采用 0402 封装的低钳位电压 ESD351 单通道 30kV ESD 保护二极管

1 特性

- IEC 61000-4-2 4 级静电放电 (ESD) 保护
  - ±30kV 接触放电
  - ±30kV 气隙放电
- IEC 61000-4-4 瞬态放电 (EFT) 保护
  - 80A (5/50ns)
- IEC 61000-4-5 浪涌保护
  - 6A (8μs/20μs)
- IO 电容：1.8pF（典型值）
- 直流击穿电压：4.5V（最小值）
- 低泄漏电流 0.1nA（典型值）
- 极低 ESD 钳位电压
  - 在 16A TLP 下为 6.5V（I/O 引脚至 GND）
  - R_{DYN}：0.1Ω（I/O 引脚至 GND）
- 工业温度范围：-40°C 至 +125°C
- 行业标准的 0402 封装 (DFN1006P2)

2 应用

- 终端设备
  - 可穿戴产品
  - 工业和服务机器人
  - 便携式计算机和台式机
  - 手机和平板电脑
  - 机顶盒
  - 数字视频录像机 (DVR) 和网络视频录像机 (NVR)
  - 电视和监视器
  - EPOS（电子销售终端）
- 接口
  - USB 2.0/1.1
  - 通用输入/输出 (GPIO)
  - 按钮
  - 音频

3 说明

ESD351 是一种单向 TVS ESD 保护二极管，具有低动态电阻 R_{DYN} 和低钳位电压。ESD351 的额定 ESD 冲击消散值高达 30kV（接触放电和空气放电），级别符合 IEC 61000-4-2 标准。超低动态电阻 (0.1Ω) 和极低钳位电压（16A TLP 时为 6.5V）可针对瞬变事件提供系统级保护。该器件的电容为 1.8pF（典型值），因此非常适用于保护 USB 2.0 等接口。

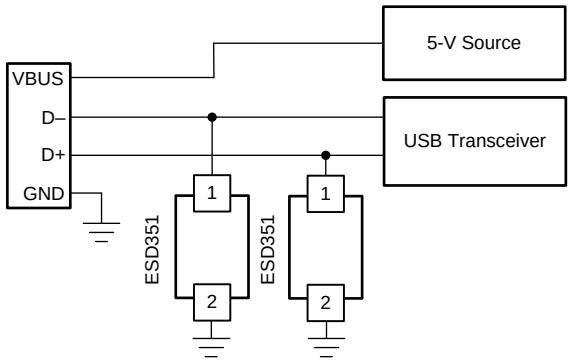
ESD351 采用符合行业标准的 0402 (DPY/DFN1006P2) 封装。

器件信息(1)

器件编号	封装	封装尺寸（标称值）
ESD351	X1SON (2)	0.60mm x 1.00mm

(1) 要了解所有可用封装，请参阅数据表末尾的可订购产品附录。

典型的 **USB 2.0** 应用原理图



本文档旨在为方便起见，提供有关 TI 产品中文版本的信息，以确认产品的概要。 有关适用的官方英文版本的最新信息，请访问 www.ti.com，其内容始终优先。 TI 不保证翻译的准确性和有效性。 在实际设计之前，请务必参考最新版本的英文版本。

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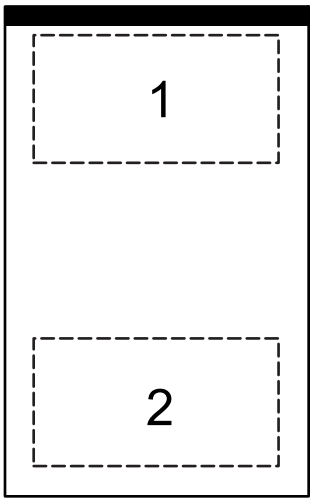
4 修订历史记录

日期	修订版本	说明
2018 年 7 月	*	初始发行版。

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5 Pin Configuration and Functions

DPY Package
2-Pin X1SON
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	IO	I/O	ESD Protected Channel. Connect this pin to the line being protected.
2	GND	GND	Connect this pin to Ground

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6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Electrical Fast Transient	IEC 61000-4-4 Peak Current at 25 °C		80	A
Surge Pulse	IEC 61000-4-5 Surge (tp 8/20 µs) Peak Power at 25 °C		36	W
	IEC 61000-4-5 Surge (tp 8/20 µs) Peak Current at 25 °C		6	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 Rating* 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 Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 ESD Ratings -JEDEC Specifications

