

SN74CB3T16211

24-BIT FET BUS SWITCH

2.5-V/3.3-V LOW-VOLTAGE BUS SWITCH WITH 5-V-TOLERANT LEVEL SHIFTER

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- Member of the Texas Instruments Widebus™ Family
- Output Voltage Translation Tracks V_{CC}
- Supports Mixed-Mode Signal Operation On All Data I/O Ports
 - 5-V Input Down to 3.3-V Output Level Shift, With 3.3-V V_{CC}
 - 5-V/3.3-V Input Down to 2.5-V Output Level Shift, With 2.5-V V_{CC}
- 5-V-Tolerant I/Os, With Device Powered Up or Powered Down
- Bidirectional Data Flow, With Near-Zero Propagation Delay
- Low ON-State Resistance (r_{on}) Characteristics ($r_{on} = 5\ \Omega$ Typical)
- Low Input/Output Capacitance Minimizes Loading ($C_{iO(OFF)} = 5\ \text{pF}$ Typical)
- Data and Control Inputs Provide Undershoot Clamp Diodes
- Low Power Consumption ($I_{CC} = 70\ \mu\text{A}$ Max)
- V_{CC} Operating Range From 2.3 V to 3.6 V
- Data I/Os Support 0- to 5-V Signaling Levels (0.8 V, 1.2 V, 1.5 V, 1.8 V, 2.5 V, 3.3 V, 5 V)
- Control Inputs Can be Driven by TTL or 5-V/3.3-V CMOS Outputs
- I_{off} Supports Partial-Power-Down Mode Operation
- Latch-Up Performance Exceeds 250 mA Per JESD 17
- ESD Performance Tested Per JESD 22
 - 2000-V Human-Body Model (A114-B, Class II)
 - 1000-V Charged-Device Model (C101)
- Supports Digital Applications: Level Translation, PCI Interface, Bus Isolation
- Ideal for Low-Power Portable Equipment

DGG, DGV, OR DL PACKAGE
(TOP VIEW)

| | | | |
|----------|----|----|------------------|
| NC | 1 | 56 | $\overline{1OE}$ |
| 1A1 | 2 | 55 | $\overline{2OE}$ |
| 1A2 | 3 | 54 | 1B1 |
| 1A3 | 4 | 53 | 1B2 |
| 1A4 | 5 | 52 | 1B3 |
| 1A5 | 6 | 51 | 1B4 |
| 1A6 | 7 | 50 | 1B5 |
| GND | 8 | 49 | GND |
| 1A7 | 9 | 48 | 1B6 |
| 1A8 | 10 | 47 | 1B7 |
| 1A9 | 11 | 46 | 1B8 |
| 1A10 | 12 | 45 | 1B9 |
| 1A11 | 13 | 44 | 1B10 |
| 1A12 | 14 | 43 | 1B11 |
| 2A1 | 15 | 42 | 1B12 |
| 2A2 | 16 | 41 | 2B1 |
| V_{CC} | 17 | 40 | 2B2 |
| 2A3 | 18 | 39 | 2B3 |
| GND | 19 | 38 | GND |
| 2A4 | 20 | 37 | 2B4 |
| 2A5 | 21 | 36 | 2B5 |
| 2A6 | 22 | 35 | 2B6 |
| 2A7 | 23 | 34 | 2B7 |
| 2A8 | 24 | 33 | 2B8 |
| 2A9 | 25 | 32 | 2B9 |
| 2A10 | 26 | 31 | 2B10 |
| 2A11 | 27 | 30 | 2B11 |
| 2A12 | 28 | 29 | 2B12 |

NC – No internal connection

description/ordering information

The SN74CB3T16211 is a high-speed TTL-compatible FET bus switch with low ON-state resistance (r_{on}), allowing for minimal propagation delay. The device fully supports mixed-mode signal operation on all data I/O ports by providing voltage translation that tracks V_{CC} . The SN74CB3T16211 supports systems using 5-V TTL, 3.3-V LVTTTL, and 2.5-V CMOS switching standards, as well as user-defined switching levels (see Figure 1).



