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SCDS156B - OCTOBER 2003-REVISED JULY 2012

# 20-BIT FET BUS SWITCH 2.5-V/3.3-V LOW-VOLTAGE BUS SWITCH WITH 5-V-TOLERANT LEVEL SHIFTER

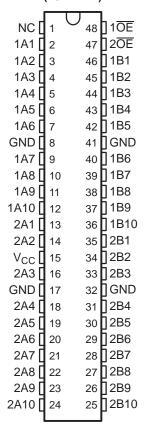
Check for Samples: SN74CB3T16210

#### **FEATURES**

- Member of the Texas Instruments Widebus™ **Family**
- **Output Voltage Translation Tracks V<sub>CC</sub>**
- **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<sub>CC</sub>
  - 5-V/3.3-V Input Down to 2.5-V Output Level Shift With 2.5-V V<sub>CC</sub>
- 5-V-Tolerant I/Os With Device Powered Up or **Powered Down**
- **Bidirectional Data Flow With Near-Zero Propagation Delay**
- Low ON-State Resistance (ron) Characteristics  $(r_{on} = 5 \Omega Typ)$
- Low Input/Output Capacitance Minimizes Loading ( $C_{io(OFF)} = 5 pF Typ$ )
- **Data and Control Inputs Provide Undershoot** Clamp Diodes
- **Low Power Consumption**  $(I_{CC} = 40 \mu A Max)$
- V<sub>CC</sub> 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<sub>off</sub> 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, USB Interface, Memory Interleaving, and Bus Isolation
- Ideal for Low-Power Portable Equipment

#### DGG OR DGV PACKAGE (TOP VIEW)



NC - No internal connection

#### DESCRIPTION/ORDERING INFORMATION

The SN74CB3T16210 is a high-speed TTL-compatible FET bus switch with low ON-state resistance (ron), 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<sub>CC</sub>. The SN74CB3T16210 supports systems using 5-V TTL, 3.3-V LVTTL, and 2.5-V CMOS switching standards, as well as user-defined switching levels (see Figure 1).

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## **DESCRIPTION/ORDERING INFORMATION (CONTINUED)**

The SN74CB3T16210 is organized as two 10-bit bus switches with separate ouput-enable ( $\overline{10E}$ ,  $\overline{20E}$ ) inputs. It can be used as two 10-bit bus switches or as one 20-bit bus switch. When  $\overline{0E}$  is low, the associated 10-bit bus switch is ON, and the A port is connected to the B port, allowing bidirectional data flow between ports. When  $\overline{0E}$  is high, the associated 10-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<sub>off</sub>. The I<sub>off</sub> 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.

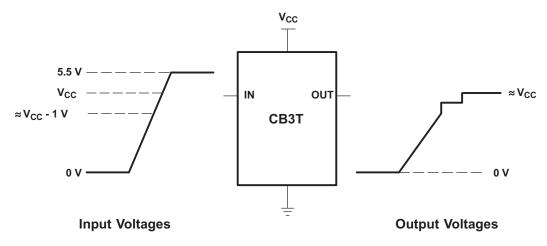
#### ORDERING INFORMATION

T <sub>A</sub>	PACKAGE	E <sup>(1)</sup>	ORDERABLE PART NUMBER	TOP-SIDE MARKING
40°C to 95°C	TSSOP – DGG Tape and reel		SN74CB3T16210DGGR	CB3T16210
-40°C to 85°C	TVSOP – DGV	Tape and reel	SN74CB3T16210DGVR	KR210

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

# FUNCTION TABLE (EACH 10-BIT BUS SWITCH)

INPUT OE	INPUT/OUTPUT A	FUNCTION
L	В	A port = B port
Н	Z	Disconnect

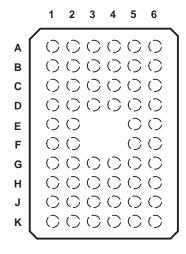


If the input high voltage  $(V_{IH})$  level is greater than or equal to  $V_{CC}$  + 1 V, and less than or equal to 5.5 V, the output high voltage  $(V_{OH})$  level will be equal to approximately the  $V_{CC}$  voltage level.

