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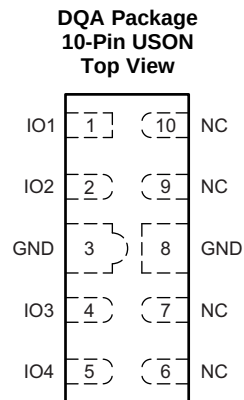
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4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

Changes from Original (November 2015) to Revision A	Page
• 已将器件状态由“产品预览”更改为“量产数据”	1

5 Pin Configuration and Functions



Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO.		
GND	3	Ground	Ground. Connect to ground.
GND	8	Ground	
IO1	1	I/O	ESD Protected Channel
IO2	2		
IO3	4		
IO4	5		
NC	6	NC	Not Connected; Used for optional straight-through routing. Can be left floating or grounded.
NC	7		
NC	9		
NC	10		

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Electrical Fast Transient	IEC 61000-4-5 (5/50 ns)		80	A
Peak Pulse	IEC 61000-4-5 Power (t_p - 8/20 μ s)		17	W
	IEC 61000-4-5 Current (t_p - 8/20 μ s)		2	A
T_A	Operating free-air temperature	-40	125	°C
T_{stg}	Storage temperature	-65	155	°C

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

6.2 ESD Ratings

		VALUE	UNIT
$V_{(ESD)}$ Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±2500	V
	Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±1000	
	IEC 61000-4-2 contact discharge	±12000	
	IEC 61000-4-2 air-gap discharge	±15000	

- (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	MAX	UNIT
V_{IO}	Input pin voltage	-3.6	3.6	V
T_A	Operating free-air temperature	-40	125	°C

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TPD4E02B04	UNIT
		DQA (USON)	
		10 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	348.7	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	214.1	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	270.7	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	81.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	270.7	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	°C/W

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

6.5 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V _{RWM}	Reverse stand-off voltage	I _{IO} < 10 nA	-3.6		3.6	V
V _{BRF}	Breakdown Voltage, any IO pin to GND ⁽¹⁾	I _{IO} = 1 mA, T _A = 25°C	5.5	6.4	7.5	V
V _{BRR}	Breakdown Voltage, GND to any IO pin ⁽¹⁾	I _{IO} = 1 mA, T _A = 25°C	-5.5	-6.4	-7.5	V
V _{HOLD}	Holding voltage ⁽²⁾	I _{IO} = 1 mA		5.8		V
V _{CLAMP}	Clamping voltage	I _{PP} = 1 A, TLP, from IO to GND		6.6		V
		I _{PP} = 5 A, TLP, from IO to GND		8.8		
		I _{PP} = 1 A, TLP, from GND to IO		6.6		
		I _{PP} = 5A, TLP, from GND to IO		8.8		
I _{LEAK}	Leakage current, any IO to GND	V _{IO} = ±2.5 V			10	nA
R _{DYN}	Dynamic Resistance	IO to GND		0.47		Ω
		GND to IO		0.47		
C _L	Line Capacitance	V _{IO} = 0 V, f = 1 MHz, IO to GND, T _A = 25°C		0.27	0.37	pF
ΔC _L	Variation of Line Capacitance	Delta of capacitance between any two IO pins, V _{IO} = 0 V, f = 1 MHz, T _A = 25°C, GND = 0 V		0.01	0.07	pF
C _{CROSS}	Channel to Channel Capacitance	Capacitance from one IO to another, V _{IO} = 0 V, f = 1 MHz, GND = 0 V		0.13		pF

(1) V_{BRF} and V_{BRR} are defined as the voltage when 1mA is applied in the positive-going direction, before the device latches into the snapback state

(2) V_{HOLD} is defined as the voltage when 1mA is applied in the negative-going direction, after the device has successfully latched into the snapback state

6.6 Typical Characteristics

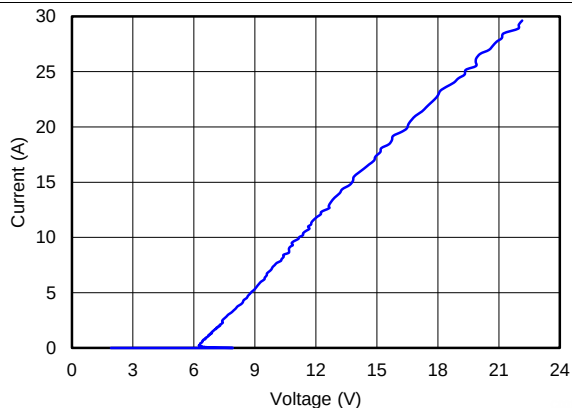


Figure 1. Positive TLP Curve

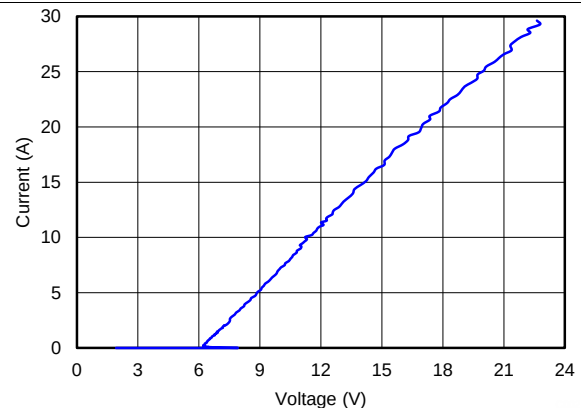


Figure 2. Negative TLP Curve

Typical Characteristics (continued)

