

## FEATURES

- Offers Bandwidth Allocation of PCI Express™ Signal Using Two-Lane 1:2 Multiplexer/Demultiplexer
- Vcc Operating Range From 1.7 V to 1.9 V
- Supports Data Rates of 2.5 Gbps
- Port-Port Crosstalk (–39 dB at 1.25 GHz)
- OFF Port Isolation (–38 dB at 1.25 GHz)
- Low ON-State Resistance (10 Ω Typ)
- Low Input/Output Capacitance (3.5 pF Typ)
- Excellent Differential Skew (5 ps Max)
- Minimal Propagation Delay
- ESD Performance Tested Per JESD 22
  - 2000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)

## DESCRIPTION/ORDERING INFORMATION

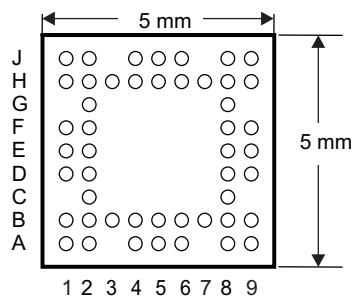
The TS2PCIE2212 can be used to muxitplex/demultiplex two PCI Express™ lanes, each representing differential pairs of receive (RX) and transmit (TX) signals. The switch operates at the PCI Express bandwidth standard of 2.5-Gbps signal-processing speed. The device is composed of two banks, with each bank accommodating two sources (source A and source B) and two destinations (destination A and destination B).

When a logic-level low is applied to the control (CTRL) pin, source A is connected to destination A and source B is connected to destination B. When a logic-level high is applied to CTRL, source A is connected to destination B, while source B and destination A are open.

## ORDERING INFORMATION

T <sub>A</sub>	PACKAGE		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 85°C	BGA – ZAH	Tape and reel	TS2PCIE2212ZAHR	

ZAH PACKAGE  
(BOTTOM VIEW)



## TERMINAL ASSIGNMENTS

	1	2	3	4	5	6	7	8	9
<b>A</b>	CTRL0	TxSB:0P		TxSA:0P	GND	TxDA:0P		TxDB:0P	NC
<b>B</b>	RxSA:0P	GND	TxSB:0N	TxSA:0N	VDD	TxDA:0N	TxDB:0N	GND	RxDA:0P
<b>C</b>		RxSA:0N						RxDA:0N	
<b>D</b>	RxSB:0P	RxSB:0N						RxDB:0N	RxDB:0P
<b>E</b>	GND	VDD						VDD	GND
<b>F</b>	TxSA:1P	TxSA:1N						TxDA:1N	TxDA:1P
<b>G</b>		TxSB:1N						TxDB:1N	
<b>H</b>	TxSB:1P	GND	RxSA:1N	RxSB:1N	VDD	RxDB:1N	RxDA:1N	GND	TxDB:1P
<b>J</b>	NC	RxSA:1P		RXSB:1P	GND	RXDB:1P		RxDA:1P	CTRL1



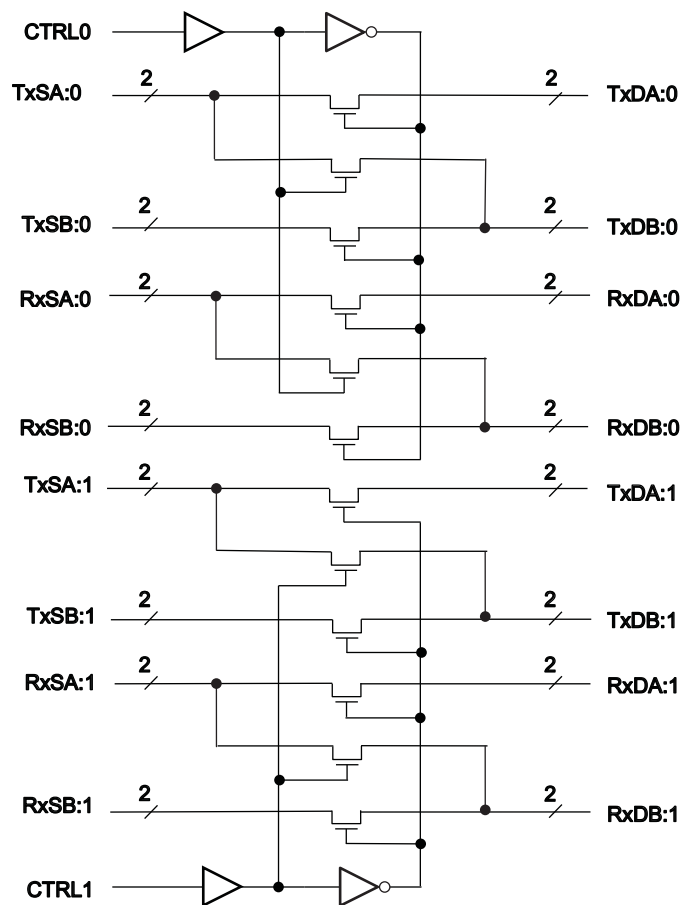
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PCI Express is a trademark of PCI-SIG.