Figure 1. Typical DC Voltage Translation Characteristics



## GQL PACKAGE (TOP VIEW)

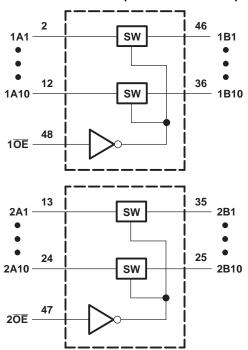


## TERMINAL ASSIGNMENTS(1)

	1	2	3	4	5	6
Α	1A2	1A1	NC	1 <del>OE</del>	2 <del>OE</del>	1B1
В	1A5	1A4	1A3	1B2	1B3	1B4
С	NC	GND	1A6	1B5	1B6	NC
D	1A8	NC	1A7	NC	1B7	1B8
Е	1A10	1A9			1B9	1B10
F	2A1	2A2			2B2	2B1
G	$V_{CC}$	GND	2A3	GND	2B4	2B3
Н	NC	NC	2A4	2B5	NC	NC
J	2A5	2A6	2A7	2B7	2B6	2B5
K	2A8	2A9	2A10	2B10	2B9	2B8

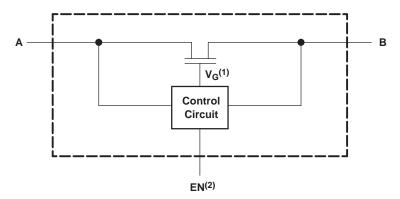
(1) NC - No internal connection

## **LOGIC DIAGRAM (POSITIVE LOGIC)**





## SIMPLIFIED SCHEMATIC, EACH FET SWITCH (SW)



- (1) Gate voltage (V<sub>G</sub>) is equal to approximately V<sub>CC</sub> + V<sub>T</sub> when the switch is ON and V<sub>I</sub> > V<sub>CC</sub> + V<sub>T</sub>.
- (2) EN is the internal enable signal applied to the switch.

## Absolute Maximum Ratings(1)

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

				MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage range		-	-0.5	7	V
V <sub>IN</sub>	Control input voltage range <sup>(2)</sup> (3)				7	V
V <sub>I/O</sub>	Switch I/O voltage range <sup>(2) (3) (4)</sup>		-	-0.5	7	V
lıĸ	Control input clamp current	V <sub>IN</sub> < 0			-50	mA
I/OK	I/O port clamp current	V <sub>I/O</sub> < 0			-50	mA
IO	ON-state switch current <sup>(5)</sup>				±128	mA
	Continuous current through V <sub>CC</sub> or GND				±100	mA
,	D1(6)	DGG package			70	0000
$\Theta_{JA}$	Package thermal impedance (6)	DGV package			58	°C/W
T <sub>stg</sub>	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.
- (2) All voltages are with respect to ground unless otherwise specified.
- (3) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
- (4) V<sub>I</sub> and V<sub>O</sub> are used to denote specific conditions for V<sub>I/O</sub>.
- (5)  $I_I$  and  $I_O$  are used to denote specific conditions for  $I_{I/O}$ .
- (6) The package thermal impedance is calculated in accordance with JESD 51-7.

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# Recommended Operating Conditions<sup>(1)</sup>

			MIN	MAX	UNIT
$V_{CC}$	Supply voltage		2.3	3.6	V
M	High level control input valtage	$V_{CC} = 2.3 \text{ V to } 2.7 \text{ V}$	1.7	5.5	V
V <sub>IH</sub>	High-level control input voltage	$V_{CC} = 2.7 \text{ V to } 3.6 \text{ V}$	2	5.5	V
	Laveland control in motor reliance	V <sub>CC</sub> = 2.3 V to 2.7 V	0	0.7	V
$V_{IL}$	Low-level control input voltage	$V_{CC} = 2.7 \text{ V to } 3.6 \text{ V}$	0	0.8	V
V <sub>I/O</sub>	Data input/output voltage		0	5.5	V
$T_A$	Operating free-air temperature		-40	85	°C

<sup>(1)</sup> All unused control inputs of the device must be held at V<sub>CC</sub> or GND to ensure proper device operation. Refer to the TI application report, Implications of Slow or Floating CMOS Inputs, literature number SCBA004.

