TVS1400 14V 平缓钳位浪涌保护器件

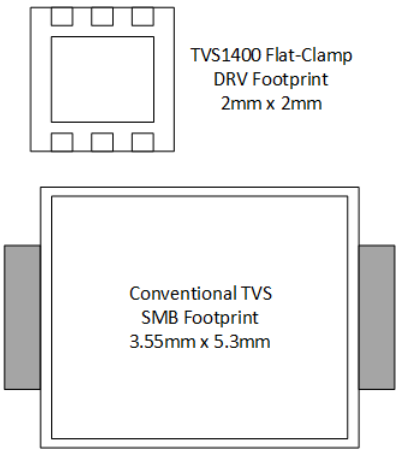
1 特性

- 保护特性符合针对工业信号线路的 ±2kV、42Ω IEC 61000-4-5 浪涌测试要求
- 43A、8/20μs 浪涌电流下的最大钳位电压为 19.3V
- 关态电压：14V
- 4mm^2 小型封装尺寸
- 在 125°C 时，可耐受超过 5,000 次的 35A 8/20μs 浪涌电流的重复冲击
- 强大的浪涌保护：
  - IEC 61000-4-5 (8/20μs)：43A
  - IEC 61643-321 (10/1000μs)：8A
- 低泄漏电流
  - 27°C 下为 2.2nA（典型值）
  - 85°C 下为 16nA（典型值）
- 低电容：120pF
- 集成 4 级 IEC 61000-4-2 ESD 保护

2 应用

- 工业传感器 I/O
- 固态硬盘
- PLC I/O 模块
- 网保护和控制
- 12V 电源线路
- 电器
- 医疗设备

封装比较



3 说明

TVS1400 可将高达 43A 的 IEC 61000-4-5 故障电流进行可靠分流，以保护系统免受高功率瞬态冲击或雷击。该器件为满足常见的工业信号线路 EMC 要求提供了解决方案，可通过 42Ω 阻抗进行耦合的方式承受高达 ±2kV 的 IEC 61000-4-5 开路电压。TVS1400 使用独特的反馈机制确保在故障期间发挥精确的平缓钳位能力，保证系统接触电压低于 20V。精确的电压调节允许设计人员放心地选择具有较低电压容差的系统组件，不但减少了系统成本和复杂度，而且不损害可靠性。

此外，TVS1400 还采用 2mm × 2mm 小型 SON 封装，非常适用于空间受限 应用，与业内标准的 SMA 和 SMB 封装相比，尺寸减小了 70%。极低的器件泄露电流和电容确保最大限度地降低了对受保护线路的影响。为了确保在产品的整个寿命期间提供可靠保护，TI 在高温环境下对 TVS1400 进行了 5,000 次重复浪涌冲击测试，但器件性能未发生任何变化。

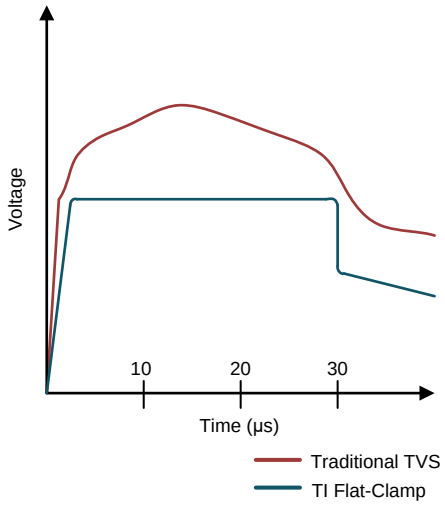
TVS1400 是 TI 的平缓钳位系列浪涌器件中的一款产品。有关该系列其他器件的更多信息，请参阅*器件比较表*。

器件信息(1)

器件型号	封装	封装尺寸（标称值）
TVS1400	SON (6)	2.00mm × 2.00mm

(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。

对 8/20μs 浪涌事件的电压钳位响应



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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4 修订历史记录

Changes from Original (December 2017) to Revision A **Page**

- 已更改 将产品状态从“预告信息”更改成了“生产数据” ... 1

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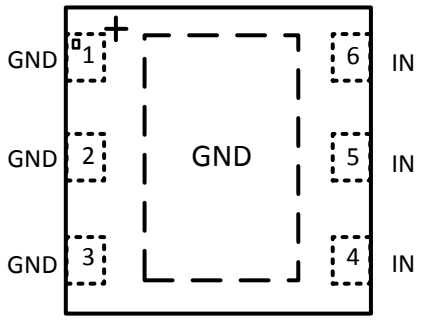
5 Device Comparison Table

Device	V_{rwm}	V_{clamp} at I_{pp}	I_{pp} (8/20 µs)	V_{rwm} leakage (nA)	Package Options	Polarity
TVS0500	5	9.2	43	0.07	SON	Unidirectional
TVS1400	14	18.4	43	2	SON	Unidirectional
TVS1800	18	22.8	40	0.5	SON	Unidirectional
TVS2200	22	27.7	40	3.2	SON	Unidirectional
TVS2700	27	32.5	40	1.7	SON	Unidirectional
TVS3300	33	38	35	19	WCSP, SON	Unidirectional

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6 Pin Configuration and Functions

DRV Package
6-Pin SON
Top View



Pin Functions

PIN		TYPE	DESCRIPTION
NAME	No.		
IN	4, 5, 6	I	ESD and surge protected channel
GND	1, 2, 3, exposed thermal pad	GND	Ground

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7 Specifications

7.1 Absolute Maximum Ratings

T_A =27°C (unless otherwise noted)(1)

		MIN	MAX	UNIT
Maximum Surge	IEC 61000-4-5 Current (8/20 µs)		43	A
	IEC 61000-4-5 Power (8/20 µs)		820	W
	IEC 61643-321 Current (10/1000 µs)		8	A
	IEC 61643-321 Power (10/1000 µs)		140	W
Maximum Forward Surge	IEC 61000-4-5 Current (8/20 µs)		50	A
	IEC 61000-4-5 Power (8/20 µs)		80	W
	IEC 61643-321 Current (10/1000 µs)		23	A
	IEC 61643-321 Power (10/1000 µs)		60	W
EFT	IEC 61000-4-4 EFT Protection		80	A
I_{BR}	DC Breakdown current		23	mA
I_F	DC Forward Current		500	mA
T_A	Ambient Operating Temperature	-40	125	°C
T_{stg}	Storage Temperature	-65	125	°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.

