TXS0102-Q1 2-Bit Bidirectional Voltage-Level Translator for Open-Drain and Push-Pull Applications

1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified With the Following Results:
  - Device Temperature Grade 1: –40°C to +125°C Ambient Operating Temperature Range
  - Device HBM ESD Classification Level 2
  - Device CDM ESD Classification Level C5
- ESD Protection per JESD 22
  - A Port
    - 2500-V Human-Body Model (A114-B)
    - 750-V Charged-Device Model (C101)
  - B Port
    - 8-kV Human-Body Model (A114-B)
    - 750-V Charged-Device Model (C101)
- No Direction-Control Signal Required
- Maximum Data Rates
  - 24 Mbps Maximum (Push Pull)
  - 2 Mbps (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

2 Applications

- Automotive Infotainment
- Advance Driver-Assistance Systems (ADAS)
- Isolates and Level-Translates Between Main Processor and Peripheral Modules
- I^2C or 1-Wire Voltage-Level Translation

3 Description

The TXS0102-Q1 device connects an incompatible logic communication from chip-to-chip due to voltage mismatch. This auto-direction translator can be conveniently used to bridge the gap without the need of direction control from the host. Each channel can be mixed and matched with different output types (open-drain or push-pull) and mixed data flows (transmit or receive) without intervention from the host. This 4-bit noninverting translator uses two separate configurable power-supply rails. The A and B ports are designed to track V_{CCA} and V_{CCB} respectively. The V_{CCB} pin accepts any supply voltage from 2.3 V to 5.5 V while the V_{CCA} pin accepts any supply voltage from 1.65 V to 3.6 V such that V_{CCA} is less than or equal to V_{CCB}. This tracking 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 TXS0102-Q1 device is designed so that the OE input circuit is supplied by V_{CCA}.

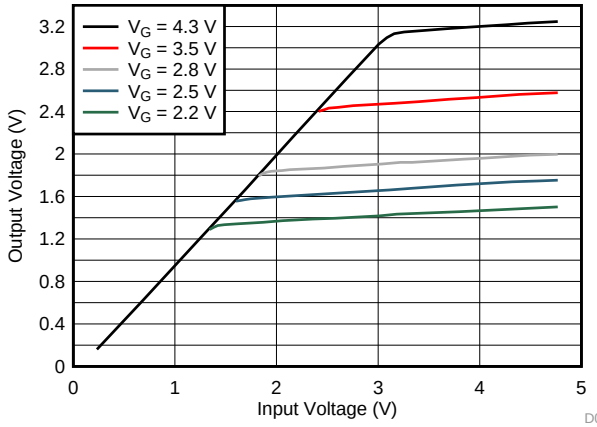
To assure the high-impedance state during power up or power down, the OE pin must be tied to the GND pin through a pulldown resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TXS0102-Q1	VSSOP (8)	2.30 mm × 2.00 mm

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

Transfer Characteristics of an N-Channel Transistor



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4 Revision History

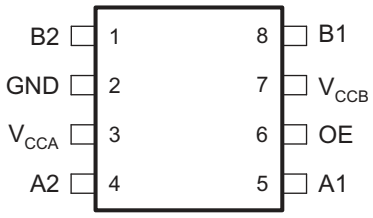
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (May 2014) to Revision A **Page**

- Changed *Handling Ratings* table to *ESD Ratings* table ... 4
- Changed *Functional Block Diagram* with new figure ... 14
- Changed *TXS0102-Q1 Layout Example* with new figure ... 18
- Added *Documentation Support*, *Receiving Notification of Documentation Updates* and *Community Resources* ... 19

5 Pin Configuration and Functions

DCU Package
8-Pin VSSOP
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
A1	5	I/O	Input-output 1 for the A port. This pin is referenced to V_{CCA}.
A2	4	I/O	Input-output 2 for the A port. This pin is referenced to V_{CCA}.
B1	8	I/O	Input-output 1 for the B port. This pin is referenced to V_{CCB}.
B2	1	I/O	Input-output 2 for the B port. This pin is referenced to V_{CCB}.
GND	2	—	Ground
OE	6	I	Tri-state output-mode enable. Pull the OE pin low to place all outputs in tri-state mode. This pin is referenced to V_{CCA}.
V_{CCA}	3	—	A-port supply voltage. 1.65 V ≤ V_{CCA} ≤ 3.6 V and V_{CCA} ≤ V_{CCB}.
V_{CCB}	7	—	B-port supply voltage. 2.3 V ≤ V_{CCB} ≤ 5.5 V.

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
	V_{CCB}		–0.5	6.5	
Input-output pin voltage, V_{IO} (2)	A1, A2	A port	–0.5	4.6	V
	B1, B2	B port	–0.5	6.5	
Output voltage, V_O	Voltage range applied to any output in the high-impedance or power-off state (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 (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	mA
Continuous current through each V_{CCA}, V_{CCB}, or GND				±100	mA
T_{stg}	Storage temperature		–65	150	°C
T_J	Junction temperature			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 AEC Q100-002 (1)	A Port	±2500	V
			B Port	8000	
		Charged device model (CDM), per AEC Q100-011	A Port	±750	V
			B Port		

(1) AEC Q100-002 indicates HBM stressing is done in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.3 Recommended Operating Conditions

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

			V_{CCA}	V_{CCB}	MIN	MAX	UNIT
V_{CCA}	Supply voltage (1)				1.65	3.6	V
V_{CCB}	Supply voltage (1)				2.3	5.5	V
$V_{IH(Ax)}$	High-level input voltage	A-port I/Os	1.65 to 1.95 V	2.3 to 5.5 V	V_{CCA} – 0.2	V_{CCA}	V
			2.3 to 3.6 V		V_{CCA} – 0.4	V_{CCA}	
$V_{IH(Bx)}$	High-level input voltage	B-port I/Os	1.65 to 3.6 V	2.3 to 5.5 V	V_{CCB} – 0.4	V_{CCB}	
$V_{IH(OE)}$	High-level input voltage	OE input			V_{CCA} × 0.65	5.5	
$V_{IL(Ax)}$	Low-level input voltage	A-port I/Os	1.65 to 3.6 V	2.3 to 5.5 V	0	0.15	V
$V_{IL(Bx)}$	Low-level input voltage	B-port I/Os			0	0.15	
$V_{IL(OE)}$	Low-level input voltage	OE input			0	V_{CCA} × 0.35	
$\Delta t/\Delta v_{(Ax)}$	Input transition rise or fall rate	A-port I/Os, push-pull driving	1.65 to 3.6 V	2.3 to 5.5 V		10	ns/V
$\Delta t/\Delta v_{(Bx)}$	Input transition rise or fall rate	B-port I/Os, push-pull driving				10	
$\Delta t/\Delta v_{(OE)}$	Input transition rise or fall rate	OE input				10	
T_A	Operating free-air temperature				–40	125	°C

(1) V_{CCA} must be less than or equal to V_{CCB}, and V_{CCA} must not exceed 3.6 V.

