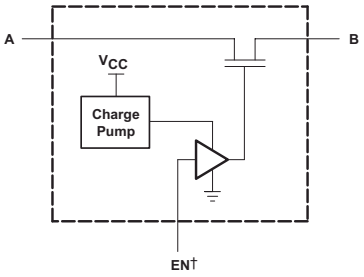
TEXAS INSTRUMENTS
SN74CB3Q16211
SCDS167A – MAY 2004 – REVISED JULY 2022

SN74CB3Q16211 24-Bit Switch 2.5-V/3.3-V Low-Voltage FET Bus Switch

1 Features

- Member of the Texas Instruments Widebus® family
- High-bandwidth data path (up to 500 MHz(1))
- 5-V tolerant I/Os with device powered up or powered down
- Low and flat ON-state resistance (r_{on}) characteristics over operating range (r_{on} = 5 Ω typical)
- Rail-to-rail switching on data I/O ports
  - 0-V to 5-V switching with 3.3-V V_{CC}
  - 0-V to 3.3-V switching with 2.5-V V_{CC}
- Bidirectional data flow, with near-zero propagation delay
- Low input or output capacitance minimizes loading and signal distortion ($C_{io(OFF)}$ = 4 pF typical)
- Fast switching frequency ($f_{\overline{OE}}$ = 20 MHz maximum)
- Data and control inputs provide undershoot clamp diodes
- Low power consumption (I_{CC} = 1 mA typical)
- V_{CC} operating range from 2.3 V to 3.6 V
- Data I/Os support 0-V to 5-V signaling levels (0.8 V, 1.2 V, 1.5 V, 1.8 V, 2.5 V, 3.3 V, and 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 100 mA Per JESD 78, Class II
- ESD Performance Tested Per JESD 22
  - 2000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)
- Supports both digital and analog applications: PCI interface, differential signal interface, memory interleaving, bus isolation, low-distortion signal gating [1]



† EN is the internal enable signal applied to the switch.

Simplified Schematic, Each FET Switch (SW)

2 Applications

- AV receiver
- Blu-ray recorder and player
- Embedded PC
- Portable audio dock
- DLP front projection system

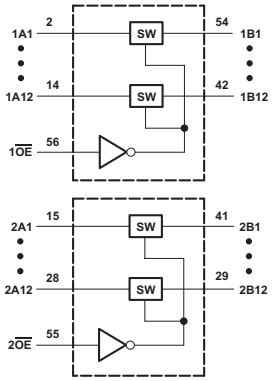
3 Description

The SN74CB3Q16211 device is a high-bandwidth FET bus switch utilizing a charge pump to elevate the gate voltage of the pass transistor, providing a low and flat ON-state resistance (r_{on}). The low and flat ON-state resistance allows for minimal propagation delay and supports rail-to-rail switching on the data input/output (I/O) ports. The device also features low data I/O capacitance to minimize capacitive loading and signal distortion on the data bus. Specifically designed to support high-bandwidth applications, the SN74CB3Q16211 device provides an optimized interface solution ideally suited for broadband communications, networking, and data-intensive computing systems.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE
SN74CB3Q16211	TSSOP (56)	14.00 mm × 6.10 mm
	TVSOP (56)	11.30 mm × 4.40 mm
	SSOP (56)	18.40 mm × 7.49 mm
	BGA MICROSTAR JUNIOR (56)	7.00 mm × 4.50 mm

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



Terminal numbers shown are for the DGG, DGV, and DL packages.

Logic Diagram (Positive Logic)

[1] For additional information regarding the performance characteristics of the CB3Q family, refer to the TI application report, *CBT-C, CB3T, and CB3Q Signal-Switch Families*.

Table of Contents

4 Revision History

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

Changes from Revision * (May 2004) to Revision A (July 2022)	Page
• Updated document to new TI data sheet format - no specification changes	1
• Removed Ordering Information table	1
• Added Applications	1
• Added Device Information table	1
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Changed the BGA package from: *GQL* to: *ZQL* in the *Pin Configuration and Functions* section	3
• Moved T_{stg} to Handling Ratings table	4
• Added Mechanical, Packaging, and Orderable Information section	8

5 Description (continued)

The SN74CB3Q16211 device is organized as two 12-bit bus switches with separate output-enable (1 $\overline{OE}$, 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.

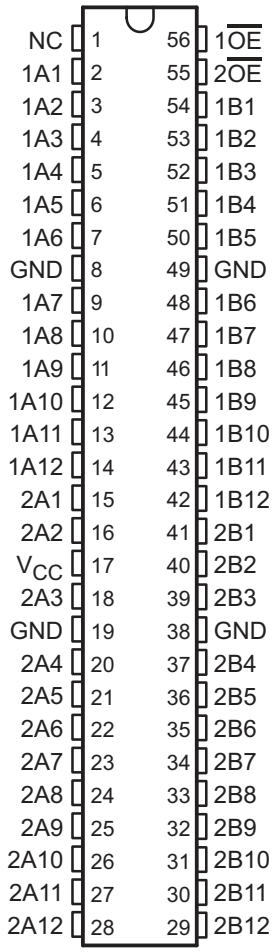
This device is fully specified for partial-power-down applications using I_{off}. The I_{off} circuitry prevents damaging current backflow through the device when it is powered down.

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.