## Electrical Characteristics(1)

DAI		TEGT COMPLETION	T <sub>A</sub> = -	-40°C TO	85°C					
PAI	RAMETER	TEST CONDITION	NS	MIN	TYP <sup>(2)</sup>	MAX	UNIT			
V <sub>IK</sub>		V <sub>CC</sub> = 3 V, I <sub>I</sub> = -18 mA				-1.2	V			
V <sub>OH</sub>		See Figure 3 and Figure 4								
I <sub>IN</sub>	Control inputs	V <sub>CC</sub> = 3.6 V, V <sub>IN</sub> = 3.6 V to 5.5 V or GND				±10	μΑ			
	*	V <sub>CC</sub> = 3.6 V.	$V_{I} = V_{CC} - 0.7 \text{ V to } 5.5 \text{ V}$			±20				
I		Switch ON,	$V_{I} = 0.7 \text{ V to } V_{CC} - 0.7 \text{ V}$			-40	μΑ			
	$V_{IN} = V_{CC}$ or GND		V <sub>I</sub> = 0 to 0.7 V	±t						
I <sub>OZ</sub> (3)		$V_{CC} = 3.6 \text{ V}, V_{O} = 0 \text{ to } 5.5 \text{ V}, V_{I} = 0, \text{ Switch Ol}$	FF, V <sub>IN</sub> = V <sub>CC</sub> or GND	±10	μΑ					
I <sub>off</sub>		$V_{CC} = 0$ , $V_{O} = 0$ to 5.5 V, $V_{I} = 0$ ,				10	0 μΑ			
		$V_{CC} = 3.6 \text{ V}, I_{I/O} = 0,$	$V_I = V_{CC}$ or GND			40				
I <sub>CC</sub>		Switch ON or OFF, $V_{IN} = V_{CC}$ or GND	$V_1 = 5.5 \text{ V}$				μA			
ΔI <sub>CC</sub> (4)	Control inputs	$V_{CC}$ = 3 V to 3.6 V, One input at $V_{CC}$ – 0.6 V,	Other inputs at V <sub>CC</sub> or GND			300	μΑ			
C <sub>in</sub>	Control inputs	$V_{CC} = 3.3 \text{ V}, V_{IN} = V_{CC} \text{ or GND}$			4		pF			
C <sub>io(OFF)</sub>		$V_{CC} = 3.3 \text{ V}, V_{I/O} = 5.5 \text{ V}, 3.3 \text{ V}, \text{ or GND, Swit}$	ch OFF, V <sub>IN</sub> = V <sub>CC</sub> or GND		5		pF			
		V 22V Switzh ON V V 22 CND	V <sub>I/O</sub> = 5.5 V or 3.3 V		5					
C <sub>io(ON)</sub>		$V_{CC} = 3.3 \text{ V}$ , Switch ON, $V_{IN} = V_{CC}$ or GND	$V_{I/O} = GND$		13		pF			
		V 22V TVD etV 25V V 2	I <sub>O</sub> = 24 mA		5	9.5	Ω			
" (5)		$V_{CC} = 2.3 \text{ V}$ , TYP at $V_{CC} = 2.5 \text{ V}$ , $V_I = 0$	I <sub>O</sub> = 16 mA		5	9.5				
r <sub>on</sub> (5)		V 2VV 0	I <sub>O</sub> = 64 mA		5	8.5				
		$V_{CC} = 3 \text{ V}, \text{ V}_{I} = 0$	I <sub>O</sub> = 32 mA		5	8.5				

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 $V_{IN}$  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.



# **Switching Characteristics**

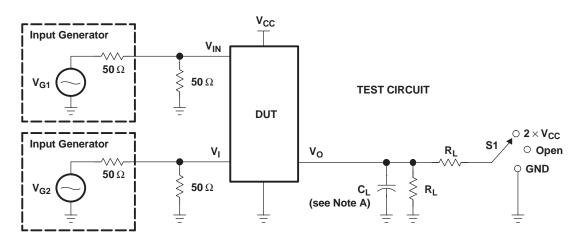
for  $V_{CC} = 2.5 \text{ V} \pm 0.2 \text{ V}$  (see Figure 2)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub> = ± 0.2	2.5 V 2 V	V <sub>CC</sub> = ± 0.3	UNIT	
	(INFOT)	(001701)	MIN	MAX	MIN	MAX	
t <sub>pd</sub> <sup>(1)</sup>	A or B	B or A		0.15		0.25	ns
t <sub>en</sub>	ŌE	A or B	1	12	1	10	ns
t <sub>dis</sub>	ŌĒ	A or B	1	7.5	1	8.5	ns