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, allpins(1)	±2500	V
		Charged device model (CDM), per JEDEC specificationJESD22-C101, all pins(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 ESD Ratings - IEC Specifications

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	IEC 61000-4-2 Contact Discharge, all pins	±30000	V
		IEC 61000-4-2 Air Discharge, all pins	±30000	

6.4 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{IN}	Input voltage	0		3.6	V
T_A	Operating Free Air Temperature	–40		125	°C

6.5 Thermal Information

THERMAL METRIC(1)		ESD351 DPY (X1SON) 2 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	409.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	216.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	140.4	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	81.4	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	140.0	°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.

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6.6 Electrical Characteristics

At TA = 25°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{RWM}	Reverse stand-off voltage	I_{IO} < 50 nA, across operating temperature range			3.6	V
$I_{LEAKAGE}$	Leakage current at 3.6 V	V_{IO} = 3.6 V, I/O to GND		0.1	10	nA
V_{BRF}	Breakdown voltage, I/O to GND (1)	I_{IO} = 1 mA	4.5		7.5	V
V_{FWD}	Forward Voltage, GND to I/O (1)	I_{IO} = 1 mA		0.8		V
V_{HOLD}	Holding voltage, I/O to GND (2)	I_{IO} = 1 mA		5.1		V
V_{CLAMP}	Clamping voltage	I_{PP} = 6 A (8/20 µs Surge), I/O to GND		6.1		V
		I_{PP} = 16 A (100 ns TLP), I/O to GND		6.5		V
		I_{PP} = 16 A (100 ns TLP), GND to I/O		2.5		V
R_{DYN}	Dynamic resistance	I/O to GND, 100 ns TLP, between 10 to 20 A I_{PP}		0.1		Ω
		GND to I/O , 100 ns TLP, between 10 to 20 A I_{PP}		0.08		
C_{LINE}	Line capacitance, IO to GND	V_{IO} = 0 V, V_{p-p} = 30 mV, f = 1 MHz		1.8	2.2	pF

(1) V_{BRF} and V_{BRR} are defined as the voltage obtained at 1 mA when sweeping the voltage up, before the device latches into the snapback state

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

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6.7 Typical Characteristics



图 1. TLP I-V Curve, I/O Pin to GND (t_p = 100 ns)

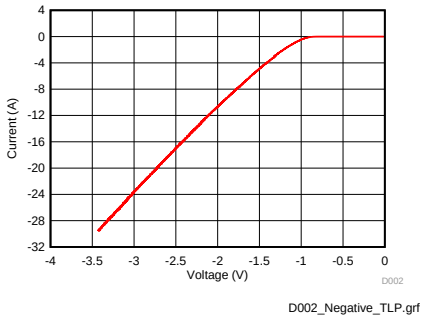


图 2. TLP I/V Curve, GND to I/O Pin (t_p = 100 ns)

