

2-Bit Bidirectional Voltage-Level Translator with Automatic Direction Sensing

Check for Samples: [TXB0302](#)

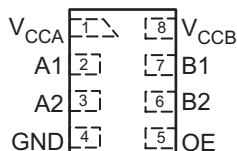
FEATURES

- **Fully Symmetric Supply Voltages.**
0.9 V to 3.6 V on A Port and 0.9 V to 3.6 V
- **V_{CC} Isolation Feature — If Either V_{CC} Input Is at GND, All Outputs Are in the High-Impedance State**
- **OE Input Circuit Referenced to V_{CCA}**
- **Low Power Consumption, 5- μ A Max I_{CC}**
- **I_{off} Supports Partial-Power-Down Mode Operation**
- **Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II**
- **ESD Protection Exceeds JESD 22**
 - **4000-V Human-Body Model (A114-B)**
 - **1000-V Charged-Device Model (C101)**

DESCRIPTION

This 2-bit noninverting translator uses two separate configurable power-supply rails. The A port is designed to track V_{CCA}. V_{CCA} accepts any supply voltage from 0.9 V to 3.6 V. The B port is designed to track V_{CCB}. V_{CCB} accepts any supply voltage from 0.9 V to 3.6 V. This allows for low-voltage bidirectional translation between 1-V, 1.2-V, 1.5-V, 1.8-V, 2.5-V and 3.3-V voltage nodes. For the TXB0302, when the output-enable (OE) input is low, all outputs are placed in the high-impedance state. To ensure the high-impedance state during power up or power down, OE should be tied to GND through a pulldown resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver. The TXB0302 is designed so that the OE input circuit is supplied by V_{CCA}. This device is fully specified for partial-power-down applications using I_{off}. The I_{off} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

**DQM PACKAGE
(TOP VIEW)**



- A. Pull up resistors are not required on both sides for Logic I/O.
- B. If pull up or pull down resistors are needed, the resistor value must be over 20 k Ω .
- C. 20 k Ω is a safe recommended value, if the customer can accept higher Vol or lower Voh, smaller pull up or pull down resistor is allowed, the draft estimation is Vol = Vccout \times 1.5k/(1.5k + Rpu) and Voh = Vccout \times Rdw/(1.5k + Rdw).
- D. If pull up resistors are needed, please refer to the TXS0102 or contact TI.
- E. For detailed information, please refer to application note [SCEA043](#).

ORDERING INFORMATION⁽¹⁾

| T _A | PACKAGE ⁽²⁾ | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|------------------------|-----------------------|------------------|
| -40°C to 85°C | DQM – MicroQFN | TXB0302DQMR | 77A |

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
- (2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

PIN DESCRIPTION

| PIN NO. | NAME | FUNCTION |
|---------|---------|---|
| DQM | TXB0302 | |
| 1 | VCCA | A-port supply voltage $0.9\text{ V} \leq V_{CCA} \leq 3.6\text{ V}$ |
| 2 | A1 | Input/output 1. Referenced to V_{CCA} . |
| 3 | A2 | Input/output 2. Referenced to V_{CCA} . |
| 4 | GND | Ground |
| 5 | OE | 3-state output-mode enable. Pull OE (TXB0302) low to place all outputs in 3-state mode. |
| 6 | B2 | Input/output 2. Referenced to V_{CCB} . |
| 7 | B1 | Input/output 1. Referenced to V_{CCB} . |
| 8 | VCCB | B-port supply voltage $0.9\text{ V} \leq V_{CCB} \leq 3.6\text{ V}$. |

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

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

| | | MIN | MAX | UNIT | |
|-----------|--|-----------|-----------|-----------------|---|
| V_{CCA} | Supply voltage range | -0.5 | 4.6 | V | |
| V_{CCB} | | -0.5 | 4.6 | | |
| V_I | Input voltage range | A port | -0.5 | 4.6 | V |
| | | B port | -0.5 | 6.5 | |
| V_O | Voltage range applied to any output in the high-impedance or power-off state | A port | -0.5 | 4.6 | V |
| | | B port | -0.5 | 6.5 | |
| V_O | Voltage range applied to any output in the high or low state ⁽²⁾ | 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 | mA | |
| | Continuous current through VCCA, VCCB, or GND | | ± 100 | mA | |
| T_{stg} | Storage temperature range | -65 | 150 | °C | |

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

THERMAL IMPEDANCE RATINGS⁽¹⁾⁽²⁾

| THERMAL METRIC | | TXB0302 | UNIT |
|----------------|---------------------------|---------|------|
| | | DQM | |
| | | 8 PINS | |
| θ_{JA} | Package thermal impedance | 259 | °C/W |

- (1) The package thermal impedance is calculated in accordance with JESD 51-7.
 (2) The package thermal impedance is calculated in accordance with JESD 51-5.

