

## LOW-CAPACITANCE 2-CHANNEL $\pm 15$ -kV ESD-PROTECTION ARRAY FOR HIGH-SPEED DATA INTERFACES

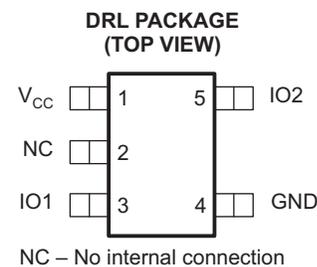
Check for Samples: [TPD2E001-Q1](#)

### FEATURES

- Qualified for Automotive Applications
- ESD Protection Exceeds
  - $\pm 15$ -kV Human-Body Model (HBM)
  - $\pm 8$ -kV IEC 61000-4-2 Contact Discharge
  - $\pm 15$ -kV IEC 61000-4-2 Air-Gap Discharge
- Low 1.5-pF Input Capacitance
- Low 1-nA (Max) Leakage Current
- 0.9-V to 5.5-V Supply-Voltage Range
- Two-Channel Device
- Space-Saving DRL Package
- Alternate 3-, 4-, 6-Channel Options Available:  
TPD3E001, TPD4E001, and TPD6E001

### APPLICATIONS

- USB 2.0
- Ethernet
- FireWire™
- Video
- Cell Phones
- SVGA Video Connections
- Glucose Meters



### DESCRIPTION/ORDERING INFORMATION

The TPD2E001 is a low-capacitance  $\pm 15$ -kV ESD-protection diode array designed to protect sensitive electronics attached to communication lines. Each channel consists of a pair of diodes that steer ESD current pulses to  $V_{CC}$  or GND. The TPD2E001 protects against ESD pulses up to  $\pm 15$ -kV Human-Body Model (HBM),  $\pm 8$ -kV Contact Discharge, and  $\pm 15$ -kV Air-Gap Discharge, as specified in IEC 61000-4-2. This device has a 1.5-pF capacitance per channel, making it ideal for use in high-speed data IO interfaces.

The TPD2E001 is a two-channel device intended for USB and USB 2.0 applications.

The TPD2E001 is available in the DRL package and is specified for  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  operation.

#### ORDERING INFORMATION<sup>(1)</sup>

$T_A$	PACKAGE <sup>(2)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
$-40^{\circ}\text{C}$ to $85^{\circ}\text{C}$	SOT-533 – DRL	Reel of 4000	TPD2E001DRLRQ1	OEQ

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).

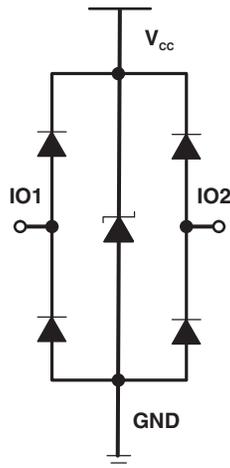
(2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

FireWire is a trademark of Apple Computer, Inc.

**LOGIC BLOCK DIAGRAM**



**PIN DESCRIPTION**

NO.	NAME	FUNCTION
3, 5	IOx	ESD-protected channel
4	GND	Ground
1	V <sub>CC</sub>	Power-supply input. Bypass V <sub>CC</sub> to GND with a 0.1-μF ceramic capacitor.
2	N.C.	No connection. Not internally connected.
	EP	Exposed pad. Connect to GND.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

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

		MIN	MAX	UNIT
$V_{CC}$		-0.3	7	V
$V_{IO}$		-0.3	$V_{CC} + 0.3$	V
$T_{stg}$	Storage temperature range	-65	150	°C
$T_J$	Junction temperature		150	°C
Bump temperature (soldering)	Infrared (15 s)		220	°C
	Vapor phase (60 s)		215	
Lead temperature (soldering, 10 s)			300	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute-maximum-rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

 $V_{CC} = 5\text{ V} \pm 10\%$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP <sup>(1)</sup>	MAX	UNIT
$V_{CC}$	Supply voltage	0.9		5.5	V
$I_{CC}$	Supply current		1	120	nA
$V_F$	Diode forward voltage	$I_F = 10\text{ mA}$		0.95	V
$V_{BR}$	Breakdown Voltage	$I_{BR} = 10\text{ mA}$		11	V
$V_C$	Channel clamp voltage <sup>(2)</sup>	$T_A = 25^\circ\text{C}$ , $\pm 15\text{-kV HBM}$ , $I_F = 10\text{ A}$	Positive transients	$V_{CC} + 25$	V
			Negative transients	-25	
		$T_A = 25^\circ\text{C}$ , $\pm 8\text{-kV Contact Discharge}$ (IEC 61000-4-2), $I_F = 24\text{ A}$	Positive transients	$V_{CC} + 60$	
			Negative transients	-60	
		$T_A = 25^\circ\text{C}$ , $\pm 15\text{-kV Air-Gap Discharge}$ (IEC 61000-4-2), $I_F = 45\text{ A}$	Positive transients	$V_{CC} + 100$	
			Negative transients	-100	
$I_{i/o}$	Channel leakage current <sup>(2)</sup>	$V_{i/o} = \text{GND to } V_{CC}$		$\pm 1$	nA
$C_{i/o}$	Channel input capacitance	$V_{CC} = 5\text{ V}$ , Bias of $V_{CC}/2$		1.5	pF

