

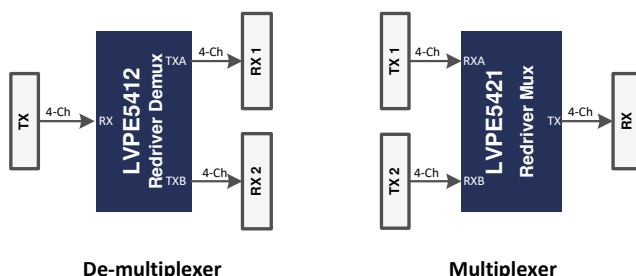
# SN75LVPE5421 PCIe® 5.0 32Gbps 4-Channel Linear Redriver with 2:1 Mux

## 1 Features

- Quad channel PCIe 5.0 linear redriver or repeater with integrated 2:1 multiplexer
- Protocol agnostic linear redriver compatible to PCIe, UPI, CCIX, NVLink, DisplayPort, SAS, SATA, and XFI
- Single 3.3V supply – PCIe power rail can be used
- Low 720mW active power for 4-channel operation
- No heat sink required
- Provides equalization up to 24dB at 16GHz
- Excellent RX/TX differential RL of -10dB for 8-16GHz
- Low additive RJ of 55 fs RMS with PRBS data
- Low latency of 90ps
- Automatic receiver detection and seamless support for PCIe link training
- Device configuration by pin control or SMBus / I<sup>2</sup>C.
- Mux selection through pin
- Internal voltage regulator provides immunity to supply noise
- High speed production testing for reliable manufacturing
- Support for x4, x8, and x16 bus width with one or multiple device
- Available companion demultiplexer product [SN75LVPE5412](#)
- -40°C to 85°C temperature range
- 3.5 × 9mm 42 Pin 0.5mm pitch WQFN package

## 2 Applications

- [Desktop PC and motherboard](#)
- [Display panel, gaming console](#)
- [Rack server, microserver, and tower server](#)
- [High performance computing, hardware accelerator](#)
- [Data storage, network attached storage](#)
- [Storage area network \(SAN\) and host bus adapter \(HBA\) card](#)
- [Network interface card \(NIC\)](#)



## Application Use Case

## 3 Description

The SN75LVPE5421 is a four channel linear redriver with integrated multiplexer (mux). The low-power high-performance linear redriver is designed to support PCIe 5.0 and other interfaces up to 32Gbps.

The SN75LVPE5421 receivers deploy continuous time linear equalizers (CTLE) to provide a high-frequency boost. The equalizer can open an input eye that is completely closed due to inter-symbol interference (ISI) induced by an interconnect medium, such as PCB traces and cables. During PCIe link training the linear redriver along with the passive channel in between a Root Complex (RC) and Endpoint (EP) as a whole get trained for best transmit and receive equalization settings resulting in the best electrical link. Low channel to channel cross-talk, low additive jitter and excellent return loss allows the device to become almost a passive element in the link. The device has internal linear voltage regulator to provide clean power supply for high speed data paths that provides high immunity to any supply noise on the board.

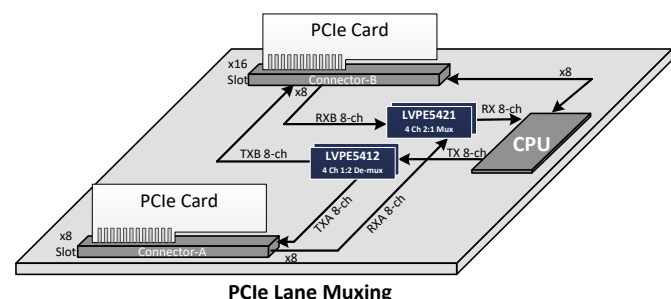
The SN75LVPE5421 implements high speed testing during production for reliable high volume manufacturing. The device also has low AC and DC gain variation providing consistent equalization in high volume platform deployment.

### Package Information

PART NUMBER	PACKAGE <sup>(1)</sup>	PACKAGE SIZE <sup>(2)</sup>
SN75LVPE5421	RUA (WQFN, 42)	9mm × 3.5mm

(1) For more information, see [Section 10](#).

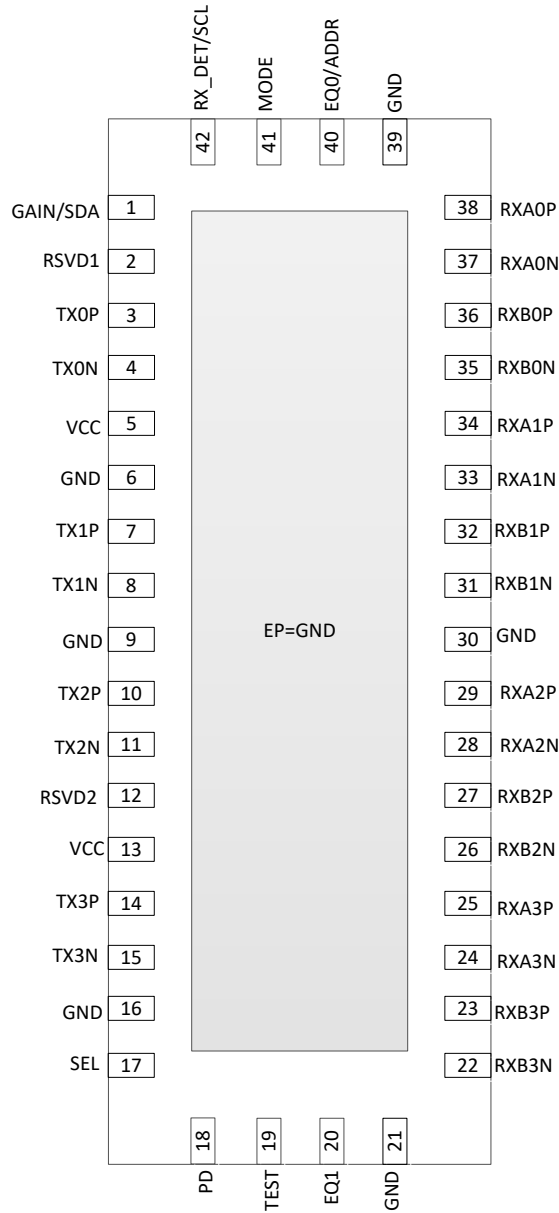
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



## Table of Contents

<b>1 Features</b> .....	1	6.3 Feature Description.....	13
<b>2 Applications</b> .....	1	6.4 Device Functional Modes.....	15
<b>3 Description</b> .....	1	6.5 Programming.....	15
<b>4 Pin Configuration and Functions</b> .....	3	<b>7 Application and Implementation</b> .....	19
<b>5 Specifications</b> .....	6	7.1 Application Information.....	19
5.1 Absolute Maximum Ratings.....	6	7.2 Typical Applications.....	19
5.2 ESD Ratings.....	6	7.3 Power Supply Recommendations.....	23
5.3 Recommended Operating Conditions.....	6	7.4 Layout.....	23
5.4 Thermal Information.....	7	<b>8 Device and Documentation Support</b> .....	25
5.5 DC Electrical Characteristics.....	7	8.1 Receiving Notification of Documentation Updates....	25
5.6 High Speed Electrical Characteristics.....	8	8.2 Support Resources.....	25
5.7 SMBUS/I2C Timing Characteristics.....	9	8.3 Trademarks.....	25
5.8 Typical Characteristics.....	10	8.4 Electrostatic Discharge Caution.....	25
5.9 Typical Jitter Characteristics.....	11	8.5 Glossary.....	25
<b>6 Detailed Description</b> .....	12	<b>9 Revision History</b> .....	25
6.1 Overview.....	12	<b>10 Mechanical, Packaging, and Orderable Information</b> .....	25
6.2 Functional Block Diagram.....	12		

## 4 Pin Configuration and Functions



**Figure 4-1. RUA Package, 42-Pin WQFN (Top View)**

**Table 4-1. Pin Functions**

PIN		TYPE <sup>(1)</sup>	DESCRIPTION
NAME	NO.		
MODE	41	I, 5-level	Sets device control configuration modes. The 5-level IO pin is defined in <a href="#">Table 6-1</a> . The pin can be exercised at device power up or in normal operation mode. L0: <i>Pin Mode</i> – device control configuration is done solely by strap pins. L1 or L2: <i>SMBus/I<sup>2</sup>C Mode</i> – device control configuration is done by an external controller with SMBus/I <sup>2</sup> C primary. This pin along with ADDR pin sets devices secondary address. L3 and L4 (Float): RESERVED – TI internal test modes.
EQ0 /ADDR	40	I, 5-level	<i>In Pin Mode:</i> The EQ0 and EQ1 pins sets receiver linear equalization CTLE (AC gain) for all channels according to <a href="#">Table 6-2</a> . These pins are sampled at device power-up only.
EQ1	20	I, 5-level	<i>In SMBus/I<sup>2</sup>C Mode:</i> The ADDR pin in conjunction with MODE pin sets SMBus / I <sup>2</sup> C secondary address according to <a href="#">Table 6-5</a> . The pin is sampled at device power-up only.
GAIN /SDA	1	I, 5-level / IO	<i>In Pin Mode:</i> Flat gain (broadband gain – DC and AC) from the input to the output of the device for all channels. Note: the device also provides AC (high frequency) gain in the form of equalization controlled by EQ pins or SMBus/I <sup>2</sup> C registers. The pin is sampled at device power-up only. <i>In SMBus/I<sup>2</sup>C Mode:</i> 3.3V SMBus/I <sup>2</sup> C data. External pullup resistor such as 4.7 kΩ required for operation.
GND	EP, 6, 9, 16, 21, 30, 39	P	Ground reference for the device. EP: the Exposed Pad at the bottom of the QFN package. It is used as the GND return for the device. The EP should be connected to one or more ground planes through the low resistance path. A via array provides a low impedance path to GND. The EP also improves thermal dissipation.
PD	18	I, 3.3V LVCMOS	2-level logic controlling the operating state of the redriver. Active in both <i>Pin Mode</i> and <i>SMBus/I<sup>2</sup>C Mode</i> . The pin is used part of PCIe RX_DET state machine as outlined in <a href="#">Table 6-4</a> . High: power down for all channels Low: power up, normal operation for all channels
RSVD1, 2	2, 12	—	Reserved pins – for best signal integrity performance connect the pins to GND. Alternate option would be 0 Ω resistors from pins to GND.
RX_DET /SCL	42	I, 5-level / IO	<i>In Pin Mode:</i> Sets receiver detect state machine options according to <a href="#">Table 6-4</a> . The pin is sampled at device power-up only. <i>In SMBus/I<sup>2</sup>C Mode:</i> 3.3V SMBus/I <sup>2</sup> C clock. External pullup resistor such as 4.7 kΩ required for operation.
RXA0N	37	I	Inverting differential RX input – Port A, Channel 0.
RXA0P	38	I	Noninverting differential RX input – Port A, Channel 0.
RXA1N	33	I	Inverting differential RX input – Port A, Channel 1.
RXA1P	34	I	Noninverting differential RX input – Port A, Channel 1.
RXA2N	28	I	Inverting differential RX input – Port A, Channel 2.
RXA2P	29	I	Noninverting differential RX input – Port A, Channel 2.
RXA3N	24	I	Inverting differential RX input – Port A, Channel 3.
RXA3P	25	I	Noninverting differential RX input – Port A, Channel 3.
RXB0N	35	I	Inverting differential RX input – Port B, Channel 0.
RXB0P	36	I	Noninverting differential RX input – Port B, Channel 0.
RXB1N	31	I	Inverting differential RX input – Port B, Channel 1.
RXB1P	32	I	Noninverting differential RX input – Port B, Channel 1.
RXB2N	26	I	Inverting differential RX input – Port B, Channel 2.
RXB2P	27	I	Noninverting differential RX input – Port B, Channel 2.
RXB3N	22	I	Inverting differential RX input – Port B, Channel 3.