RECOMMENDED OPERATING CONDITIONS⁽¹⁾

| | | VCCA | VCCB | MIN | MAX | UNIT | |
|------------------|--|---------------|----------------|----------------|--|--|------|
| V _{CCA} | Supply voltage | | | 0.9 | 3.6 | V | |
| V _{CCB} | | | | 0.9 | 3.6 | | |
| V _{IH} | High-level input voltage | Data inputs | 0.9 V to 3.6 V | 0.9 V to 3.6 V | V _{CC1} ⁽²⁾ × 0.65 | V _{CC1} ⁽²⁾ | V |
| | | OE | 0.9 V to 3.6 V | 0.9 V to 3.6 V | V _{CCA} × 0.65 | 3.6 | |
| V _{IL} | Low-level input voltage | Data inputs | 0.9 V to 3.6 V | 0.9 V to 3.6 V | 0 | V _{CC1} ⁽²⁾ × 0.35 | V |
| | | OE | 0.9 V to 3.6 V | 0.9 V to 3.6 V | 0 | V _{CCA} × 0.35 | |
| V _O | Voltage range applied to any output in the high-impedance or power-off state | A-port | 0.9 V to 3.6 V | 0.9 V to 3.6 V | 0 | 3.6 | V |
| | | B-port | 0.9 V to 3.6 V | 0.9 V to 3.6 V | 0 | 3.6 | |
| Δt/Δv | Input transition rise or fall rate | A-port inputs | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | 40 | ns/V |
| | | B-port inputs | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | 40 | |
| T _A | Operating free-air temperature | | | –40 | 85 | °C | |

(1) The A and B sides of an unused data I/O pair must be held in the same state, i.e., both at V_{CC1} or both at GND.

(2) V_{CC1} is the supply voltage associated with the input port.

ELECTRICAL CHARACTERISTICS

| PARAMETER | TEST CONDITIONS | VCCA | VCCB | T _A = 25°C | | | –40°C to 85°C | | UNIT |
|-------------------------------------|--------------------------|--|----------------|-----------------------|-----|------------|---------------|-----|------|
| | | | | MIN | TYP | MAX | MIN | MAX | |
| V _{OHA} | I _{OH} = –20 μA | 0.9 V to 3.6 V | | | | 0.9 × VCCA | | | V |
| V _{OLA} | I _{OL} = 20 μA | 0.9 V to 3.6 V | | | | | 0.2 | | V |
| V _{OHB} | I _{OH} = –20 μA | | 0.9 V to 3.6 V | | | 0.9 × VCCB | | | V |
| V _{OLB} | I _{OL} = 20 μA | 0.9 V to 3.6 V | | | | | 0.2 | | V |
| I _I | OE | V _I = V _{CC1} or GND | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | | ±1 | ±2 | μA |
| I _{off} | A port | V _I or V _O = 0 to 3.6 V | 0 V | 0 V to 3.6 V | | | ±1 | ±2 | μA |
| | B port | V _I or V _O = 0 to 3.6 V | 0.9 V to 3.6 V | 0 V | | | ±1 | ±2 | |
| I _{OZ} | A or B port | OE = GND | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | | ±1 | ±2 | μA |
| I _{CCA} | | V _I = V _{CC1} or GND, I _O = 0 | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | | | 5 | μA |
| I _{CCB} | | V _I = V _{CC1} or GND, I _O = 0 | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | | | 5 | μA |
| I _{CCA} + I _{CCB} | | V _I = V _{CC1} or GND, I _O = 0 | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | | | 10 | μA |
| I _{CCZA} | | V _I = V _{CC1} or GND, I _O = 0, OE = GND | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | | | 5 | μA |
| I _{CCZB} | | V _I = V _{CC1} or GND, I _O = 0, OE = GND | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | | | 5 | μA |
| C _i | OE | | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | 3 | | | pF |
| C _{io} | A port | | 0.9 V to 3.6 V | 0.9 V to 3.6 V | | 9 | | | pF |
| | B port | | | | | 12 | | | |