Table 5-1. Function Table (Each 12-Bit Bus Switch)

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

6 Pin Configuration and Functions



NC − No internal connection

Figure 6-1. DGG, DGV, or DL Package, 56-Pin TSSOP and TVSOP (Top View)

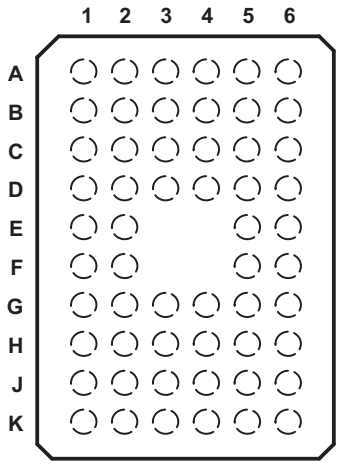


Figure 6-2. ZQL Package, 56-Pin BGA (Top View)

	1	2	3	4	5	6
A	1A2	1A1	NC	1$\overline{OE}$	2$\overline{OE}$	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	V_{CC}	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

Figure 6-3. Functions Table

7 Specifications

7.1 Absolute Maximum Ratings

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

			MIN	MAX	UNIT
V_{CC}	Supply voltage range(2)		–0.5	4.6	V
V_{IN}	Control input voltage range(2) (3)		–0.5	7	V
$V_{I/O}$	Switch I/O voltage range(2) (3) (4)		–0.5	7	V
I_{IK}	Control input clamp current	V_{IN} < 0		–50	mA
$I_{I/OK}$	I/O port clamp current	$V_{I/O}$ < 0		–50	mA
$I_{I/O}$	ON-state switch current(5)			±64	mA
	Continuous current through V_{CC} or GND terminals			±100	mA
θ_{JA}	Package thermal impedance(6)	DGG package		64	°C/W
		DGV package		48	
		DL package		56	
		GQL package		42	

(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_I and V_O are used to denote specific conditions for $V_{I/O}$.
(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.

7.2 Handling Ratings

PARAMETER	DEFINITION	MIN	MAX	UNIT
T_{stg}	Storage temperature range	–65	150	°C

7.3 Recommended Operating Conditions

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

			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

(1) 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.

7.4 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS			MIN	TYP(2)	MAX	UNIT
V_{IK}		V_{CC} = 3.6 V,	I_I = –18 mA				–1.8	V
I_{IN}	Control inputs	V_{CC} = 3.6 V,	V_{IN} = 0 to 5.5 V				±1	µA
I_{OZ} (3)		V_{CC} = 3.6 V,	V_O = 0 to 5.5 V, V_I = 0	Switch OFF, V_{IN} = V_{CC} or GND			±1	µA
I_{off}		V_{CC} = 0,	V_O = 0 to 5.5 V,	V_I = 0			1	µA
I_{CC}		V_{CC} = 3.6 V,	$I_{I/O}$ = 0,	Switch ON or OFF, V_{IN} = V_{CC} or GND		1	3	mA
ΔI_{CC} (4)	Control inputs	V_{CC} = 3.6 V,	One input at 3 V,	Other inputs at V_{CC} or GND			30	µA
I_{CCD} (5)	Per control input	V_{CC} = 3.6 V,	A and B ports open, Control input switching at 50% duty cycle			0.15	0.25	mA/ MHz
C_{in}	Control inputs	V_{CC} = 3.3 V,	V_{IN} = 5.5 V, 3.3 V, or 0			3.5	5	pF
$C_{io(OFF)}$		V_{CC} = 3.3 V,	V_{IN} = V_{CC} or GND,	Switch OFF, $V_{I/O}$ = 5.5 V, 3.3 V, or 0		4	5	pF
$C_{io(ON)}$		V_{CC} = 3.3 V,	V_{IN} = V_{CC} or GND,	Switch ON, $V_{I/O}$ = 5.5 V, 3.3 V, or 0		10	12.5	pF
r_{on} (6)		V_{CC} = 2.3 V, TYP at V_{CC} = 2.5 V	V_I = 0,	I_O = 30 mA		5	8	Ω
			V_I = 1.7 V,	I_O = –15 mA		5	9	
		V_{CC} = 3 V	V_I = 0,	I_O = 30 mA		5	6.5	
			V_I = 2.4 V,	I_O = –15 mA		5	8	

(1) V_{IN} and I_{IN} refer to control inputs. V_I, V_O, I_I, and I_O refer to data pins.
(2) All typical values are at V_{CC} = 3.3 V (unless otherwise noted), T_A = 25°C.
(3) For I/O ports, the parameter I_{OZ} includes the input leakage current.
(4) This is the increase in supply current for each input that is at the specified TTL voltage level, rather than V_{CC} or GND.
(5) This parameter specifies the dynamic power-supply current associated with the operating frequency of a single control input (see Figure 7-2).
(6) Measured by the voltage drop between the 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.

7.5 Switching Characteristics

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 8-1)

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	
$f_{\overline{OE}}$ (1)	$\overline{OE}$	A or B		10		20	MHz
t_{pd} (2)	A or B	B or A		0.15		0.25	ns
t_{en}	$\overline{OE}$	A or B	1.5	8	1.5	8	ns
t_{dis}	$\overline{OE}$	A or B	1	7.5	1	7.5	ns

(1) Maximum switching frequency for control input (V_O > V_{CC}, V_I = 5 V, R_L ≥ 1 MΩ, C_L = 0).
(2) 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).

