

TPD2E2U06 双通道高速 ESD 保护器件

1 特性

- IEC 61000-4-2 4 级
 - $\pm 25\text{kV}$ (接触放电)
 - $\pm 30\text{kV}$ (气隙放电)
- IEC 61000-4-5 浪涌保护
 - 5.5A 峰值脉冲电流 (8/20 μs 脉冲)
- IO 电容值 1.5pF (典型值)
- 直流击穿电压 6.5V (最小值)
- 超低泄漏电流 10nA (最大值)
- 低 ESD 钳位电压
- 工业温度范围: -40°C 至 $+125^{\circ}\text{C}$
- 易于布线的小型 DRL 和 DCK 封装

2 应用

- 终端设备
 - 机顶盒
 - 笔记本
 - 服务器
 - 电子销售点 (EPOS)
- 接口
 - USB 2.0
 - 以太网
 - MIPI 总线
 - LVDS
 - I²C

3 说明

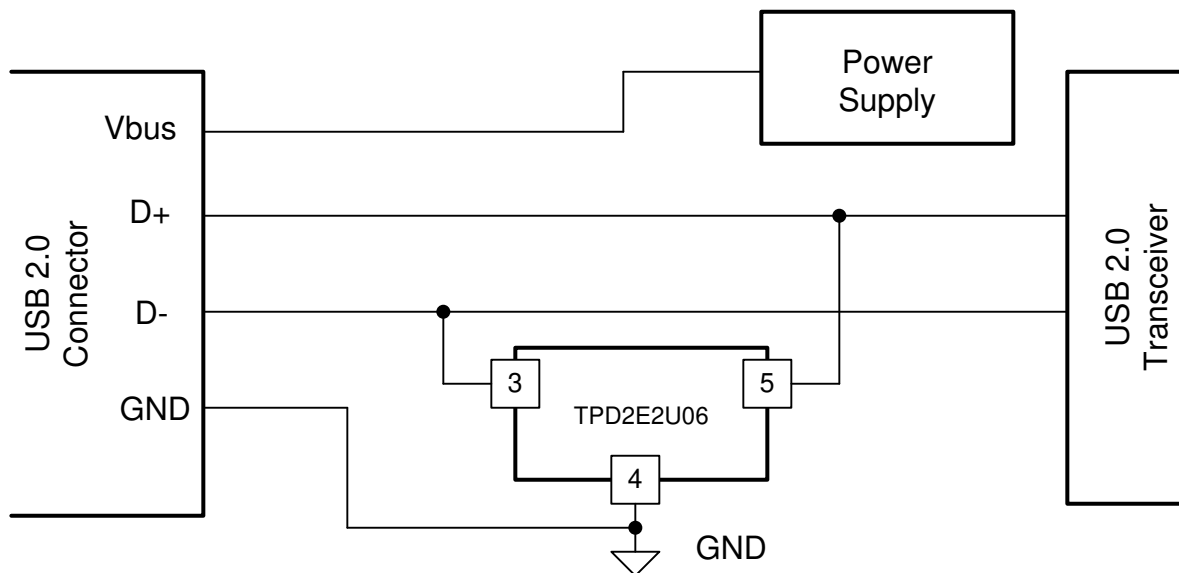
TPD2E2U06 是一款双通道低电容瞬态电压抑制器 (TVS) 二极管静电放电 (ESD) 保护器件。该器件可提供符合 IEC 61000-4-2 标准的 $\pm 25\text{kV}$ 接触 ESD 保护和 $\pm 30\text{kV}$ 气隙 ESD 保护。TPD2E2U06 的 1.5pF 线路电容使得此器件适合于广泛的应用中的数字输入 D 类音频放大器。典型应用接口为 USB 2.0, 低压差分信令 (LVDS) 接口和 I²C™。

器件信息⁽¹⁾

器件型号	封装	封装尺寸 (标称值)
TPD2E2U06DRL	SOT (5)	1.60mm × 1.20mm
TPD2E2U06DCK	SC70 (3)	2.0mm × 1.25mm

(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。

简化原理图



目录

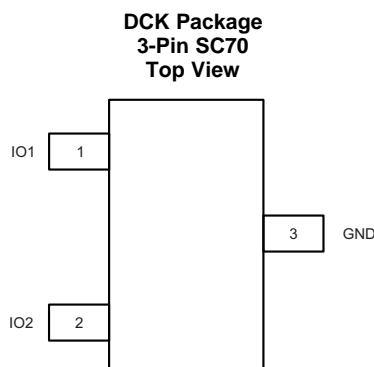
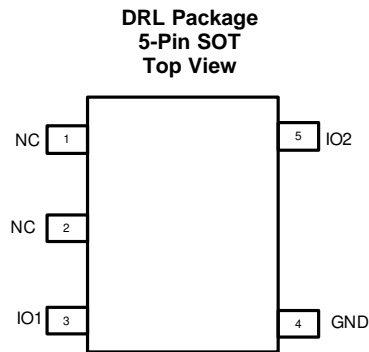
1	特性	1	7.3	Feature Description	8
2	应用	1	7.4	Device Functional Modes	9
3	说明	1	8	Application and Implementation	10
4	修订历史记录	2	8.1	Application Information	10
5	Pin Configuration and Functions	3	8.2	Typical Application	10
6	Specifications	3	9	Power Supply Recommendations	11
6.1	Absolute Maximum Ratings	3	10	Layout	11
6.2	ESD Ratings	4	10.1	Layout Guidelines	11
6.3	Recommended Operating Conditions	4	10.2	Layout Example	12
6.4	Thermal Information	4	11	器件和文档支持	12
6.5	Electrical Characteristics	4	11.1	商标	12
6.6	Typical Characteristics	6	11.2	接收文档更新通知	12
7	Detailed Description	8	11.3	支持资源	12
7.1	Overview	8	11.4	Glossary	12
7.2	Functional Block Diagram	8	12	机械、封装和可订购信息	12

