# TMUXHS4212 双通道差分 2:1 多路复用器或 1:2 多路信号分离器

## 1 特性

- 提供双向 2:1 多路复用器或 1:2 多路信号分离器
- 支持 USB 3.2，速率高达 10Gbps (Gen 2.0)；支持 PCI Express，速率高达 16Gbps (Gen 4.0)
- 还支持 SATA、SAS、Mipi® DSI/CSI、FPD-Link III、LVDS、SFI 和以太网®接口
- 13GHz 的 -3dB 差分带宽
- 动态特性：
  - 插入损耗 = −1.3/−1.8dB（5/8GHz 时）
  - 回损 = −13/−12dB（5/8GHz 时）
  - 关断隔离 = −22/−20dB（5/8GHz 时）
- 自适应共模电压跟踪
- 支持高达 0V 至 1.8V 的共模电压
- 单电源电压 $V_{CC}$ 为 3.3 或 1.8V
- 超低有效 (180 µA) 和待机功耗 (< 2 µA)
- -40° 至 105°C 的工业温度选项
- 采用 2.5mm x 4.5mm QFN 封装

## 2 应用

- PC 和笔记本电脑
- 智能手机、平板电脑和电视
- 游戏、家庭影院和娱乐
- 数据中心和企业级计算
- 医疗应用
- 测试和测量
- 工厂自动化和控制
- 航天和国防
- 电子销售终端 (EPOS)
- 无线基础设施

## 3 说明

TMUXHS4212 是一款采用多路复用器或多路信号分离器配置的高速双向无源开关。此开关适用于多种应用，包括 USB Type-C™ 和 PCI Express。TMUXHS4212 是一款通用模拟差分无源多路复用器或多路信号分离器，适用于许多高速差分接口，其数据速率高达 16Gbps。该器件可用于电气通道具有信号完整性裕度的更高数据速率。TMUXHS4212 支持差分信号，其共模电压范围 (CMV) 高达 0V 至 1.8V，差分振幅高达 1800mVpp。自适应 CMV 跟踪可确保通过器件的通道在整个共模电压范围内保持不变。

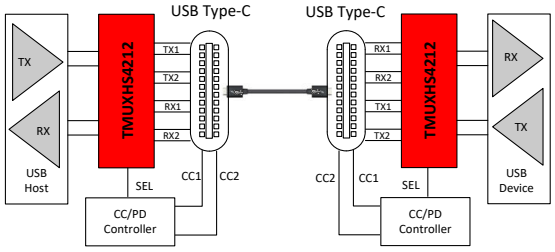
TMUXHS4212 的动态特性允许进行高速开关，使信号眼图具有最小的衰减，并且几乎不会增加抖动。该器件的芯片设计经过优化，可在较高信号频谱上实现出色的频率响应。其芯片信号布线和开关网络相匹配，以实现最佳的差分对内延迟差性能。

TMUXHS4212 具有扩展的工业温度范围，适合多种严苛应用，包括工业和高可靠性用例。

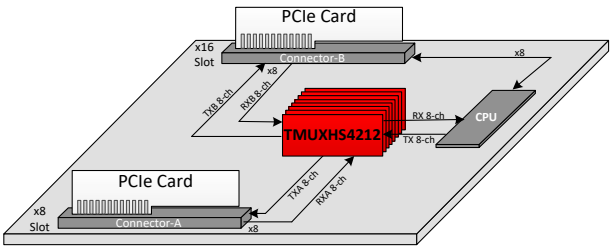
**器件信息**(1)

| 器件型号 | 封装 | 封装尺寸（标称值） |
|---|---|---|
| TMUXHS4212 | VQFN (20) | 2.50mm × 4.50mm × 0.5mm 间距 |
| TMUXHS4212I | | |

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。




USB-C DFP Port with USB 3.2　　USB-C UFP Port with USB 3.2




PCIe 3.0/4.0 Lane Switching

应用用例

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## 4 Revision History

注：以前版本的页码可能与当前版本的页码不同

| Changes from Revision * (May 2020) to Revision A (May 2022) | Page |
|---|---|
| • 更新了整个文档中的表格、图和交叉参考的编号格式 | 1 |
| • 更新了“特性”部分中的*单电源电压* $V_{CC}$ | 1 |
| • Updated the *RSVD1* and *RSVD2* description | 3 |
| • Changed single supply voltage $V_{CC}$ from: *3.3 V* to: *3.3 or 1.8 V* | 3 |

# 5 Pin Configuration and Functions

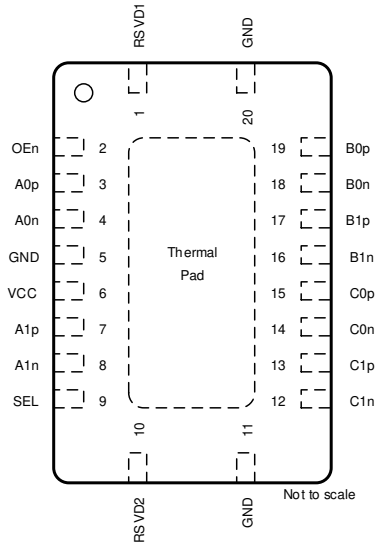



**图 5-1. RKS Package, 20-Pin VQFN (Top View)**

**表 5-1. Pin Functions**

| PIN | | TYPE(1) | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| A0n | 4 | I/O | Port A, channel 0, high-speed negative signal |
| A0p | 3 | I/O | Port A, channel 0, high-speed positive signal |
| A1n | 8 | I/O | Port A, channel 1, high-speed negative signal |
| A1p | 7 | I/O | Port A, channel 1, high-speed positive signal |
| B0n | 18 | I/O | Port B, channel 0, high-speed negative signal (connector side) |
| B0p | 19 | I/O | Port B, channel 0, high-speed positive signal (connector side) |
| B1n | 16 | I/O | Port B, channel 1, high-speed negative signal |
| B1p | 17 | I/O | Port B, channel 1, high-speed positive signal |
| C0n | 14 | I/O | Port C, channel 0, high-speed negative signal |
| C0p | 15 | I/O | Port C, channel 0, high-speed positive signal |
| C1n | 12 | I/O | Port C, channel 1, high-speed negative signal |
| C1p | 13 | I/O | Port C, channel 1, high-speed positive signal |
| GND | 5, 11, 20 | G | Ground |
| OEn | 2 | I | Active-low chip enable. The pin can be connected to GND if always on functional behavior is desired.<br>L: Normal operation, H: Shutdown. If always ON, behavior of the device is desired. The pin can be permanently connected to GND. |
| RSVD1 | 1 | NA | Reserved pins. Connect both pins to $V_{CC}$ |
| RSVD2 | 10 | NA | |
| SEL | 9 | I | Port select pin.<br>L: Port A to Port B, H: Port A to Port C |
| $V_{CC}$ | 6 | P | 3.3 V or 1.8 V power |

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

# 6 Specifications

## 6.1 Absolute Maximum Ratings

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

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $V_{CC-ABSMAX}$ | Supply voltage | | -0.5 | 4 | V |
| $V_{HS-ABSMAX}$ | Voltage | Differential I/O | -0.5 | 2.4 | V |
| $V_{CTR-ABSMAX}$ | Voltage | Control pins | -0.5 | $V_{CC}$+0.4 | V |
| $T_{STG}$ | Storage temperature | | -65 | 150 | °C |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. Theseare stress ratings only, which do not imply functional operation of the device at these or anyother conditions beyond those indicated under *Recommended OperatingConditions*. Exposure to absolute-maximum-rated conditions for extended periods mayaffect device reliability.

## 6.2 ESD Ratings

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{ESD}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1) | ±2000 | V |
| | | Charged-device model (CDM), per JEDEC specification JESD22-C101(2) | ±1000 | |

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

## 6.3 Recommended Operating Conditions

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

| | | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{CC}$ | Supply Voltage | 1.8 V mode | 1.71 | 1.8 | 1.98 | V |
| | | 3.3 V mode | 3.0 | 3.3 | 3.6 | V |
| $V_{CC-RAMP}$ | Supply voltage ramp time | | 0.1 | | 100 | ms |
| $V_{IH}$ | Input high voltage | SEL, OEn pins | 0.75 $V_{CC}$ | | | V |
| $V_{IL}$ | Input low voltage | SEL, OEn pins | | | 0.25 $V_{CC}$ | V |
| $V_{DIFF}$ | High-speed signal pins differential voltage | | 0 | | 1.8 | $V_{pp}$ |
| $V_{CM}$ | High speed signal pins common mode voltage | VCC 1.8 V mode | 0 | | 1.2 | V |
| | | VCC 3.3 V mode | 0 | | 1.8 | V |
| $T_A$ | Operating free-air/ambient temperature | TMUXHS4212 | 0 | | 70 | °C |
| | | TMUXHS4212I | -40 | | 105 | °C |

## 6.4 Thermal Information

| THERMAL METRIC(1) | | TMUXHS4212 RKS (VQFN) 20 PINS | UNIT |
|---|---|---|---|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance - High K | 53.0 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 52.3 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 27.1 | °C/W |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 2.9 | °C/W |
| $\psi_{JB}$ | Junction-to-board characterization parameter | 26.9 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | 11.1 | °C/W |

(1) For more information about traditional and new thermalmetrics, see the Semiconductor and IC Package ThermalMetrics application report.