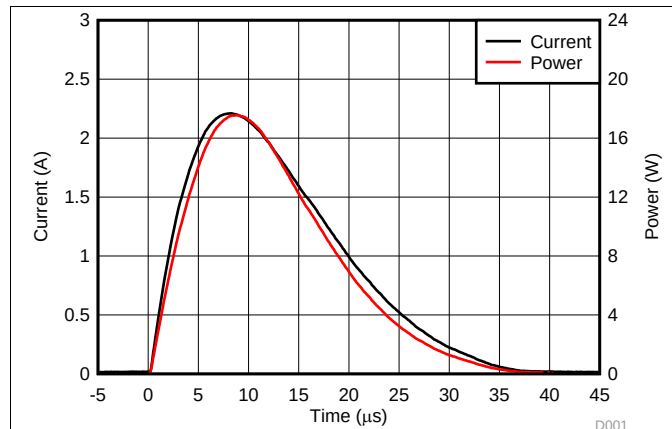


Figure 3. Surge Curve ($t_p = 8/20\mu s$), any IO pin to GND

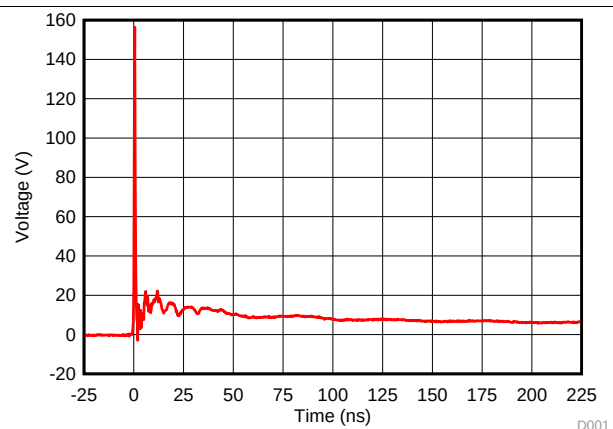


Figure 4. 8-kV IEC Waveform

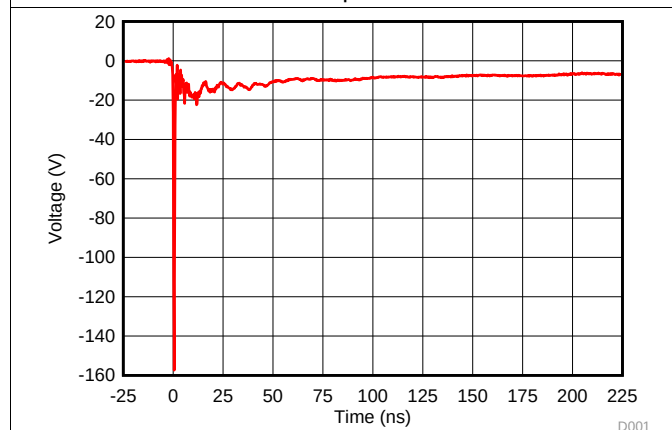


Figure 5. -8-kV IEC Waveform

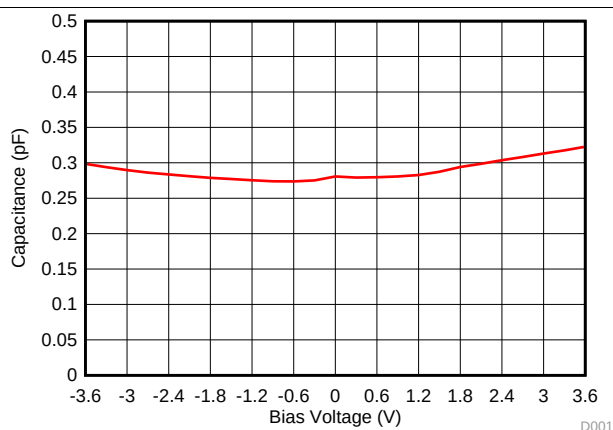


Figure 6. Capacitance vs. Bias Voltage

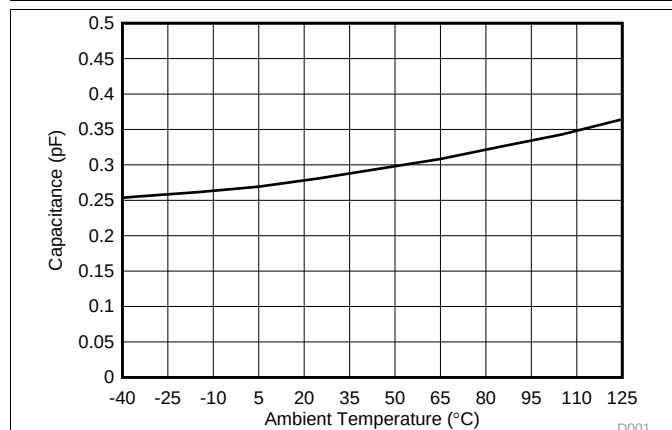


Figure 7. Capacitance vs. Ambient Temperature

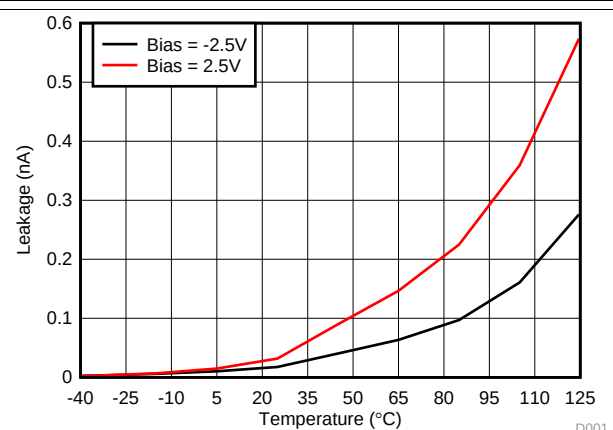


Figure 8. Leakage Current vs. Temperature

Typical Characteristics (continued)