TIMING REQUIREMENTS

| | | VCCA | VCCB | MIN | MAX | UNIT |
|-----------|------------------------|--------------|--------------|-----|-----|------|
| Data rate | C _L = 15 pF | 0.9 to 3.6 V | 0.9 to 3.6 V | | 40 | Mbps |
| | C _L = 15 pF | 1.2 to 3.6 V | 1.2 to 3.6 V | | 100 | Mbps |
| | C _L = 15 pF | 1.8 to 3.6 V | 1.8 to 3.6 V | | 140 | Mbps |
| | C _L = 30 pF | 0.9 to 3.6 V | 0.9 to 3.6 V | | 40 | Mbps |
| | C _L = 30 pF | 1.2 to 3.6 V | 1.2 to 3.6 V | | 90 | Mbps |
| | C _L = 30 pF | 1.8 to 3.6 V | 1.8 to 3.6 V | | 120 | Mbps |
| | C _L = 50 pF | 1.2 to 3.6 V | 1.2 to 3.6 V | | 70 | Mbps |
| | C _L = 50 pF | 1.8 to 3.6 V | 1.8 to 3.6 V | | 100 | Mbps |

SWITCHING CHARACTERISTICS

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

| PARAMETER | FROM (INPUT) | TO (OUTPUT) | | VCCA | VCCB | MIN | TYP T _A = 25°C | MAX | UNIT |
|-----------------------------------|----------------------------|-------------|---------------------|---------|---------|-----|------------------------------|------|------|
| t _{pd} | A | B | C _L = 15 | 0.9-3.6 | 0.9-3.6 | | 18.9 | 62.5 | ns |
| | A | B | C _L = 15 | 1.2-3.6 | 1.2-3.6 | | 7.5 | 15.5 | |
| | A | B | C _L = 15 | 1.8-3.6 | 1.8-3.6 | | 3.7 | 5.8 | |
| | A | B | C _L = 30 | 0.9-3.6 | 0.9-3.6 | | 19.5 | 64.5 | |
| | A | B | C _L = 30 | 1.2-3.6 | 1.2-3.6 | | 7.8 | 16.1 | |
| | A | B | C _L = 30 | 1.8-3.6 | 1.8-3.6 | | 3.8 | 6.1 | |
| | A | B | C _L = 50 | 1.2-3.6 | 1.2-3.6 | | 8 | 16.8 | |
| | A | B | C _L = 50 | 1.8-3.6 | 1.8-3.6 | | 4 | 6.5 | ns |
| | B | A | C _L = 15 | 0.9-3.6 | 0.9-3.6 | | 18.9 | 62.6 | |
| | B | A | C _L = 15 | 1.2-3.6 | 1.2-3.6 | | 7.5 | 15.4 | |
| | B | A | C _L = 15 | 1.8-3.6 | 1.8-3.6 | | 3.7 | 5.8 | |
| | B | A | C _L = 30 | 0.9-3.6 | 0.9-3.6 | | 19.5 | 64.5 | |
| | B | A | C _L = 30 | 1.2-3.6 | 1.2-3.6 | | 7.8 | 16.1 | |
| | B | A | C _L = 30 | 1.8-3.6 | 1.8-3.6 | | 3.8 | 5.2 | |
| t _{en} | OE | A | C _L = 15 | 0.9-3.6 | 0.9-3.6 | | | 504 | ns |
| | | B | C _L = 15 | 0.9-3.6 | 0.9-3.6 | | | 356 | |
| t _{dis} | OE | A | C _L = 15 | 0.9-3.6 | 0.9-3.6 | | | 200 | ns |
| | | B | C _L = 15 | 0.9-3.6 | 0.9-3.6 | | | 200 | ns |
| t _{rB} , t _{fB} | B-port rise and fall times | | C _L = 15 | 0.9-3.6 | 0.9-3.6 | | 2.95 | | ns |
| t _{rA} , t _{fA} | A-port rise and fall times | | C _L = 15 | 0.9-3.6 | 0.9-3.6 | | 3.1 | | ns |
| t _{SK(O)} | Channel-to-channel skew | | C _L = 15 | 0.9-3.6 | 0.9-3.6 | | | 0.5 | ns |