6.4 Thermal Information

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

THERMAL METRIC (1)		TXS0102-Q1 DCU (VSSOP) 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	199.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	72.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	77.8	°C/W
ψ_{JT}	Junction-to-top characterization parameter	6.2	°C/W
ψ_{JB}	Junction-to-board characterization parameter	77.4	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	°C/W

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

6.5 Electrical Characteristics

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

PARAMETER			TEST CONDITIONS		V_{CCA}	V_{CCB}	MIN	TYP	MAX	UNIT
$V_{OH(Ax)}$	High-level output voltage, A port		I_{OH} = –20 µA, $V_{I(Bx)}$ ≥ V_{CCB} – 0.4 V	T_A = –40°C to +125°C	1.65 to 3.6 V	2.3 to 5.5 V	V_{CCA} × 0.67			V
$V_{OL(Ax)}$	Low-level output voltage, A port		I_{OL} = 1 mA, $V_{I(Bx)}$ ≤ 0.15 V	T_A = –40°C to +125°C	1.65 to 3.6 V	2.3 to 5.5 V			0.4	V
$V_{OH(Bx)}$	High-level output voltage, B port		I_{OH} = –20 µA, $V_{I(Ax)}$ ≥ V_{CCA} – 0.2 V	T_A = –40°C to +125°C	1.65 to 3.6 V	2.3 to 5.5 V	V_{CCB} × 0.67			V
$V_{OL(Bx)}$	Low-level output voltage, B port		I_{OL} = 1 mA, $V_{I(Ax)}$ ≤ 0.15 V	T_A = –40°C to +125°C	1.65 to 3.6 V	2.3 to 5.5 V			0.4	V
$I_{I(OE)}$	Input current	OE	V_I = V_{CCI} or GND	T_A = 25°C	1.65 to 3.6 V	2.3 to 5.5 V			±1	µA
				T_A = –40°C to +125°C					±2	
I_{OFF}	Power-off leakage current	A port	T_A = 25°C		0 V	0 to 5.5 V			±1	µA
			T_A = –40°C to +125°C						±2	
		B port	T_A = 25°C		0 to 3.6 V	0 V			±1	µA
			T_A = –40°C to +125°C						±2	
I_{OZ}	Off-state output current	A or B port	OE = V_{IL}	T_A = 25°C	1.65 to 3.6 V	2.3 to 5.5 V			±1	µA
				T_A = –40°C to +125°C					±2	
I_{CCA}	Supply current, A port		V_I = V_O = Open, I_O = 0	T_A = –40°C to +125°C	1.65 to V_{CCB}	2.3 to 5.5 V			4	µA
					3.6 V	0			2.2	
					0	5.5 V			–1	
I_{CCB}	Supply current, B port		V_I = V_O = Open, I_O = 0	T_A = –40°C to +125°C	1.65 to V_{CCB}	2.3 to 5.5 V			21	µA
					3.6 V	0			–1	
					0	5.5 V			1	
I_{CCA}+I_{CCB}	Supply current, A port plus B port supply current		V_I = V_O = Open, I_O = 0	T_A = –40°C to +125°C	1.65 to V_{CCB}	2.3 to 5.5 V			25	µA
$C_{I(OE)}$	Input capacitance	OE	T_A = 25°C		3.3 V	3.3 V		2.5		pF
			T_A = –40°C to +125°C					3.5		
$C_{IO(Ax)}$	Input-output capacitance	A port	T_A = 25°C		3.3 V	3.3 V		5		pF
			T_A = –40°C to +125°C					6.5		
$C_{IO(Bx)}$		B port	T_A = 25°C					12		
			T_A = –40°C to +125°C					7.5		

(1) V_{CCA} must be less than or equal to V_{CCB}, and V_{CCA} must not exceed 3.6 V.

6.6 Timing Requirements — V_{CCA} = 1.8 V ± 0.15 V

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

				MIN	MAX	UNIT
Data rate	Push-pull driving		V_{CCB} = 2.5 V ± 0.2 V		18	Mbps
			V_{CCB} = 3.3 V ± 0.3 V		21	
			V_{CCB} = 5 V ± 0.5 V		23	
	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	
t_w Pulse duration See Figure 7	Push-pull driving	Data inputs	V_{CCB} = 2.5 V ± 0.2 V	55		ns
			V_{CCB} = 3.3 V ± 0.3 V	47		
			V_{CCB} = 5 V ± 0.5 V	43		
	Open-drain driving		V_{CCB} = 2.5 V ± 0.2 V	500		
			V_{CCB} = 3.3 V ± 0.3 V	500		
			V_{CCB} = 5 V ± 0.5 V	500		

6.7 Timing Requirements — V_{CCA} = 2.5 V ± 0.2 V

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

				MIN	MAX	UNIT
Data rate	Push-pull driving		V_{CCB} = 2.5 V ± 0.2 V		20	Mbps
			V_{CCB} = 3.3 V ± 0.3 V		22	
			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	
t_w Pulse duration See Figure 7	Push-pull driving	Data inputs	V_{CCB} = 2.5 V ± 0.2 V	50		ns
			V_{CCB} = 3.3 V ± 0.3 V	45		
			V_{CCB} = 5 V ± 0.5 V	41		
	Open-drain driving		V_{CCB} = 2.5 V ± 0.2 V	500		
			V_{CCB} = 3.3 V ± 0.3 V	500		
			V_{CCB} = 5 V ± 0.5 V	500		

6.8 Timing Requirements — V_{CCA} = 3.3 V ± 0.3 V

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

				MIN	MAX	UNIT
Data rate	Push-pull driving		V_{CCB} = 3.3 V ± 0.3 V		22	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	
t_w Pulse duration See Figure 7	Push-pull driving	Data inputs	V_{CCB} = 3.3 V ± 0.3 V	45		ns
			V_{CCB} = 5 V ± 0.5 V	41		
	Open-drain driving		V_{CCB} = 3.3 V ± 0.3 V	500		
			V_{CCB} = 5 V ± 0.5 V	500		

6.9 Switching Characteristics — V_{CCA} = 1.8 V ± 0.15 V

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

PARAMETER		TEST CONDITIONS		MIN	MAX	UNIT
$t_{PHL(A-B)}$ Propagation delay time (high to low) See Figure 8	From **A** (input) to **B** (output)	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		5.3	ns
			V_{CCB} = 3.3 V ± 0.3 V		5.4	
			V_{CCB} = 5 V ± 0.5 V		6.8	
		Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V		8.8	
			V_{CCB} = 3.3 V ± 0.3 V		9.6	
			V_{CCB} = 5 V ± 0.5 V		10	
$t_{PHL(B-A)}$ Propagation delay time (high to low) See Figure 8	From **B** (input) to **A** (output)	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		4.4	
			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		5.3	
			V_{CCB} = 3.3 V ± 0.3 V		4.4	
			V_{CCB} = 5 V ± 0.5 V		4	

