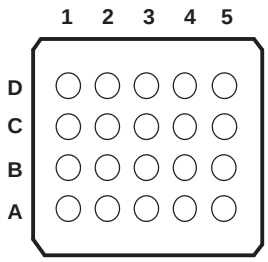
8-BIT BIDIRECTIONAL VOLTAGE-LEVEL TRANSLATOR WITH AUTO-DIRECTION SENSING AND ±15-kV ESD PROTECTION

Check for Samples: TXB0108

FEATURES

- 1.2 V to 3.6 V on A Port and 1.65 to 5.5 V on B Port ($V_{CCA} \leq V_{CCB}$)
- V_{CC} Isolation Feature – If Either V_{CC} Input Is at GND, All Outputs Are in the High-Impedance State
- OE Input Circuit Referenced to V_{CCA}
- Low Power Consumption, 4-μA Max I_{CC}
- I_{off} Supports Partial-Power-Down Mode Operation
- 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)
    - 1000-V Charged-Device Model (C101)
  - B Port
    - ±15-kV Human-Body Model (A114-B)
    - 1000-V Charged-Device Model (C101)

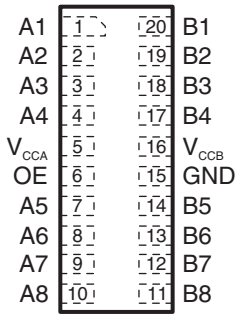
GXY OR ZXY PACKAGE
(BOTTOM VIEW)



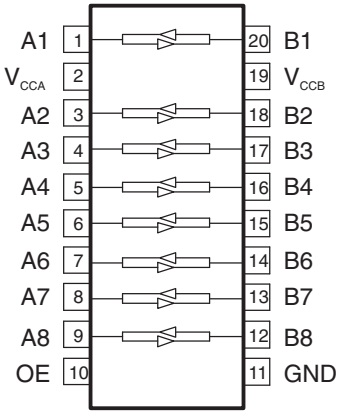
TERMINAL ASSIGNMENTS
(20-Ball GXY/ZXY Package)

	1	2	3	4	5
D	V_{CCB}	B2	B4	B6	B8
C	B1	B3	B5	B7	GND
B	A1	A3	A5	A7	OE
A	V_{CCA}	A2	A4	A6	A8

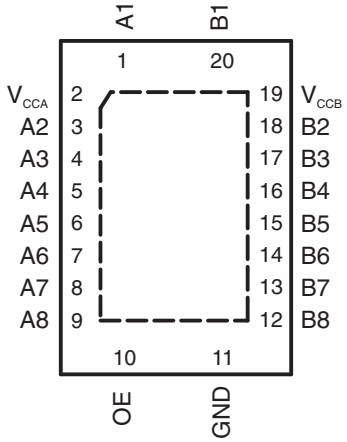
DQS PACKAGE
(TOP VIEW)



PW PACKAGE
(TOP VIEW)



RGY PACKAGE
(TOP VIEW)



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DESCRIPTION/ORDERING INFORMATION

This 8-bit noninverting translator uses two separate configurable power-supply rails. The A port is designed to track V_{CCA}. V_{CCA} accepts any supply voltage from 1.2 V to 3.6 V. The B port is designed to track V_{CCB}. V_{CCB} accepts any supply voltage from 1.65 V to 5.5 V. This allows for universal low-voltage bidirectional translation between any of the 1.2-V, 1.5-V, 1.8-V, 2.5-V, 3.3-V, and 5-V voltage nodes. V_{CCA} should not exceed V_{CCB}.

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

The TXB0101 is designed so that the OE input circuit is supplied by V_{CCA}.

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

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

Table 1. ORDERING INFORMATION(1)

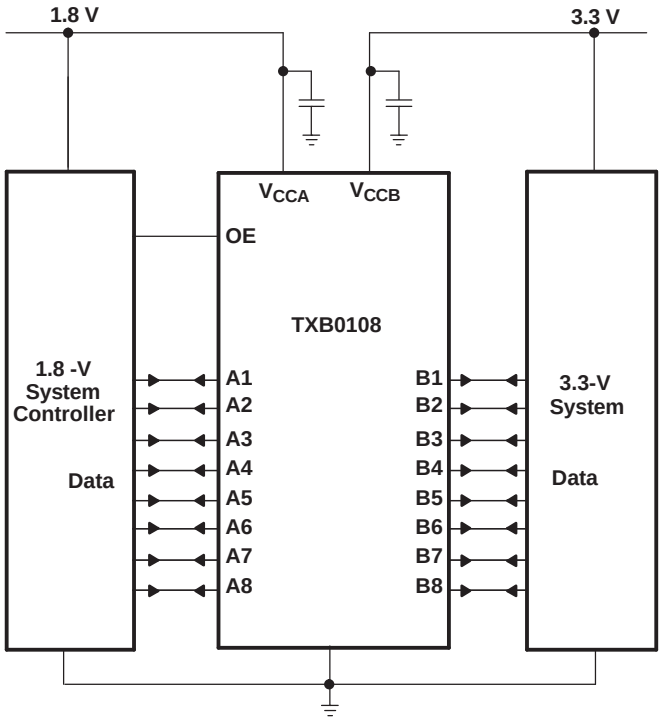
T_A	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	QFN – RGY	Reel of 1000	TXB0108RGYR	YE08
	SON – DQS	Reel of 2000	TXB0108DQSR	5MR
	TSSOP – PW	Reel of 2000	TXB0108PWR	YE08
	VFBGA – GXY	Reel of 2500	TXB0108GXYR	YE08
	VFBGA – ZXY (Pb-free)	Reel of 2500	TXB0108ZXYR	YE08

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

PIN DESCRIPTION

NO. (DQS, PW, RGY)	NAME	FUNCTION
1	A1	Input/output 1. Referenced to V_{CCA}.
2	V_{CCA}	A-port supply voltage. 1.1 V ≤ V_{CCA} ≤ 3.6 V, V_{CCA} ≤ V_{CCB}.
3	A2	Input/output 2. Referenced to V_{CCA}.
4	A3	Input/output 3. Referenced to V_{CCA}.
5	A4	Input/output 4. Referenced to V_{CCA}.
6	A5	Input/output 5. Referenced to V_{CCA}.
7	A6	Input/output 6. Referenced to V_{CCA}.
8	A7	Input/output 7. Referenced to V_{CCA}.
9	A8	Input/output 8. Referenced to V_{CCA}.
10	OE	Output enable. Pull OE low to place all outputs in 3-state mode. Referenced to V_{CCA}.
11	GND	Ground
12	B8	Input/output 8. Referenced to V_{CCB}.
13	B7	Input/output 7. Referenced to V_{CCB}.
14	B6	Input/output 6. Referenced to V_{CCB}.
15	B5	Input/output 5. Referenced to V_{CCB}.
16	B4	Input/output 4. Referenced to V_{CCB}.
17	B3	Input/output 3. Referenced to V_{CCB}.
18	B2	Input/output 2. Referenced to V_{CCB}.
19	V_{CCB}	B-port supply voltage. 1.65 V ≤ V_{CCB} ≤ 5.5 V.
20	B1	Input/output 1. Referenced to V_{CCB}.

TYPICAL OPERATING CIRCUIT



Absolute Maximum Ratings(1)

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

			MIN	MAX	UNIT
V_{CCA}	Supply voltage range		–0.5	4.6	V
V_{CCB}	Supply voltage range		–0.5	6.5	V
V_I	Input voltage range(2)		–0.5	6.5	V
V_O	Voltage range applied to any output in the high-impedance or power-off state(2)		–0.5	6.5	V
V_O	Voltage range applied to any output in the high or low state(2) (3)	A inputs	–0.5	V_{CCA} + 0.5	V
		B inputs	–0.5	V_{CCB} + 0.5	
I_{IK}	Input clamp current	V_I < 0		–50	mA
I_{OK}	Output clamp current	V_O < 0		–50	mA
I_O	Continuous output current			±50	mA
	Continuous current through V_{CCA}, V_{CCB}, or GND			±100	mA
θ_{JA}	Package thermal impedance	DQS package		TBD	°C/W
		GXY/ZXY package(4)		78	
		PW package(4)		83	
		RGY package(5)		37	
T_{stg}	Storage temperature range		–65	150	°C

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) 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.
(4) The package thermal impedance is calculated in accordance with JESD 51-7.
(5) The package thermal impedance is calculated in accordance with JESD 51-5.

Recommended Operating Conditions (1) (2)

			V_{CCA}	V_{CCB}	MIN	MAX	UNIT
V_{CCA}	Supply voltage				1.2	3.6	V
V_{CCB}					1.65	5.5	
V_{IH}	High-level input voltage	Data inputs	1.2 V to 3.6 V	1.65 V to 5.5 V	V_{CCI} x 0.65 (3)	V_{CCI}	V
		OE			V_{CCA} x 0.65	5.5	
V_{IL}	Low-level input voltage	Data inputs	1.2 V to 5.5 V	1.65 V to 5.5 V	0	V_{CCI} x 0.35 (3)	V
		OE	1.2 V to 3.6 V		0	V_{CCA} x 0.35	
Δt/Δv	Input transition rise or fall rate	A-port inputs	1.2 V to 3.6 V	1.65 V to 5.5 V		40	ns/V
		B-port inputs	1.2 V to 3.6 V	1.65 V to 3.6 V		40	
				4.5 V to 5.5 V		30	
T_A	Operating free-air temperature				–40	85	°C

(1) The A and B sides of an unused data I/O pair must be held in the same state, i.e., both at V_{CCI} or both at GND.
(2) V_{CCA} must be less than or equal to V_{CCB} and must not exceed 3.6 V.
(3) V_{CCI} is the supply voltage associated with the input port.