7.2 ESD Ratings - JEDEC

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins(1)	±2000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins(2)	±500	

(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.

7.3 ESD Ratings - IEC

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	IEC 61000-4-2 contact discharge	±21	kV
		IEC 61000-4-2 air-gap discharge	±30	

7.4 Recommended Operating Conditions

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

PARAMETER		MIN	NOM	MAX	UNIT
V_{RWM}	Reverse Stand-off Voltage		14		V

7.5 Thermal Information

THERMAL METRIC(1)		TVS1400 DRV (SON) 6 PINS	UNIT
R_{qJA}	Junction-to-ambient thermal resistance	70.4	°C/W
$R_{qJC(top)}$	Junction-to-case (top) thermal resistance	73.7	°C/W
R_{qJB}	Junction-to-board thermal resistance	40	°C/W
Y_{JT}	Junction-to-top characterization parameter	2.2	°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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Thermal Information (continued)

THERMAL METRIC(1)		TVS1400 DRV (SON) 6 PINS	UNIT
Y_{JB}	Junction-to-board characterization parameter	40.3	°C/W
$R_{qJC(bot)}$	Junction-to-case (bottom) thermal resistance	11	°C/W

7.6 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{RWM}	Reverse Stand-off Voltage		-0.5		14	V
I_{LEAK}	Leakage Current	Measured at $V_{IN} = V_{RWM}$, T_A = 27°C		2.2	16	nA
		Measured at $V_{IN} = V_{RWM}$, T_A = 85°C		16	300	nA
		Measured at $V_{IN} = V_{RWM,}$ T_A = 105°C		60	1000	nA
V_F	Forward Voltage	I_{IN} = 1 mA from GND to IO	0.25	0.5	0.65	V
V_{BR}	Break-down Voltage	I_{IN} = 1 mA from IO to GND	16.2	16.9	17.8	V
V_{FCLAMP}	Forward Clamp Voltage	43 A IEC 61000-4-5 Surge (8/20 µs) from GND to IO, 27°C		2	5	V
V_{CLAMP}	Clamp Voltage	24 A IEC 61000-4-5 Surge (8/20 µs) from IO to GND, V_{IN} = 0 V before surge, 27°C		17.9	18.5	V
		43 A IEC 61000-4-5 Surge (8/20 µs) from IO to GND, V_{IN} = 0 V before surge, 27°C		18.4	18.8	V
		35 A IEC 61000-4-5 Surge (8/20 µs) from IO to GND, $V_{IN} = V_{rwm}$ before surge, T_A = 125°C		18.5	19.3	V
R_{DYN}	8/20 µs surge dynamic resistance	Calculated from V_{CLAMP} at .5*I_{pp} and I_{pp} surge current levels, 27°C		30		mΩ
C_{IN}	Input pin capacitance	$V_{IN} = V_{RWM}$, f = 1 MHz, 30 mV_{pp}, IO to GND		120		pF
SR	Maximum Slew Rate	0-V_{RWM} rising edge, sweep rise time and measure slew rate when I_{PK} = 1 mA, 27°C		2.5		V/µs
		0-V_{RWM} rising edge, sweep rise time and measure slew rate when I_{PK} = 1 mA, 105°C		0.7		V/µs