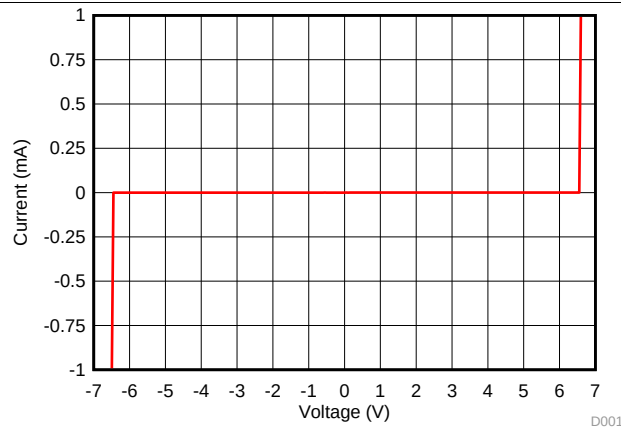


Figure 9. DC Voltage Sweep I-V Curve

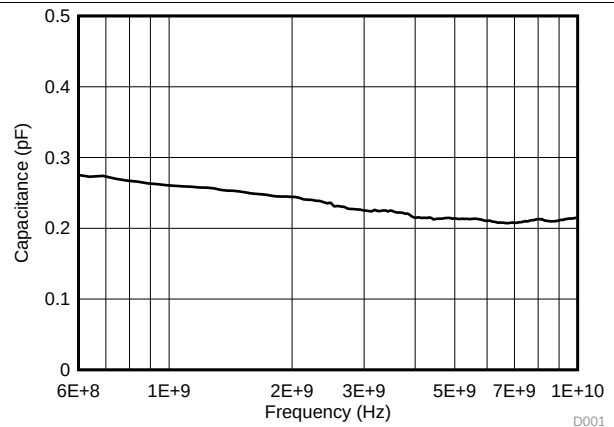


Figure 10. Capacitance vs. Frequency

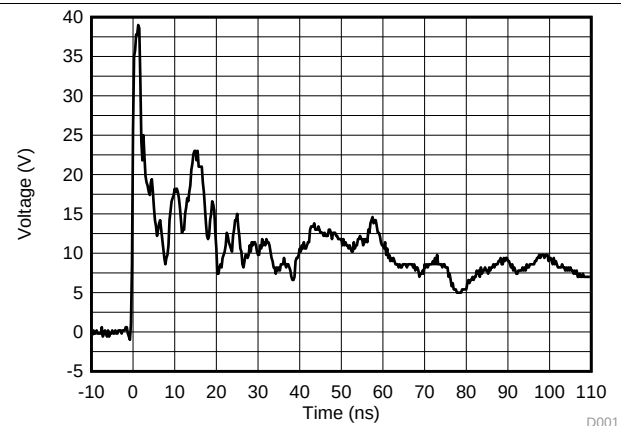


Figure 11. 8-kV IEC Waveform through 2m HDMI Cable

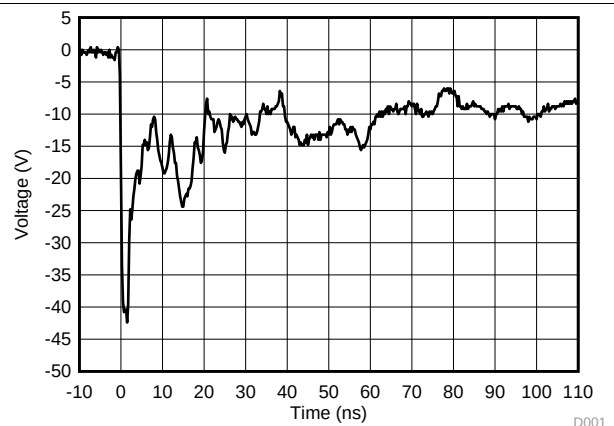


Figure 12. -8-kV IEC Waveform through 2m HDMI Cable

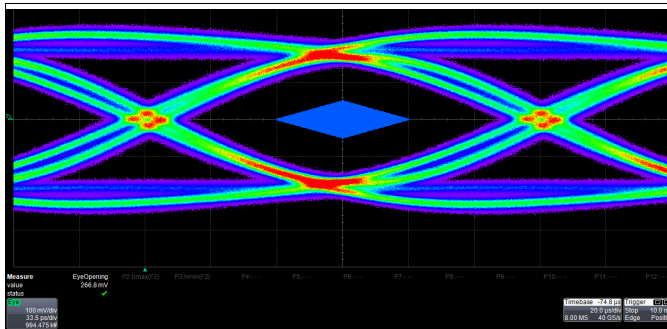


Figure 13. USB3.0 Eye Diagram (Bare Board)

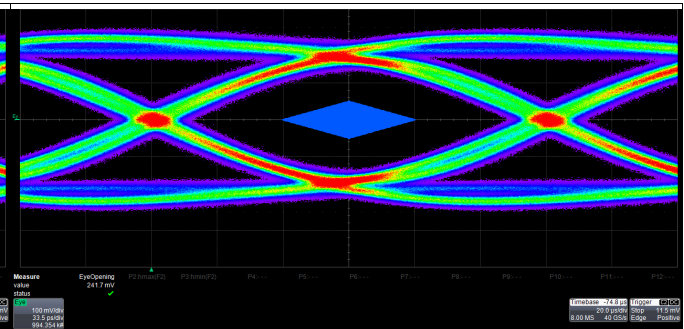


Figure 14. USB3.0 Eye Diagram (with TPD4E02B04)

Typical Characteristics (continued)

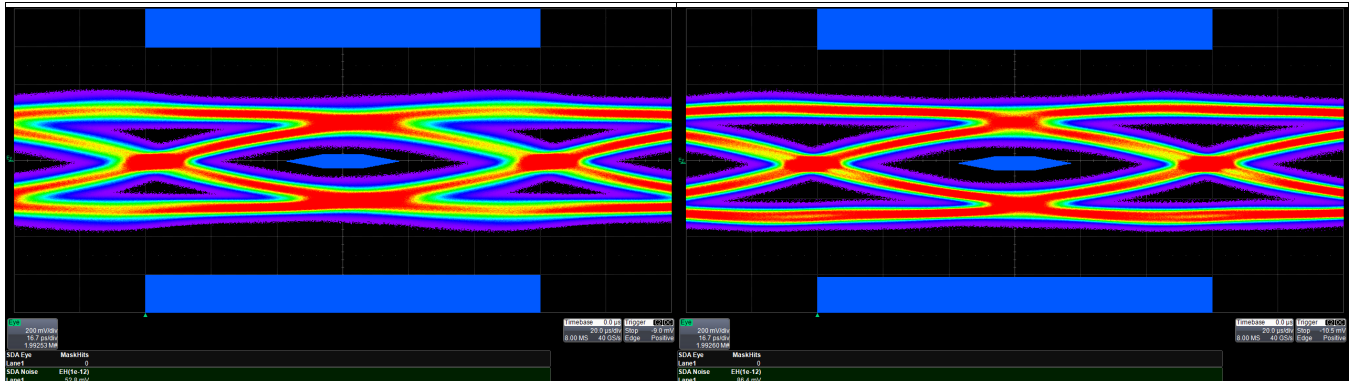


Figure 15. USB3.1 Gen 2 Eye Diagram (Bare Board)

Figure 16. USB3.1 Gen 2 Eye Diagram (with TPD4E02B04)

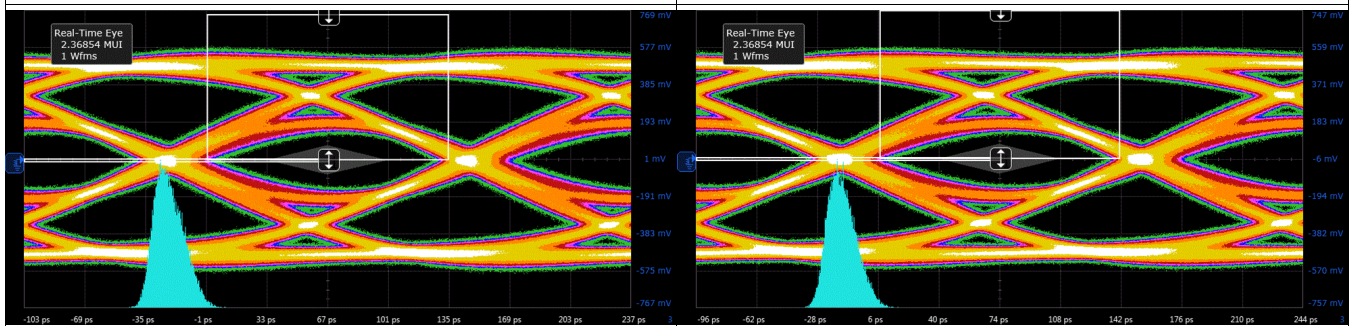


Figure 17. HDMI2.0 6Gbps TP2 Eye Diagram (Bare Board)

Figure 18. HDMI2.0 6Gbps TP2 Eye Diagram (with TPD4E02B04)

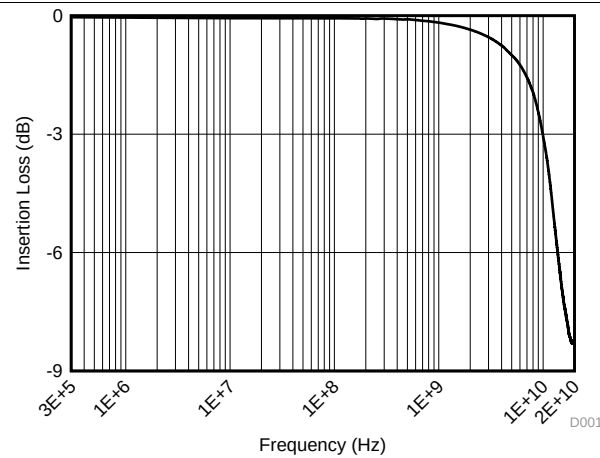


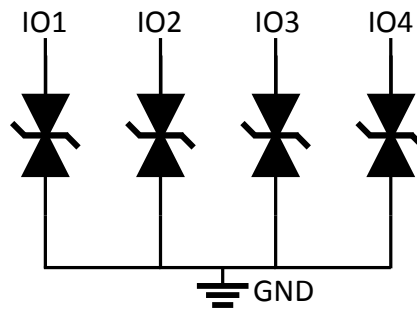
Figure 19. Differential Insertion Loss

7 Detailed Description

7.1 Overview

The TPD4E02B04 is a bidirectional ESD Protection Diode with ultra-low capacitance. This device can dissipate ESD strikes above the maximum level specified by the IEC 61000-4-2 International Standard. The ultra-low capacitance makes this device ideal for protecting any super high-speed signal pins.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 IEC 61000-4-2 ESD Protection

The I/O pins can withstand ESD events up to ± 12 -kV contact and ± 15 -kV air gap. An ESD/surge clamp diverts the current to ground.