7.6 Typical Characteristics

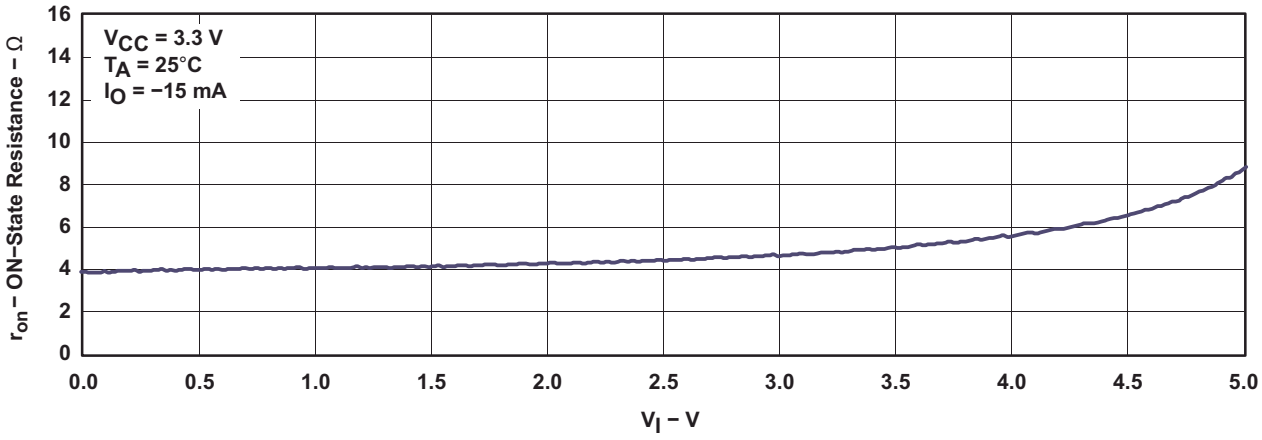


Figure 7-1. Typical r_{on} vs V_I

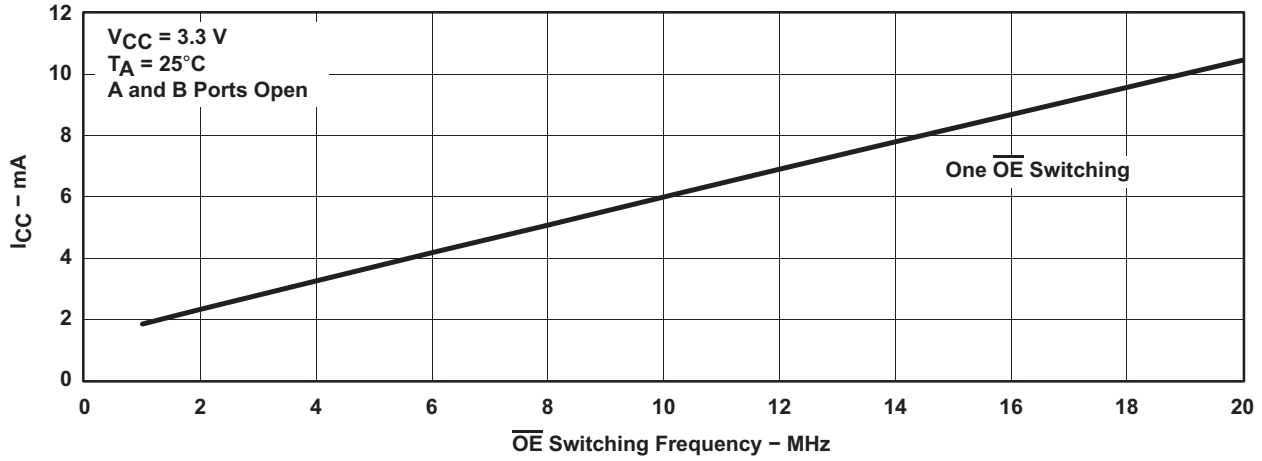
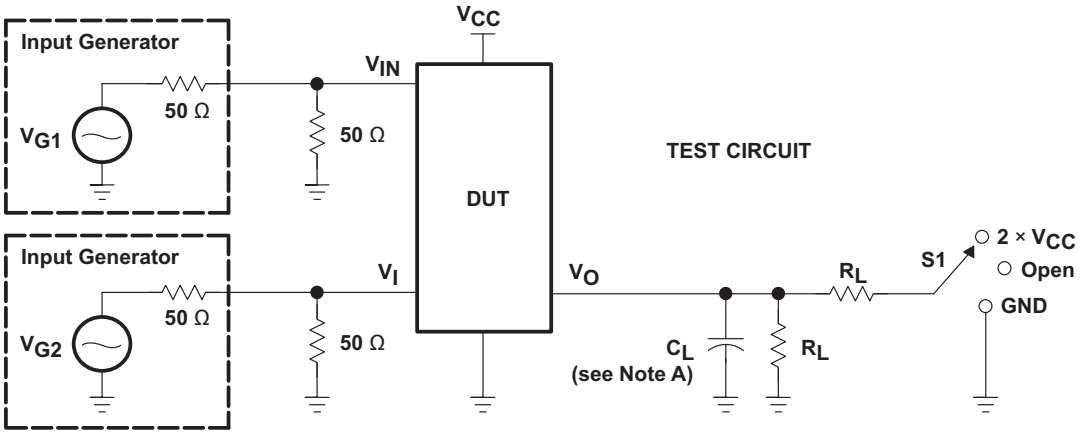
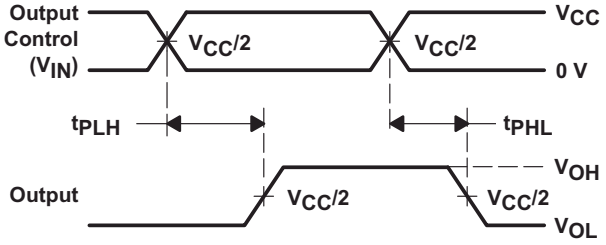


Figure 7-2. Typical I_{CC} vs $\overline{OE}$ Switching Frequency

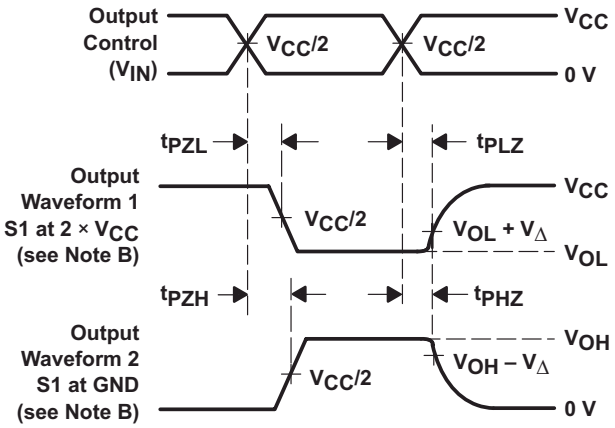
8 Parameter Measurement Information



TEST	V_{CC}	S1	R_L	V_I	C_L	V_Δ
$t_{pd(s)}$	2.5 V ± 0.2 V 3.3 V ± 0.3 V	Open Open	500 Ω 500 Ω	V_{CC} or GND V_{CC} or GND	30 pF 50 pF	
t_{PLZ}/t_{PZL}	2.5 V ± 0.2 V 3.3 V ± 0.3 V	2 × V_{CC} 2 × V_{CC}	500 Ω 500 Ω	GND GND	30 pF 50 pF	0.15 V 0.3 V
t_{PHZ}/t_{PZH}	2.5 V ± 0.2 V 3.3 V ± 0.3 V	GND GND	500 Ω 500 Ω	V_{CC} V_{CC}	30 pF 50 pF	0.15 V 0.3 V



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES ($t_{pd(s)}$)



VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES

NOTES:
A. C_L 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≤ 10 MHz, Z_O = 50 Ω, t_r ≤2.5 ns, t_f ≤2.5 ns.
D. The outputs are measured one at a time, with one transition per measurement.
E. t_{PLZ} and t_{PHZ} are the same as t_{dis}.
F. t_{PZL} and t_{PZH} are the same as t_{en}.
G. 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).
H. All parameters and waveforms are not applicable to all devices.

