TXS0104E 4-Bit Bidirectional Voltage-Level Translator for Open-Drain and Push-Pull Applications

1 Features

- No direction-control signal needed
- Maximum data rates:
  - 24Mbps (push pull)
  - 2Mbps (open drain)
- Available in the Texas Instruments NanoFree™ package
- 1.65 V to 3.6 V on A port and 2.3 V to 5.5 V on B port ($V_{CCA} \leq V_{CCB}$)
- No power-supply sequencing required – V_{CCA} or V_{CCB} can be ramped first
- Latch-up performance exceeds 100 mA per JESD 78, class II
- ESD protection exceeds JESD 22:
  - A port:
    - 2000-V Human-Body Model (A114-B)
    - 200-V Machine Model (A115-A)
    - 1000-V Charged-Device Model (C101)
  - B port:
    - 15-kV Human-Body Model (A114-B)
    - 200-V Machine Model (A115-A)
    - 1000-V Charged-Device Model (C101)
- IEC 61000-4-2 ESD (B port):
  - ±8-kV contact discharge
  - ±10-kV air-gap discharge

2 Applications

- Handset
- Smartphone
- Tablet
- Desktop PC

3 Description

This 4-bit non-inverting translator uses two separate configurable power-supply rails. The A port is designed to track V_{CCA}. V_{CCA} accepts any supply voltage from 1.65 V to 3.6 V. V_{CCA} must be less than or equal to V_{CCB}. The B port is designed to track V_{CCB}. V_{CCB} accepts any supply voltage from 2.3 V to 5.5 V. This allows for low-voltage bidirectional translation between any of the 1.8-V, 2.5-V, 3.3-V, and 5-V voltage nodes.

When the output-enable (OE) input is low, all outputs are placed in the high-impedance state.

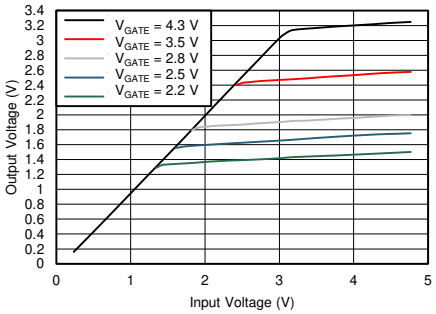
The TXS0104E is designed so that the OE input circuit is supplied by V_{CCA}.

For the high-impedance state during power up or power down, tie OE to GND through a pull-down resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
TXS0104E	D (SOIC, 14)	8.65 mm × 6 mm
	PW (TSSOP, 14)	5 mm × 6.4 mm
	ZXU (BGA, 12)	2 mm × 2.5 mm
	RGY (VQFN, 14)	3.5 mm × 3.5 mm
	YZT (DSBGA, 12)	2.25 mm × 1.75 mm
	NMN (nFBGA, 12)	2 mm × 2.5 mm
	BQA (WQFN, 12)	3 mm × 2.5 mm
	RUT (UQFN, 12)	2.00 mm × 1.70 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.
(2) The package size (length × width) is a nominal value and includes pins, where applicable



Transfer Characteristics of an N-Channel Transistor

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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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 J (August 2023) to Revision K (October 2023)	Page
• Added the *RUT* package	1

Changes from Revision I (October 2020) to Revision J (August 2023)	Page
• Updated the *Package Information* table to include package lead size	1
• Added the *BQA* package	1

Changes from Revision H (May 2018) to Revision I (October 2020)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Added NMN Package, 12-Pin nFBGA	4

Changes from Revision G (September 2017) to Revision H (May 2018)	Page
• Changed maximum values for maximum data rate within *Switching Characteristics: V_{CCA} = 3.3 V ± 0.3 V* table	15

Changes from Revision F (December 2014) to Revision G (September 2017)	Page
• Changed Device Information table	1
• Deleted GXU references throughout	4
• Added Junction temperature in the *Absolute Maximum Ratings*	8
• Reformatted *Electrical Characteristics*	10
• Added *Receiving Notification of Documentation Updates and Community Resources*	24
• Added *Basics of Voltage Translation* to Related Documentation	24

Changes from Revision E (August 2013) to Revision F (December 2014)	Page
• Added *Pin Configuration and Functions* section, *Handling Rating* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout*	

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section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1
- Deleted the Package thermal impedance information from the Absolute max ratings table into the Thermal Information table. Moved the T_{stg} row into the new Handling Ratings table. 8
- Changed the last 2 rows of MIN MAX (24 MAX and 2 MAX) to the MIN columns, in the first switching characteristics table 12

Changes from Revision D (May 2008) to Revision E (August 2013) **Page**

- Deleted the ordering table 1

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5 Pin Configuration and Functions

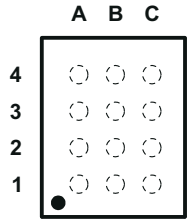


Figure 5-1. ZXU Package, 12-Pin MICROSTAR JUNIOR (Top View)

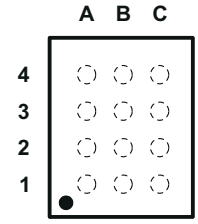


Figure 5-2. NMN Package, 12-Pin nFBGA (Top View)

Table 5-1. Pin Functions: ZXU/ NMN

PIN		TYPE[1]	DESCRIPTION
NO.	NAME		
A1	A1	I/O	Input/output A1. Referenced to V_{CCA}.
A2	A2	I/O	Input/output A2. Referenced to V_{CCA}.
A3	A3	I/O	Input/output A3. Referenced to V_{CCA}.
A4	A4	I/O	Input/output A4. Referenced to V_{CCA}.
C1	B1	I/O	Input/output B1. Referenced to V_{CCB}.
C2	B2	I/O	Input/output B2. Referenced to V_{CCB}.
C3	B3	I/O	Input/output B3. Referenced to V_{CCB}.
C4	B4	I/O	Input/output B4. Referenced to V_{CCB}.
B4	GND	—	Ground
B3	OE	I	3-state output-mode enable. Pull OE low to place all outputs in 3-state mode. Referenced to V_{CCA}.
B2	V_{CCA}	—	A-port supply voltage. 1.65 V ≤ V_{CCA} ≤ 3.6 V and V_{CCA} ≤ V_{CCB}.
B1	V_{CCB}	—	B-port supply voltage. 2.3 V ≤ V_{CCB} ≤ 5.5 V.

(1) I = input, O = output

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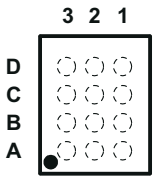


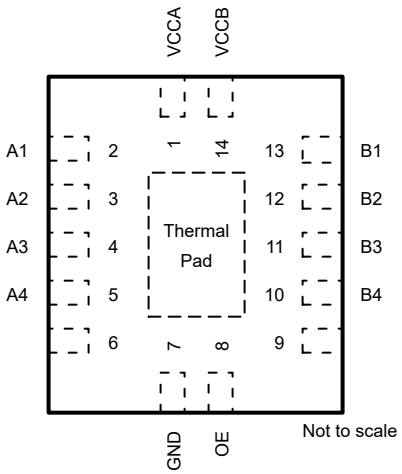
Figure 5-3. YZT Package, 12-Pin DSBGA (Top View)

Table 5-2. Pin Functions: DSBGA

PIN		TYPE(1)	DESCRIPTION
NO.	NAME		
A3	A1	I/O	Input/output A1. Referenced to V_{CCA}.
B3	A2	I/O	Input/output A2. Referenced to V_{CCA}.
C3	A3	I/O	Input/output A3. Referenced to V_{CCA}.
D3	A4	I/O	Input/output A4. Referenced to V_{CCA}.
A1	B1	I/O	Input/output B1. Referenced to V_{CCB}.
B1	B2	I/O	Input/output B2. Referenced to V_{CCB}.
C1	B3	I/O	Input/output B3. Referenced to V_{CCB}.
D1	B4	I/O	Input/output B4. Referenced to V_{CCB}.
D2	GND	—	Ground
C2	OE	I	3-state output-mode enable. Pull OE low to place all outputs in 3-state mode. Referenced to V_{CCA}.
B2	V_{CCA}	—	A-port supply voltage. 1.65 V ≤ V_{CCA} ≤ 3.6 V and V_{CCA} ≤ V_{CCB}.
A2	V_{CCB}	—	B-port supply voltage. 2.3 V ≤ V_{CCB} ≤ 5.5 V.

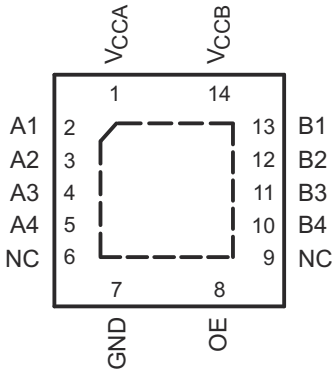
(1) I = input, O = output

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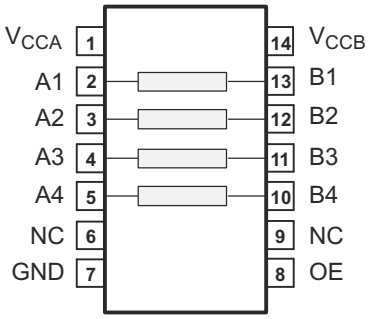
NC - No internal connection

Figure 5-4. BQA Package, 14-Pin WQFN (Top View)



NC - No internal connection

Figure 5-5. RGY Package, 14-Pin VQFN (Top View)



NC - No internal connection

Figure 5-6. D and PW Package, 14-Pin SOIC and TSSOP (Top View)

Table 5-3. Pin Functions: D, PW, or RGY

PIN		TYPE[1]	DESCRIPTION
NAME	NO.		
A1	2	I/O	Input/output A1. Referenced to V_{CCA}.
A2	3	I/O	Input/output A2. Referenced to V_{CCA}.
A3	4	I/O	Input/output A3. Referenced to V_{CCA}.
A4	5	I/O	Input/output A4. Referenced to V_{CCA}.
B1	13	I/O	Input/output B1. Referenced to V_{CCB}.
B2	12	I/O	Input/output B2. Referenced to V_{CCB}.
B3	11	I/O	Input/output B3. Referenced to V_{CCB}.
B4	10	I/O	Input/output B4. Referenced to V_{CCB}.
GND	7	—	Ground
OE	8	I	3-state output-mode enable. Pull OE low to place all outputs in 3-state mode. Referenced to V_{CCA}.
V_{CCA}	1	—	A-port supply voltage. 1.65 V ≤ V_{CCA} ≤ 3.6 V and V_{CCA} ≤ V_{CCB}.
V_{CCB}	14	—	B-port supply voltage. 2.3 V ≤ V_{CCB} ≤ 5.5 V.
Thermal Pad		—	For the RGY package, the exposed center thermal pad must be connected to ground

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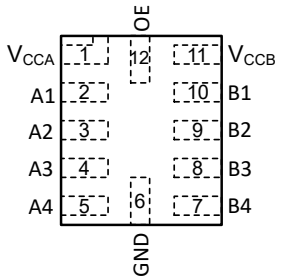


Figure 5-7. RUT Package, 12-Pin UQFN (Transparent Top View)

Table 5-4. Pin Functions: RUT

PIN		TYPE(1)	DESCRIPTION
NAME	NO.		
A1	2	I/O	Input/output A1. Referenced to V_{CCA}.
A2	3	I/O	Input/output A2. Referenced to V_{CCA}.
A3	4	I/O	Input/output A3. Referenced to V_{CCA}.
A4	5	I/O	Input/output A4. Referenced to V_{CCA}.
B1	10	I/O	Input/output B1. Referenced to V_{CCB}.
B2	9	I/O	Input/output B2. Referenced to V_{CCB}.
B3	8	I/O	Input/output B3. Referenced to V_{CCB}.
B4	7	I/O	Input/output B4. Referenced to V_{CCB}.
GND	6	—	Ground
OE	12	I	3-state output-mode enable. Pull OE low to place all outputs in 3-state mode. Referenced to V_{CCA}.
V_{CCA}	1	—	A-port supply voltage. 1.65 V ≤ V_{CCA} ≤ 3.6 V and V_{CCA} ≤ V_{CCB}.
V_{CCB}	11	—	A-port supply voltage. 1.65 V ≤ V_{CCA} ≤ 3.6 V and V_{CCA} ≤ V_{CCB}.

(1) I = input, O = output

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6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Supply voltage, V_{CCA}		–0.5	4.6	V
Supply voltage, V_{CCB}		–0.5	6.5	V
Input voltage, V_I (2)	A port	–0.5	4.6	V
	B port	–0.5	6.5	
Voltage range applied to any output in the high-impedance or power-off state, V_O (2)	A port	–0.5	4.6	V
	B port	–0.5	6.5	
Voltage range applied to any output in the high or low state, V_O (2) (3)	A port	–0.5	V_{CCA} + 0.5	V
	B port	–0.5	V_{CCB} + 0.5	
Input clamp current, I_{IK}	V_I < 0		–50	mA
Output clamp current, I_{OK}	V_O < 0		–50	mA
Continuous output current, I_O		–50	50	mA
Continuous current through each V_{CCA}, V_{CCB}, or GND		–100	100	mA
Operating junction temperature, T_J			150	°C
Storage temperature, T_{STG}		–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) The input and output negative-voltage ratings may be exceeded if the input and output current ratings are observed.
(3) The value of V_{CCA} and V_{CCB} are provided in the recommended operating conditions table.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$ Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins(1)	A Port	±2000	V
		B Port	±15	kV
	Charged device model (CDM), per JEDEC specification JESD22-C101, all pins(2)	A Port	±1000	V
		B Port	±1000	
	Machine model (MM)	A Port	±200	V
		B Port	±200	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

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6.3 Recommended Operating Conditions

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

			V_{CCA}	V_{CCB}	MIN	MAX	UNIT
V_{CCA}	Supply voltage(3)				1.65	3.6	V
V_{CCB}	Supply voltage(3)				2.3	5.5	V
V_{IH}	High-level input voltage	A-port I/Os	1.65 V to 1.95 V	2.3 V to 5.5 V	V_{CCI} – 0.2	V_{CCI}	V
			2.3 V to 3.6 V	2.3 V to 5.5 V	V_{CCI} – 0.4	V_{CCI}	
		B-port I/Os	1.65 V to 3.6 V	2.3 V to 5.5 V	V_{CCI} – 0.4	V_{CCI}	
		OE input	1.65 V to 3.6 V	2.3 V to 5.5 V	V_{CCA} × 0.65	5.5	
V_{IL}	Low-level input voltage	A-port I/Os	1.65 V to 3.6 V	2.3 V to 5.5 V	0	0.15	V
		B-port I/Os	1.65 V to 3.6 V	2.3 V to 5.5 V	0	0.15	
		OE input	1.65 V to 3.6 V	2.3 V to 5.5 V	0	V_{CCA} × 0.35	
Δt/Δv	Input transition rise or fall rate	A-port I/Os push-pull driving	1.65 V to 3.6 V	2.3 V to 5.5 V		10	ns/V
		B-port I/Os push-pull driving	1.65 V to 3.6 V	2.3 V to 5.5 V		10	
		Control input	1.65 V to 3.6 V	2.3 V to 5.5 V		10	
T_A	Operating free-air temperature				–40	85	°C

(1) V_{CCI} is the supply voltage associated with the input port.
(2) V_{CCO} is the supply voltage associated with the output port.
(3) V_{CCA} must be less than or equal to V_{CCB}, and V_{CCA} must not exceed 3.6 V.