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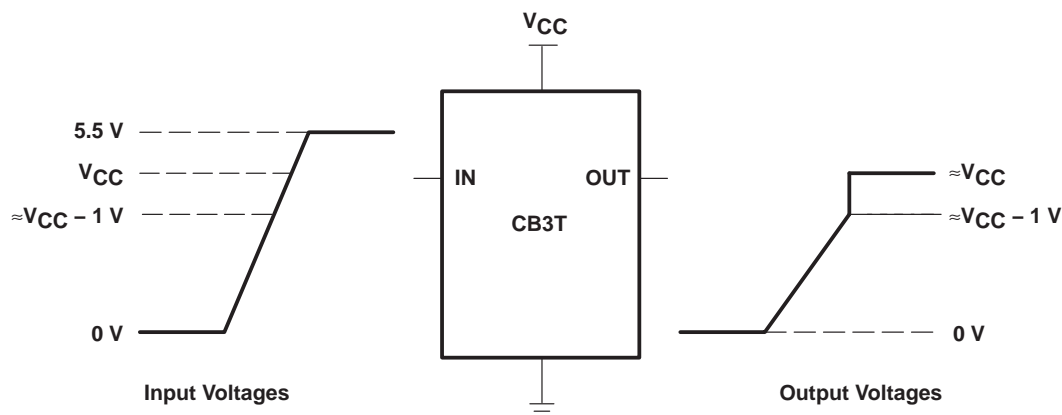
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description/ordering information (continued)



NOTE A: If the input high-voltage (V_{IH}) level is greater than or equal to $V_{CC} - 1V$ and less than or equal to 5.5 V, the output high-voltage (V_{OH}) level is equal to approximately the V_{CC} voltage level.

Figure 1. Typical DC Voltage-Translation Characteristics

The I/O port of this device has a pullup current source that maintains the output voltage at V_{CC} when the device is ON and the input is greater than or equal to $V_{CC} - 1V$. Because of the pullup current source, the output voltage level may be less than V_{CC} when the operating frequency is low and the I/O port is connected to a pulldown resistor. In order to maintain the output voltage at V_{CC} , a pullup resistor must be connected to V_{CC} , instead of a pulldown resistor to ground.

The SN74CB3T16211 is organized as two 12-bit bus switches with separate output-enable (\overline{OE} , $2\overline{OE}$) inputs. It can be used as two 12-bit bus switches or as one 24-bit bus switch. When \overline{OE} is low, the associated 12-bit bus switch is ON, and the A port is connected to the B port, allowing bidirectional data flow between ports. When \overline{OE} is high, the associated 12-bit bus switch is OFF, and a high-impedance state exists between the A and B ports.

This device is fully specified for partial-power-down applications using I_{off} . The I_{off} feature ensures that damaging current will not backflow through the device when it is powered down. The device has isolation during power off.

To ensure the high-impedance state during power up or power down, \overline{OE} should be tied to V_{CC} through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

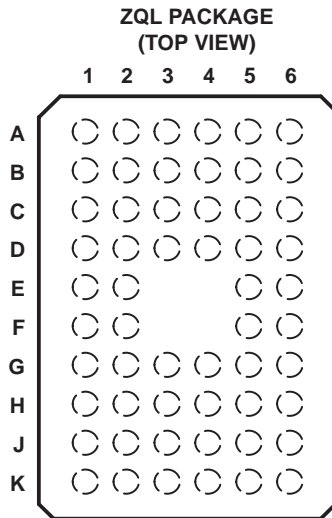
ORDERING INFORMATION

| T_A | PACKAGE† | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---------------|-----------------------|---------------|-----------------------|------------------|
| -40°C to 85°C | SSOP – DL | Tube | SN74CB3T16211DL | CB3T16211 |
| | | Tape and reel | SN74CB3T16211DLR | |
| | TSSOP – DGG | Tube | SN74CB3T16211DGG | CB3T16211 |
| | | Tape and reel | SN74CB3T16211DGGR | |
| | TVSOP – DGV | Tape and reel | SN74CB3T16211DGVR | KR211 |
| | VFBGA – ZQL (PB-Free) | Tape and reel | SN74CB3T16211ZQLR | KR211 |

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

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terminal assignments

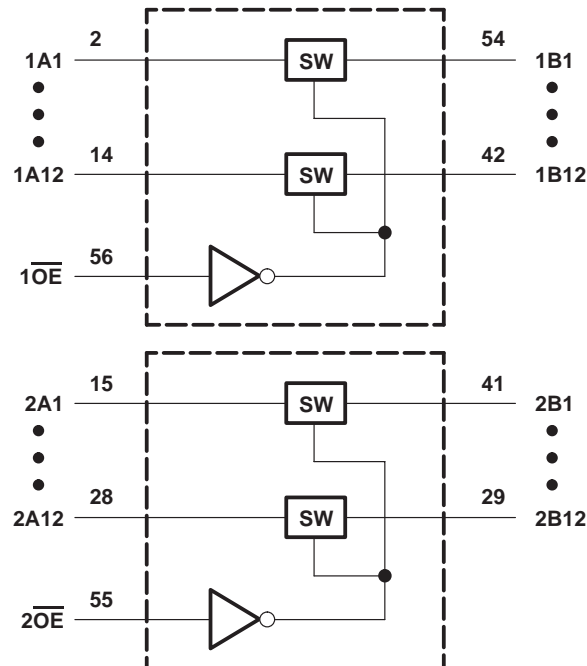
| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|------|------|------|------------------|------------------|------|
| A | 1A2 | 1A1 | NC | $\overline{1OE}$ | $\overline{2OE}$ | 1B1 |
| B | 1A5 | 1A4 | 1A3 | 1B2 | 1B3 | 1B4 |
| C | 1A7 | GND | 1A6 | 1B5 | GND | 1B6 |
| D | 1A10 | 1A8 | 1A9 | 1B8 | 1B7 | 1B9 |
| E | 1A12 | 1A11 | | | 1B10 | 1B11 |
| F | 2A1 | 2A2 | | | 2B1 | 1B12 |
| G | VCC | GND | 2A3 | 2B3 | GND | 2B2 |
| H | 2A4 | 2A5 | 2A6 | 2B6 | 2B5 | 2B4 |
| J | 2A7 | 2A8 | 2A9 | 2B9 | 2B8 | 2B7 |
| K | 2A10 | 2A11 | 2A12 | 2B12 | 2B11 | 2B10 |