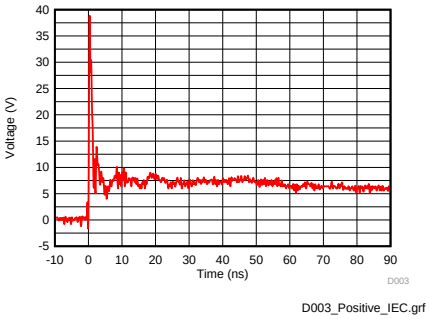


图 3. 8-kV IEC 61000-4-2 Clamping Voltage, I/O pin to GND

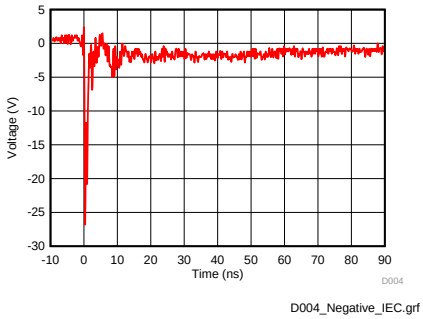


图 4. 8-kV IEC 61000-4-2 Clamping Voltage, GND to I/O Pin

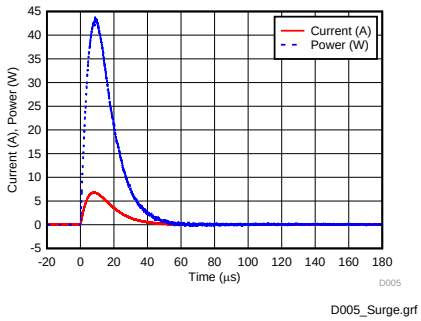


图 5. Surge Curve (IEC 61000-4-5, t_p = 8/20 µs), I/O Pin to GND

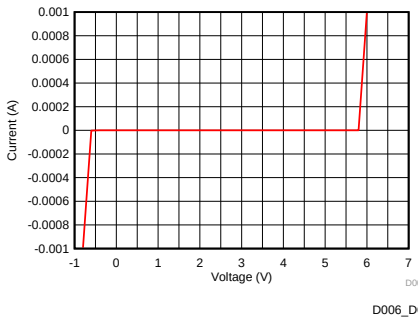


图 6. DC IV-Curve, I/O Pin to GND

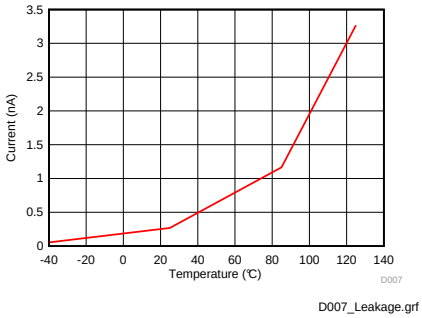


图 7. Leakage Current at 3.6 V Bias Voltage Across Temperature, I/O Pin to GND

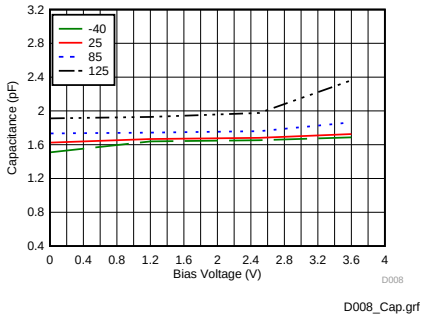


图 8. Capacitance Vs. Bias Voltage at Different Temperatures (°C)

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Typical Characteristics (接下页)

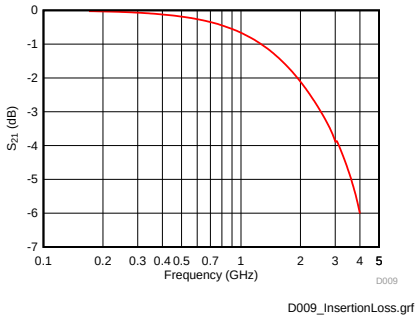


图 9. Insertion Loss Vs. Frequency

7 Detailed Description

7.1 Overview

The ESD351 is a uni-directional ESD Protection Diode with 30 kV IEC 61000-4-2 level (Contact and Air) with ultra-low clamping voltage in a 1 mm × 0.6 mm package. The ultra-low clamping makes this device capable of protecting any ESD-sensitive pins.

7.2 Functional Block Diagram



7.3 Feature Description

ESD351 provides ESD protection up to ±30-kV contact and ±30-kV air gap per IEC 61000-4-2 standard. During an ESD event, ESD diode connected to the I/O pin turns on and diverts the current to ground. Additionally, ESD351 also provides protection against IEC 61000-4-5 Surge currents up to 6 A (8/20µs waveform) and up to 80 A per IEC 61000-4-4 (5/50 ns waveform, 4 kV with 50-Ω impedance) electrical fast transient (EFT) standard. The capacitance between the I/O pin and ground is 1.8 pF (typical) and 2.2 pF (maximum). The device features a low leakage current of 0.1 nA (typical) and 50 nA (maximum, across operating temperature range) with a bias of 3.6 V. The ESD diode at the I/O pin protects the ESD-sensitive devices by clamping the voltage to a low value of 6.5 V (I_{PP} = 16 A 100 ns TLP). The layout of this device makes it simple and easy to add protection to an existing layout. The packages offers flow-through routing, requiring minimal modification to an existing layout.

7.4 Device Functional Modes

The ESD351 is a passive integrated circuit that triggers when voltages are above V_{BRF} or below V_{FWD}. During ESD events, voltages as high as ±30 kV (contact or air) can be directed to ground via the internal diode network. When the voltages on the protected line fall below the trigger levels of ESD351 (usually within 10s of nano-seconds) the device reverts to passive.