4 修订历史记录

Changes from Revision B (May 2015) to Revision C	Page
• Added DCK Package to the Pin Configuration and Functions section	3
• Added DCK Package to the Electrical Characteristics table	4

Changes from Revision A (June 2013) to Revision B	Page
• 已添加 添加了“ESD 额定值”表、“特性 说明 ”部分、器件功能模式、“应用和实施”部分、“电源相关建议”部分、“布局”部分、“器件和文档支持”部分以及“机械、封装和可订购信息”部分。	1

5 Pin Configuration and Functions



Pin Functions

NAME	PIN		I/O	DESCRIPTION
	DRL	DCK		
IO1	3	1	I/O	The IO1 and IO2 pins are an ESD protected channel. Connect these pins to the data line as close to the connector as possible.
IO2	5	2	I/O	
NC	1, 2	—	-	This pin is not connected and is left floating, grounded, or connected to VCC.
GND	4	3	G	The GND (ground) pin is connected to ground.

6 Specifications

6.1 Absolute Maximum Ratings

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

	MIN	MAX	UNIT
I_{PP} Peak pulse current ($t_p = 8/20 \mu s$)		5.5 ⁽¹⁾	A
P_{PP} Peak pulse power ($t_p = 8/20 \mu s$) DRL package		85 ⁽¹⁾	W
P_{PP} Peak pulse power ($t_p = 8/20 \mu s$) DCK package		75 ⁽¹⁾	W
Operating temperature	–40	125	°C
Storage temperature	–65	155	°C

(1) Measured at 25°C.

6.2 ESD Ratings

		VALUE	UNIT
V _(ESD) Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±4000	V
	Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±1500	
	EC 61000-4-2 contact	±25000	
	EC 61000-4-2 air-gap	±30000	

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 500-V HBM is possible with the necessary precautions.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 250-V CDM is possible with the necessary precautions.

6.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V _{IO}	Input Pin Voltage	0		5.5	V
T _A	Operating Free Air Temperature	-40		125	°C

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TPD2E2U06		UNIT
		DRL	DCK	
		5 PINS	3 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	286.8	308.3	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	130.7	170.7	
R _{θJB}	Junction-to-board thermal resistance	104.8	89.2	
ψ _{JT}	Junction-to-top characterization parameter	25.6	34.2	
ψ _{JB}	Junction-to-board characterization parameter	104.3	88.6	

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

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 μA			5.5	V
V _{CLAMP}	IO to GND	I _{PP} = 1 A, TLP ⁽¹⁾		9.7		V
		I _{PP} = 5 A, TLP ⁽¹⁾		12.4		
V _{CLAMP}	GND to IO	I _{PP} = 1 A, TLP ⁽¹⁾		1.9		V
		I _{PP} = 5 A, TLP ⁽¹⁾		4		
R _{DYN}	Dynamic resistance DRL package	IO to GND ⁽²⁾		0.5		Ω
R _{DYN}	Dynamic resistance DRL package	GND to IO ⁽²⁾		0.25		Ω
R _{DYN}	Dynamic resistance DCK package	IO to GND ⁽²⁾		0.6		Ω
R _{DYN}	Dynamic resistance DCK package	GND to IO ⁽²⁾		0.4		Ω
CL	Line capacitance	f = 1 MHz, V _{BIAS} = 2.5 V ⁽³⁾		1.5	1.9	pF
C _{CROSS}	Channel-to-channel input capacitance	Pin 4 = 0 V, f = 1 MHz, V _{BIAS} = 2.5 V, between channel pins ⁽³⁾		0.02	0.03	pF

(1) Transmission Line Pulse with 10-ns rise time, 100-ns width.

(2) Extraction of R_{DYN} Using least squares fit of TLP characteristics between I = 20 A and I = 30 A.

(3) Measured at 25°C.

Electrical Characteristics (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$\Delta_{C_{IO-TO-GND}}$	Variation of channel input capacitance	Pin 4 = 0 V, $f = 1$ MHz, $V_{BIAS} = 2.5$ V, channel_x pin to GND – channel_y pin to GND ⁽³⁾		0.03	0.1	pF
V_{BR}	Break-down voltage	$I_{IO} = 1$ mA	6.5		8.5	V
I_{LEAK}	Leakage current	$V_{IO} = 2.5$ V		1	10	nA