### PIN DESCRIPTION

NAME	FUNCTION
TxSA:nP, TxSA:nN	Source A transmit pair
RxSA:nP, RxSA:nN	Source A receive pair
TxSB:nP, TxSB:nN	Source B transmit pair
RxSB:nP, RxSB:nN	Source B receive pair
TxDA:nP, TxDA:nN	Destination A transmit pair
RxDA:nP, RxDA:nN	Destination A receive pair
TxDB:nP, TxDB:nN	Destination B transmit pair
RxDB:nP, RxDB:nN	Destination B receive pair
CTRL0	Control signal for bank 0
CTRL1	Control signal for bank 1
V <sub>DD</sub>	Positive supply voltage
GND	Ground (0 V)
NC	No internal connection

### LOGIC DIAGRAM



**FUNCTION TABLE**

CTRLn	FUNCTION
L	SA:n = DA:n, SB:n = DB:n
H	SA:n = DB:n, DA:n = open, SBin = open

**Absolute Maximum Ratings<sup>(1)</sup>**

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

		MIN	MAX	UNIT
V <sub>DD</sub>	Supply voltage range	-0.5	2.5	V
V <sub>IN</sub>	Control input voltage range <sup>(2)(3)</sup>	-0.5	2.5	V
V <sub>I/O</sub>	Switch I/O voltage range <sup>(2)(3)(4)</sup>	-0.5	2.5	V
I <sub>IK</sub>	Control input clamp current	V <sub>IN</sub> < 0 and V <sub>I/O</sub> < 0		50 mA
I <sub>I/O</sub> K	I/O port clamp current	V <sub>IN</sub> < 0 and V <sub>I/O</sub> < 0		50 mA
I <sub>I/O</sub>	ON-state switch current <sup>(5)</sup>		±100	mA
	Continuous current through V <sub>DD</sub> or GND		±100	mA
θ <sub>JA</sub>	Package thermal impedance <sup>(6)</sup>		TBD	°C/W
T <sub>stg</sub>	Storage temperature range	-65	150	°C

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages are with respect to ground, unless otherwise specified.
- (3) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
- (4) V<sub>I</sub> and V<sub>O</sub> are used to denote specific conditions for V<sub>I/O</sub>.
- (5) I<sub>I</sub> and I<sub>O</sub> are used to denote specific conditions for I<sub>I/O</sub>.
- (6) The package thermal impedance is calculated in accordance with JESD 51-7.

**Recommended Operating Conditions**

		MIN	TYP	MAX	UNIT
V <sub>DD</sub>	Supply voltage	1.7	1.8	1.9	V
V <sub>IH</sub>	High-level control input voltage	CTRL		0.65 V <sub>DD</sub>	V
V <sub>IL</sub>	Low-level control input voltage	CTRL		0.35 V <sub>DD</sub>	V
V <sub>IO</sub>	Data input/output voltage	0		V <sub>DD</sub>	V
T <sub>A</sub>	Operating free-air temperature	0		85	°C