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7.7 Typical Characteristics

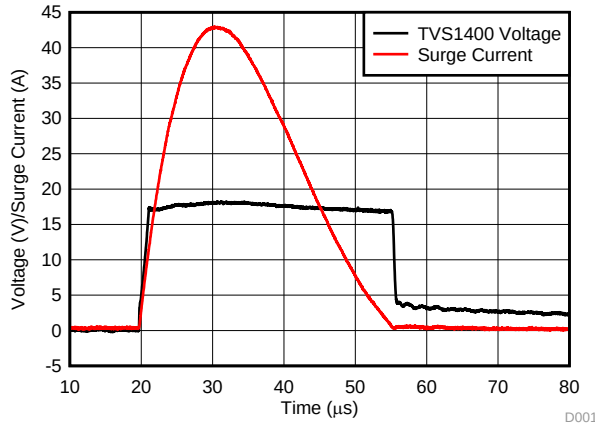


图 1. Surge Response at 43 A

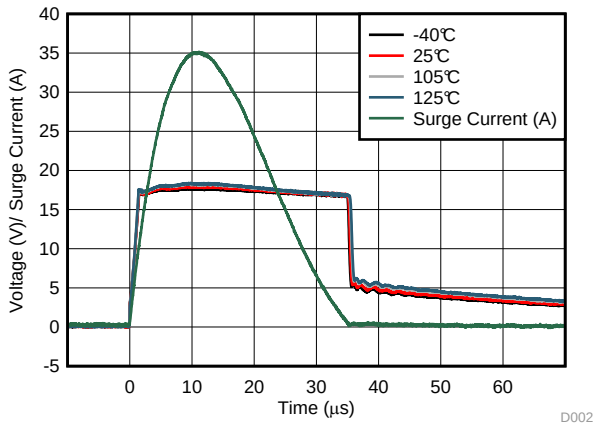
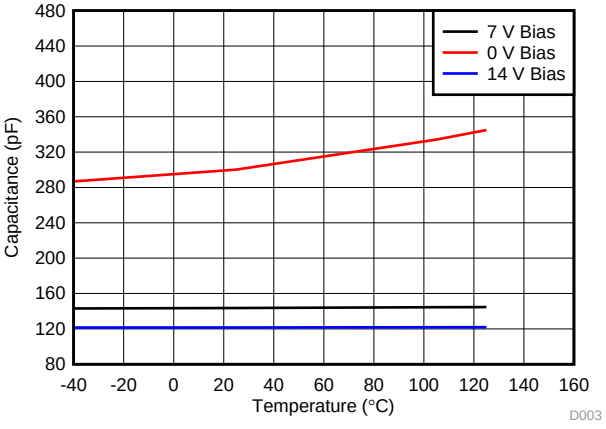


图 2. Surge Response at 35 A Across Temperature



f = 1 MHz, 30 mVpp, IO to GND

图 3. Capacitance vs Temperature Across Bias

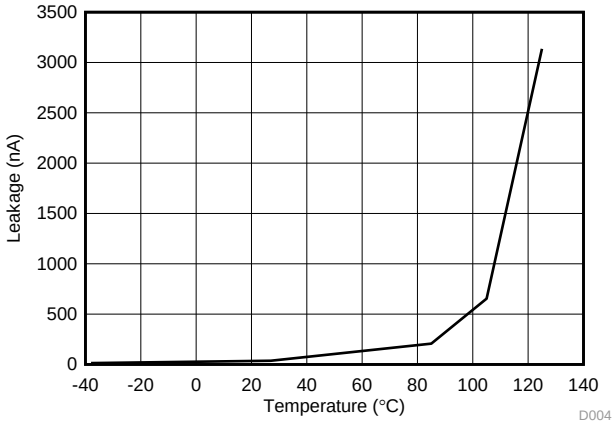


图 4. Leakage Current vs Temperature at 14 V

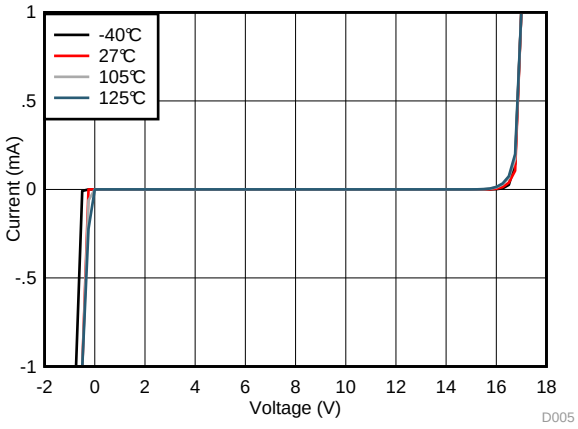


图 5. IV Across Temperature

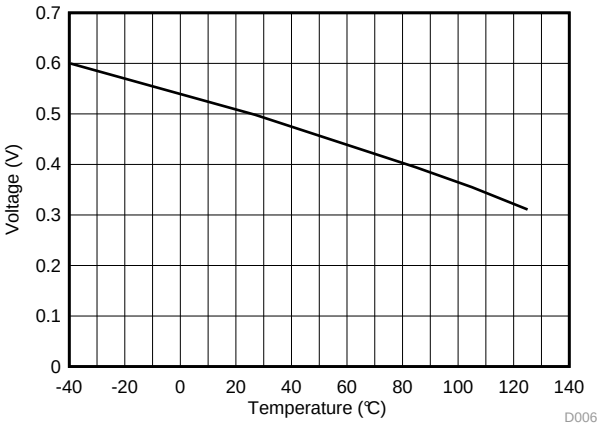


图 6. Forward Voltage vs Temperature Across Current

Typical Characteristics (接下页)

