

ESD601-Q1 Low Capacitance ESD Diode for RF and ADAS Signal Protection

1 Features

- IEC 61000-4-2 ESD Protection:
 - $\pm 15\text{kV}$ contact discharge
 - $\pm 15\text{kV}$ air gap discharge
- ISO 10605 (330pF, 330 Ω) ESD Protection:
 - $\pm 12\text{kV}$ contact discharge
 - $\pm 12\text{kV}$ air-gap discharge
- IEC 61000-4-5 surge protection:
 - 2.7A (8/20 μs)
- I/O capacitance: 0.3pF (typical)
- Ultra low leakage current: 1nA (typical)
- Low dynamic resistance 0.9 Ω (typical)
- Industry standard 0402 package

2 Applications

- Automotive Antenna ESD Protection
- RF Signal ESD Protection
- Near Field Communications (NFC)
- Automotive SerDes w/Power over Coax
- USB Type-C (short-to-Vbus tolerant)

3 Description

The ESD601-Q1 is a bidirectional ESD protection diode. The ESD601-Q1 is offered in the industry standard 0402 (DPY) package, and offers an IEC 61000-4-2 protection level of 15kV. The device can clamp 8/20 μs surges with peak pulse currents up to 2.7A in accordance with the IEC 61000-4-5 standard.

The low capacitance and low leakage current help to ensure protection against transient events in a variety of systems and applications. This protection is key for many applications, such as smaller form factors and faster data speeds, which are becoming more popular over time.

Device Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾
ESD601-Q1	DPY (X1SON, 2)	1mm × 0.6mm

(1) For more information, see [Section 9](#).

(2) The package size (length × width) is a nominal value and includes pins, where applicable.

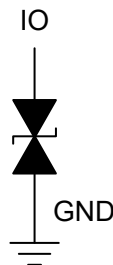


Figure 3-1. Functional Block Diagram



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4 Pin Configuration and Functions

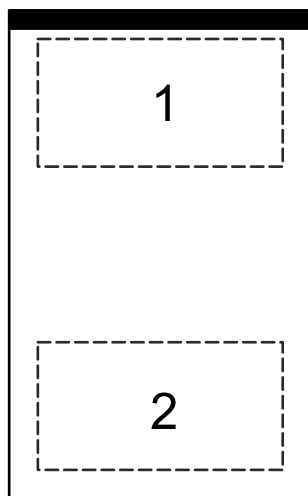


Figure 4-1. DPY Package, 2-Pin X1SON (Top View)

Table 4-1. Pin Functions

PIN		TYPE ⁽¹⁾	DESCRIPTION
NAME	NO.		
IO	1	I/O	ESD Protected Channel. If used as ESD I/O, connect pin 2 to ground
IO	2	I/O	ESD Protected Channel. If used as ESD I/O, connect pin 1 to ground

(1) I = input, O = output

5 Specifications

5.1 Absolute Maximum Ratings

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

Parameter		MIN	MAX	UNIT
P _{PPM}	IEC 61000-4-5 Surge (t _p = 8/20 μs) Peak Pulse Power at 25 °C		75	W
I _{PPM}	IEC 61000-4-5 Surge (t _p = 8/20 μs) Peak Pulse Current at 25 °C		2.7	A
T _A	Operating free-air temperature	–55	150	°C
T _{stg}	Storage temperature	–65	155	°C

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. Absolute maximum ratings do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If briefly operating outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not sustain damage, but it may not be fully functional. Operating the device in this manner may affect device reliability, functionality, performance, and shorten the device lifetime.

5.2 ESD Ratings - AEC Specifications

Parameter		Test Conditions	VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human body model (HBM), per AEC Q101-001 ⁽¹⁾	±2500	V
		Charged device model (CDM), per AEC Q101-005 ⁽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.

5.3 ESD Ratings - IEC Specifications

Parameter		Test Conditions	VALUE	UNIT
V _(ESD)	Electrostatic discharge	IEC 61000-4-2 Contact Discharge, all pins	±15000	V
		IEC 61000-4-2 Air Discharge, all pins	±15000	

5.4 ESD Ratings - ISO Specifications

Parameter		Test Conditions		VALUE	UNIT
V _(ESD)	ISO 10605 Electrostatic Discharge	C = 150 pF; R = 330 Ω	Contact Discharge, all pins	±15000	V
V _(ESD)	ISO 10605 Electrostatic Discharge	C = 150 pF; R = 330 Ω	Air-gap Discharge, all pins	±15000	V
V _(ESD)	ISO 10605 Electrostatic Discharge	C = 330 pF; R = 330 Ω	Contact Discharge, all pins	±12000	V
V _(ESD)	ISO 10605 Electrostatic Discharge	C = 330 pF; R = 330 Ω	Air-gap Discharge, all pins	±12000	V

