TVS2200 22-V Flat-Clamp Surge Protection Device

1 Features

- Ultra-Low and Flat Clamping Voltage
  - 27.7 V at 40 A (8/20 µs)
  - R_{DYN}: 30 mΩ
- Standoff Voltage: 22 V
- Survives 10,000 Strikes of 35 A 8/20 µs Surge Pulses at 125°C
- Robust Surge Protection:
  - IEC61000-4-5 (8/20 µs): 40 A
  - Protection Against 1 kV, 42 Ω IEC 61000-4-5 Surge Pulses
  - IEC61643-321 (10/1000 µs): 5 A
- Low Leakage Current
  - 3.2 nA at 27°C
  - 22 nA at 85°C
- Low Capacitance: 105 pF
- Peak Pulse Power:
  - IEC61000-4-5 (8/20 µs): 1000 W
  - IEC61643-321 (10/1000 µs): 150 W
- IEC 61000-4-2 Level 4 ESD Protection
  - ±11-kV Contact Discharge
  - ±30-kV Air Gap Discharge
- IEC 61000-4-4 EFT Protection
  - 80 A (5/50 ns)
- Industrial Temperature Range: –40°C to +125°C
- Compact Package
  - 6-Pin SON Package (2 mm × 2 mm)

2 Applications

- Industrial Sensor I/O
- Medical Equipment
- USB Type-C V_{bus}
- PLC I/O Modules
- Appliances

3 Description

The TVS2200 Flat-Clamp diode is a transient voltage suppressor which provides robust protection for circuits exposed to high transient voltage events. The IC is designed to protect against 40 A of IEC61000-4-5 surge current, robustly protecting systems in harsh industrial environments. Unlike traditional TVS diodes, the TVS2200 regulates with a feedback mechanism to ensure precise flat clamping protection below 28 V during a fault. The lower clamping enables a unique protection solution that can significantly lower the voltage a system is exposed during a surge event. This allows designers to confidently select downstream system components with a lower voltage rating, lower system costs and complexity without sacrificing robustness.

In addition, the TVS2200 ultra low leakage and low capacitance enable an input protection stage that has less effect on system operation than traditional TVS diodes. Typical leakage of 3.2 nA at 22 V is smaller than comparable conventional technology, guaranteeing low power dissipation. The device capacitance of 105 pF is also much lower than typical TVS diodes, lowering distortion on sensitive analog input signals and increasing system flexibility.

The TVS2200 is available in a small 2×2 SON footprint which is ideal for space constrained applications, offering a 70 percent reduction in size compared to industry standard SMA and SMB packages. The unique precision surge technology allows the TVS2200 to dissipate large surge currents even in a small package, helping system designers save space without sacrificing robustness.

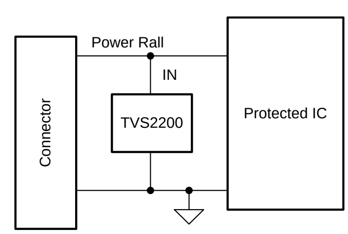
Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TVS2200	SON (6)	2.00 mm × 2.00 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

ADVANCE INFORMATION

System Diagram



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ADVANCE INFORMATION

4 Revision History

DATE	REVISION	NOTES
December 2017	*	Initial release.

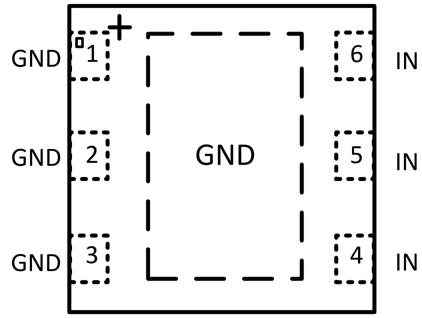
5 Device Comparison Table

DEVICE	V_{rwm}	V_{clamp} at I_{pp}	I_{pp} (8/20 µs)	V_{rwm} leakage (nA)	POLARITY
TVS0500	5	9.2	45	0.3	Unidirectional
TVS1400	14	18.6	45	2	Unidirectional
TVS1800	18	22.8	40	0.3	Unidirectional
TVS2200	22	27.7	40	3.2	Unidirectional
TVS2700	27	32.5	40	1.7	Unidirectional
TVS3300	33	38	35	19	Unidirectional

ADVANCE INFORMATION

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

ADVANCE INFORMATION

7 Specifications

7.1 Absolute Maximum Ratings

T_A = 27℃ (unless otherwise noted)[1]