**Table 4-1. Pin Functions (continued)**

PIN		TYPE <sup>(1)</sup>	DESCRIPTION
NAME	NO.		
RXB3P	23	I	Noninverting differential RX input – Port B, Channel 3.
SEL	17	I, 3.3V LVCMOS	Selects the mux path. Active in both <i>Pin Mode</i> and <i>SMBus/I<sup>2</sup>C Mode</i> . The pin has a weak internal pull-down resistor. Note: the SEL pin must be exercised in system implementations for mux selection between Port A vs Port B. The pin is used for PCIe RX_DET state machine as outlined in <a href="#">Table 6-4</a> . L: Port A selected. H: Port B selected.
TX0N	4	O	Inverting differential TX output, Channel 0.
TX0P	3	O	Noninverting differential TX output, Channel 0.
TX1N	8	O	Inverting differential TX output, Channel 1.
TX1P	7	O	Noninverting differential TX output, Channel 1.
TX2N	11	O	Inverting differential TX output, Channel 2.
TX2P	10	O	Noninverting differential TX output, Channel 2.
TX3N	15	O	Inverting differential TX output, Channel 3.
TX3P	14	O	Noninverting differential TX output, Channel 3.
TEST	19	O	TI internal test pin. Keep no connect.
VCC	5, 13	P	Power supply, VCC = 3.3V ± 10%. The VCC pins on this device should be connected through a low-resistance path to the board VCC plane.

(1) I = input, O = output, P = power, GND = ground

## 5 Specifications

### 5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT
VCC_ABSMAX	Supply voltage (VCC)	-0.5	4.0	V
VIO_CMOS_ABSMAX	3.3V LVCMOS and open drain I/O voltage	-0.5	4.0	V
VIO_5LVL_ABSMAX	5-level input I/O voltage	-0.5	2.75	V
VIO_HS-RX_ABSMAX	High-speed I/O voltage (RXnP, RXnN)	-0.5	3.2	V
VIO_HS-TX_ABSMAX	High-speed I/O voltage (TXnP, TXnN)	-0.5	2.75	V
T_J_ABSMAX	Junction temperature		150	°C
T_stg	Storage temperature range	-65	150	°C

- (1) Operation outside the *Absolute Maximum Rating* may cause permanent device damage. *Absolute Maximum Rating* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Condition*. If used outside the *Recommended Operating Condition* but within the *Absolute Maximum Rating*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

### 5.2 ESD Ratings

			VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±2000	V
		Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup>	±500	

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Pins listed as ±2 kV may actually have higher performance.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 5.3 Recommended Operating Conditions

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

			MIN	NOM	MAX	UNIT
VCC	Supply voltage, VCC to GND	DC plus AC power should not exceed these limits	3.0	3.3	3.6	V
N <sub>VCC</sub>	Supply noise tolerance	DC to <50 Hz, sinusoidal <sup>1</sup>			250	mVpp
		50 Hz to 500 kHz, sinusoidal <sup>1</sup>			100	mVpp
		500 kHz to 2.5MHz, sinusoidal <sup>1</sup>			33	mVpp
		Supply noise, >2.5MHz, sinusoidal <sup>1</sup>			10	mVpp
T <sub>RampVCC</sub>	VCC supply ramp time	From 0V to 3.0V	0.150		100	ms
T <sub>J</sub>	Operating junction temperature		-40		115	°C
T <sub>A</sub>	Operating ambient temperature		-40		85	°C
PW <sub>LVCMOS</sub>	Minimum pulse width required for the device to detect a valid signal on LVCMOS inputs	PD and SEL	200			µs
VCC <sub>SMBUS</sub>	SMBus/I <sup>2</sup> C SDA and SCL open drain termination voltage	Supply voltage for open drain pull-up resistor			3.6	V
F <sub>SMBus</sub>	SMBus/I <sup>2</sup> C clock (SCL) frequency in SMBus secondary mode		10		400	kHz
VID <sub>LAUNCH</sub>	Source differential launch amplitude		800		1200	mVpp
DR	Data rate		1		32	Gbps

## 5.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		SN75LVPE5421	UNIT
		RUA, 42 Pins	
R <sub>θJA</sub> -High K	Junction-to-ambient thermal resistance	26.1	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	14.1	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	8.7	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	1.6	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	8.6	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	2.6	°C/W

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

## 5.5 DC Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Power</b>						
P <sub>ACT</sub>	Device active power	All channels enabled (PD = L)		720	970	mW
P <sub>STBY</sub>	Device power consumption in standby power mode	All channels disabled (PD = H)		23	36	mW
<b>Control IO</b>						
V <sub>IH</sub>	High level input voltage	SDA, SCL, PD, SEL pins	2.1			V
V <sub>IL</sub>	Low level input voltage	SDA, SCL, PD, SEL pins			1.08	V
V <sub>OH</sub>	High level output voltage	R <sub>pull-up</sub> = 4.7kΩ (SDA, SCL pins)	2.1			V
V <sub>OL</sub>	Low level output voltage	I <sub>OL</sub> = -4mA (SDA, SCL pins)			0.4	V
I <sub>IH,SEL</sub>	Input high leakage current for SEL pins	V <sub>Input</sub> = VCC, for SEL pin			100	μA
I <sub>IH</sub>	Input high leakage current	V <sub>Input</sub> = VCC, (SCL, SDA, PD pins)			10	μA
I <sub>IL</sub>	Input low leakage current	V <sub>Input</sub> = 0V, (SCL, SDA, PD, SEL pins)	-10			μA
I <sub>IH,FS</sub>	Input high leakage current for fail safe input pins	V <sub>Input</sub> = 3.6V, VCC = 0V, (SCL, SDA, PD, SEL pins)			200	μA
C <sub>IN-CTRL</sub>	Input capacitance	SCL, SDA, PD, SEL pins		1.6		pF
<b>5 Level IOs (MODE, GAIN, EQ1, EQ0, RX_DET pins)</b>						
I <sub>IH_5L</sub>	Input high leakage current, 5 level IOs	VIN = 2.5V			10	μA
I <sub>IL_5L</sub>	Input low leakage current for all 5 level IOs except MODE.	VIN = GND	-10			μA
I <sub>IL_5L,MODE</sub>	Input low leakage current for MODE pin	VIN = GND	-200			μA
<b>Receiver</b>						
V <sub>RX-DC-CM</sub>	RX DC common mode voltage	Device is in active or standby state		1.4		V
Z <sub>RX-DC</sub>	Rx DC single-ended impedance			50		Ω
Z <sub>RX-HIGH-IMP-DC-POS</sub>	DC input CM input impedance during Reset or power-down	Inputs are at V <sub>RX-DC-CM</sub> voltage	20			kΩ
<b>Transmitter</b>						
Z <sub>TX-DIFF-DC</sub>	DC differential Tx impedance	Impedance of Tx during active signaling, VID,diff = 1Vpp		100		Ω
V <sub>TX-DC-CM</sub>	Tx DC common mode Voltage			1.0		V
I <sub>TX-SHORT</sub>	Tx short circuit current	Total current the Tx can supply when shorted to GND		70		mA

## 5.6 High Speed Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Receiver</b>						
RL <sub>RX-DIFF</sub>	Input differential return loss	50MHz to 1.25GHz		-22		dB
		1.25GHz to 2.5GHz		-22		dB
		2.5GHz to 4.0GHz		-22		dB
		4.0GHz to 8.0GHz		-16		dB
		8.0GHz to 16GHz		-9		dB
RL <sub>RX-CM</sub>	Input common-mode return loss	50MHz to 2.5GHz		-20		dB
		2.5GHz to 8.0GHz		-14		dB
		8.0GHz to 16GHz		-8		dB
XT <sub>RX</sub>	Receive-side pair-to-pair isolation	Pair-to-pair isolation (SDD21) between two adjacent receiver pairs from 10MHz to 16GHz.		-55		dB
<b>Transmitter</b>						
V <sub>TX-AC-CM-PP</sub>	Tx AC peak-to-peak common mode voltage	Measured with lowest EQ, GAIN = L4; PRBS-7, 32Gbps, over at least 10 <sup>6</sup> bits using a bandpass filter from 30 kHz to 500MHz			50	mVpp
V <sub>TX-RCV-DETECT</sub>	Amount of voltage change allowed during receiver detection	Measured while Tx is sensing whether a low-impedance receiver is present. No load is connected to the driver output	0		600	mV
RL <sub>TX-DIFF</sub>	Output differential return loss	50MHz to 1.25GHz		-22		dB
		1.25GHz to 2.5GHz		-22		dB
		2.5GHz to 4.0GHz		-21		dB
		4.0GHz to 8.0GHz		-15		dB
		8.0GHz to 16GHz		-9		dB
RL <sub>TX-CM</sub>	Output common-mode return loss	50MHz to 2.5GHz		-16		dB
		2.5GHz to 8.0GHz		-12		dB
		8.0GHz to 16GHz		-11		dB
XT <sub>TX</sub>	Transmit-side pair-to-pair isolation	Minimum pair-to-pair isolation (SDD21) between two adjacent transmitter pairs from 10MHz to 16GHz.		-45		dB
<b>Device Datapath</b>						
T <sub>PLHD/PHLD</sub>	Input-to-output latency (propagation delay) through a data channel	For either low-to-high or high-to-low transition.		90	130	ps
L <sub>TX-SKEW</sub>	Lane-to-lane output skew	Between any two lanes within a single transmitter.			20	ps
T <sub>RJ-DATA</sub>	Additive random jitter with data	Jitter through redriver minus the calibration trace. 32Gbps PRBS15. 800 mVpp-diff input swing.		55		fs
T <sub>RJ-INTRINSIC</sub>	Intrinsic additive random jitter with clock	Jitter through redriver minus the calibration trace. 32GHz clock. 800 mVpp-diff input swing.		35		fs
JITTER <sub>TOTAL-DATA</sub>	Additive total jitter with data	Jitter through redriver minus the calibration trace. 32Gbps PRBS15. 800 mVpp-diff input swing.		1.0		ps
JITTER <sub>TOTAL-INTRINSIC</sub>	Intrinsic additive total jitter with clock	Jitter through redriver minus the calibration trace. 16GHz clock. 800 mVpp-diff input swing.		0.1		ps