Figure 8-1. Test Circuit and Voltage Waveforms

9 Device and Documentation Support

9.1 Documentation Support

9.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, *CBT-C, CB3T, and CB3Q Signal-Switch Families* application report

9.2 Receiving Notification of Documentation Updates

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

9.3 Support Resources

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

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9.5 Electrostatic Discharge Caution

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

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

9.6 Glossary

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

10 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
SN74CB3Q16211DGGR	Active	Production	TSSOP (DGG) | 56	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3Q16211
SN74CB3Q16211DGGR.B	Active	Production	TSSOP (DGG) | 56	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3Q16211
SN74CB3Q16211DGVR	Active	Production	TVSOP (DGV) | 56	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	BW211
SN74CB3Q16211DGVR.B	Active	Production	TVSOP (DGV) | 56	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	BW211
SN74CB3Q16211DL	Active	Production	SSOP (DL) | 56	20 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3Q16211
SN74CB3Q16211DL.B	Active	Production	SSOP (DL) | 56	20 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3Q16211
SN74CB3Q16211DLG4	Active	Production	SSOP (DL) | 56	20 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3Q16211
SN74CB3Q16211DLG4.B	Active	Production	SSOP (DL) | 56	20 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3Q16211
SN74CB3Q16211DLR	Active	Production	SSOP (DL) | 56	1000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3Q16211
SN74CB3Q16211DLR.B	Active	Production	SSOP (DL) | 56	1000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3Q16211

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

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

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

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

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

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

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

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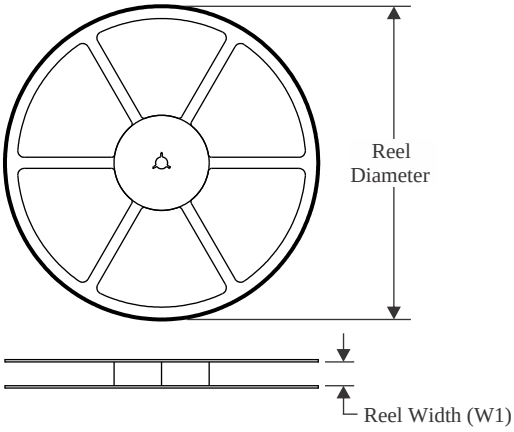
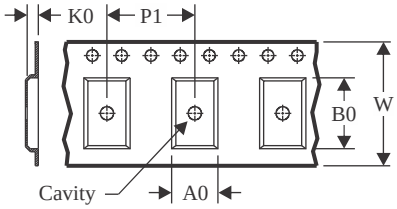
TAPE AND REEL INFORMATION

REEL DIMENSIONS

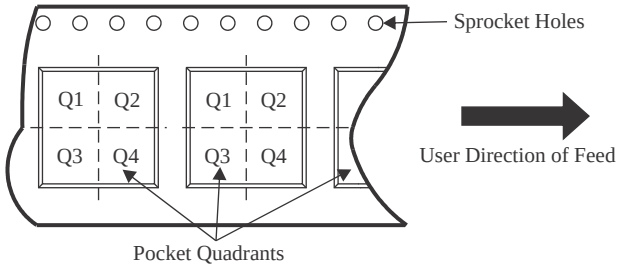


TAPE DIMENSIONS



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

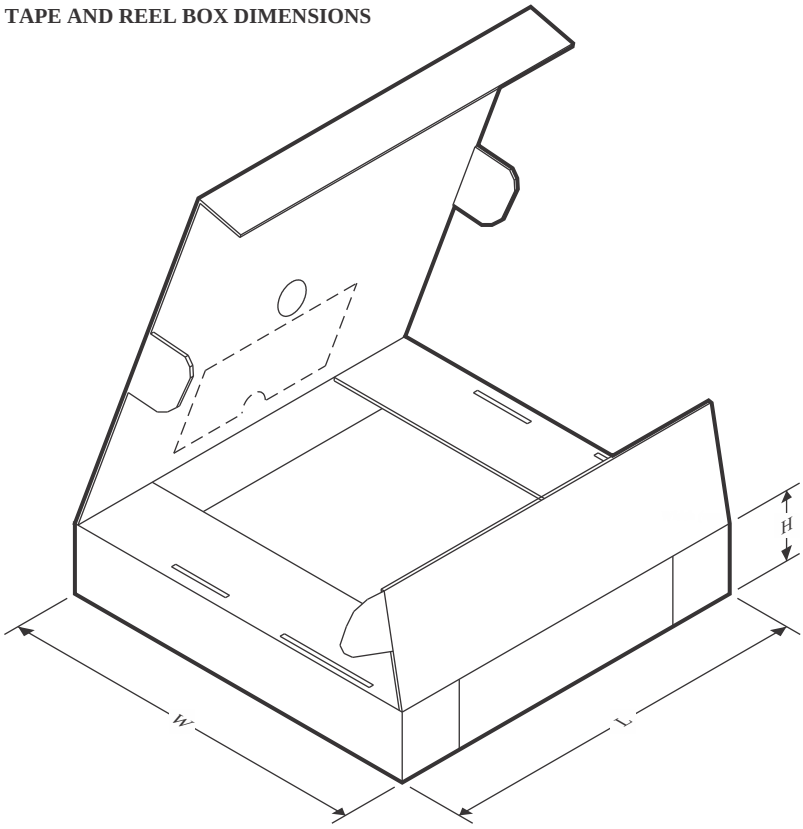
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
SN74CB3Q16211DGGR	TSSOP	DGG	56	2000	330.0	24.4	8.9	14.7	1.4	12.0	24.0	Q1
SN74CB3Q16211DGVR	TVSOP	DGV	56	2000	330.0	24.4	6.8	11.7	1.6	12.0	24.0	Q1
SN74CB3Q16211DLR	SSOP	DL	56	1000	330.0	32.4	11.35	18.67	3.1	16.0	32.0	Q1

