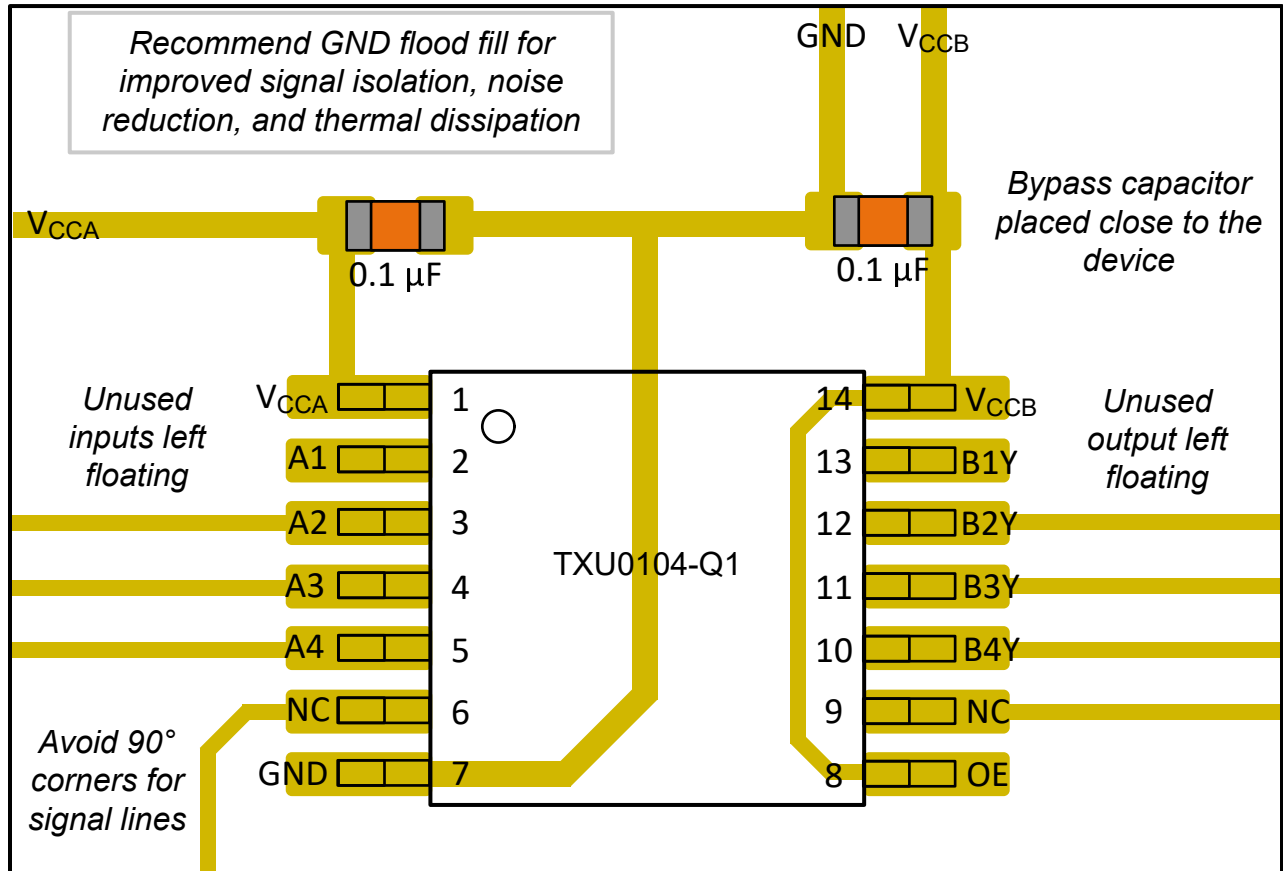


Figure 12-1. Layout Example – TXU0104-Q1

13 Device and Documentation Support

13.1 Device Support

13.1.1 Regulatory Requirements

No statutory or regulatory requirements apply to this device.

There are no special characteristics for this product.

13.2 Documentation Support

13.2.1 Related Documentation

- Texas Instruments, [Understanding Schmitt Triggers application report](#)
- Texas Instruments, [CMOS Power Consumption and \$C_{pd}\$ Calculation application report](#)

13.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* 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.

13.4 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.

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13.5 Trademarks

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13.6 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.