## 6.5 Electrical Characteristics

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $I_{CC}$ | Device active current | OEn = 0; 0 V ≤ $V_{CM}$ ≤ 1.8; SEL = 0 or $V_{CC}$ | | 180 | 250 | µA |
| $I_{STDN}$ | Device shutdown current | OEn = $V_{CC}$ | | 2 | 5 | µA |
| $C_{ON}$ | Output ON capacitance to GND | OEn = 0 | | | 0.6 | pF |
| $R_{ON}$ | Output ON resistance | 0 V ≤ $V_{CM}$ ≤ 1.8 V; $I_O$ = –8 mA | | 5 | 8.4 | Ω |
| $\Delta R_{ON}$ | On-resistance match between pairs for the same channel at same $V_{CM}$, $V_{CC}$ and $T_A$ | | | | 0.5 | Ω |
| $R_{FLAT\_ON}$ | On-resistance flatness $R_{ON}$(MAX) – $R_{ON}$(MIN) over $V_{CM}$ range for the same channel at same $V_{CC}$ and $T_A$ | | | | 0.75 | Ω |
| $I_{IH,CTRL}$ | Input high current, control pins (SEL, OEn) | $V_{IN}$ = $V_{CC}$ | | | 2 | µA |
| $I_{IL,CTRL}$ | Input low current, control pins (SEL, OEn) | $V_{IN}$ = 0 V | | | 1 | µA |
| $R_{CM,HS}$ | Common mode resistance to ground on Ax pins | Each pin to GND | | 1.0 | 1.6 | MΩ |
| $I_{IH,HS,SEL}$ | Input high current, high-speed pins [Ax/Bx/Cx][p/n] | $V_{IN}$ = 1.8 V for selected port - A and B with SEL = 0, and A and C with SEL = $V_{CC}$ | | | 8 | µA |
| $I_{IH,HS,NSEL}$ | Input high current, high-speed pins [Ax/Bx/Cx][p/n] | $V_{IN}$ = 1.8 V for non-selected port - C with SEL = 0, and B with SEL = $V_{CC}$ (1) | | | 150 | µA |
| $I_{IL,HS}$ | Input low current, high-speed pins [Ax/Bx/Cx][p/n] | $V_{IN}$ = 0 V | | | 1 | µA |
| $I_{HIZ,HS}$ | Leakage current through turned off switch between Ax[p/n] to [B]x[p/n] and [C]x[p/n] | OEn = VCC; Ax[p/n] = 1.8 V, [B and C]x[p/n] = 0 V and Ax[p/n] = 0 V, [B and C]x[p/n] = 1.8 V | | | 5 | µA |
| $R_{A,p2n}$ | DC Impedance between p and n for Ax pins | OEn = 0 and $V_{CC}$ | | 20 | | KΩ |

(1) There is a 20-kΩ pull-down in non-selected port.

## 6.6 High-Speed Performance Parameters

| PARAMETER | | TEST CONDITION | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $I_L$ | Differential insertion loss | $f$ = 10 MHz | | -0.5 | | dB |
| | | $f$ = 2.5 GHz | | -0.8 | | |
| | | $f$ = 4 GHz | | -1.1 | | |
| | | $f$ = 5 GHz | | -1.3 | | |
| | | $f$ = 8 GHz | | -1.8 | | |
| | | $f$ = 10 GHz | | -2.1 | | |
| BW | –3-dB bandwidth | | | 13 | | GHz |
| $R_L$ | Differential return loss | $f$ = 10 MHz | | -28 | | dB |
| | | $f$ = 2.5 GHz | | -17 | | |
| | | $f$ = 4 GHz | | -13 | | |
| | | $f$ = 5 GHz | | -13 | | |
| | | $f$ = 8 GHz | | -12 | | |
| | | $f$ = 10 GHz | | -12 | | |
| $O_{IRR}$ | Differential OFF isolation | $f$ = 10 MHz | | -55 | | dB |
| | | $f$ = 2.5 GHz | | -27 | | |
| | | $f$ = 4 GHz | | -24 | | |
| | | $f$ = 5 GHz | | -22 | | |
| | | $f$ = 8 GHz | | -20 | | |
| | | $f$ = 10 GHz | | -18 | | |

## 6.6 High-Speed Performance Parameters (continued)

| PARAMETER | | TEST CONDITION | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $X_{TALK}$ | Differential crosstalk | $f$ = 10 MHz | | -65 | | dB |
| | | $f$ = 2.5 GHz | | -40 | | |
| | | $f$ = 4 GHz | | -35 | | |
| | | $f$ = 5 GHz | | -32 | | |
| | | $f$ = 8 GHz | | -30 | | |
| | | $f$ = 10 GHz | | -27 | | |
| SCD11,22 | Mode conversion - differential to common mode | $f$ = 5 GHz | | -29 | | dB |
| SCD21,12 | Mode conversion - differential to common mode | $f$ = 5 GHz | | -27 | | dB |
| SDC11,22 | Mode conversion - common mode to differential | $f$ = 5 GHz | | -29 | | dB |
| SDC21,12 | Mode conversion - common mode to differential | $f$ = 5 GHz | | -26 | | dB |

## 6.7 Switching Characteristics

| PARAMETER | | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{PD}$ | Switch propagation delay | f = 1 Ghz | | | 70 | ps |
| $t_{SW\_ON\_CM\_SHIFT}$ | Switching time SEL-to-Switch ON | For different CMV | | | 5 | us |
| $t_{SW\_ON}$ | Switching time SEL-to-Switch ON | For same CMV | | | 100 | ns |
| $t_{SW\_OFF\_CM\_SHIFT}$ | Switching time SEL-to-Switch OFF | For different CMV | | | 1 | us |
| $t_{SW\_OFF}$ | Switching time SEL-to-Switch OFF | For same CMV | | | 100 | ns |
| $t_{SK\_INTRA}$ | Intra-pair output skew between P and N pins for same channel | f = 1 Ghz | | | 8 | ps |
| $t_{SK\_INTER}$ | Inter-pair output skew between channels | f = 1 Ghz | | | 10 | ps |

## 6.8 Typical Characteristics

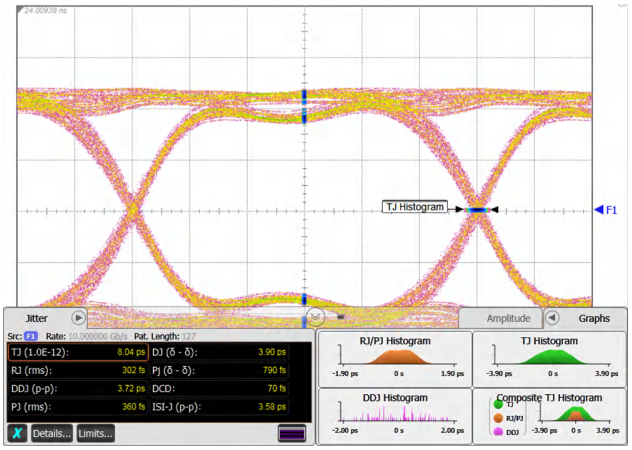



图 6-1. Jitter Decomposition of 10 Gbps PRBS-7 Signals Through Calibration Traces in TI Evaluation Board

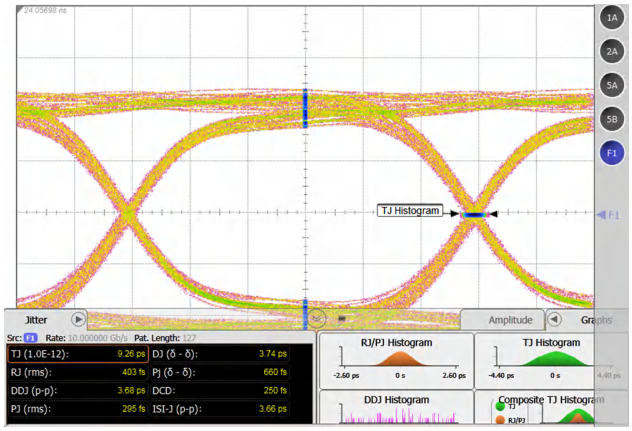



图 6-2. Jitter Decomposition of 10 Gbps PRBS-7 Signals Through a Typical TMUXHS4212 Channel in TI Evaluation Board

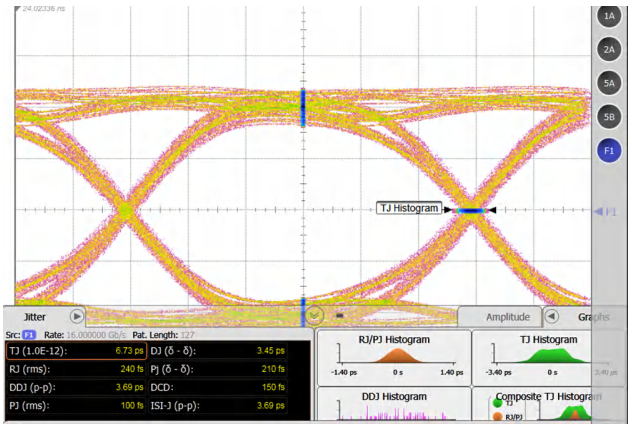



图 6-3. Jitter Decomposition of 16 Gbps PRBS-7 Signals Through Calibration Traces in TI Evaluation Board

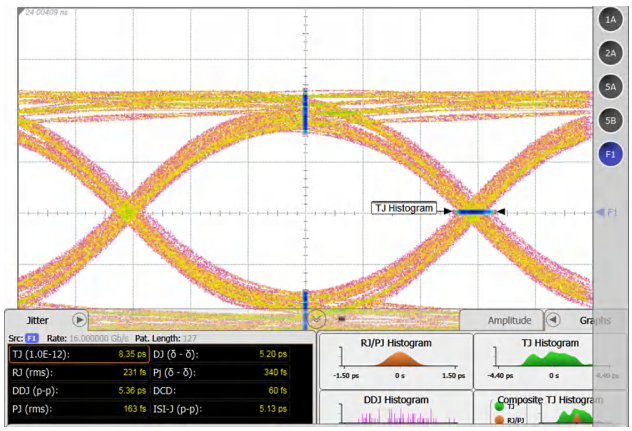



图 6-4. Jitter Decomposition of 16 Gbps PRBS-7 Signals Through a Typical TMUXHS4212 Channel in TI Evaluation Board