(1) Typical values are at  $V_{CC} = 5\text{ V}$  and  $T_A = 25^\circ\text{C}$

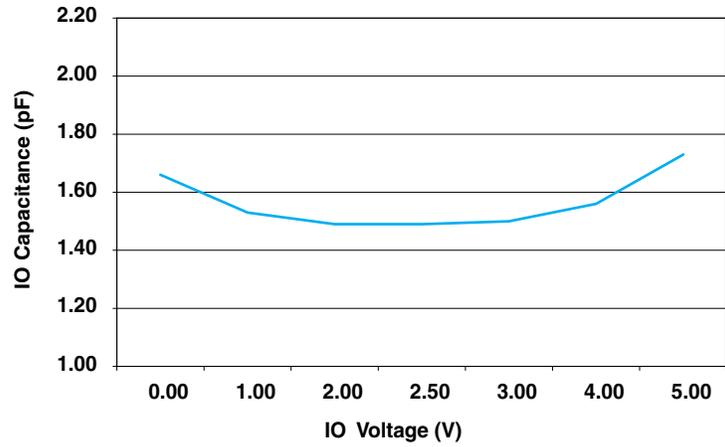
(2) Not production tested

## ESD PROTECTION

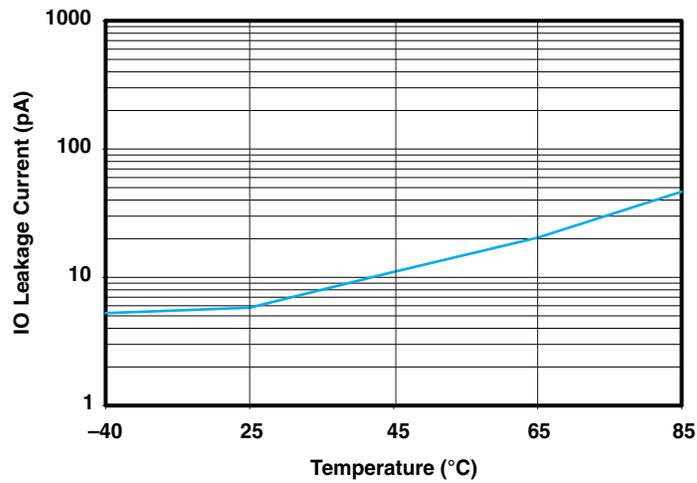
PARAMETER	TYP	UNIT
HBM	$\pm 15$	kV
IEC 61000-4-2 Contact Discharge	$\pm 8$	kV
IEC 61000-4-2 Air-Gap Discharge	$\pm 15$	kV

**TYPICAL OPERATING CHARACTERISTICS**

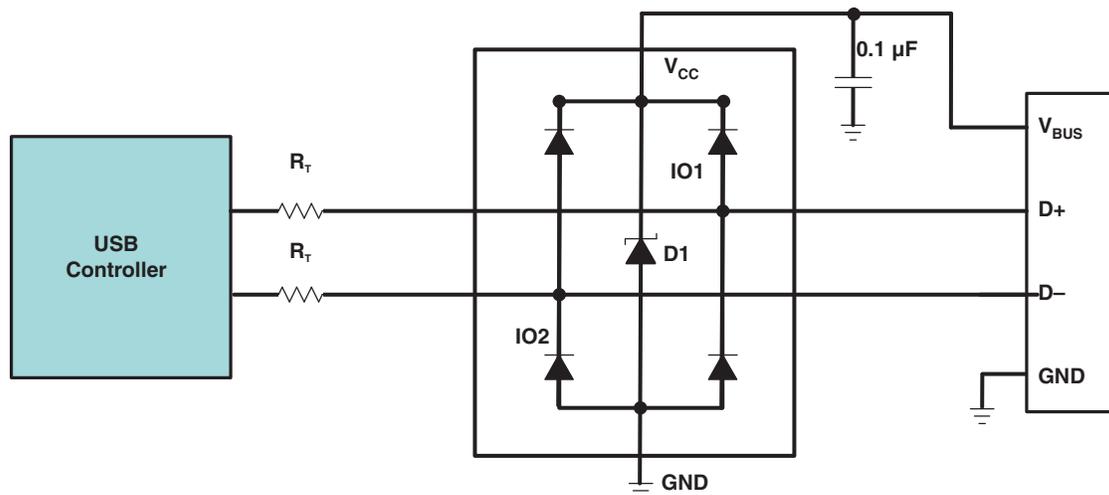
**IO CAPACITANCE  
VS  
IO VOLTAGE  
(V<sub>CC</sub> = 5.0 V)**