## Electrical Characteristics

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

PARAMETER		TEST CONDITIONS		T <sub>A</sub> = 0°C to 85°C			UNIT
				MIN	TYP	MAX	
V <sub>IK</sub>	Control inputs	V <sub>DD</sub> = 1.7 V,	I <sub>IN</sub> = -18 mA			-1.8	V
I <sub>IN</sub>	Control inputs	V <sub>DD</sub> = 1.9 V,	V <sub>IN</sub> = V <sub>DD</sub> or GND			±1	μA
I <sub>OZ</sub>		V <sub>DD</sub> = 1.9 V,	V <sub>O</sub> = 0 to 1.9 V, V <sub>I</sub> = 0, Switch OFF			±5	μA
I <sub>CC</sub>		V <sub>DD</sub> = 1.9 V, V <sub>IN</sub> = V <sub>DD</sub> or GND,	I <sub>I/O</sub> = 0, Switch ON or OFF	160	300		μA
C <sub>in</sub>	Control inputs	V <sub>DD</sub> = 1.9 V,	V <sub>IN</sub> = V <sub>DD</sub> or GND	0.5	1.0		pF
C <sub>IO(OFF)</sub>	SB or DA port	V <sub>I/O</sub> = 0 V,	Switch OFF	1.4	1.5		pF
C <sub>IO(ON)</sub>		V <sub>I/O</sub> = 0 V,	Switch ON	3.5	4		pF
r <sub>on</sub>		V <sub>DD</sub> = 1.7 V,	V <sub>I</sub> = 0 V, I <sub>O</sub> = 10 mA	10	14		Ω
		V <sub>DD</sub> = 1.7 V,	V <sub>I</sub> = 1.5 V, I <sub>O</sub> = -10 mA	12	17		
Δr <sub>on(flat)</sub>		V <sub>DD</sub> = 1.7 V,	I <sub>O</sub> = 10 mA, V <sub>I</sub> = 1.5 V ± 0.4 V	2.5	5		Ω

## Switching Characteristics

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

PARAMETER	DESCRIPTION	TEST CONDITIONS	T <sub>A</sub> = 0°C to 85°C			UNIT
			MIN	TYP	MAX	
DR	Data rate per TX or RX pair			2.5		Gbps
t <sub>pd</sub>	Propagation delay, Sx to Dx	See <a href="#">Figure 7</a>		250		ps
t <sub>sk</sub>	Intra-pair skew	f = 1.25 GHz, See <a href="#">Figure 7</a>			5	ps
t <sub>en</sub> (t <sub>PZL</sub> , t <sub>PZH</sub> )	Switch turn-on delay, CTRL to DA	See <a href="#">Figure 6</a>			5	ns
t <sub>dis</sub> (t <sub>PLZ</sub> , t <sub>PHZ</sub> )	Switch turn-off delay, CTRL to DA	See <a href="#">Figure 6</a>			2.5	ns
I <sub>LOSS</sub>	Differential insertion loss	f = 1.25 GHz, R <sub>LOAD</sub> = 50 Ω, See <a href="#">Figure 1</a>		-2.5	-3.2	dB
R <sub>LOSS</sub>	Differential return loss	f = 1.25 GHz, R <sub>LOAD</sub> = 50 Ω, See <a href="#">Figure 2</a>	-7.2	-9.5		dB
I <sub>LOSS(CM)</sub>	Common-mode insertion loss	f = 1.25 GHz, R <sub>LOAD</sub> = 50 Ω, See <a href="#">Figure 3</a>		-2		dB
O <sub>IFF</sub>	Differential OFF isolation	f = 1.25 GHz, R <sub>LOAD</sub> = 50 Ω, See <a href="#">Figure 4</a>	-33	-38		dB
X <sub>TALK</sub>	Differential crosstalk	f = 1.25 GHz, R <sub>LOAD</sub> = 50 Ω, See <a href="#">Figure 5</a>	-33	-39		dB