6.6 Typical Characteristics

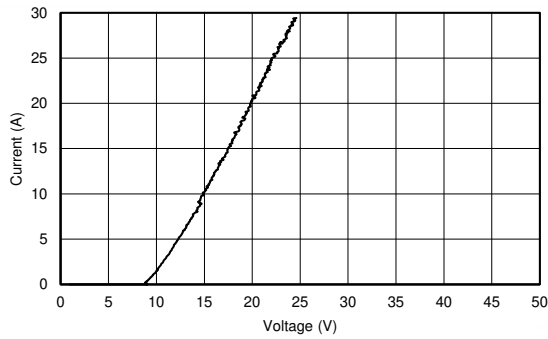


Figure 1. TLP, Data to GND

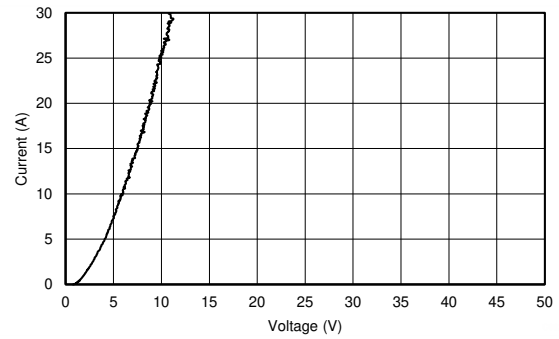


Figure 2. TLP, GND to Data

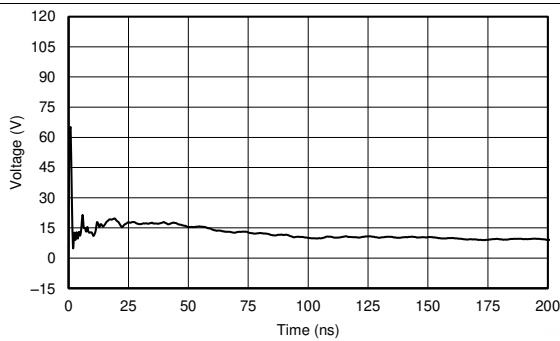


Figure 3. IEC 61000-4-2 Clamping Voltage, +8 kV Contact

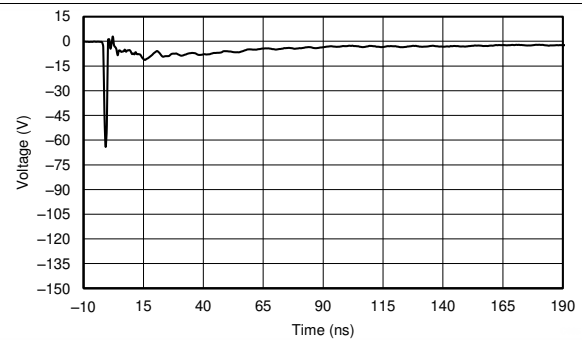
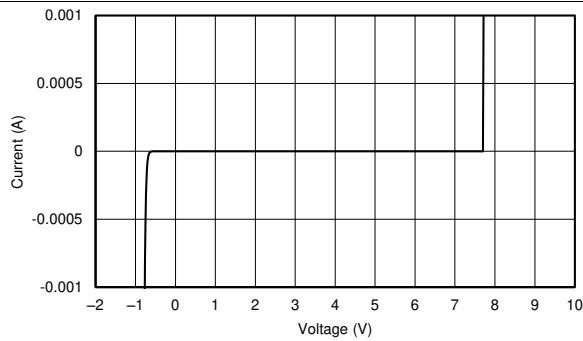
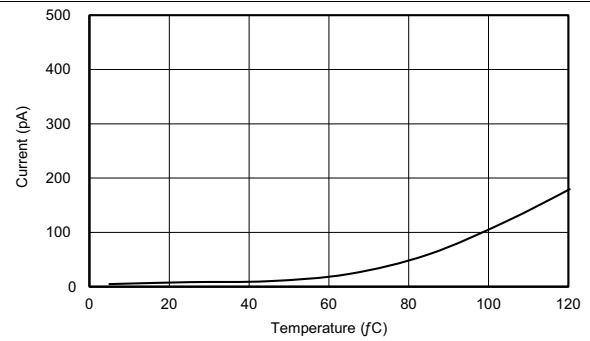


Figure 4. IEC 61000-4-2 Clamping Voltage, -8 kV Contact



$T_A = 25^\circ\text{C}$

Figure 5. IV Curve



$V_{IN} = 2.5\text{ V}$

Figure 6. I_{LEAK} vs Temperature

Typical Characteristics (continued)