## 5.6 High Speed Electrical Characteristics (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
FLAT-GAIN	Broadband DC and AC flat gain - input to output, measured at DC	Minimum EQ, GAIN1/0=L0		-5.6		dB
		Minimum EQ, GAIN1/0=L1		-3.8		dB
		Minimum EQ, GAIN1/0=L2		-1.2		dB
		Minimum EQ, GAIN1/0=L3		2.6		dB
		Minimum EQ, GAIN1/0=L4 (Float)		0.6		dB
EQ-MAX <sub>16G</sub>	EQ boost at max setting (EQ INDEX = 19)	AC gain at 16GHz relative to gain at 100MHz.		24		dB
LINEARITY-DC	Output DC linearity	at 0 dB flat gain		1700		mVpp
LINEARITY-AC	Output AC linearity at 32Gbps	at 0 dB flat gain		930		mVpp

## 5.7 SMBUS/I2C Timing Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Secondary Mode</b>						
t <sub>SP</sub>	Pulse width of spikes which must be suppressed by the input filter				50	ns
t <sub>HD-STA</sub>	Hold time (repeated) START condition. After this period, the first clock pulse is generated		0.6			μs
t <sub>LOW</sub>	LOW period of the SCL clock		1.3			μs
T <sub>HIGH</sub>	HIGH period of the SCL clock		0.6			μs
t <sub>SU-STA</sub>	Set-up time for a repeated START condition		0.6			μs
t <sub>HD-DAT</sub>	Data hold time		0			μs
T <sub>SU-DAT</sub>	Data setup time		0.1			μs
t <sub>r</sub>	Rise time of both SDA and SCL signals	Pull-up resistor = 4.7 kΩ, C <sub>b</sub> = 10pF		120		ns
t <sub>f</sub>	Fall time of both SDA and SCL signals	Pull-up resistor = 4.7 kΩ, C <sub>b</sub> = 10pF		2		ns
t <sub>SU-STO</sub>	Set-up time for STOP condition		0.6			μs
t <sub>BUF</sub>	Bus free time between a STOP and START condition		1.3			μs
t <sub>VD-DAT</sub>	Data valid time				0.9	μs
t <sub>VD-ACK</sub>	Data valid acknowledge time				0.9	μs
C <sub>b</sub>	Capacitive load for each bus line				400	pF

## 5.8 Typical Characteristics

Figure 5-1 shows typical EQ gain curves versus frequency for different EQ settings. Figure 5-2 shows EQ gain variation over temperature for maximum EQ setting of 19. Figure 5-3 shows typical differential return loss for Rx and Tx pins.

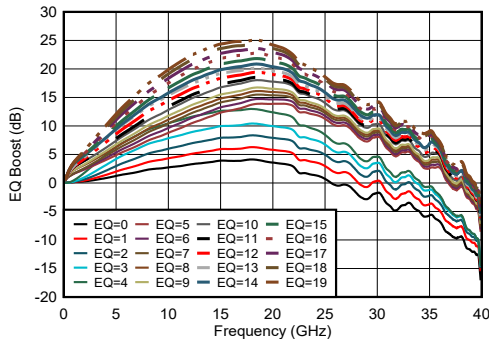


Figure 5-1. Typical EQ Boost vs Frequency

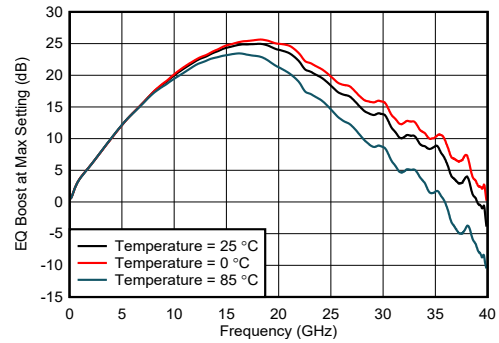


Figure 5-2. Typical EQ Boost vs Frequency at Different Temperature with EQ=19

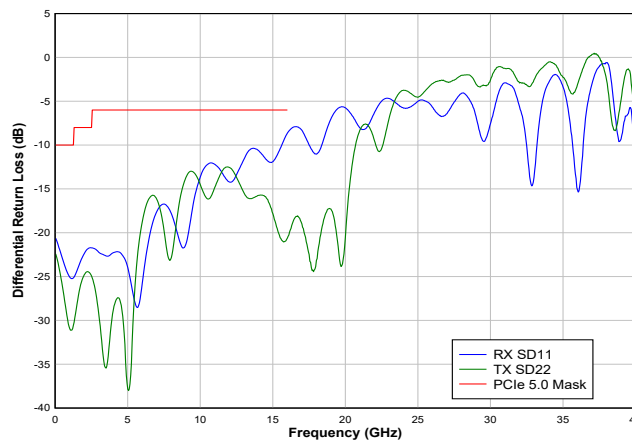


Figure 5-3. Typical Differential Return Loss

### 5.9 Typical Jitter Characteristics

Figure 5-4, Figure 5-5, and Figure 5-6 illustrate eye diagrams at source, through calibration traces, and through SN75LVPE5421 respectively.

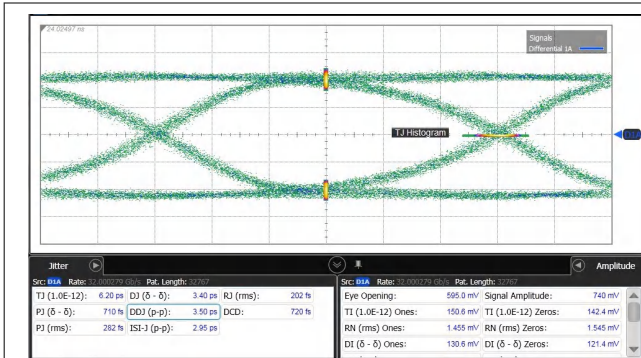


Figure 5-4. 32 Gbps 800 mV PRBS15 Source (1dB Loss)

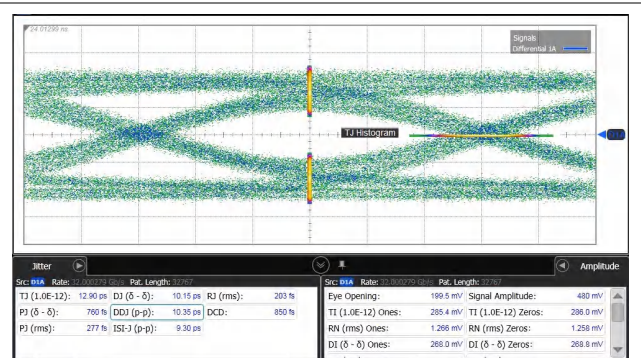


Figure 5-5. Through Calibration Trace (6.5dB Loss)

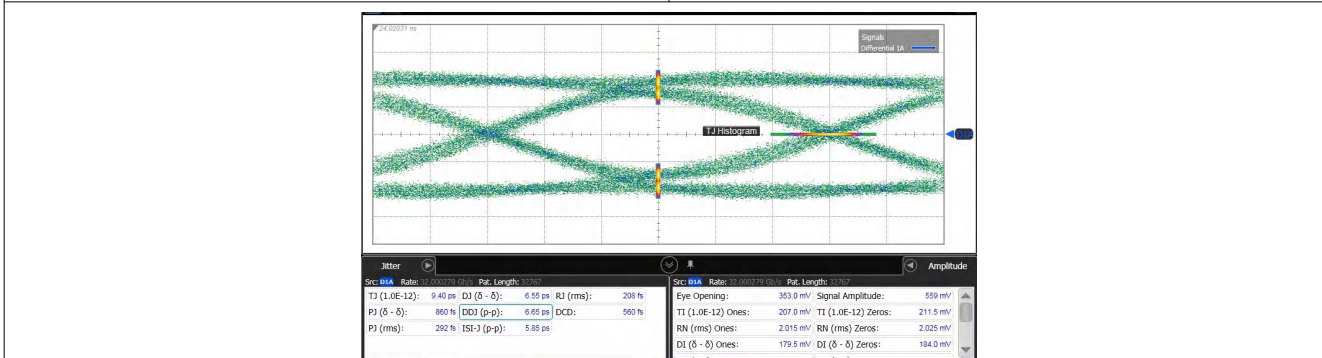


Figure 5-6. Through SN75LVPE5421 (6.5dB loss and DUT EQ=0)

## 6 Detailed Description

### 6.1 Overview

The SN75LVPE5421 is a four channel linear redriver with integrated multiplexer (mux). The low-power high-performance linear repeater or redriver is designed to support PCIe 1.0, 2.0, 3.0, 4.0, and 5.0. The device is a protocol agnostic linear redriver that can operate for other AC-coupled interface up to 32Gbps.