**OPERATING CHARACTERISTICS**

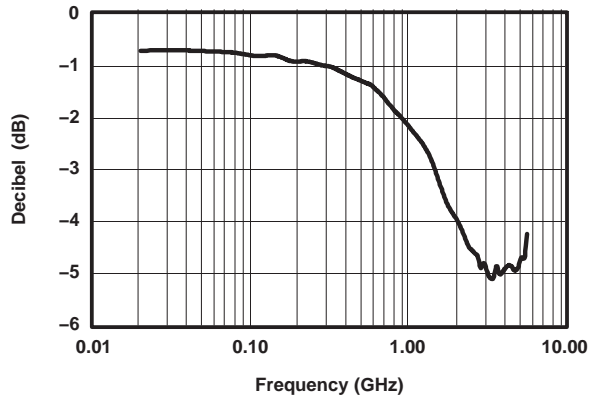


Figure 1. Differential Insertion Loss vs Frequency

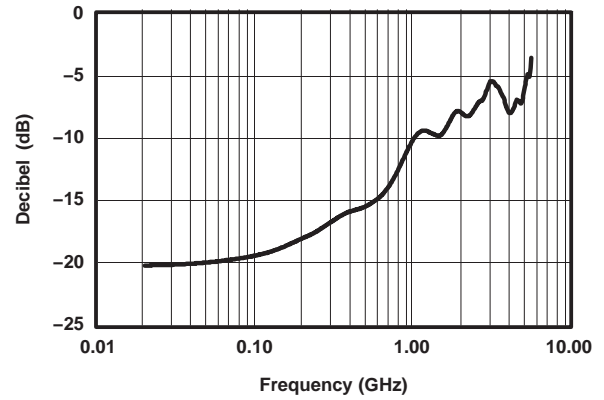


Figure 2. Differential Return Loss vs Frequency

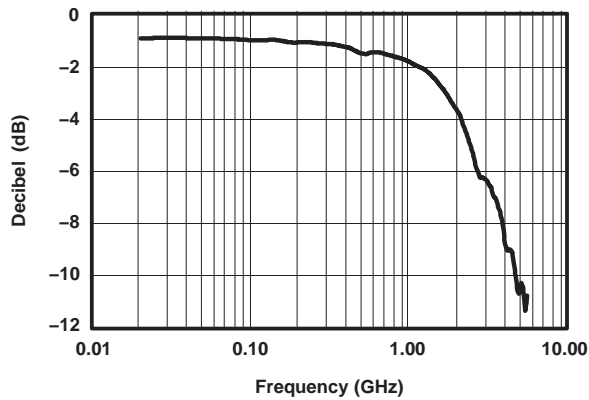


Figure 3. Common-Mode Insertion Loss vs Frequency

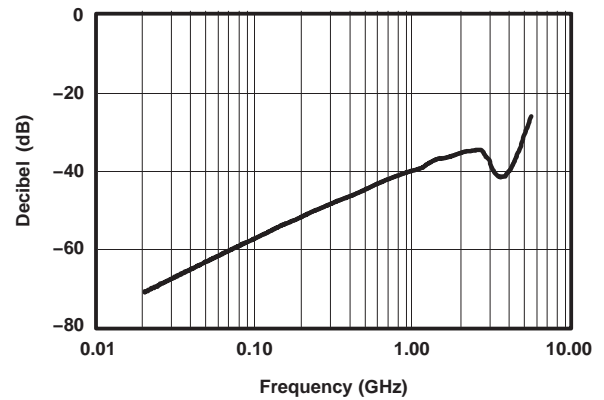


Figure 4. Differential OFF Isolation vs Frequency

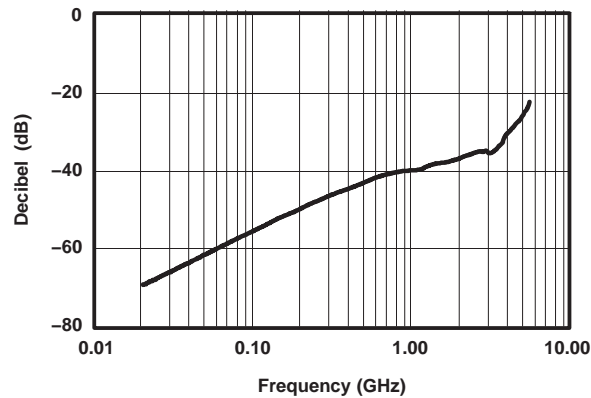
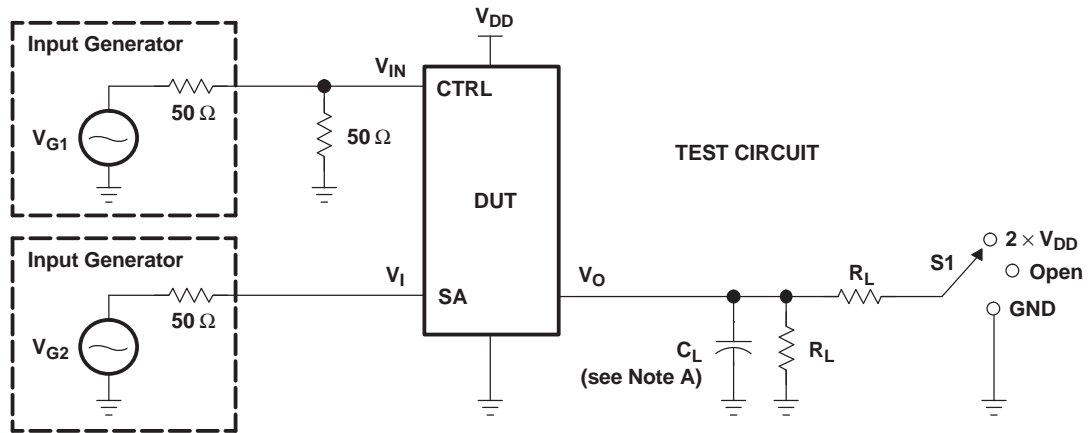
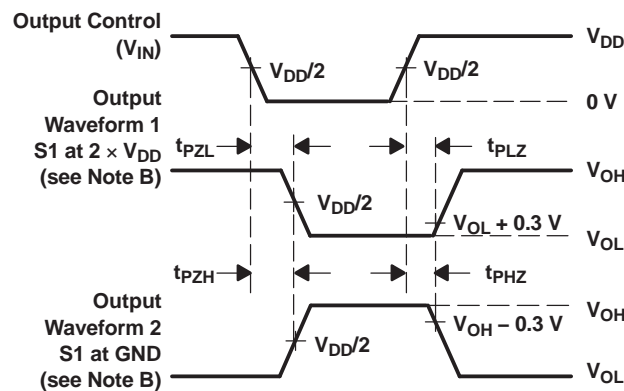