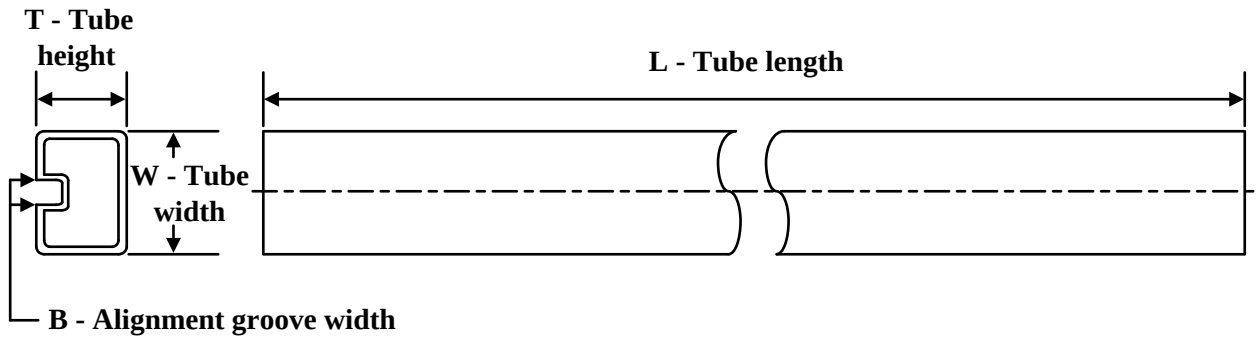
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74CB3Q16211DGGR	TSSOP	DGG	56	2000	356.0	356.0	45.0
SN74CB3Q16211DGVR	TVSOP	DGV	56	2000	356.0	356.0	45.0
SN74CB3Q16211DLR	SSOP	DL	56	1000	356.0	356.0	53.0

TUBE



*All dimensions are nominal

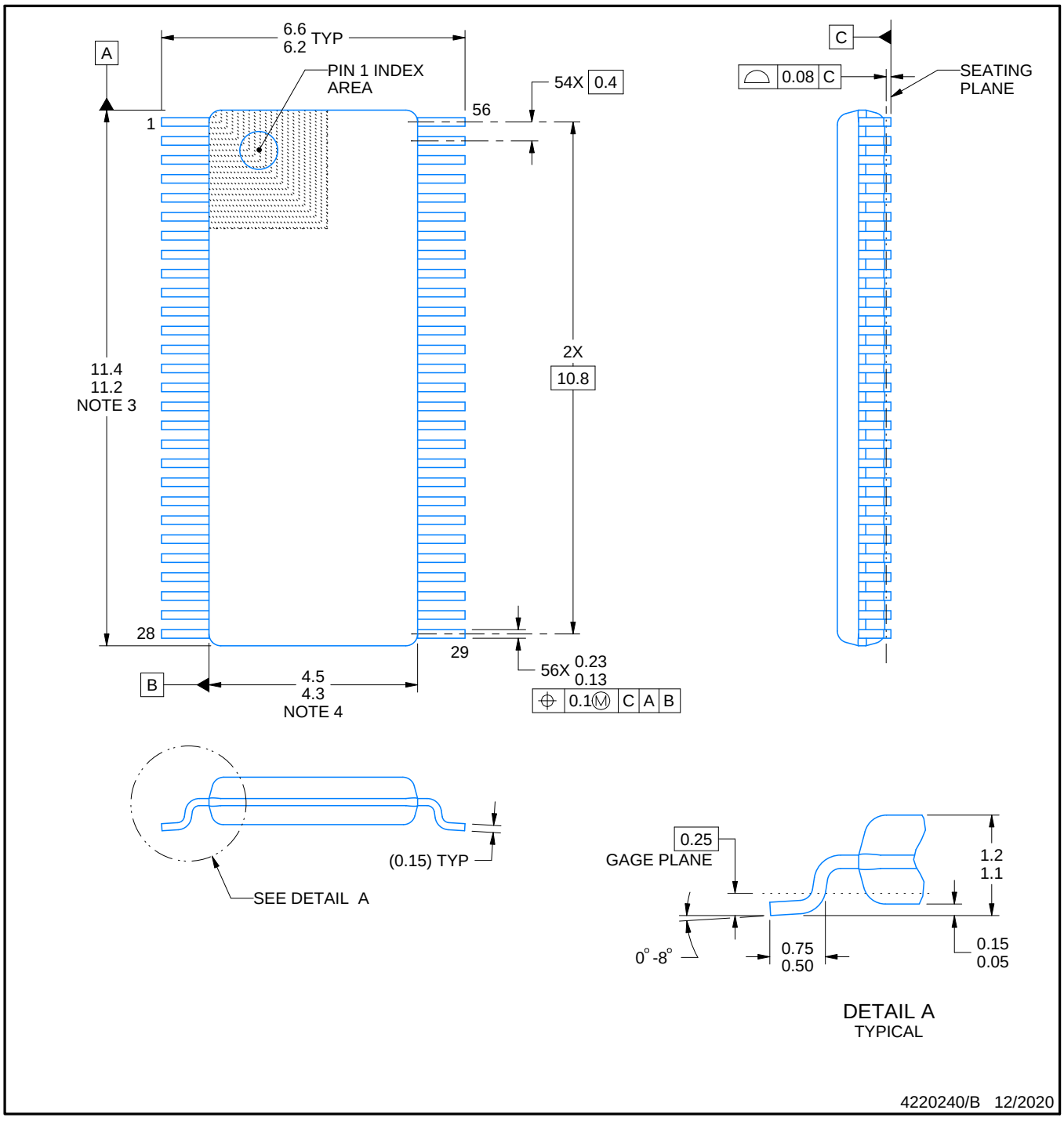
Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
SN74CB3Q16211DL	DL	SSOP	56	20	473.7	14.24	5110	7.87
SN74CB3Q16211DL.B	DL	SSOP	56	20	473.7	14.24	5110	7.87
SN74CB3Q16211DLG4	DL	SSOP	56	20	473.7	14.24	5110	7.87
SN74CB3Q16211DLG4.B	DL	SSOP	56	20	473.7	14.24	5110	7.87