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

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

PARAMETER			TEST CONDITIONS		MIN	MAX	UNIT
$t_{PLH(A-B)}$	Propagation delay time (low to high) See Figure 8	From **A** (input) to **B** (output)	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		6.8	ns
				V_{CCB} = 3.3 V ± 0.3 V		7.1	
				V_{CCB} = 5 V ± 0.5 V		7.5	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V		50	
				V_{CCB} = 3.3 V ± 0.3 V		40	
				V_{CCB} = 5 V ± 0.5 V		33	
$t_{PLH(B-A)}$	Propagation delay time (low to high) See Figure 8	From **B** (input) to **A** (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		36	
				V_{CCB} = 3.3 V ± 0.3 V		26	
				V_{CCB} = 5 V ± 0.5 V		20	
$t_{en(OE-A)}$ $t_{en(OE-B)}$	Enable time	From **OE** (input) to **A** or **B** (output)	V_{CCB} = 2.5 V ± 0.2 V			200	ns
			V_{CCB} = 3.3 V ± 0.3 V			250	
			V_{CCB} = 5 V ± 0.5 V			275	
$t_{dis(OE-A)}$ $t_{dis(OE-B)}$	Disable time	From **OE** (input) to **A** or **B** (output)	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	
$t_{r(Ax)}$	Rise time, A port		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		9.5	ns
				V_{CCB} = 3.3 V ± 0.3 V		9.3	
				V_{CCB} = 5 V ± 0.5 V		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	
$t_{r(Bx)}$	Rise time, B port		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		10.8	ns
				V_{CCB} = 3.3 V ± 0.3 V		9.1	
				V_{CCB} = 5 V ± 0.5 V		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	
$t_{f(Ax)}$	Fall time, A port		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		5.9	ns
				V_{CCB} = 3.3 V ± 0.3 V		6	
				V_{CCB} = 5 V ± 0.5 V		13.3	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V		6.9	
				V_{CCB} = 3.3 V ± 0.3 V		6.4	
				V_{CCB} = 5 V ± 0.5 V		6.1	
$t_{f(Bx)}$	Fall time, B port		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		13.8	
				V_{CCB} = 3.3 V ± 0.3 V		16.2	
				V_{CCB} = 5 V ± 0.5 V		16.2	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V		13.8	
				V_{CCB} = 3.3 V ± 0.3 V		16.2	
				V_{CCB} = 5 V ± 0.5 V		16.2	
t_{sk}	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	

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

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

PARAMETER		TEST CONDITIONS		MIN	MAX	UNIT
Maximum data rate		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	18		Mbps
			V_{CCB} = 3.3 V ± 0.3 V	21		
			V_{CCB} = 5 V ± 0.5 V	23		
		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		

6.10 Switching Characteristics — V_{CCA} = 2.5 V ± 0.2 V

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

PARAMETER			TEST CONDITIONS		MIN	MAX	UNIT
$t_{PHL(A-B)}$	Propagation delay time (high to low) See Figure 8	From **A** (input) to **B** (output)	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		3.2	ns
				V_{CCB} = 3.3 V ± 0.3 V		3.7	
				V_{CCB} = 5 V ± 0.5 V		3.8	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V		6.3	
				V_{CCB} = 3.3 V ± 0.3 V		6	
				V_{CCB} = 5 V ± 0.5 V		5.8	
$t_{PHL(B-A)}$	Propagation delay time (high to low) See Figure 8	From **B** (input) to **A** (output)	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		3	
				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		4.7	
				V_{CCB} = 3.3 V ± 0.3 V		4.2	
				V_{CCB} = 5 V ± 0.5 V		4	
$t_{PLH(A-B)}$	Propagation delay time (low to high) See Figure 8	From **A** (input) to **B** (output)	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		3.5	ns
				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		3.5	
				V_{CCB} = 3.3 V ± 0.3 V		4.1	
				V_{CCB} = 5 V ± 0.5 V		4.4	
$t_{PLH(B-A)}$	Propagation delay time (low to high) See Figure 8	From **B** (input) to **A** (output)	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		1	
			Open-drain 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		1	
$t_{en(OE-A)}$ $t_{en(OE-B)}$	Enable time	From **OE** (input) to **A** or **B** (output)	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			250	
$t_{dis(OE-A)}$ $t_{dis(OE-B)}$	Disable time	From **OE** (input) to **A** or **B** (output)	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	
$t_{r(Ax)}$	Rise time, A port		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		7.4	ns
				V_{CCB} = 3.3 V ± 0.3 V		6.6	
				V_{CCB} = 5 V ± 0.5 V		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	

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

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

PARAMETER		TEST CONDITIONS		MIN	MAX	UNIT
$t_{r(Bx)}$	Rise time, B port	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		8.3	ns
			V_{CCB} = 3.3 V ± 0.3 V		7.2	
			V_{CCB} = 5 V ± 0.5 V		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	
$t_{f(Ax)}$	Fall time, A port	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		5.7	ns
			V_{CCB} = 3.3 V ± 0.3 V		5.5	
			V_{CCB} = 5 V ± 0.5 V		5.3	
		Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V		6.9	
			V_{CCB} = 3.3 V ± 0.3 V		6.2	
			V_{CCB} = 5 V ± 0.5 V		5.8	
$t_{f(Bx)}$	Fall time, B port	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		7.8	ns
			V_{CCB} = 3.3 V ± 0.3 V		6.7	
			V_{CCB} = 5 V ± 0.5 V		6.6	
		Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V		8.8	
			V_{CCB} = 3.3 V ± 0.3 V		9.4	
			V_{CCB} = 5 V ± 0.5 V		10.4	
t_{sk}	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	20		Mbps
			V_{CCB} = 3.3 V ± 0.3 V	22		
			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} = 3.3 V ± 0.3 V