Figure 5. Differential Crosstalk vs Frequency

PARAMETER MEASUREMENT INFORMATION  
(Enable and Disable Times)



TEST	V <sub>CC</sub>	S1	R <sub>L</sub>	V <sub>I</sub>	C <sub>L</sub>	V <sub>Δ</sub>
t <sub>PLZ</sub> /t <sub>PZL</sub>	1.8 V ± 0.1 V	2 × V <sub>DD</sub>	100 Ω	GND	No Load	0.3 V
t <sub>PHZ</sub> /t <sub>PZH</sub>	1.8 V ± 0.1 V	GND	100 Ω	V <sub>DD</sub>	No Load	0.3 V

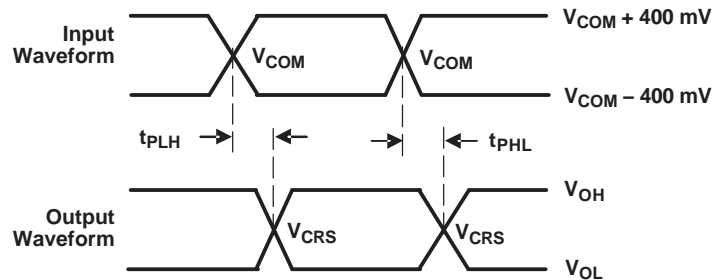
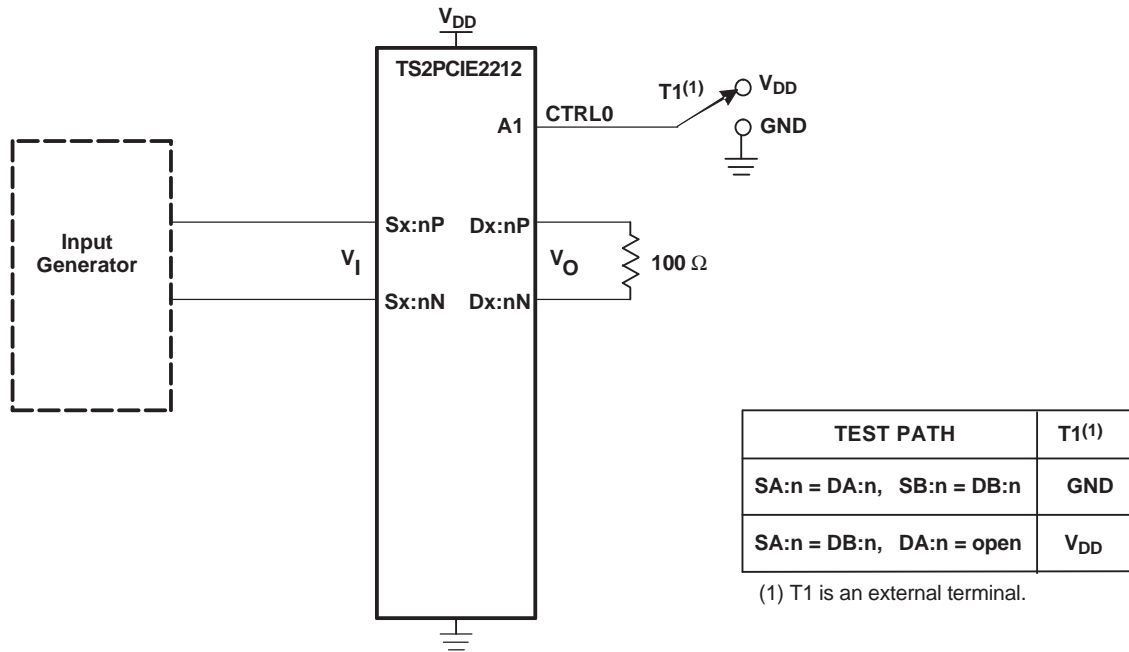