PACKAGE OUTLINE

DGV0056A

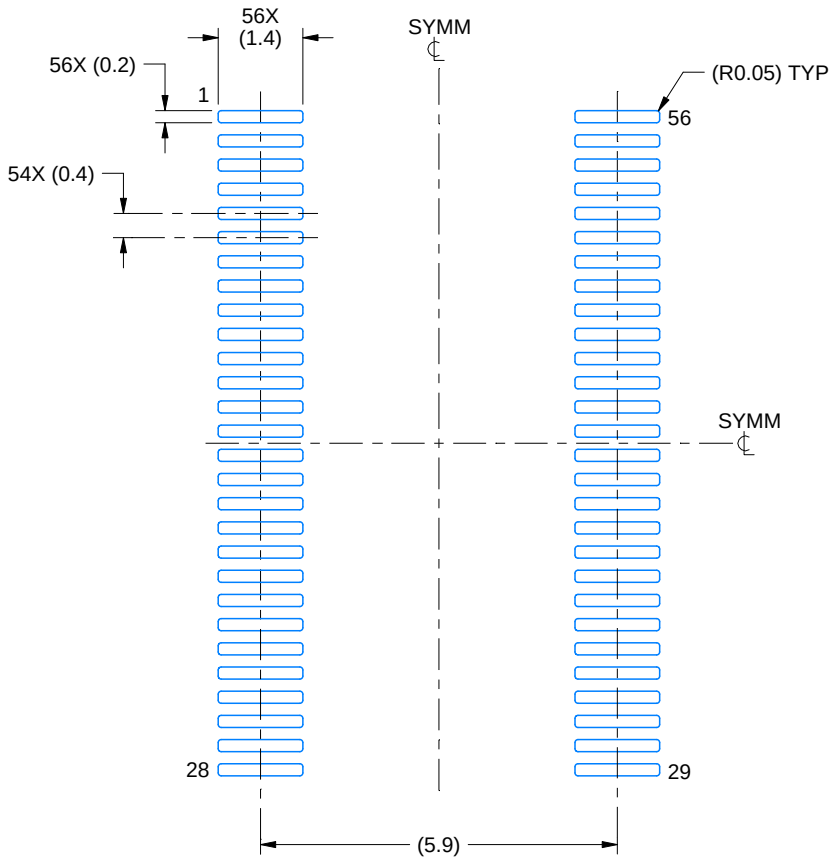
TVSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

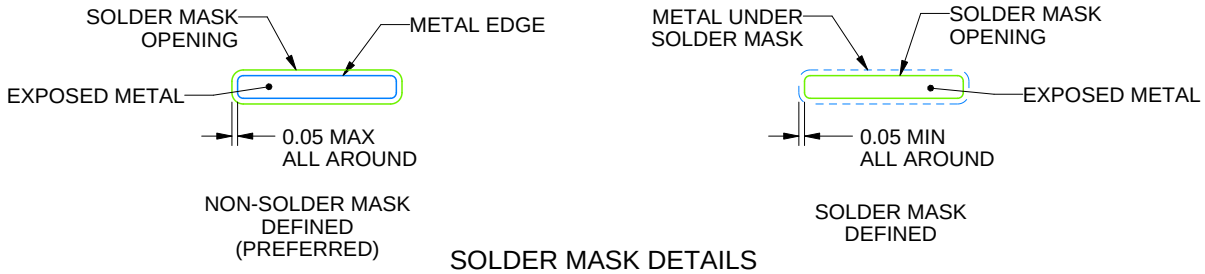


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-194.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 8X