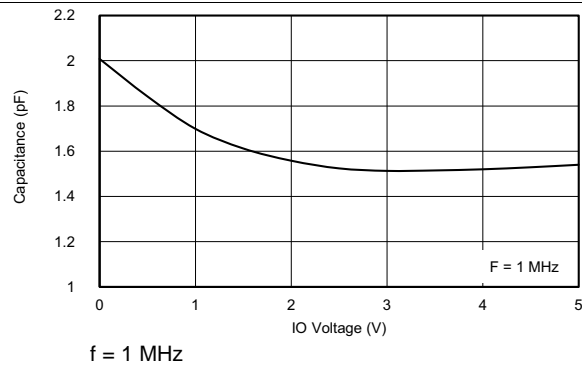


Figure 7. Capacitance Across V_{BIAS}

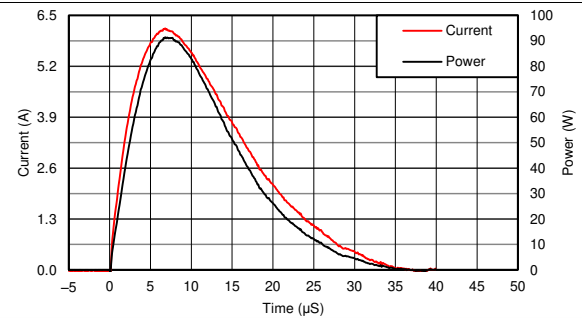


Figure 8. Surge Curve ($t_p = 8/20 \mu\text{s}$) IO to GND

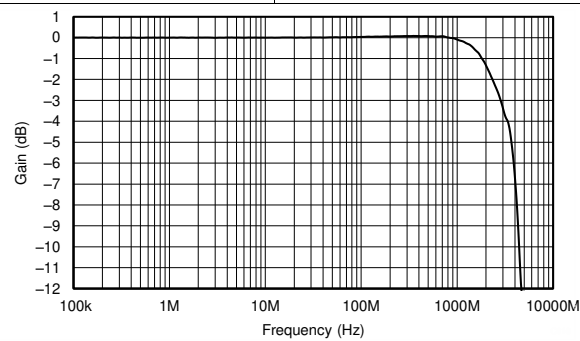


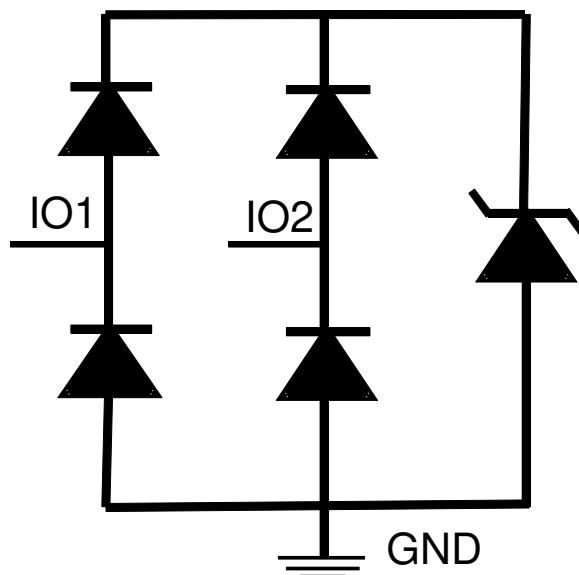
Figure 9. Insertion Loss

7 Detailed Description

7.1 Overview

The TPD2E2U06 is a dual-channel low capacitance TVS diode ESD protection device. The device offers ± 25 -kV contact and ± 30 -kV air-gap ESD protection in accordance with the IEC 61000-4-2 standard. The 1.5-pF line capacitance of the TPD2E2U06 makes the device suitable for a wide range of applications. Typical application interfaces are USB 2.0, LVDS, and I2C.

7.2 Functional Block Diagram



7.3 Feature Description

The TPD2E2U06 is a dual-channel low capacitance TVS diode ESD protection device. The device offers ± 25 -kV contact and ± 30 -kV air-gap ESD protection in accordance with the IEC 61000-4-2 standard. The 1.5-pF line capacitance of the TPD2E2U06 makes the device suitable for a wide range of applications. Typical application interfaces are USB 2.0, LVDS, and I2C.

7.3.1 IEC 61000-4-2 Level 4

The I/O pins can withstand ESD events up to ± 25 -kV contact and ± 30 -kV air. An ESD/surge clamp diverts the current to ground.

7.3.2 IO Capacitance

The capacitance between each I/O pin to ground is 1.5 pF. These capacitances support data rates in excess of 1.5 Gbps.

7.3.3 DC Breakdown Voltage

The DC breakdown voltage of each I/O pin is a minimum of 6.5 V. This ensures that sensitive equipment is protected from surges above the reverse standoff voltage of 5.5 V.

7.3.4 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.

7.3.5 Low ESD Clamping Voltage

The I/O pins feature an ESD clamp that is capable of clamping the voltage to 9.7 V ($I_{PP} = 1$ A).

Feature Description (continued)

7.3.6 Industrial Temperature Range

This device is designed to operate from -40°C to 125°C .

7.3.7 Small Easy-to-Route 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

TPD2E2U06 is a passive integrated circuit that triggers when voltages are above V_{BR} or below the lower diodes V_f (-0.6 V). During ESD events, voltages as high as $\pm 30\text{ kV}$ (air) can be directed to ground via the internal diode network. Once the voltages on the protected line fall below the trigger levels of TPD2E2U06 (usually within 10's of nano-seconds) 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

TPD2E2U06 is a diode type TVS which is typically used to provide a path to ground for dissipating ESD events on hi-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

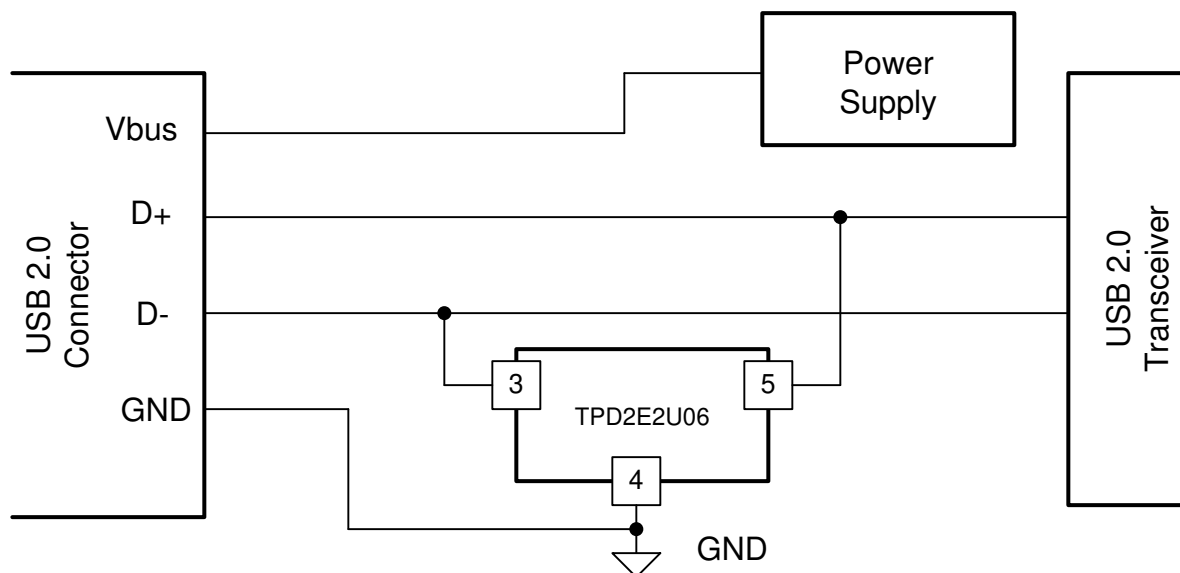


Figure 10. Typical USB Application Diagram

8.2.1 Design Requirements

For this design example, one TPD2E2U06 device will be used in a USB 2.0 application. This will provide complete port protection.