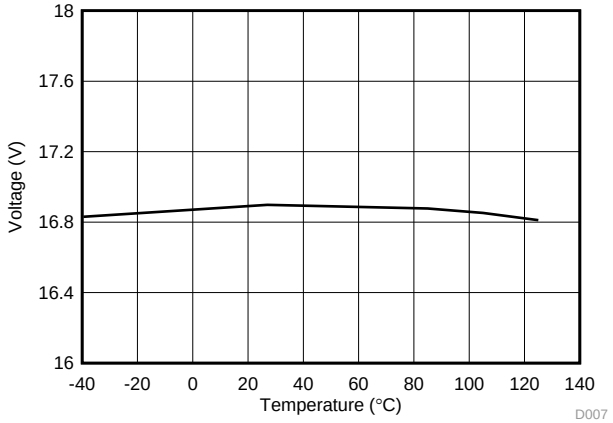


图 7. Breakdown Voltage at 1 mA vs Temperature

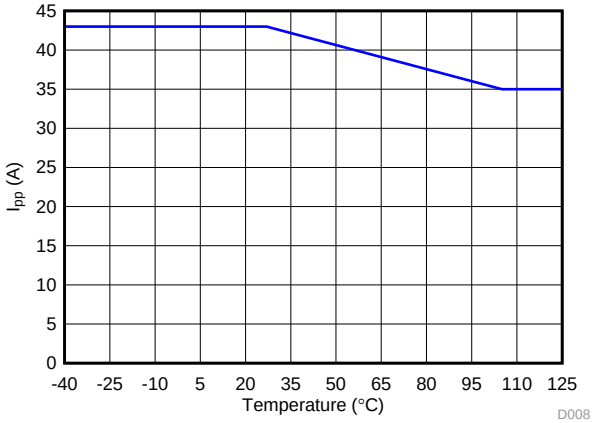


图 8. Max Surge Current (8/20 µs) vs Temperature

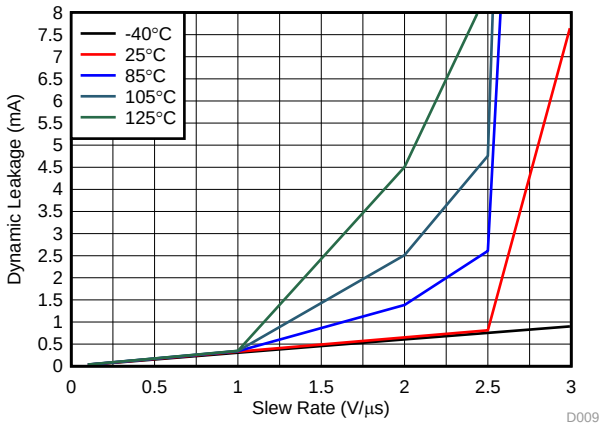


图 9. Maximum Leakage vs Signal Slew Rate across Temperature

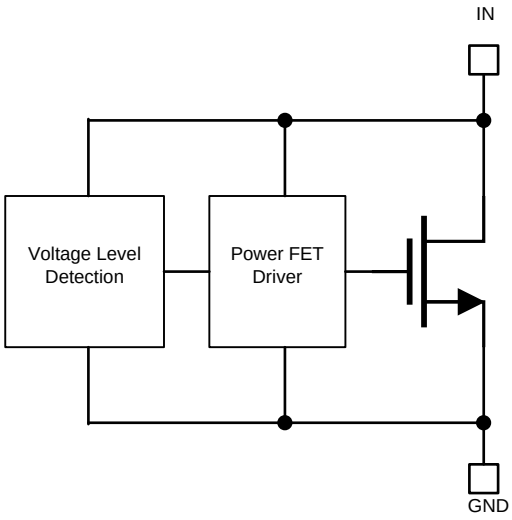
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8 Detailed Description

8.1 Overview

The TVS1400 is a precision clamp with a low, flat clamping voltage during transient overvoltage events like surge and protects the system with zero voltage overshoot. For a detailed overview of the Flat-Clamp family of devices, please reference TI's *Flat-Clamp surge protection technology for efficient system protection* white paper. This document explains in detail the functional operation of the devices and how they impact and improve system design.

8.2 Functional Block Diagram



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8.3 Feature Description

The TVS1400 is a precision clamp that handles 43 A of IEC 61000-4-5 8/20 µs surge pulse. The flat clamping feature helps keep the clamping voltage very low to keep the downstream circuits from being stressed. The flat clamping feature can also help end-equipment designers save cost by opening up the possibility to use lower-cost lower voltage tolerant downstream ICs. The TVS1400 has minimal leakage under the standoff voltage of 14 V, making it an ideal candidate for applications where low leakage and power dissipation is a necessity. IEC 61000-4-2 and IEC 61000-4-4 ratings make it a robust protection solution for ESD and EFT events. Wide ambient temperature range of –40°C to +125°C makes it a good candidate for most applications. Compact packages enable it to be used in small devices and save board area.

8.4 Reliability Testing

To ensure device reliability, the TVS1400 is characterized against 5000 repetitive pulses of 35 A IEC 61000-4-5 8/20 µs surge pulses at 125°C. The test is performed with less than 10 seconds between each pulse at high temperature to simulate worst case scenarios for fault regulation. After each surge pulse, the TVS1400 clamping voltage, breakdown voltage, and leakage are recorded to ensure that there is no variation or performance degradation. By ensuring robust, reliable, high temperature protection, the TVS1400 enables fault protection in applications that must withstand years of continuous operation with no performance change.

8.5 Device Functional Modes

8.5.1 Protection Specifications

The TVS1400 is specified according to both the IEC 61000-4-5 and IEC 61643-321 standards. This enables usage in systems regardless of which standard is required in relevant product standards or best matches measured fault conditions. The IEC 61000-4-5 standard requires protection against a pulse with a rise time of 8 µs and a half length of 20 µs while the IEC 61643-321 standard requires protection against a much longer pulse with a rise time of 10 µs and a half length of 1000 µs.

The positive and negative surges are imposed to the TVS1400 by a combinational waveform generator (CWG) with a 2-Ω coupling resistor at different peak voltage levels. For powered on transient tests that need power supply bias, inductances are usually used to decouple the transient stress and protect the power supply. The TVS01400 is post tested by guaranteeing that there is no shift in device breakdown or leakage at V_{rwm}.

In addition, the TVS1400 has been tested according to IEC 61000-4-5 to pass a ±2 kV surge test through a 42-Ω coupling resistor and a 0.5 µF capacitor. This test is a common test requirement for industrial signal I/O lines and the TVS1400 will serve an ideal protection solution for applications with that requirement.

The TVS1400 also integrates IEC 61000-4-2 Level 4 ESD Protection and 80 A of IEC 61000-4-4 EFT Protection. These combine to ensure that the device is able to protect against all transient conditions regardless of length or type.

For more information on TI's test methods for Surge, ESD, and EFT testing, reference *TI's IEC 61000-4-x Testing Application Note*.

8.5.2 Minimal Derating

Unlike traditional diodes The TVS1400 has very little derating of max power dissipation and ensures robust performance up to 125°C, shown in Figure 8. Traditional TVS diodes lose up to 50% of their current carrying capability when at high temperatures, so a surge pulse above 85°C ambient can cause failures that are not seen at room temperature. The TVS1400 prevents this and ensures that you will see the same level of protection regardless of temperature.