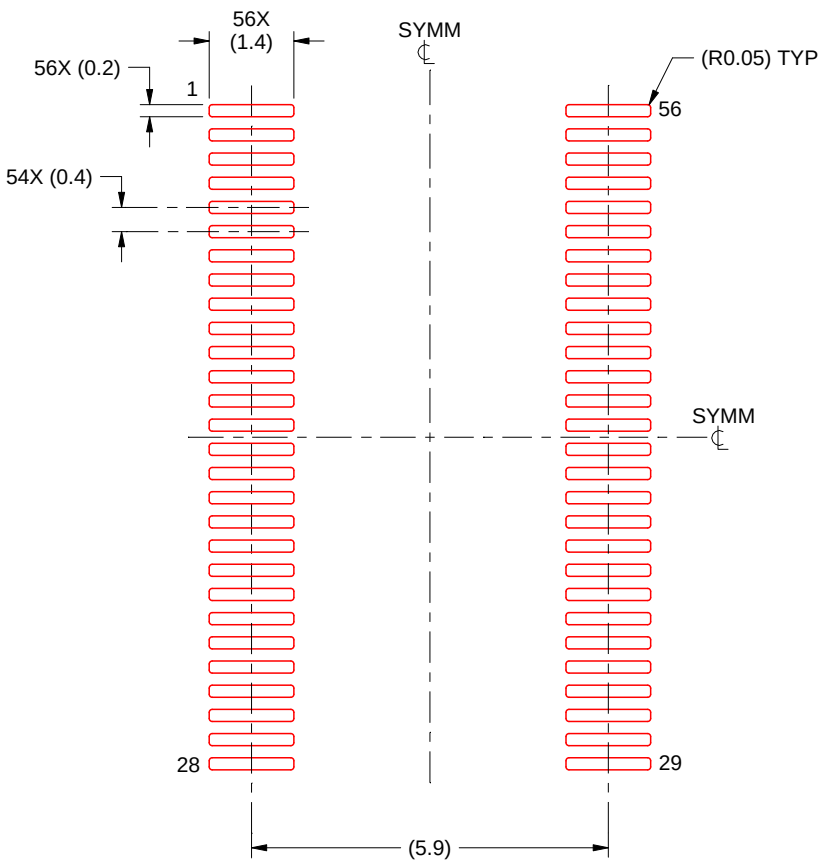


SOLDER MASK DETAILS

4220240/B 12/2020

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



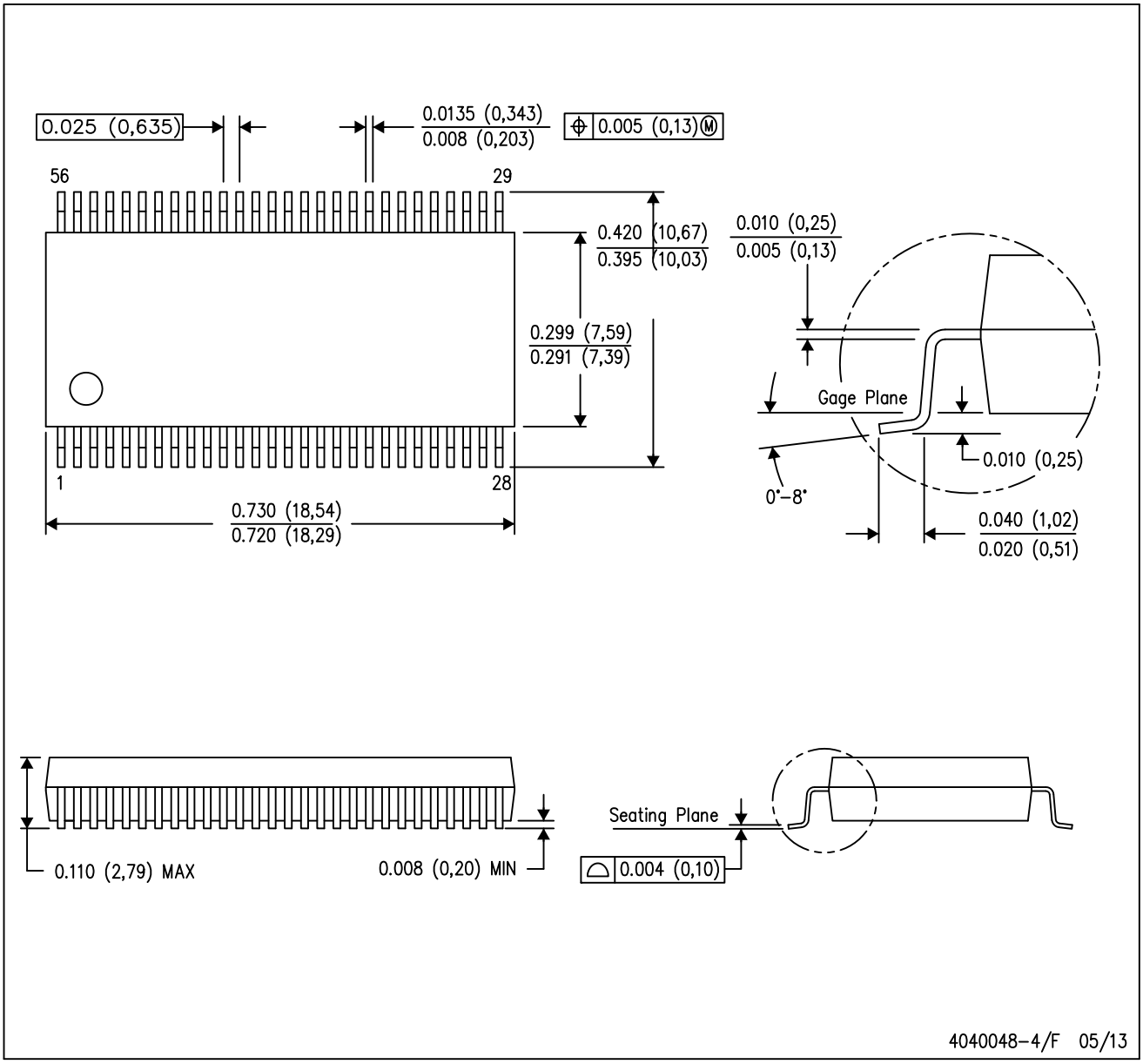
SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 8X

4220240/B 12/2020

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

DL (R–PDSO–G56) 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

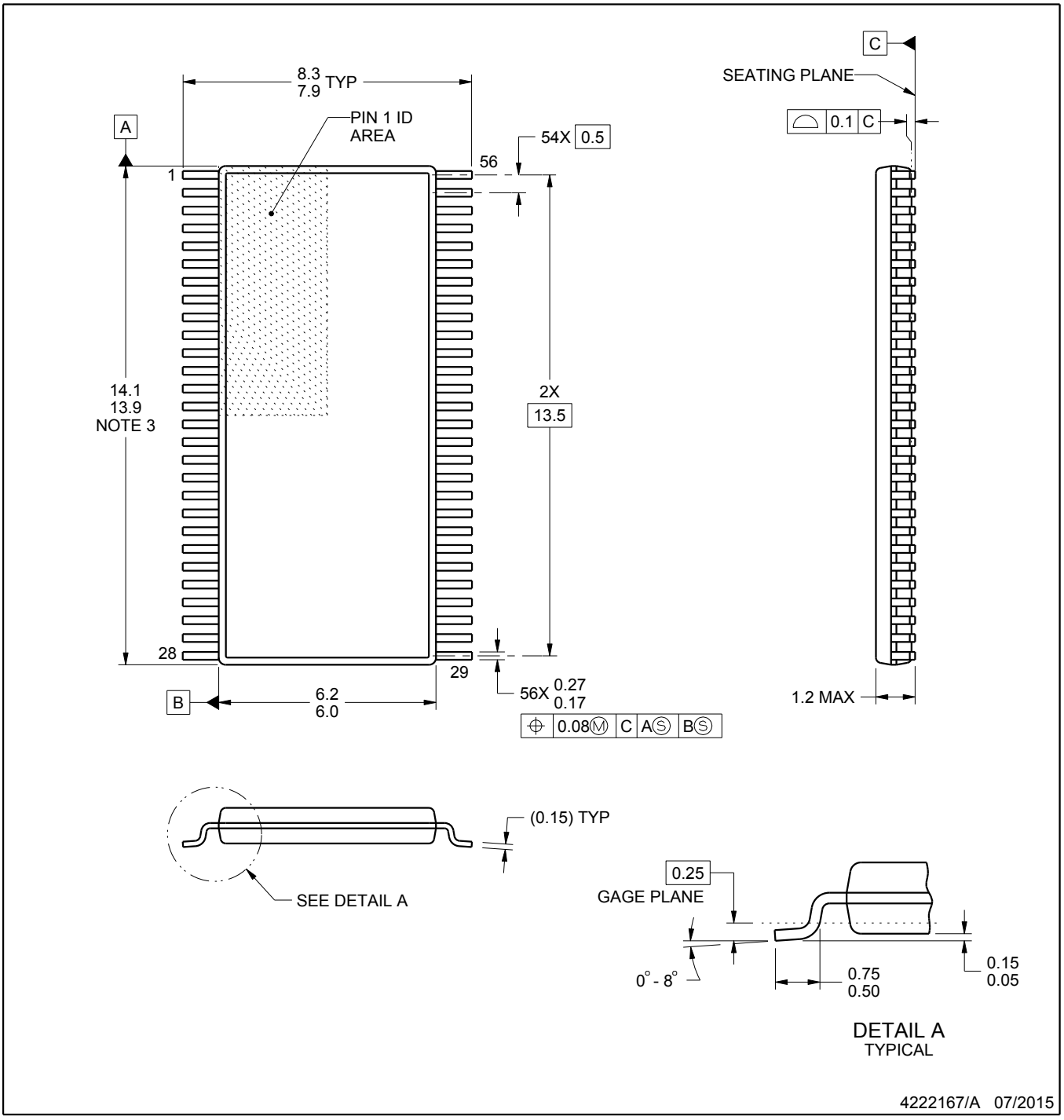
PowerPAD is a trademark of Texas Instruments.