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8 Application and Implementation

注

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 ESD351 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

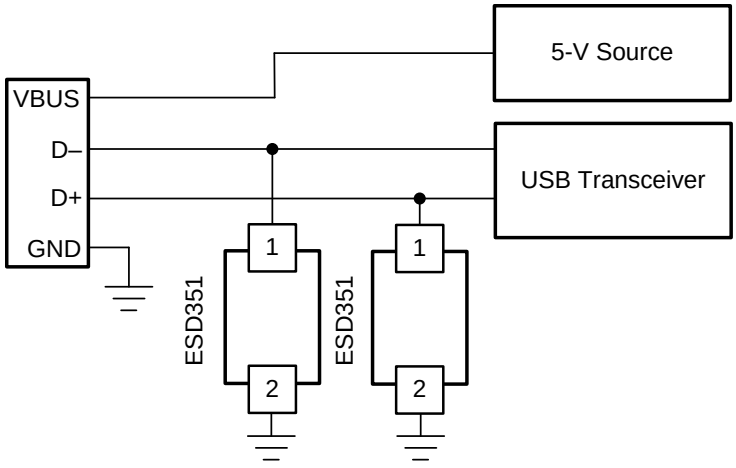


图 10. USB 2.0 ESD Schematic

8.2.1 Design Requirements

For this design example, two ESD351 devices are being used in a USB 2.0 application. This provides a complete ESD protection scheme.

Given the USB 2.0 application, the parameters listed in 表 1 are known.

表 1. Design Parameters

DESIGN PARAMETER	VALUE
Signal range on DP-DM lines	0 V to 3.6 V
Operating frequency on DP-DM lines	up to 240 MHz

8.2.2 Detailed Design Procedure

8.2.2.1 Signal Range

The ESD351 supports signal ranges between 0 V and 3.6 V, which supports the USB 2.0 signal pair on the USB 2.0 application.

8.2.2.2 Operating Frequency

The ESD351 has a 1.8 pF (typical) capacitance, which supports the USB 2.0 data rates of 480 Mbps.

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8.2.3 Application Curve

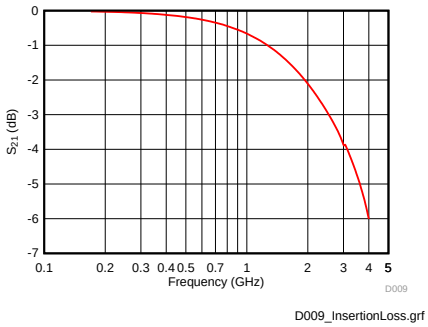


图 11. Insertion Loss

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9 Power Supply Recommendations

The ESD351 is a passive ESD device so there is no need to power it. Take care not to violate the recommended I/O specification (0 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 must 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

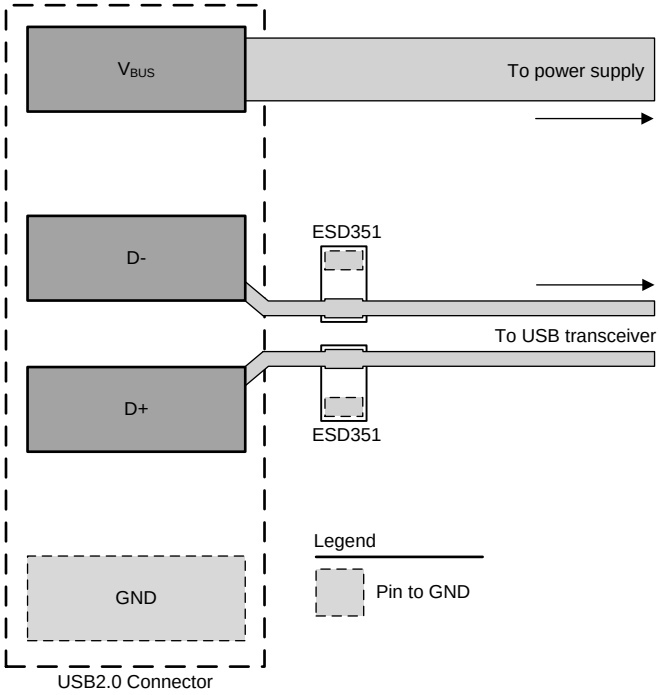


图 12. USB 2.0 ESD Layout

11 器件和文档支持

11.1 文档支持

11.1.1 相关文档

请参阅如下相关文档：

《通用 ESD 器件评估模块》，SLVUBG5

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.cn 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 社区资源