8.5.3 Transient Performance

During large transient swings, the TVS1400 will begin clamping the input signal to protect downstream conditions. While this prevents damage during fault conditions, it can cause leakage when the intended input signal has a fast slew rate. In order to keep power dissipation low and remove the chance of signal distortion, it is recommended to keep the slew rate of any input signal on the TVS1400 below 2.5 V/µs at room temperature and below 0.7 V/µs at 125°C as shown in Figure 9. Faster slew rates will cause the device to clamp the input signal and draw current through the device for a few microseconds, increasing the rise time of the signal. This will not cause any harm to the system or to the device, however if the fast input voltage swings occur regularly it can cause device overheating.

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9 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.

9.1 Application Information

The TVS1400 can be used to protect any power, analog, or digital signal from transient fault conditions caused by the environment or other electrical components.

9.2 Typical Application

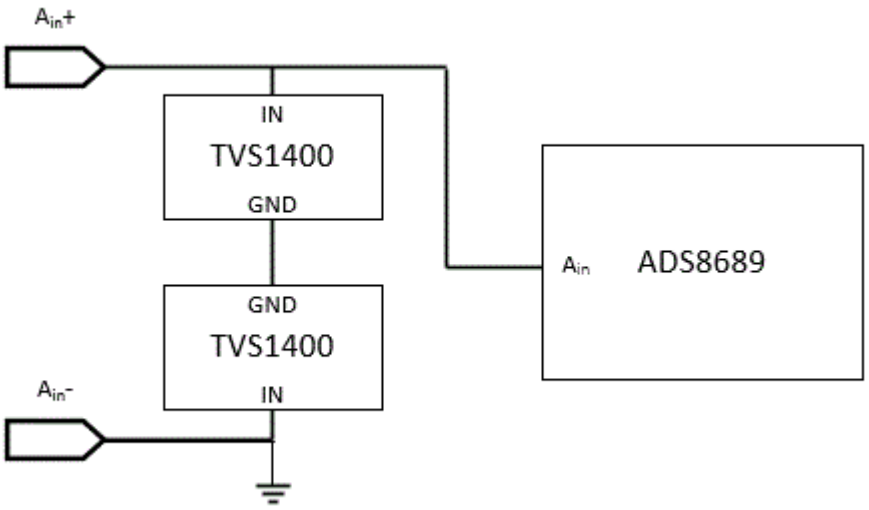


图 10. TVS1400 Application Schematic

9.2.1 Design Requirements

A typical operation for the TVS1400 would be protecting in a factory control application, protecting an analog input to an ADC input similar to 图 10. In this example, two TVS1400's are in a bidirectional configuration protecting the input to an ADS8689, an ADC with an input voltage range of ±12.288 V and an absolute maximum input voltage range of ±20 V. Without any input protection, if a surge event is caused by lightning, coupling, ringing, or any other fault condition this input voltage will rise to hundreds of volts for multiple microseconds, violating the absolute maximum input voltage and harming the device. An ideal surge protection diode will maximize the useable voltage range while still clamping at a safe level for the system, so TI's Flat-Clamp technology provides the best protection solution.

9.2.2 Detailed Design Procedure

If the TVS1400 is in place to protect the device, during a surge event the voltage will rise to the breakdown of the diode at 16.8 V, and then the TVS1400 will turn on, shunting the surge current to ground. With the low dynamic resistance of the TVS1400, even large amounts of surge current will have minimal impact on the clamping voltage. The dynamic resistance of the TVS1400 is around 30 mΩ, which means 43 A of surge current will cause a voltage raise of 43 A × 30 mΩ = 1.29 V. Because the device turns on at 16.8 V, this means the ADC input will be exposed to a maximum of 16.8 V + 1.29 V = 18.09 V during surge pulses, well within the ADS8689 absolute maximum. This pulse is shown in Figure 11 and ensures robust protection of your circuit.

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Typical Application (接下页)

In addition, the low leakage and capacitance of the TVS1400 guarantees low input distortion. At 14 V, giving margin on the ±12.288 V range of the ADS8689, the device will see typical 10 nA leakage, which will have minimal effect on the overall system. The TVS1400 low capacitance of 125 pF will also cause less effect on signal integrity compared to industry standard devices like the SMBJ14A which has 1500 pF of capacitance and can cause up to 3 dB of THD attenuation in measured systems.

Finally, the small size of the device also improves fault protection by lowering the effect of fault current coupling onto neighboring traces. The small form factor of the TVS1400 allows the device to be placed extremely close to the input connector, lowering the length of the path fault current will take through the system compared to larger protection solutions.

9.2.3 Application Curves

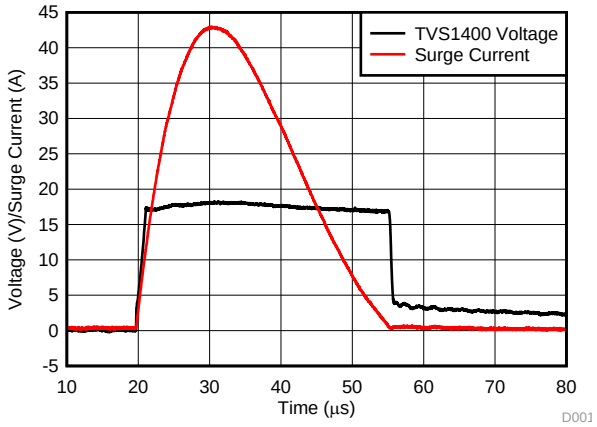


图 11. TVS1400 Clamping Response at 43 A

9.2.4 Configuration Options

The TVS1400 can be used in either unidirectional or bidirectional configuration. shows bidirectional usage to protect an input. By placing two TVS1400's in series with reverse orientation, bidirectional operation can be utilized which will allow a working voltage of ±14 V. TVS1400 operation in bidirectional will be similar to unidirectional operation, with a minor increase in breakdown voltage and clamping voltage. The TVS3300 bidirectional performance has been characterized in the *TVS3300 Configurations Characterization*. While the TVS1400 in bidirectional configuration has not specifically been characterized, it will have similar relative changes to the TVS3300 in bidirectional configuration.