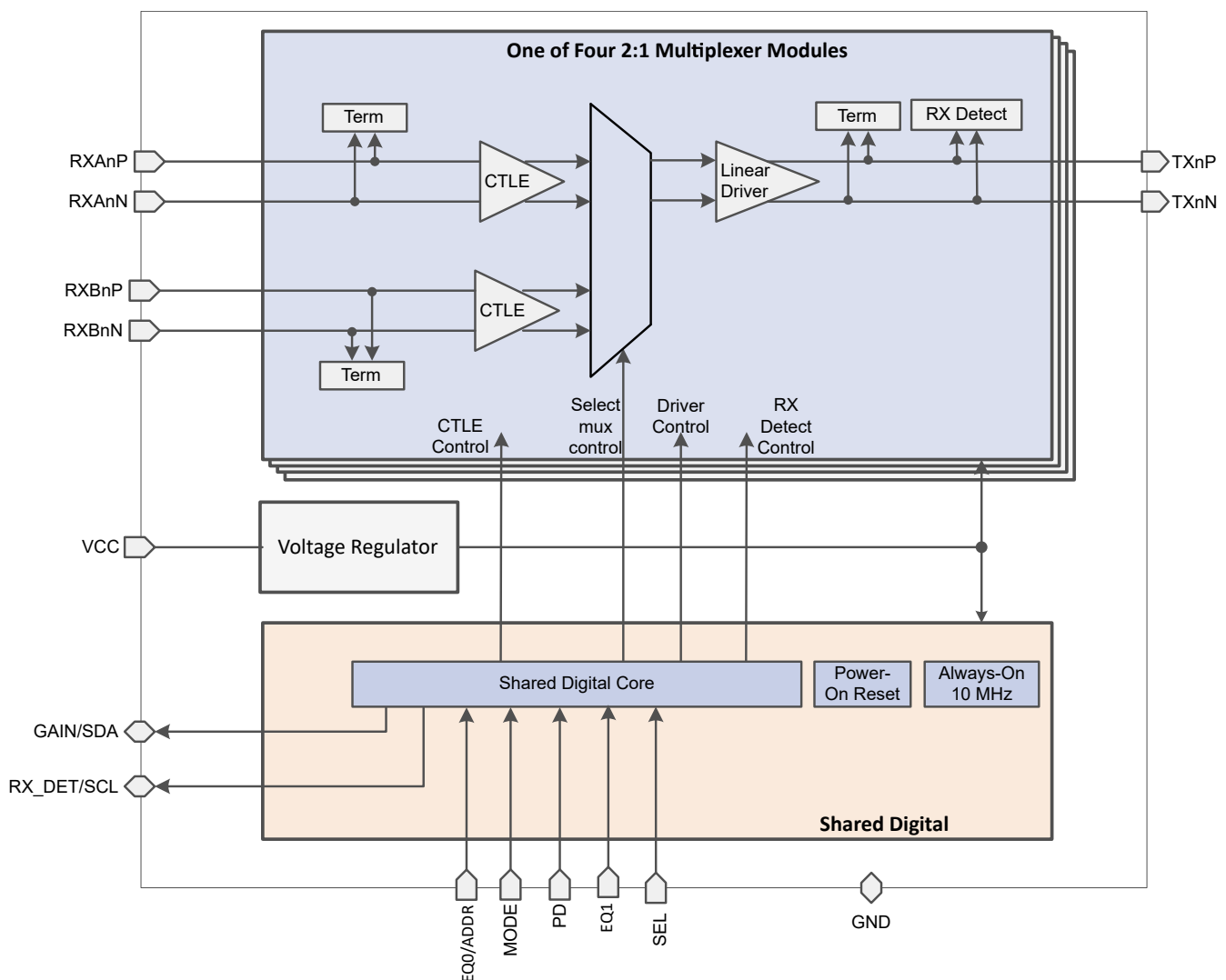
The signal channels of the SN75LVPE5421 operate independently from one another. Each channel includes a continuous-time linear equalizer (CTLE) and a linear output driver, which together compensate for a lossy transmission channel between the source transmitter and the final receiver. The linearity of the data path is specifically designed to preserve any transmit equalization while keeping PCIe receiver's (either from Root Complex or Endpoint) equalization effective.

The SN75LVPE5421 can be configured in two different ways:

**Pin Mode** – device control configuration is done solely by strap pins. Pin mode is expected to be good enough for many system implementation needs.

**SMBus/I<sup>2</sup>C Secondary Mode** – provides most flexibility. Requires an external SMBus/I<sup>2</sup>C primary device to configure SN75LVPE5421 though writing to its secondary address.

### 6.2 Functional Block Diagram



## 6.3 Feature Description

### 6.3.1 Five-Level Control Inputs

The SN75LVPE5421 has five 5-level inputs pins (EQ1, EQ0, GAIN, MODE, and RX\_DET) that are used to control the configuration of the device. These 5-level inputs use a resistor divider to help set the 5 valid levels and provide a wider range of control settings. External resistors must be of 10% tolerance or better. The EQ0, EQ1, GAIN, and RX\_DET pins are sampled at power-up only. The MODE pin can be exercised at device power up or in normal operation mode.

**Table 6-1. 5-Level Control Pin Settings**

LEVEL	SETTING
L0	1 kΩ to GND
L1	8.25 kΩ to GND
L2	24.9 kΩ to GND
L3	75 kΩ to GND
L4	F (Float)

### 6.3.2 Linear Equalization

The SN75LVPE5421 receivers feature a continuous-time linear equalizer (CTLE) that applies high-frequency boost and low-frequency attenuation to help equalize the frequency-dependent insertion loss effects of a passive channel. The receivers implement two stage linear equalizer for wide range of equalization capability. The equalizer stages also provide flexibility to make subtle modifications of mid-frequency boost for best EQ gain profile match with wide range of channel media characteristics. The EQ profile control feature is only available in SMBus/I<sup>2</sup>C Mode. In Pin Mode the settings are optimized for FR4 traces.

Table 6-2 shows available equalization boost through EQ control pins or SMBus/I<sup>2</sup>C registers. In Pin Control mode EQ1 and EQ0 pins set equalization boost for all channels. In I<sup>2</sup>C Mode individual channels can be independently programmed for EQ boost.

**Table 6-2. Equalization Control Settings**

EQ INDEX	EQUALIZATION SETTING						TYPICAL EQ BOOST (dB)	
	Pin Mode		SMBus/I <sup>2</sup> C Mode				At 8 GHz	At 16 GHz
	EQ1	EQ0	eq_stage1_3:0	eq_stage2_2:0	eq_profile_3:0	eq_stage1_bypass		
0	L0	L0	0	0	0	1	2.0	4.0
1	L0	L1	1	0	0	1	4.0	6.0
2	L0	L2	3	0	0	1	5.0	8.0
3	L0	L3	7	0	0	1	7.0	10.0
4	L0	L4	7	1	0	1	8.0	12.0
5	L1	L0	0	0	1	0	7.0	12.0
6	L1	L1	1	0	1	0	7.5	13.0
7	L1	L2	2	0	1	0	8.0	14.0
8	L1	L3	3	0	3	0	9.0	15.0
9	L1	L4	4	0	3	0	10.0	15.5
10	L2	L0	5	1	7	0	10.5	16.0
11	L2	L1	6	1	7	0	11.0	17.0
12	L2	L2	8	1	7	0	12.0	17.5
13	L2	L3	10	1	7	0	12.5	18.5

**Table 6-2. Equalization Control Settings (continued)**

EQ INDEX	EQUALIZATION SETTING						TYPICAL EQ BOOST (dB)	
	Pin Mode		SMBus/I <sup>2</sup> C Mode				At 8 GHz	At 16 GHz
	EQ1	EQ0	eq_stage1_3:0	eq_stage2_2:0	eq_profile_3:0	eq_stage1_bypass		
14	L2	L4	10	2	15	0	13.0	19.0
15	L3	L0	11	3	15	0	14.0	20.0
16	L3	L1	12	4	15	0	15.0	21.0
17	L3	L2	13	5	15	0	16.0	22.0
18	L3	L3	14	6	15	0	16.5	23.0
19	L3	L4	15	7	15	0	17.0	24.0

### 6.3.3 Flat Gain

The GAIN pin can be used to set the overall datapath flat gain (broadband gain including high frequency) of the SN75LVPE5421 when the device is in Pin Mode. The pin GAIN sets the Flat-Gain for all channels. In I<sup>2</sup>C Mode each channel can be independently set. Table 6-3 shows flat gain control configuration settings. The default recommendation for most systems will be GAIN = L4 (float) that provides flat gain of 0dB.

The flat gain and equalization of the SN75LVPE5421 must be set such that the output signal swing at DC and high frequency does not exceed the DC and AC linearity ranges of the devices, respectively.

**Table 6-3. Flat Gain Configuration Settings**

Pin Mode GAIN	I <sup>2</sup> C Mode flat_gain_2:0	Flat Gain
L0	0	-5.6dB
L1	1	-3.8dB
L2	3	-1.2dB
L3	7	+2.6dB
L4 (float)	5	+0.6dB (default recommendation)

### 6.3.4 Receiver Detect State Machine

The SN75LVPE5421 deploys an RX detect state machine that governs the RX detection cycle as defined in the PCI express specifications. At device power up or through manually triggered event using PD or SEL pin or writing to the relevant I<sup>2</sup>C/SMBus register, the redriver determines whether or not a valid PCI express termination is present at the far end of the link. The RX\_DET pin of SN75LVPE5421 provides additional flexibility for system designers to appropriately set the device in desired mode according to Table 6-4. For the PCIe application the RX\_DET pin can be left floating for default settings.

Note: power up ramp or PD/SEL event triggers RX detect for all four channels. In applications where SN75LVPE5421 channels are used for multiple PCIe links, the RX detect function can be performed for individual channels through writing in appropriate I<sup>2</sup>C/SMBus registers.

**Table 6-4. Receiver Detect State Machine Settings**

PD	RX_DET	RX Common-mode Impedance	COMMENTS
L	L0	Always 50 Ω	PCI Express RX detection state machine is disabled. Recommended for non PCIe interface use case where the SN75LVPE5421 is used as buffer with equalization.
L	L1	Pre Detect: Hi-Z Post Detect: 50 Ω.	Outputs polls until 3 consecutive valid detections

**Table 6-4. Receiver Detect State Machine Settings (continued)**

PD	RX_DET	RX Common-mode Impedance	COMMENTS
L	L2	Pre Detect: Hi-Z Post Detect: 50 Ω.	Outputs polls until 2 consecutive valid detections
L	L3	Pre Detect: Hi-Z Post Detect: 50 Ω.	Reserved
L	L4 (Float)	Pre Detect: Hi-Z Post Detect: 50 Ω.	TX polls every $\approx 150 \mu\text{s}$ until valid termination is detected. RX CM impedance held at Hi-Z until detection Reset by asserting PD high for 200 $\mu\text{s}$ then low. Recommended default setting for PCIe.
H	X	Hi-Z	Reset Channels and set their RX impedance to Hi-Z

## 6.4 Device Functional Modes

### 6.4.1 Active PCIe Mode

The device is in normal operation with PCIe state machine enabled by RX\_DET = L4 (float). This mode is recommended for PCIe use cases. In this mode, the PD pin is driven low in a system (for example, by PCIe connector *PRSNT* signal). In this mode, the device redrives and equalizes PCIe RX or TX signals to provide better signal integrity.