**IO LEAKAGE CURRENT  
VS  
TEMPERATURE  
(V<sub>CC</sub> = 5.5 V)**



## APPLICATION INFORMATION



### Detailed Description

When placed near the connector, the TPD2E001 ESD solution offers little or no signal distortion during normal operation due to low IO capacitance and ultra-low leakage current specifications. The TPD2E001 ensures that the core circuitry is protected and the system is functioning properly in the event of an ESD strike. For proper operation, the following layout/ design guidelines should be followed:

1. Place the TPD2E001 solution close to the connector. This allows the TPD2E001 to take away the energy associated with ESD strike before it reaches the internal circuitry of the system board.
2. Place a 0.1- $\mu\text{F}$  capacitor very close to the  $V_{CC}$  pin. This limits any momentary voltage surge at the IO pin during the ESD strike event.
3. Make sure that there is enough metallization for the  $V_{CC}$  and GND loop. During normal operation, the TPD2E001 consumes nA leakage current. But during the ESD event,  $V_{CC}$  and GND may see 15 A to 30 A of current, depending on the ESD level. Sufficient current path enables safe discharge of all the energy associated with the ESD strike.
4. Leave the unused IO pins floating.
5. The  $V_{CC}$  pin can be connected in two different ways:
  - (a) If the  $V_{CC}$  pin is connected to the system power supply, the TPD2E001 works as a transient suppressor for any signal swing above  $V_{CC} + V_F$ . A 0.1- $\mu\text{F}$  capacitor on the device  $V_{CC}$  pin is recommended for ESD bypass.
  - (b) If the  $V_{CC}$  pin is not connected to the system power supply, the TPD2E001 can tolerate higher signal swing in the range up to 10 V. Please note that a 0.1- $\mu\text{F}$  capacitor is still recommended at the  $V_{CC}$  pin for ESD bypass.

**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)
<a href="#">TPD2E001IDRLRQ1</a>	Active	Production	SOT-5X3 (DRL)   5	4000   LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	OEQ
TPD2E001IDRLRQ1.B	Active	Production	SOT-5X3 (DRL)   5	4000   LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	OEQ

(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.

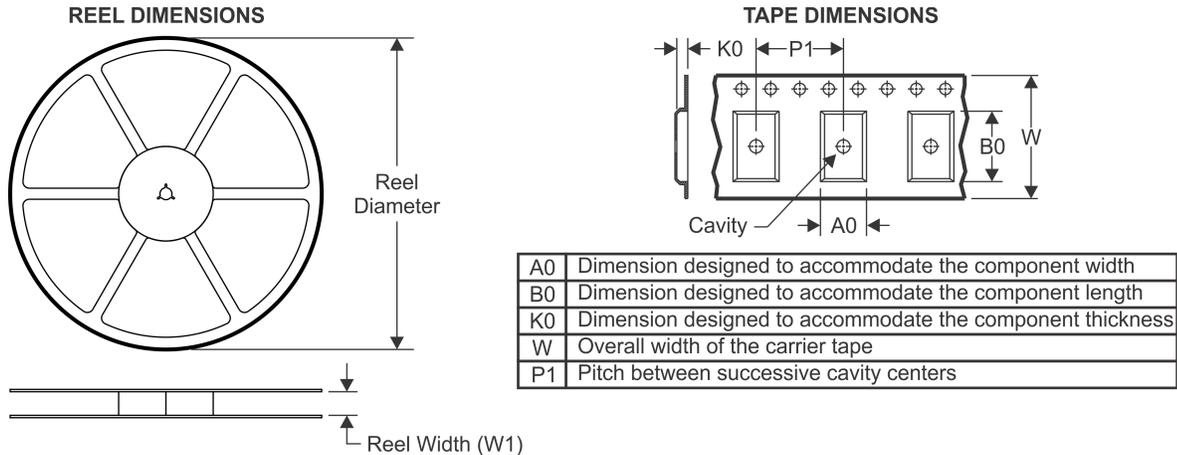
**OTHER QUALIFIED VERSIONS OF TPD2E001-Q1 :**