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ESD 的损坏小至导致微小的性能降级，大至整个器件故障。 精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

11.6 术语表

SLYZ022 — *TI 术语表*。

这份术语表列出并解释术语、缩写和定义。

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。

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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)
ESD351DPYR	Active	Production	X1SON (DPY) | 2	10000 | LARGE T&R	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	DE
ESD351DPYR.B	Active	Production	X1SON (DPY) | 2	10000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	DE
ESD351DPYRG4	Active	Production	X1SON (DPY) | 2	10000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	DE
ESD351DPYRG4.B	Active	Production	X1SON (DPY) | 2	10000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	DE

(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.

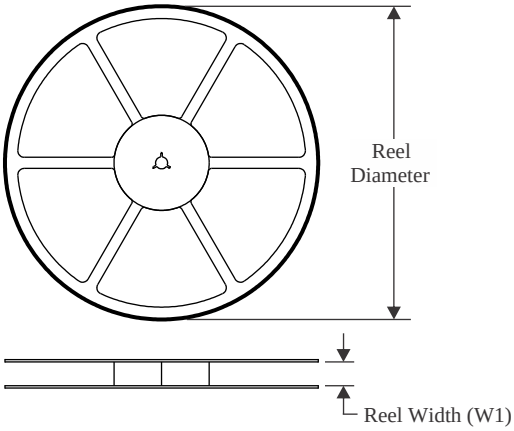
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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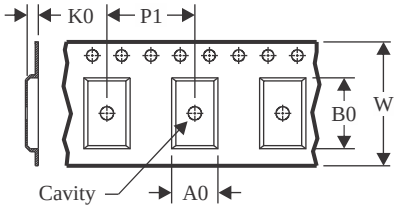
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

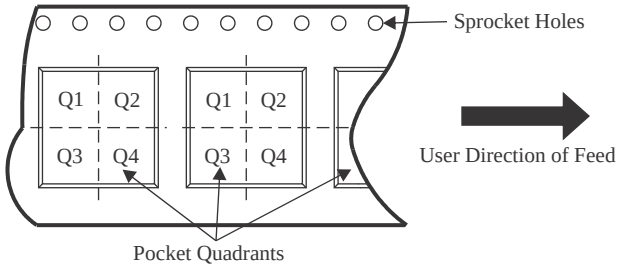


TAPE DIMENSIONS



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

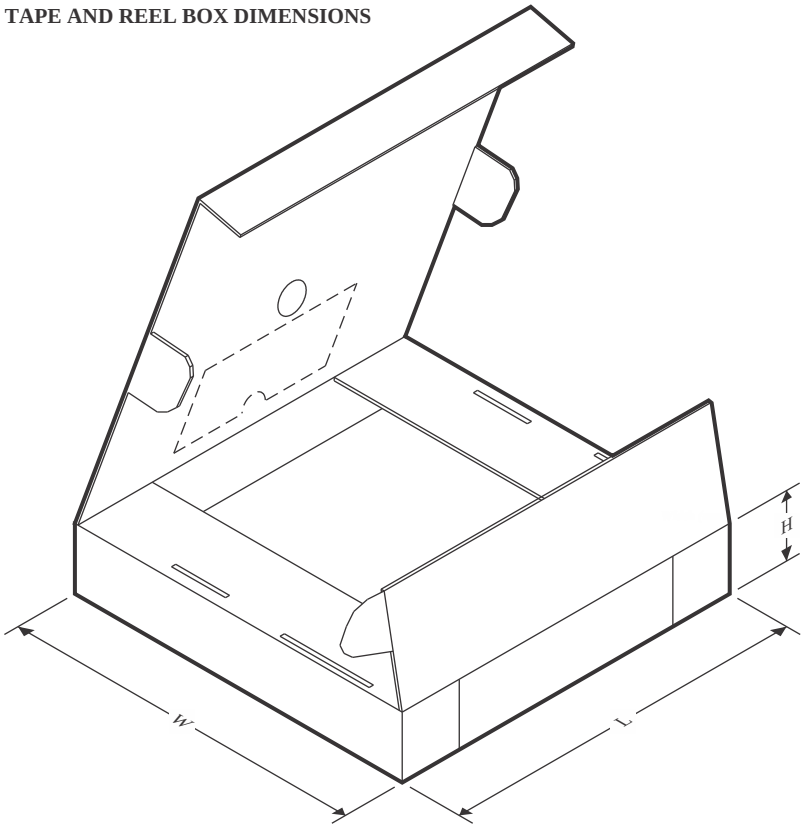
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
ESD351DPYR	X1SON	DPY	2	10000	178.0	8.4	0.67	1.15	0.46	2.0	8.0	Q2
ESD351DPYR	X1SON	DPY	2	10000	178.0	8.4	0.7	1.15	0.47	2.0	8.0	Q1
ESD351DPYR	X1SON	DPY	2	10000	180.0	8.4	0.7	1.1	0.47	2.0	8.0	Q1
ESD351DPYRG4	X1SON	DPY	2	10000	180.0	8.4	0.67	1.15	0.46	2.0	8.0	Q2