### 6.4.2 Active Buffer Mode

The device is in normal operation with PCIe state machine disabled by RX\_DET = L0. This mode is recommended for non-Pcie use cases. In this mode, the device is working as a buffer to provide linear equalization to improve signal integrity.

### 6.4.3 Standby Mode

The device is in standby mode invoked by PD = H. In this mode, the device is in standby mode conserving power.

## 6.5 Programming

### 6.5.1 Pin Mode

The SN75LVPE5421 can be fully configured through pin-strap pins. In this mode the device uses 2-level and 5-level pins for device control and signal integrity optimum settings.

### 6.5.2 SMBUS/I<sup>2</sup>C Register Control Interface

If MODE = L2 (SMBus / I<sup>2</sup>C secondary control mode), the SN75LVPE5421 is configured for best signal integrity through a standard I<sup>2</sup>C or SMBus interface that may operate up to 400 kHz. The secondary address of the SN75LVPE5421 is determined by the pin strap settings on the ADDR and MODE pins. Table 6-5 provides the eight possible secondary addresses (7-bit) for each channel banks of the device. In SMBus/I<sup>2</sup>C modes the SCL, SDA pins must be pulled up to a 3.3V supply with a pull-up resistor. The value of the resistor depends on total bus capacitance. 4.7kΩ is a good first approximation for a bus capacitance of 10pF.

**Table 6-5. SMBUS/I<sup>2</sup>C Secondary Address Settings**

MODE	ADDR	7-bit Secondary Address Channels 0-1	7-bit Secondary Address Channels 2-3
L1	L0	0x18	0x19
L1	L1	0x1A	0x1B
L1	L2	0x1C	0x1D
L1	L3	0x1E	0x1F
X	L4	Reserved	Reserved
L2	L0	0x20	0x21
L2	L1	0x22	0x23
L2	L2	0x24	0x25
L2	L3	0x26	0x27

The SN75LVPE5421 has two types of registers:

- **Shared Registers:** These registers can be accessed at any time and are used for device-level configuration, status read back, control, or to read back the device ID information.
- **Channel Registers:** These registers are used to control and configure specific features for each individual channel. All channels have the same register set and can be configured independent of each other or configured as a group through broadcast writes to Bank 0 or Bank 1.

The SN75LVPE5421 features two banks of channels, Bank 0 (Channels 0-1) and Bank 1 (Channels 2-), each featuring a separate register set and requiring a unique SMBus secondary address.

Channel Registers Base Address	Channel Bank 0 Access	Channel Bank 1 Access
0x00	Channel 0 registers	Channel 2 registers
0x20	Channel 0 registers	Channel 2 registers
0x40	Channel 1 registers	Channel 3 registers
0x60	Channel 1 registers	Channel 3 registers
0x80	Broadcast write channel Bank 0 registers, read channel 0 registers	Broadcast write channel Bank 1 registers, read channel 2 registers
0xE0	Bank 0 Share registers	Bank 1 Share registers

### 6.5.2.1 Shared Registers

**Table 6-6. General Registers (Offset = 0xE2)**

Bit	Field	Type	Reset	Description
7	RESERVED	R	0x0	Reserved
6	rst_i2c_regs	R/W/SC	0x0	Device reset control: Reset all I2C registers to default values (self-clearing).
5	rst_i2c_mas	R/W/SC	0x0	Reset I <sup>2</sup> C Primary (self-clearing).
4-0	RESERVED	R	0x0000	Reserved

**Table 6-7. DEVICE\_ID0 Register (Offset = 0xF0)**

Bit	Field	Type	Reset	Description
7-4	RESERVED	R	0x0001	Reserved
3	device_id0_3	R	0x1	Device ID0 [3:1]: 101
2	device_id0_2	R	0x0	see MSB
1	device_id0_1	R	0x1	see MSB
0	RESERVED	R	X	Reserved

**Table 6-8. DEVICE\_ID1 Register (Offset = 0xF1)**

Bit	Field	Type	Reset	Description
7	device_id[7]	R	0x0	Device ID 0010 1000: SN75LVPE5421
6	device_id[6]	R	0x0	see MSB
5	device_id[5]	R	0x1	see MSB
4	device_id[4]	R	0x0	see MSB
3	device_id[3]	R	0x1	see MSB
2	device_id[2]	R	0x0	see MSB
1	device_id[1]	R	0x0	see MSB
0	device_id[0]	R	0x1	see MSB



### 6.5.2.2 Channel Registers

**Table 6-9. RX Detect Status Register (Channel Register Base + Offset = 0x00)**

Bit	Field	Type	Reset	Description
7	RX_det_comp_p	R	0x0	RX Detect positive data pin status: 0: Not detected 1: Detected – the value is latched
6	RX_det_comp_n	R	0x0	RX Detect negative data pin status: 0: Not detected 1: Detected – the value is latched
5-0	RESERVED	R	0x0	Reserved

**Table 6-10. EQ Gain Control Register (Channel Register Base + Offset = 0x01)**

Bit	Field	Type	Reset	Description
7	eq_stage1_bypass	R/W	0x0	Enable EQ stage 1 bypass: 0: Bypass disabled 1: Bypass enabled
6	eq_stage1_3	R/W	0x0	EQBoost stage 1 control See <a href="#">Table 6-2</a> for details
5	eq_stage1_2	R/W	0x0	
4	eq_stage1_1	R/W	0x0	
3	eq_stage1_0	R/W	0x0	
2	eq_stage2_2	R/W	0x0	EQ Boost stage 2 control See <a href="#">Table 6-2</a> for details
1	eq_stage2_1	R/W	0x0	
0	eq_stage2_0	R/W	0x0	

**Table 6-11. EQ Gain / Flat Gain Control Register (Channel Register Base + Offset = 0x03)**

Bit	Field	Type	Reset	Description
7	RESERVED	R	0x0	Reserved
6	eq_profile_3	R/W	0x0	EQ mid-frequency boost profile See <a href="#">Table 6-2</a> for details
5	eq_profile_2	R/W	0x0	
4	eq_profile_1	R/W	0x0	
3	eq_profile_0	R/W	0x0	
2	flat_gain_2	R/W	0x1	Flat gain select: See <a href="#">Table 6-3</a> for details
1	flat_gain_1	R/W	0x0	
0	flat_gain_0	R/W	0x1	

**Table 6-12. RX Detect Control Register (Channel Register Base + Offset = 0x04)**

Bit	Field	Type	Reset	Description
7-3	RESERVED	R	0x0	Reserved
2	mr_RX_det_man	R/W	0x0	Manual override of RX_detect_p/n decision: 0: RX detect state machine is enabled 1: RX detect state machine is overridden – always valid RX termination detected
1	en_RX_det_count	R/W	0x0	Enable additional RX detect polling 0: Additional RX detect polling disabled 1: Additional RX detect polling enabled
0	sel_RX_det_count	R/W	0x0	Select number of valid RX detect polls – gated by en_RX_det_count = 1 0: Device transmitters poll until 2 consecutive valid detections 1: Device transmitters poll until 3 consecutive valid detections

**Table 6-13. PD Override Register (Channel Register Base + Offset = 0x05)**

Bit	Field	Type	Reset	Description
7	device_en_override	R/W	0x0	Enable power down overrides through SMBus/I <sup>2</sup> C 0: Manual override disabled 1: Manual override enabled
6-0	device_en	R/W	0x111111	Manual power down of redriver various blocks – gated by device_en_override = 1 111111: All blocks are enabled 000000: All blocks are disabled

**Table 6-14. RX Detect Reset Register (Channel Register Base + Offset = 0x0A)**

Bit	Field	Type	Reset	Description
7-3	RESERVED	R	0x0	Reserved
2	mr_RX_det_rst	R/W	0x0	RX Detect state machine reset. Toggle the bit if RX Detect machine needs to be reset in I <sup>2</sup> C mode 0: state machine is not reset 1: RX detect state machine is reset
1-0	RESERVED	R/W	0x0	Reserved

## 7 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.

---

### 7.1 Application Information

The SN75LVPE5421 is a high-speed linear repeater with integrated mux. The device extends the reach of differential channels impaired by loss from transmission media like PCBs and cables. It can be deployed in a variety of different systems. The following sections outline typical applications and their associated design considerations.

### 7.2 Typical Applications

The SN75LVPE5421 is a PCI Express linear redriver that can also be configured as interface agnostic redriver by disabling its RX detect feature. The device can be used in a wide range of interfaces including:

- PCI Express
- Ultra Path Interconnect (UPI)
- SATA
- SAS
- DisplayPort

SN75LVPE5421

SNLS692B – DECEMBER 2021 – REVISED DECEMBER 2023

7.2.1 PCIe x8 Lane Switching

The SN75LVPE5412 and SN75LVPE5421 can be used to switch PCIe lanes from a CPU into one of the two PCIe CEM connectors. Figure 7-1 shows a simplified schematic for the following configuration:

- Two SN75LVPE5412 demultiplex eight TX channels from the CPU into one of the two PCIe slots.
- Two SN75LVPE5421 multiplex eight RX channels from one of the two PCIe slots to CPU.