NC – No internal connection

FUNCTION TABLE
(each 12-bit bus switch)

| INPUT \overline{OE} | INPUT/OUTPUT A | FUNCTION |
|--------------------------|-------------------|-----------------|
| L | B | A port = B port |
| H | Z | Disconnect |

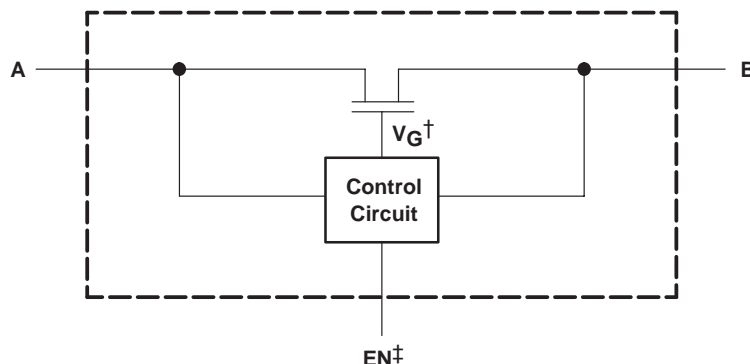
logic diagram (positive logic)



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simplified schematic, each FET switch (SW)



[†] Gate voltage (V_G) is equal to approximately $V_{CC} + V_T$ when the switch is ON and $V_I > V_{CC} + V_T$.

‡ Internal enable signal applied to the switch

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

| | |
|--|----------------|
| Supply voltage range, V_{CC} (see Note 1) | −0.5 V to 7 V |
| Control input voltage range, V_{IN} (see Notes 1 and 2) | −0.5 V to 7 V |
| Switch I/O voltage range, $V_{I/O}$ (see Notes 1, 2, and 3) | −0.5 V to 7 V |
| Control input clamp current, I_{IK} ($V_{IN} < 0$) | −50 mA |
| I/O port clamp current, $I_{I/OK}$ ($V_{I/O} < 0$) | −50 mA |
| ON-state switch current, $I_{I/O}$ (see Note 4) | ±128 mA |
| Continuous current through V_{CC} or GND terminals | ±100 mA |
| Package thermal impedance, θ_{JA} (see Note 5): DGG package | 64°C/W |
| DGV package | 48°C/W |
| DL package | 56°C/W |
| ZQL package | 42°C/W |
| Storage temperature range, T_{stg} | −65°C to 150°C |

† 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.

NOTES: 1. All voltages are with respect to ground, unless otherwise specified.

1. All voltages are with respect to ground, unless otherwise specified.
2. The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.

3. V_I and V_O are used to denote specific conditions for V_I/O .

4. I_I and I_O are used to denote specific conditions for I_I/O .

5. The package thermal impedance is calculated in accordance with JEDEC 51-7.

recommended operating conditions (see Note 6)

| | | | MIN | MAX | UNIT |
|------------------|----------------------------------|----------------------------------|-----|-----|------|
| V _{CC} | Supply voltage | | 2.3 | 3.6 | V |
| V _{IH} | High-level control input voltage | V _{CC} = 2.3 V to 2.7 V | 1.7 | 5.5 | V |
| | | V _{CC} = 2.7 V to 3.6 V | 2 | 5.5 | |
| V _{IL} | Low-level control input voltage | V _{CC} = 2.3 V to 2.7 V | 0 | 0.7 | V |
| | | V _{CC} = 2.7 V to 3.6 V | 0 | 0.8 | |
| V _{I/O} | Data input/output voltage | | 0 | 5.5 | V |
| T _A | Operating free-air temperature | | −40 | 85 | °C |