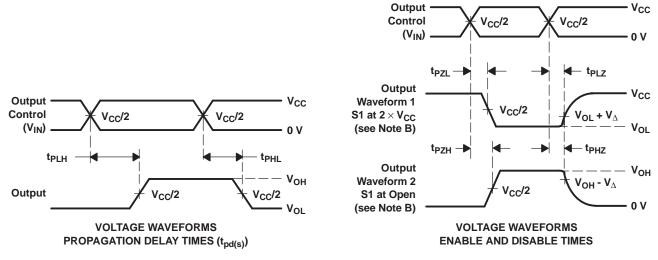
<sup>(1)</sup> The propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).



#### PARAMETER MEASUREMENT INFORMATION



TEST	V <sub>CC</sub>	S1	R <sub>L</sub>	VI	CL	$V_{\Delta}$
t <sub>pd(s)</sub>	2.5 V ± 0.2 V	Open	500 Ω	3.6 V or GND	30 pF	
	3.3 V ± 0.3 V	Open	500 Ω	5.5 V or GND	50 pF	
t <sub>PLZ</sub> /t <sub>PZL</sub>	2.5 V $\pm$ 0.2 V	$2 \times V_{CC}$	500 Ω	GND	30 pF	0.15 V
1 1 1 1 2 1	3.3 V ± 0.3 V	2×V <sub>CC</sub>	500 Ω	GND	50 pF	0.3 V
t <sub>PHZ</sub> /t <sub>PZH</sub>	2.5 V ± 0.2 V	Open	500 Ω	3.6 V	30 pF	0.15 V
PHZ/PZH	3.3 V $\pm$ 0.3 V	Open	500 Ω	5.5 V	50 pF	0.3 V



NOTES: A. C<sub>L</sub> includes probe and jig capacitance.

- B. 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.
- C. All input pulses are supplied by generators having the following characteristics: PRR  $\leq$  10 MHz,  $Z_O = 50 \Omega$ ,  $t_r \leq$  2.5 ns,  $t_f \leq$  2.5 ns.
- D. The outputs are measured one at a time, with one transition per measurement.
- E. t<sub>PLZ</sub> and t<sub>PHZ</sub> are the same as t<sub>dis</sub>.
- F. t<sub>PZL</sub> and t<sub>PZH</sub> are the same as t<sub>en</sub>.
- G. t<sub>PLH</sub> and t<sub>PHL</sub> are the same as t<sub>pd(s)</sub>. The tpd 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).
- H. All parameters and waveforms are not applicable to all devices.

Figure 2. Test Circuit and Voltage Waveforms



## **TYPICAL CHARACTERISTICS**

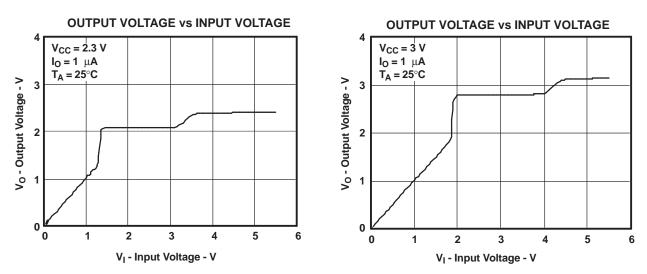


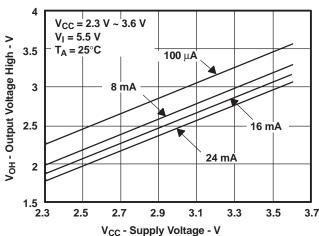
Figure 3. Data Output Voltage vs Data Input Voltage



## **TYPICAL CHARACTERISTICS**

#### **OUTPUT VOLTAGE HIGH vs SUPPLY VOLTAGE** V<sub>CC</sub> = 2.3 V ~ 3.6 V $V_1 = 5.5 \text{ V}$ V<sub>OH</sub> - Output Voltage High - V **100** μ**A** T<sub>A</sub> = 85°C 8 mA 3 2.5 16 mA 24 mA 2 1.5 L 2.3 2.5 2.7 2.9 3.1 3.3 3.5 3.7 V<sub>CC</sub> - Supply Voltage - V