7.3.2 IEC 61000-4-4 EFT Protection

The I/O pins can withstand an electrical fast transient burst of up to 80 A (5/50 ns waveform, 4 kV with 50 Ω impedance). An ESD/surge clamp diverts the current to ground.

7.3.3 IEC 61000-4-5 Surge Protection

The I/O pins can withstand surge events up to 2 A and 17 W (8/20 μ s waveform). An ESD/surge clamp diverts this current to ground.

7.3.4 IO Capacitance

The capacitance between each I/O pin to ground is 0.27 pF (typical) and 0.37 pF (maximum). This device supports data rates up to 10 Gbps.

7.3.5 DC Breakdown Voltage

The DC breakdown voltage of each I/O pin is a minimum of ± 5.5 V. This ensures that sensitive equipment is protected from surges above the reverse standoff voltage of ± 3.6 V.

7.3.6 Ultra Low Leakage Current

The I/O pins feature an ultra-low leakage current of 10 nA (max) with a bias of ± 2.5 V.

7.3.7 Low ESD Clamping Voltage

The I/O pins feature an ESD clamp that is capable of clamping the voltage to 8.8 V ($I_{PP} = 5$ A).

7.3.8 Supports High Speed Interfaces

This device is capable of supporting high speed interfaces up to 10 Gbps, because of the extremely low IO capacitance.

Feature Description (continued)

7.3.9 Industrial Temperature Range

This device features an industrial operating range of -40°C to 125°C .

7.3.10 Easy Flow-Through Routing Package

The layout of this device makes it simple and easy to add protection to an existing layout. The package offers flow-through routing, requiring minimal modification to an existing layout.

7.4 Device Functional Modes

The TPD4E02B04 is a passive integrated circuit that triggers when voltages are above V_{BRF} or below V_{BRR} . During ESD events, voltages as high as $\pm 15\text{ kV}$ (air) can be directed to ground via the internal diode network. When the voltages on the protected line fall below the trigger levels of TPD4E02B04 (usually within 10s of nanoseconds) the device reverts to passive.

8 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.

8.1 Application Information

The TPD4E02B04 is a diode type TVS which is used to provide a path to ground for dissipating ESD events on high-speed signal lines between a human interface connector and a system. As the current from ESD passes through the TVS, only a small voltage drop is present across the diode. This is the voltage presented to the protected IC. The low R_{DYN} of the triggered TVS holds this voltage, V_{CLAMP} , to a safe level for the protected IC.

8.2 Typical Application

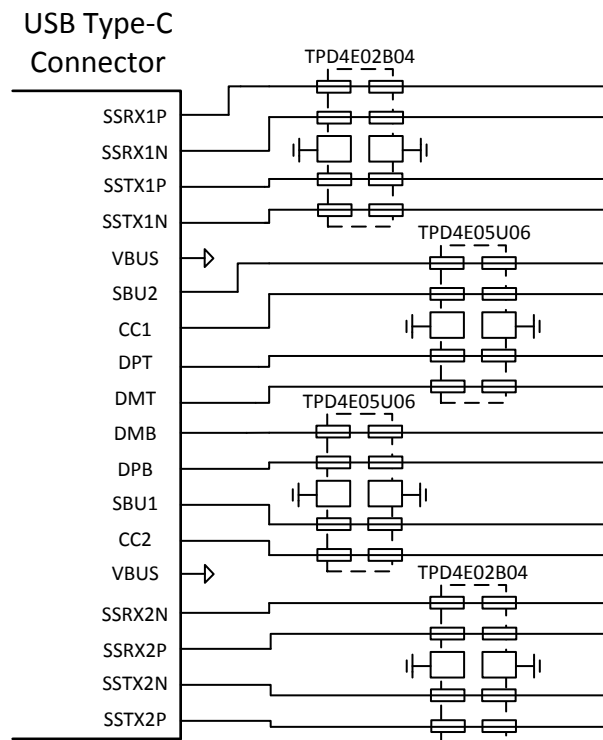


Figure 20. USB 3.1 Gen 2 Type-C ESD Schematic

Typical Application (continued)

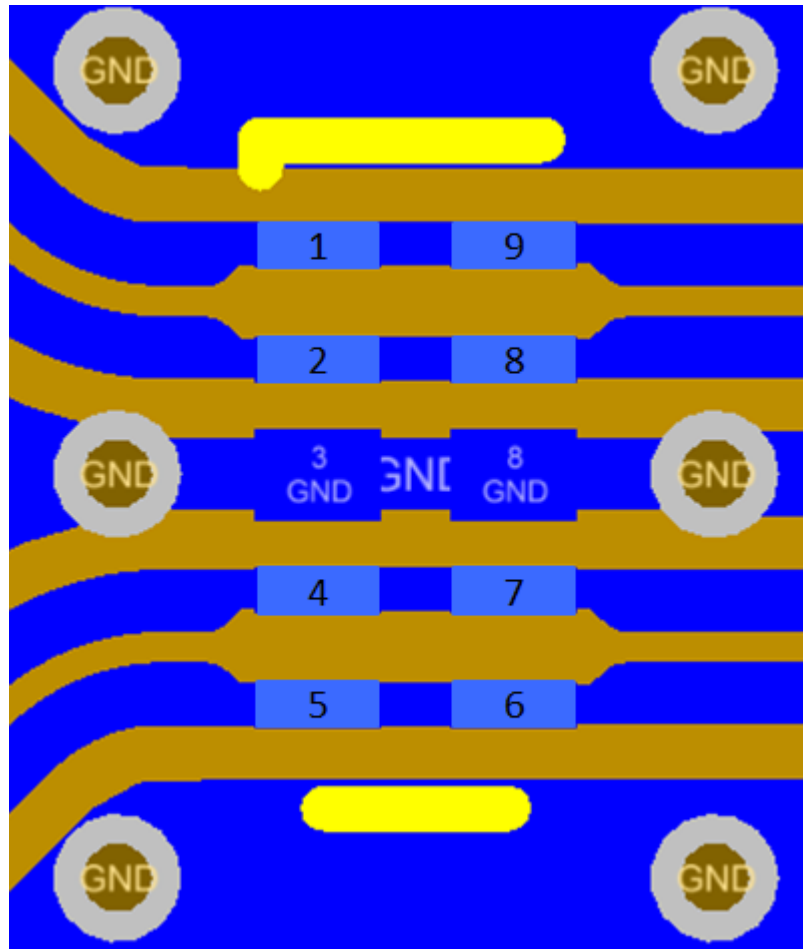


Figure 21. USB 3.1 Gen 2 SuperSpeed Layout

8.2.1 Design Requirements

For this design example two TPD4E02B04 devices and two TPD4E05U06 devices are being used in a USB 3.1 Gen 2 Type-C application. This will provide a complete ESD protection scheme.