		MIN	MAX	UNIT
Maximum Surge	IEC61000-4-5 Current (8/20 µs)		40	A
	IEC 61000-4-5 Power (8/20 µs)		1000	W
	IEC 61643-321 Current (10/1000 µs)		5	A
	IEC 61643-321 Power (10/1000 µs)		150	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)		8	A
	IEC 61643-321 Power (10/1000 µs)		150	W
EFT	IEC 61000-4-4 EFT Protection		80	A
I_{br}	DC Breakdown current		10	mA
I_f	DC Forward Current		500	mA
T_A	Ambient Operating Temperature	–40	125	°C
T_{stg}	Storage Temperature	–65	150	°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	±11	kV
		IEC 61000-4-2 air-gap discharge	±30	

7.4 Thermal Information

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

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

ADVANCE INFORMATION

7.5 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{RWM}	Reverse Stand-off Voltage			22		V
I_{LEAK}	Leakage Current	Measured at V_{IN} = V_{rwm} T_A = 27°C		3.2	TBD	nA
I_{LEAK}	Leakage Current	Measured at V_{IN} = V_{rwm} T_A = 85°C		22	TBD	nA
I_{LEAK}	Leakage Current	Measured at V_{IN} = V_{rwm} T_A = 105°C		TBD	TBD	nA
V_F	Forward Voltage	I_{IN} = 1 mA from GND to IO		0.5		V
V_{BR}	Break-down Voltage	I_{IN} = 1 mA from IO to GND	TBD	25.9	TBD	V
V_{FCLAMP}	Forward Clamp Voltage	40 A IEC 61000-4-5 Surge (8/20 µs) from GND to IO, 27°C	1	4	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		27	TBD	V
V_{CLAMP}	Clamp Voltage	40 A IEC 61000-4-5 Surge (8/20 µs) from IO to GND, V_{IN} = 0 V before surge, 27°C		27.7	TBD	V
V_{CLAMP}	Clamp Voltage	35 A IEC 61000-4-5 Surge (8/20 µs) from IO to GND, V_{IN} = V_{rwm} before surge, T_A = 125°C		27.75	TBD	V
R_{DYN}	8/20 µs surge dynamic resistance	Calculated from V_{CLAMP} at 0.5 × I_{pp} and I_{pp} surge current levels, 27°C		30		mΩ
C_{IN}	Input pin capacitance	V_{IN} = 22 V, f = 1 MHz, 30 mV_{pp}, IO to GND		105		pF
SR	Maximum Slew Rate	0-V_{rwm} rising edge, measure slew rate when Ipk = 1 mA, 27°C		2.5		V/µs
SR	Maximum Slew Rate	0-V_{rwm} rising edge, measure slew rate when Ipk = 1 mA, 105°C		0.7		V/µs

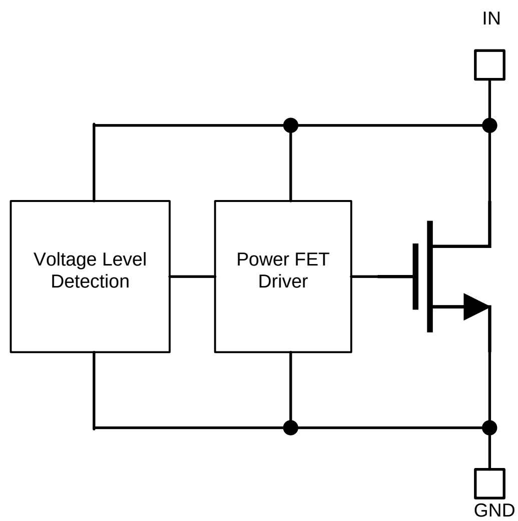
ADVANCE INFORMATION

8 Detailed Description

8.1 Overview

The TVS2200 is a precision clamp with a low, flat clamping voltage during transient overvoltage events like surge and protecting the system with zero voltage overshoot.

8.2 Functional Block Diagram



8.3 Feature Description

The TVS2200 is a precision clamp that handles 40 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 TVS2200 has minimal leakage under the standoff voltage of 22 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 Device Functional Modes

8.4.1 Protection Specifications

The TVS2200 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 standards 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 TVS2200 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 TVS2200 is post tested by guaranteeing that there is no shift in device breakdown or leakage at V_{rwm}.

The TVS2200 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

ADVANCE INFORMATION

Device Functional Modes (continued)

8.4.2 Minimal Derating

Unlike traditional diodes the TVS2200 has very little derating of max power dissipation and ensures robust performance up to 125°C. 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 TVS2200 prevents this and ensures that you will see the same level of protection regardless of temperature.