# 7 Parameter Measurement Information

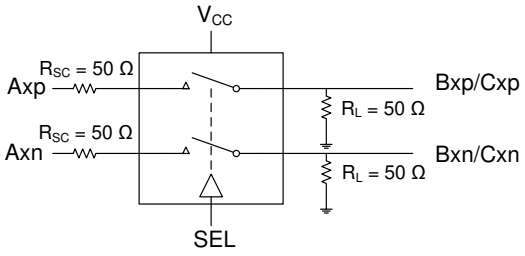



**图 7-1. Test Setup**

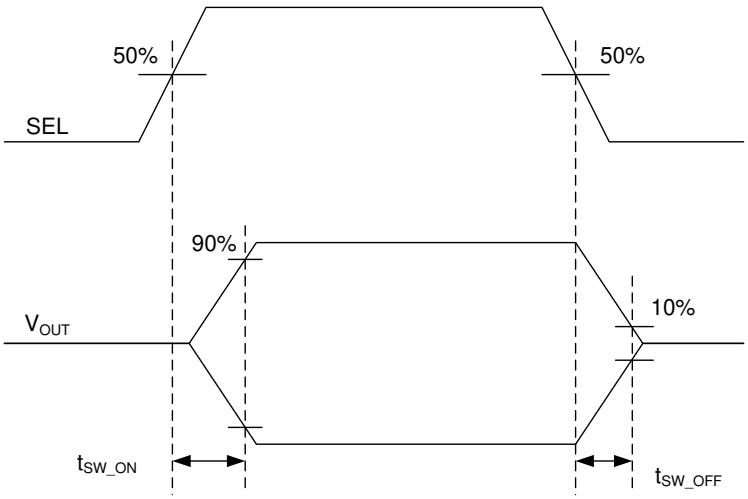



**图 7-2. Switch On and Off Timing Diagram**

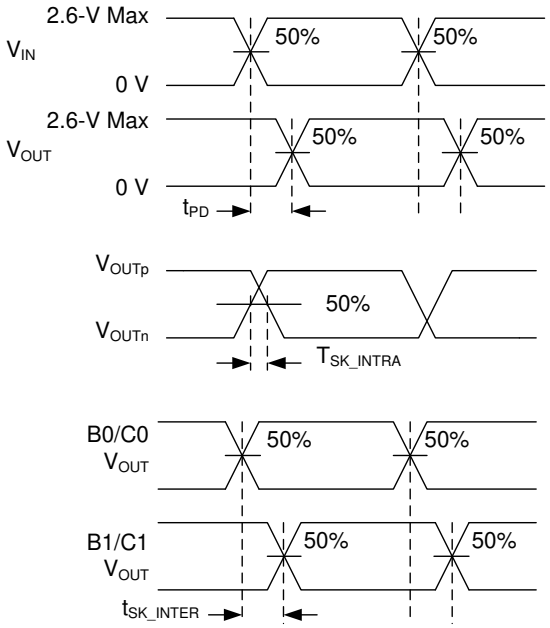



**图 7-3. Timing Diagrams and Test Setup**

# 8 Detailed Description

## 8.1 Overview

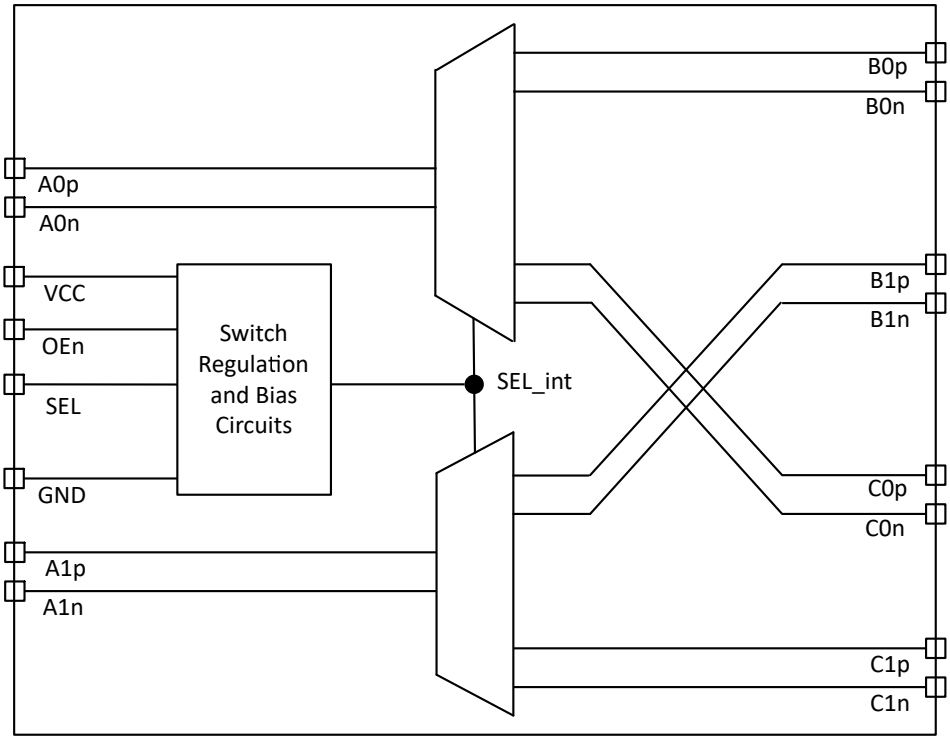
The TMUXHS4212 is a generic analog differential passive mux or demux that can work for any high-speed interface with differential signaling where common mode voltage (CMV) and differential amplitude up to 1800 mVpp. It employs adaptive input voltage tracking that ensures the channel remains unchanged for the entire common mode voltage range. Two channels of the device can be used for electrical signals that have different CMV between them. Two channels can also be used in such a way that the device switches two different interface signals with different data and electrical characteristics.

Excellent dynamic characteristics of the device allow high speed switching with minimum attenuation to the signal eye diagram with very little added jitter. While the device is recommended for the interfaces up to 16 Gbps, actual data rate where the device can be used highly depends on the electrical channels. For low loss channels where adequate margin is maintained, the device can potentially be used for higher data rates.

The TMUXHS4212 is only recommended for differential signaling. However, certain low voltage single ended signaling (such as, Mipi DPHY LP signaling) can pass through the device. It is recommended to analyze the data line biasing of the device for such single ended use cases.

The TMUXHS4212 comes in two different pinout options that provide layout implementation choices.

## 8.2 Functional Block Diagram




## 8.3 Feature Description

### 8.3.1 Output Enable and Power Savings

The TMUXHS4212 has two power modes, active/normal operating mode and standby/shutdown mode. During standby mode, the device consumes very-little current to achieve ultra low power in systems where power saving is critical. To enter standby mode, the OEn control pin is pulled high through a resistor and must remain high. For active/normal operation, the OEn control pin should be pulled low to GND or dynamically controlled to switch between H or L.

The TMUXHS4212 consumes 180 μA of power when operational and has a shutdown mode exercisable by the OEn pin resulting < 2 μA.

### 8.3.2 Data Line Biasing

The TMUXHS4212 has a weak pull-down of 1 MΩ from A[0/1][p/n] pins to GND. While these resistors biases the device data channels to common mode voltage (CMV) of 0 V with very weak strength, it is recommended that the device is biased by a stronger impedance from either side of the device to a valid value in the range of 0 – 1.8 V. To avoid double biasing, ensure that the appropriate ac coupling capacitors are on either side of the device.

In certain use cases, if both sides of the TMUXHS4212 are ac coupled, then it is recommended to use appropriate CMV biasing for the device. 10 kΩ to GND or any other bias voltage in the CMV range for each A[0/1][p/n] pin will suffice for most use cases.

The high-speed data ports incorporate 20 kΩ pull-down resistors that are switched in when a port is not selected and switched out when the port is selected. For example, when SEL = L, the C[0/1][p/n] pins have 20 kΩ resistors to GND. The feature ensures that the unselected port is always biased to a known voltage for long term reliability of the device and the electrical channel.

The positive and negative terminals of data pins A[0/1] have a weak (20 kΩ) differential resistor for device switch regulation operation. This does not impact signal integrity or functionality of high speed differential signaling that typically has much stronger differential impedance (such as 100 Ω).

## 8.4 Device Functional Modes

表 8-1. Port Select Control Logic(1)

| PORT A CHANNEL | PORT B OR PORT C CHANNEL CONNECTED TO PORT A CHANNEL | |
|---|---|---|
| | SEL = L | SEL = H |
| A0p | B0p | C0p |
| A0n | B0n | C0n |
| A1p | B1p | C1p |
| A1n | B1n | C1n |

(1) The TMUXHS4212 can tolerate polarity inversions for all differential signals on Ports A, B, and C. Ensure that the same polarity is maintained on Port A versus Ports B or C in such flexible implementation.

# 9 Application and Implementation

**备注**

以下应用部分中的信息不属于 TI 器件规格的范围，TI 不担保其准确性和完整性。TI 的客 户应负责确定器件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

## 9.1 Application Information

The TMUXHS4212 is a generic 2-channel high-speed mux or demux type of switch that can be used for routing high-speed signals between two different locations on a circuit board. The TMUXHS4212 supports many high-speed data protocols, provided the signals' differential amplitude and common mode voltage are within <1800 mVpp and a common mode voltage is <1.8 V. The TMUXHS4212 can be used for many high speed interfaces including the following:

- Universal Serial Bus (USB) 3.2 Gen 1.0 and 2.0
- USB Type-C
- Peripheral Component Interconnect Express (PCIe™) Gen 1.0, 2.0, 3.0, and 4.0
- Serial ATA (SATA/eSATA)
- Serial Attached SCSI (SAS)
- DisplayPort (DP) 1.4 and 2.0
- Thunderbolt™ (TBT) 3.0
- Mipi Camera Serial Interface (CSI-2), Display Serial Interface (DSI)
- Low Voltage Differential Signalling (LVDS)
- Serdes Framer Interface (SFI)
- Ethernet Interfaces

The device’s mux or demux selection pin SEL can easily be controlled by an available GPIO pin of a controller or hard tie to voltage level H or L as an application requires.