NOTE 6: All unused control inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|--------------------|----------------|--|--|------|----------|---------------|
| V_{IK} | | $V_{CC} = 3\text{ V}$, $I_I = -18\text{ mA}$ | | | -1.2 | V |
| V_{OH} | | See Figures 3 and 4 | | | | |
| I_{IN} | Control inputs | $V_{CC} = 3.6\text{ V}$, $V_{IN} = 3.6\text{ V to } 5.5\text{ V or GND}$ | | | ± 10 | μA |
| I_I | | $V_{CC} = 3.6\text{ V}$, Switch ON, $V_{IN} = V_{CC}$ or GND | $V_I = V_{CC} - 0.7\text{ V to } 5.5\text{ V}$ | | ± 20 | μA |
| | | | $V_I = 0.7\text{ V to } V_{CC} - 0.7\text{ V}$ | | -40 | |
| | | | $V_I = 0\text{ to } 0.7\text{ V}$ | | ± 5 | |
| I_{OZ}^\ddagger | | $V_{CC} = 3.6\text{ V}$, $V_O = 0\text{ to } 5.5\text{ V}$, $V_I = 0$, Switch OFF, $V_{IN} = V_{CC}$ or GND | | | ± 10 | μA |
| I_{off} | | $V_{CC} = 0$, $V_O = 0\text{ to } 5.5\text{ V}$, $V_I = 0$ | | | 10 | μA |
| I_{CC} | | $V_{CC} = 3.6\text{ V}$, $I_{I/O} = 0$, Switch ON or OFF, $V_{IN} = V_{CC}$ or GND | $V_I = V_{CC}$ or GND | | 70 | μA |
| | | | $V_I = 5.5\text{ V}$ | | 70 | |
| ΔI_{CC}^\S | Control inputs | $V_{CC} = 3\text{ V to } 3.6\text{ V}$, One input at $V_{CC} - 0.6\text{ V}$, Other inputs at V_{CC} or GND | | | 300 | μA |
| C_{in} | Control inputs | $V_{CC} = 3.3\text{ V}$, $V_{IN} = V_{CC}$ or GND | | 4 | | pF |
| $C_{io(OFF)}$ | | $V_{CC} = 3.3\text{ V}$, $V_{I/O} = 5.5\text{ V, } 3.3\text{ V, or GND}$, Switch OFF, $V_{IN} = V_{CC}$ or GND | | 5 | | pF |
| $C_{io(ON)}$ | | $V_{CC} = 3.3\text{ V}$, Switch ON, $V_{IN} = V_{CC}$ or GND | $V_{I/O} = 5.5\text{ V or } 3.3\text{ V}$ | 5 | | pF |
| | | | $V_{I/O} = \text{GND}$ | 13 | | |
| r_{on}^\P | | $V_{CC} = 2.3\text{ V}$, TYP at $V_{CC} = 2.5\text{ V}$, $V_I = 0$ | $I_O = 24\text{ mA}$ | 5 | 9.5 | Ω |
| | | | $I_O = 16\text{ mA}$ | 5 | 9.5 | |
| | | $V_{CC} = 3\text{ V}$, $V_I = 0$ | $I_O = 64\text{ mA}$ | 5 | 8.5 | |
| | | | $I_O = 32\text{ mA}$ | 5 | 8.5 | |

V_{IN} and I_{IN} refer to control inputs. V_I , V_O , I_I , and I_O refer to data pins.

† All typical values are at $V_{CC} = 3.3\text{ V}$ (unless otherwise noted), $T_A = 25^\circ\text{C}$.

‡ For I/O ports, the parameter I_{OZ} includes the input leakage current.

§ This is the increase in supply current for each input that is at the specified TTL voltage level, rather than V_{CC} or GND.

¶ Measured by the voltage drop between A and B terminals at the indicated current through the switch. ON-state resistance is determined by the lower of the voltages of the two (A or B) terminals.

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switching characteristics over recommended operating free-air temperature range (unless otherwise noted) (see Figure 2)