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

PARAMETER			TEST CONDITIONS		MIN	MAX	UNIT
$t_{PHL(A-B)}$	Propagation delay time (high to low) See Figure 8	From **A** (input) to **B** (output)	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		4.2	
				V_{CCB} = 5 V ± 0.5 V		4.6	
$t_{PHL(B-A)}$	Propagation delay time (high to low) See Figure 8	From **B** (input) to **A** (output)	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		2.5	
				V_{CCB} = 5 V ± 0.5 V		3.3	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V		2.5	
				V_{CCB} = 5 V ± 0.5 V		3.3	
$t_{PLH(A-B)}$	Propagation delay time (low to high) See Figure 8	From **A** (input) to **B** (output)	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		4.2	ns
				V_{CCB} = 5 V ± 0.5 V		4.4	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V		4.2	
				V_{CCB} = 5 V ± 0.5 V		4.4	
$t_{PLH(B-A)}$	Propagation delay time (low to high) See Figure 8	From **B** (input) to **A** (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		2.5	
				V_{CCB} = 5 V ± 0.5 V		2.6	
$t_{en(OE-A)}$ $t_{en(OE-B)}$	Enable time	From **OE** (input) to **A** or **B** (output)	V_{CCB} = 3.3 V ± 0.3 V			200	ns
			V_{CCB} = 5 V ± 0.5 V			250	
$t_{dis(OE-A)}$ $t_{dis(OE-B)}$	Disable time	From **OE** (input) to **A** or **B** (output)	V_{CCB} = 3.3 V ± 0.3 V			200	ns
			V_{CCB} = 5 V ± 0.5 V			200	
$t_{r(Ax)}$	Rise time, A port		Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		5.6	ns
				V_{CCB} = 5 V ± 0.5 V		4.8	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	25	116	
				V_{CCB} = 5 V ± 0.5 V	19	85	
$t_{r(Bx)}$	Rise time, B port		Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		6.4	ns
				V_{CCB} = 5 V ± 0.5 V		7.4	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	26	116	
				V_{CCB} = 5 V ± 0.5 V	14	72	
$t_{f(Ax)}$	Fall time, A port		Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		5.4	ns
				V_{CCB} = 5 V ± 0.5 V		5	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V		6.1	
				V_{CCB} = 5 V ± 0.5 V		5.7	
$t_{f(Bx)}$	Fall time, B port		Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		7.4	ns
				V_{CCB} = 5 V ± 0.5 V		7.6	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V		7.6	
				V_{CCB} = 5 V ± 0.5 V		8.3	
t_{sk}	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	22		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		

6.12 Typical Characteristics

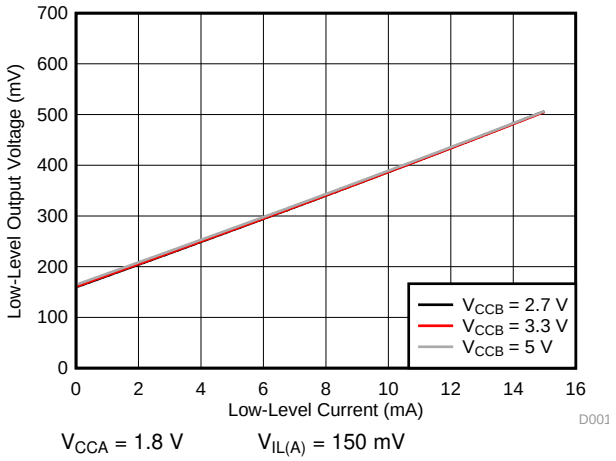


Figure 1. Low-Level Output Voltage ($V_{OL(Bx)}$) vs Low-Level Current ($I_{OL(Bx)}$)

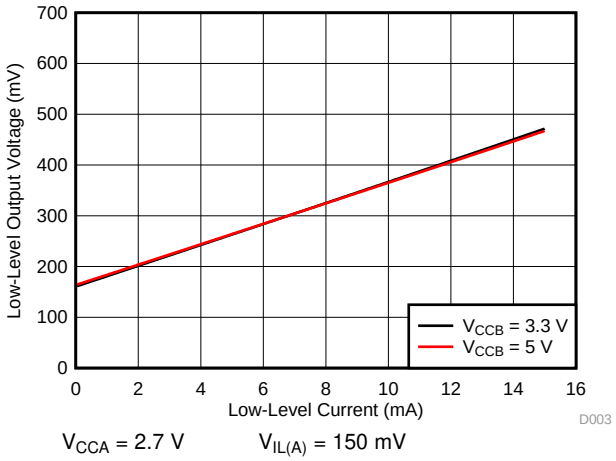


Figure 2. Low-Level Output Voltage ($V_{OL(Bx)}$) vs Low-Level Current ($I_{OL(Bx)}$)

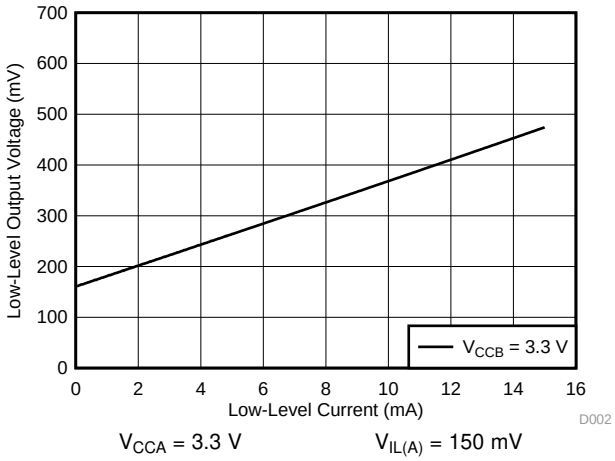


Figure 3. Low-Level Output Voltage ($V_{OL(Bx)}$) vs Low-Level Current ($I_{OL(Bx)}$)

7 Parameter Measurement Information

7.1 Load Circuits

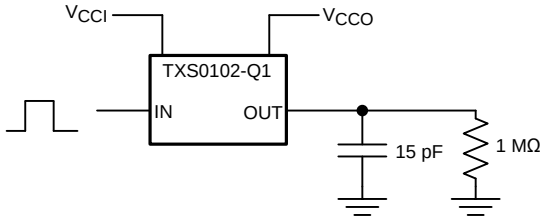


Figure 4. Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement Using a Push-Pull Driver

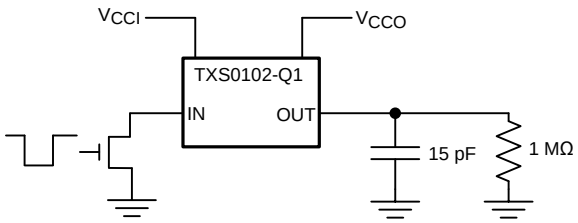
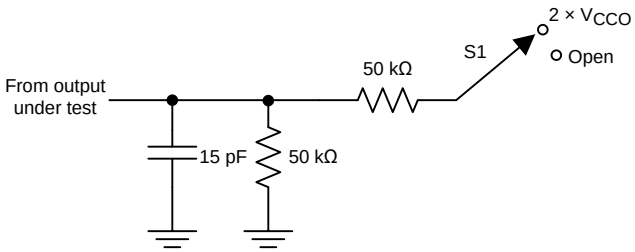


Figure 5. Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement Using an Open-Drain Driver



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

Figure 6. 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.