The TMUXHS4212 with adaptive voltage tracking technology can support applications where the common mode is different between the RX and TX pair. The switch paths of the TMUXHS4212 have internal weak pull-down resistors of 1 MΩ on the A port pins. While these resistors bias the device data channels to common mode voltage (CMV) of 0 V with a weak strength, it is recommended that the device is biased from either side of the device to a valid value in the range of 0 – 1.8 V. It is expected that the system/host controller and Device/End point common mode bias impedances are much stronger (smaller) than the TMUXHS4212 internal pull-down resistors; therefore, they are not impacted.

Many interfaces require ac coupling between the transmitter and receiver. The 0201 or 0402 capacitors are the preferred option to provide ac coupling. Avoid the 0603 and 0805 size capacitors and C-packs. When placing ac coupling capacitors, symmetric placement is best. The capacitor value must be chosen according to the specific interface the device is being used. The value of the capacitor should match for the positive and negative signal pair. For many interfaces (such as, USB 3.2 and PCIe) the designer should place them along the TX pairs on the system board, which are usually routed on the top layer of the board. Depending upon the application and interface specifications, use the appropriate value for ac coupling capacitors.

The ac coupling capacitors have several placement options. Typical use cases warrant that the capacitors are placed on one side of the TMUXHS4212. In certain use cases, if both sides of the TMUXHS4212 are ac coupled, then it is recommended to use appropriate CMV biasing for the device. 10 kΩ to GND or any other bias voltage in the range of 0 – 1.8 V for each A[0/1][p/n] pin will suffice for most use cases. 图 9-1 shows a few placement options. Some interfaces such as USB SS and PCIe recommends ac coupling capacitors on the TX signals before it goes to a connector. Option (a) features TX ac coupling capacitors on the connector side of the TMUXHS4212. Option (b) illustrates the capacitors on the host of the TMUXHS4212. Option (c) showcases where the TMUXHS4212 is ac coupled on both sides. Range for $V_{BIAS}$ is range of 0 – 1.8 V.

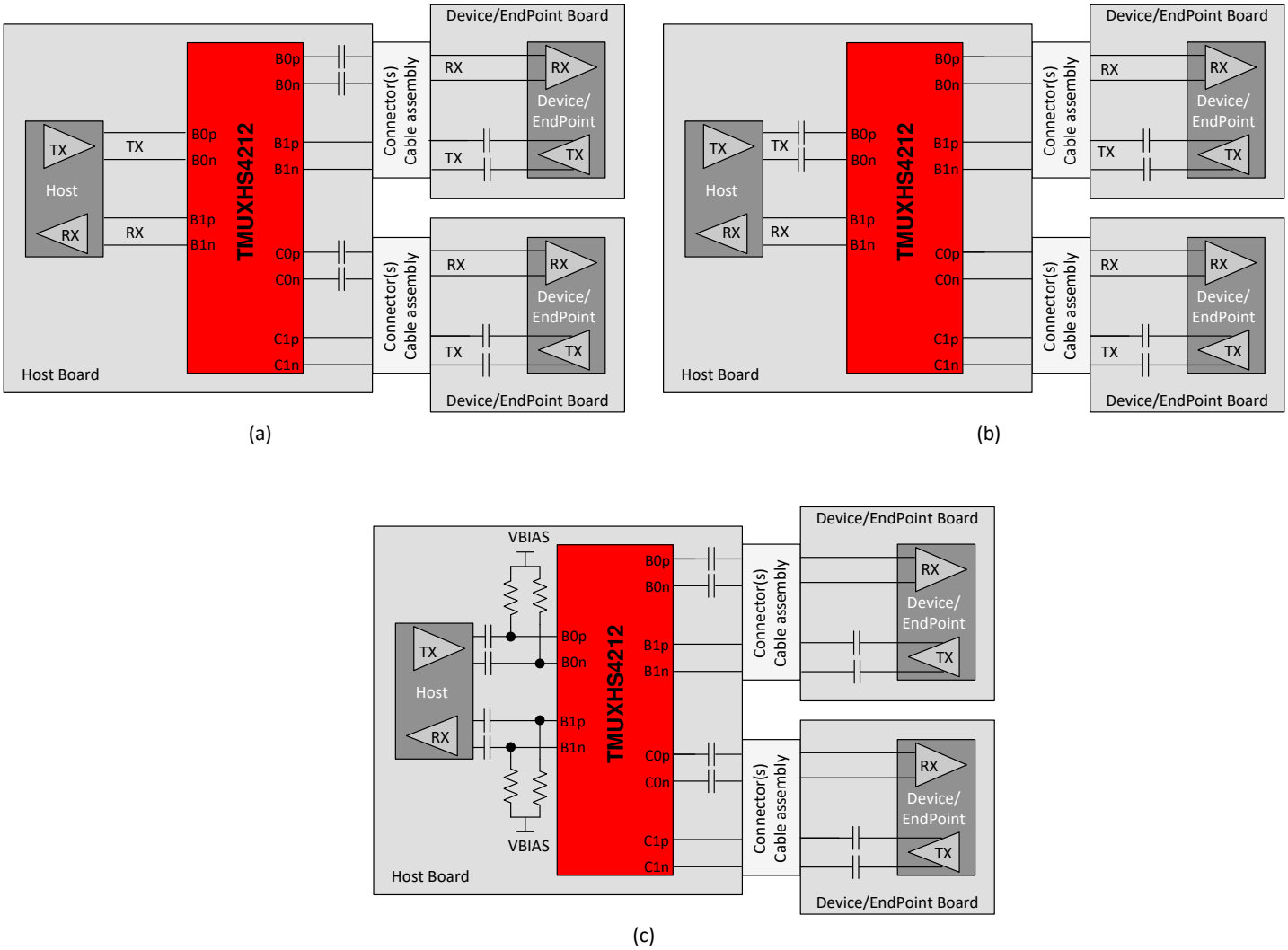



**图 9-1. AC Coupling Capacitors Placement Options Between Host and Device/Endpoint Through TMUXHS4212**

## 9.2 Typical Applications

### 9.2.1 USB 3.2 Implementation for USB Type-C

The TMUXHS4212 can be used in USB Type-C implementation to mux USB 3.2 superspeed signals (TX1 and RX1 pairs versus TX2 and RX2 pairs) to accommodate plug flips. In typical use cases, the mux selection is done by a USB Type-C Channel Configuration (CC) or Power Delivery (PD) controller. The device can used on a USB Type-C DFP, UFP, or DRP port. 图 9-2 shows two USB Type-C connector applications with both a host and device side. The cable between the two connectors swivels the pairs to properly route the signals to the correct pin. The other applications are more generic because different connectors can be used.