6.4 Thermal Information: ZXU, YZT, and NMN

THERMAL METRIC(1)		TXS0104E			UNIT
		ZXU (BGA MICROSTAR JUNIOR) (2)	YZT (DSBGA)	NMN (NFGBA)	
		12 PINS	12 PINS	12 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	132.0	89.2	134.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	98.4	0.9	90.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	68.7	14.4	88.4	°C/W
ψ_{JT}	Junction-to-top characterization parameter	3.1	3.0	4.3	°C/W
ψ_{JB}	Junction-to-board characterization parameter	68.2	14.4	89.3	°C/W

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

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6.5 Thermal Information: D, PW, and RGY

THERMAL METRIC[1]		TXS0104E			UNIT
		D (SOIC)[1]	PW (TSSOP)[2]	RGY (VQFN)[3]	
		14 PINS	14 PINS	14 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	90.4	120.1	56.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	50.1	49.4	68.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	45.0	61.8	32.1	°C/W
ψ_{JT}	Junction-to-top characterization parameter	14.4	6.2	3.1	°C/W
ψ_{JB}	Junction-to-board characterization parameter	44.7	61.2	32.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	12.8	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.
(2) The package thermal impedance is calculated in accordance with JESD 51-7.
(3) The package thermal impedance is calculated in accordance with JESD 51-5.

6.6 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	V_{CCA}	V_{CCB}	MIN	TYP	MAX	UNIT
V_{OHA}	Port A output high voltage	I_{OH} = –20 µA, $V_{IB} \geq V_{CCB}$ – 0.4 V, T_A = –40°C to 85°C	1.65 V to 3.6 V	2.3 V to 5.5 V	V_{CCA} × 0.8			V
V_{OLA}	Port A output low voltage	I_{OL} = 1 mA, $V_{IB} \leq$ 0.15 V, T_A = –40°C to 85°C	1.65 V to 3.6 V	2.3 V to 5.5 V			0.4	V
V_{OHB}	Port B output high voltage	I_{OH} = –20 µA, $V_{IA} \geq V_{CCA}$ – 0.2 V, T_A = –40°C to 85°C	1.65 V to 3.6 V	2.3 V to 5.5 V	V_{CCB} × 0.8			V
V_{OLB}	Port B output low voltage	I_{OL} = 1 mA, $V_{IA} \leq$ 0.15 V, T_A = –40°C to 85°C	1.65 V to 3.6 V	2.3 V to 5.5 V			0.4	V
I_I	Input leakage current	OE: $V_I = V_{CCI}$ or GND, T_A = 25°C	1.65 V to 3.6 V	2.3 V to 5.5 V	–1		1	µA
		$V_I = V_{CCI}$ or GND, T_A = –40°C to 85°C	1.65 V to 3.6 V	2.3 V to 5.5 V	–2		2	
I_{OZ}	High-impedance state output current	A or B port: OE = V_{IL}, T_A = 25°C	1.65 V to 3.6 V	2.3 V to 5.5 V	–1		1	µA
		A or B port: OE = V_{IL}, T_A = –40°C to 85°C	1.65 V to 3.6 V	2.3 V to 5.5 V	–2		2	
I_{CCA}	V_{CCA} supply current	$V_I = V_O$ = Open, I_O = 0, T_A = –40°C to 85°C	1.65 V to V_{CCB}	2.3 V to 5.5 V			2.4	µA
			3.6 V	0			2.2	
			0	5.5 V			–1	
I_{CCB}	V_{CCB} supply current	$V_I = V_O$ = Open, I_O = 0, T_A = –40°C to 85°C	1.65 V to V_{CCB}	2.3 V to 5.5 V			12	µA
			3.6 V	0			–1	
			0	5.5 V			1	
$I_{CCA} + I_{CCB}$	Combined supply current	$V_I = V_O$ = Open, I_O = 0, T_A = –40°C to 85°C	1.65 V to V_{CCB}	2.3 V to 5.5 V			14.4	µA
C_I	Input capacitance	OE: T_A = 25°C	3.3 V	3.3 V		2.5		pF
		OE: T_A = –40°C to 85°C	3.3 V	3.3 V			3.5	

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6.6 Electrical Characteristics (continued)

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

PARAMETER		TEST CONDITIONS	V_{CCA}	V_{CCB}	MIN	TYP	MAX	UNIT
C_{io}	Input-to-output internal capacitance	A port: T_A = 25°C	3.3 V	3.3 V		5		pF
			3.3 V	3.3 V			6.5	
		B port: T_A = –40°C to 85°C	3.3 V	3.3 V		12		
			3.3 V	3.3 V			16.5	

(1) V_{CCI} is the supply voltage associated with the input port.
(2) V_{CCO} is the supply voltage associated with the output port.
(3) V_{CCA} must be less than or equal to V_{CCB}, and V_{CCA} must not exceed 3.6 V.

6.7 Timing Requirements: V_{CCA} = 1.8 V ± 0.15 V

over recommended operating free-air temperature range, V_{CCA} = 1.8 V ± 0.15 V (unless otherwise noted)

				MIN	MAX	UNIT
Data rate	Push-pull driving		V_{CCB} = 2.5 V ± 0.2 V V_{CCB} = 3.3 V ± 0.3 V V_{CCB} = 5 V ± 0.5 V		24	Mbps
	Open-drain driving		V_{CCB} = 2.5 V ± 0.2 V V_{CCB} = 3.3 V ± 0.3 V V_{CCB} = 5 V ± 0.5 V		2	
t_w Pulse duration	Push-pull driving	Data inputs	V_{CCB} = 2.5 V ± 0.2 V V_{CCB} = 3.3 V ± 0.3 V V_{CCB} = 5 V ± 0.5 V	41		ns
	Open-drain driving	Data inputs	V_{CCB} = 2.5 V ± 0.2 V V_{CCB} = 3.3 V ± 0.3 V V_{CCB} = 5 V ± 0.5 V	500		

6.8 Timing Requirements: V_{CCA} = 2.5 V ± 0.2 V

over recommended operating free-air temperature range, V_{CCA} = 2.5 V ± 0.2 V (unless otherwise noted)

				MIN	MAX	UNIT
Data rate	Push-pull driving		V_{CCB} = 2.5 V ± 0.2 V $_{CCB}$ = 3.3 V ± 0.3 V $_{CCB}$ = 5 V ± 0.5 V		24	Mbps
	Open-drain driving		V_{CCB} = 2.5 V ± 0.2 V $_{CCB}$ = 3.3 V ± 0.3 V $_{CCB}$ = 5 V ± 0.5 V		2	
t_w Pulse duration	Push-pull driving	Data inputs	V_{CCB} = 2.5 V ± 0.2 V $_{CCB}$ = 3.3 V ± 0.3 V $_{CCB}$ = 5 V ± 0.5 V	41		ns
	Open-drain driving	Data inputs	V_{CCB} = 2.5 V ± 0.2 V $_{CCB}$ = 3.3 V ± 0.3 V $_{CCB}$ = 5 V ± 0.5 V	500		

6.9 Timing Requirements: V_{CCA} = 3.3 V ± 0.3 V

over recommended operating free-air temperature range, V_{CCA} = 3.3 V ± 0.3 V (unless otherwise noted)

				MIN	MAX	UNIT
Data rate	Push-pull driving		V_{CCB} = 3.3 V ± 0.3 V V_{CCB} = 5 V ± 0.5 V		24	Mbps
	Open-drain driving		V_{CCB} = 3.3 V ± 0.3 V V_{CCB} = 5 V ± 0.5 V		2	
t_w Pulse duration	Push-pull driving	Data inputs	V_{CCB} = 3.3 V ± 0.3 V V_{CCB} = 5 V ± 0.5 V	41		ns
	Open-drain driving	Data inputs	V_{CCB} = 3.3 V ± 0.3 V V_{CCB} = 5 V ± 0.5 V	500		

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6.10 Switching Characteristics: V_{CCA} = 1.8 V ± 0.15 V

over recommended operating free-air temperature range, V_{CCA} = 1.8 V ± 0.15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{PHL}	Propagation delay time (high-to-low output)	A-to-B	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		4.6	ns
				V_{CCB} = 3.3 V ± 0.3 V		4.7	
				V_{CCB} = 5 V ± 0.5 V		5.8	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	2.9	8.8	
				V_{CCB} = 3.3 V ± 0.3 V	2.9	9.6	
				V_{CCB} = 5 V ± 0.5 V	3	10	
t_{PLH}	Propagation delay time (low-to-high output)		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		6.8	
				V_{CCB} = 3.3 V ± 0.3 V		6.8	
				V_{CCB} = 5 V ± 0.5 V		7	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	45	260	
				V_{CCB} = 3.3 V ± 0.3 V	36	208	
				V_{CCB} = 5 V ± 0.5 V	27	198	
t_{PHL}	Propagation delay time (high-to-low output)	B-to-A	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		4.4	ns
				V_{CCB} = 3.3 V ± 0.3 V		4.5	
				V_{CCB} = 5 V ± 0.5 V		4.7	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	1.9	5.3	
				V_{CCB} = 3.3 V ± 0.3 V	1.1	4.4	
				V_{CCB} = 5 V ± 0.5 V	1.2	4	
t_{PLH}	Propagation delay time (low-to-high output)		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		5.3	
				V_{CCB} = 3.3 V ± 0.3 V		4.5	
				V_{CCB} = 5 V ± 0.5 V		0.5	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	45	175	
				V_{CCB} = 3.3 V ± 0.3 V	36	140	
				V_{CCB} = 5 V ± 0.5 V	27	102	
t_{en}	Enable time	OE-to-A or B		V_{CCB} = 2.5 V ± 0.2 V		200	ns
				V_{CCB} = 3.3 V ± 0.3 V		200	
				V_{CCB} = 5 V ± 0.5 V		200	
t_{dis}	Disable time	OE-to-A or B		V_{CCB} = 2.5 V ± 0.2 V		50	ns
				V_{CCB} = 3.3 V ± 0.3 V		40	
				V_{CCB} = 5 V ± 0.5 V		35	
t_{rA}	Input rise time	A-port rise time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	3.2	9.5	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.3	9.3	
				V_{CCB} = 5 V ± 0.5 V	2	7.6	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	38	165	
				V_{CCB} = 3.3 V ± 0.3 V	30	132	
				V_{CCB} = 5 V ± 0.5 V	22	95	
t_{rB}	Input rise time	B-port rise time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	4	10.8	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.7	9.1	
				V_{CCB} = 5 V ± 0.5 V	2.7	7.6	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	34	145	
				V_{CCB} = 3.3 V ± 0.3 V	23	106	
				V_{CCB} = 5 V ± 0.5 V	10	58	

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6.10 Switching Characteristics: V_{CCA} = 1.8 V ± 0.15 V (continued)

over recommended operating free-air temperature range, V_{CCA} = 1.8 V ± 0.15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{fA}	Input fall time	A-port fall time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	2	5.9	ns
				V_{CCB} = 3.3 V ± 0.3 V	1.9	6	
				V_{CCB} = 5 V ± 0.5 V	1.7	13.3	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	4.4	6.9	
				V_{CCB} = 3.3 V ± 0.3 V	4.3	6.4	
				V_{CCB} = 5 V ± 0.5 V	4.2	6.1	
t_{fB}	Input fall time	B-port fall time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	2.9	7.6	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.8	7.5	
				V_{CCB} = 5 V ± 0.5 V	2.8	8.8	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	6.9	13.8	
				V_{CCB} = 3.3 V ± 0.3 V	7.5	16.2	
				V_{CCB} = 5 V ± 0.5 V	7	16.2	
$t_{SK(O)}$	Skew (time), output	Channel-to-channel skew		V_{CCB} = 2.5 V ± 0.2 V		1	ns
				V_{CCB} = 3.3 V ± 0.3 V		1	
				V_{CCB} = 5 V ± 0.5 V		1	
	Maximum data rate		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	24		Mbps
				V_{CCB} = 3.3 V ± 0.3 V	24		
				V_{CCB} = 5 V ± 0.5 V	24		
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	2		
				V_{CCB} = 3.3 V ± 0.3 V	2		
				V_{CCB} = 5 V ± 0.5 V	2		

6.11 Switching Characteristics: V_{CCA} = 2.5 V ± 0.2 V

over recommended operating free-air temperature range, V_{CCA} = 2.5 V ± 0.2 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{PHL}	Propagation delay time (high-to-low output)	A-to-B	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		3.2	ns
				V_{CCB} = 3.3 V ± 0.3 V		3.3	
				V_{CCB} = 5 V ± 0.5 V		3.4	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	1.7	6.3	
				V_{CCB} = 3.3 V ± 0.3 V	2	6	
				V_{CCB} = 5 V ± 0.5 V	2.1	5.8	
t_{PLH}	Propagation delay time (low-to-high output)	A-to-B	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		3.5	
				V_{CCB} = 3.3 V ± 0.3 V		4.1	
				V_{CCB} = 5 V ± 0.5 V		4.4	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	43	250	
				V_{CCB} = 3.3 V ± 0.3 V	36	206	
				V_{CCB} = 5 V ± 0.5 V	27	190	
t_{PHL}	Propagation delay time (high-to-low output)	B-to-A	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		3	ns
				V_{CCB} = 3.3 V ± 0.3 V		3.6	
				V_{CCB} = 5 V ± 0.5 V		4.3	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	1.8	4.7	
				V_{CCB} = 3.3 V ± 0.3 V	2.6	4.2	
				V_{CCB} = 5 V ± 0.5 V	1.2	4	