8.4.3 Transient Performance

During large transient swings, the TVS2200 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 TVS2200 below 2.5 V/µs at room temperature and below 0.7 V/µs at 125°C. 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.

9 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.

9.1 Application Information

The TVS2200 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

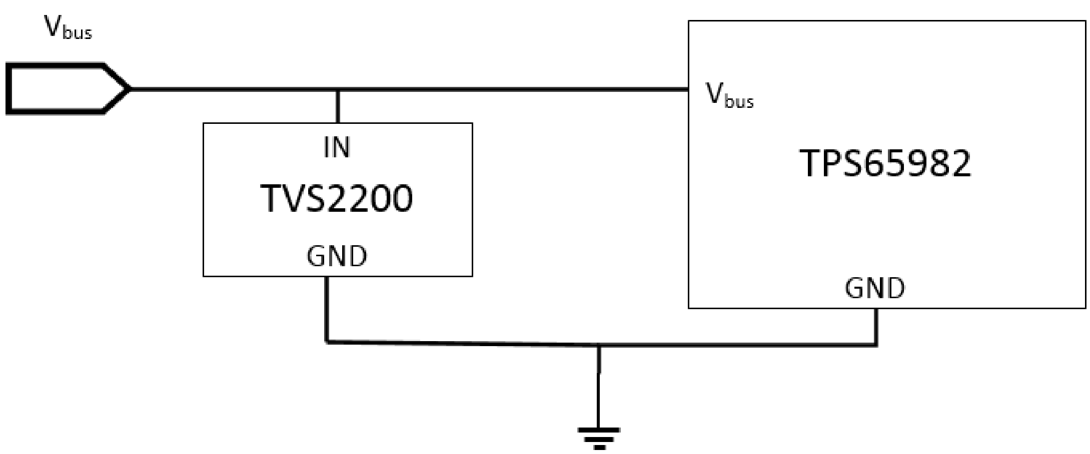


Figure 1. TVS2200 Application Schematic

9.2.1 Design Requirements

A typical operation for the TVS2200 would be protecting a USB Type-C V_{bus} input, with a nominal input voltage of 20 V and a required withstand of 22 V, as shown in Figure 1. In this example, a TVS2200 is protecting the input to a TPS65982 Type-C Port Controller. Without any input protection, if a surge event is caused by lightning, coupling, hot-swap 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.

9.2.2 Detailed Design Procedure

If the TVS2200 is in place to protect the device, during a surge event the voltage will rise to the breakdown of the diode at 25.9 V, and then the TVS2200 will turn on, shunting the surge current to ground. With the low dynamic resistance of the TVS2200, even large amounts of surge current will have minimal impact on the clamping voltage. The dynamic resistance of the TVS2200 is around 30 mΩ, which means 30 A of surge current will cause a voltage raise of 30 A × 30 mΩ = 0.9 V. Because the device turns on at 25.9 V, this means the input will be exposed to a maximum of 25.9 V + 0.9 V = 26.8 V during surge pulses, robustly protecting the USB Type-C port.

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 TVS2200 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.

ADVANCE INFORMATION

Typical Application (continued)

9.2.3 Application Curves

TBD

9.2.4 Configuration Options

The TVS2200 can be used in either unidirectional or bidirectional configuration. The TVS2200 shows unidirectional usage to protect an input. By placing two TVS2200's in series with reverse orientation, bidirectional operation can be utilized which will allow a working voltage of ±22 V. TVS2200 operation in bidirectional will be similar to unidirectional operation, with a minor increase in breakdown voltage and clamping voltage.

10 Power Supply Recommendations

The TVS2200 is a clamping device so there is no need to power it. Take care not to violate the recommended V_{IN} voltage range (0 V to 22 V) to ensure the device functions properly.