Electrical Characteristics (1) (2)

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

PARAMETER		TEST CONDITIONS	V_{CCA}	V_{CCB}	T_A = 25°C			–40°C to 85°C		UNIT
					MIN	TYP	MAX	MIN	MAX	
V_{OHA}		I_{OH} = –20 μA	1.2 V			1.1				V
			1.4 V to 3.6 V					V_{CCA} – 0.4		
V_{OLA}		I_{OL} = 20 μA	1.2 V			0.9				V
			1.4 V to 3.6 V						0.4	
V_{OHB}		I_{OH} = –20 μA		1.65 V to 5.5 V				V_{CCB} – 0.4		V
V_{OLB}		I_{OL} = 20 μA		1.65 V to 5.5 V					0.4	V
I_I	OE		1.2 V to 3.6 V	1.65 V to 5.5 V			±1		±2	μA
I_{off}	A port		0 V	0 V to 5.5 V			±1		±2	μA
	B port		0 V to 3.6 V	0 V			±1		±2	
I_{OZ}	A or B port	OE = GND	1.2 V to 3.6 V	1.65 V to 5.5 V			±1		±2	μA
I_{CCA}		V_I = V_{CCI} or GND, I_O = 0	1.2 V	1.65 V to 5.5 V		0.06				μA
			1.4 V to 3.6 V						5	
			3.6 V	0 V					2	
			0 V	5.5 V					–2	
I_{CCB}		V_I = V_{CCI} or GND, I_O = 0	1.2 V	1.65 V to 5.5 V		3.4				μA
			1.4 V to 3.6 V						5	
			3.6 V	0 V					–2	
			0 V	5.5 V					2	
I_{CCA} + I_{CCB}		V_I = V_{CCI} or GND, I_O = 0	1.2 V	1.65 V to 5.5 V		3.5				μA
			1.4 V to 3.6 V						10	
I_{CCZA}		V_I = V_{CCI} or GND, I_O = 0, OE = GND	1.2 V	1.65 V to 5.5 V		0.05				μA
			1.4 V to 3.6 V						5	
I_{CCZB}		V_I = V_{CCI} or GND, I_O = 0, OE = GND	1.2 V	1.65 V to 5.5 V		3.3				μA
			1.4 V to 3.6 V						5	
C_I	OE		1.2 V to 3.6 V	1.65 V to 5.5 V		5			5.5	pF
C_{io}	A port		1.2 V to 3.6 V	1.65 V to 5.5 V		5			6.5	pF
	B port					8			10	

(1) V_{CCI} is the supply voltage associated with the input port.
(2) V_{CCO} is the supply voltage associated with the output port.

Timing Requirements

T_A = 25°C, V_{CCA} = 1.2 V

			V_{CCB} = 1.8 V	V_{CCB} = 2.5 V	V_{CCB} = 3.3 V	V_{CCB} = 5 V	UNIT
			TYP	TYP	TYP	TYP	
	Data rate		20	20	20	20	Mbps
t_w	Pulse duration	Data inputs	50	50	50	50	ns

Timing Requirements

over recommended operating free-air temperature range, V_{CCA} = 1.5 V ± 0.1 V (unless otherwise noted)

			V_{CCB} = 1.8 V ± 0.15 V		V_{CCB} = 2.5 V ± 0.2 V		V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
	Data rate			50		50		50		50	Mbps
t_w	Pulse duration	Data inputs	20		20		20		20		ns

Timing Requirements

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

			V_{CCB} = 1.8 V ± 0.15 V		V_{CCB} = 2.5 V ± 0.2 V		V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
	Data rate			52		60		60		60	Mbps
t_w	Pulse duration	Data inputs	19		17		17		17		ns

Timing Requirements

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

			V_{CCB} = 2.5 V ± 0.2 V		V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
	Data rate			70		100		100	Mbps
t_w	Pulse duration	Data inputs	14		10		10		ns

Timing Requirements

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

			V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	
	Data rate			100		100	Mbps
t_w	Pulse duration	Data inputs	10		10		ns

Switching Characteristics

T_A = 25°C, V_{CCA} = 1.2 V

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.8 V	V_{CCB} = 2.5 V	V_{CCB} = 3.3 V	V_{CCB} = 5 V	UNIT
			TYP	TYP	TYP	TYP	
t_{pd}	A	B	9.5	7.9	7.6	8.5	ns
	B	A	9.2	8.8	8.4	8	
t_{en}	OE	A	1	1	1	1	µs
		B	1	1	1	1	
t_{dis}	OE	A	20	17	17	18	ns
		B	20	16	15	15	
t_{rA}, t_{fA}	A-port rise and fall times		4.1	4.4	4.1	3.9	ns
t_{rB}, t_{fB}	B-port rise and fall times		5	5	5.1	5.1	ns
$t_{SK(O)}$	Channel-to-channel skew		2.4	1.7	1.9	7	ns
Max data rate			20	20	20	20	Mbps

Switching Characteristics

over recommended operating free-air temperature range, V_{CCA} = 1.5 V ± 0.1 V (unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.8 V ± 0.15 V		V_{CCB} = 2.5 V ± 0.2 V		V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{pd}	A	B	1.4	12.9	1.2	10.1	1.1	10	0.8	9.9	ns
	B	A	0.9	14.2	0.7	12	0.4	11.7	0.3	13.7	
t_{en}	OE	A		1		1		1		1	µs
		B		1		1		1		1	
t_{dis}	OE	A	6.6	33	6.4	25.3	6.1	23.1	5.9	24.6	ns
		B	6.6	35.6	5.8	25.6	5.5	22.1	5.6	20.6	
t_{rA}, t_{fA}	A-port rise and fall times		0.8	6.5	0.8	6.3	0.8	6.3	0.8	6.3	ns
t_{rB}, t_{fB}	B-port rise and fall times		1	7.3	0.7	4.9	0.7	4.6	0.6	4.6	ns
$t_{SK(O)}$	Channel-to-channel skew			2.6		1.9		1.6		1.3	ns
Max data rate			50		50		50		50		Mbps

Switching Characteristics

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

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.8 V ± 0.15 V		V_{CCB} = 2.5 V ± 0.2 V		V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{pd}	A	B	1.6	11	1.4	7.7	1.3	6.8	1.2	6.5	ns
	B	A	1.5	12	1.2	8.4	0.8	7.6	0.5	7.1	
t_{en}	OE	A		1		1		1		1	µs
		B		1		1		1		1	
t_{dis}	OE	A	5.9	26.7	5.6	21.6	5.4	18.9	4.8	18.7	ns
		B	6.1	33.9	5.2	23.7	5	19.9	5	17.6	
t_{rA}, t_{fA}	A-port rise and fall times		0.7	5.1	0.7	5	1	5	0.7	5	ns
t_{rB}, t_{fB}	B-port rise and fall times		1	7.3	0.7	5	0.7	3.9	0.6	3.8	ns
$t_{SK(O)}$	Channel-to-channel skew			0.8		0.7		0.6		0.6	ns
Max data rate			52		60		60		60		Mbps

Switching Characteristics

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

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 2.5 V ± 0.2 V		V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t_{pd}	A	B	1.1	6.4	1	5.3	0.9	4.7	ns
	B	A	1	7	0.6	5.6	0.3	4.4	
t_{en}	OE	A		1		1		1	µs
		B		1		1		1	
t_{dis}	OE	A	5	16.9	4.9	15	4.5	13.8	ns
		B	4.8	21.8	4.5	17.9	4.4	15.2	
t_{rA}, t_{fA}	A-port rise and fall times		0.8	3.6	0.6	3.6	0.5	3.5	ns
t_{rB}, t_{fB}	B-port rise and fall times		0.6	4.9	0.7	3.9	0.6	3.2	ns
$t_{SK(O)}$	Channel-to-channel skew			0.4		0.3		0.3	ns
Max data rate			70		100		100		Mbps

Switching Characteristics

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

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	
t_{pd}	A	B	0.9	4.9	0.8	4	ns
	B	A	0.5	5.4	0.2	4	
t_{en}	OE	A		1		1	µs
		B		1		1	
t_{dis}	OE	A	4.5	13.9	4.1	12.4	ns
		B	4.1	17.3	4	14.4	
t_{rA}, t_{fA}	A-port rise and fall times		0.5	3	0.5	3	ns
t_{rB}, t_{fB}	B-port rise and fall times		0.7	3.9	0.6	3.2	ns
$t_{SK(O)}$	Channel-to-channel skew			0.4		0.3	ns
Max data rate			100		100		Mbps

Operating Characteristics

T_A = 25°C

PARAMETER		TEST CONDITIONS	V_{CCA}							UNIT
			1.2 V	1.2 V	1.5 V	1.8 V	2.5 V	2.5 V	3.3 V	
			V_{CCB}							
			5 V	1.8 V	1.8 V	1.8 V	2.5 V	5 V	3.3 V to 5 V	
			TYP	TYP	TYP	TYP	TYP	TYP	TYP	
C_{pdA}	A-port input, B-port output	C_L = 0, f = 10 MHz, $t_r = t_f$ = 1 ns, OE = V_{CCA} (outputs enabled)	9	8	7	7	7	7	8	pF
	B-port input, A-port output		12	11	11	11	11	11	11	
C_{pdB}	A-port input, B-port output		35	26	27	27	27	27	28	
	B-port input, A-port output		26	19	18	18	18	20	21	
C_{pdA}	A-port input, B-port output	C_L = 0, f = 10 MHz, $t_r = t_f$ = 1 ns, OE = GND (outputs disabled)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	pF
	B-port input, A-port output		0.01	0.01	0.01	0.01	0.01	0.01	0.01	
C_{pdB}	A-port input, B-port output		0.01	0.01	0.01	0.01	0.01	0.01	0.03	
	B-port input, A-port output		0.01	0.01	0.01	0.01	0.01	0.01	0.03	

PRINCIPLES OF OPERATION

Applications

The TXB0108 can be used in level-translation applications for interfacing devices or systems operating at different interface voltages with one another.