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6.11 Switching Characteristics: V_{CCA} = 2.5 V ± 0.2 V (continued)

over recommended operating free-air temperature range, V_{CCA} = 2.5 V ± 0.2 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{PLH}	Propagation delay time (low-to-high output)	B-to-A	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		2.5	
				V_{CCB} = 3.3 V ± 0.3 V		1.6	
				V_{CCB} = 5 V ± 0.5 V		0.7	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	44	170	
				V_{CCB} = 3.3 V ± 0.3 V	37	140	
				V_{CCB} = 5 V ± 0.5 V	27	103	
t_{en}	Enable time	OE-to-A or B		V_{CCB} = 2.5 V ± 0.2 V		200	ns
				V_{CCB} = 3.3 V ± 0.3 V		200	
				V_{CCB} = 5 V ± 0.5 V		200	
t_{dis}	Disable time	OE-to-A or B		V_{CCB} = 2.5 V ± 0.2 V		50	ns
				V_{CCB} = 3.3 V ± 0.3 V		40	
				V_{CCB} = 5 V ± 0.5 V		35	
t_{rA}	Input rise time	A-port rise time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	2.8	7.4	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.6	6.6	
				V_{CCB} = 5 V ± 0.5 V	1.8	5.6	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	34	149	
				V_{CCB} = 3.3 V ± 0.3 V	28	121	
				V_{CCB} = 5 V ± 0.5 V	24	89	
t_{rB}	Input rise time	B-port rise time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	3.2	8.3	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.9	7.2	
				V_{CCB} = 5 V ± 0.5 V	2.4	6.1	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	35	151	
				V_{CCB} = 3.3 V ± 0.3 V	24	112	
				V_{CCB} = 5 V ± 0.5 V	12	64	
t_{fA}	Input fall time	A-port fall time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	1.9	5.7	ns
				V_{CCB} = 3.3 V ± 0.3 V	1.9	5.5	
				V_{CCB} = 5 V ± 0.5 V	1.8	5.3	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	4.4	6.9	
				V_{CCB} = 3.3 V ± 0.3 V	4.3	6.2	
				V_{CCB} = 5 V ± 0.5 V	4.2	5.8	
t_{fB}	Input fall time	B-port fall time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	2.2	7.8	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.4	6.7	
				V_{CCB} = 5 V ± 0.5 V	2.6	6.6	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	5.1	8.8	
				V_{CCB} = 3.3 V ± 0.3 V	5.4	9.4	
				V_{CCB} = 5 V ± 0.5 V	5.4	10.4	
$t_{SK(O)}$	Skew (time), output	Channel-to-channel skew		V_{CCB} = 2.5 V ± 0.2 V		1	ns
				V_{CCB} = 3.3 V ± 0.3 V		1	
				V_{CCB} = 5 V ± 0.5 V		1	

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6.11 Switching Characteristics: V_{CCA} = 2.5 V ± 0.2 V (continued)

over recommended operating free-air temperature range, V_{CCA} = 2.5 V ± 0.2 V (unless otherwise noted)

PARAMETER	TEST CONDITIONS			MIN	MAX	UNIT
Maximum data rate		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	24		Mbps
			V_{CCB} = 3.3 V ± 0.3 V	24		
			V_{CCB} = 5 V ± 0.5 V	24		
		Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	2		
			V_{CCB} = 3.3 V ± 0.3 V	2		
			V_{CCB} = 5 V ± 0.5 V	2		

6.12 Switching Characteristics: V_{CCA} = 3.3 V ± 0.3 V

over recommended operating free-air temperature range, V_{CCA} = 3.3 V ± 0.3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{PHL}	Propagation delay time (high-to-low output)	A-to-B	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		2.4	ns
				V_{CCB} = 5 V ± 0.5 V		3.1	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	1.3	4.2	
				V_{CCB} = 5 V ± 0.5 V	1.4	4.6	
t_{PLH}	Propagation delay time (low-to-high output)		Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		4.2	
				V_{CCB} = 5 V ± 0.5 V		4.4	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	36	204	
				V_{CCB} = 5 V ± 0.5 V	28	165	
t_{PHL}	Propagation delay time (high-to-low output)	B-to-A	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		2.5	ns
				V_{CCB} = 5 V ± 0.5 V		3.3	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	1	124	
				V_{CCB} = 5 V ± 0.5 V	1	97	
t_{PLH}	Propagation delay time (low-to-high output)		Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		2.5	
				V_{CCB} = 5 V ± 0.5 V		2.6	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	3	139	
				V_{CCB} = 5 V ± 0.5 V	3	105	
t_{en}	Enable time	OE-to-A or B		V_{CCB} = 3.3 V ± 0.3 V		200	ns
				V_{CCB} = 5 V ± 0.5 V		200	
t_{dis}	Disable time	OE-to-A or B		V_{CCB} = 3.3 V ± 0.3 V		40	ns
				V_{CCB} = 5 V ± 0.5 V		35	
t_{rA}	Input rise time	A-port rise time	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V	2.3	5.6	ns
				V_{CCB} = 5 V ± 0.5 V	1.9	4.8	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	25	116	
				V_{CCB} = 5 V ± 0.5 V	19	85	
t_{rB}	Input rise time	B-port rise time	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V	2.5	6.4	ns
				V_{CCB} = 5 V ± 0.5 V	2.1	7.4	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	26	116	
				V_{CCB} = 5 V ± 0.5 V	26	116	
t_{fA}	Input fall time	A-port fall time	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V	2	5.4	ns
				V_{CCB} = 5 V ± 0.5 V	1.9	5	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	4.3	6.1	
				V_{CCB} = 5 V ± 0.5 V	4.2	5.7	

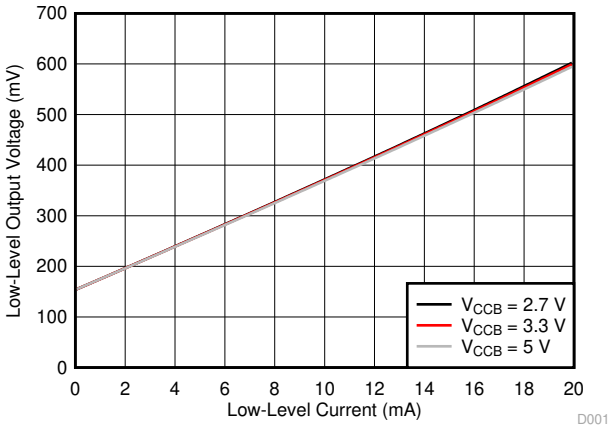
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6.12 Switching Characteristics: V_{CCA} = 3.3 V ± 0.3 V (continued)

over recommended operating free-air temperature range, V_{CCA} = 3.3 V ± 0.3 V (unless otherwise noted)

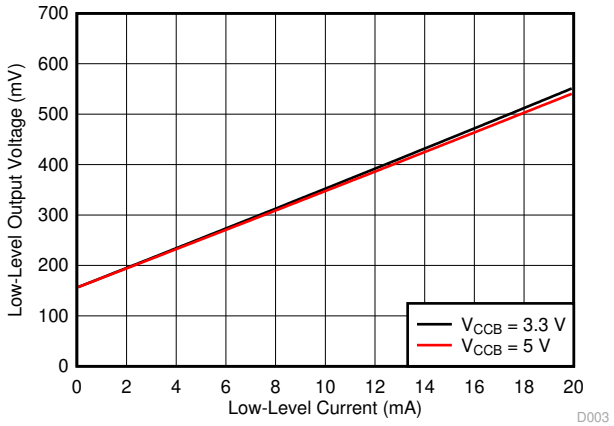
PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{fB}	Input fall time	B-port fall time	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V	2.3	7.4	ns
				V_{CCB} = 5 V ± 0.5 V	2.4	7.6	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	5	7.6	
				V_{CCB} = 5 V ± 0.5 V	4.8	8.3	
$t_{SK(O)}$	Skew (time), output	Channel-to-channel skew		V_{CCB} = 3.3 V ± 0.3 V		1	ns
				V_{CCB} = 5 V ± 0.5 V		1	
	Maximum data rate		Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V	24		Mbps
				V_{CCB} = 5 V ± 0.5 V	24		
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	2		
				V_{CCB} = 5 V ± 0.5 V	2		

6.13 Typical Characteristics



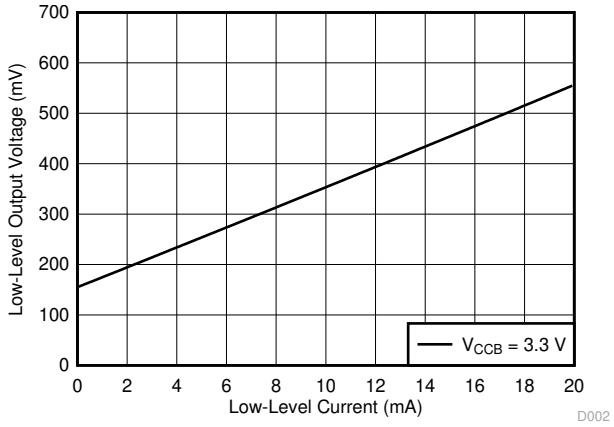
V_{CCA} = 1.8 V $V_{IL(A)}$ = 150 mV

Figure 6-1. Low-Level Output Voltage ($V_{OL(Ax)}$) vs Low-Level Current ($I_{OL(Ax)}$)



V_{CCA} = 2.7 V $V_{IL(A)}$ = 150 mV

Figure 6-2. Low-Level Output Voltage ($V_{OL(Ax)}$) vs Low-Level Current ($I_{OL(Ax)}$)



V_{CCA} = 3.3 V $V_{IL(A)}$ = 150 mV

Figure 6-3. Low-Level Output Voltage ($V_{OL(Ax)}$) vs Low-Level Current ($I_{OL(Ax)}$)

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7 Parameter Measurement Information

7.1 Load Circuits

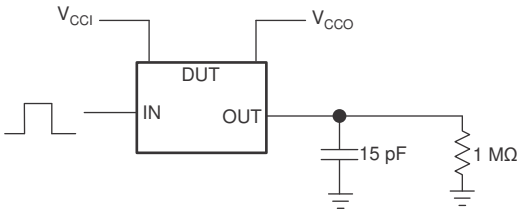


Figure 7-1. Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement Using a Push-Pull Driver

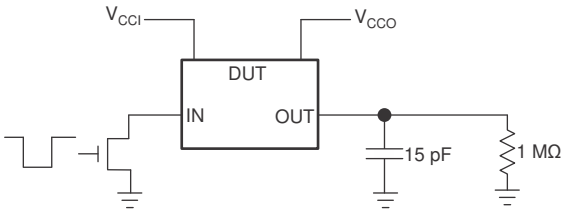
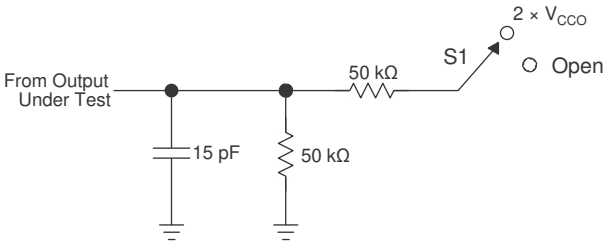


Figure 7-2. Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement Using an Open-Drain Driver



TEST	S1
t_{PZL} / t_{PLZ} (t_{dis})	2 × V_{CCO}
t_{PHZ} / t_{PZH} (t_{en})	Open

Figure 7-3. Load Circuit for Enable-Time and Disable-Time Measurement

1. t_{PLZ} and t_{PHZ} are the same as t_{dis}.
2. t_{PZL} and t_{PZH} are the same as t_{en}.
3. V_{CCI} is the V_{CC} associated with the input port.
4. V_{CCO} is the V_{CC} associated with the output port.

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7.2 Voltage Waveforms

The outputs are measured one at a time, with one transition per measurement. All input pulses are supplied by generators that have the following characteristics:

- PRR ≤ 10 MHz
- Z_O = 50 Ω
- dv/dt ≥ 1 V/ns

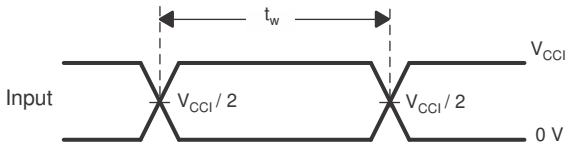


Figure 7-4. Pulse Duration

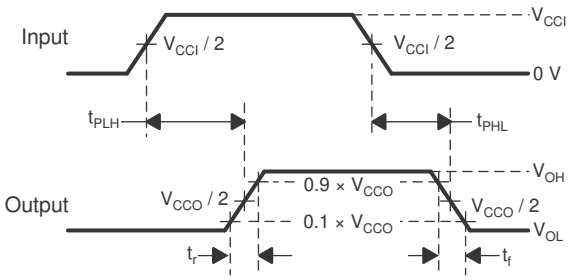
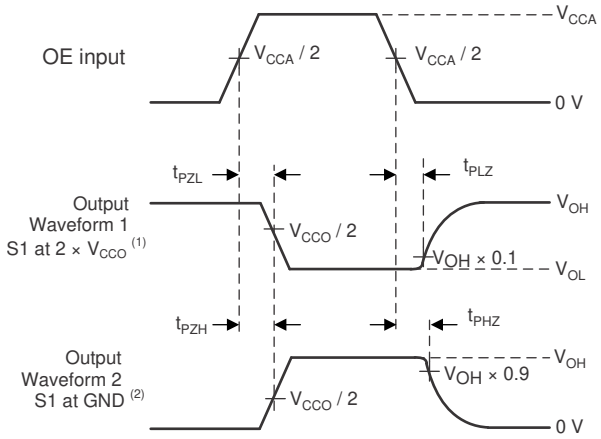