7.2 Voltage Waveforms

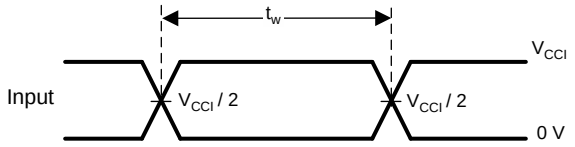


Figure 7. Pulse Duration

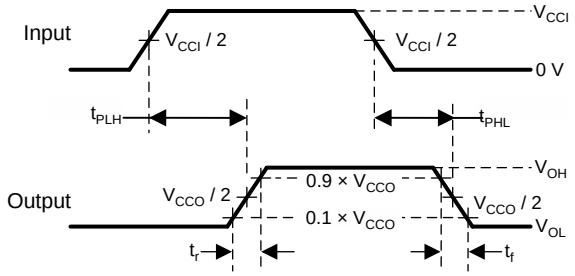


Figure 8. Propagation Delay Times

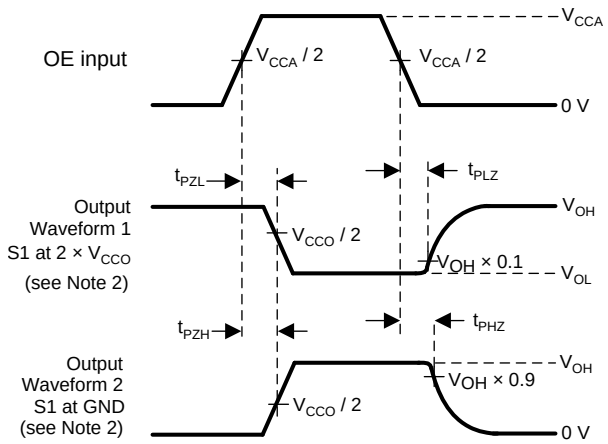


Figure 9. Enable and Disable Times

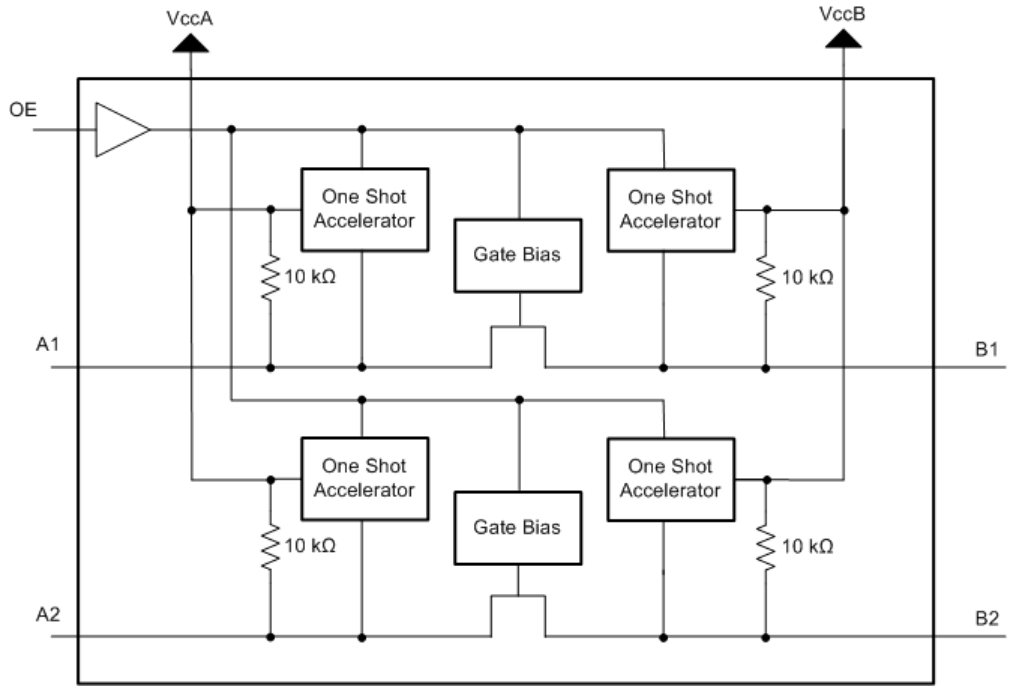
1. C_L includes probe and jig capacitance.
2. Waveform 1 in Figure 9 is for an output with internal such that the output is high, except when OE is high (see Figure 6). Waveform 2 in Figure 9 is for an output with conditions such that the output is low, except when OE is high.
3. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, dv/dt ≥ 1 V/ns.
4. The outputs are measured one at a time, with one transition per measurement.
5. t_{PLZ} and t_{PHZ} are the same as t_{dis}.
6. t_{PZL} and t_{PZH} are the same as t_{en}.
7. t_{PLH} and t_{PHL} are the same as t_{pd}.
8. V_{CCI} is the V_{CC} associated with the input port.
9. V_{CCO} is the V_{CC} associated with the output port.

8 Detailed Description

8.1 Overview

The TXS0102-Q1 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 TXS0102-Q1 architecture (see Figure 10) 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.

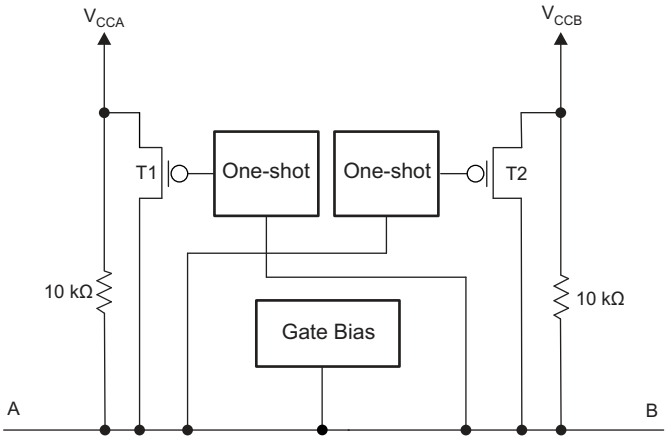


Figure 10. Architecture of a TXS01xx Cell

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 TXS0102-Q1 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, assure 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 TXS0102-Q1 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 TXS0102-Q1 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.

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. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

The TXS0102-Q1 device can be used in level-translation applications for interfacing devices or systems operating at different interface voltages with one another. The TXS0102-Q1 device is ideal for use in applications where an open-drain driver is connected to the data I/Os.