Architecture

The TXB0108 architecture (see Figure 1) does not require a direction-control signal to control the direction of data flow from A to B or from B to A. In a dc state, the output drivers of the TXB0108 can maintain a high or low, but are designed to be weak, so that they can be overdriven by an external driver when data on the bus starts flowing the opposite direction.

The output one shots detect rising or falling edges on the A or B ports. During a rising edge, the one shot turns on the PMOS transistors (T1, T3) for a short duration, which speeds up the low-to-high transition. Similarly, during a falling edge, the one shot turns on the NMOS transistors (T2, T4) for a short duration, which speeds up the high-to-low transition. The typical output impedance during output transition is 70Ω at V_{CCO} = 1.2 V to 1.8 V, 50Ω at V_{CCO} = 1.8 V to 3.3 V and 40Ω at V_{CCO} = 3.3 V to 5 V.

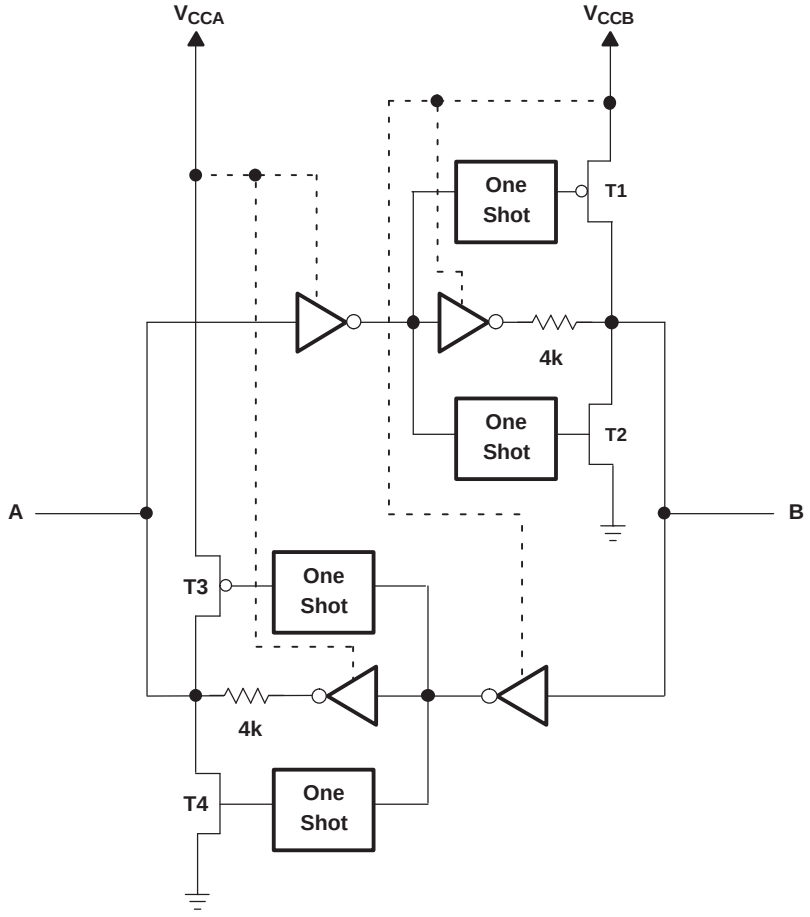
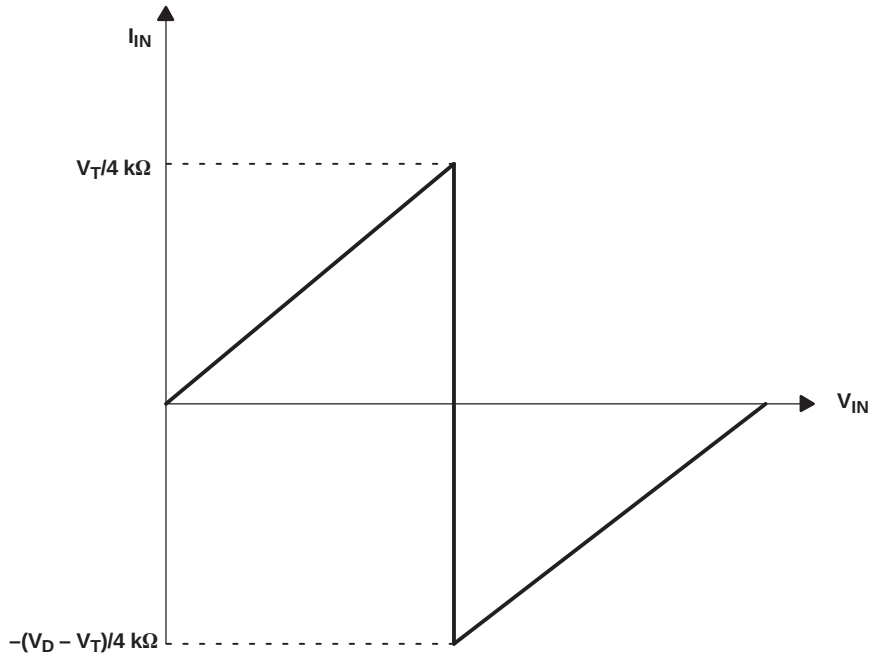


Figure 1. Architecture of TXB0108 I/O Cell

Input Driver Requirements

Typical I_{IN} vs V_{IN} characteristics of the TXB0108 are shown in Figure 2. For proper operation, the device driving the data I/Os of the TXB0108 must have drive strength of at least ±2 mA.



A. V_T is the input threshold voltage of the TXB0108 (typically V_{CCI}/2).
B. V_D is the supply voltage of the external driver.

Figure 2. Typical I_{IN} vs V_{IN} Curve

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. The TXB0108 has circuitry that disables all output ports when either V_{CC} is switched off ($V_{CCA/B}$ = 0 V).

Enable and Disable

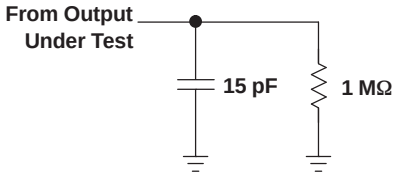
The TXB0108 has an OE input that is used to disable the device by setting OE = low, which places all I/Os in the high-impedance (Hi-Z) state. The disable time (t_{dis}) indicates the delay between when OE goes low and when the outputs actually get disabled (Hi-Z). The enable time (t_{en}) indicates the amount of time the user must allow for the one-shot circuitry to become operational after OE is taken high.

Pullup or Pulldown Resistors on I/O Lines

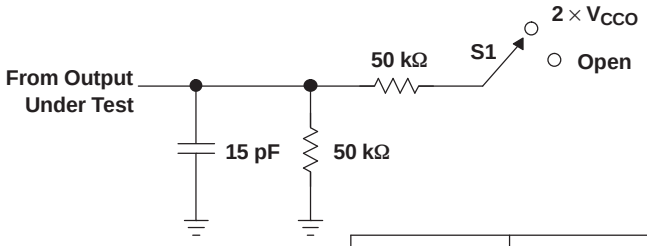
The TXB0108 is designed to drive capacitive loads of up to 70 pF. The output drivers of the TXB0108 have low dc drive strength. If pullup or pulldown resistors are connected externally to the data I/Os, their values must be kept higher than 50 kΩ to ensure that they do not contend with the output drivers of the TXB0108.

For the same reason, the TXB0108 should not be used in applications such as I^2C or 1-Wire where an open-drain driver is connected on the bidirectional data I/O. For these applications, use a device from the TI TXS01xx series of level translators.

PARAMETER MEASUREMENT INFORMATION

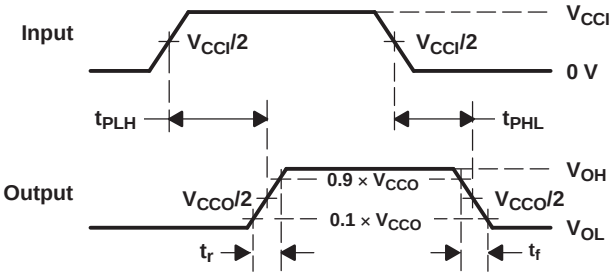


LOAD CIRCUIT FOR MAX DATA RATE, PULSE DURATION PROPAGATION DELAY OUTPUT RISE AND FALL TIME MEASUREMENT

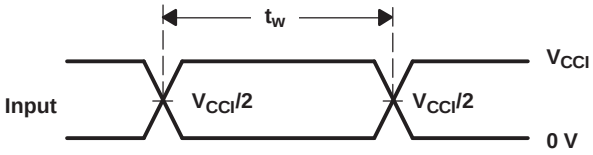


LOAD CIRCUIT FOR ENABLE/DISABLE TIME MEASUREMENT

TEST	S1
t_{PZL}/t_{PLZ} t_{PHZ}/t_{PZH}	$2 \times V_{CCO}$ Open



VOLTAGE WAVEFORMS PROPAGATION DELAY TIMES



VOLTAGE WAVEFORMS PULSE DURATION

A. C_L includes probe and jig capacitance.
B. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, dv/dt ≥ 1 V/ns.
C. The outputs are measured one at a time, with one transition per measurement.
D. t_{PLH} and t_{PHL} are the same as t_{pd}.
E. V_{CCI} is the V_{CC} associated with the input port.
F. V_{CCO} is the V_{CC} associated with the output port.
G. All parameters and waveforms are not applicable to all devices.