VOLTAGE WAVEFORMS  
ENABLE AND DISABLE TIMES

- NOTES:
- A. C<sub>L</sub> includes probe and jig capacitance.
  - B. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
  - C. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z<sub>O</sub> = 50 Ω, t<sub>r</sub> ≤ 2.5 ns, t<sub>f</sub> ≤ 2.5 ns.
  - D. The outputs are measured one at a time, with one transition per measurement.
  - E. t<sub>PLZ</sub> and t<sub>PHZ</sub> are the same as t<sub>dis</sub>.
  - F. t<sub>PZL</sub> and t<sub>PZH</sub> are the same as t<sub>en</sub>.

Figure 6. Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION



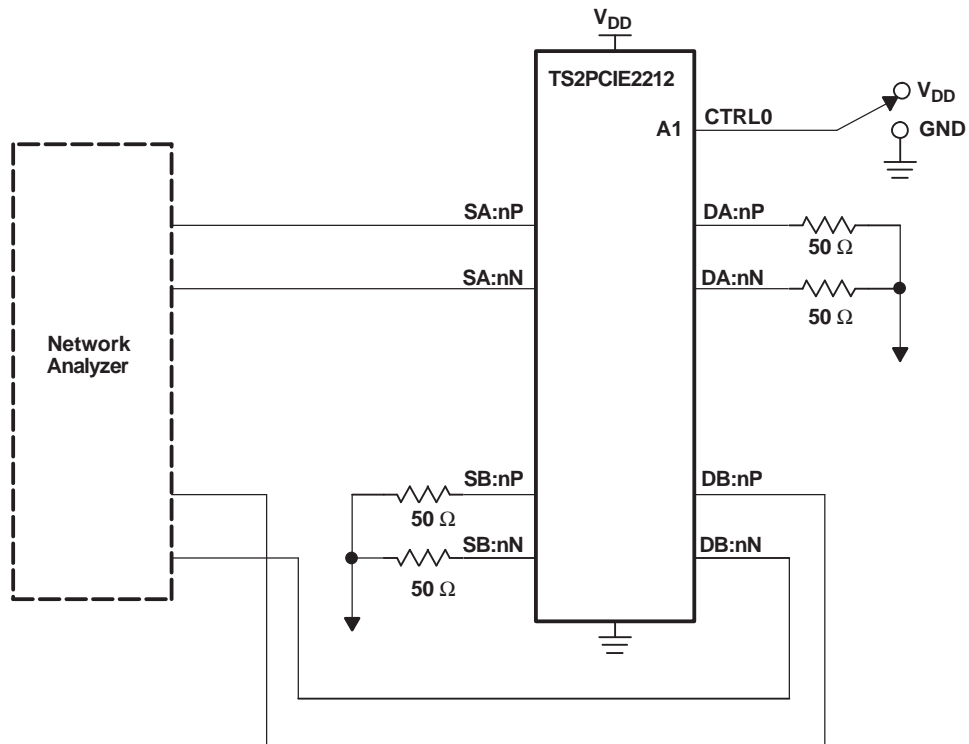
$V_{COM} = 1.5\text{ V}$

$V_{CRS}$  is the cross point of the differential signal.

$t_{sk} = |t_{PLHn} - t_{PHLn}|$

Figure 7. Test Circuit for Propagation Delay and Intra-Pair Skew

PARAMETER MEASUREMENT INFORMATION (continued)