Given the USB 3.1 Gen 2 Type-C application, the parameters listed in [Table 1](#) are known.

Table 1. Design Parameters

DESIGN PARAMETER	VALUE
Signal Range on SuperSpeed+ Lines	0 V to 3.6 V
Operating Frequency on SuperSpeed+ Lines	5 GHz
Signal Range on CC, SBU, and DP/DM Lines	0 V to 5 V
Operating Frequency on CC, SBU, and DP/DM Lines	up to 480 MHz

8.2.2 Detailed Design Procedure

8.2.2.1 Signal Range

The TPD4E02B04 supports signal ranges between -3.6 V and 3.6 V, which supports the SuperSpeed+ pairs on the USB Type-C application. The TPD4E05U06 supports signal ranges between 0 and 5.5 V, which supports the CC, SBU, and DP/DM lines.

8.2.2.2 Operating Frequency

The TPD4E02B04 has a 0.27 pF (typ) capacitance, which supports the USB3.1 Gen 2 data rates of 10 Gbps. The layout example in Figure 21 is intended to negate some of the loading capacitance of the TPD4E02B04 by narrowing the traces slightly over the device itself. The TPD4E05U06 has a 0.5 pF (typical) capacitance, which easily supports the CC, SBU, and DP/DM data rates.

8.2.3 Application Curves

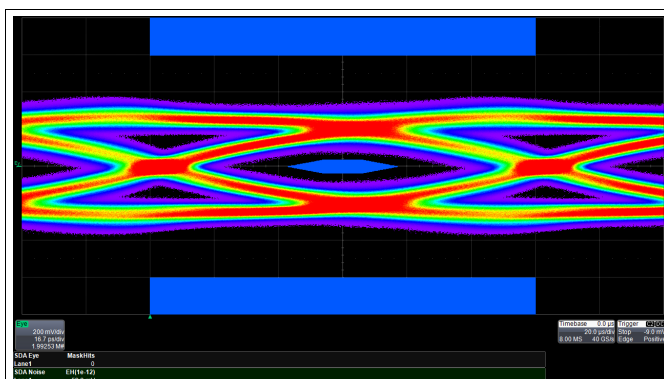


Figure 22. USB 3.1 Gen 2 10Gbps Eye Diagram (Bare Board)

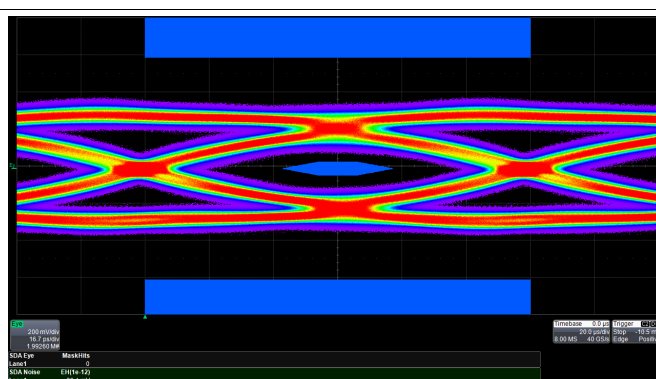


Figure 23. USB 3.1 Gen 2 10Gbps Eye Diagram (with TPD4E02B04)

9 Power Supply Recommendations

This device is a passive ESD device so there is no need to power it. Take care not to violate the recommended I/O specification (-3.6 V to 3.6 V) to ensure the device functions properly.

10 Layout

10.1 Layout Guidelines

- The optimum placement is as close to the connector as possible.
 - EMI during an ESD event can couple from the trace being struck to other nearby unprotected traces, resulting in early system failures.
 - The PCB designer needs to minimize the possibility of EMI coupling by keeping any unprotected traces away from the protected traces which are between the TVS and the connector.
- Route the protected traces as straight as possible.
- Eliminate any sharp corners on the protected traces between the TVS and the connector by using rounded corners with the largest radii possible.
 - Electric fields tend to build up on corners, increasing EMI coupling.