5.5 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V _{IN}	Input voltage	–18		18	V
T _A	Operating Free Air Temperature	–55		150	°C

5.6 Thermal Information

THERMAL METRIC ⁽¹⁾		ESD601-Q1	UNIT
		DPY (X1SON)	
		2 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	284.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	150.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	100.6	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	10.1	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	99.8	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	NA	°C/W

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

5.7 Electrical Characteristics

At TA = 25°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{RWM}	Reverse stand-off voltage	$I_{IO} < 10 \text{ nA}$	-18		18	V
I_{LEAK}	Leakage current at V_{RWM}	$V_{IO} = \pm 18 \text{ V}$, I/O to GND		1	10	nA
V_{BR}	Breakdown voltage, I/O to GND ⁽¹⁾	$I_{IO} = \pm 10 \text{ mA}$	19	21		V
V_{CLAMP}	Surge clamping voltage, $t_p = 8/20 \text{ }\mu\text{s}$ ⁽²⁾	$I_{PP} = 2.7 \text{ A}$, I/O to GND		33		V
		$I_{PP} = 2.7 \text{ A}$, GND to I/O		33		V
	TLP clamping voltage, $t_p = 100 \text{ ns}$ ⁽³⁾	$I_{PP} = \pm 8 \text{ A}$ (100 ns TLP), I/O to GND		29		V
		$I_{PP} = \pm 16 \text{ A}$ (100 ns TLP), I/O to GND		36		V
R_{DYN}	Dynamic resistance ⁽⁴⁾	I/O to GND		0.9		Ω
		GND to I/O		0.9		
C_{LINE}	Line capacitance, IO to GND	$V_{IO} = 0 \text{ V}$, $f = 1 \text{ MHz}$		0.3	0.5	pF

(1) V_{BR} is defined as the voltage obtained at 10 mA when sweeping the voltage up, before the device latches into the snapback state

(2) Device stressed with 8/20 μs exponential decay waveform according to IEC 61000-4-5

(3) Non-repetitive square wave current pulse, Transmission Line Pulse (TLP); ANSI / ESD STM5.5.1-2008

(4) Extraction of R_{DYN} using least squares fit of TLP characteristics between $I = 10 \text{ A}$ and $I = 20 \text{ A}$