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
ESD351DPYR	X1SON	DPY	2	10000	208.0	191.0	35.0
ESD351DPYR	X1SON	DPY	2	10000	205.0	200.0	33.0
ESD351DPYR	X1SON	DPY	2	10000	203.2	196.8	33.3
ESD351DPYRG4	X1SON	DPY	2	10000	210.0	185.0	35.0

GENERIC PACKAGE VIEW

DPY 2

X1SON - 0.45 mm max height

1 x 0.6 mm

PLASTIC SMALL OUTLINE - NO LEAD

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



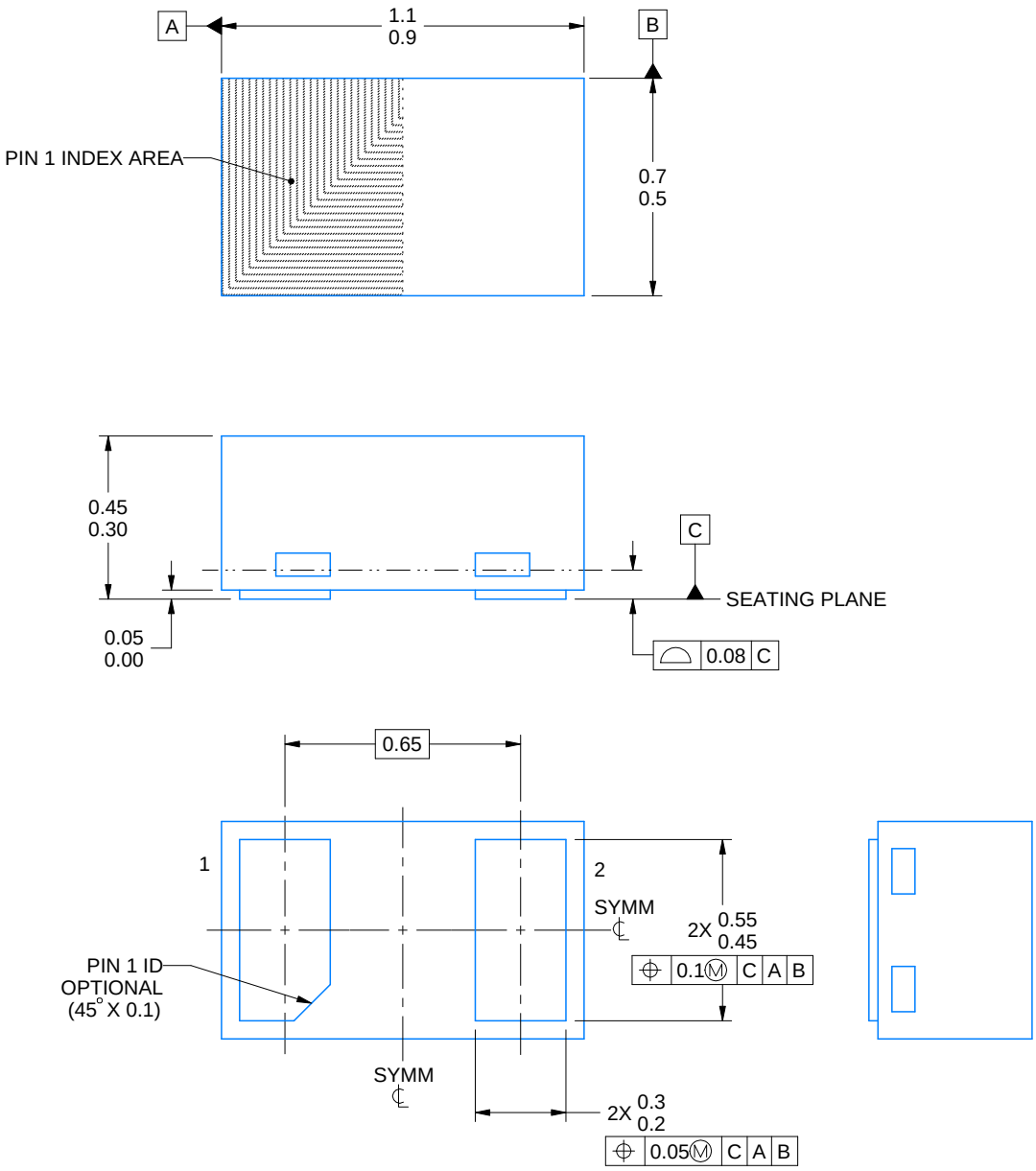
4231484/A

PACKAGE OUTLINE

DPY0002A

X1SON - 0.45 mm max height

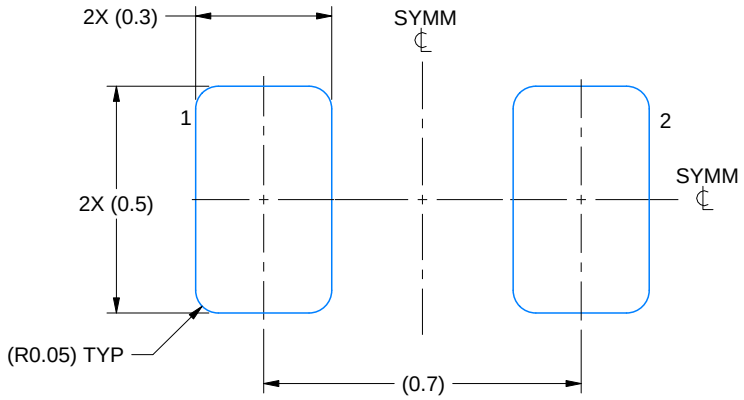
PLASTIC SMALL OUTLINE - NO LEAD



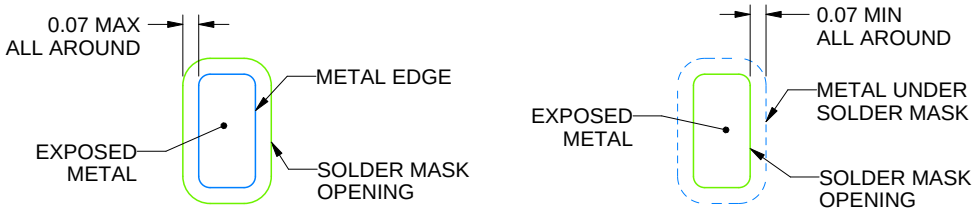