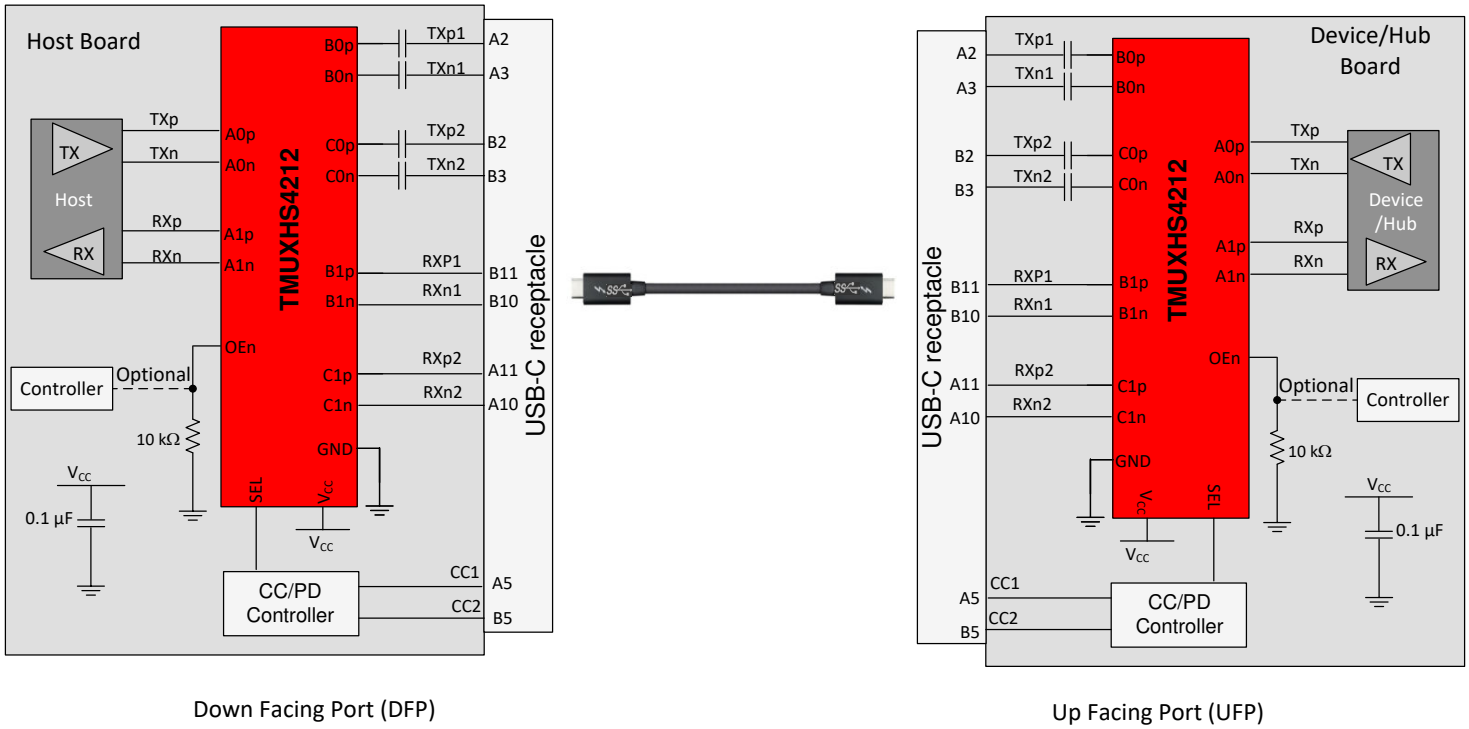



图 9-2. USB 3.2 Implementation for USB Type-C Connector

#### 9.2.1.1 Design Requirements

The TMUXHS4212 can be designed into many different applications. All the applications have certain requirements for the system to work properly. The TMUXHS4212 requires 3.3 V ±10% $V_{CC}$ rail. The OEn pin must be low for the device to work; otherwise, it disables the outputs. A processor can drive the OEn pin. The expectation is that one side of the device has ac coupling capacitors. 表 9-1 provides information on expected values to perform properly.

表 9-1. Design Parameters

| DESIGN PARAMETER | VALUE |
|---|---|
| $V_{CC}$ | 3.3 V |
| AXp/n, BXp/n, CXp/n CM input voltage | 0 V to 1.8 V |
| Control/OEn pin max voltage for low | 0.5 V |
| Control/OEn pin min voltage for high | 1.42 V |
| ac coupling capacitor | 75 nF to 265 nF |
| $R_{BIAS}$ (图 9-2) when needed | 1 kΩ to 100 kΩ |

### 9.2.1.2 Detailed Design Procedure

The TMUXHS4212 is a high-speed passive switch device that can behave as a mux or demux. Because this is a passive switch, signal integrity is important because the device provides no signal conditioning capability. The device can support 2 to 3 inches of board trace and a connector on either end.

To design in the TMUXHS4212, the designer needs to understand the following:

- Determine the loss profile between circuits that are to be muxed or demuxed.
- Provide clean impedance and electrical length matched board traces.
- Provide a control signal for the SEL and OEn pins.
- The thermal pad must be connected to ground.
- See the application schematics on recommended decouple capacitors from $V_{CC}$ pins to ground.

### 9.2.1.3 Application Curves

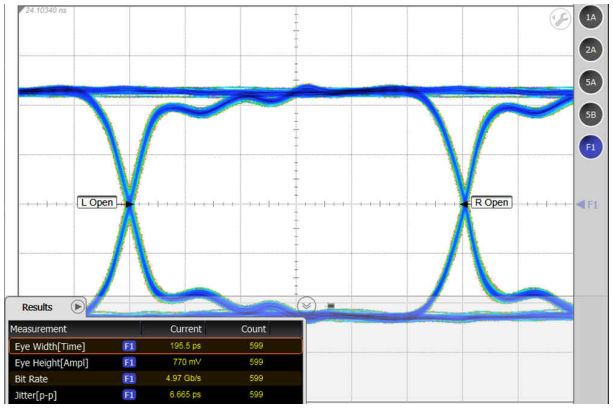



图 9-3. 5 Gbps PRBS-7 Signals Through Calibration Traces in TI Evaluation Board

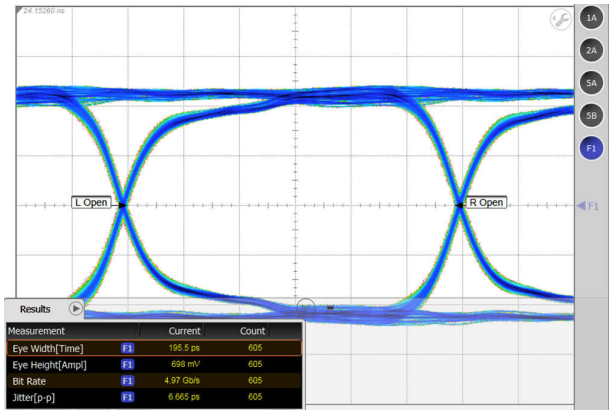



图 9-4. 5 Gbps PRBS-7 Signals Through a Typical TMUXHS4212 Channel in TI Evaluation Board

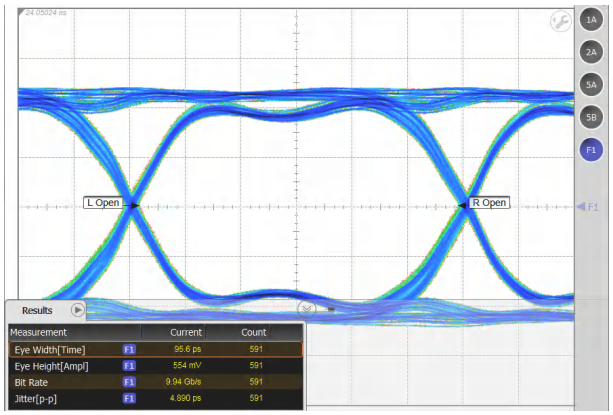



图 9-5. 10 Gbps PRBS-7 Signals Through Calibration Traces in TI Evaluation Board

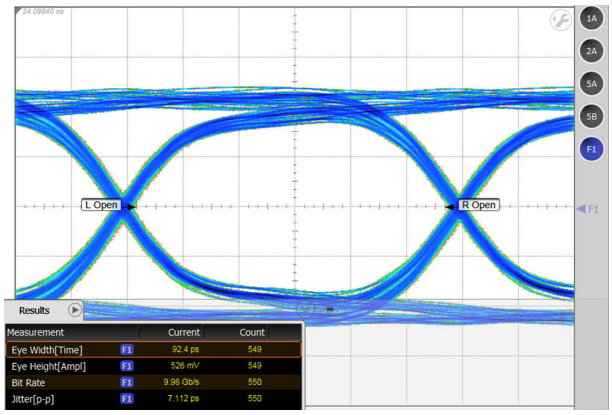



图 9-6. 10 Gbps PRBS-7 Signals Through a Typical TMUXHS4212 Channel in TI Evaluation Board

### 9.2.2 PCIe Lane Muxing

The TMUXHS4212 can be used to switch PCIe lanes between two slots. In many PC and server motherboards, the CPU does not have enough PCIe lanes to provide desired system flexibility for end customers. In such applications, the TMUXHS4212 can be used to switch PCIe TX and RX lanes between two slots. 图 9-7 provides a schematic where eight TMUXHS4212 devices are used to switch eight PCIe TX and eight RX lanes. Note: the common mode voltage (CMV) bias for the TMUXHS4212 must be within the range of 0 – 1.8 V. In implementations where receiver CMV bias of a PCIe root complex or an end point can not be ensured within the CMV range, additional DC blocking capacitors and appropriate CMV biasing must be implemented.