10.2 Layout Examples

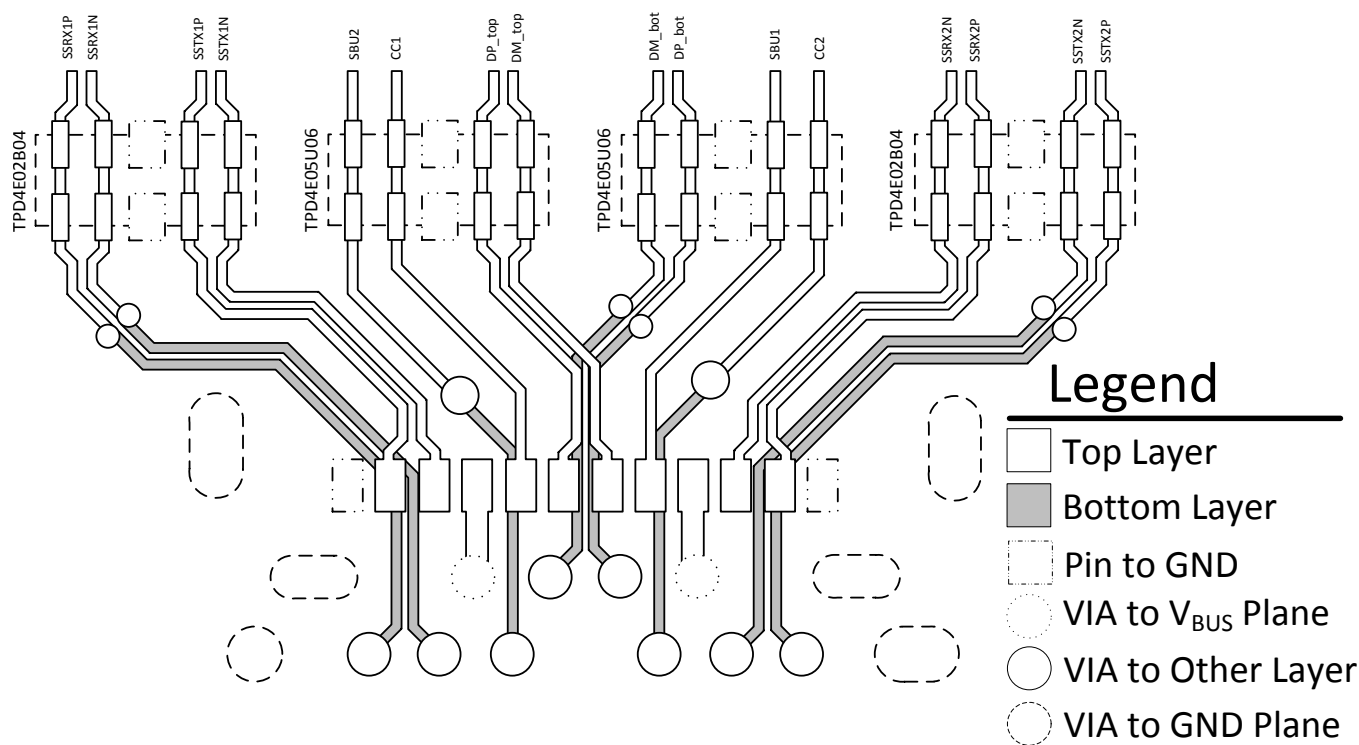


Figure 24. USB Type-C Mid-Mount, Hybrid Connector with One-Sided ESD Layout

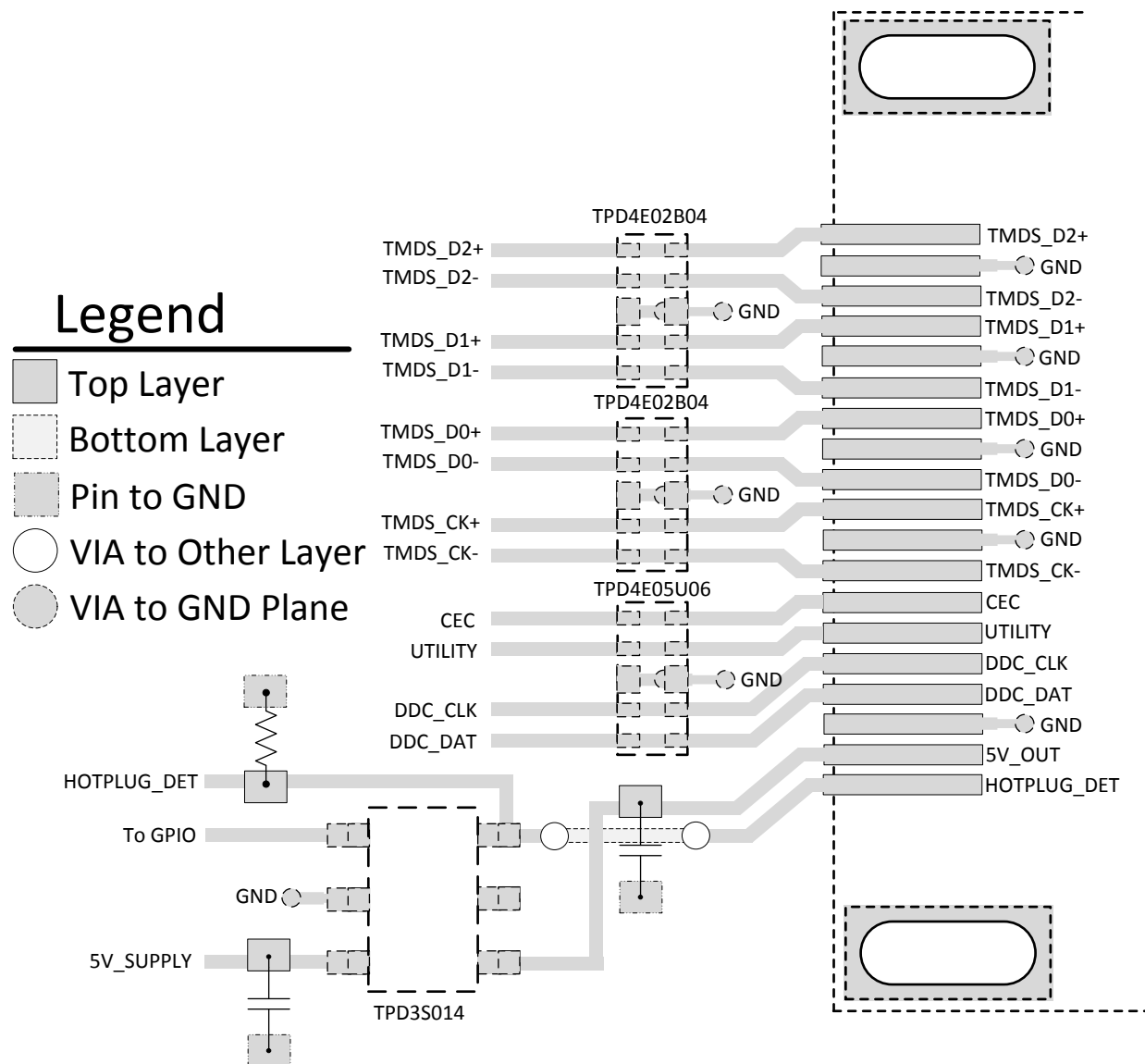


Figure 25. HDMI2.0 Type-A Transmitter Port Layout

11 器件和文档支持

11.1 文档支持

11.1.1 相关文档

相关文档请参见以下部分：

- 《阅读并理解 ESD 保护数据表》， [SLLA305](#)
- 《ESD 布局布线指南》， [SLVA680](#)
- 《TPD4E02B04EVM 用户指南》， [SLVUAH6](#)

11.2 社区资源

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

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

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

11.3 商标

E2E is a trademark of Texas Instruments.

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11.4 静电放电警告



这些装置包含有限的内置 ESD 保护。存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

11.5 Glossary

[SLYZ022](#) — *TI Glossary*.

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

12 机械、封装和可订购信息

以下页中包括机械、封装和可订购信息。这些信息是针对指定器件可提供的最新数据。这些数据会在无通知且不对本文档进行修订的情况下发生改变。欲获得该数据表的浏览器版本，请查阅左侧的导航栏。

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在某些场合中, 为了推进安全相关应用有可能对 TI 组件进行特别的促销。TI 的目标是利用此类组件帮助客户设计和创立其特 有的可满足适用的功能安全性标准和要求的终端产品解决方案。尽管如此, 此类组件仍然服从这些条款。

TI 组件未获得用于 FDA Class III (或类似的生命攸关医疗设备) 的授权许可, 除非各方授权官员已经达成了专门管控此类使 用的特别协议。

只有那些 TI 特别注明属于军用等级或“增强型塑料”的 TI 组件才是设计或专门用于军事/航空应用或环境的。购买者认可并同 意, 对并非指定面向军事或航空航天用途的 TI 组件进行军事或航空航天方面的应用, 其风险由客户单独承担, 并且由客户独 力负责满足与此类使用相关的所有法律和法规要求。

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	产品		应用
数字音频	www.ti.com.cn/audio	通信与电信	www.ti.com.cn/telecom
放大器和线性器件	www.ti.com.cn/amplifiers	计算机及周边	www.ti.com.cn/computer
数据转换器	www.ti.com.cn/dataconverters	消费电子	www.ti.com.cn/consumer-apps
DLP® 产品	www.dlp.com	能源	www.ti.com.cn/energy
DSP - 数字信号处理器	www.ti.com.cn/dsp	工业应用	www.ti.com.cn/industrial
时钟和计时器	www.ti.com.cn/clockandtimers	医疗电子	www.ti.com.cn/medical
接口	www.ti.com.cn/interface	安防应用	www.ti.com.cn/security
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微控制器 (MCU)	www.ti.com.cn/microcontrollers		
RFID 系统	www.ti.com.cn/rfidsys		
OMAP应用处理器	www.ti.com.cn/omap		
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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
TPD4E02B04DQAR	ACTIVE	USON	DQA	10	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1SG 1SY	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.