Given the USB 2.0 application, the following parameters are known.

DESIGN PARAMETER	VALUE
Signal range on Pins 3 or 5	0 V to 3.3 V
Operating Frequency	240 MHz

8.2.2 Detailed Design Procedure

To begin the design process, some parameters must be decided upon; the designer needs to know the following:

- Signal range of all the protected lines
- Operating frequency

8.2.2.1 Signal Range

The TPD2E2U06 has 2 identical protection channels for signal lines. The symmetry of the device provides flexibility when selecting which of the 2 I/O channels will protect which signal lines. Any I/O will support a signal range of 0 to 5.5 V.

8.2.2.2 Operating Frequency

The TPD2E2U06 has a capacitance of 1.5 pF (Typ), supporting USB 2.0 data rates.

8.2.3 Application Curves

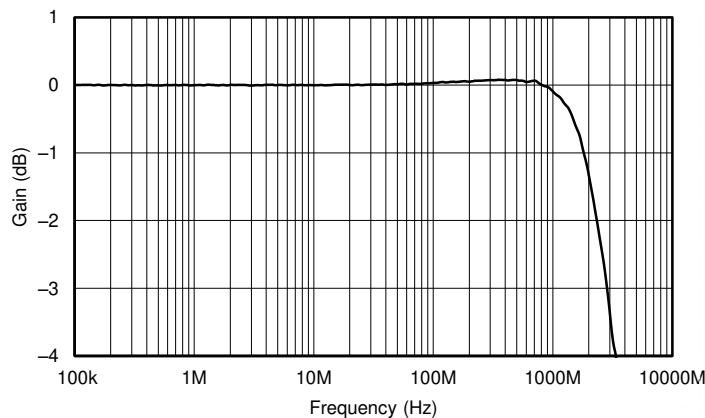


Figure 11. Insertion Loss Graph

9 Power Supply Recommendations

This device is a passive ESD protection device and there is no need to power it. Care should be taken to make sure that the maximum voltage specifications for each line are not violated.

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 Example

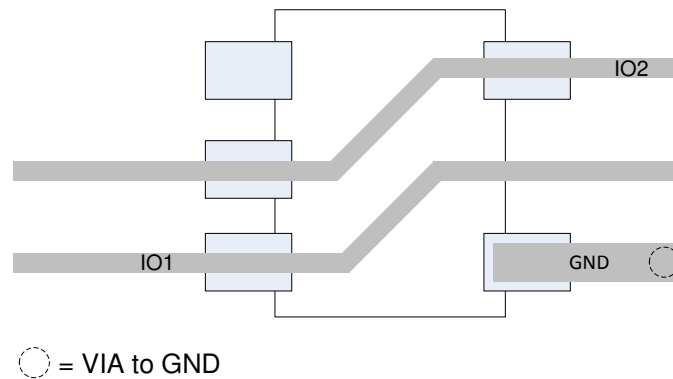


Figure 12. Routing with DRL Package

11 器件和文档支持

11.1 商标

E2E is a trademark of Texas Instruments.

I²C is a trademark of NXP Semiconductors.

All other trademarks are the property of their respective owners.

11.2 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。单击右上角的通知我进行注册，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。

11.3 支持资源

[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](#).

11.4 Glossary

[SLYZ022](#) — *TI Glossary*.

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

12 机械、封装和可订购信息

以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知，且不会对此文档进行修订。如需获取此数据表的浏览器版本，请查阅左侧的导航栏。

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPD2E2U06DCKR	Active	Production	SC70 (DCK) 3	3000 LARGE T&R	Yes	NIPDAU SN	Level-1-260C-UNLIM	-40 to 125	1GH
TPD2E2U06DRLR	Active	Production	SOT-5X3 (DRL) 5	4000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	DT

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts 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.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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.

OTHER QUALIFIED VERSIONS OF TPD2E2U06 :

- Automotive : [TPD2E2U06-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION



*All dimensions are nominal

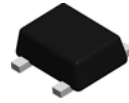
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPD2E2U06DCKR	SC70	DCK	3	3000	180.0	8.4	2.3	2.75	1.2	4.0	8.0	Q3
TPD2E2U06DRLR	SOT-5X3	DRL	5	4000	180.0	8.4	1.98	1.78	0.69	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS

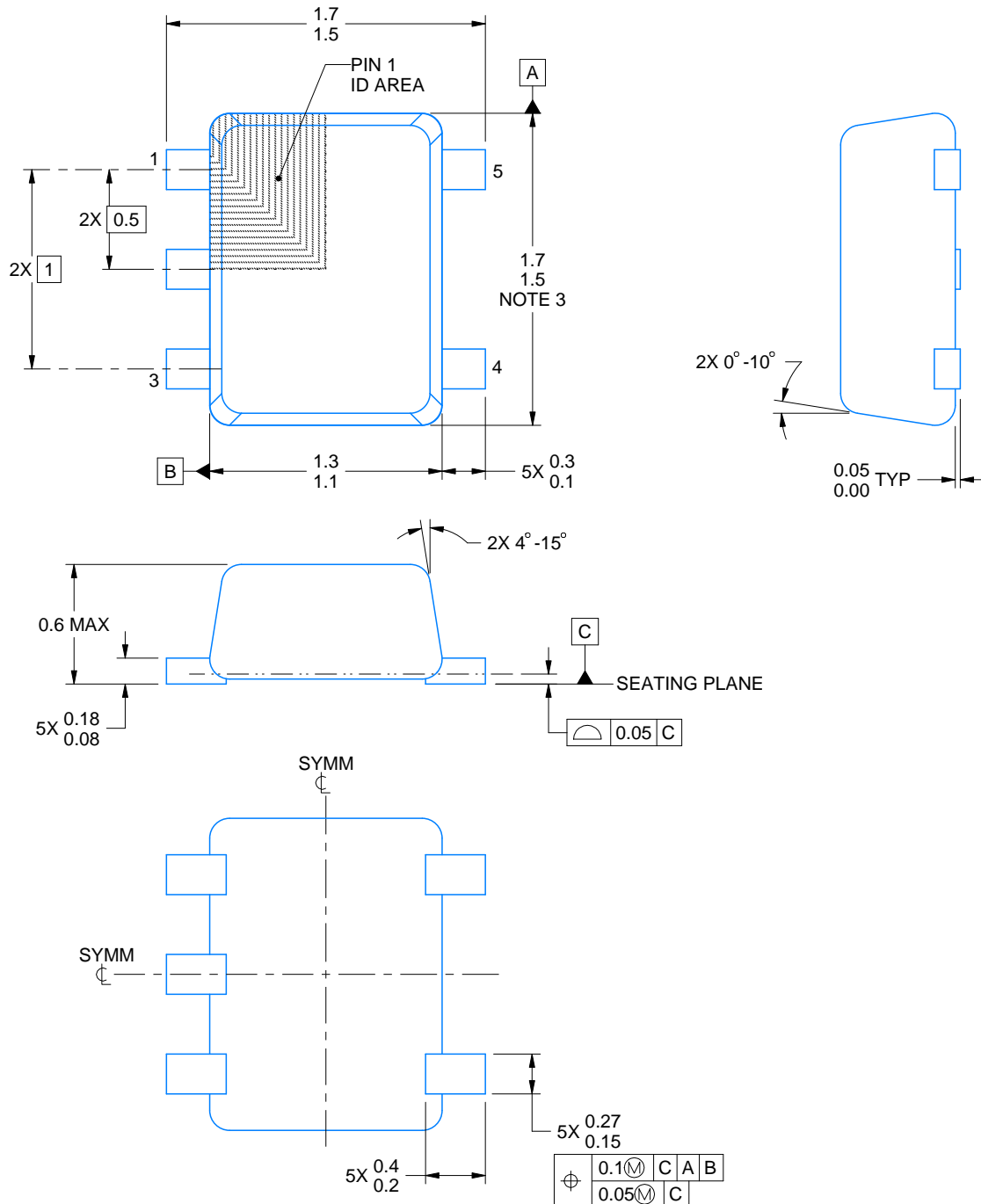


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPD2E2U06DCKR	SC70	DCK	3	3000	210.0	185.0	35.0
TPD2E2U06DRLR	SOT-5X3	DRL	5	4000	183.0	183.0	20.0

DRL0005A**PACKAGE OUTLINE****SOT - 0.6 mm max height**

PLASTIC SMALL OUTLINE



4220753/E 11/2024

NOTES:

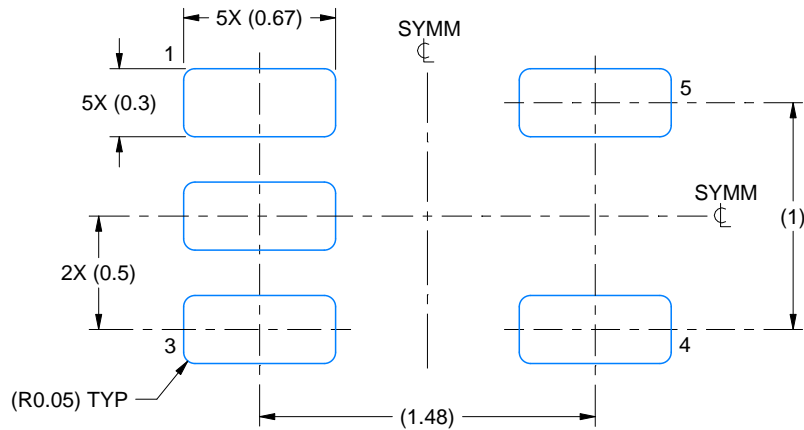
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-293 Variation UAAD-1

EXAMPLE BOARD LAYOUT

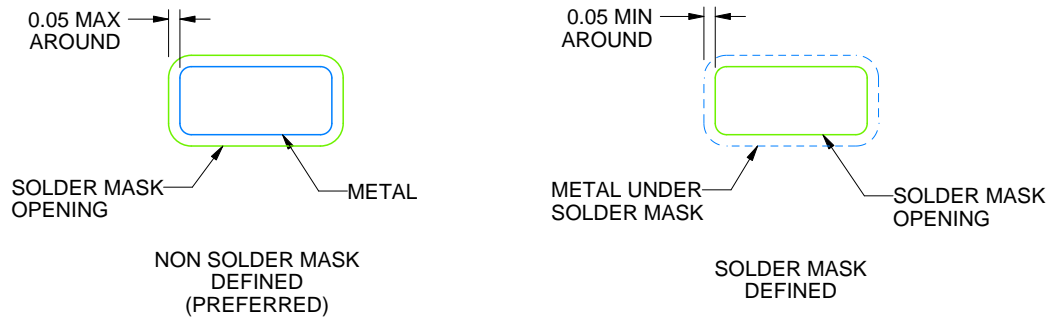
DRL0005A

SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE
SCALE:30X



SOLDERMASK DETAILS

4220753/E 11/2024

NOTES: (continued)