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NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:60X

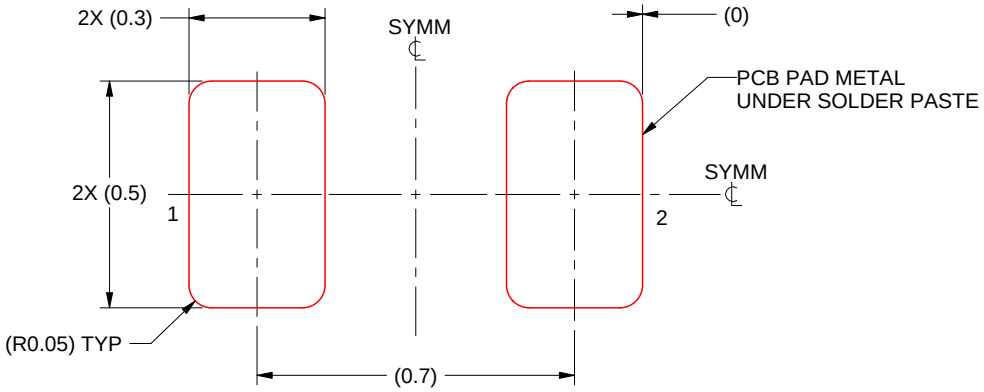


SOLDER MASK DETAILS

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NOTES: (continued)

3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
4. 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.



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:60X

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NOTES: (continued)

5. 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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