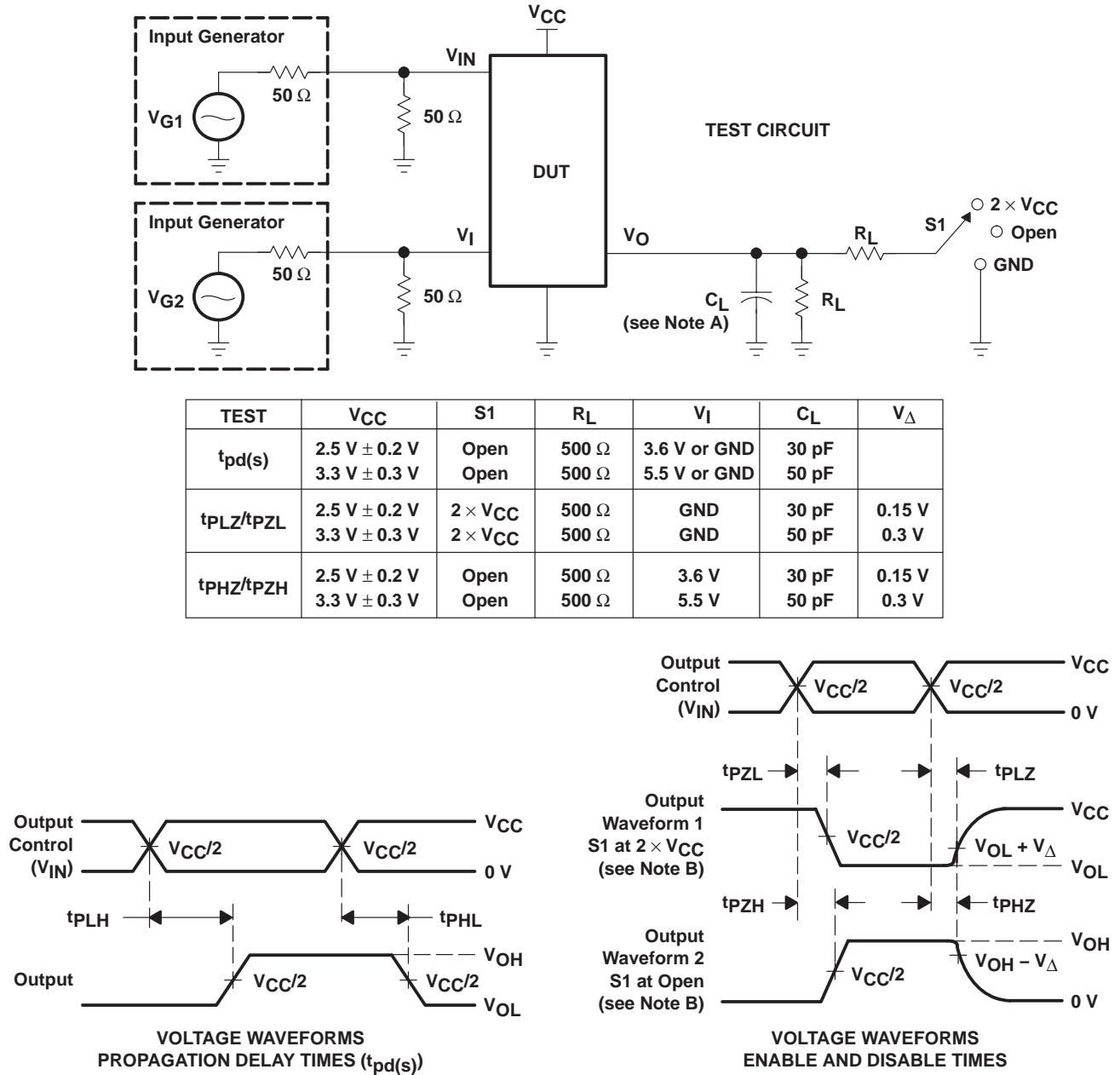
| PARAMETER | FROM (INPUT) | TO (OUTPUT) | V _{CC} = 2.5 V ± 0.2 V | | V _{CC} = 3.3 V ± 0.3 V | | UNIT |
|------------------------------|-----------------|----------------|------------------------------------|-----|------------------------------------|-----|------|
| | | | MIN | MAX | MIN | MAX | |
| t _{pd} [†] | A or B | B or A | 0.15 | | 0.25 | | ns |
| t _{en} | \overline{OE} | A or B | 1 | 12 | 1 | 10 | ns |
| t _{dis} | \overline{OE} | A or B | 1 | 7.5 | 1 | 8.5 | ns |

[†] The propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).

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PARAMETER MEASUREMENT INFORMATION



- NOTES:
- B. C_L includes probe and jig capacitance.
 - C. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
 - D. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r ≤ 2.5 ns, t_f ≤ 2.5 ns.
 - E. The outputs are measured one at a time, with one transition per measurement.
 - F. t_{PLZ} and t_{PHZ} are the same as t_{dis}.
 - G. t_{PZL} and t_{PZH} are the same as t_{en}.
 - H. t_{PLH} and t_{PHL} are the same as t_{pd}(s). The t_{pd} propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).
 - I. All parameters and waveforms are not applicable to all devices.