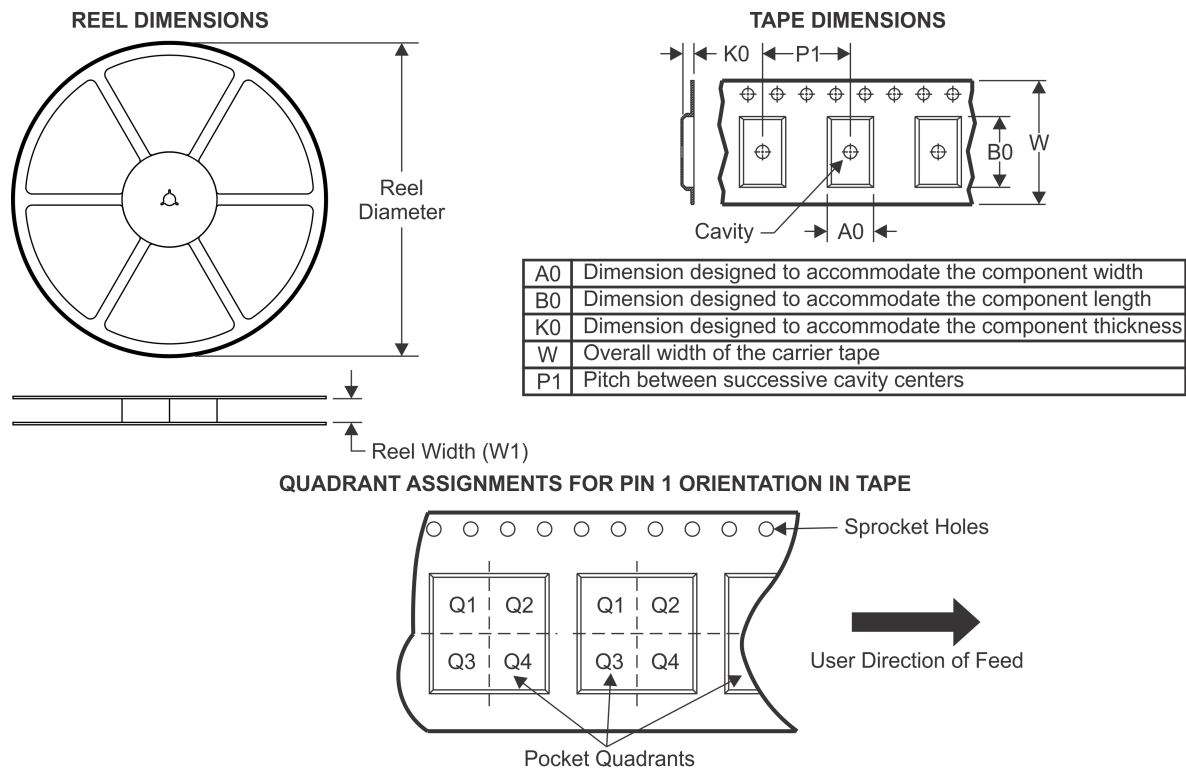
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

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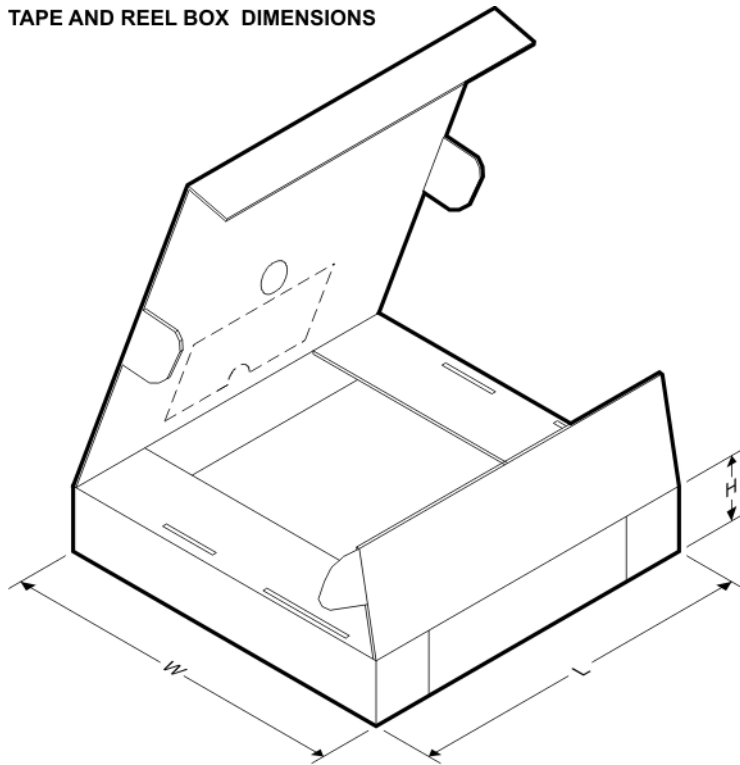
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION