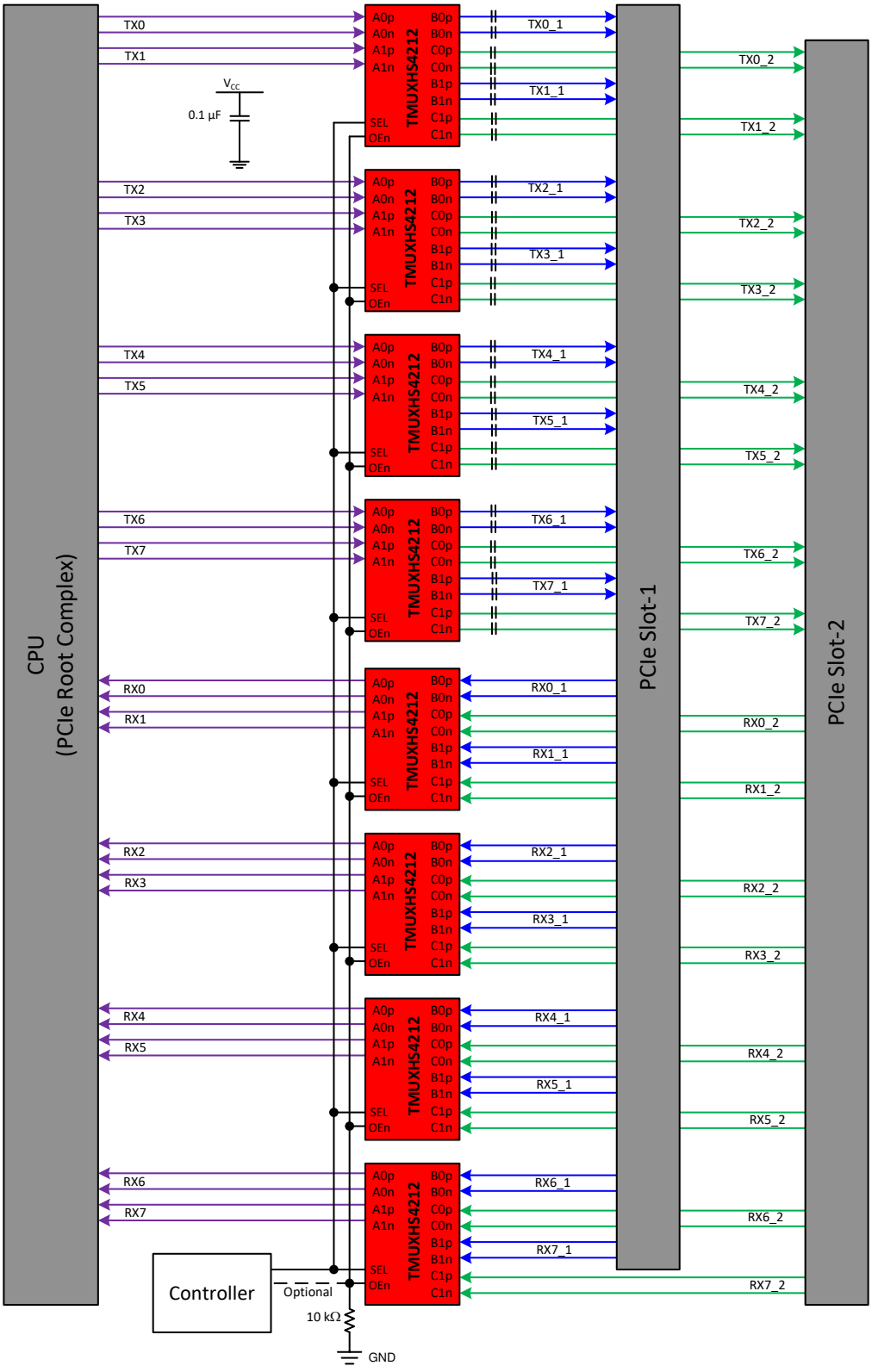



**图 9-7. PCIe Lane Muxing**

### 9.2.2.1 Application Curves

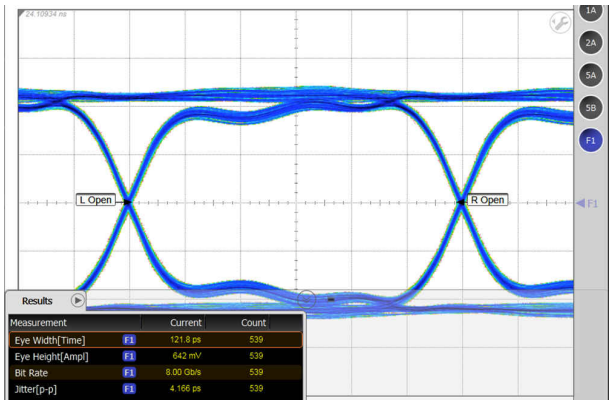



图 9-8. 8 Gbps PRBS-7 Signals Through Calibration Traces in TI Evaluation Board

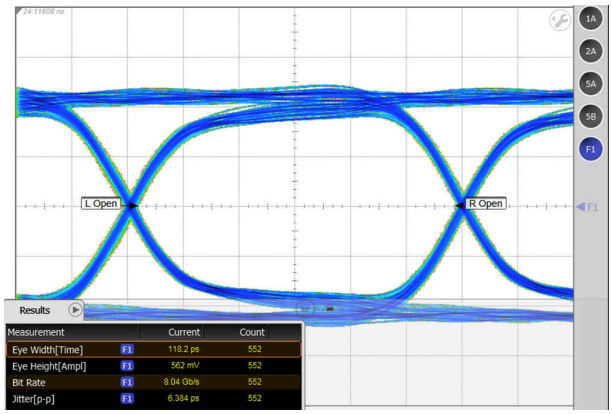



图 9-9. 8 Gbps PRBS-7 Signals Through a Typical TMUXHS4212 Channel in TI Evaluation Board

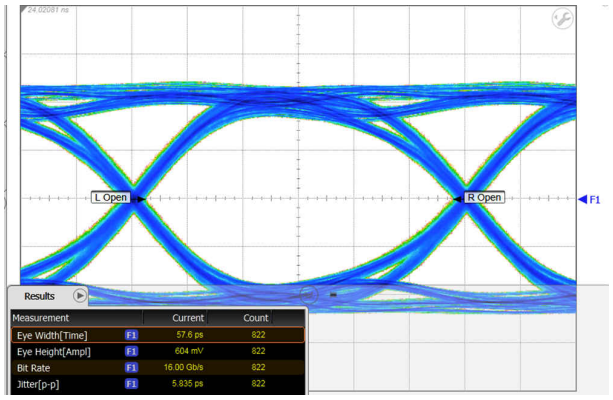



图 9-10. 16 Gbps PRBS-7 Signals Through Calibration Traces in TI Evaluation Board

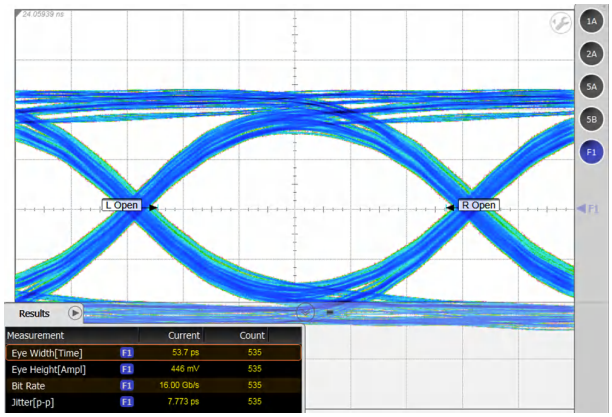



图 9-11. 16 Gbps PRBS-7 Signals Through a Typical TMUXHS4212 Channel in TI Evaluation Board

## 9.3 Systems Examples

### 9.3.1 USB/eSATA

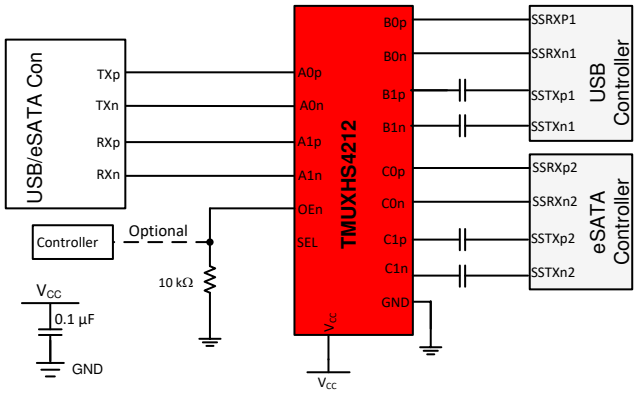



图 9-12. eSATA and USB 3.2 Combo Connector

### 9.3.2 MIPI Camera Serial Interface

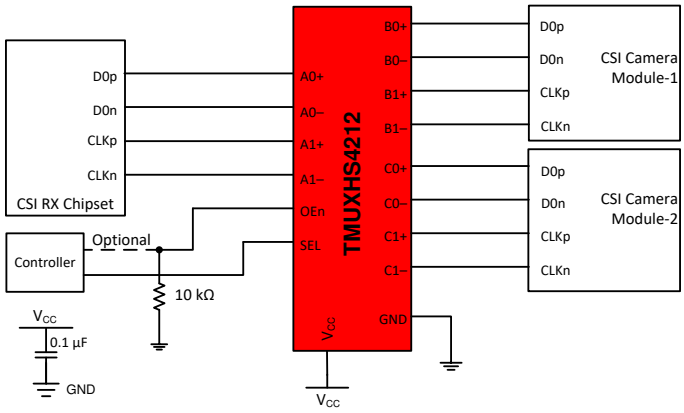



图 9-13. CSI Camera Selection

## 10 Power Supply Recommendations

The TMUXHS4212 does not require a power supply sequence. TI, however, recommends that OEn is asserted low after the device supply $V_{CC}$ is stable and in specification. TI also recommends to place ample decoupling capacitors at the device $V_{CC}$ near the pin.

# 11 Layout

## 11.1 Layout Guidelines

On a high-K board, TI always recommends to solder the Power-pad™ onto the thermal land. A thermal land is the area of solder-tinned-copper underneath the Power-pad package. On a high-K board, the TMUXHS4212 can operate over the full temperature range by soldering the Power-pad onto the thermal land without vias.

For high speed layout guidelines, refer to *High-Speed Layout Guidelines for Signal Conditioners and USB Hubs*.

The designer must use a 1-oz Cu trace connecting the GND pins to the thermal land for the device to operate across the temperature range on a low-K board. A general PCB design guide for Power-pad packages is provided in *Power-pad Thermally-Enhanced Package*.

## 11.2 Layout Example

图 11-1 shows a basic layout example for the application shown in 节 9.2.1

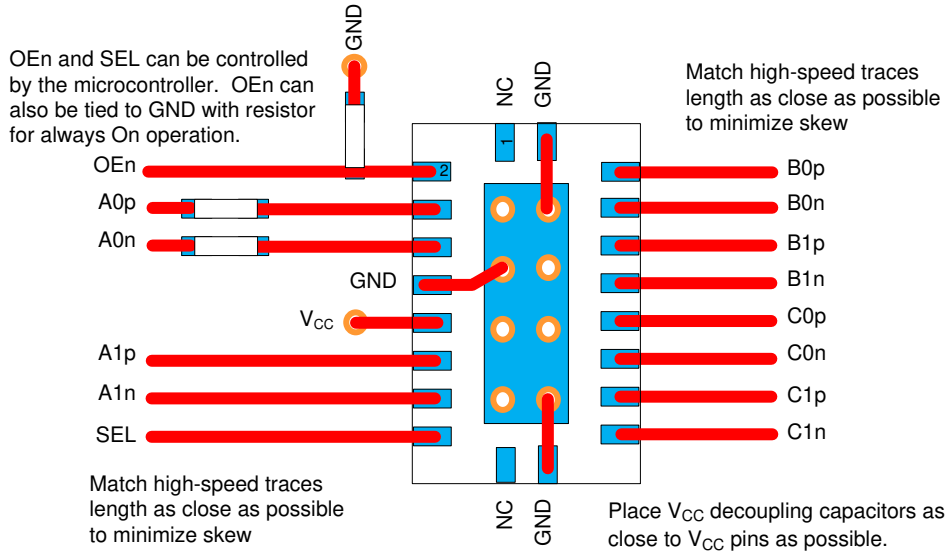



**图 11-1. TMUXHS4212 Layout Example**

# 12 Device and Documentation Support

## 12.1 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击 *订阅更新* 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