Figure 2. Test Circuit and Voltage Waveforms

TYPICAL CHARACTERISTICS

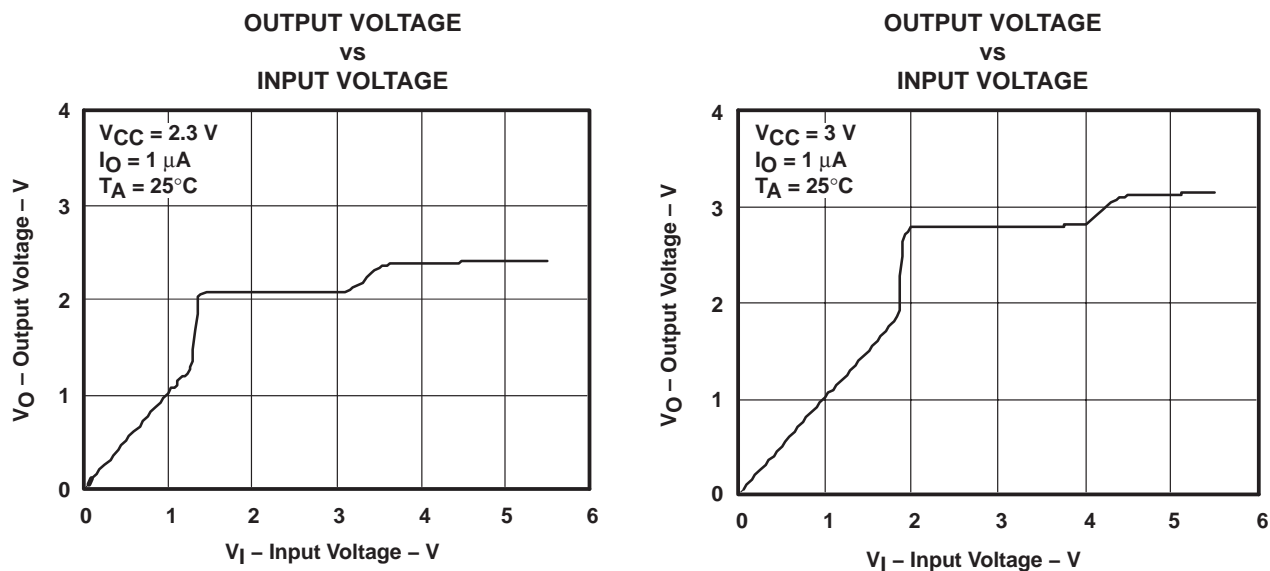


Figure 3. Data Output Voltage vs Data Input Voltage

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TYPICAL CHARACTERISTICS

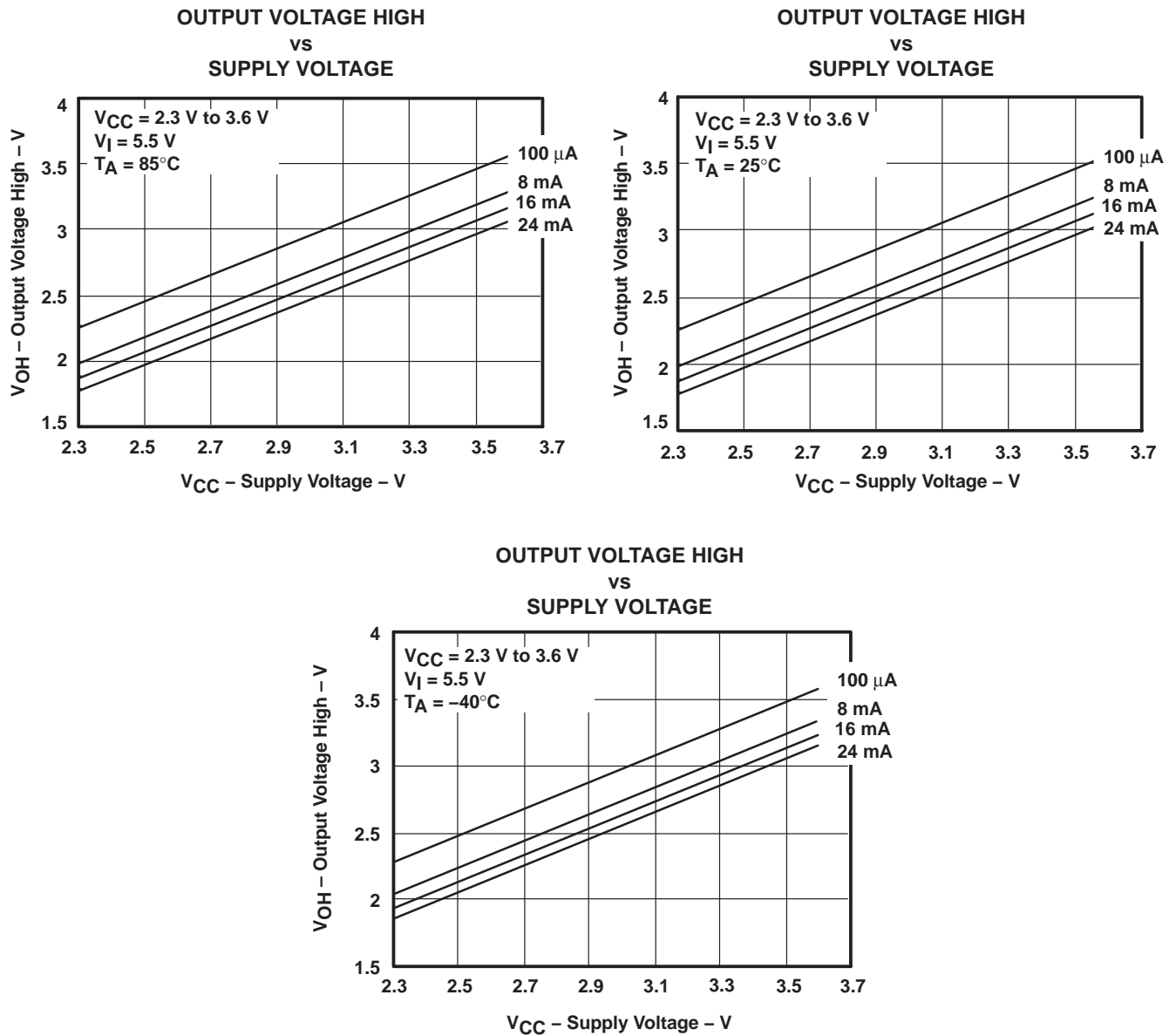


Figure 4. V_{OH} Values

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|-------------------|-----------------------|----------------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| 74CB3T16211DGGRE4 | ACTIVE | TSSOP | DGG | 56 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| 74CB3T16211DGGRG4 | ACTIVE | TSSOP | DGG | 56 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| 74CB3T16211DGVRE4 | ACTIVE | TVSOP | DGV | 56 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| 74CB3T16211DGVRG4 | ACTIVE | TVSOP | DGV | 56 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| 74CB3T16211DLRG4 | ACTIVE | SSOP | DL | 56 | 1000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CB3T16211DGG | PREVIEW | TSSOP | DGG | 56 | 35 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CB3T16211DGGR | ACTIVE | TSSOP | DGG | 56 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CB3T16211DGVR | ACTIVE | TVSOP | DGV | 56 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CB3T16211DL | ACTIVE | SSOP | DL | 56 | 20 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CB3T16211DLG4 | ACTIVE | SSOP | DL | 56 | 20 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CB3T16211DLR | ACTIVE | SSOP | DL | 56 | 1000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CB3T16211GQLR | NRND | BGA MICROSTAR JUNIOR | GQL | 56 | 1000 | TBD | SNPB | Level-1-240C-UNLIM |
| SN74CB3T16211ZQLR | ACTIVE | BGA MICROSTAR JUNIOR | ZQL | 56 | 1000 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM |

⁽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.