Figure 3. Load Circuits and Voltage Waveforms

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/ Ball Finish	MSL Peak Temp [3]	Samples (Requires Login)
TXB0108DQSR	ACTIVE	USON	DQS	20	3000	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM	Request Free Samples
TXB0108PWR	ACTIVE	TSSOP	PW	20	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Request Free Samples
TXB0108PWRG4	ACTIVE	TSSOP	PW	20	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Request Free Samples
TXB0108RGYR	ACTIVE	VQFN	RGY	20	3000	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	Request Free Samples
TXB0108RGYRG4	ACTIVE	VQFN	RGY	20	3000	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	Request Free Samples
TXB0108ZXYR	ACTIVE	BGA MICROSTAR JUNIOR	ZXY	20	2500	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	Request Free 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.

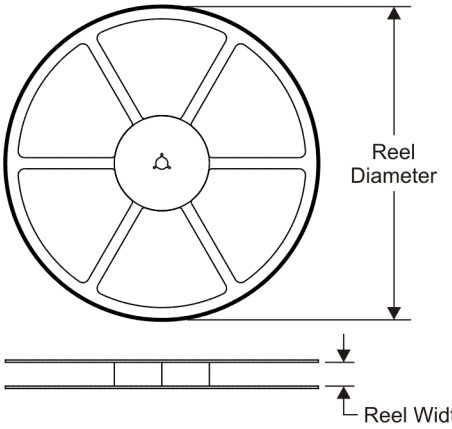
[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

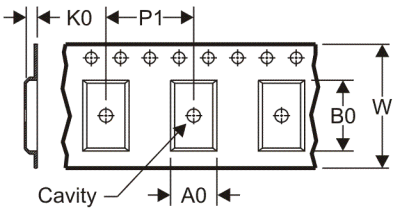
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

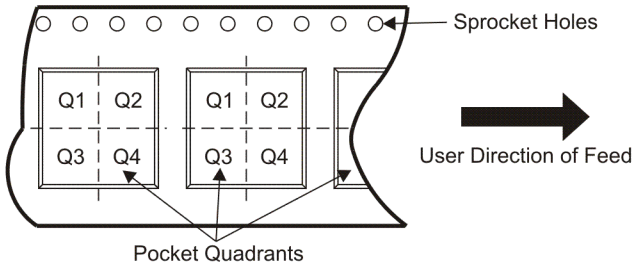


TAPE DIMENSIONS



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

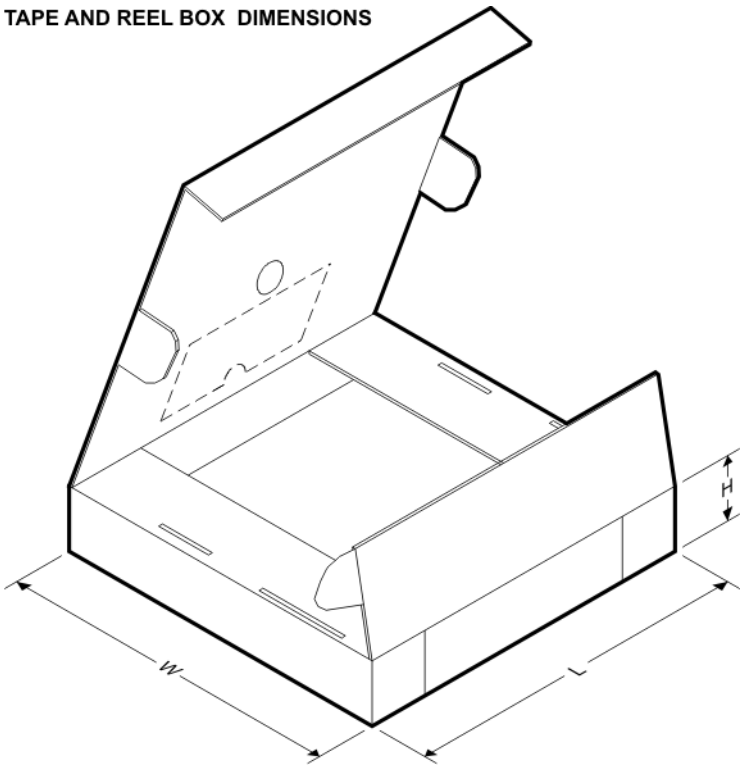
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TXB0108DQSR	USON	DQS	20	3000	177.8	12.4	2.21	4.22	0.81	4.0	12.0	Q1
TXB0108PWR	TSSOP	PW	20	2000	330.0	16.4	6.95	7.1	1.6	8.0	16.0	Q1
TXB0108RGYR	VQFN	RGY	20	3000	330.0	12.4	3.8	4.8	1.6	8.0	12.0	Q1
TXB0108ZXYR	BGA MICROSTAR JUNIOR	ZXY	20	2500	330.0	12.4	2.8	3.3	1.0	4.0	12.0	Q2

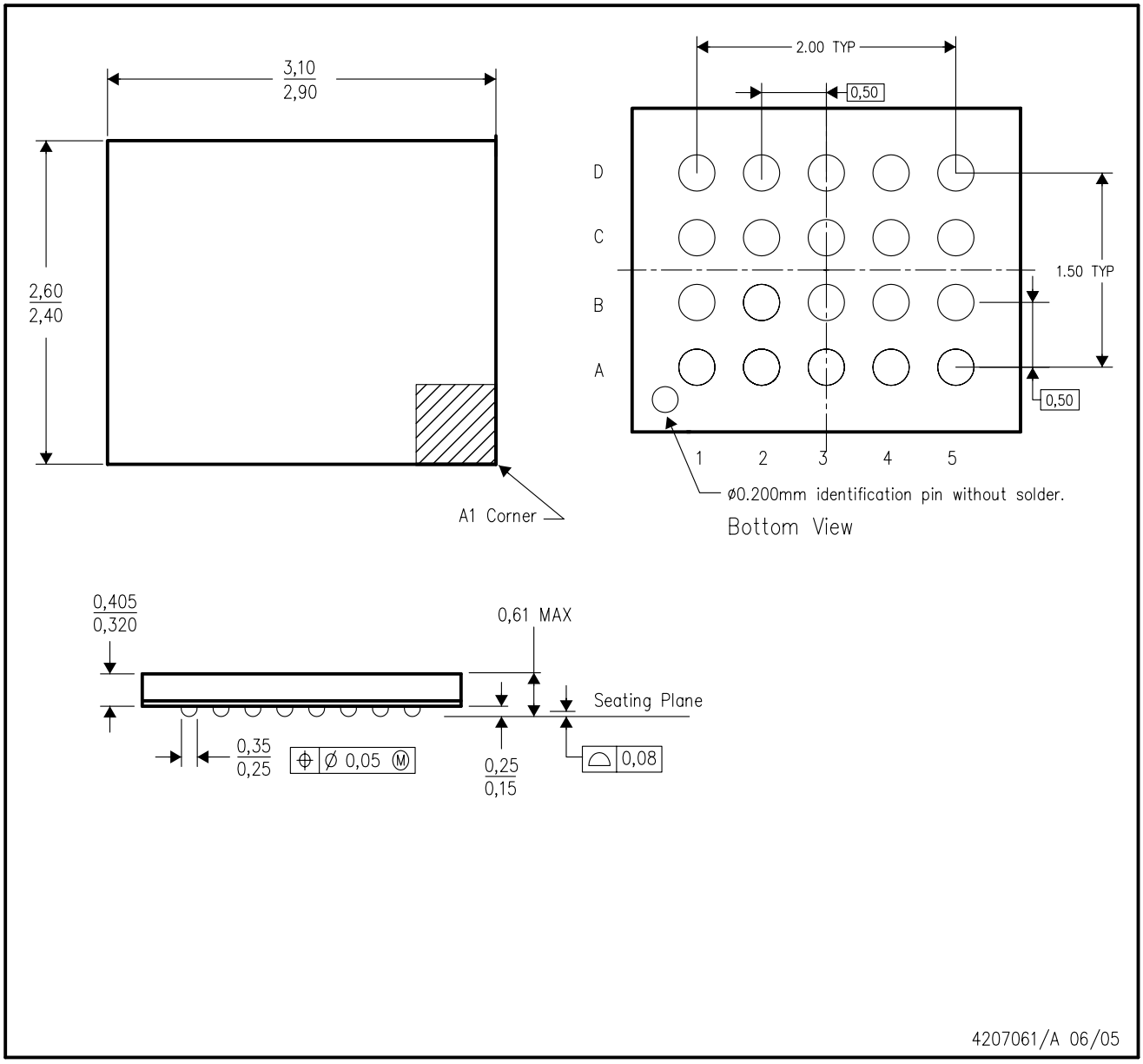
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