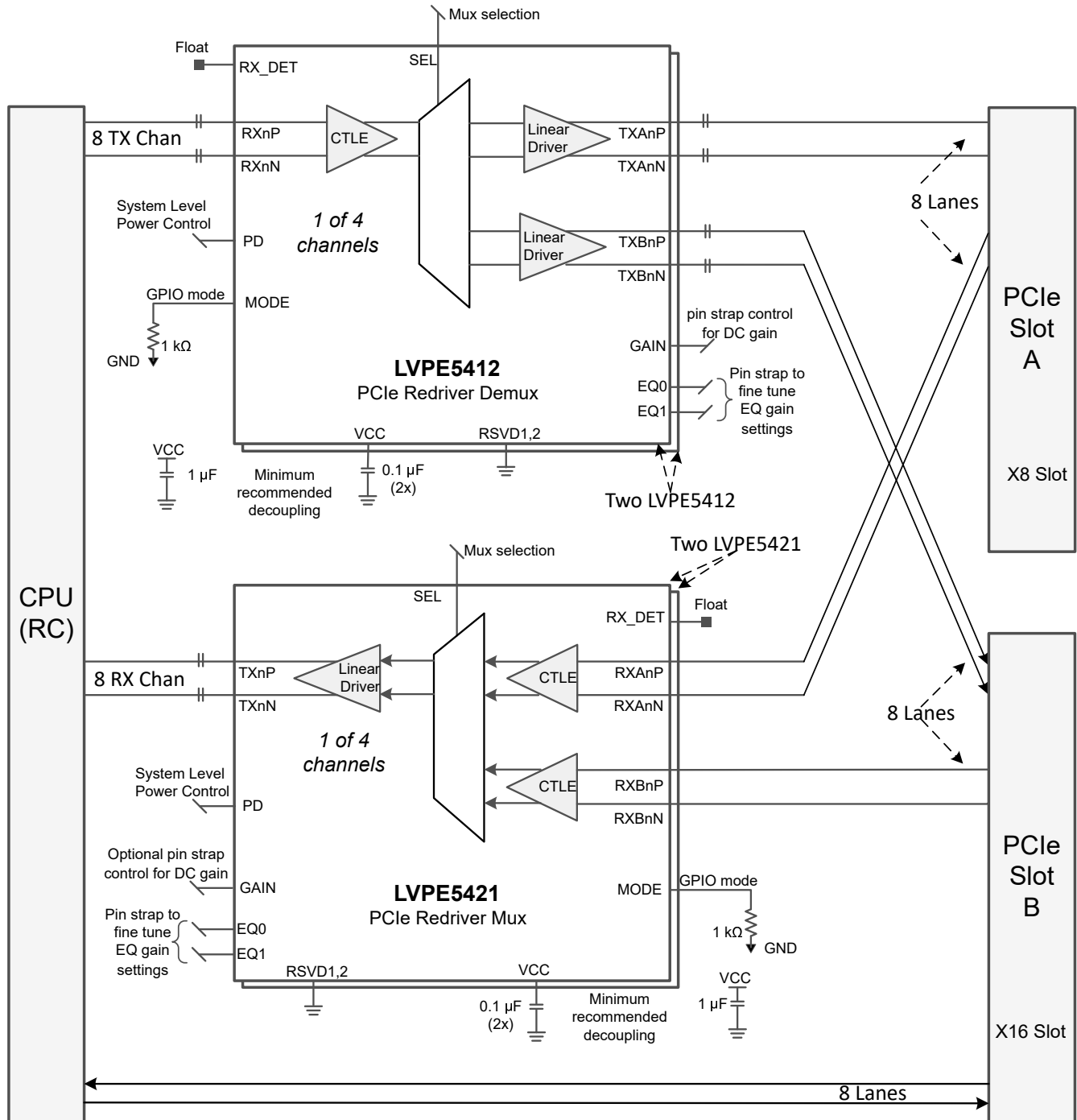


Figure 7-1. Simplified Schematic for PCIe Lane Switching

### 7.2.1.1 Design Requirements

As with any high-speed design, there are many factors which influence the overall performance. The following list indicates critical areas for consideration during design:

- Use 85  $\Omega$  impedance traces when interfacing with PCIe CEM connectors. Length matching on the P and N traces should be done on the single-ended segments of the differential pair.
- Use a uniform trace width and trace spacing for differential pairs.
- Place AC-coupling capacitors near to the receiver end of each channel segment to minimize reflections.
- For Gen 3.0, 4.0, and 5.0, AC-coupling capacitors of 220 nF are recommended, set the maximum body size to 0402, and add a cutout void on the GND plane below the landing pad of the capacitor to reduce parasitic capacitance to GND.
- Back-drill connector vias and signal vias to minimize stub length.
- Use reference plane vias to ensure a low inductance path for the return current.

### 7.2.1.2 Detailed Design Procedure

In PCIe Gen 3.0, 4.0, and 5.0 applications, the specification requires RX-TX link training to establish and optimize signal conditioning settings at 8.0, 16.0, and 32.0Gbps, respectively. In link training, the RX partner requests a series of FIR – pre-shoot and de-emphasis coefficients (10 presets) from the TX partner. The RX partner includes CTLE and DFE. The link training would pre-condition the signal, with an equalized link between the Root Complex and Endpoint.

Note: there is no link training in PCIe Gen 1.0 (2.5Gbps) or PCIe Gen 2.0 (5.0Gbps) applications. The SN75LVPE5421 is placed in between the TX and RX. It helps extend the PCB trace reach distance by boosting the attenuated signals with its equalization, which allows the user to recover the signal by the downstream RX more easily.

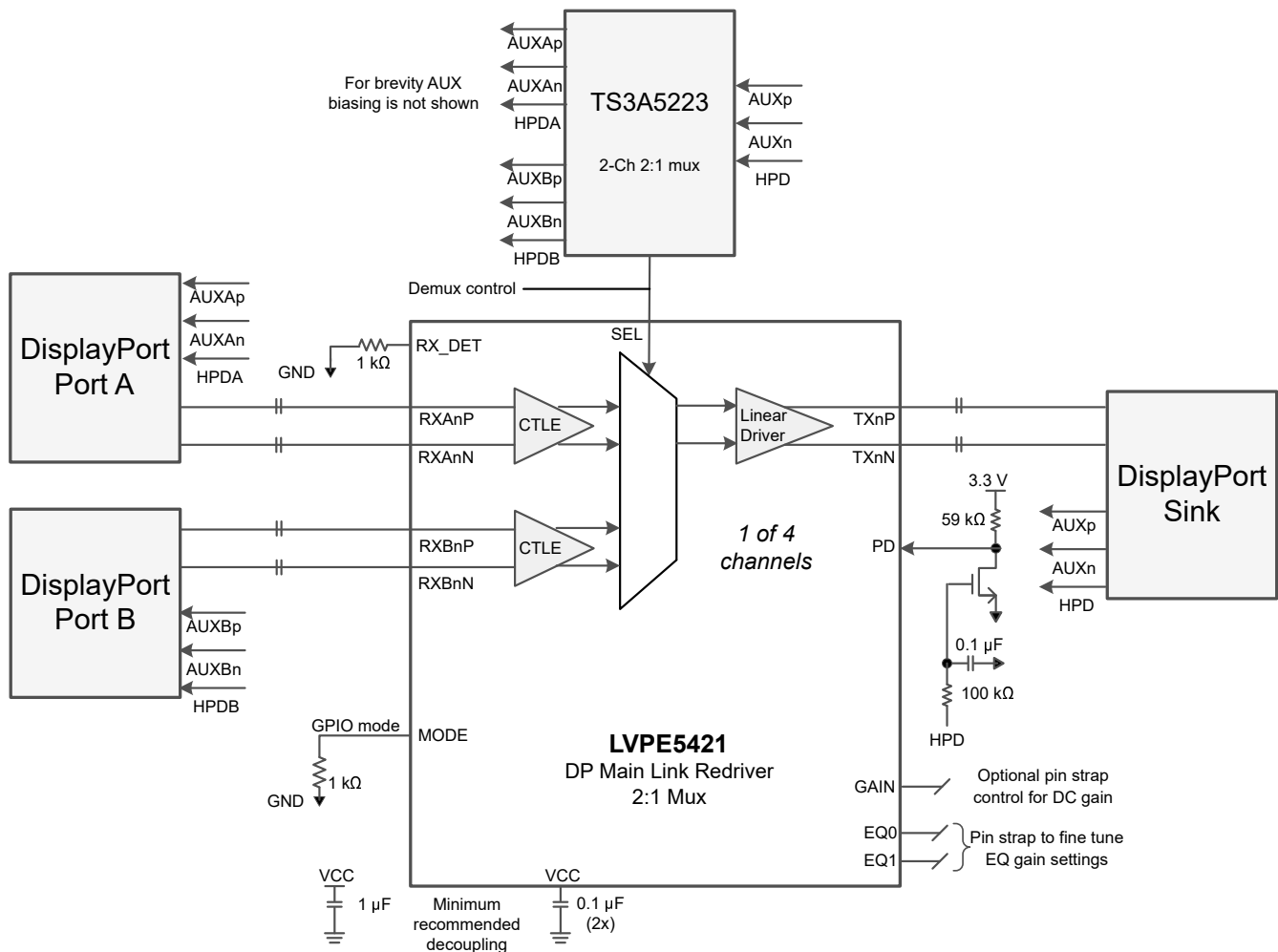
For operation in Gen 5.0, 4.0, and 3.0 links, the SN75LVPE5421 transmit outputs are designed to pass the TX Preset signaling onto the RX for the PCIe Gen 5.0, 4.0, and 3.0 link to train and optimize the equalization settings. The suggested setting for the device is GAIN = L4 (default). Adjustments to the EQ setting should be performed based on the channel loss to optimize the eye opening in the RX partner. The TX equalization presets or CTLE and DFE coefficients in the RX can also be adjusted to further improve the eye opening.

## 7.2.2 Protocol Agnostic Linear Redriver for High Speed Interfaces

The SN75LVPE5421 can be used as a four channel protocol agnostic linear redriver multiplexer (mux) for data rates up to 32Gbps. To use the device in a non-PCIe application, the RX\_DET pin must be pin-strapped to GND with 1k $\Omega$  resistor (L0).

This section explains how the SN75LVPE5421 can be used in DisplayPort (DP) application. The device is a linear redriver which is agnostic to DP link training. The DP link training negotiation between a display source and sink stays effective through the device. The redriver becomes part of the electrical channel along with passive traces, cables, and so forth, resulting in optimum source and sink parameters for best electrical link.

Figure 7-2 shows a simplified schematic for DisplayPort multiplexing application using SN75LVPE5421. Auxiliary and Hot plug detect (HPD) are muxed outside of the device. If system use case requires implementing DP power states, then the device must be controlled by the I<sup>2</sup>C.



**Figure 7-2. Simplified Schematic for DisplayPort Multiplexer Application**

The inverted DisplayPort HPD signal can be used to put the device into standby mode by using its PD pin. Note: in a DisplayPort link a sink can use HPD line to create an interrupt for its link partner source. If HPD signal is used for power management, then an RC filter must be installed to filter out HPD interrupt signals.

The SN75LVPE5421 can similarly be used for other AC-coupled high speed interfaces. Care must be taken to understand the specifications of the interface to ensure feasibility.

## 7.3 Power Supply Recommendations

Follow these general guidelines when designing the power supply:

1. The power supply should be designed to provide the operating conditions outlined in the recommended operating conditions section in terms of DC voltage, AC noise, and start-up ramp time.
2. The SN75LVPE5421 does not require any special power supply filtering, such as ferrite beads, provided that the recommended operating conditions are met. Only standard supply decoupling is required. Typical supply decoupling consists of a 0.1  $\mu\text{F}$  capacitor per VCC pin, one 1.0  $\mu\text{F}$  bulk capacitor per device, and one 10  $\mu\text{F}$  bulk capacitor per power bus that delivers power to one or more devices. The local decoupling (0.1  $\mu\text{F}$ ) capacitors must be connected as close to the VCC pins as possible and with minimal path to the device ground pad.