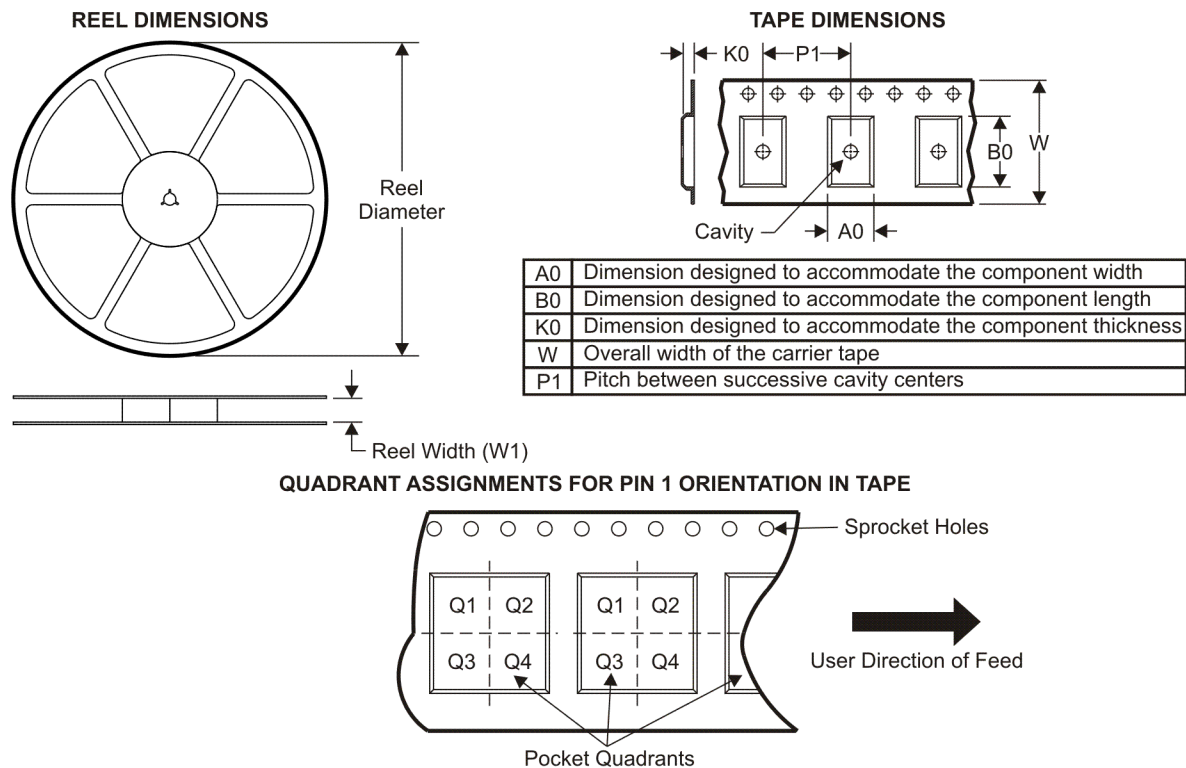
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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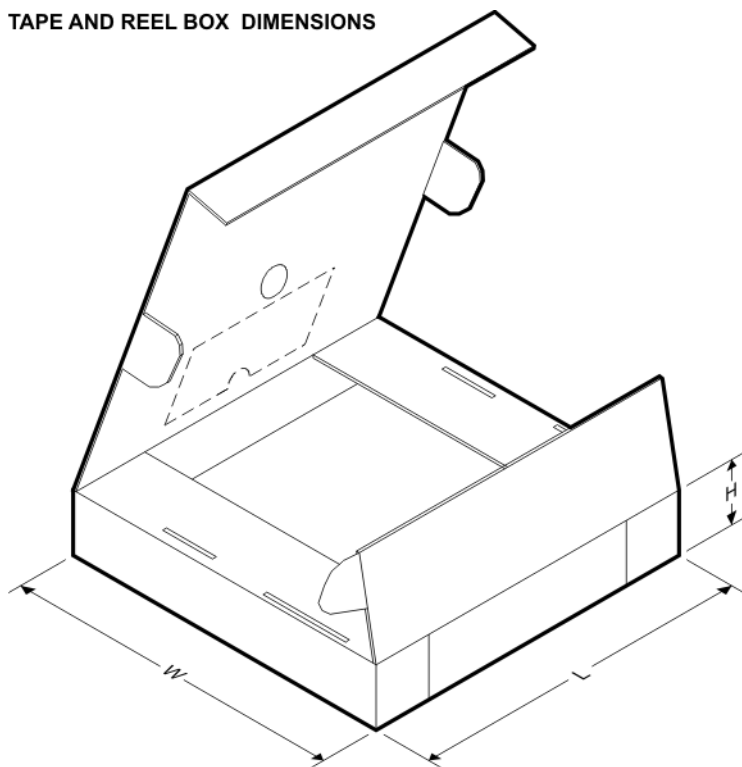
TAPE AND REEL INFORMATION



*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 |
|-------------------|----------------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| SN74CB3T16211DGGR | TSSOP | DGG | 56 | 2000 | 330.0 | 24.4 | 8.6 | 15.6 | 1.8 | 12.0 | 24.0 | Q1 |
| SN74CB3T16211DGVR | TVSOP | DGV | 56 | 2000 | 330.0 | 24.4 | 6.8 | 11.7 | 1.6 | 12.0 | 24.0 | Q1 |
| SN74CB3T16211DLR | SSOP | DL | 56 | 1000 | 330.0 | 32.4 | 11.35 | 18.67 | 3.1 | 16.0 | 32.0 | Q1 |
| SN74CB3T16211GQLR | BGA MICROSTAR JUNIOR | GQL | 56 | 1000 | 330.0 | 16.4 | 4.8 | 7.3 | 1.45 | 8.0 | 16.0 | Q1 |
| SN74CB3T16211ZQLR | BGA MICROSTAR JUNIOR | ZQL | 56 | 1000 | 330.0 | 16.4 | 4.8 | 7.3 | 1.45 | 8.0 | 16.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-------------------|-------------------------|-----------------|------|------|-------------|------------|-------------|
| SN74CB3T16211DGGR | TSSOP | DGG | 56 | 2000 | 346.0 | 346.0 | 41.0 |
| SN74CB3T16211DGVR | TVSOP | DGV | 56 | 2000 | 346.0 | 346.0 | 41.0 |
| SN74CB3T16211DLR | SSOP | DL | 56 | 1000 | 346.0 | 346.0 | 49.0 |
| SN74CB3T16211GQLR | BGA MICROSTAR JUNIOR | GQL | 56 | 1000 | 346.0 | 346.0 | 33.0 |
| SN74CB3T16211ZQLR | BGA MICROSTAR JUNIOR | ZQL | 56 | 1000 | 346.0 | 346.0 | 33.0 |

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