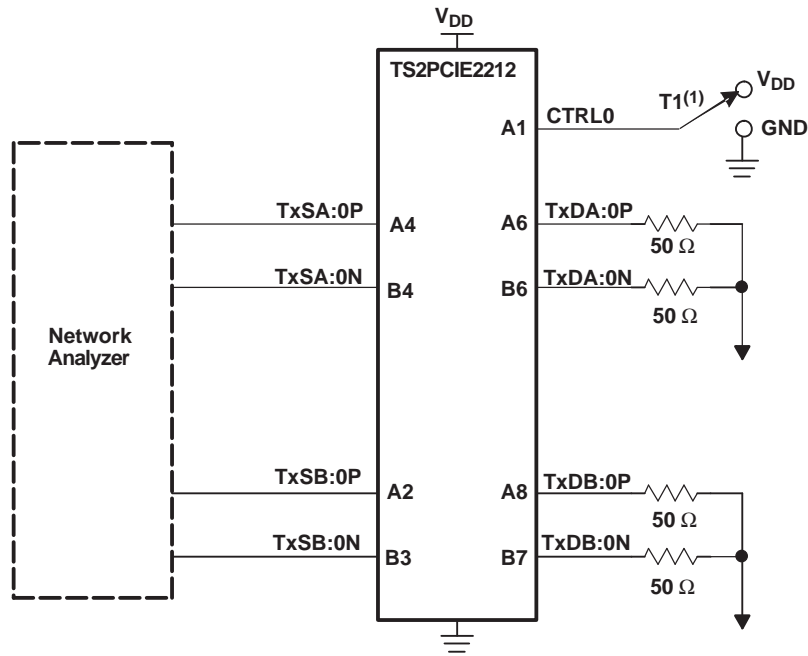


TEST	VNA MEASUREMENT
Differential insertion loss	$S_{21}$
Differential return loss	$S_{11}$
Common-mode insertion loss	$S_{21}$

Figure 8. Differential Insertion Loss, Differential Return Loss, and Common-Mode Insertion Loss Test Circuit



PARAMETER MEASUREMENT INFORMATION (continued)



TEST	T1 <sup>(1)</sup>
Differential crosstalk	GND
Differential OFF isolation	V <sub>DD</sub>

(1) T1 is an external terminal.

Figure 9. Differential Crosstalk and OFF Isolation Test Circuit

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TS2PCIE2212ZAHR	ACTIVE	NFBGA	ZAH	48	3000	Pb-Free (RoHS)	SNAGCU	Level-3-260C-168 HR	0 to 85	SE212	<a href="#">Samples</a>
TS2PCIE2212ZAHRG1	ACTIVE	NFBGA	ZAH	48	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR		SE212	<a href="#">Samples</a>

(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.

(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.

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## TAPE AND REEL INFORMATION



### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*All dimensions are nominal

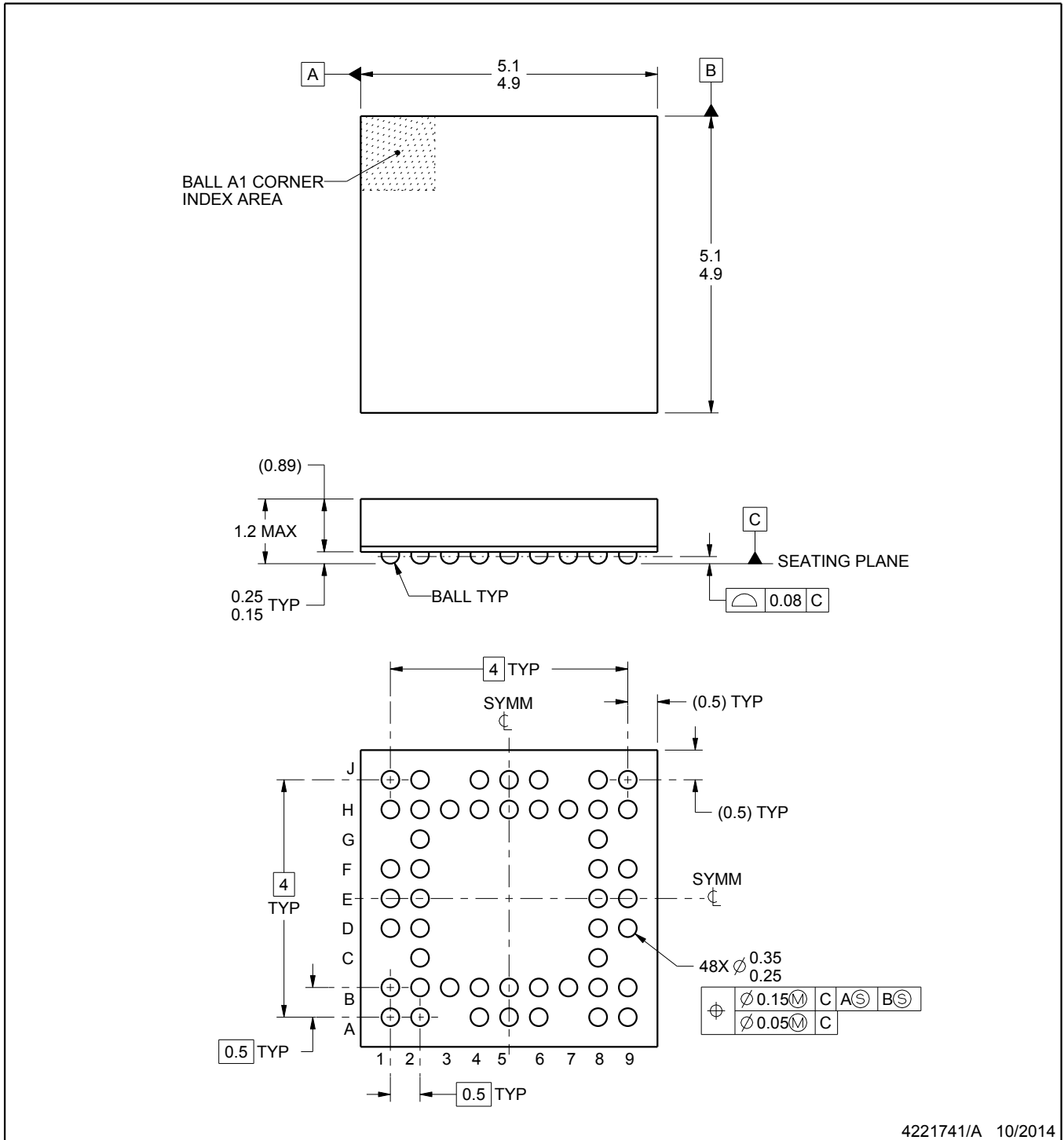
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TS2PCIE2212ZAHRG1	NFBGA	ZAH	48	3000	330.0	12.4	5.3	5.3	1.5	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TS2PCIE2212ZAHRG1	NFBGA	ZAH	48	3000	336.6	336.6	31.8