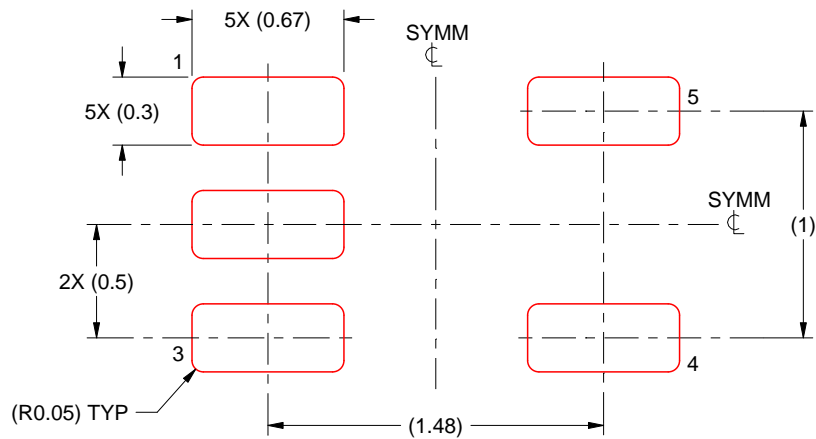
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DRL0005A

SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE



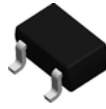
SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:30X

4220753/E 11/2024

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

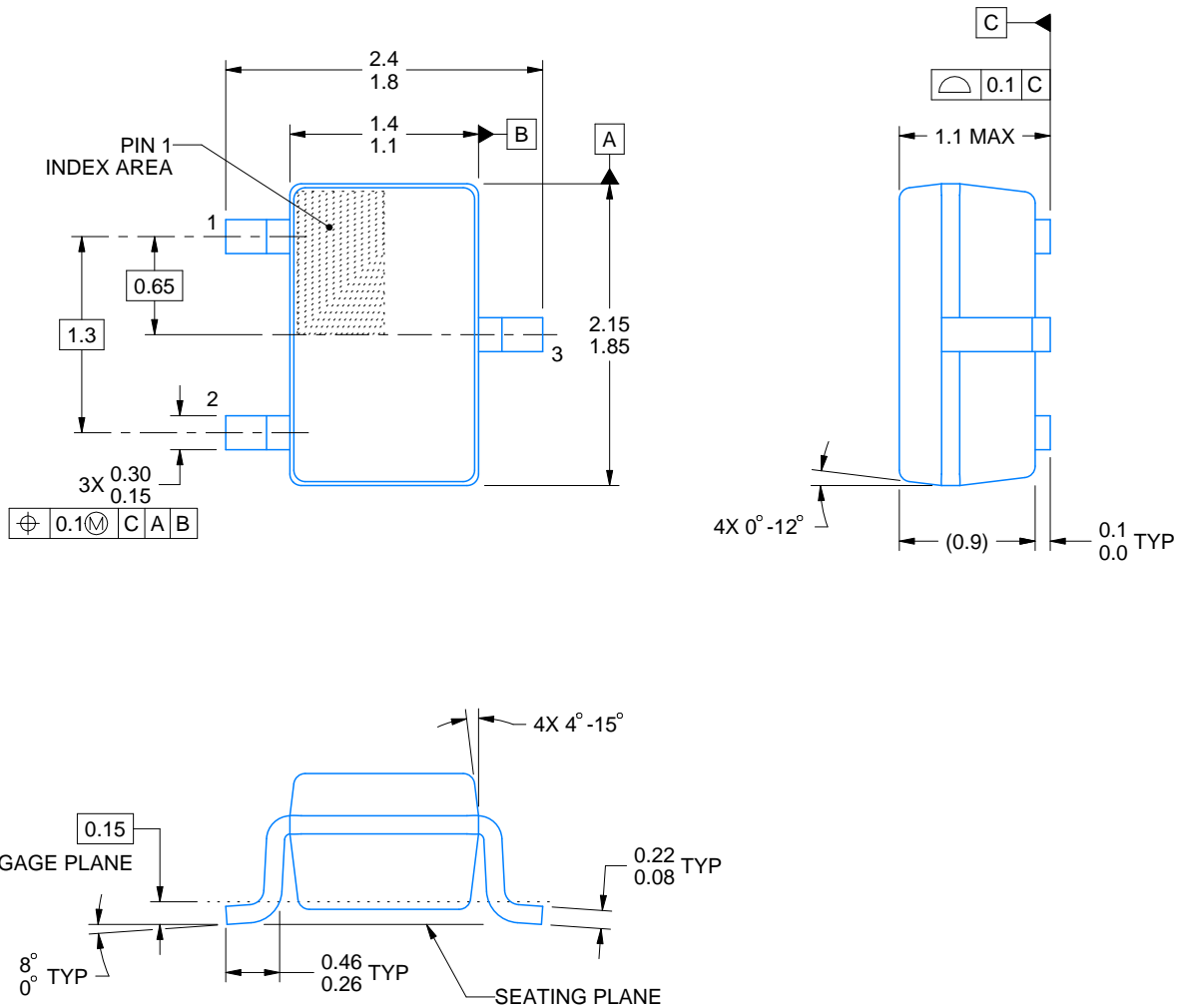
DCK0003A



PACKAGE OUTLINE

SOT-SC70 - 1.1 max height

SMALL OUTLINE TRANSISTOR SC70



4220745/F 11/2024

NOTES:

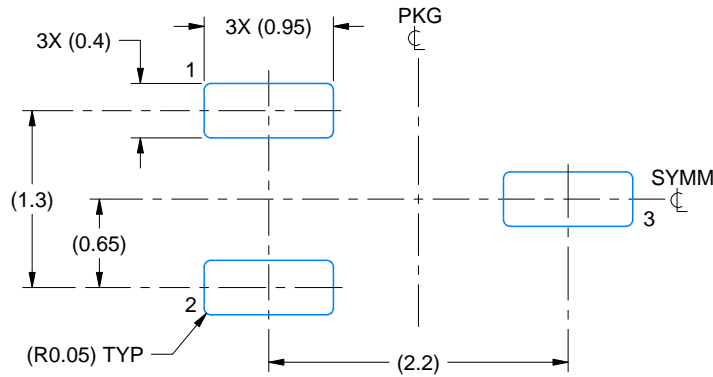
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side

EXAMPLE BOARD LAYOUT

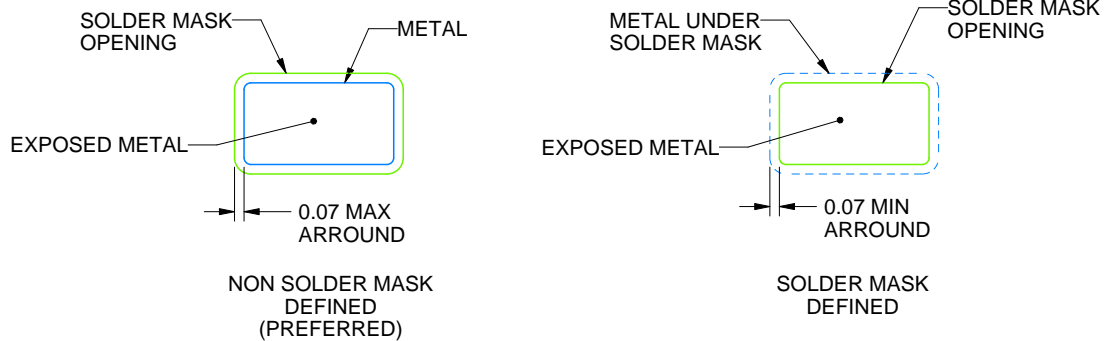
DCK0003A

SOT-SC70 - 1.1 max height

SMALL OUTLINE TRANSISTOR SC70



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X



SOLDER MASK DETAILS

4220745/F 11/2024

NOTES: (continued)

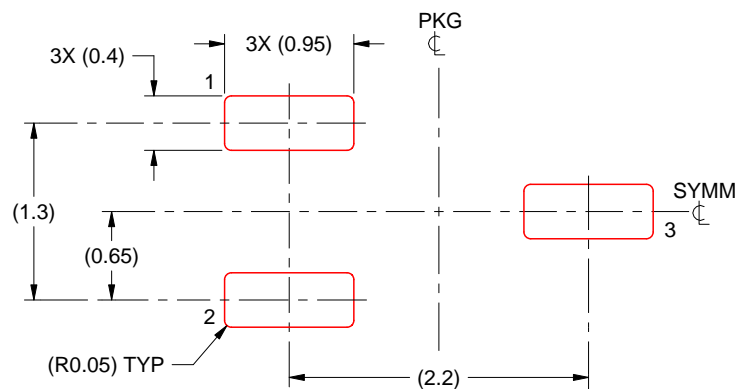
4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DCK0003A

SOT-SC70 - 1.1 max height

SMALL OUTLINE TRANSISTOR SC70



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:18X

4220745/F 11/2024

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
7. Board assembly site may have different recommendations for stencil design.

重要通知和免责声明

TI“按原样”提供技术和可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证没有瑕疵且不做任何明示或暗示的担保，包括但不限于对适销性、某特定用途方面的适用性或不侵犯任何第三方知识产权的暗示担保。

这些资源可供使用 TI 产品进行设计的熟练开发人员使用。您将自行承担以下全部责任：(1) 针对您的应用选择合适的 TI 产品，(2) 设计、验证并测试您的应用，(3) 确保您的应用满足相应标准以及任何其他功能安全、信息安全、监管或其他要求。

这些资源如有变更，恕不另行通知。TI 授权您仅可将这些资源用于研发本资源所述的 TI 产品的相关应用。严禁以其他方式对这些资源进行复制或展示。您无权使用任何其他 TI 知识产权或任何第三方知识产权。您应全额赔偿因在这些资源的使用中对 TI 及其代表造成的任何索赔、损害、成本、损失和债务，TI 对此概不负责。

TI 提供的产品受 [TI 的销售条款](#) 或 [ti.com](#) 上其他适用条款/TI 产品随附的其他适用条款的约束。TI 提供这些资源并不会扩展或以其他方式更改 TI 针对 TI 产品发布的适用的担保或担保免责声明。

TI 反对并拒绝您可能提出的任何其他或不同的条款。

邮寄地址：Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
版权所有 © 2025，德州仪器 (TI) 公司