OPERATING CHARACTERISTICS

 T_A = 25°C

| PARAMETER | | TEST CONDITIONS | VCCA, VCCB 0.9 V to 3.6 V | | UNIT |
|------------------|-----------------------------|--|---------------------------|--|------|
| | | | TYP | | |
| C _{pdA} | A-port input, B-port output | C _L = 0, f = 10 MHz, t _r = t _f = 1 ns, OE = V _{CCA} (outputs enabled) | 40 | | pF |
| | B-port input, A-port output | | 40 | | |
| C _{pdB} | A-port input, B-port output | | 40 | | pF |
| | B-port input, A-port output | | 40 | | |
| C _{pdA} | A-port input, B-port output | C _L = 0, f = 10 MHz, t _r = t _f = 1 ns, OE = GND (outputs disabled) | 0.01 | | pF |
| | B-port input, A-port output | | 0.01 | | |
| C _{pdB} | A-port input, B-port output | | 0.01 | | pF |
| | B-port input, A-port output | | 0.01 | | |

PRINCIPLES OF OPERATION

Applications

The TXB0302 can be used in level-translation applications for interfacing devices or systems operating at different interface voltages with one another.

Architecture

The TXB0302 architecture (see Figure 1) does not require a direction-control signal to control the direction of data flow from A to B or from B to A. In a dc state, the output drivers of the TXB0302 can maintain a high or low, but are designed to be weak, so that they can be over driven by an external driver when data on the bus starts flowing the opposite direction. The output one shots detect rising or falling edges on the A or B ports. During a rising edge, the one shot turns on the PMOS transistors (T1, T3) for a short duration, which speeds up the low-to-high transition. Similarly, during a falling edge, the one shot turns on the NMOS transistors (T2, T4) for a short duration, which speeds up the high-to-low transition. The typical output impedance during output transition is 35 Ω at $V_{CC0} = 0.9\text{ V}$ to 1.1 V, 25 Ω at $V_{CC0} = 1.2\text{ V}$ to 3.3 V.

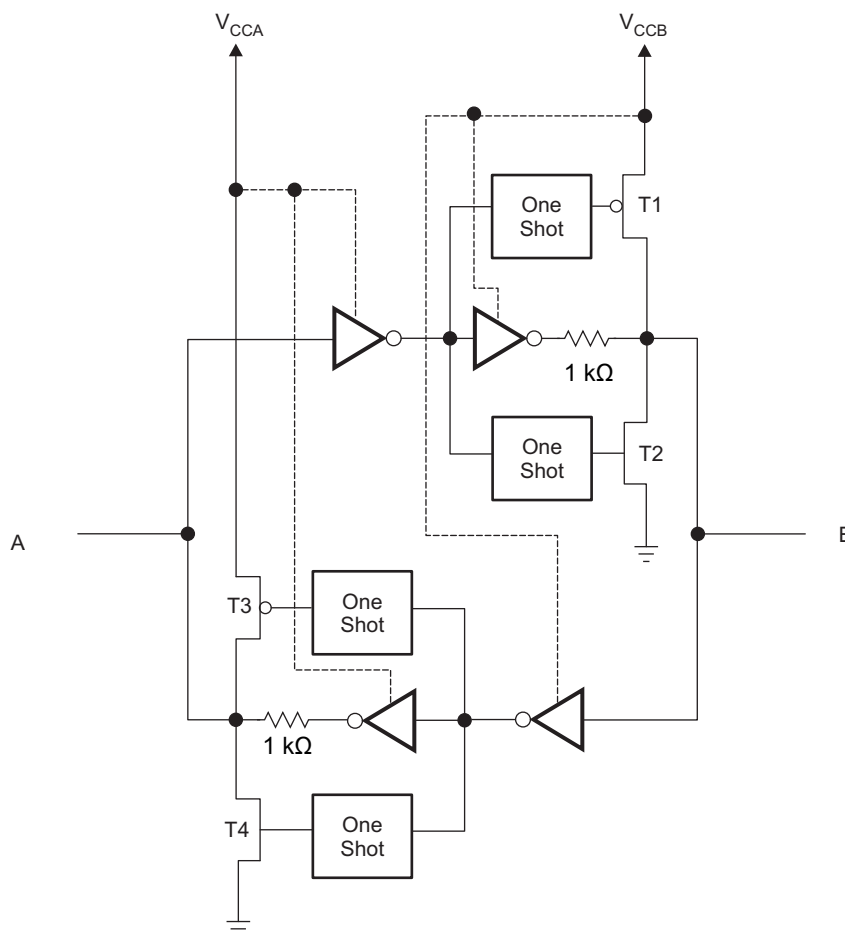
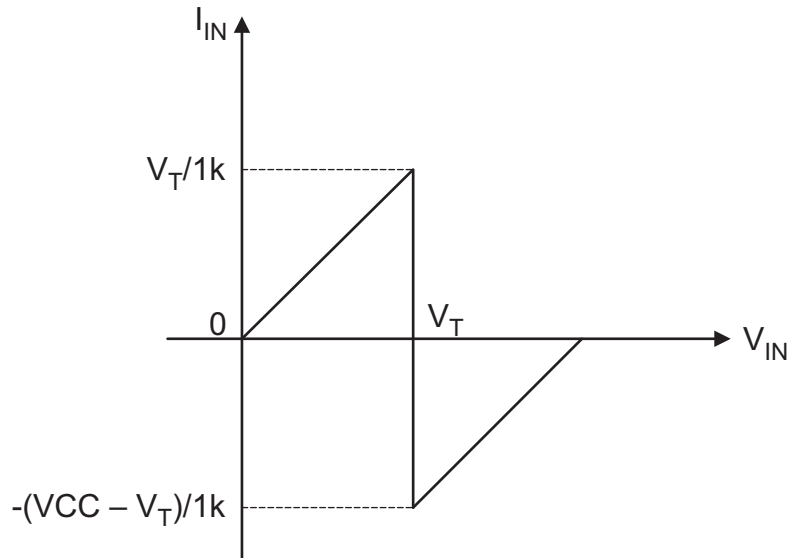