## 7.4 Layout

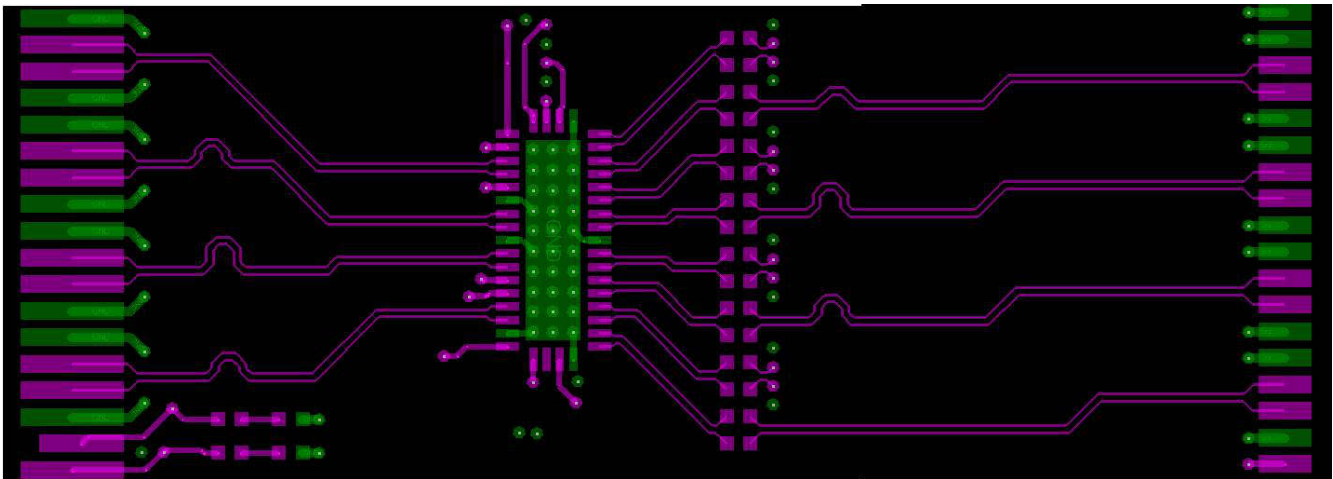
### 7.4.1 Layout Guidelines

The following guidelines should be followed when designing the layout:

1. Decoupling capacitors should be placed as close to the VCC pins as possible. Placing the decoupling capacitors directly underneath the device is recommended if the board design permits.
2. High-speed differential signals TXnP/TXnN and RXnP/RXnN should be tightly coupled, skew matched, and impedance controlled.
3. Vias should be avoided when possible on the high-speed differential signals. When vias must be used, take care to minimize the via stub, either by transitioning through most or all layers or by back drilling.
4. GND relief can be used (but is not required) beneath the high-speed differential signal pads to improve signal integrity by counteracting the pad capacitance.
5. GND vias should be placed directly beneath the device connecting the GND plane attached to the device to the GND planes on other layers. This has the added benefit of improving thermal conductivity from the device to the board.

### 7.4.2 Layout Example

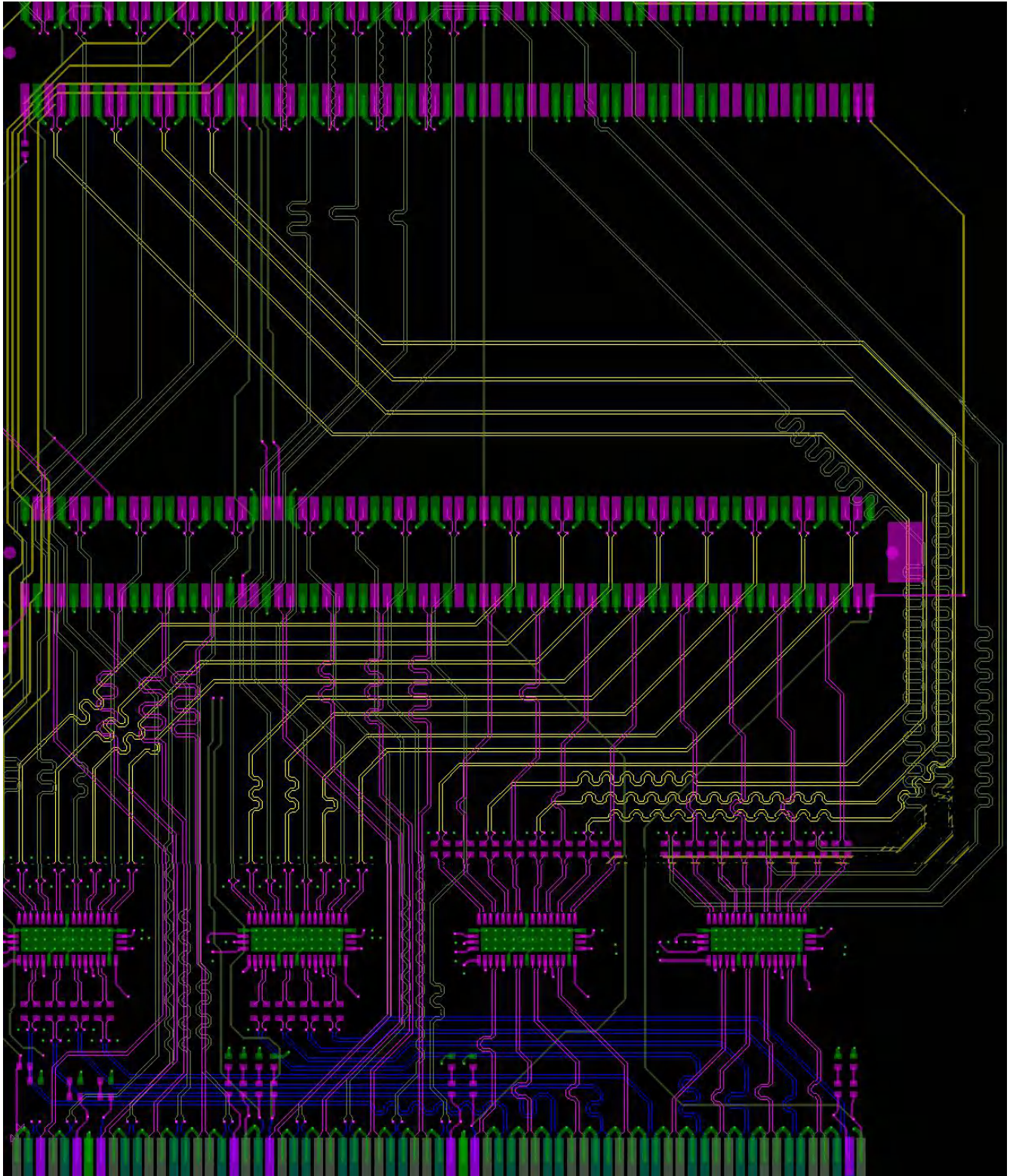
Figure 7-3 shows SN75LVPE5421 layout example.



**Figure 7-3. SN75LVPE5421 Layout Example**

Figure 7-4 shows a layout illustration where two SN75LVPE5412 and two SN75LVPE5421 are used to switch 8 lanes between the two PCIe slots.





**Figure 7-4. Layout Example for PCIe Lane Muxing Application**



## 8 Device and Documentation Support

### 8.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](http://ti.com). Click on *Notifications* 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.

### 8.2 Support Resources

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

Linked content is 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](#).

### 8.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.

PCIe® is a registered trademark of PCI-SIG.

All trademarks are the property of their respective owners.

### 8.4 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.

### 8.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 9 Revision History

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

Changes from Revision A (October 2022) to Revision B (December 2023)	Page
• Changed operating ambient temperature from: 0 to 85°C to: -40 to 85°C .....	6

Changes from Revision * (December 2021) to Revision A (October 2022)	Page
• Changed the <i>Reset</i> value for the 7-4 Bit in the <i>DEVICE_ID0 Register (Offset = 0xF0)</i> table.....	16

## 10 Mechanical, Packaging, and Orderable Information

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

**PACKAGING INFORMATION**

Orderable 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
SN75LVPE5421RUAR	ACTIVE	WQFN	RUA	42	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	0 to 85	5PR421	<a href="#">Samples</a>
SN75LVPE5421RUAT	ACTIVE	WQFN	RUA	42	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	0 to 85	5PR421	<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) **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.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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**

**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
SN75LVPE5421RUAR	WQFN	RUA	42	3000	330.0	16.4	3.8	9.3	1.0	8.0	16.0	Q1
SN75LVPE5421RUAT	WQFN	RUA	42	250	180.0	16.4	3.8	9.3	1.0	8.0	16.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN75LVPE5421RUAR	WQFN	RUA	42	3000	367.0	367.0	35.0
SN75LVPE5421RUAT	WQFN	RUA	42	250	210.0	185.0	35.0