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NOTES:

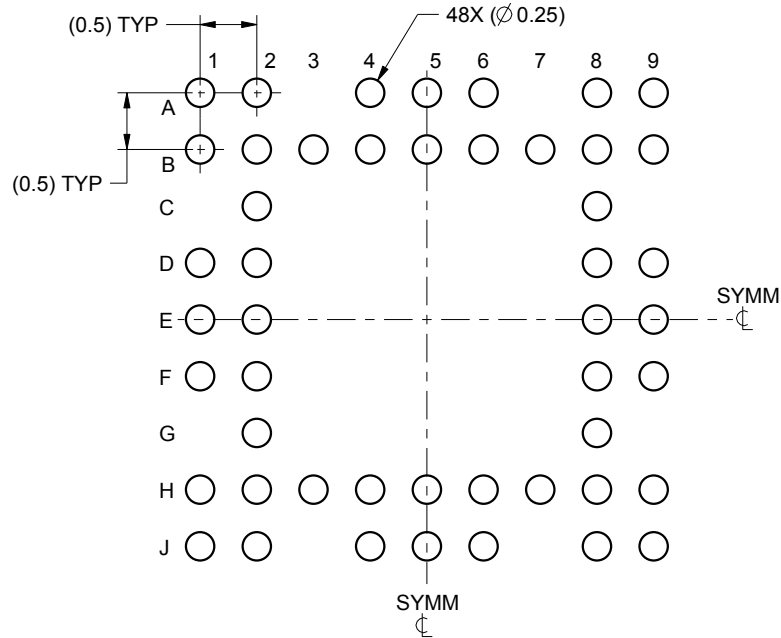
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

# EXAMPLE BOARD LAYOUT

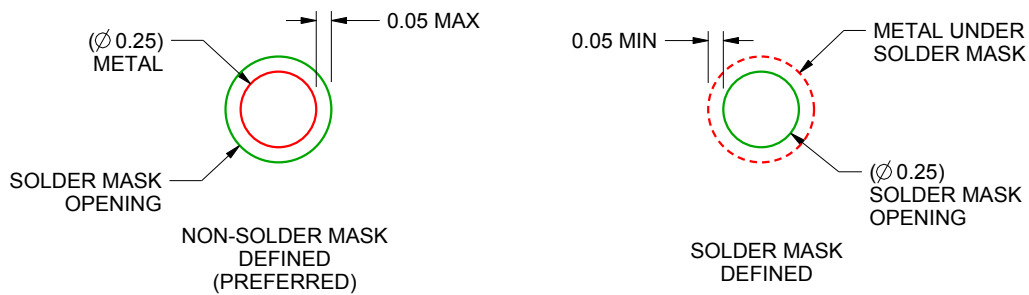
ZAH0048A

NFBGA - 1.2 mm max height

PLASTIC BALL GRID ARRAY



LAND PATTERN EXAMPLE  
SCALE:15X



SOLDER MASK DETAILS  
NOT TO SCALE

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NOTES: (continued)

- 3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. For information, see Texas Instruments literature number SSYZ015 ([www.ti.com/lit/ssyz015](http://www.ti.com/lit/ssyz015)).



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Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
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