- Catalog : [TPD2E001](#)

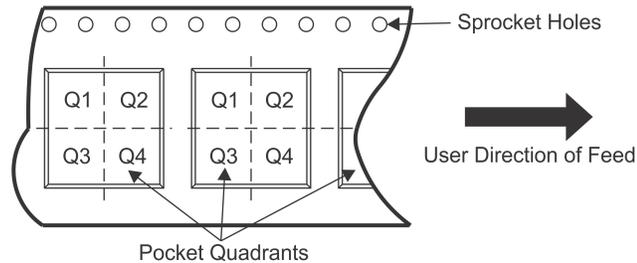
NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

## TAPE AND REEL INFORMATION



### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*All dimensions are nominal

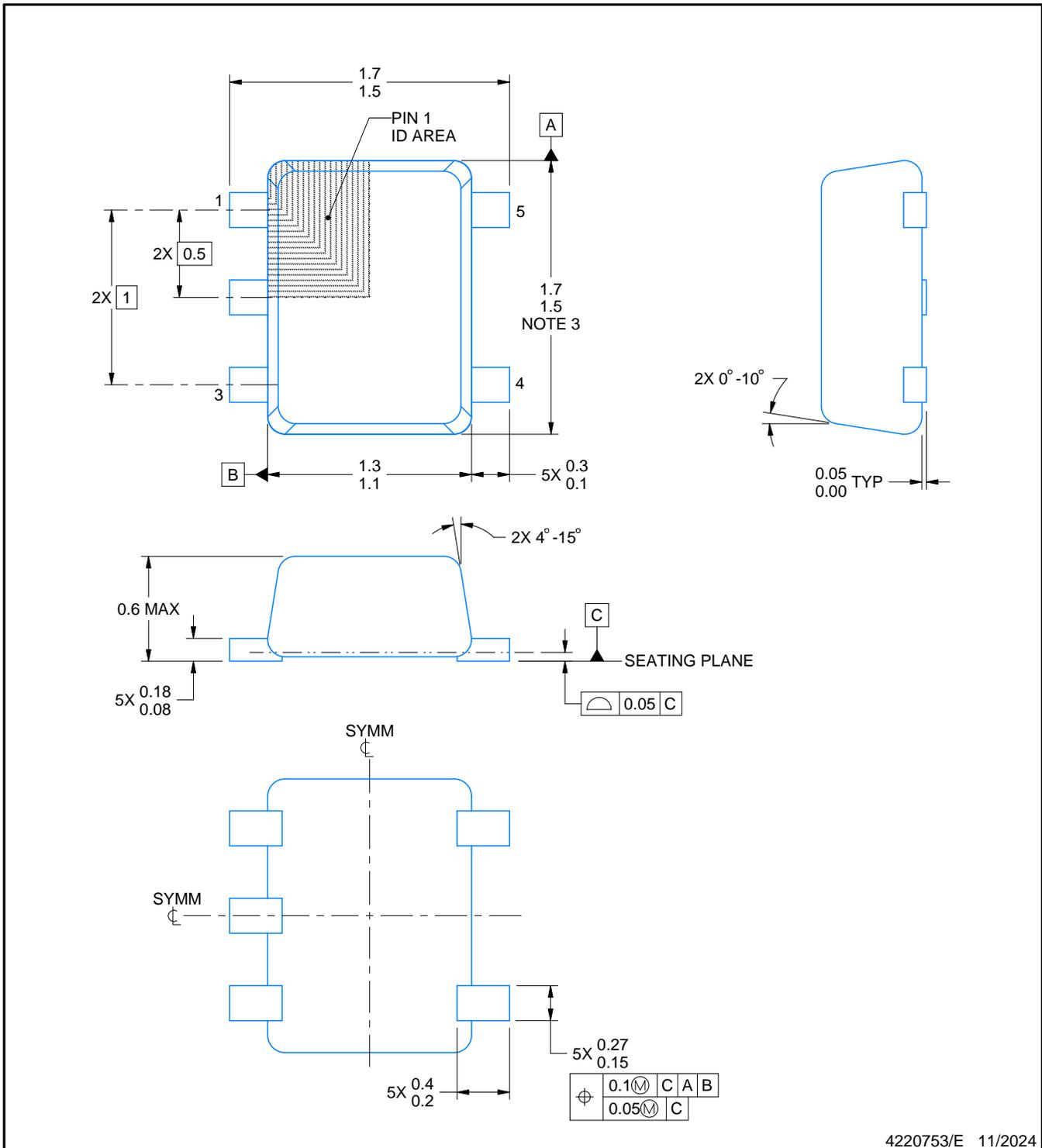
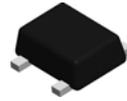
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPD2E001IDRLRQ1	SOT-5X3	DRL	5	4000	180.0	8.4	1.78	1.78	0.69	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPD2E001IDRLRQ1	SOT-5X3	DRL	5	4000	183.0	183.0	20.0