Figure 7-5. Propagation Delay Times



A. Waveform 1 is for an output with internal such that the output is high, except when OE is high (see Figure 7-3).

B. Waveform 2 is for an output with conditions such that the output is low, except when OE is high.

Figure 7-6. Enable and Disable Times

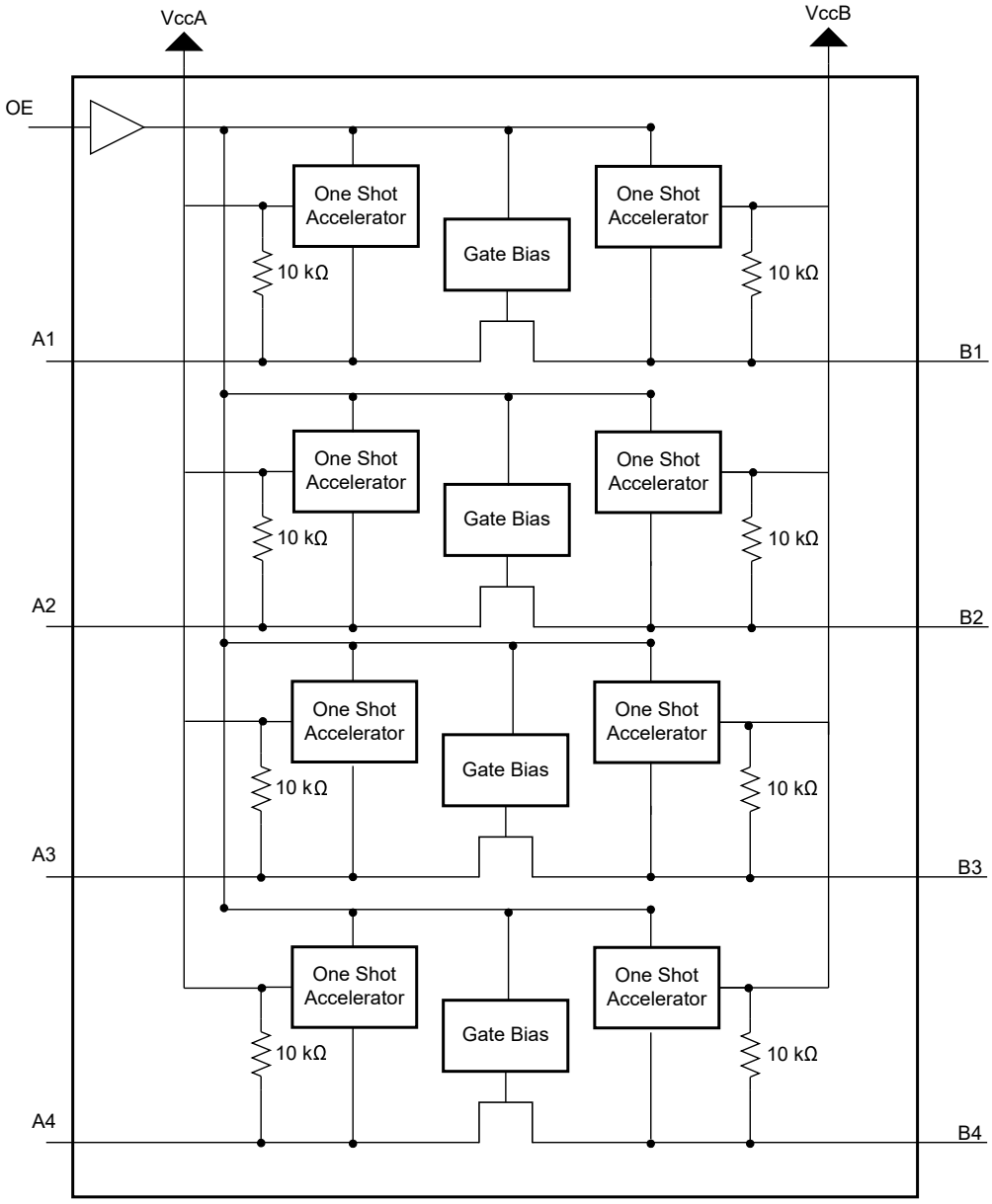
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8 Detailed Description

8.1 Overview

The TXS0104E device is a directionless voltage-level translator specifically designed for translating logic voltage levels. The A port is able to accept I/O voltages ranging from 1.65 V to 3.6 V, while the B port can accept I/O voltages from 2.3 V to 5.5 V. The device is a pass gate architecture with edge rate accelerators (one shots) to improve the overall data rate. 10-kΩ pullup resistors, commonly used in open drain applications, have been conveniently integrated so that an external resistor is not needed. While this device is designed for open drain applications, the device can also translate push-pull CMOS logic outputs.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Architecture

The TXS0104E architecture (see Figure 8-1) does not require a direction-control signal in order to control the direction of data flow from A to B or from B to A.

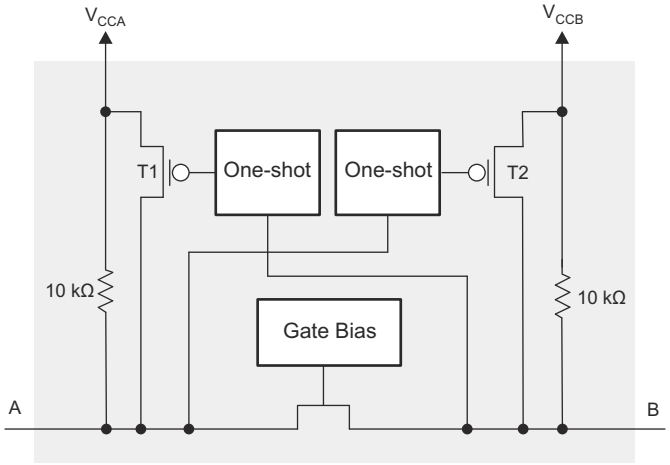


Figure 8-1. Architecture of a TXS01xx Cell

Each A-port I/O has an internal 10-kΩ pullup resistor to V_{CCA}, and each B-port I/O has an internal 10-kΩ pullup resistor to V_{CCB}. The output one-shots detect rising edges on the A or B ports. During a rising edge, the one-shot turns on the PMOS transistors (T1, T2) for a short duration which speeds up the low-to-high transition.

8.3.2 Input Driver Requirements

The fall time (t_{fA}, t_{fB}) of a signal depends on the output impedance of the external device driving the data I/Os of the TXS0104E device. Similarly, the t_{PHL} and maximum data rates also depend on the output impedance of the external driver. The values for t_{fA}, t_{fB}, t_{PHL}, and maximum data rates in the data sheet assume that the output impedance of the external driver is less than 50 Ω.

8.3.3 Power Up

During operation, ensure that $V_{CCA} \leq V_{CCB}$ at all times. During power-up sequencing, $V_{CCA} \geq V_{CCB}$ does not damage the device, so any power supply can be ramped up first.

8.3.4 Enable and Disable

The TXS0104E device has an OE input that disables the device by setting OE low, which places all I/Os in the high-impedance state. The disable time (t_{dis}) indicates the delay between the time when the OE pin goes low and when the outputs actually enter the high-impedance state. The enable time (t_{en}) indicates the amount of time the user must allow for the one-shot circuitry to become operational after the OE pin is taken high.

8.3.5 Pullup and Pulldown Resistors on I/O Lines

Each A-port I/O has an internal 10-kΩ pullup resistor to V_{CCA}, and each B-port I/O has an internal 10-kΩ pullup resistor to V_{CCB}. If a smaller value of pullup resistor is required, an external resistor must be added from the I/O to V_{CCA} or V_{CCB} (in parallel with the internal 10-kΩ resistors).

8.4 Device Functional Modes

The TXS0104E device has two functional modes, enabled and disabled. To disable the device set the OE input low, which places all I/Os in a high impedance state. Setting the OE input high will enable the device.

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9 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.

9.1 Application Information

The TXS0104E device can be used in level-translation applications for interfacing devices or systems operating at different interface voltages with one another. The TXS0104E device is an excellent choice for applications where an open-drain driver is connected to the data I/Os. The TXS0104E device can also be used in applications where a push-pull driver is connected to the data I/Os, but the TXB0104 device might be a better option for such push-pull applications.

9.2 Typical Application

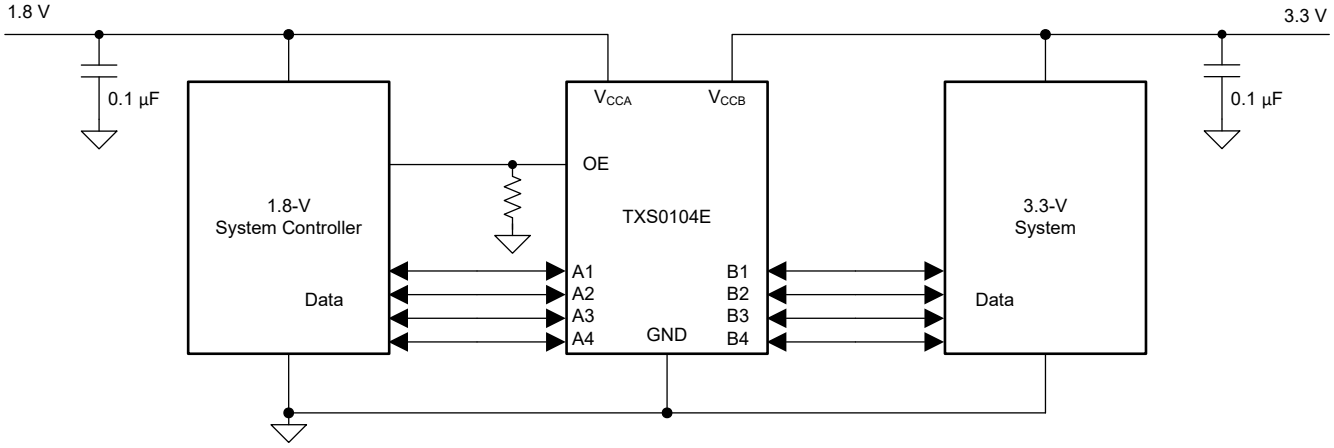


Figure 9-1. Application Schematic

9.2.1 Design Requirements

For this design example, use the parameters listed in Table 9-1.

Table 9-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input voltage range	1.65 to 3.6 V
Output voltage range	2.3 to 5.5 V

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9.2.2 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 TXS0104E device to determine the input voltage range. For a valid logic high the value must exceed the V_{IH} of the input port. For a valid logic low the value must be less than the V_{IL} of the input port.
- Output voltage range
  - Use the supply voltage of the device that the TXS0104E device is driving to determine the output voltage range.
  - The TXS0104E device has 10-kΩ internal pullup resistors. External pullup resistors can be added to reduce the total RC of a signal trace if necessary.
- An external pull down resistor decreases the output V_{OH} and V_{OL}. Use Equation 1 to calculate the V_{OH} as a result of an external pull down resistor.

$$V_{OH} = V_{CCx} \times R_{PD} / (R_{PD} + 10\ k\Omega) \quad (1)$$

where

V_{CCx} is the supply voltage on either V_{CCA} or V_{CCB}
R_{PD} is the value of the external pull down resistor

9.2.3 Application Curve

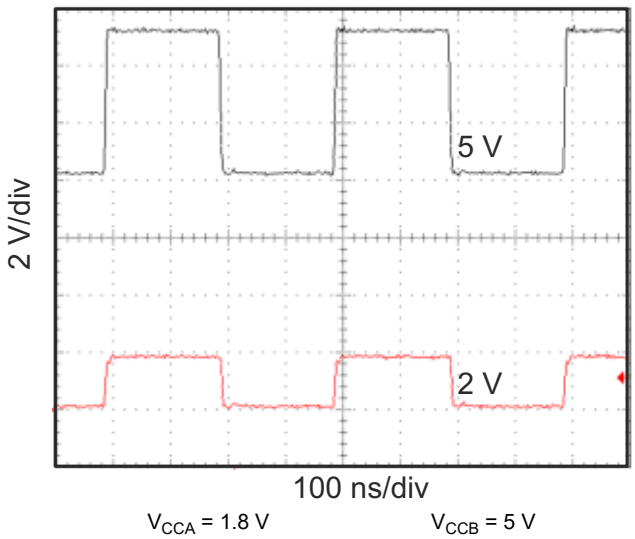


Figure 9-2. Level-Translation of a 2.5-MHz Signal

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9.3 Power Supply Recommendations

The TXS0104E device uses two separate configurable power-supply rails, V_{CCA} and V_{CCB}. V_{CCB} accepts any supply voltage from 2.3 V to 5.5 V and V_{CCA} accepts any supply voltage from 1.65 V to 3.6 V as long as Vs is less than or equal to V_{CCB}. The A port and B port are designed to track V_{CCA} and V_{CCB} respectively allowing for low-voltage bidirectional translation between any of the 1.8-V, 2.5-V, 3.3-V, and 5-V voltage nodes.

The TXS0104E device does not require power sequencing between V_{CCA} and V_{CCB} during power-up so the power-supply rails can be ramped in any order. A V_{CCA} value greater than or equal to V_{CCB} ($V_{CCA} \geq V_{CCB}$) does not damage the device, but during operation, V_{CCA} must be less than or equal to V_{CCB} ($V_{CCA} \leq V_{CCB}$) at all times.

The output-enable (OE) input circuit is designed so that it is supplied by V_{CCA} and when the (OE) input is low, all outputs are placed in the high-impedance state. For the high-impedance state of the outputs during power up or power down, the OE input pin must be tied to GND through a pulldown resistor and must not be enabled until V_{CCA} and V_{CCB} are fully ramped and stable. The minimum value of the pulldown resistor to ground is determined by the current-sourcing capability of the driver.

9.4 Layout

9.4.1 Layout Guidelines

For device reliability, following common printed-circuit board layout guidelines is recommended.

- Bypass capacitors should be used on power supplies.
- Short trace lengths should be used to avoid excessive loading.
- PCB signal trace-lengths must be kept short enough so that the round-trip delay of any reflection is less than the one shot duration, approximately 30 ns, and encounters low impedance at the source driver.
- Placing pads on the signal paths for loading capacitors or pullup resistors to help adjust rise and fall times of signals depending on the system requirements

9.4.2 Layout Example

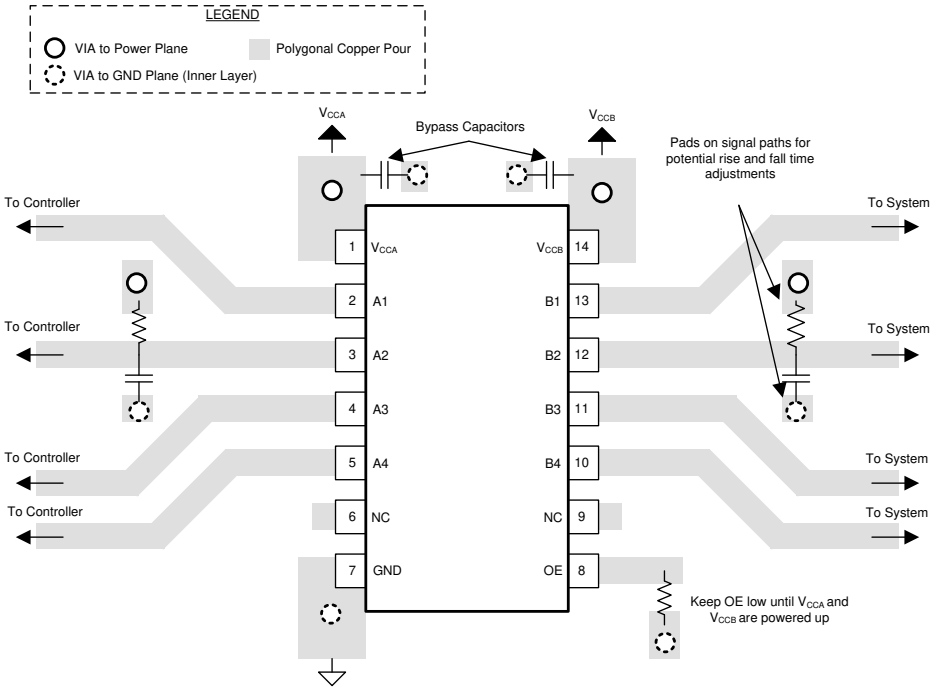


Figure 9-3. TXS0104E Layout Example

10 Device and Documentation Support

10.1 Documentation Support

10.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, *Effects of External Pullup and Pulldown Resistors on TXS and TXB Devices* application report
- Texas Instruments, *Basics of Voltage Translation* application report
- Texas Instruments, *A Guide to Voltage Translation With TXS-Type Translators* application report

10.2 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.