*All dimensions are nominal

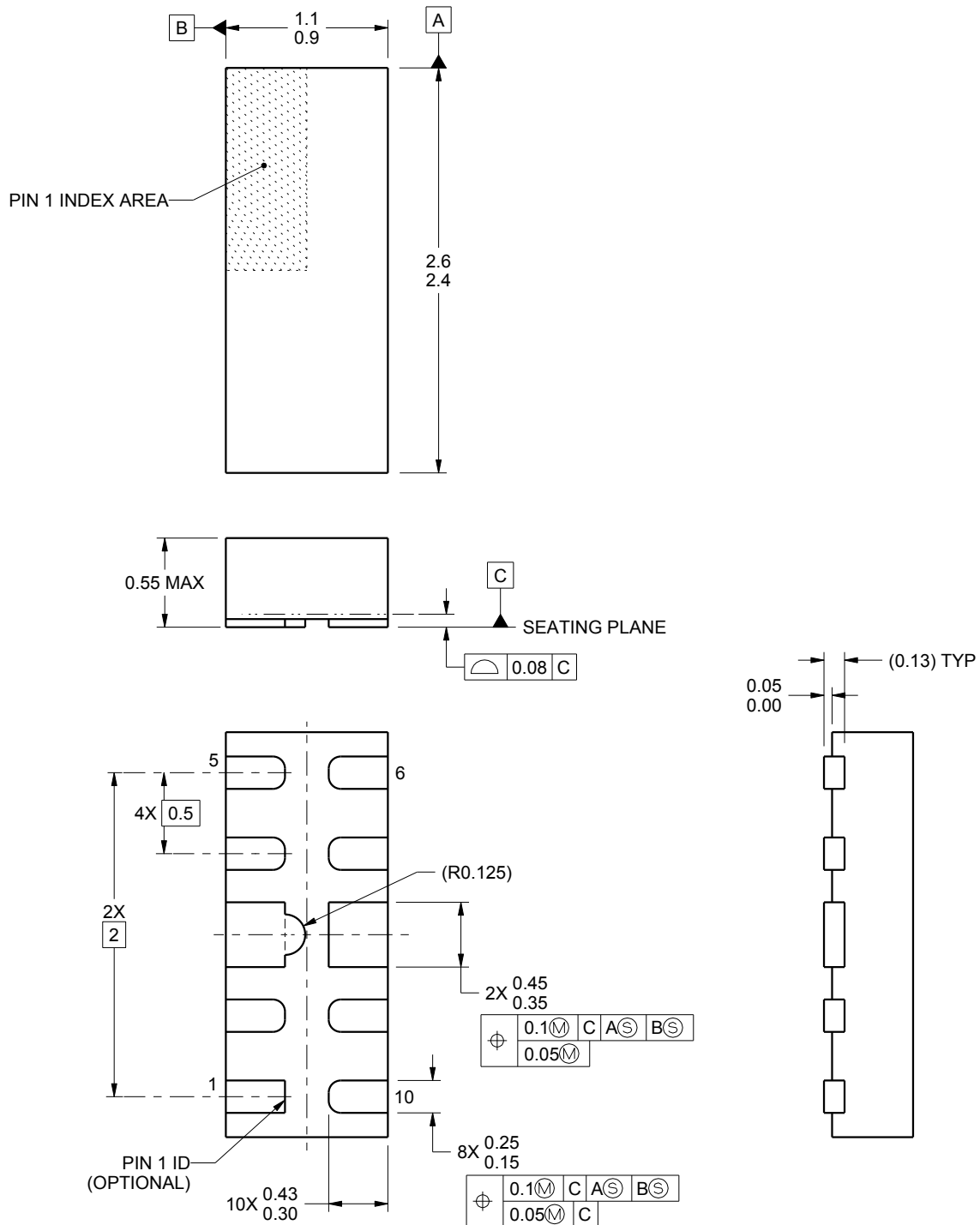
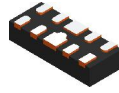
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPD4E02B04DQAR	USON	DQA	10	3000	180.0	9.5	1.18	2.68	0.72	4.0	8.0	Q1
TPD4E02B04DQAR	USON	DQA	10	3000	180.0	8.4	1.23	2.7	0.6	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPD4E02B04DQAR	USON	DQA	10	3000	189.0	185.0	36.0
TPD4E02B04DQAR	USON	DQA	10	3000	203.2	196.8	33.3



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NOTES:

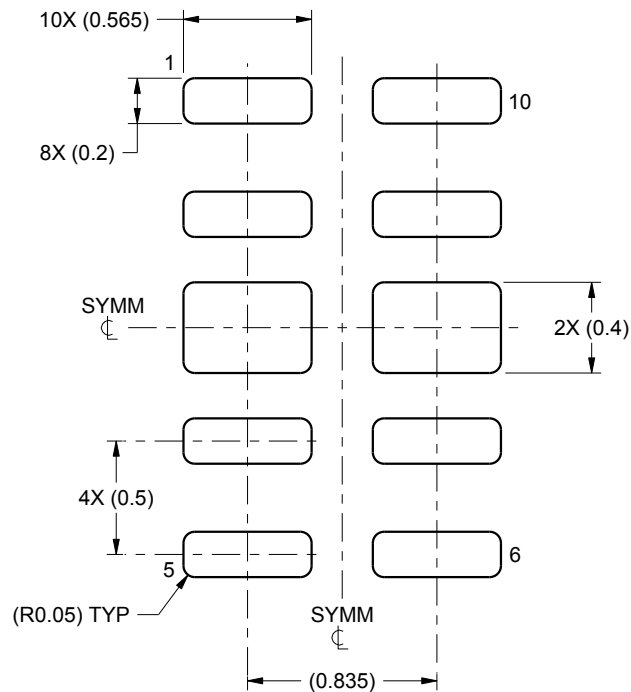
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

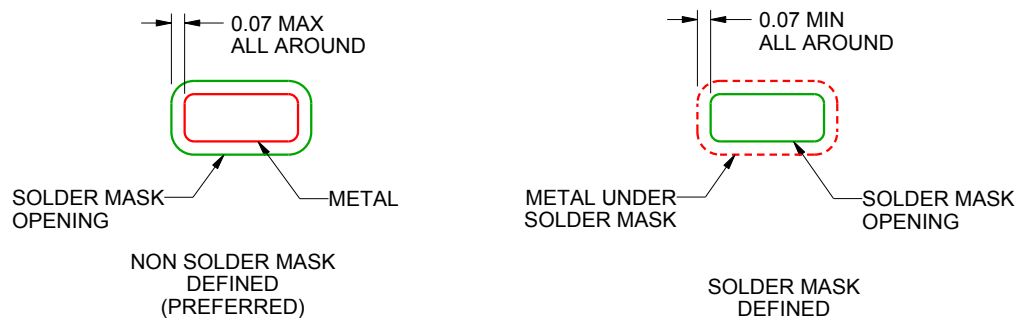
DQA0010A

USON - 0.55 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE
SCALE:30X



SOLDER MASK DETAILS

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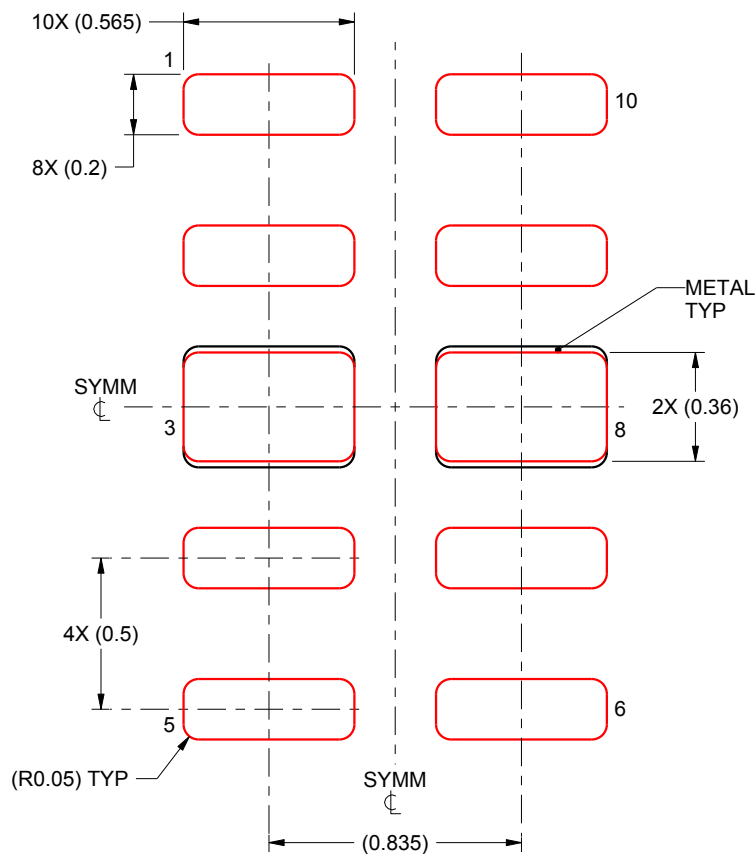
NOTES: (continued)

3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).

DQA0010A

USON - 0.55 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE BASED ON 0.1 mm THICK STENCIL

EXPOSED PADS 3 & 8:
90% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:40X

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NOTES: (continued)

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

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