4220753/E 11/2024

NOTES:

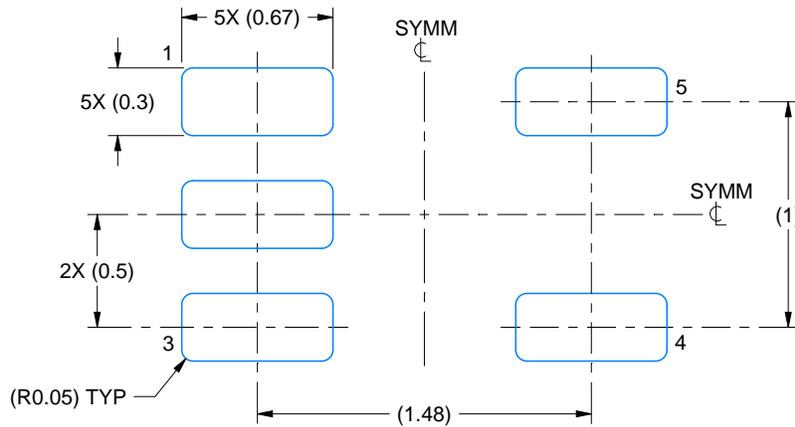
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or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

# EXAMPLE BOARD LAYOUT

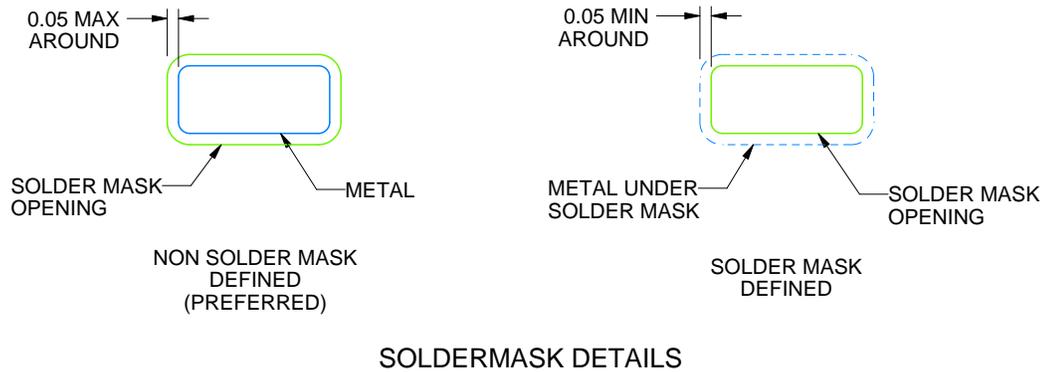
DRL0005A

SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE  
SCALE:30X



SOLDERMASK DETAILS

4220753/E 11/2024

NOTES: (continued)

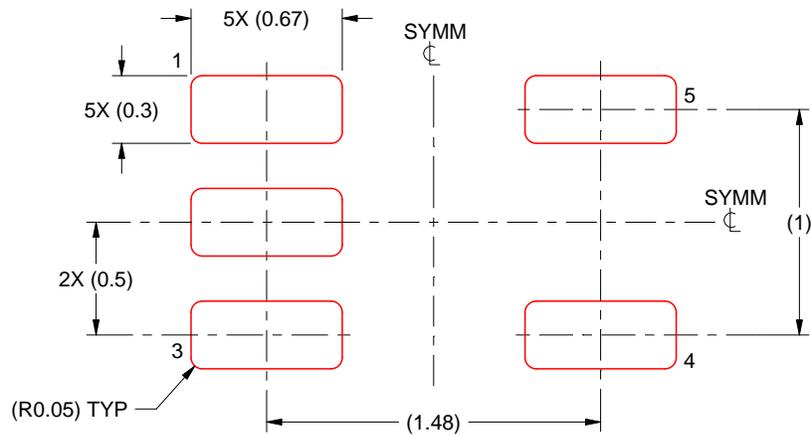
- 5. Publication IPC-7351 may have alternate designs.
- 6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# 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.

## IMPORTANT NOTICE AND DISCLAIMER

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

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

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

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

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

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

Copyright © 2025, Texas Instruments Incorporated