10.3 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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10.5 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.

10.6 Glossary

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

11 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.

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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)
TXS0104EBQAR	Active	Production	WQFN (BQA) | 14	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	YF04E
TXS0104EBQAR.A	Active	Production	WQFN (BQA) | 14	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	YF04E
TXS0104ED	Active	Production	SOIC (D) | 14	50 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	TXS0104E
TXS0104ED.B	Active	Production	SOIC (D) | 14	50 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	TXS0104E
TXS0104EDG4	Active	Production	SOIC (D) | 14	50 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	TXS0104E
TXS0104EDR	Active	Production	SOIC (D) | 14	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	TXS0104E
TXS0104EDR.A	Active	Production	SOIC (D) | 14	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	TXS0104E
TXS0104EDR.B	Active	Production	SOIC (D) | 14	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	TXS0104E
TXS0104EDRG4	Active	Production	SOIC (D) | 14	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TXS0104E
TXS0104EDRG4.A	Active	Production	SOIC (D) | 14	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TXS0104E
TXS0104EDRG4.B	Active	Production	SOIC (D) | 14	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TXS0104E
TXS0104ENMNR	Active	Production	NFBGA (NMN) | 12	2500 | LARGE T&R	Yes	SNAGCU	Level-2-260C-1 YEAR	-40 to 85	29XW
TXS0104ENMNR.B	Active	Production	NFBGA (NMN) | 12	2500 | LARGE T&R	Yes	SNAGCU	Level-2-260C-1 YEAR	-40 to 85	29XW
TXS0104EPWR	Active	Production	TSSOP (PW) | 14	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	YF04E
TXS0104EPWR.A	Active	Production	TSSOP (PW) | 14	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	YF04E
TXS0104EPWR.B	Active	Production	TSSOP (PW) | 14	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	YF04E
TXS0104EPWRG4	Active	Production	TSSOP (PW) | 14	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	YF04E
TXS0104ERGYR	Active	Production	VQFN (RGY) | 14	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	YF04E
TXS0104ERGYR.A	Active	Production	VQFN (RGY) | 14	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	YF04E
TXS0104ERGYR.B	Active	Production	VQFN (RGY) | 14	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	YF04E
TXS0104ERGYRG4	Active	Production	VQFN (RGY) | 14	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	YF04E
TXS0104ERUTR	Active	Production	UQFN (RUT) | 12	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1RP
TXS0104ERUTR.A	Active	Production	UQFN (RUT) | 12	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1RP
TXS0104EYZTR	Active	Production	DSBGA (YZT) | 12	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	2N
TXS0104EYZTR.B	Active	Production	DSBGA (YZT) | 12	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	2N

(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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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF TXS0104E :

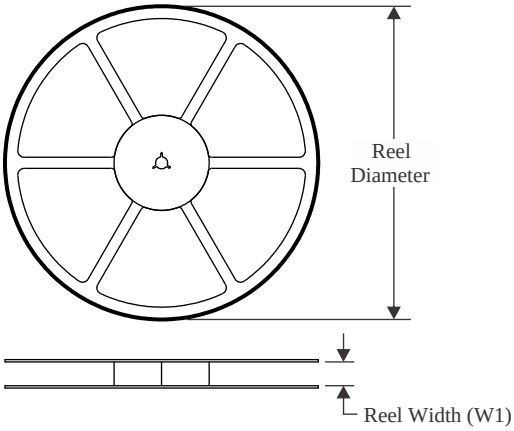
- Automotive : TXS0104E-Q1

NOTE: Qualified Version Definitions:

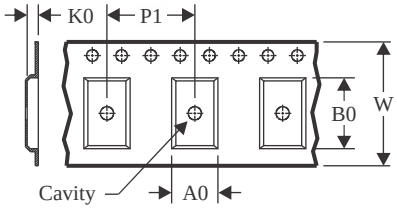
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

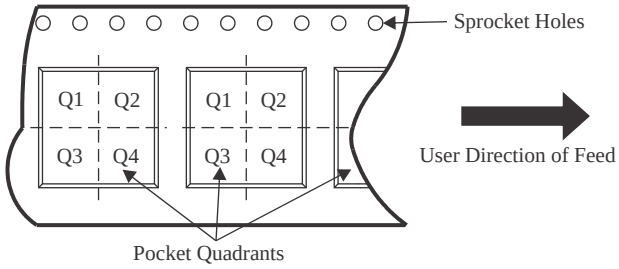


TAPE DIMENSIONS



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

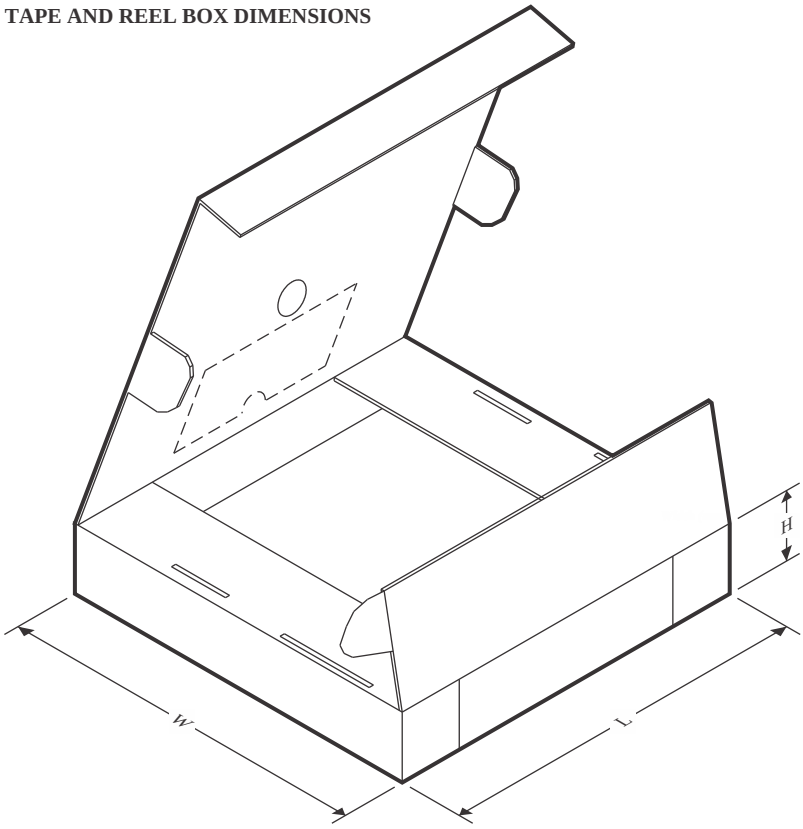
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TXS0104EBQAR	WQFN	BQA	14	3000	180.0	12.4	2.8	3.3	1.1	4.0	12.0	Q1
TXS0104EDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TXS0104EDR	SOIC	D	14	2500	330.0	12.4	3.75	3.75	1.15	8.0	12.0	Q1
TXS0104EDRG4	SOIC	D	14	2500	330.0	12.4	3.75	3.75	1.15	8.0	12.0	Q1
TXS0104ENMNR	NFBGA	NMN	12	2500	180.0	8.4	2.3	2.8	1.15	4.0	8.0	Q2
TXS0104EPWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TXS0104ERGYR	VQFN	RGY	14	3000	330.0	12.4	3.75	3.75	1.15	8.0	12.0	Q1
TXS0104ERUTR	UQFN	RUT	12	3000	180.0	8.4	2.0	2.3	0.75	4.0	8.0	Q1
TXS0104EYZTR	DSBGA	YZT	12	3000	180.0	8.4	1.49	1.99	0.75	4.0	8.0	Q2

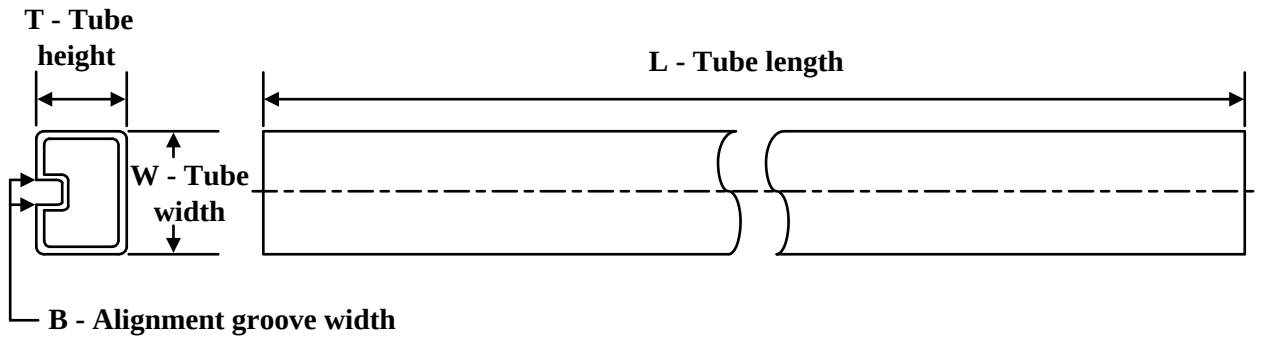
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TXS0104EBQAR	WQFN	BQA	14	3000	210.0	185.0	35.0
TXS0104EDR	SOIC	D	14	2500	353.0	353.0	32.0
TXS0104EDR	SOIC	D	14	2500	353.0	353.0	32.0
TXS0104EDRG4	SOIC	D	14	2500	353.0	353.0	32.0
TXS0104ENMNR	NFBGA	NMN	12	2500	210.0	185.0	35.0
TXS0104EPWR	TSSOP	PW	14	2000	353.0	353.0	32.0
TXS0104ERGYR	VQFN	RGY	14	3000	353.0	353.0	32.0
TXS0104ERUTR	UQFN	RUT	12	3000	210.0	185.0	35.0
TXS0104EYZTR	DSBGA	YZT	12	3000	182.0	182.0	20.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
TXS0104ED	D	SOIC	14	50	506.6	8	3940	4.32
TXS0104ED.B	D	SOIC	14	50	506.6	8	3940	4.32
TXS0104EDG4	D	SOIC	14	50	506.6	8	3940	4.32

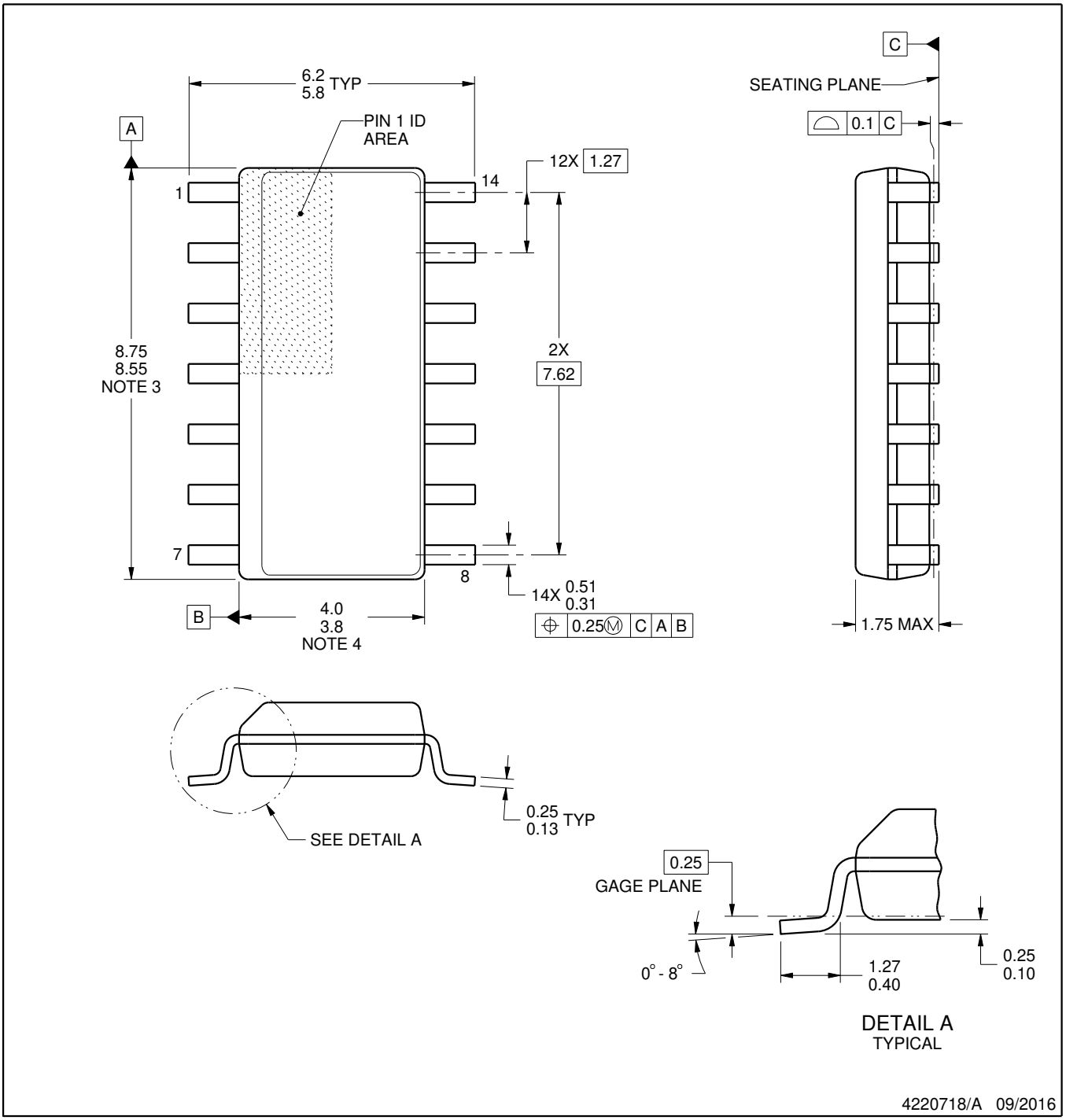


PACKAGE OUTLINE

D0014A

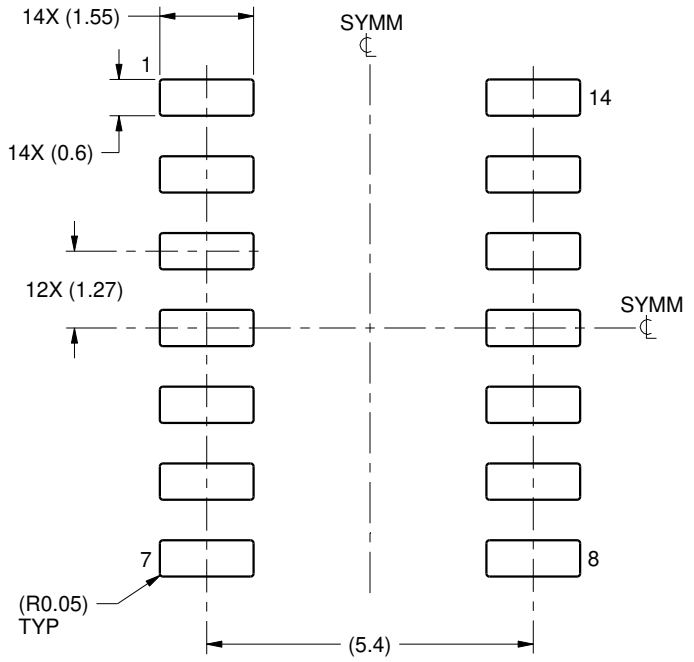
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