9.2 Typical Application

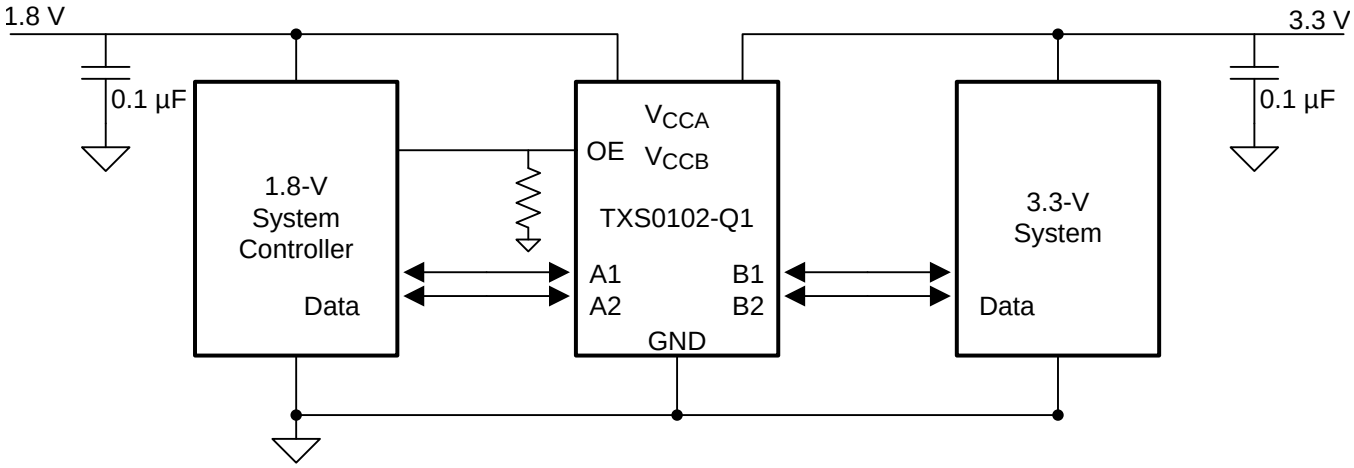


Figure 11. Application Schematic

9.2.1 Design Requirements

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

Table 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

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 TXS0102-Q1 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 TXS0102-Q1 device is driving to determine the output voltage range.
  - The TXS0102-Q1 device has 10-kΩ internal pullup resistors. External pullup resistors can be added to reduce the total RC of a signal trace if necessary.

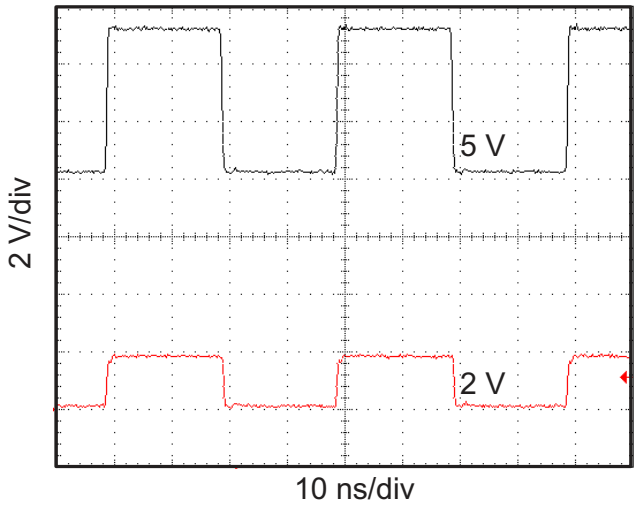
- An external pull down resistor decreases the output V_{OH} and V_{OL}. Use Equation 1 to calculate the V_{OH} as a result of an external pull down resistor.

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

  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 (1)

9.2.3 Application Curve



V_{CCA} = 1.8 V V_{CCB} = 5 V

Figure 12. Level-Translation of a 2.5-MHz Signal

10 Power Supply Recommendations

The TXS0102-Q1 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 V_{CCA} 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 TXS0102-Q1 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. To assure 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.

11 Layout

11.1 Layout Guidelines

To assure reliability of the device, 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, assuring that any reflection encounters low impedance at the source driver.
- To help adjust rise and fall times of signals depending on system requirements, place pads on the signal paths for loading capacitors or pullup resistors.

11.2 Layout Example

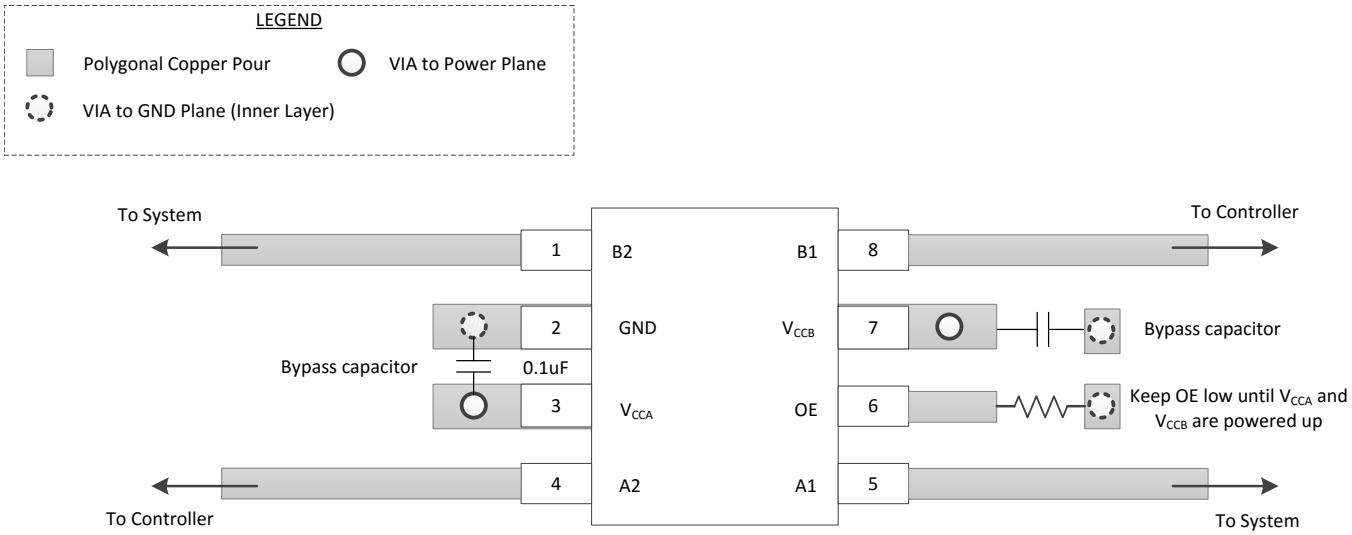


Figure 13. TXS0102-Q1 Layout Example

12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation

For related documentation see the following:

Introduction to Logic

12.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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.

12.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.4 Trademarks

NanoFree, E2E are trademarks of Texas Instruments.
All other trademarks are the property of their respective owners.

12.5 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.

12.6 Glossary

SLYZ022 — *TI Glossary*.