5.8 Typical Characteristics

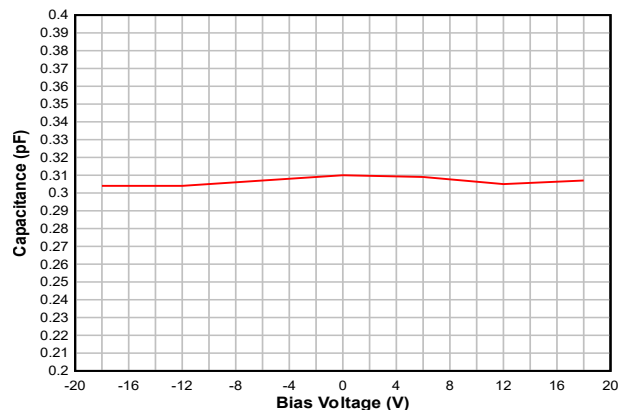


Figure 5-1. Bias Voltage vs. Capacitance

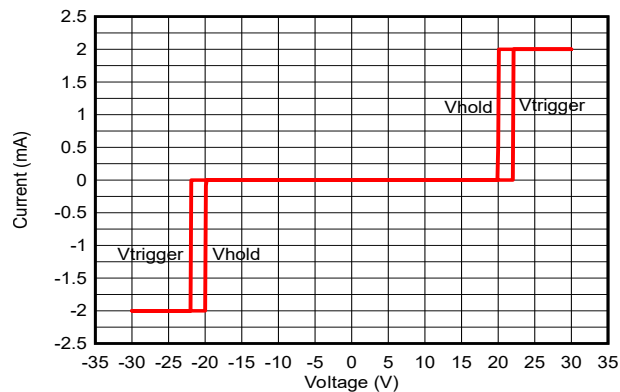


Figure 5-2. DC I-V Curve

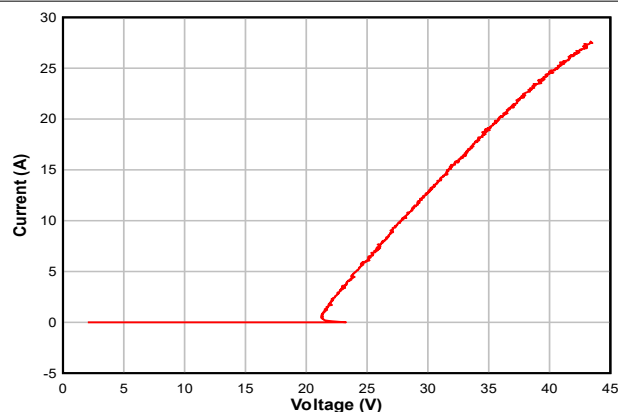


Figure 5-3. Positive TLP Curve

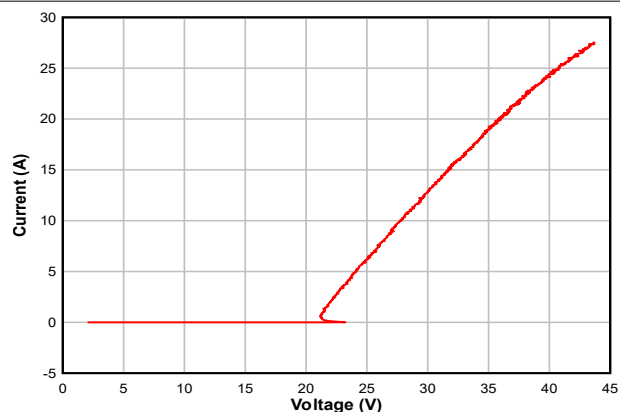


Figure 5-4. Negative TLP Curve

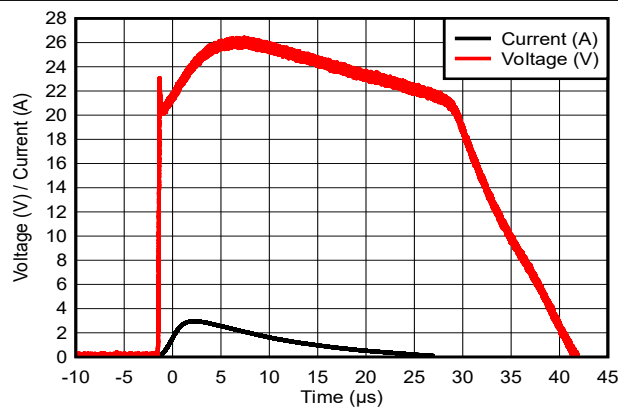


Figure 5-5. 8/20 μ s Surge Response

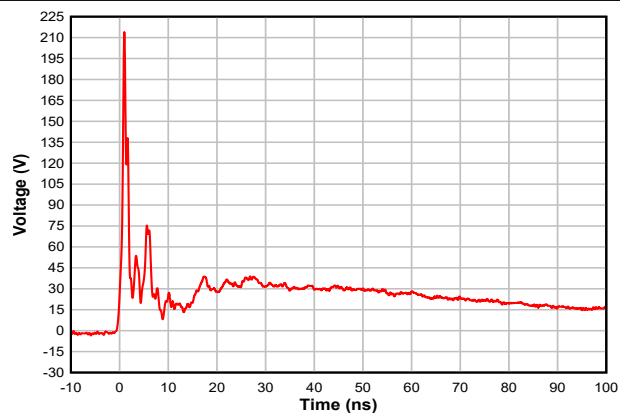


Figure 5-6. +8kV Clamped IEC Waveform

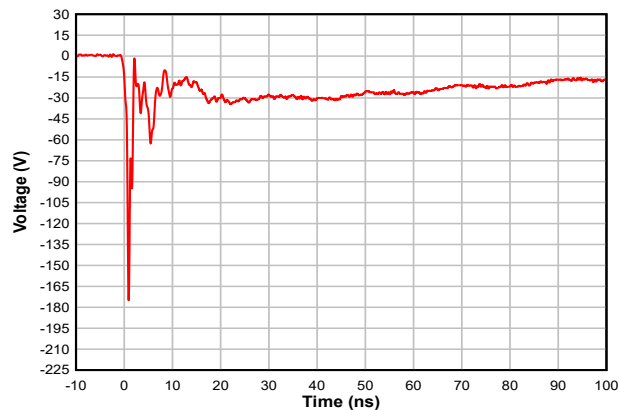


Figure 5-7. -8kV Clamped IEC Waveform

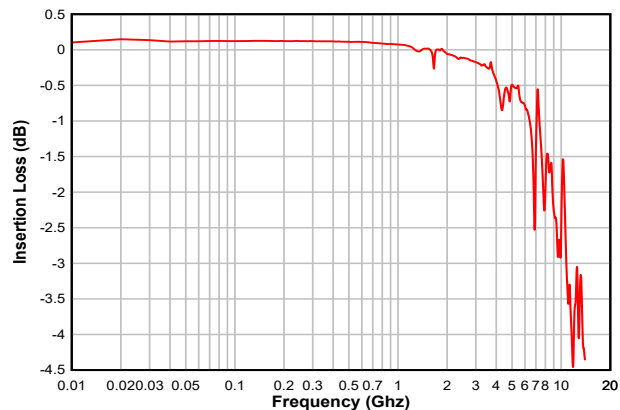


Figure 5-8. Insertion Loss

6 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, as well as validating and testing their design implementation to confirm system functionality.

6.1 Application Information

The ESD601-Q1 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.

7 Device and Documentation Support

7.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

7.2 Support Resources

[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.

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7.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

7.4 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.

7.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

8 Revision History

DATE	REVISION	NOTES
August 2024	*	Initial Release

9 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 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)
ESD601DPYRQ1	Active	Production	X1SON (DPY) 2	10000 LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-55 to 150	P7
ESD601DPYRQ1.B	Active	Production	X1SON (DPY) 2	10000 LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-55 to 150	P7

⁽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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OTHER QUALIFIED VERSIONS OF ESD601-Q1 :