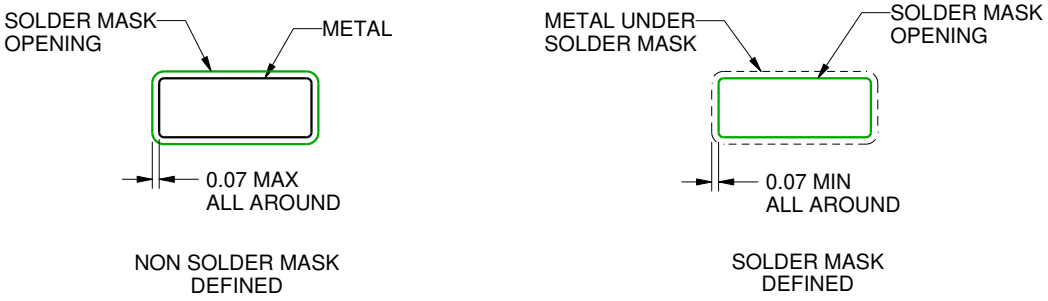


NOTES:

1. All linear dimensions are in millimeters. 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 0.43 mm, per side.
5. Reference JEDEC registration MS-012, variation AB.



LAND PATTERN EXAMPLE
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

NOTES: (continued)

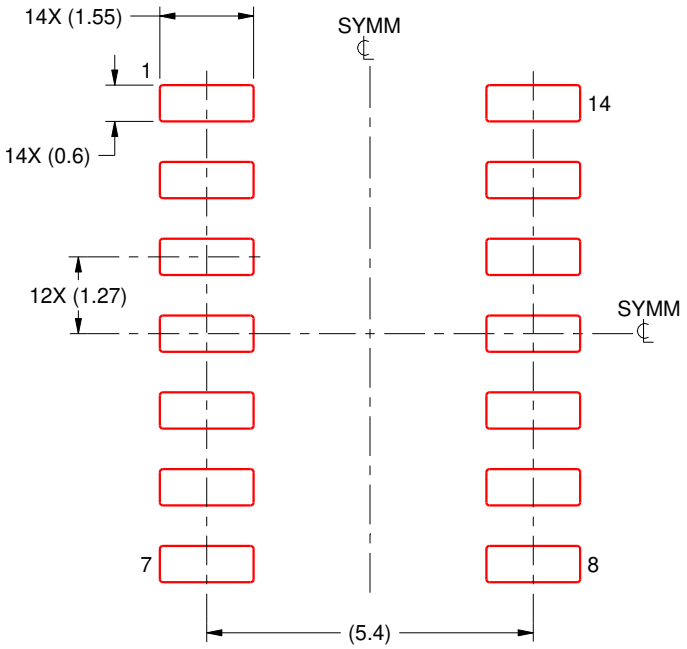
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



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

4220718/A 09/2016

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.

GENERIC PACKAGE VIEW

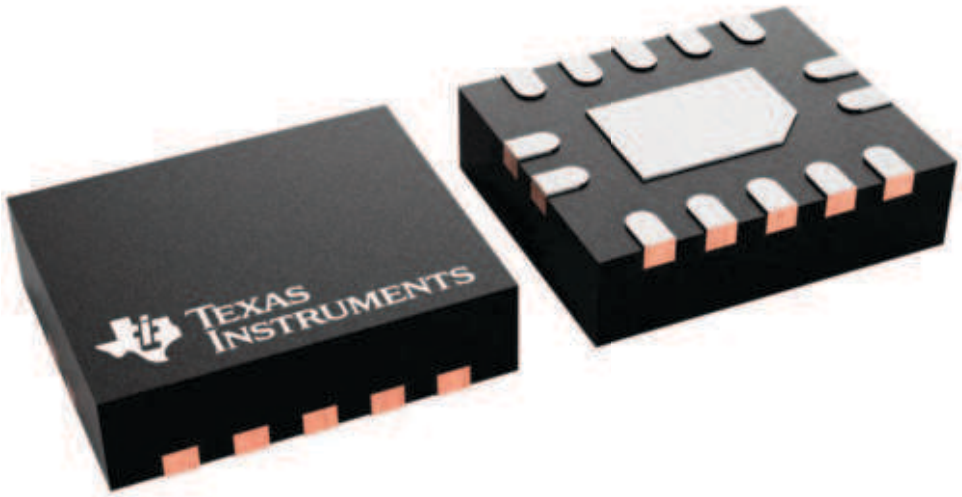
BQA 14

WQFN - 0.8 mm max height

2.5 x 3, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



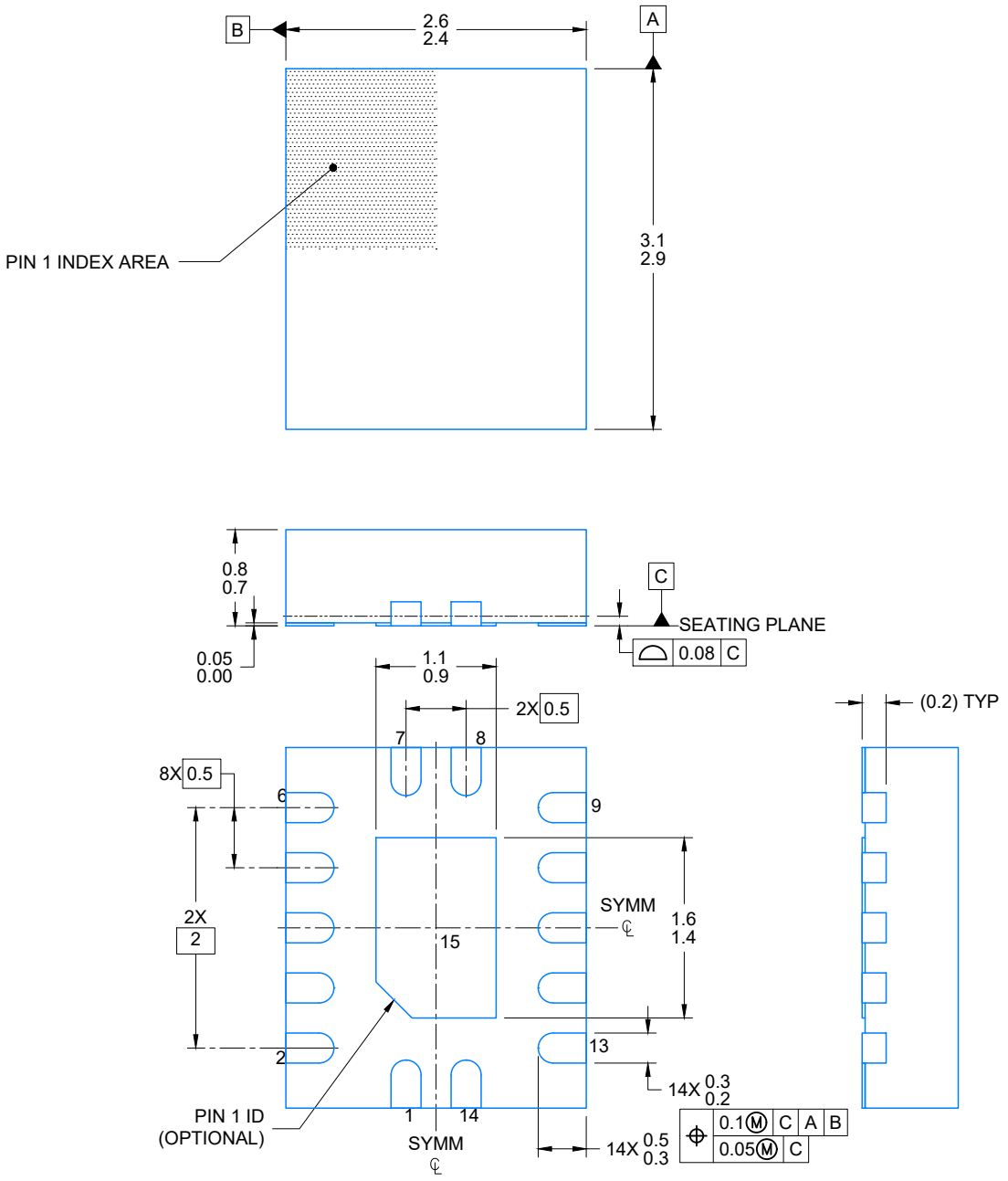
4227145/A

PACKAGE OUTLINE

BQA0014A

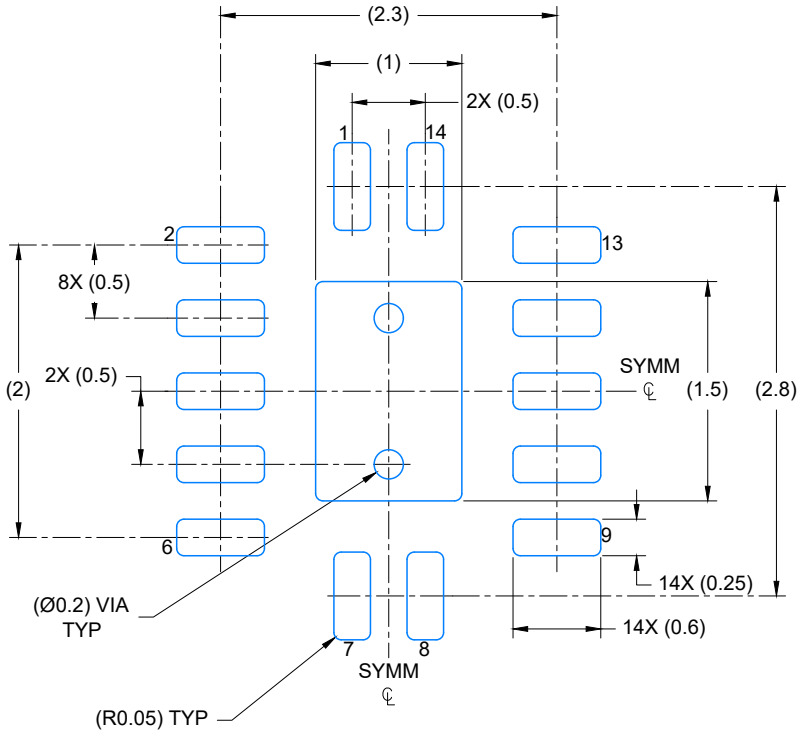
WQFN - 0.8 mm max height

PLASTIC QUAD FLAT PACK-NO LEAD

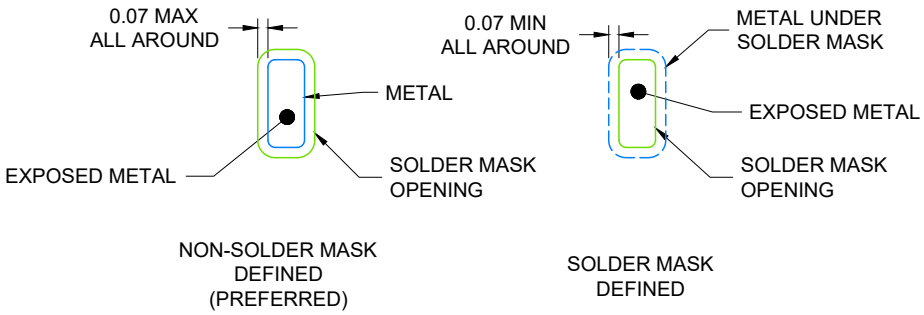


NOTES:

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. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.