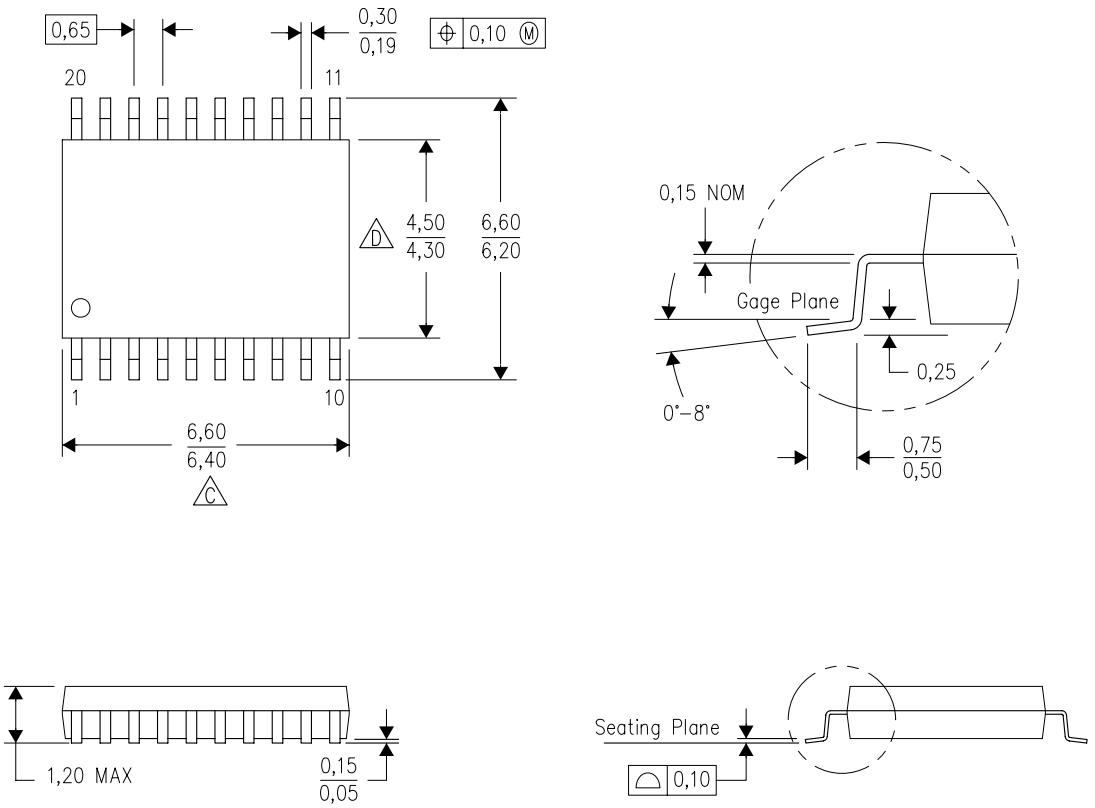
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TXB0108DQSR	USON	DQS	20	3000	202.0	201.0	28.0
TXB0108PWR	TSSOP	PW	20	2000	346.0	346.0	33.0
TXB0108RGYR	VQFN	RGY	20	3000	355.0	350.0	50.0
TXB0108ZXYR	BGA MICROSTAR JUNIOR	ZXY	20	2500	340.5	338.1	20.6

ZXY (S–PBGA–N20) PLASTIC BALL GRID ARRAY



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. This package is a lead–free solder ball design.

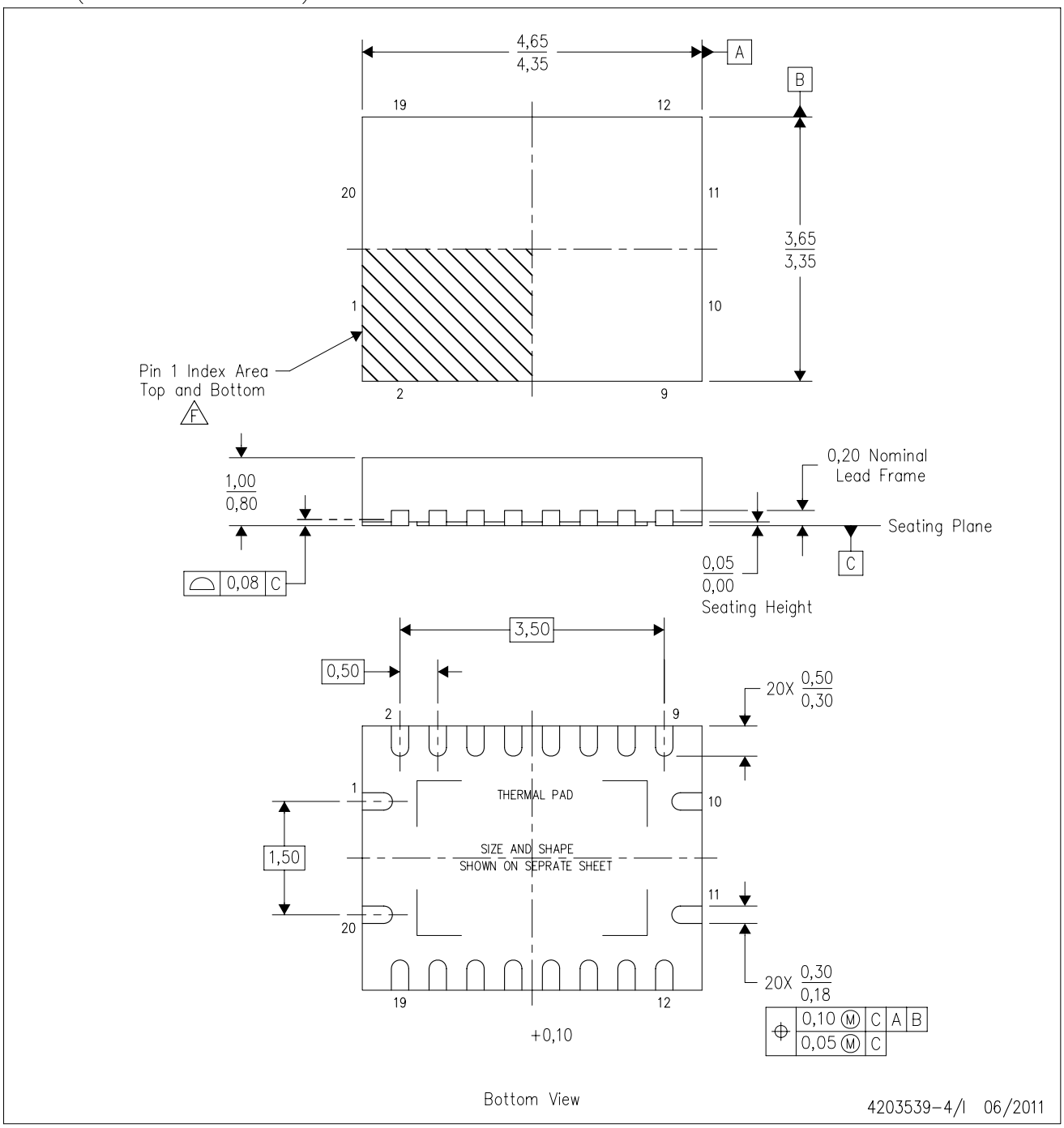
PW (R–PDSO–G20) PLASTIC SMALL OUTLINE



4040064–5/G 02/11

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. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
E. Falls within JEDEC MO–153

RGY (R–PVQFN–N20) PLASTIC QUAD FLATPACK NO–LEAD



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. QFN (Quad Flatpack No–Lead) package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
F. Pin 1 identifiers are located on both top and bottom of the package and within the zone indicated. The Pin 1 identifiers are either a molded, marked, or metal feature.
G. Package complies to JEDEC MO–241 variation BA.

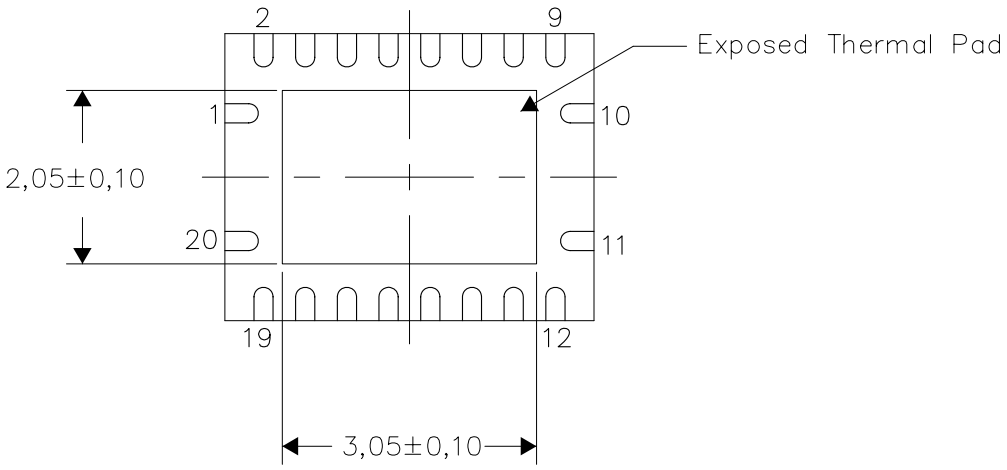
RGY (R–PVQFN–N20) PLASTIC QUAD FLATPACK NO–LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No–Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