- Catalog : [ESD601](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

GENERIC PACKAGE VIEW

DPY 2

X1SON - 0.45 mm max height

1 x 0.6 mm

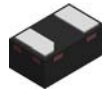
PLASTIC SMALL OUTLINE - NO LEAD

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



4231484/A

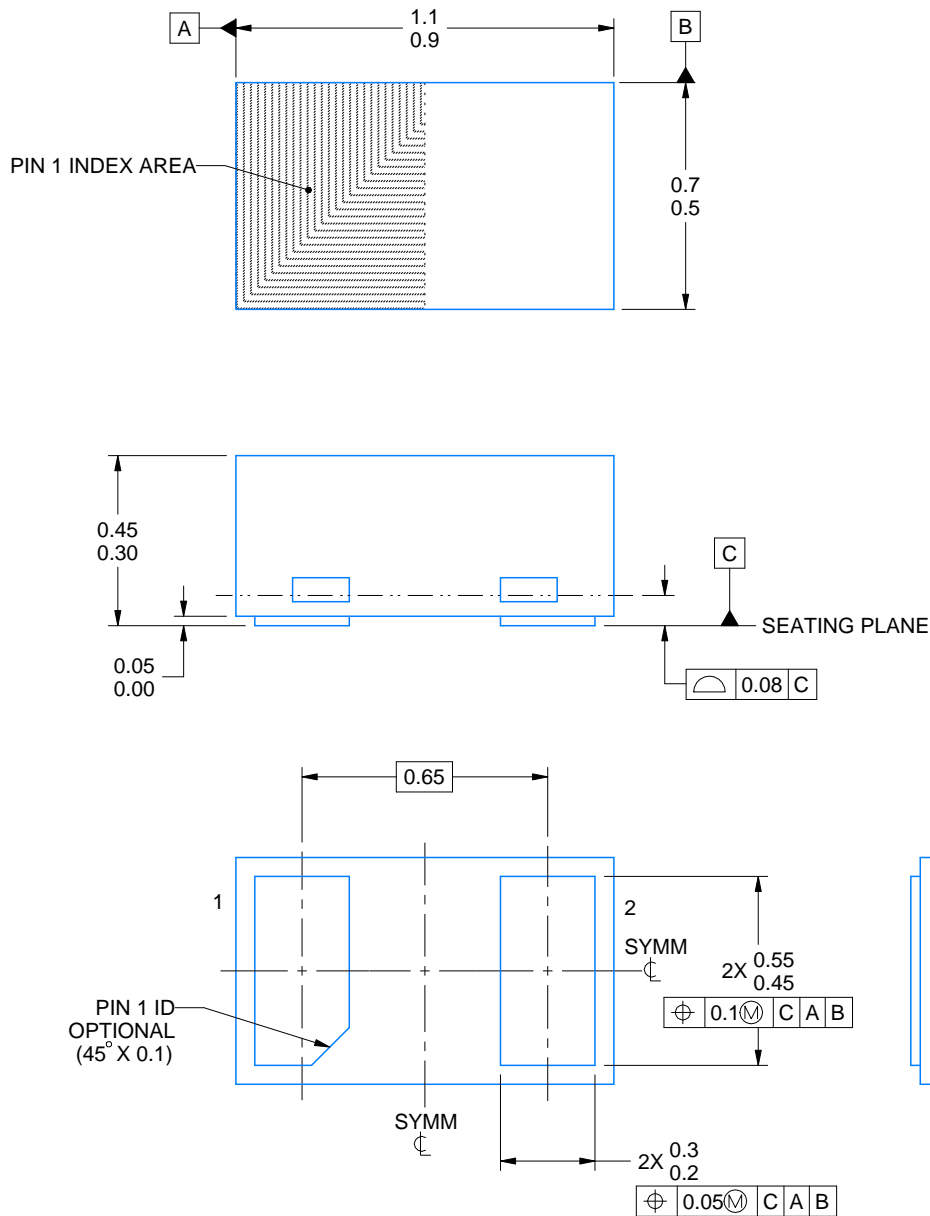
DPY0002A



PACKAGE OUTLINE

X1SON - 0.45 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



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NOTES:

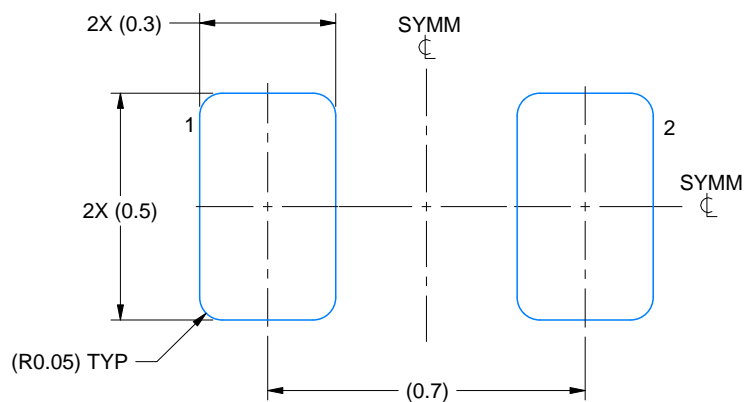
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

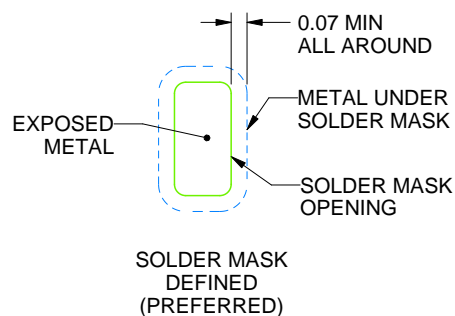
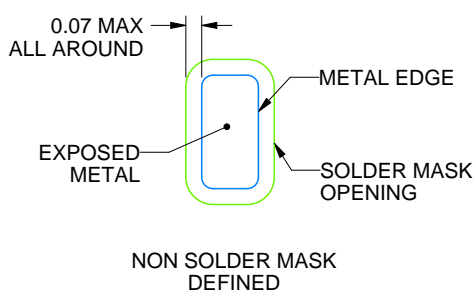
DPY0002A

X1SON - 0.45 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:60X



SOLDER MASK DETAILS

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NOTES: (continued)

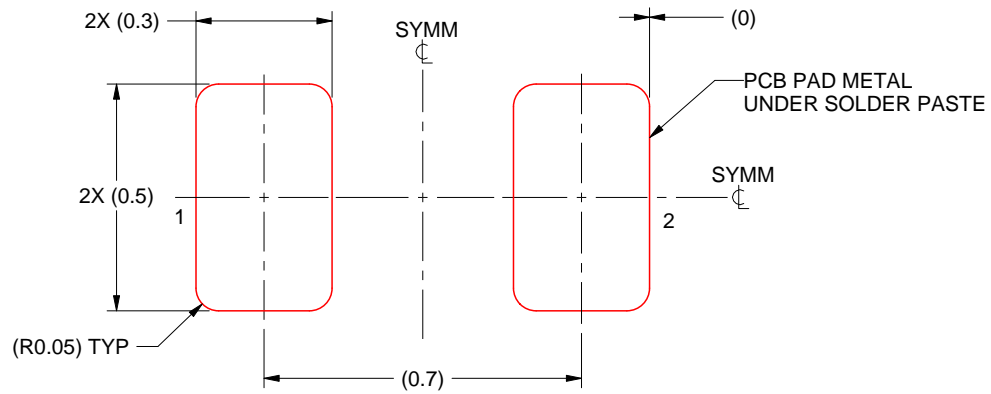
3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slue271).
4. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

DPY0002A

X1SON - 0.45 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



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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