10 Power Supply Recommendations

The TVS1400 is a clamping device so there is no need to power it. Be careful not to violate the recommended V_{IN} voltage range (0 V to 14 V) to ensure the device functions properly.

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11 Layout

11.1 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 TVS1400 and the connector by using rounded corners with the largest radii possible. Electric fields tend to build up on corners, increasing EMI coupling.

11.2 Layout Example

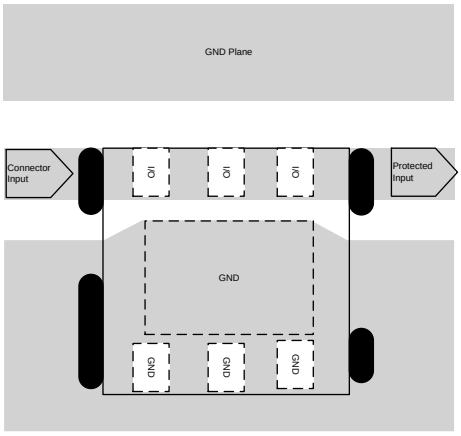


图 12. TVS1400 Layout

12 器件和文档支持

12.1 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。请单击右上角的*提醒我* 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。

12.2 社区资源

下列链接提供到 TI 社区资源的连接。链接的内容由各个分销商“按照原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的 《使用条款》。

TI E2E™ 在线社区 ***TI 的工程师对工程师 (E2E) 社区。*** **此社区的创建目的在于促进工程师之间的协作。在 e2e.ti.com 中，您可以咨询问题、分享知识、拓展思路并与同行工程师一道帮助解决问题。**

设计支持 ***TI 参考设计支持*** **可帮助您快速查找有帮助的 E2E 论坛、设计支持工具以及技术支持的联系信息。**

12.3 商标

E2E is a trademark of Texas Instruments.

12.4 静电放电警告

ESD 可能会损坏该集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理措施和安装程序，可能会损坏集成电路。

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。

12.5 Glossary

SLYZ022 — *TI Glossary*.

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

13 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)
TVS1400DRVR	Active	Production	WSON (DRV) | 6	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HSH
TVS1400DRVR.A	Active	Production	WSON (DRV) | 6	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HSH
TVS1400DRVRG4	Active	Production	WSON (DRV) | 6	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HSH
TVS1400DRVRG4.A	Active	Production	WSON (DRV) | 6	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HSH

(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.

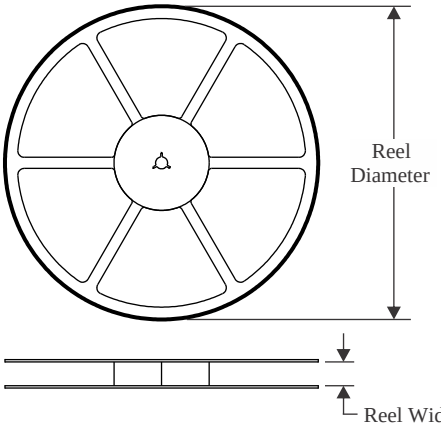
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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.

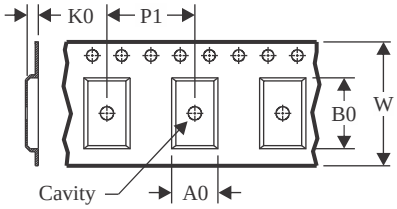
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

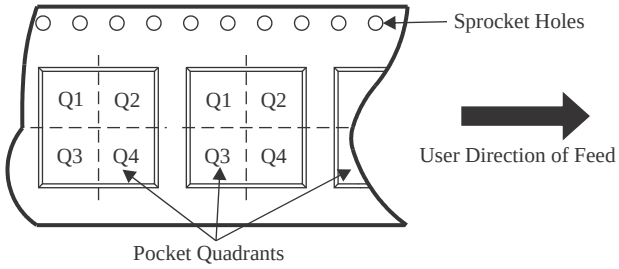


TAPE DIMENSIONS



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

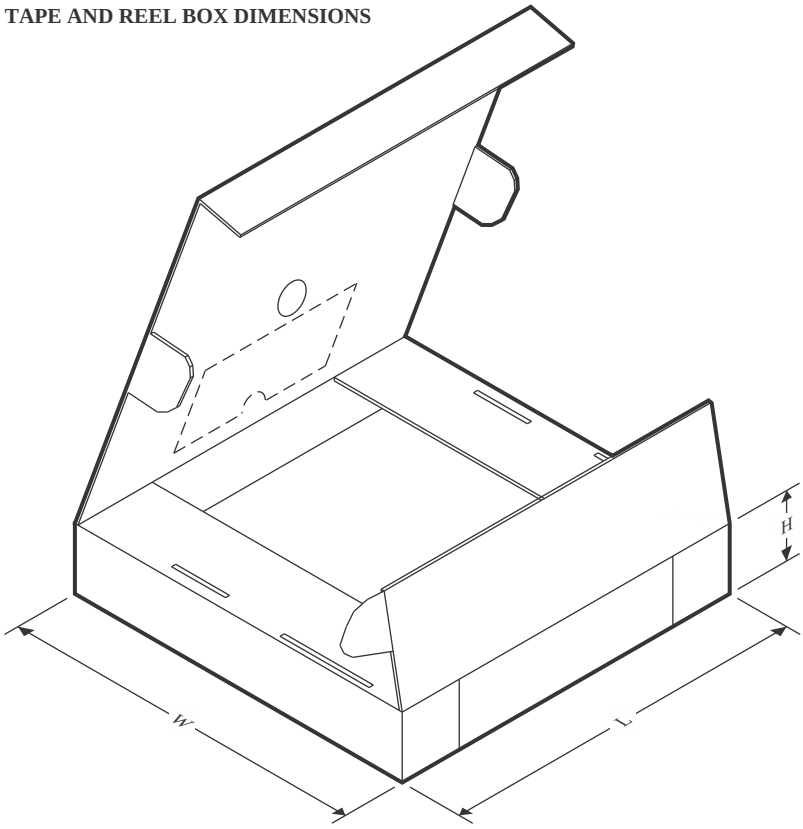
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TVS1400DRVR	WSON	DRV	6	3000	178.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2
TVS1400DRVRG4	WSON	DRV	6	3000	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2