Figure 1. Architecture of TXB0302 I/O Cell

Input Driver Requirements

Typical I_{IN} vs V_{IN} characteristics of the TXB0302 are shown in Figure 2. For proper operation, the device driving the data I/Os of the TXB0302 must have drive strength of at least $\pm 3\text{ mA}$.



- (1) V_T is the input threshold voltage of the TXB0302 (typical $V_{CC1}/2$).
- (2) V_D is the supply voltage of the external driver.

Figure 2. Typical I_{IN} vs V_{IN} Curve

Power Up

There is no requirement for the power sequence. During operation, TXB0302 can work at both $V_{CCA} \leq V_{CCB}$ and $V_{CCA} \geq V_{CCB}$. During power-up sequencing, any power supply can be ramped up first. The TXB0302 has circuitry that disables all output ports when either V_{CC} is switched off ($V_{CCA/B} = 0$ V).

Enable and Disable

The TXB0302 has an OE input that is used to disable the device by setting OE = low, which places all I/Os in the high-impedance (Hi-Z) state. The disable time (t_{dis}) indicates the delay between when OE goes low and when the outputs actually get disabled (Hi-Z). The enable time (t_{en}) indicates the amount of time the user must allow for the one-shot circuitry to become operational after OE is taken high.

Pullup or Pulldown Resistor on I/O Lines

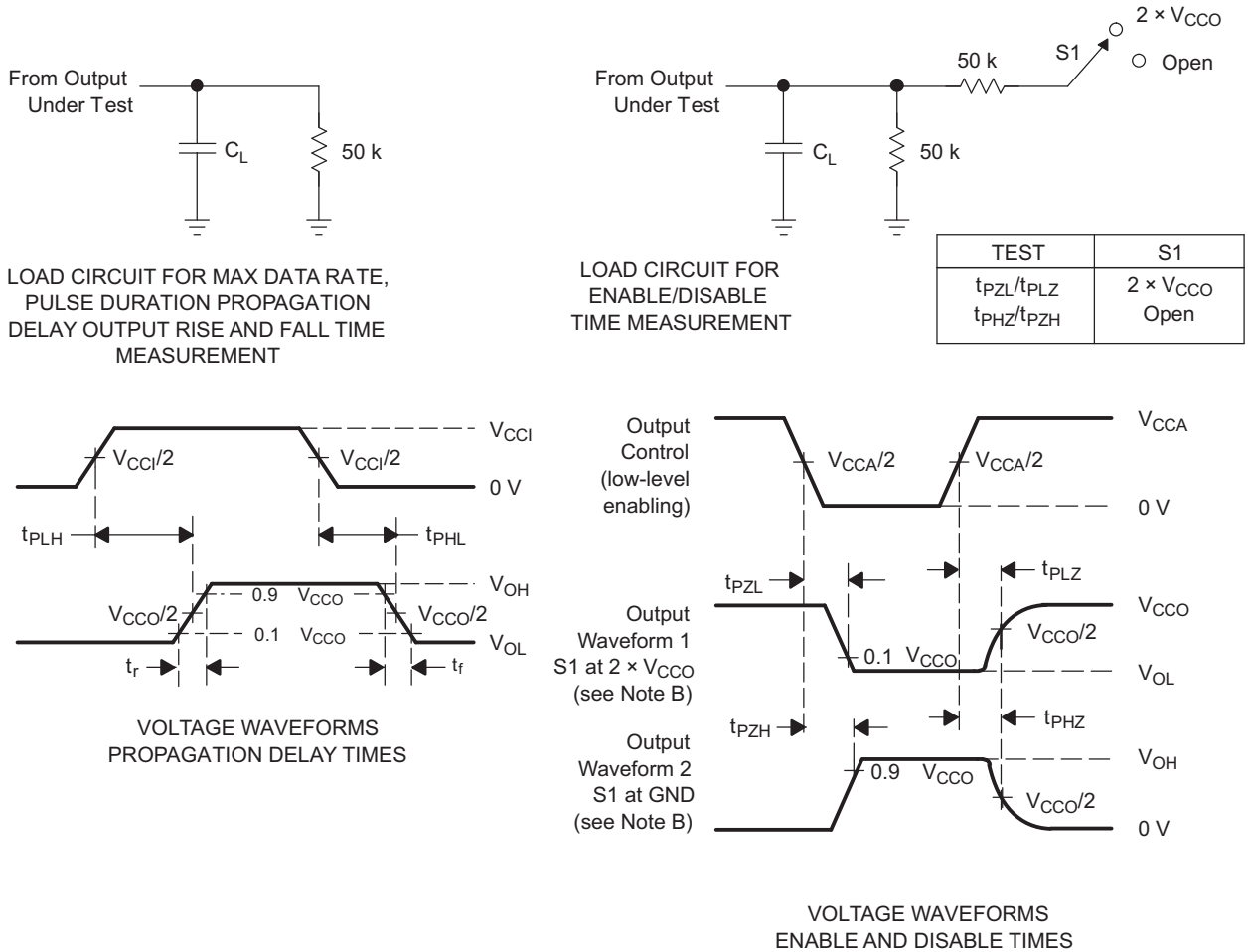
The TXB0302 is designed to drive capacitive loads of up to 50 pF. The output drivers of the TXB0302 have low dc drive strength. If pullup or pulldown resistors are connected externally to the data I/Os, their values must be kept higher than 20 k Ω to ensure that they do not contend with the output drivers of the TXB0302. but if the receiver is integrated with the smaller pull down or pull up resistor, below formula can be used for estimation to evaluate the V_{oh} and V_{ol} .