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

13 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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TXS0102QDCURQ1	ACTIVE	VSSOP	DCU	8	3000	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	NG3R	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

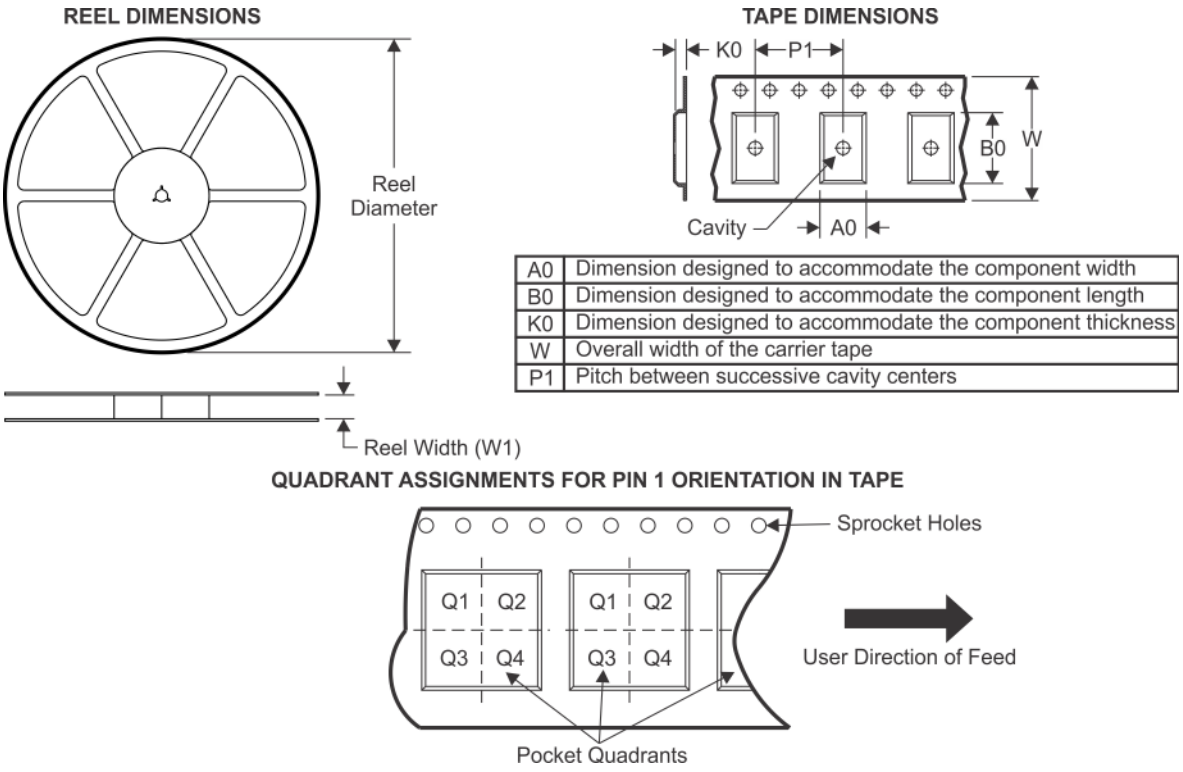
OTHER QUALIFIED VERSIONS OF TXS0102-Q1 :

- Catalog : TXS0102

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

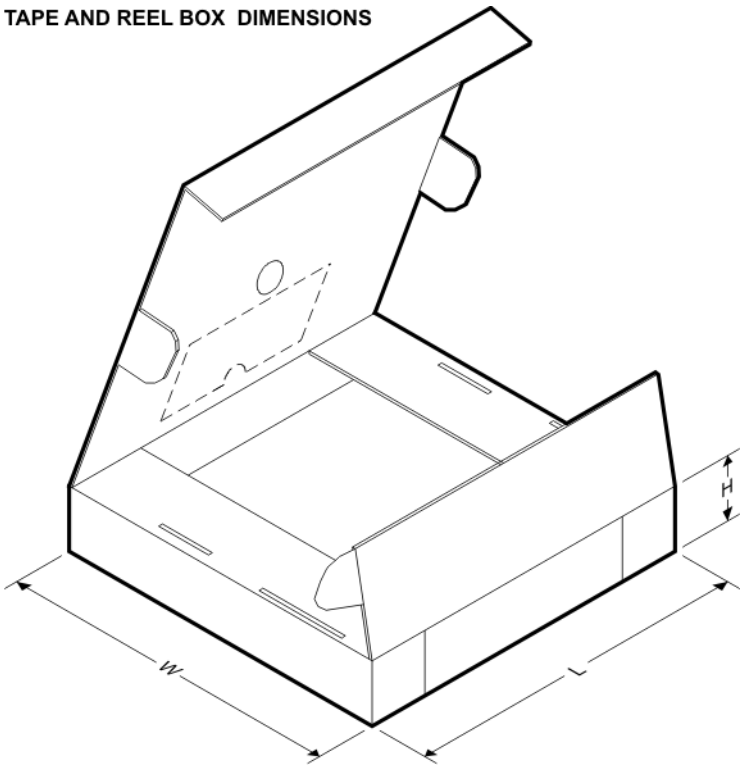


A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

*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
TXS0102QDCURQ1	VSSOP	DCU	8	3000	180.0	8.4	2.25	3.35	1.05	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

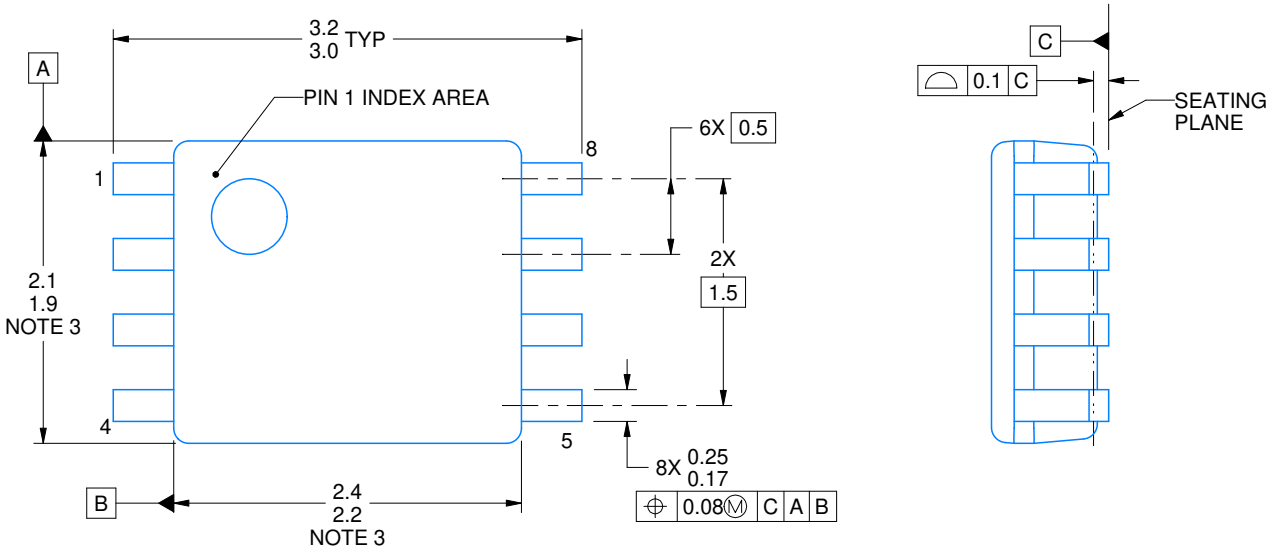
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TXS0102QDCURQ1	VSSOP	DCU	8	3000	213.0	191.0	35.0