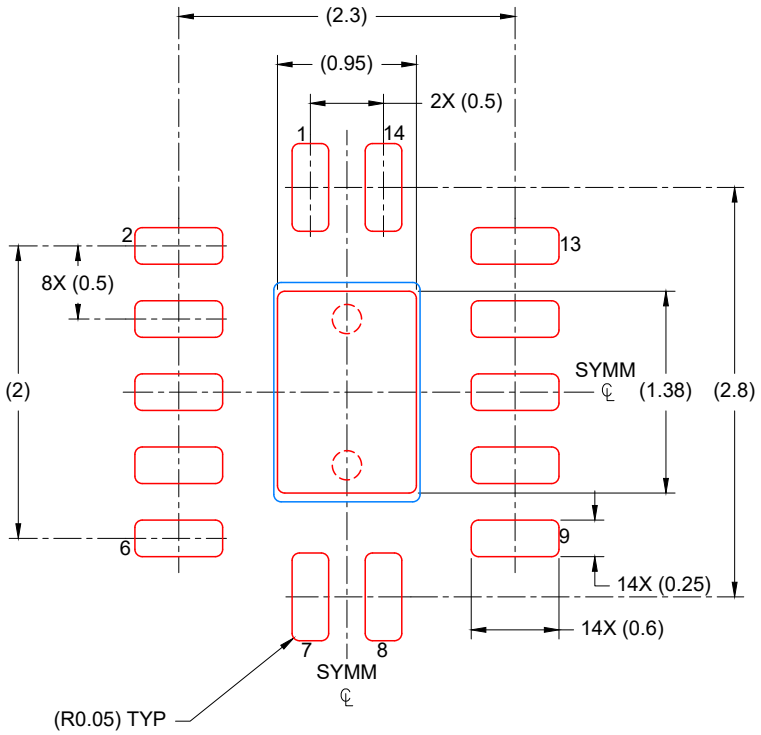
LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X



4224636/A 11/2018

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD
88% PRINTED COVERAGE BY AREA
SCALE: 20X

4224636/A 11/2018

NOTES: (continued)

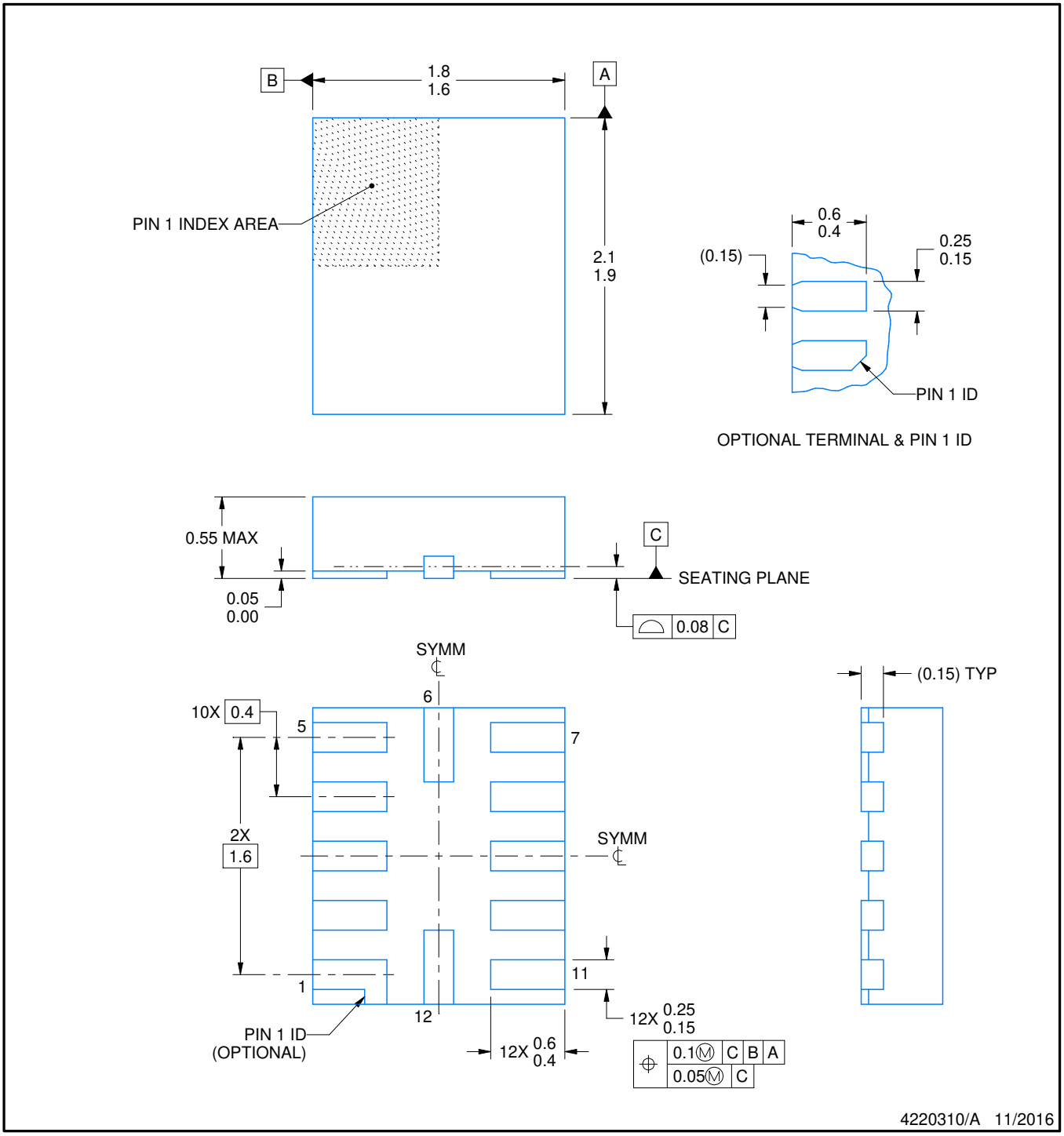
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

RUT0012A

PACKAGE OUTLINE

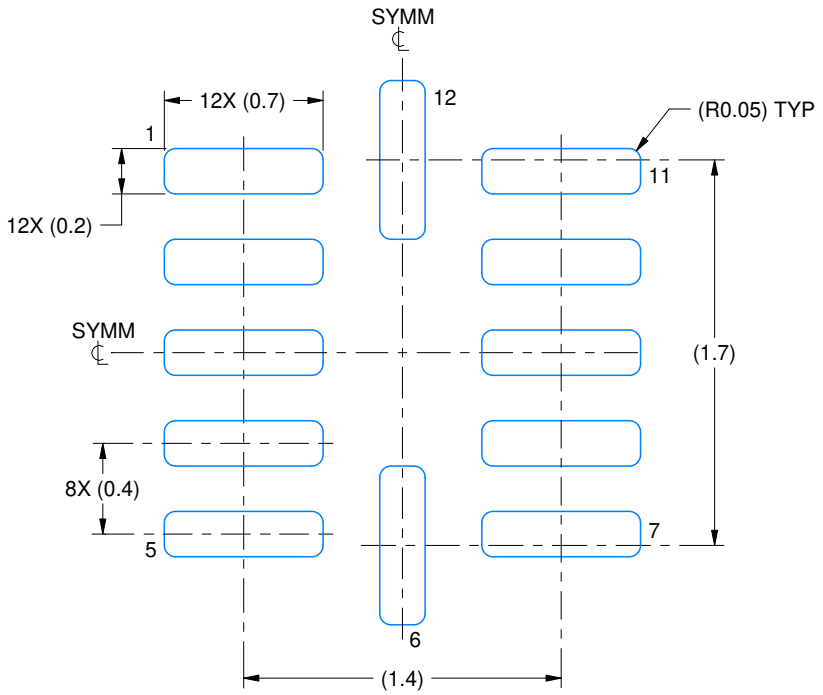
UQFN - 0.55 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

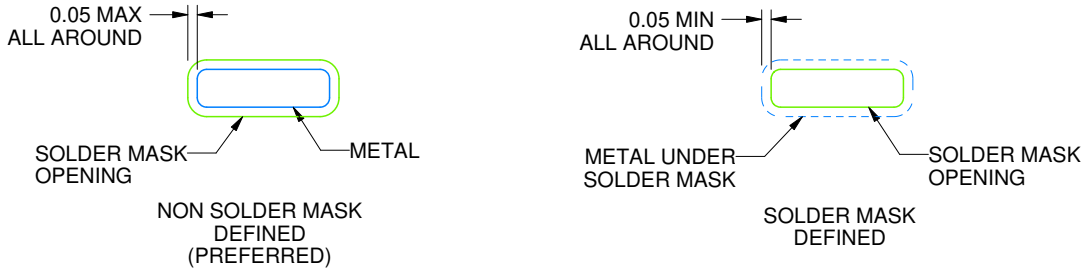


NOTES:

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.



LAND PATTERN EXAMPLE
SCALE:30X

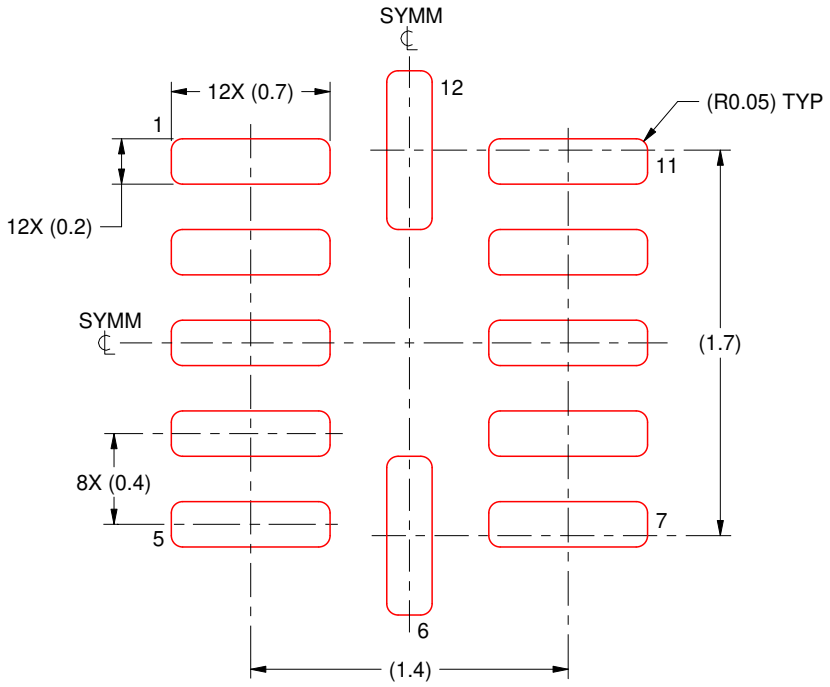


SOLDER MASK DETAILS

4220310/A 11/2016

NOTES: (continued)

3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 30X

4220310/A 11/2016

NOTES: (continued)

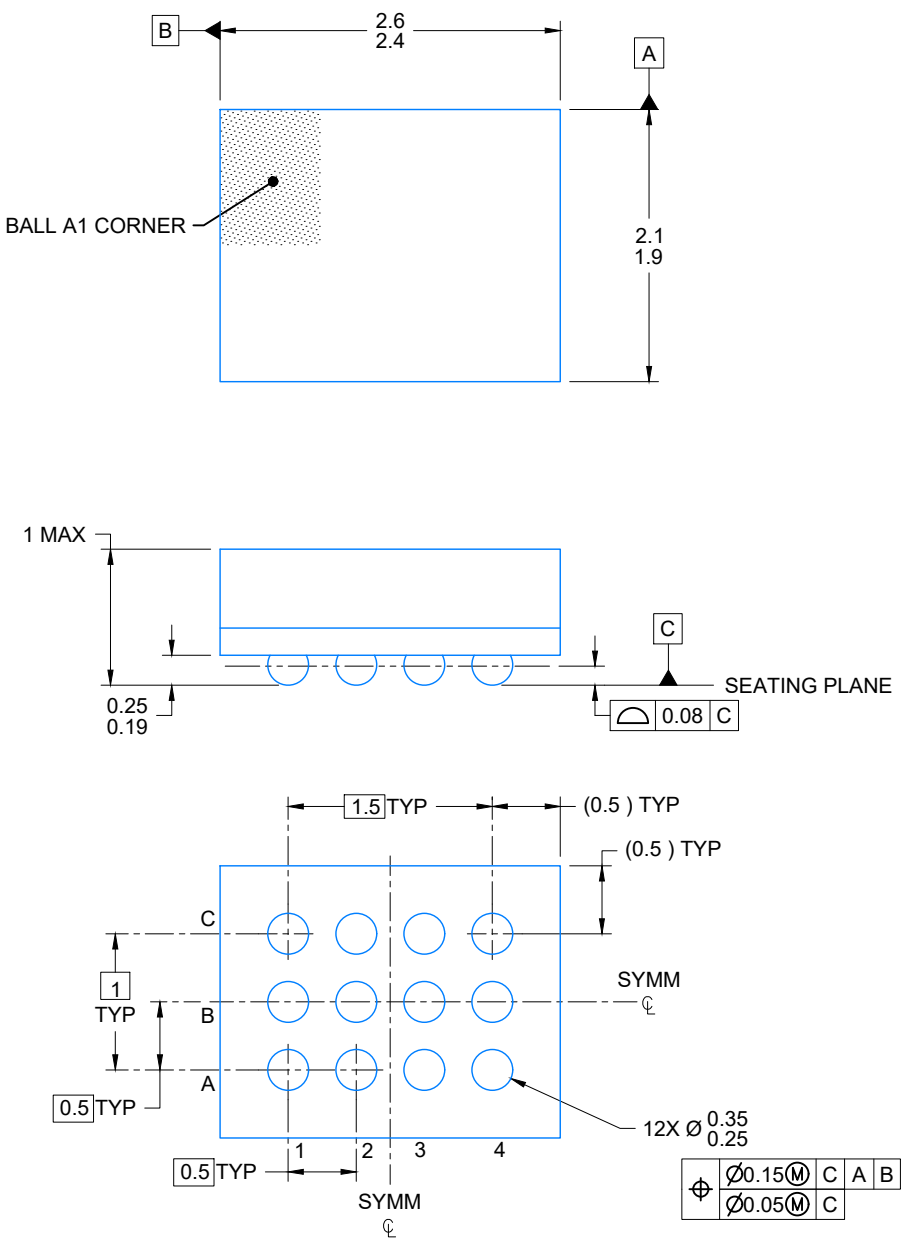
4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

PACKAGE OUTLINE

NMN0012A

NFBGA - 1 mm max height

PLASTIC BALL GRID ARRAY

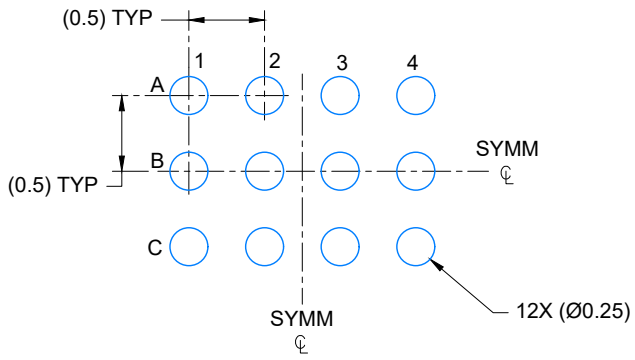


4225768/A 03/2020

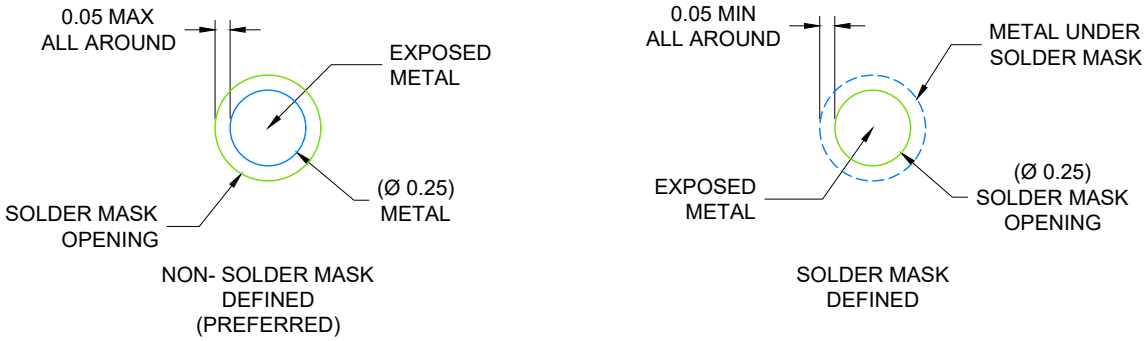
NOTES:

NanoFree is a trademark of Texas Instruments.