$$V_{ol} = V_{CCout} \times \frac{1.5k\Omega}{1.5k\Omega + R_{pu}} \quad (1)$$

$$V_{oh} = V_{CCout} \times \frac{R_{pd}}{1.5k\Omega + R_{pd}} \quad (2)$$

For the same reason, the TXB0302 should not be used in applications such as I²C or 1-Wire where an open-drain driver is connected on the bidirectional data I/O. For these applications, use a device from the TI TXS01xx series of level translators.

PARAMETER MEASUREMENT INFORMATION



- A. C_L includes probe and jig capacitance.
- B. All input pulses are supplied by generators having the following characteristics: PRR 10 MHz, $Z_O = 50 \Omega$, $dv/dt \geq 1$ V/ns.
- C. The outputs are measured one at a time, with one transition per measurement.
- D. t_{PLH} and t_{PHL} are the same as t_{pd} .
- E. V_{CCI} is the V_{CC} associated with the input port.
- F. V_{CCO} is the V_{CC} associated with the output port.
- G. All parameters and waveforms are not applicable to all devices.

Figure 3. Load Circuits and Voltage Waveforms

REVISION HISTORY

Changes from Original (March 2012) to Revision A **Page**

-
- Added package pin out diagram notes. **1**
-

Changes from Revision A (May 2012) to Revision B **Page**

-
- Added Application Information Section **5**
-

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|------------------|----------------------|--------------|-------------------------|---------|
| TXB0302DQMR | ACTIVE | X2SON | DQM | 8 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 77A | 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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(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.