PACKAGE OUTLINE

DGG0056A

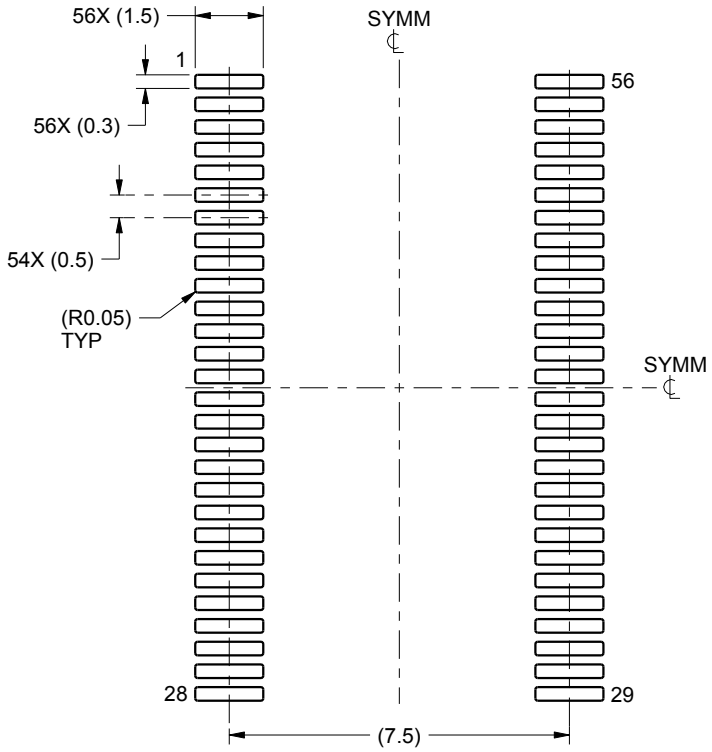
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

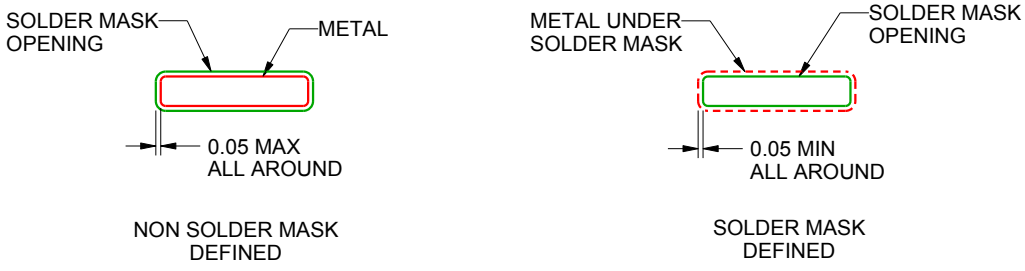


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-153.



LAND PATTERN EXAMPLE
SCALE:6X

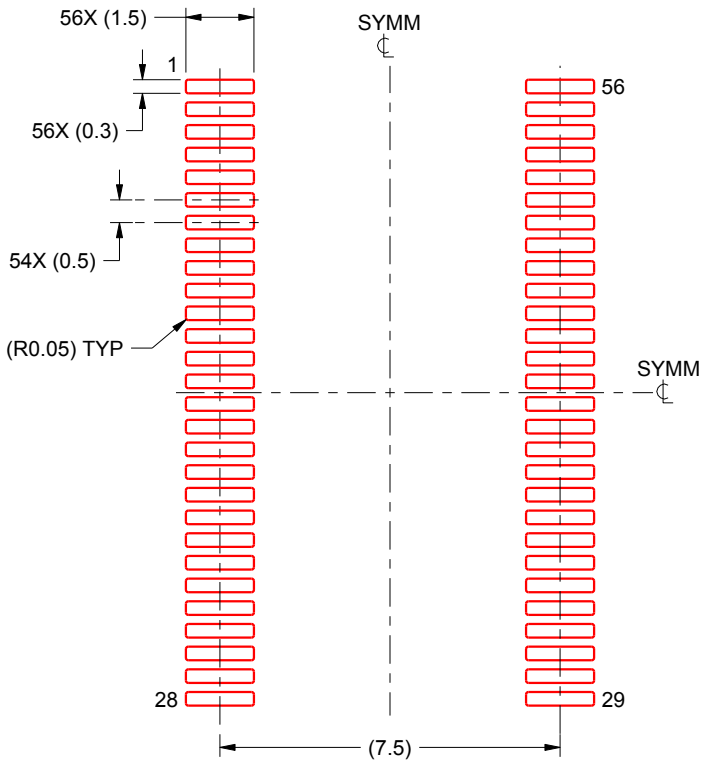


SOLDER MASK DETAILS

4222167/A 07/2015

NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:6X

4222167/A 07/2015

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

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