TAPE AND REEL BOX DIMENSIONS

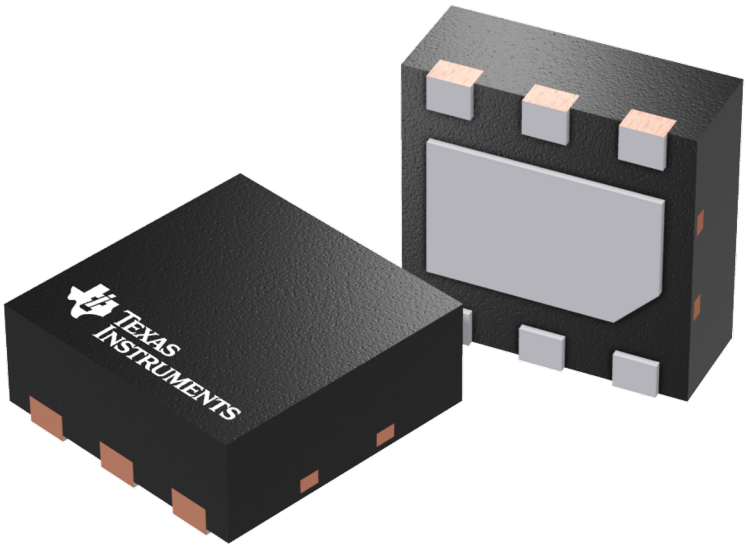


*All dimensions are nominal

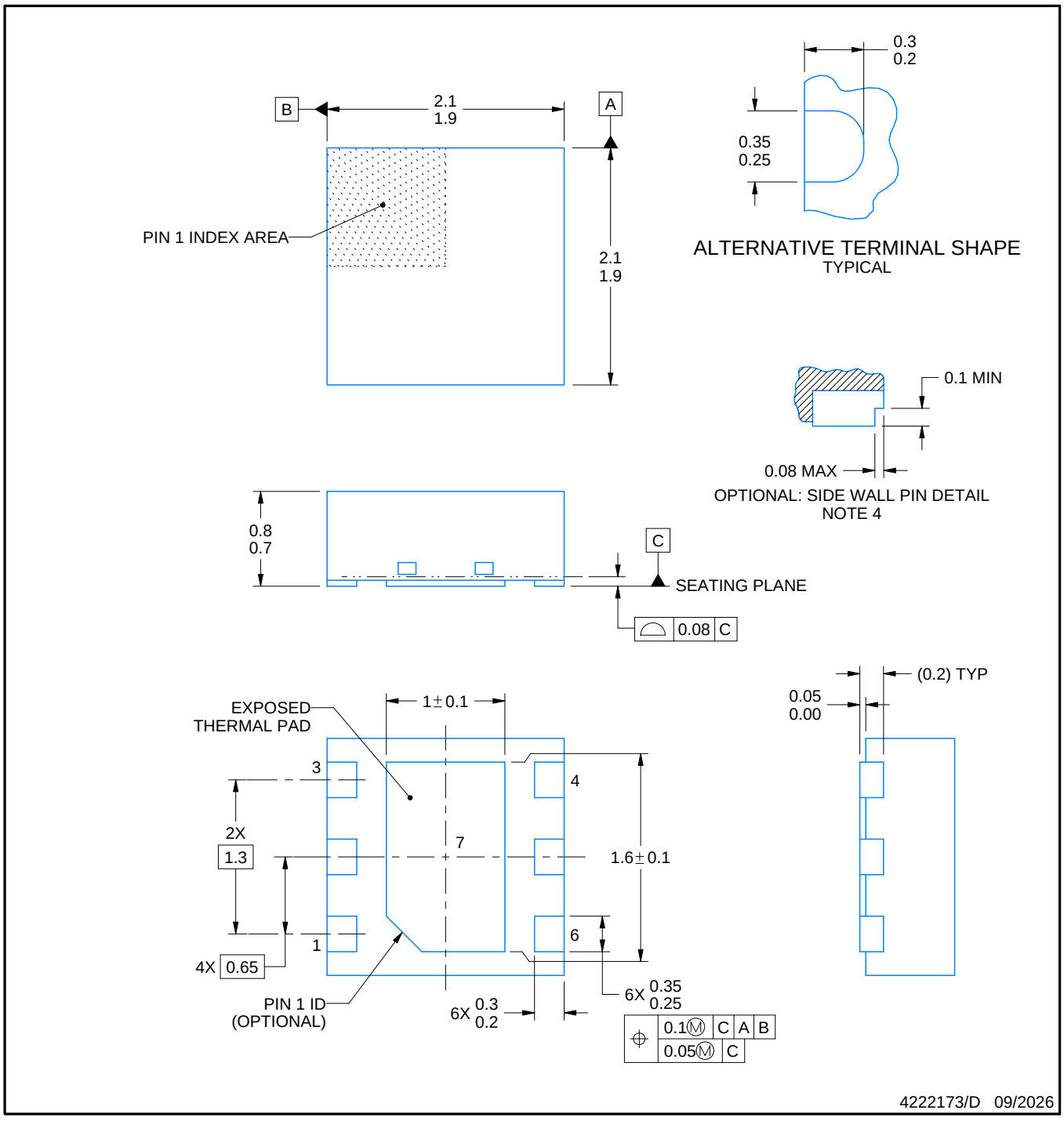
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TVS1400DRVR	WSON	DRV	6	3000	208.0	191.0	35.0
TVS1400DRVRG4	WSON	DRV	6	3000	210.0	185.0	35.0