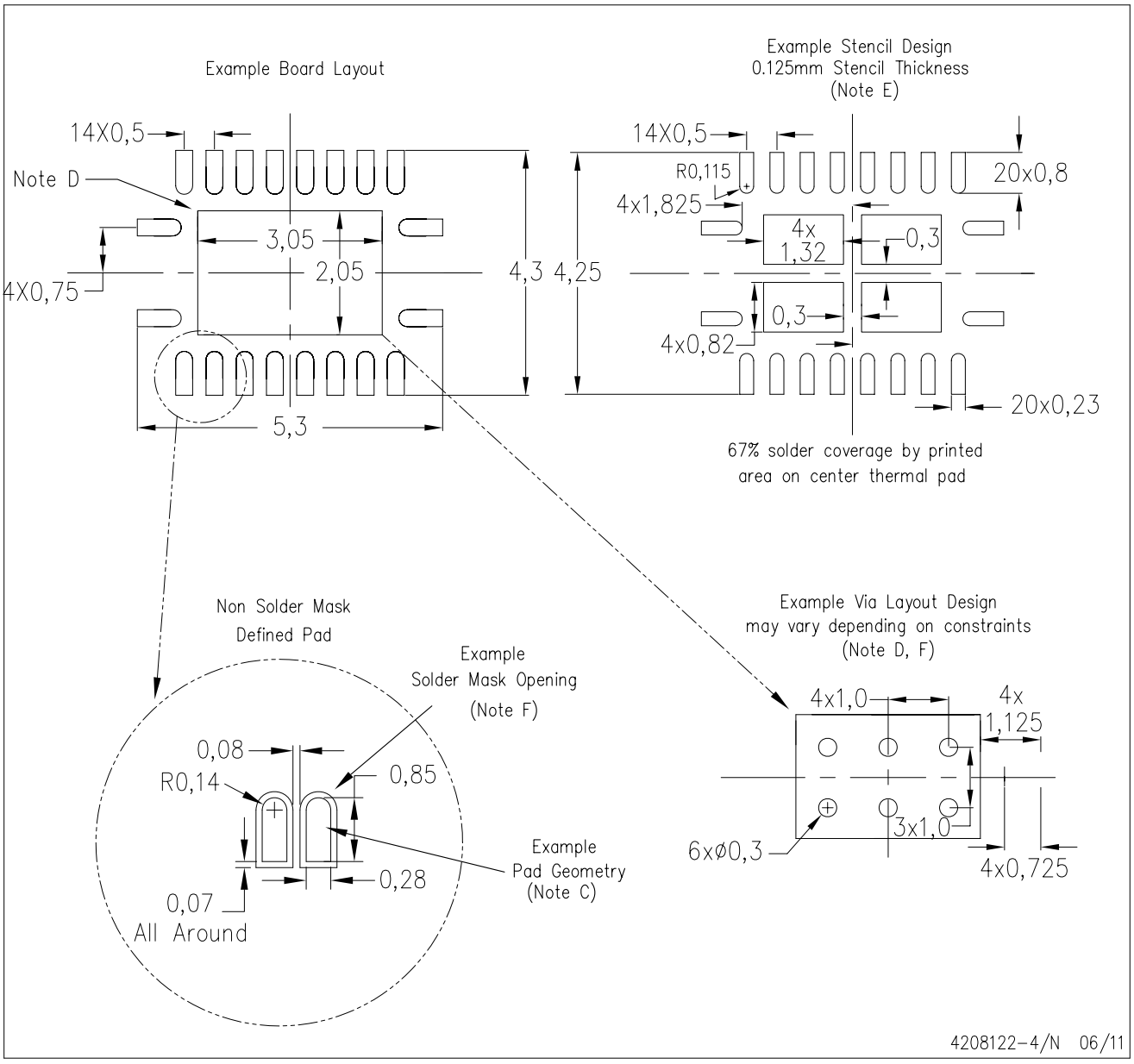
Bottom View

Exposed Thermal Pad Dimensions

4206353–4/N 06/11

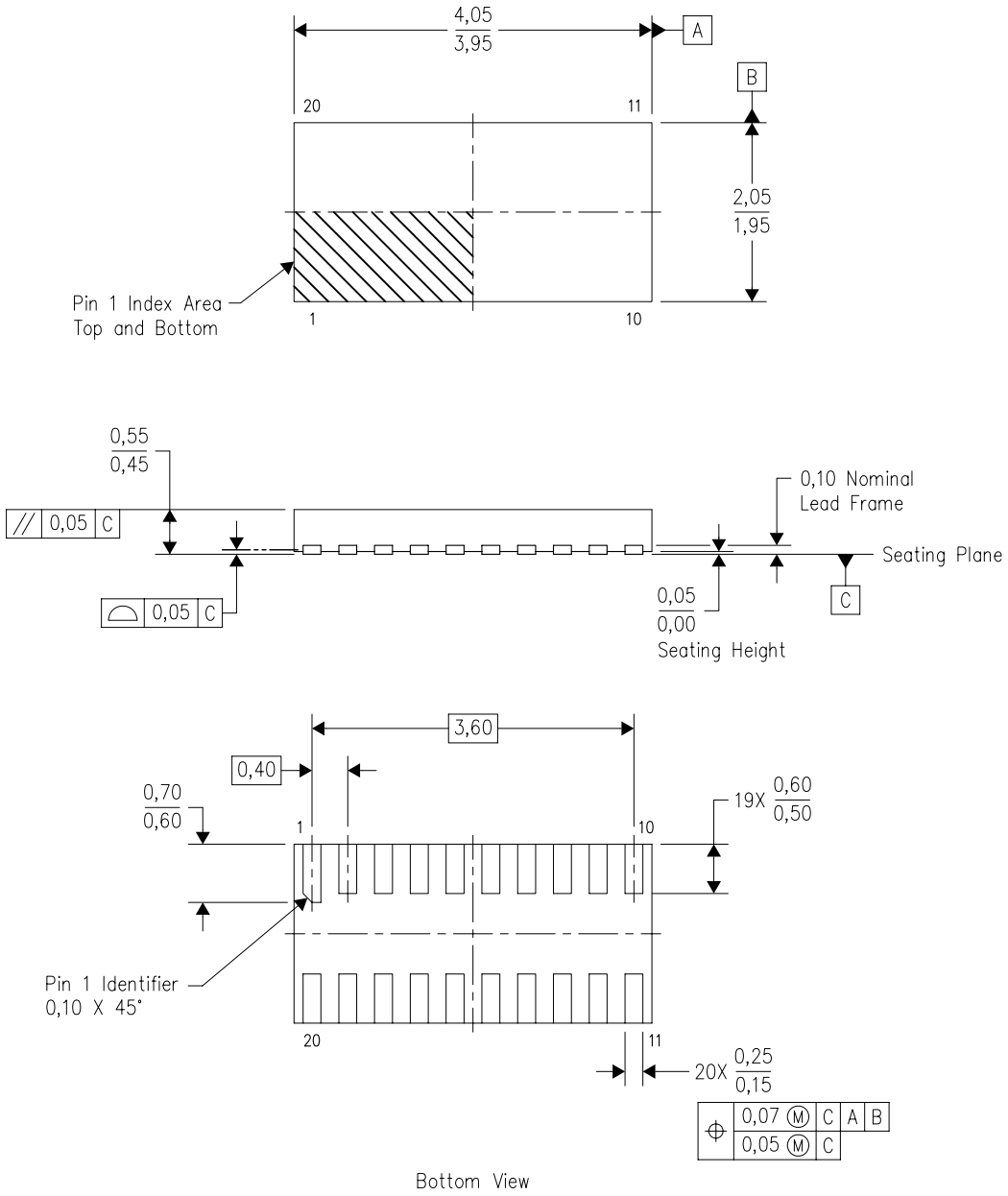
NOTE: A. All linear dimensions are in millimeters

RGY (R–PVQFN–N20) PLASTIC QUAD FLATPACK NO–LEAD



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat–Pack QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http://www.ti.com>.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
F. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.

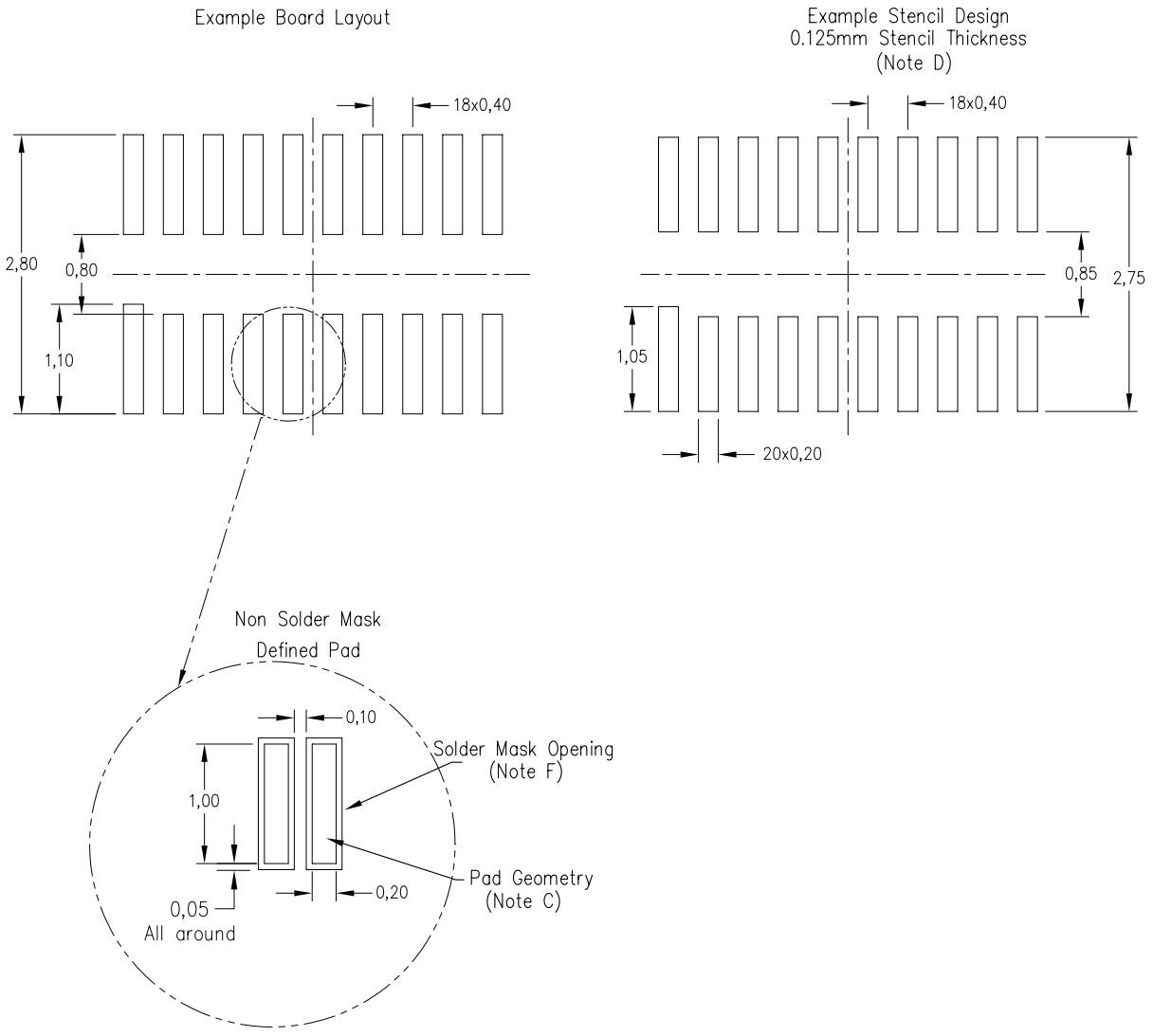
DQS (R–PUSON–N20) PLASTIC SMALL OUTLINE NO–LEAD



4210558/B 03/11

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. SON (Small Outline No–Lead) package configuration.