## 12.2 支持资源

TI E2E™ 支持论坛是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

## 12.3 Trademarks

USB Type-C™ is a trademark of USB Implementation Forum.
PCIe™ is a trademark of PCI-SIG.
Thunderbolt™ is a trademark of Intel Corporation.
Power-pad™ is a trademark of Texas Instruments.
TI E2E™ is a trademark of Texas Instruments.
Mipi® is a registered trademark of MIPI Alliance, Inc..
以太网® is a registered trademark of Fuji Xerox Co., Ltd.
所有商标均为其各自所有者的财产。

## 12.4 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.

## 12.5 术语表

| | |
|---|---|
| TI 术语表 | 本术语表列出并解释了术语、首字母缩略词和定义。 |

# 13 Mechanical, Packaging, and Orderable Information

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

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TMUXHS4212IRKSR | ACTIVE | VQFN | RKS | 20 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 105 | HS4212 | Samples |
| TMUXHS4212IRKST | ACTIVE | VQFN | RKS | 20 | 250 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 105 | HS4212 | Samples |
| TMUXHS4212RKSR | ACTIVE | VQFN | RKS | 20 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | HS4212 | Samples |
| TMUXHS4212RKST | ACTIVE | VQFN | RKS | 20 | 250 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | HS4212 | Samples |

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

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

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

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

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

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

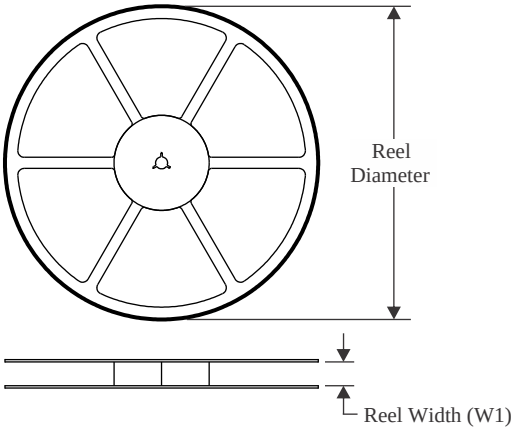
**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. 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.

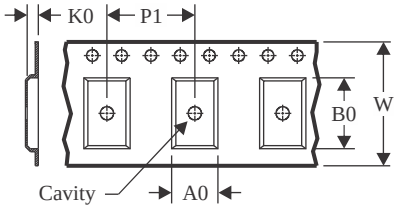
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

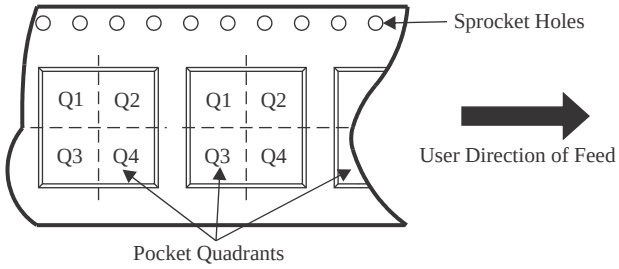



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

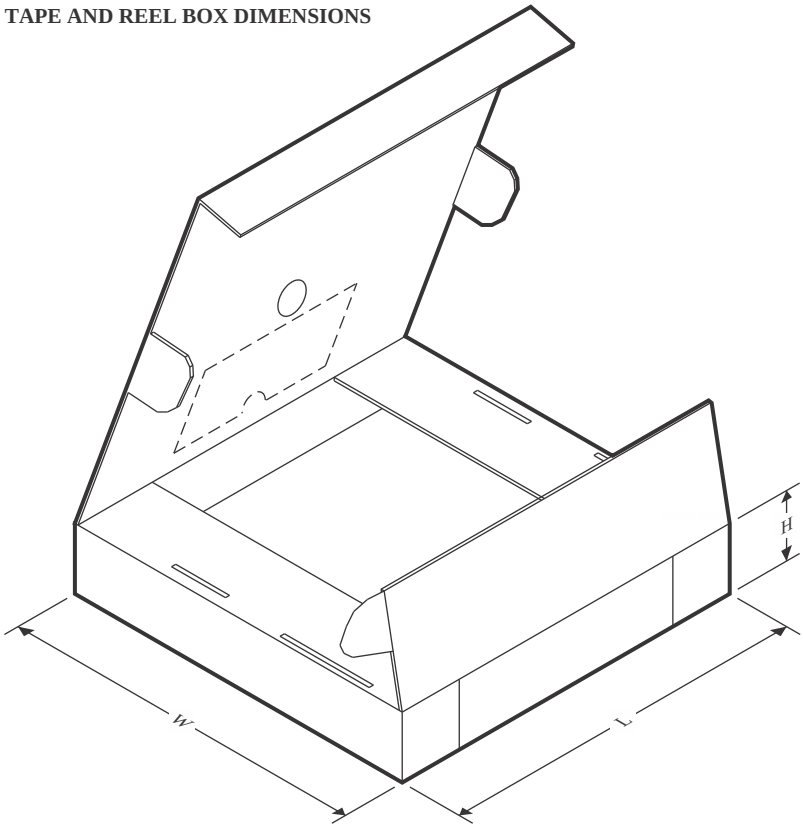
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TMUXHS4212IRKSR | VQFN | RKS | 20 | 3000 | 180.0 | 12.4 | 2.8 | 4.8 | 1.2 | 4.0 | 12.0 | Q1 |
| TMUXHS4212IRKST | VQFN | RKS | 20 | 250 | 180.0 | 12.4 | 2.8 | 4.8 | 1.2 | 4.0 | 12.0 | Q1 |
| TMUXHS4212RKSR | VQFN | RKS | 20 | 3000 | 180.0 | 12.4 | 2.8 | 4.8 | 1.2 | 4.0 | 12.0 | Q1 |
| TMUXHS4212RKST | VQFN | RKS | 20 | 250 | 180.0 | 12.4 | 2.8 | 4.8 | 1.2 | 4.0 | 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) |
|---|---|---|---|---|---|---|---|
| TMUXHS4212IRKSR | VQFN | RKS | 20 | 3000 | 210.0 | 185.0 | 35.0 |
| TMUXHS4212IRKST | VQFN | RKS | 20 | 250 | 210.0 | 185.0 | 35.0 |
| TMUXHS4212RKSR | VQFN | RKS | 20 | 3000 | 210.0 | 185.0 | 35.0 |
| TMUXHS4212RKST | VQFN | RKS | 20 | 250 | 210.0 | 185.0 | 35.0 |