# OUTPUT VOLTAGE HIGH vs SUPPLY VOLTAGE



## **OUTPUT VOLTAGE HIGH vs SUPPLY VOLTAGE**

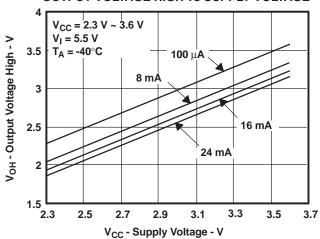


Figure 4. V<sub>OH</sub> Values



## **REVISION HISTORY**

Cł	nanges from Revision A (March 2005) to Revision B	Pag	j€
•	Updated graphic note and picture in figure 1.		2





11-Apr-2013

#### PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan	Lead/Ball Finish	MSL Peak Temp	Op Temp (°C)	Top-Side Markings	Samples
74CB3T16210DGGRE4	ACTIVE	TSSOP	DGG	48	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3T16210	Samples
74CB3T16210DGGRG4	ACTIVE	TSSOP	DGG	48	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3T16210	Samples
74CB3T16210DGVRE4	ACTIVE	TVSOP	DGV	48	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KR210	Samples
74CB3T16210DGVRG4	ACTIVE	TVSOP	DGV	48	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KR210	Samples
SN74CB3T16210DGG	PREVIEW	TSSOP	DGG	48	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3T16210	
SN74CB3T16210DGGR	ACTIVE	TSSOP	DGG	48	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3T16210	Samples
SN74CB3T16210DGVR	ACTIVE	TVSOP	DGV	48	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KR210	Samples
SN74CB3T16210DL	PREVIEW	SSOP	DL	48	25	TBD	Call TI	Call TI	-40 to 85		
SN74CB3T16210DLR	PREVIEW	SSOP	DL	48	1000	TBD	Call TI	Call TI	-40 to 85		

(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): Tl'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)

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



## PACKAGE OPTION ADDENDUM

11-Apr-2013

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side 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 Top-Side Marking for that device.

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#### OTHER QUALIFIED VERSIONS OF SN74CB3T16210:

Automotive: SN74CB3T16210-Q1

NOTE: Qualified Version Definitions:

Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

# PACKAGE MATERIALS INFORMATION

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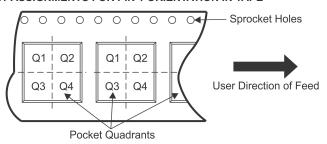
## TAPE AND REEL INFORMATION





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

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



#### \*All dimensions are nominal

Device	Package Type	Package Drawing		SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN74CB3T16210DGGR	TSSOP	DGG	48	2000	330.0	24.4	8.6	15.8	1.8	12.0	24.0	Q1
SN74CB3T16210DGVR	TVSOP	DGV	48	2000	330.0	16.4	7.1	10.2	1.6	12.0	16.0	Q1

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#### \*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74CB3T16210DGGR	TSSOP	DGG	48	2000	367.0	367.0	45.0
SN74CB3T16210DGVR	TVSOP	DGV	48	2000	367.0	367.0	38.0

## DGV (R-PDSO-G\*\*)

## **24 PINS SHOWN**

## **PLASTIC SMALL-OUTLINE**



NOTES: A. All linear dimensions are in millimeters.

B. This drawing is subject to change without notice.

C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15 per side.

D. Falls within JEDEC: 24/48 Pins – MO-153 14/16/20/56 Pins – MO-194

# DL (R-PDSO-G48)

# PLASTIC SMALL-OUTLINE PACKAGE



NOTES:

- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. Falls within JEDEC MO-118

PowerPAD is a trademark of Texas Instruments.



## DGG (R-PDSO-G\*\*)

## PLASTIC SMALL-OUTLINE PACKAGE

#### **48 PINS SHOWN**



NOTES: A. All linear dimensions are in millimeters.

B. This drawing is subject to change without notice.

C. Body dimensions do not include mold protrusion not to exceed 0,15.

D. Falls within JEDEC MO-153

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