DQS (R–PUSON–N20) PLASTIC SMALL OUTLINE NO–LEAD



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
E. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.

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Interface	interface.ti.com	Security	www.ti.com/security
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	TI E2E Community Home Page		e2e.ti.com

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Application Report
SCEA043–March 2010

A Guide to Voltage Translation With TXB-Type Translators

Susan Curtis, Dave Moon *High Volume Linear*

ABSTRACT

Modern trends are driving the need for lower supply voltages across many system-level designs. As most processor voltage levels continue to decrease in the interest of achieving the lowest possible power consumption, peripheral devices maintain a need for higher voltage levels, creating potential for voltage discontinuities within a system. To remedy this mixed voltage system incompatibility, a voltage translator can be used.

Texas Instruments High Volume Linear group offers a wide range of voltage level translators. A variety of architectures provide solutions for different application environments including dual-supply direction-controlled, auto-direction sensing, and application-specific memory card interface translators.

The information in this application report is intended to help system designers understand the architecture and operation of the TXB-type auto-direction sensing translator family.

Contents

List of Figures

1 The Need For Voltage-Level Translation

The need for voltage level translation is becoming increasingly significant in today's electronic systems. As the digital switching level standards have continued to progress toward lower voltage levels, system incompatibilities have arisen. Figure 1 illustrates the trend toward lower system voltage levels and demonstrates the incompatibilities that mixed voltage systems can face.

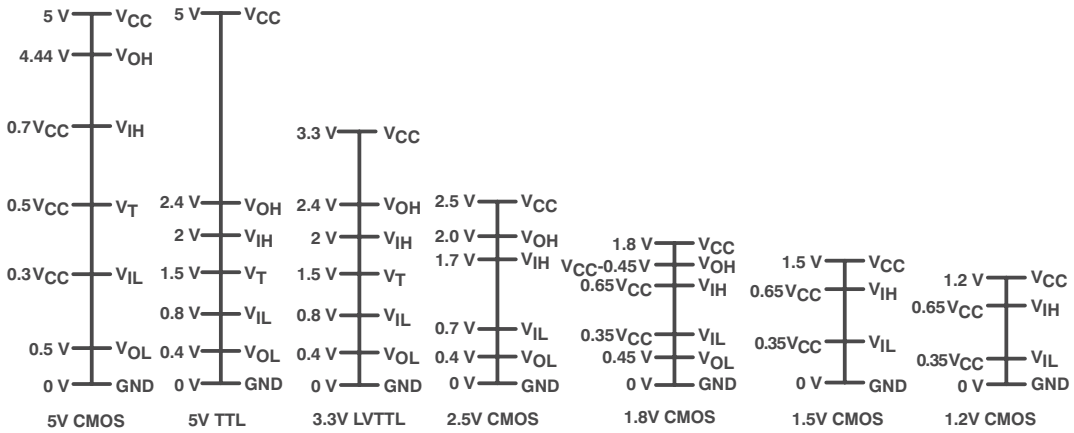

Figure 1. Digital Switching Levels

For two devices to interface reliably, the output driver voltages must be compatible with receiver input thresholds. For this condition to be met in mixed voltage systems, a voltage translator is often required.

Texas Instruments offers several unique device architectures for addressing voltage translation needs. The most familiar to system designers is probably a direction controlled buffer translator, such as the SN74AVC8T245. These translators can help remedy many problems in system voltage compatibility but do require DIR (direction) control pins. If the system environment does not provide a programmable GPIO to control the direction pin, an auto-direction sensing translator architecture can provide an alternative translation solution.

2 Auto-Direction Sensing Voltage Translator Architecture

If a processer GPIO input direction-control signal is not available or if one is not desired, an auto-direction sensing voltage translator can provide a robust solution. As the name implies, this type of translator does not require the use of a direction control signal, and each channel supports independent transmission or reception of data. This eliminates the need for a processor GPIO to control a DIR input, resulting in simplified software driver development as well as smaller device packaging due to reduced pin-count.

The TXB push-pull buffered type architecture does not require a DIR control signal to establish the direction of data flow. This architecture is designed to exclusively be connected and interfaced with a push-pull CMOS driver and is capable of driving a capacitive or high impedance loads in applications such as Secure Digital (SD) or Serial Peripheral Interface (SPI). The TXB010x devices are not intended for use in open-drain applications. For applications such as I^2C where there is a need to connect and interface with an open-drain driver, TI offers TXS-type (i.e., "S" for Switch-type) translators. Please refer to TI application report, A Guide to Voltage Translation With TXS-Type Translators, literature number SCEA044 for more information on the TXS-type voltage translators.

Figure 2 shows the basic architecture of a single-bit (or channel) of the TXB010x device.

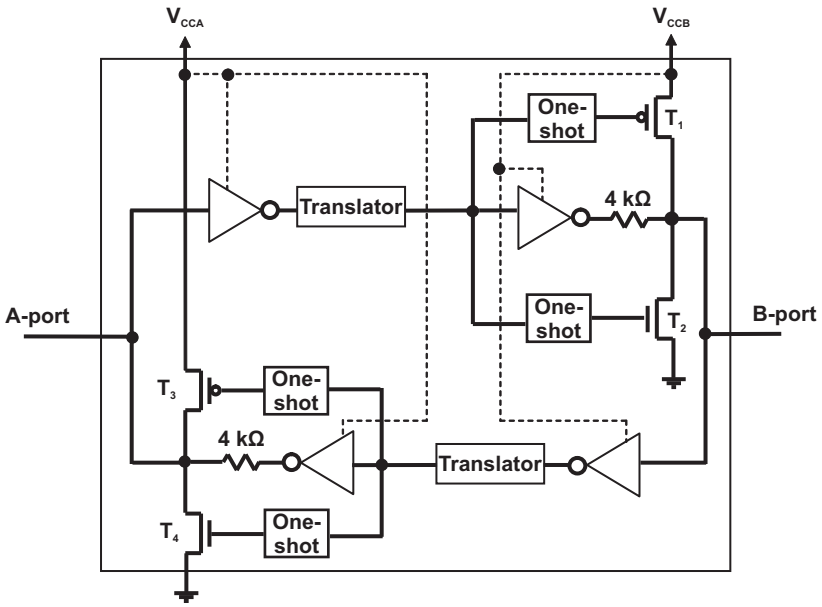

Figure 2. Basic TXB010x Architecture

The TXB translators incorporate a weak buffer with one-shot (O.S.) circuitry to improve switching speeds for rising and falling edges. When the A-port is connected to a system driver and driven high, the weak 4-kΩ buffer drives the B-port high in conjunction with the upper one shot, which becomes active when it senses a rising edge. The B-port is driven high by both the buffer and the T_1 PMOS, which lowers the output impedance seen on the B-port while the O.S. circuit is active. On the falling edge, the lower O.S. is triggered and the buffer, along with the T_2 NMOS, lowers the output impedance seen on the B-port while the O.S. circuit is operating and the output is driven low.

Figure 3 highlights with color the active circuitry involved in a low-to-high transition and a high-to-low transition. The weak buffer is shown in blue, and the active O.S. circuit is shown in green.

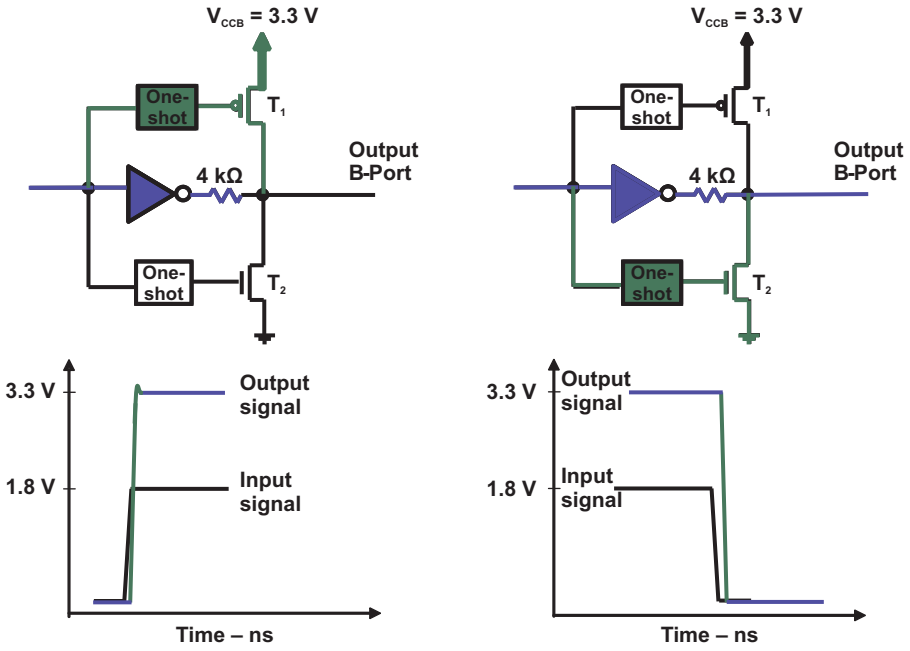

Figure 3. Active Output Rising/Falling Edge-Rate Acceleration Circuitry and DC Resistor Paths

The O.S. reduces the output impedance during the transition allowing the TXB device to drive a load while maintaining fast propagation delays and edge rates. Once the transition is completed, the O.S. circuit times out, and the buffer and the 4-kΩ pullup resistor hold the B-port signal high or low.