13.7 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

14 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 Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|---------|
| TXU0104QPWRQ1 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TXU104Q | Samples |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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OTHER QUALIFIED VERSIONS OF TXU0104-Q1 :

- Catalog : [TXU0104](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TXU0104QPWRQ1 | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |

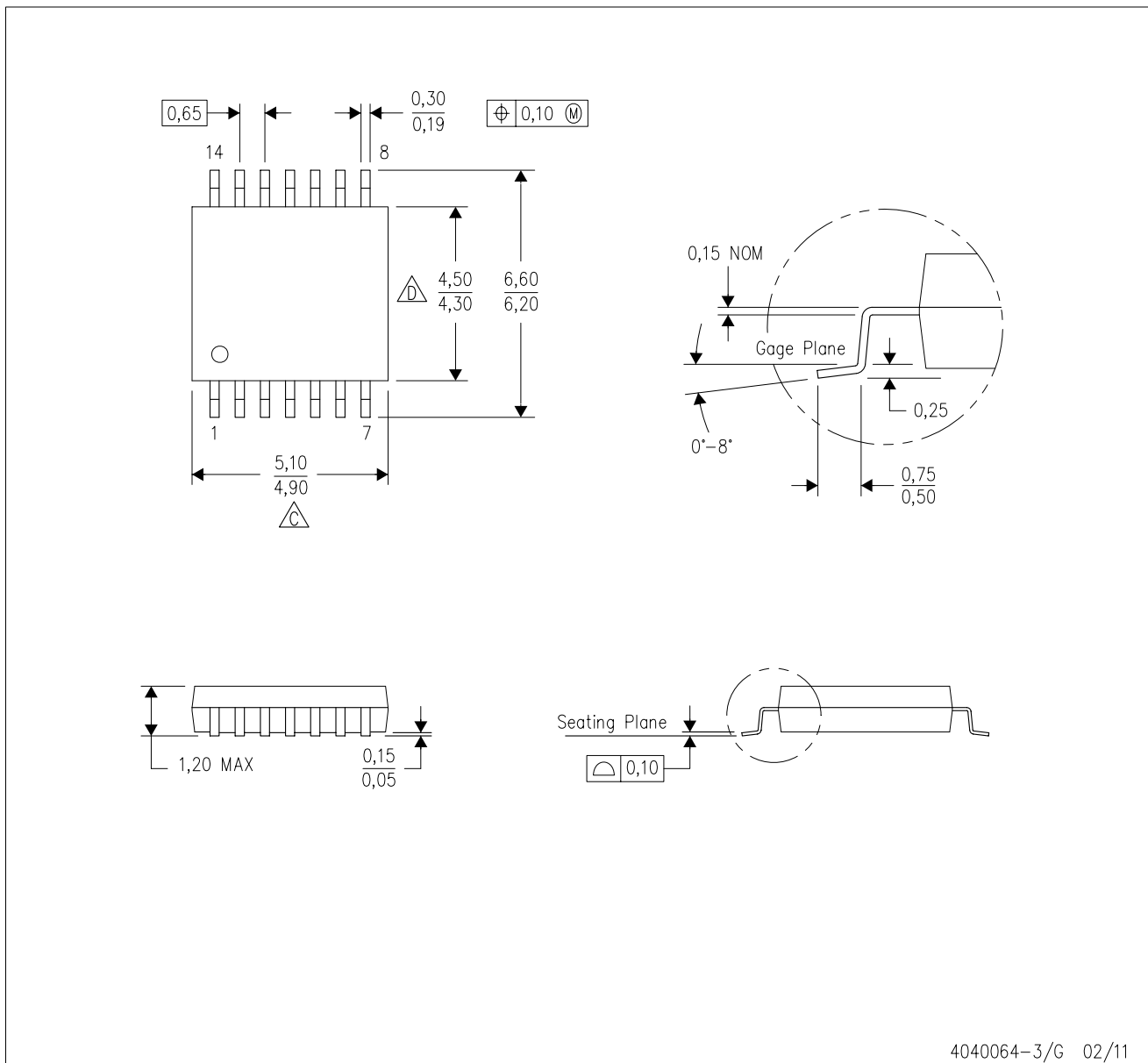
TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TXU0104QPWRQ1 | TSSOP | PW | 14 | 2000 | 853.0 | 449.0 | 35.0 |

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4040064-3/G 02/11

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
 - E. Falls within JEDEC MO-153

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4211284-2/G 08/15

- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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