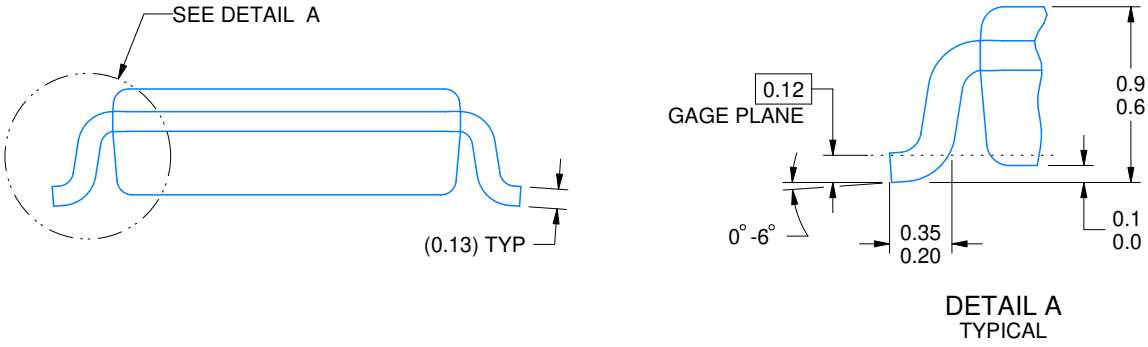
DCU0008A

PACKAGE OUTLINE

VSSOP - 0.9 mm max height

SMALL OUTLINE PACKAGE





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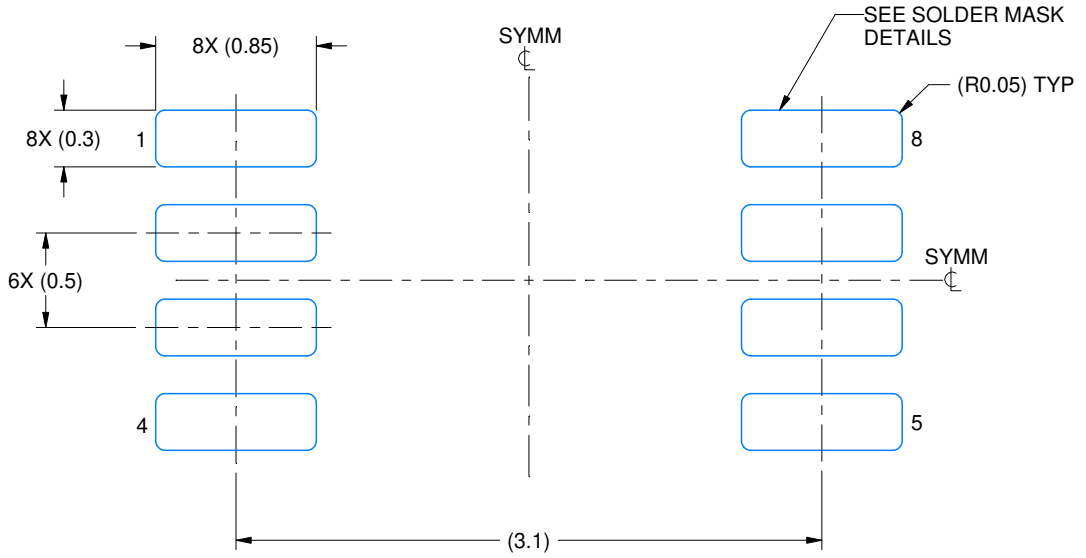
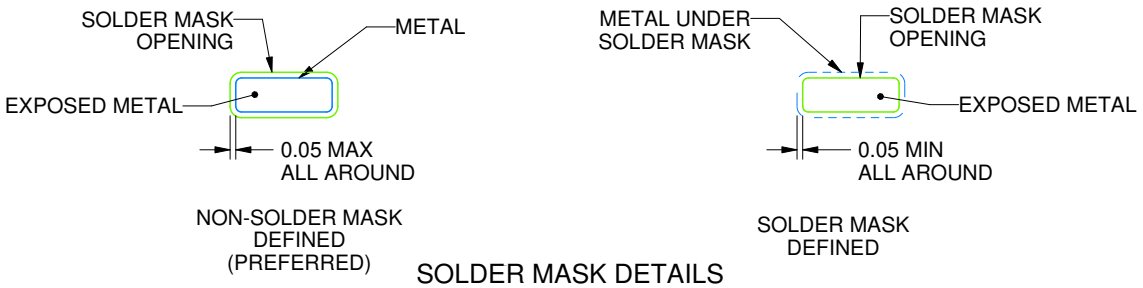
NOTES:

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-187 variation CA.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 25X



SOLDER MASK DETAILS

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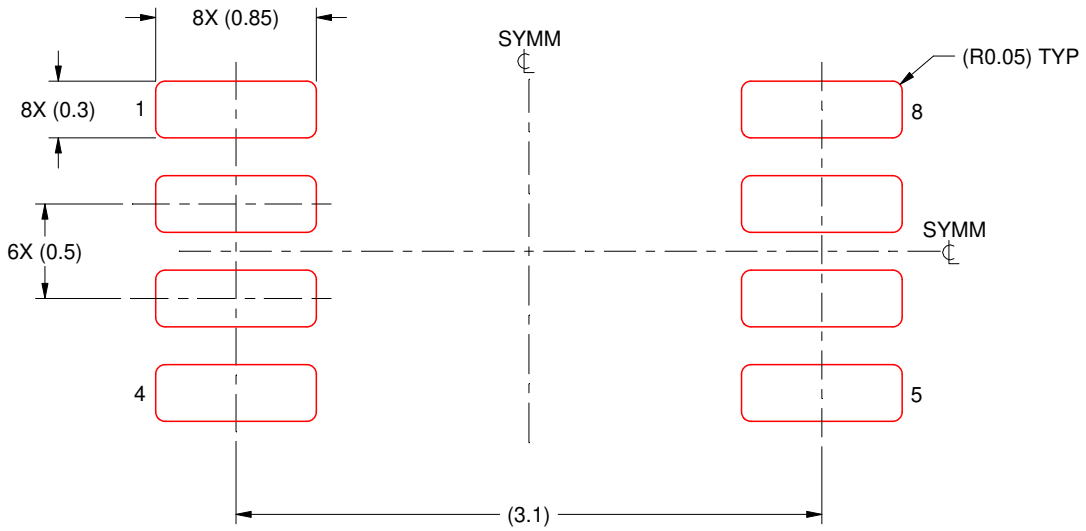
NOTES: (continued)

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: 25X

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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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