We call the TXB-type translator "weak-buffered", because it is strong enough to hold the output port high or low during a dc state, but weak in that the 4-kΩ impedance buffer can be easily over-driven by a system driver connected to the A or B port when a bus direction change is desired.

Figure 4 shows a typical I_{IN} vs V_{IN} curve.

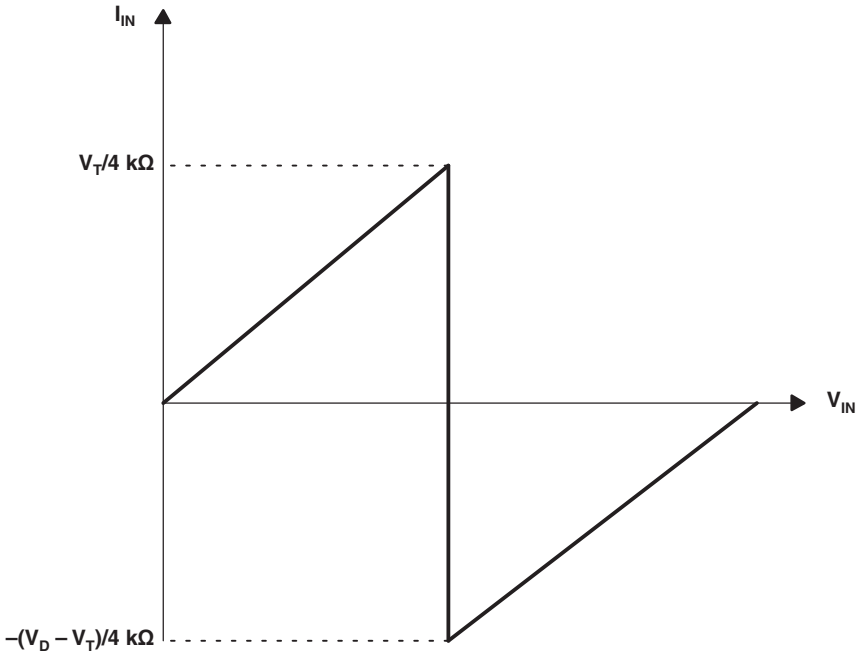

Figure 4. Typical I_{IN} vs V_{IN} Curve

Where,

V_T is the input threshold voltage of the TXB010x; V_T is typically $V_{CCI}/2$.

V_D is the supply voltage of the external system driver.

An external system driver must supply more than ±2 mA of current to reliably overdrive the hold provided by the weak buffer.

3 Driving External Loads with TXB Translators

TXB devices were architected for driving high-impedance loads. If the application requires an external pull-up or pull-down resistor (R_{pu} or R_{pd}), special consideration must be given to the resistor value. When the output is in a steady high or low dc state, it is exclusively driven by the 4-kΩ impedance buffer. If an external resistor is added as either a pull-up or pull-down, a resistor divider network will be formed with the 4kΩ buffer. If the value of the resistor is too small, the V_{OH} or V_{OL} will be adversely impacted. If the value is large, (i.e. >50kΩ), there will be very little change in the output voltage level.

Equation 1 helps to illustrate how an external pull-up resistor affects the output V_{OL} levels. If an external 50-kΩ resistor is connected as a pull-up and the output is in a low signal state, then:

$$V_{OL} = \frac{4\ k\Omega}{50\ k\Omega + 4\ k\Omega} \times V_{CCO} = 0.075 \times V_{CCO} \quad (1)$$

As a result, , if an external pull-up or pull-down resistor is needed, system designers should always choose large enough R_{pu} or R_{pd} values to ensure adequate V_{OH} and V_{OL} levels.

Figure 5 shows an illustration of a low-to-high, rising-edge signal for the TXB-type translators. The O.S. circuits turn on the PMOS transistor (T_1) for approximately 10 ns or 95% of the output edge, whichever occurs first. During this acceleration phase, the output resistance (R_{eff}) of the driver is decreased to approximately 40 Ω to 70 Ω to increase the current-drive capability of the device. When the circuits are active, a resulting high ac drive is realized by turning on T_1 and the rising-edge speeds up. The output port is maintained at a high signal level through this 4-kΩ internal resistor. With no load, the one-shots remain on for ~4.5 ns.

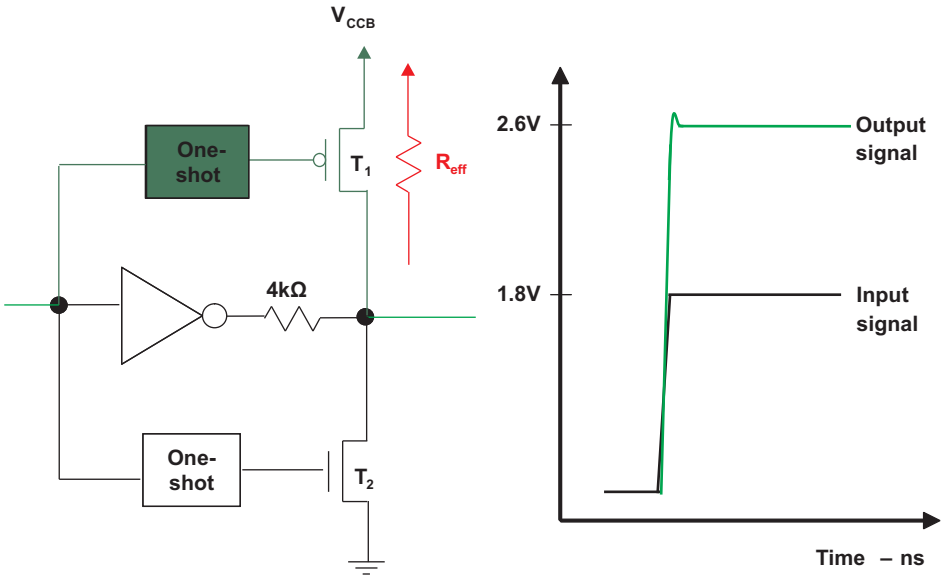

Figure 5. TXB Active Output Rising Edge-Rate Acceleration Illustration

During this ac drive acceleration period, the R_{eff} associated with the PMOS (T_1) and NMOS (T_2) is decreased to 40 Ω - 70 Ω. The typical output impedance varies based on output supply voltage, and is summarized in Table 1.

Table 1. TXB010x Effective Output Impedance Values

V_{CCO}	Output Impedance Value
1.2 V to 1.8 V	70 Ω
1.8 V to 3.3 V	50 Ω
3.3 V to 5 V	40 Ω

With regard to capacitive loads, TXB translators are designed to drive up to 70 pF without issue. If capacitive loading is larger than 70 pF, the O.S. will time-out after 10 ns and subsequently turn off before the output voltage is driven fully high or low. From there, the output will continue to rise or fall based on the RC time constant determined by the 4-kΩ buffer, load resistance and capacitive loading. To ensure reliable operation, system designers should keep capacitive loading for the TXB-type devices to 70 pF or less. With no external loading, the one-shot circuits will remain on for approximately 4.5 nsec. The duration of the one-shots is related to the output voltage level. The output high voltage at which O.S. switches off is approximately 95% of full scale, while the output low voltage at which O.S. switches off is approximately 5%.

4 Output Enable Control

The TXB devices offer low power consumption of 5-μA maximum I_{CC} when the output enable is high. When the output enable is low, the TXB translator buffer will be disabled and the outputs are put into a high impedance state for increased power savings. The $\overline{OE}$ input circuit is referenced to the V_{CCA} power-supply and when the device is disabled, the 4-kΩ buffer and the O.S. for both the A-port and B-Port are also disabled. In this state, output leakage (I_{OZ}) will be less than ±2 μA. If the application does not require output enable control, The $\overline{OE}$ pin should be tied to the V_{CCA} supply. One should never leave the $\overline{OE}$ pin floating in an indeterminate state as this can cause undesirable quiescent current to flow in the device, which subsequently increases its overall power dissipation.

Under partial power down conditions, the outputs are also disabled and put into a high-Impedance state. This feature is referred to as V_{CC} isolation. If V_{CCB} = 0 V, the A-port is disabled. Likewise, if V_{CCA} = 0V, the B-port will be disabled. In addition, the TXB type translators are fully specified for partial-power-down applications using the I_{OFF} feature. This I_{OFF} circuitry disables the outputs, preventing damaging current backflow through the device when these devices are powered-down.

5 Conclusion

The TXB translators offer system designers a versatile solution for remedying mixed-voltage system incompatibilities. These translators eliminate the need for provisioning a processor GPIO, since they change the direction of the data flow automatically without the use of a direction control pin. This simplifies system level design and allows for solutions in smaller packages.

Please visit www.ti.com for data sheets and additional information on all bit-width TXB translators along with the full line of Texas Instruments voltage-level translators.

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