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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 |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TXB0302DQMR | X2SON | DQM | 8 | 3000 | 180.0 | 9.5 | 1.4 | 2.0 | 0.5 | 4.0 | 8.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS

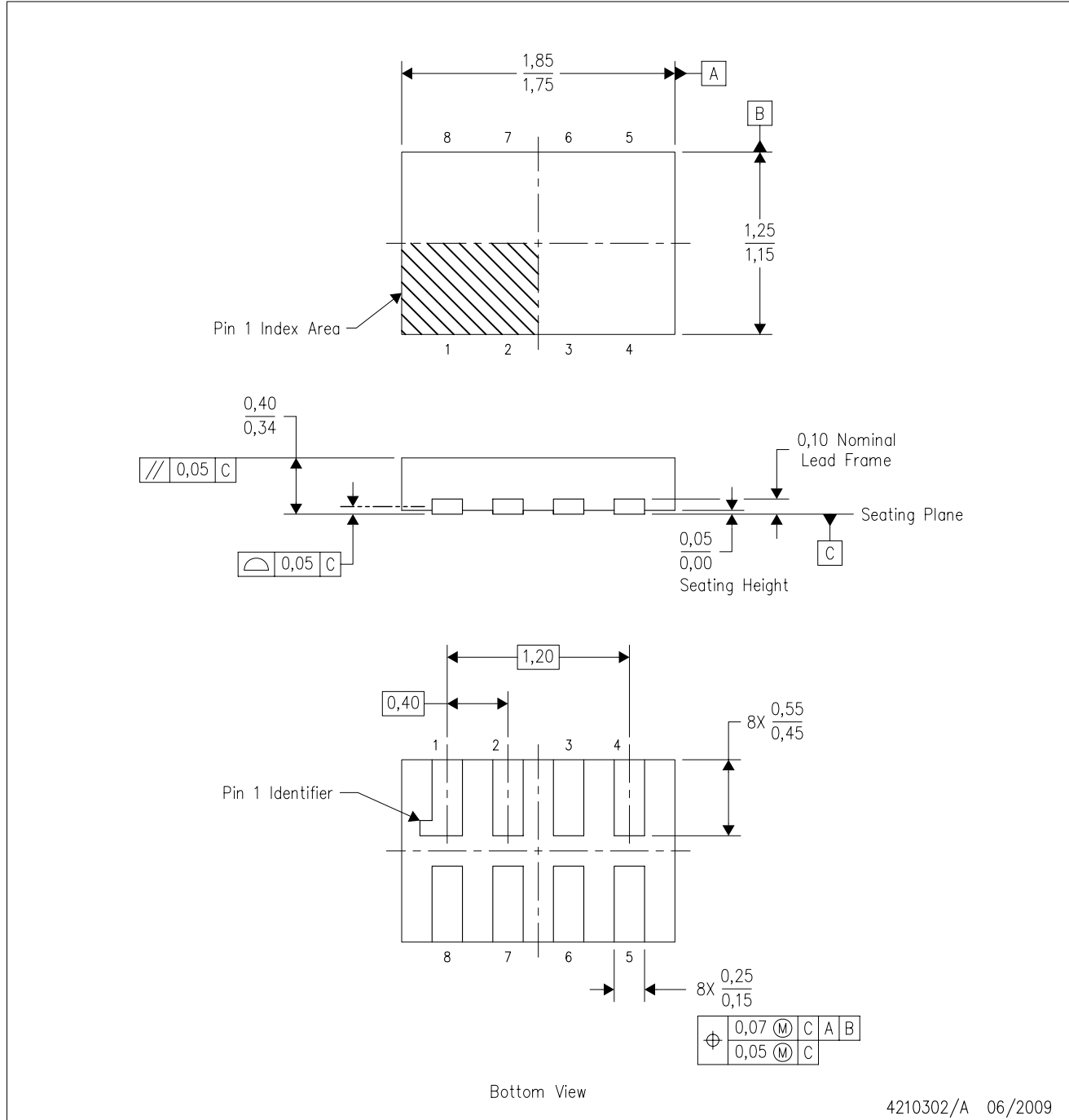


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TXB0302DQMR | X2SON | DQM | 8 | 3000 | 180.0 | 180.0 | 30.0 |

DQM (R-PX2SON-N8)

PLASTIC SMALL OUTLINE NO-LEAD



- 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. SON (Small Outline No-Lead) package configuration.

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