## GENERIC PACKAGE VIEW

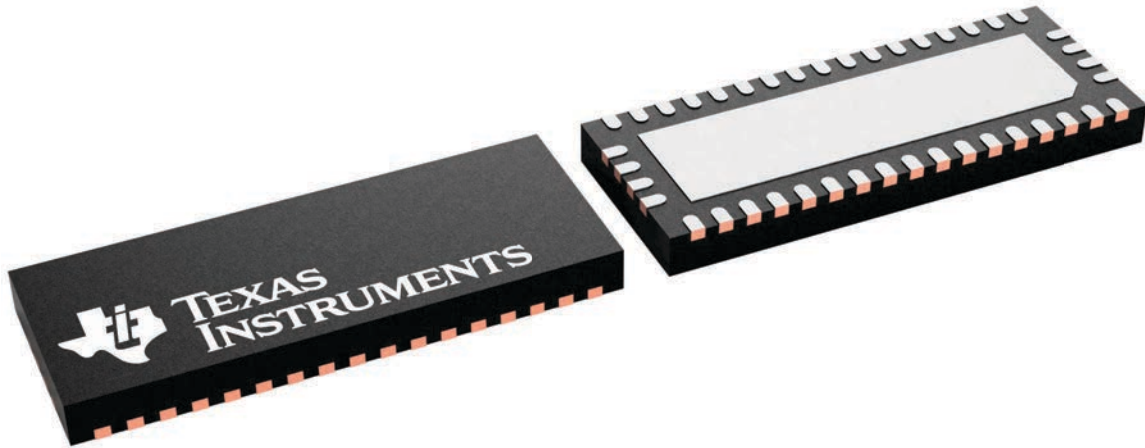
**RUA 42**

**WQFN - 0.8 mm max height**

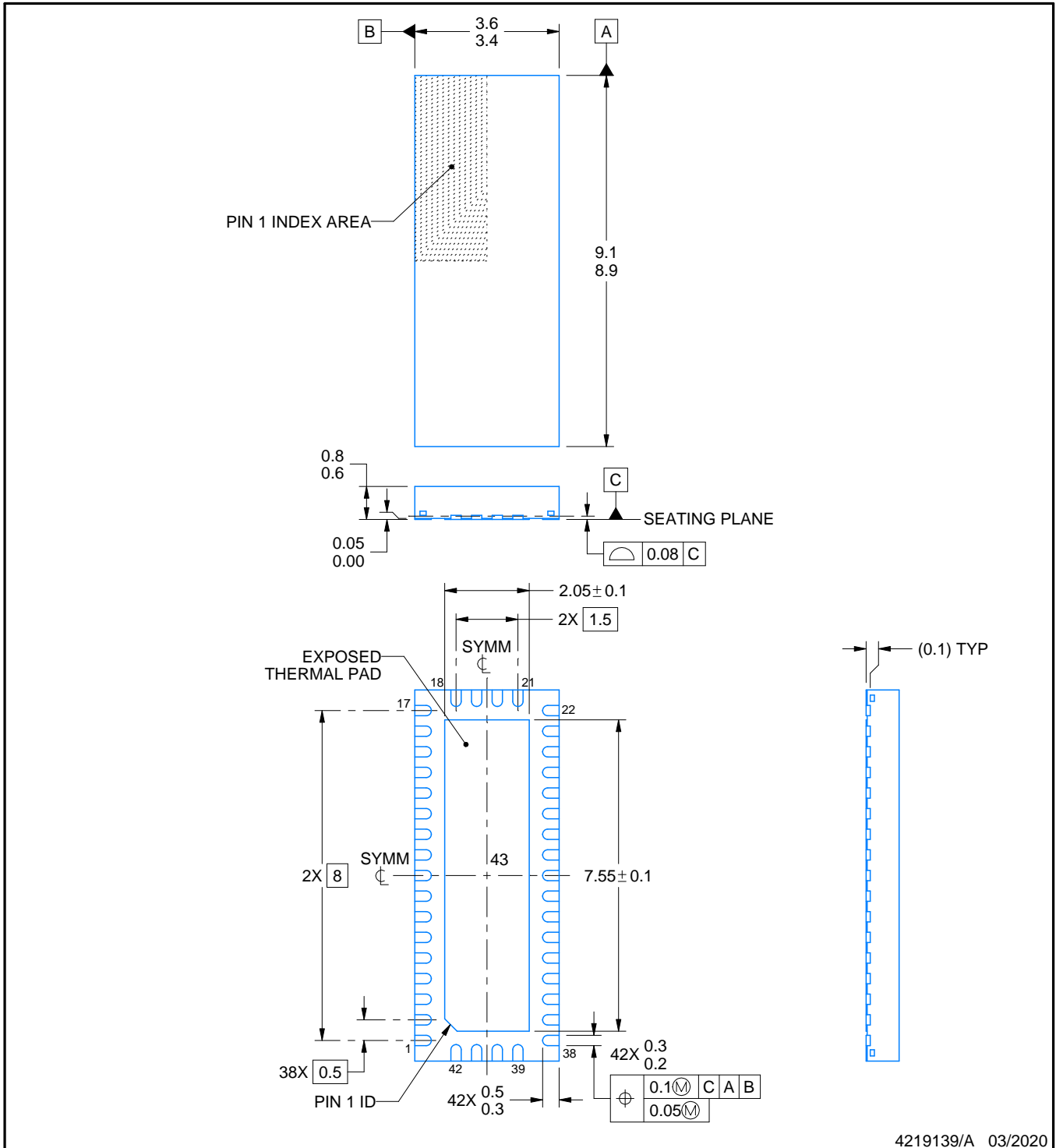
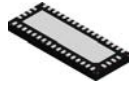
9 x 3.5, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD

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



4226504/A



4219139/A 03/2020

NOTES:

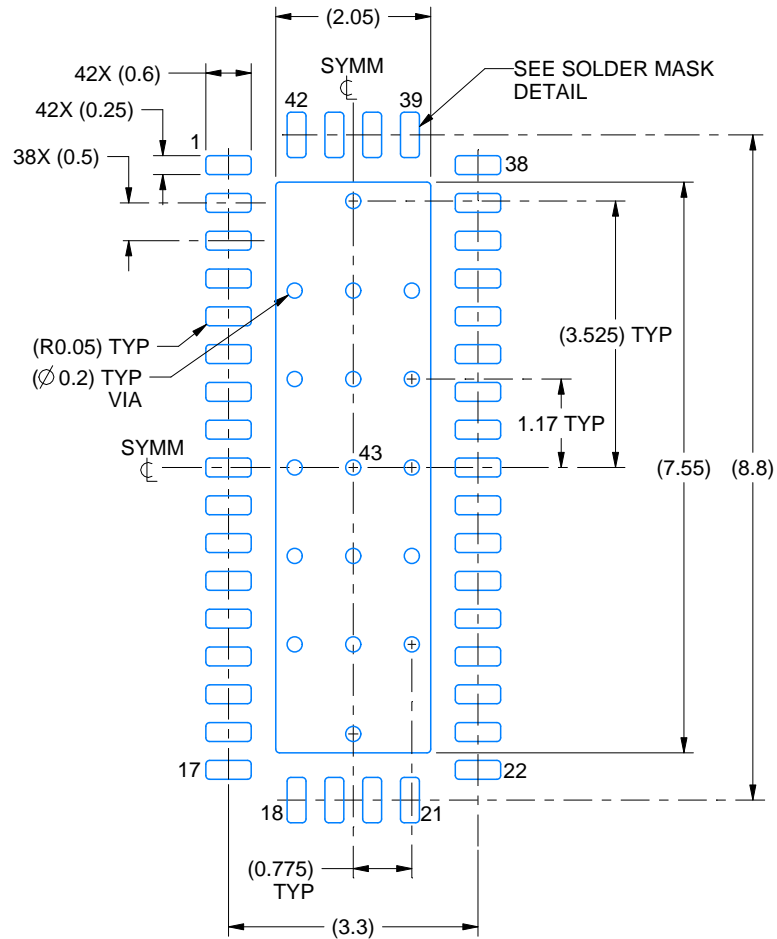
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

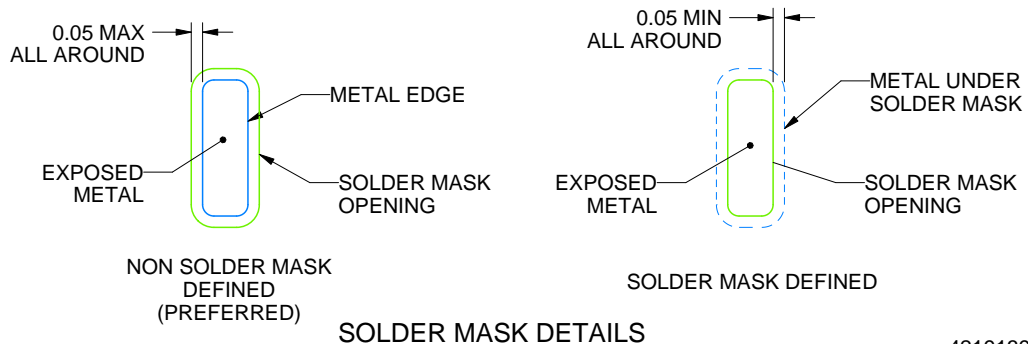
RUA0042A

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



4219139/A 03/2020

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

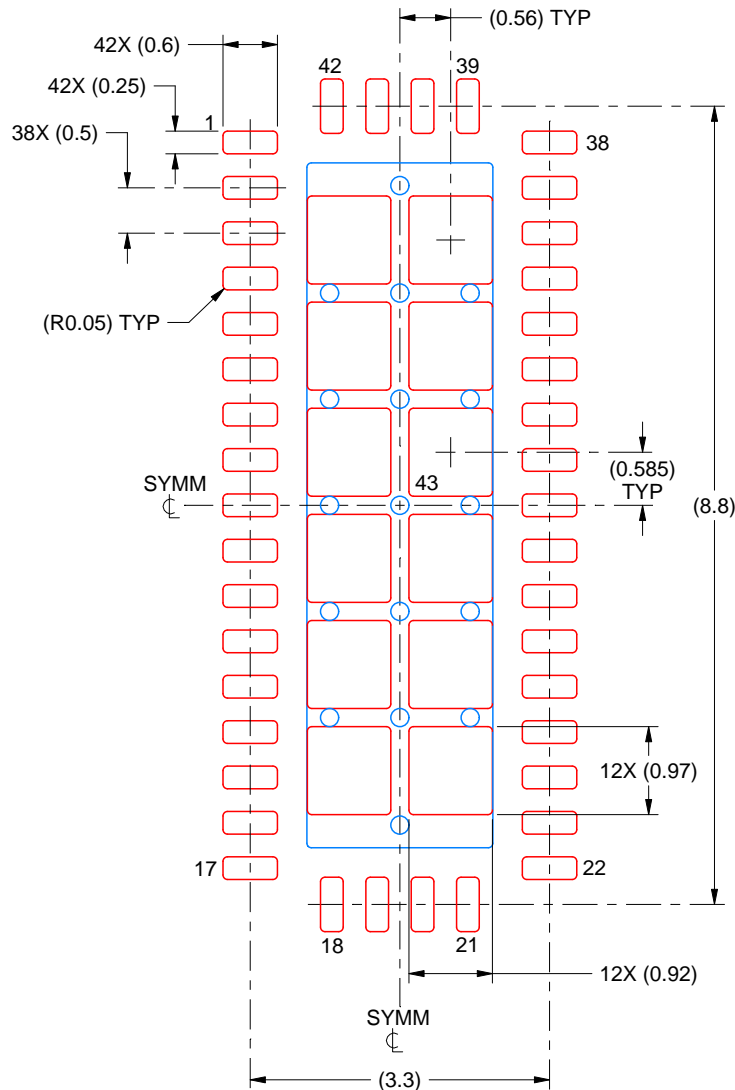


# EXAMPLE STENCIL DESIGN

RUA0042A

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 MM THICK STENCIL  
SCALE: 12X

EXPOSED PAD 43  
69% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

4219139/A 03/2020

NOTES: (continued)

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

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2023, Texas Instruments Incorporated