# GENERIC PACKAGE VIEW

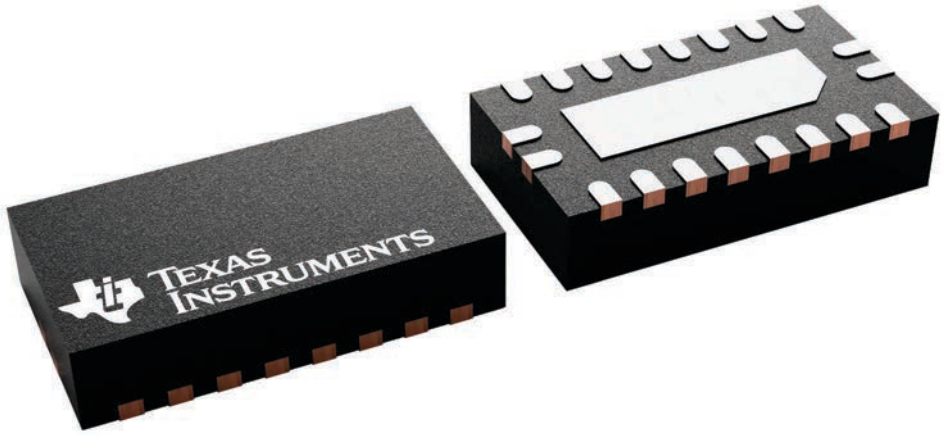
## RKS 20

## VQFN - 1 mm max height

**2.5 x 4.5, 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.

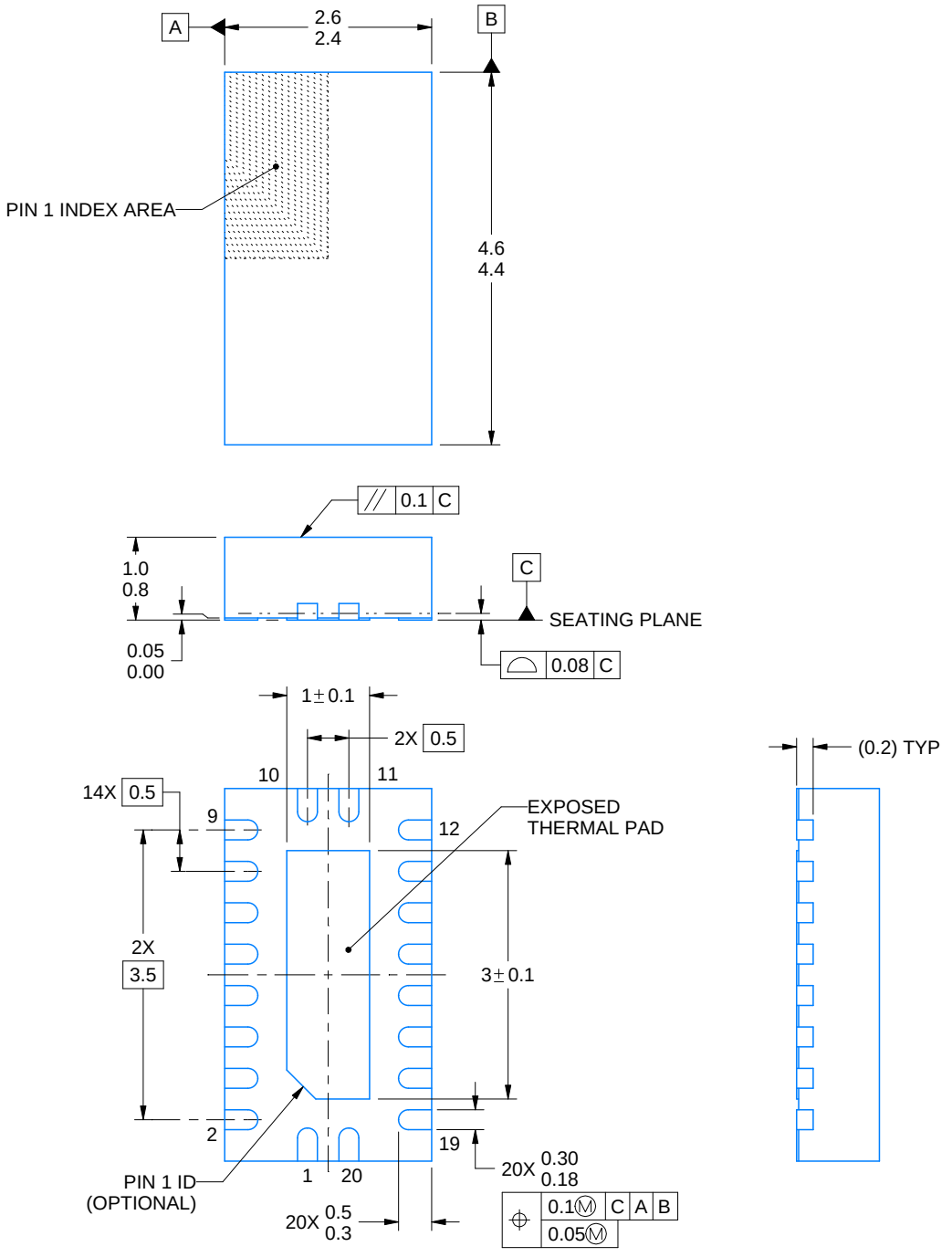


# PACKAGE OUTLINE

## RKS0020A

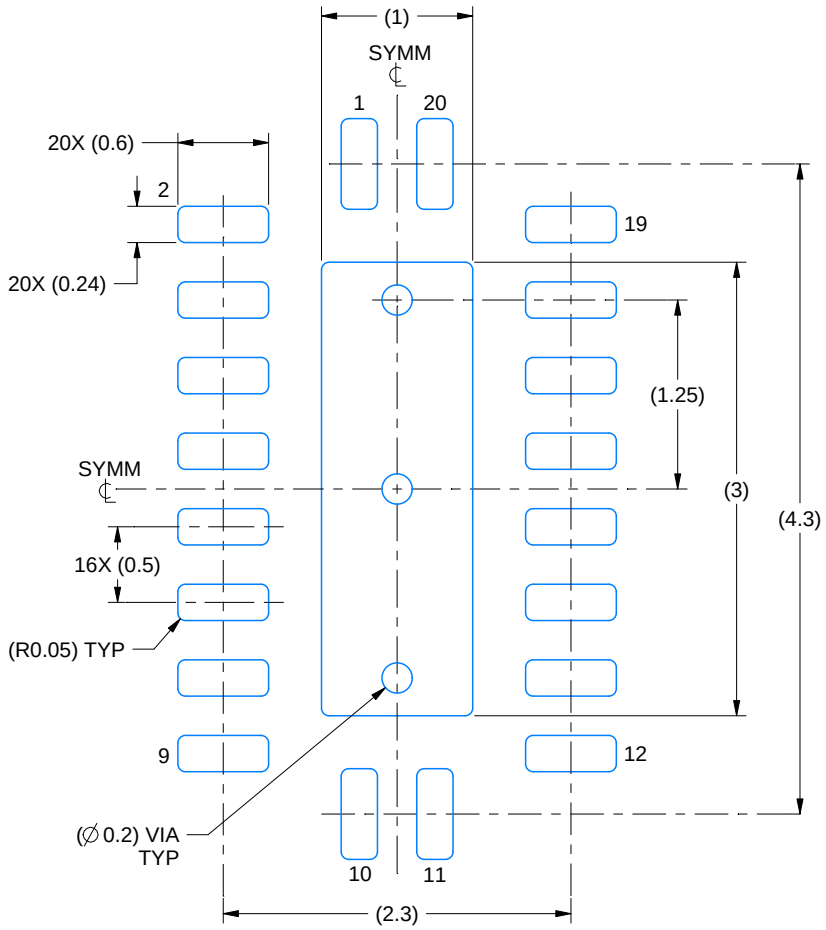
## VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

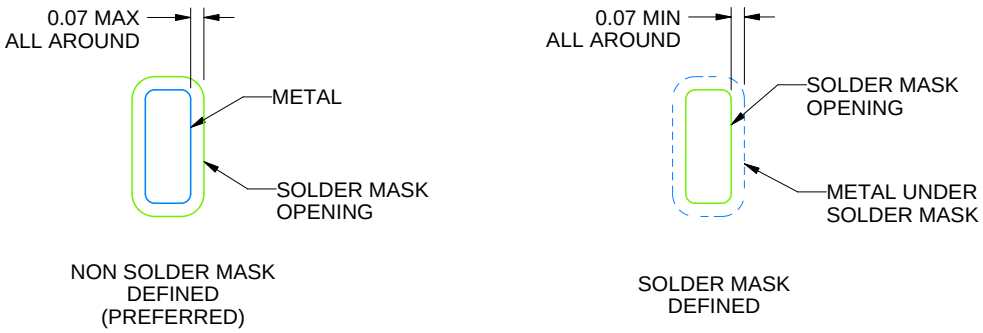



NOTES:

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




LAND PATTERN EXAMPLE
SCALE:20X




SOLDER MASK DETAILS

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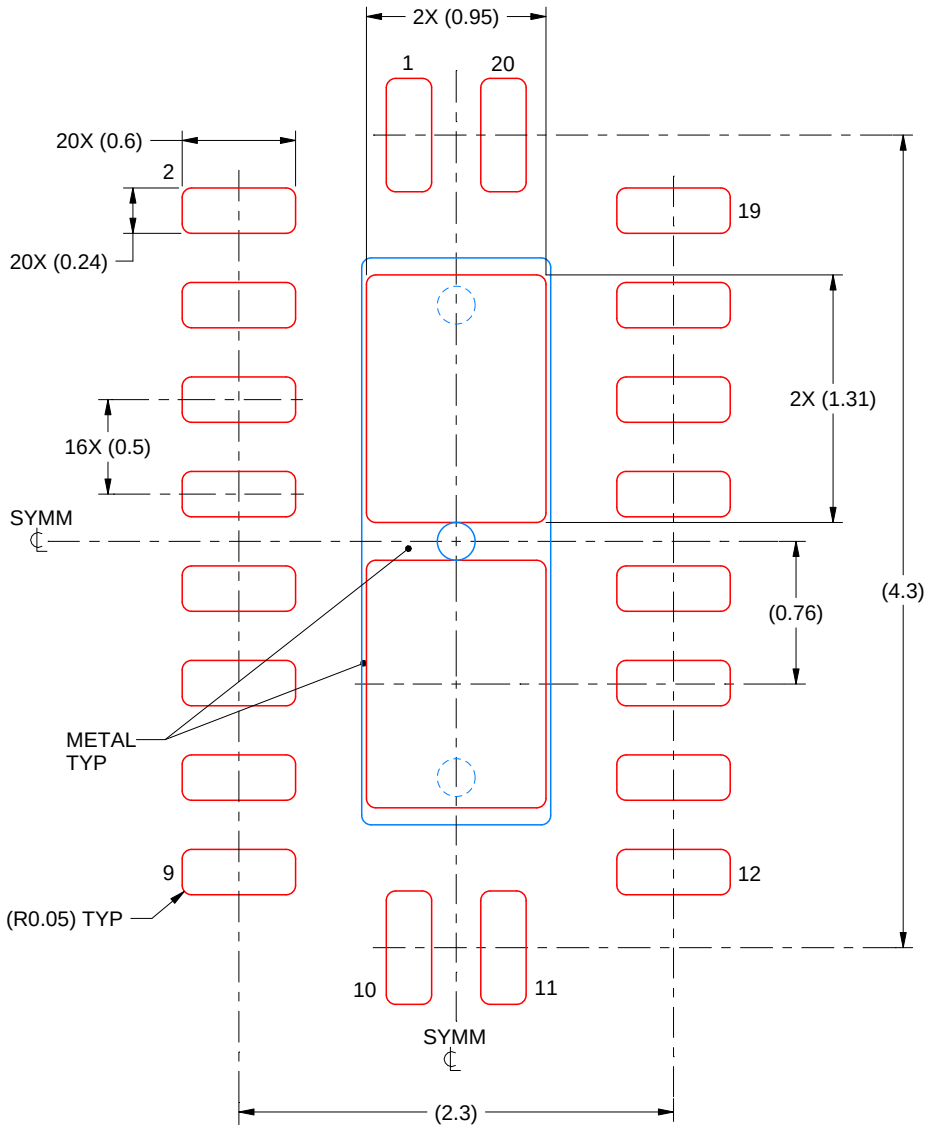
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD
83% PRINTED SOLDER COVERAGE BY AREA
SCALE:25X

4222490/B 02/2021

NOTES: (continued)

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

# 重要声明和免责声明

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