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.



LAND PATTERN EXAMPLE
SCALE: 20X

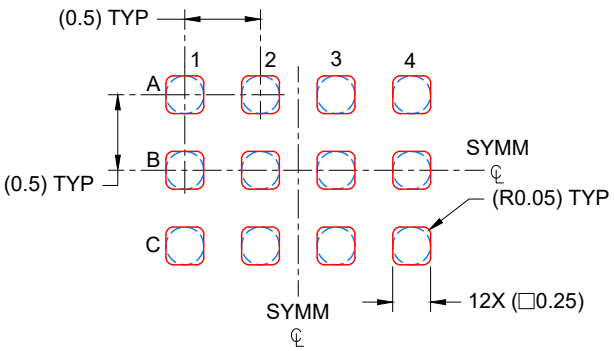


SOLDER MASK DETAILS
NOT TO SCALE

4225768/A 03/2020

NOTES: (continued)

3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. Refer to Texas Instruments Literature number SNVA009 (www.ti.com/lit/snva009).



SOLDER PASTE EXAMPLE
BASED ON 0.100 mm THICK STENCIL
SCALE: 20X

4225768/A 03/2020

NOTES: (continued)

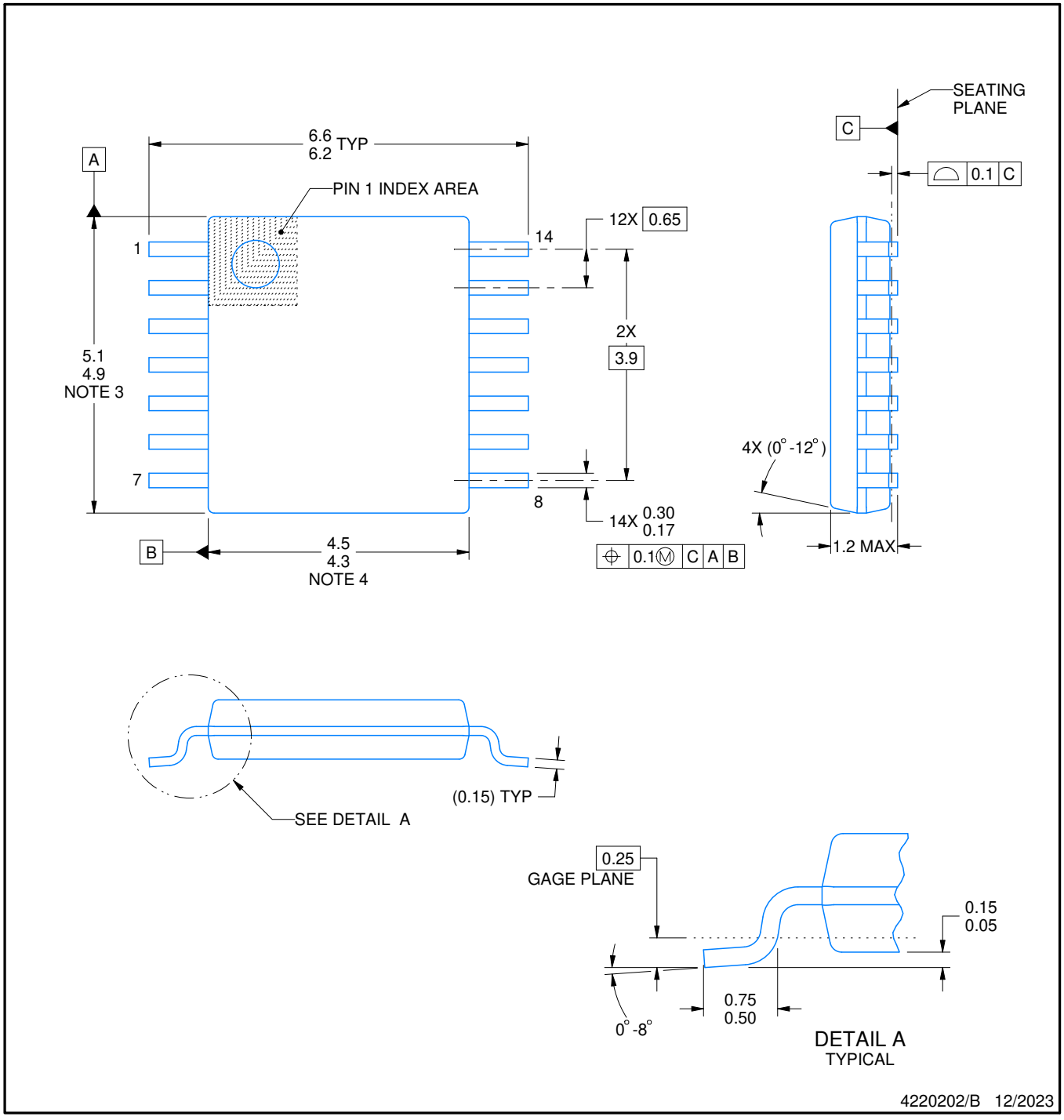
4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

PACKAGE OUTLINE

PW0014A

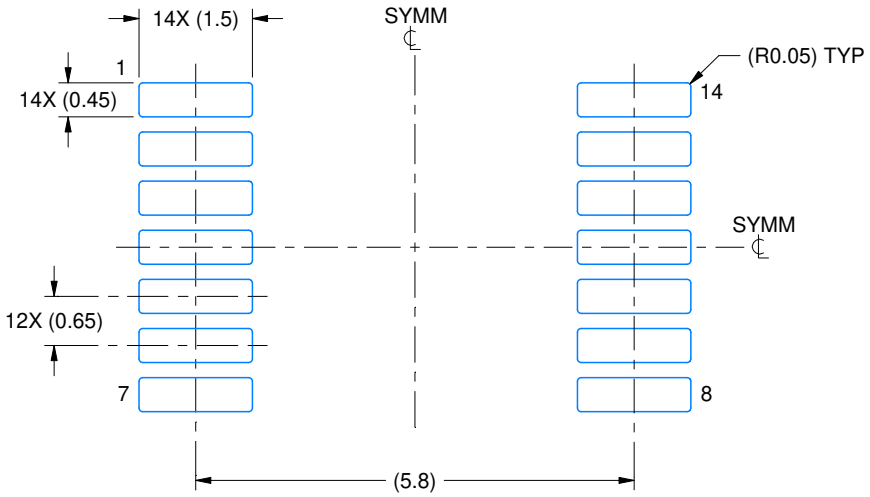
TSSOP - 1.2 mm max height

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. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



NON-SOLDER MASK DEFINED (PREFERRED)

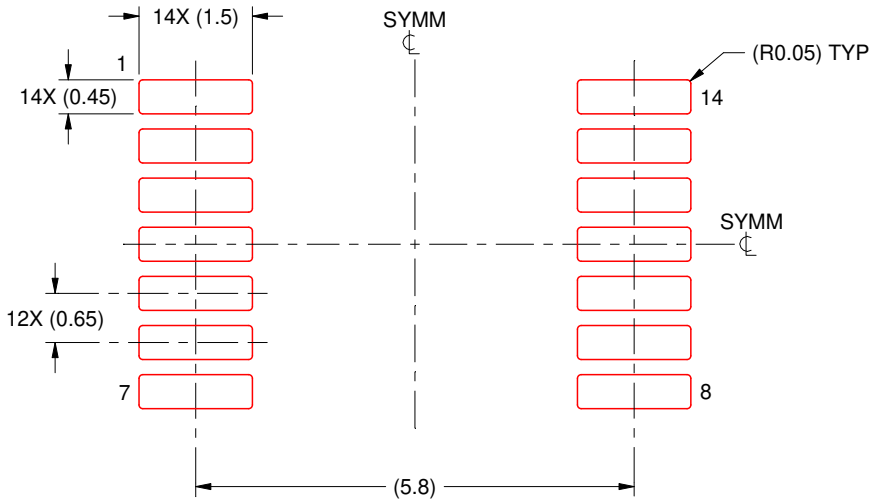
SOLDER MASK DETAILS

SOLDER MASK DEFINED

4220202/B 12/2023

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: 10X

4220202/B 12/2023

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.

GENERIC PACKAGE VIEW

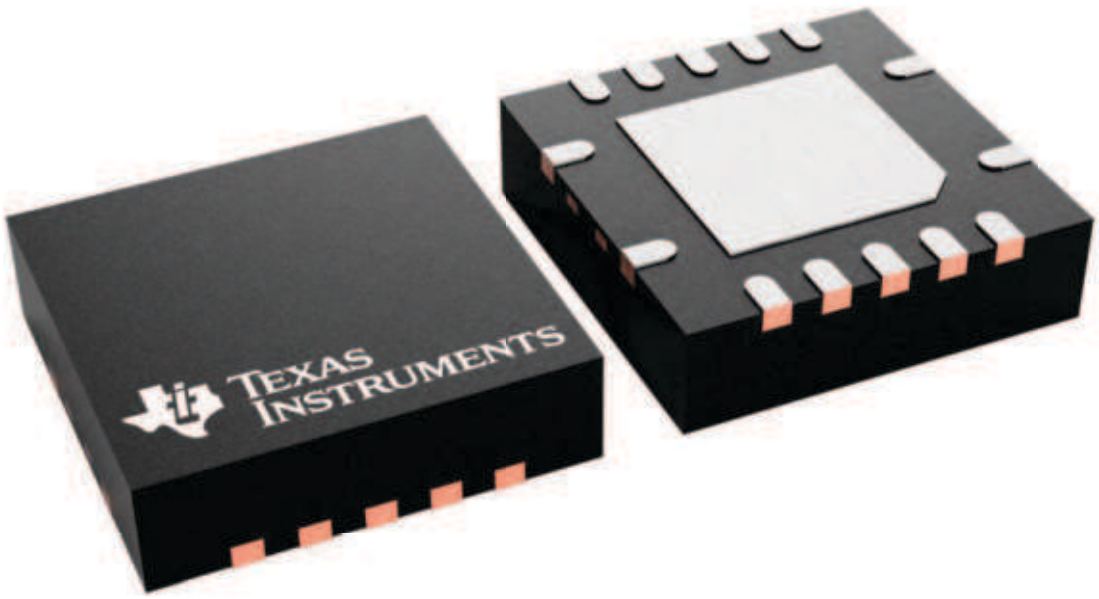
RGY 14

VQFN - 1 mm max height

3.5 x 3.5, 0.5 mm pitch

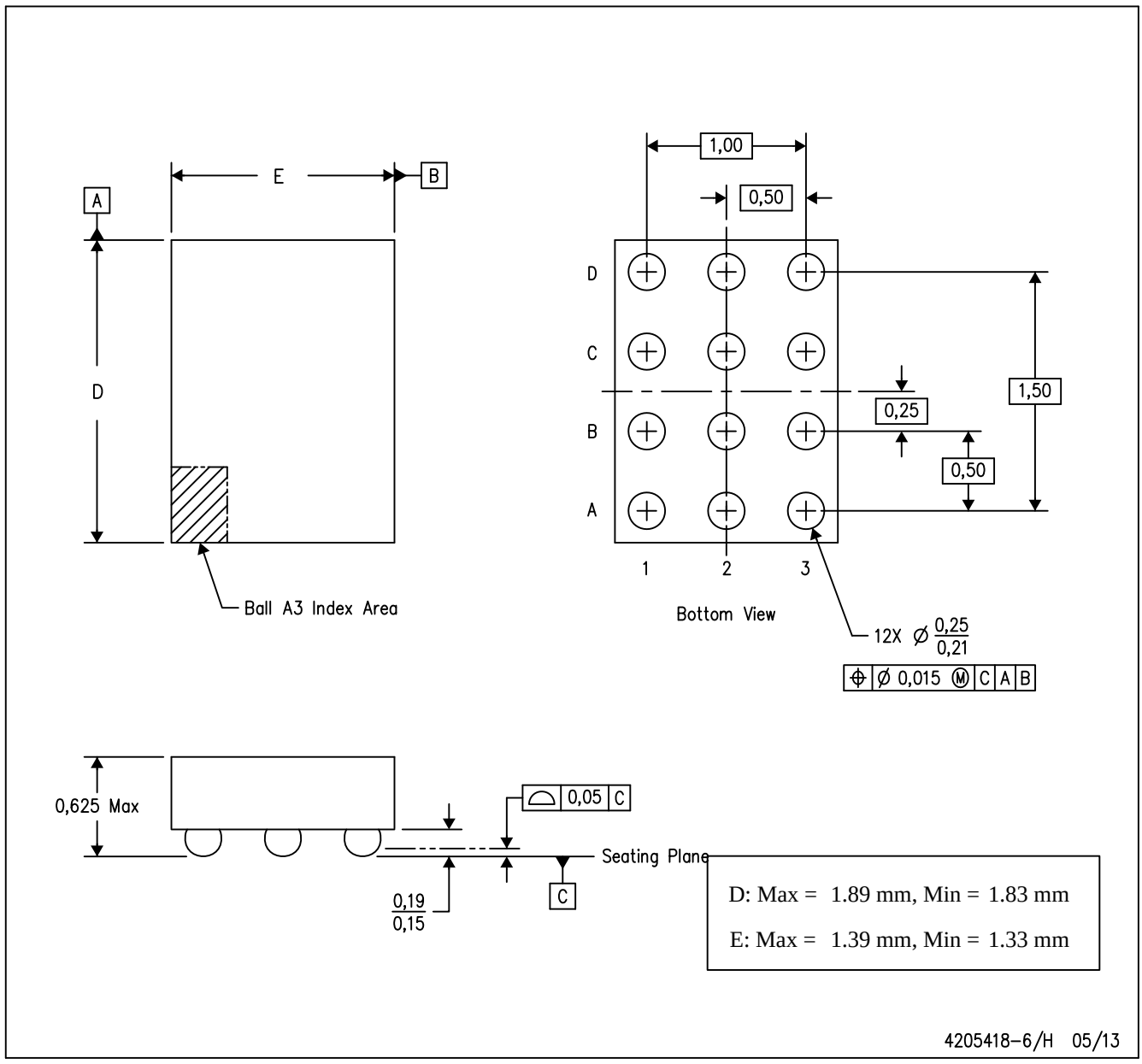
PLASTIC QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4231541/A

YZT (R–XBGA–N12) (CUSTOM) DIE–SIZE BALL GRID ARRAY



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. NanoFree™ package configuration.

NanoFree is a trademark of Texas Instruments.

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