DRV 6 WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD

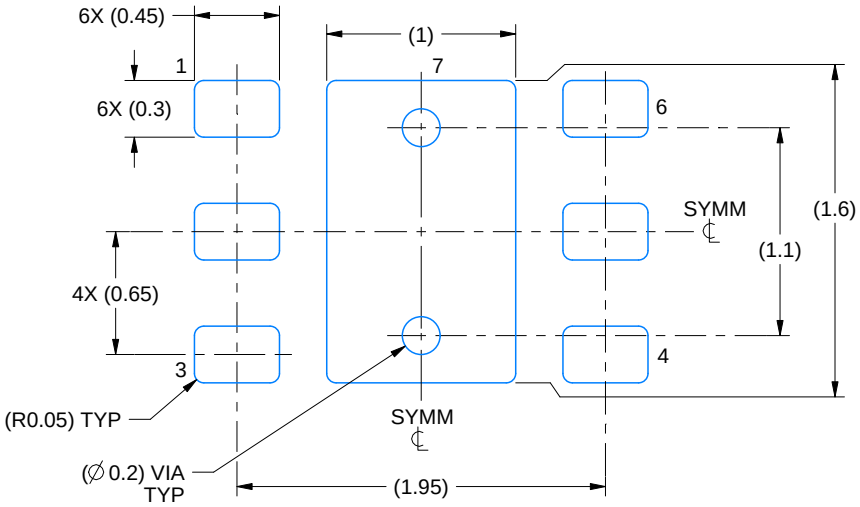


Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

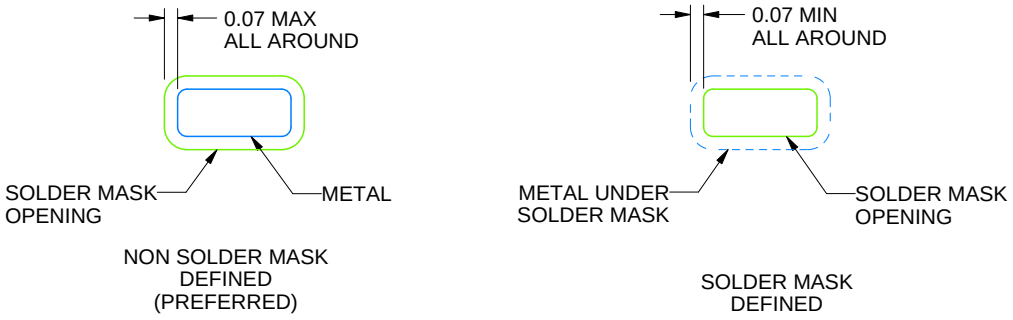


NOTES:

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. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.
4. Minimum 0.1 mm solder wetting on pin side wall. Available for wettable flank version only.



LAND PATTERN EXAMPLE
SCALE:25X

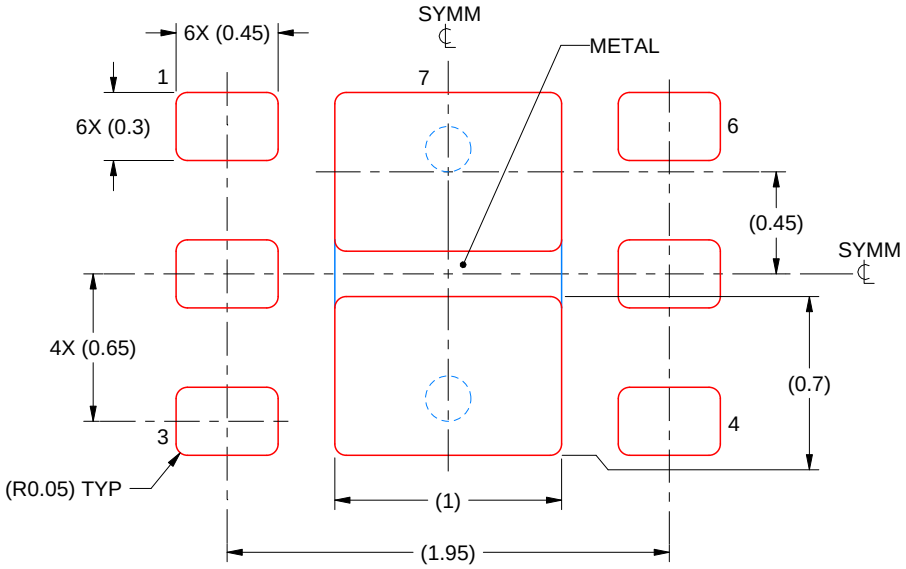


SOLDER MASK DETAILS

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NOTES: (continued)

5. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
6. Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD #7
88% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:30X

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NOTES: (continued)

7. 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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