ADVANCE INFORMATION

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 TVS2200 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

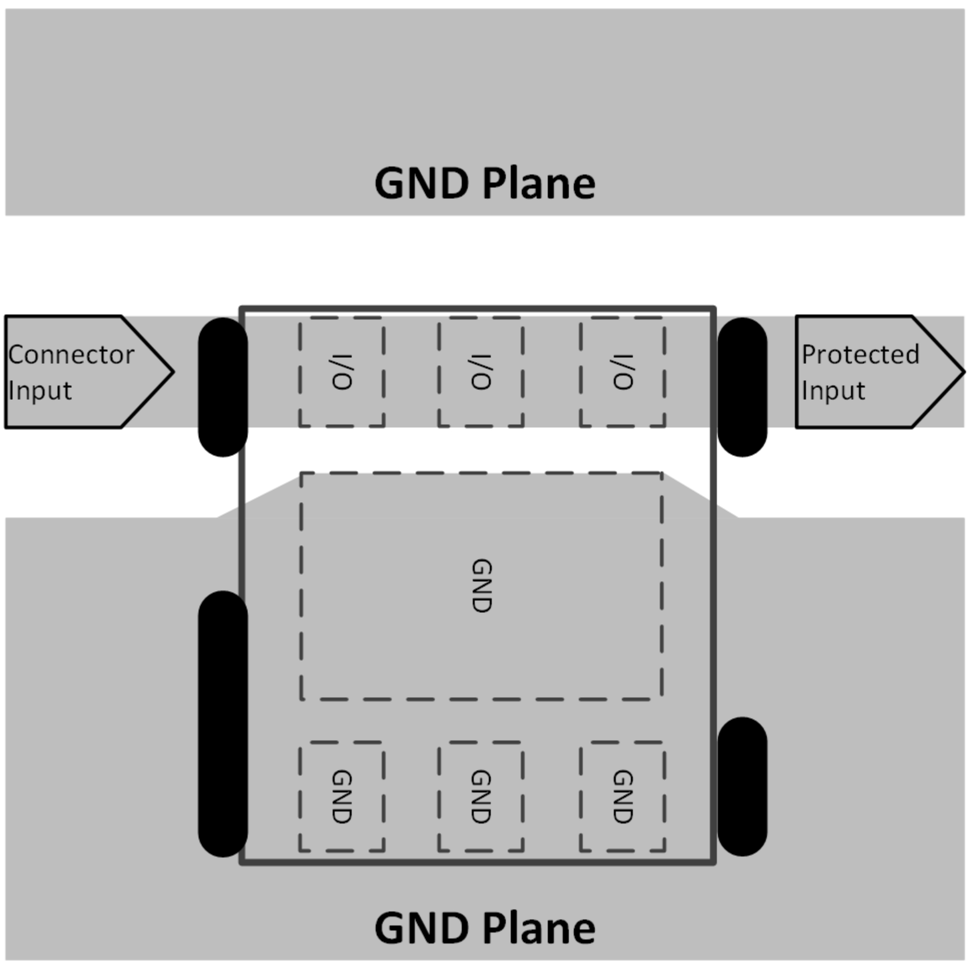


Figure 2. TVS2200 Layout

ADVANCE INFORMATION

12 Device and Documentation Support

12.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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.

12.2 Community Resources

The following links connect to TI community resources. Linked contents are 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.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.3 Trademarks

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12.4 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.

12.5 Glossary

SLYZ022 — *TI Glossary*.
This glossary lists and explains terms, acronyms, and definitions.

13 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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
PTVS2200DRVR	ACTIVE	WSON	DRV	6	3000	TBD	Call TI	Call TI	-40 to 125		Samples
TVS2200DRVR	PREVIEW	WSON	DRV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	1HVH	

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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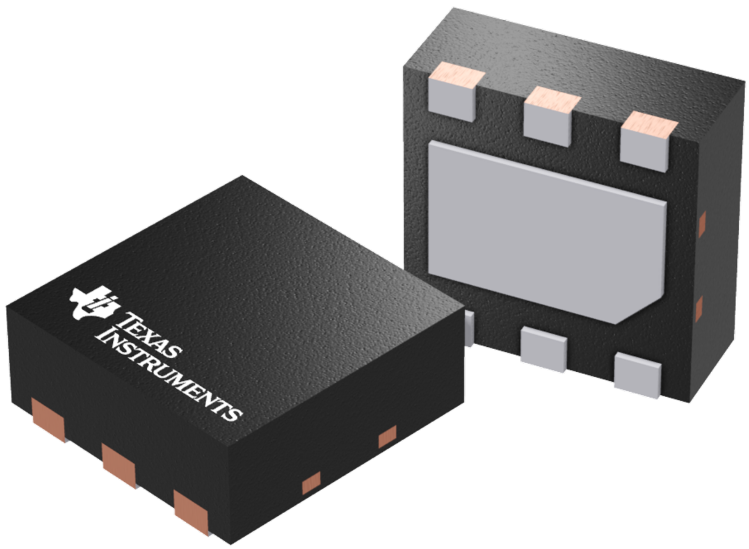
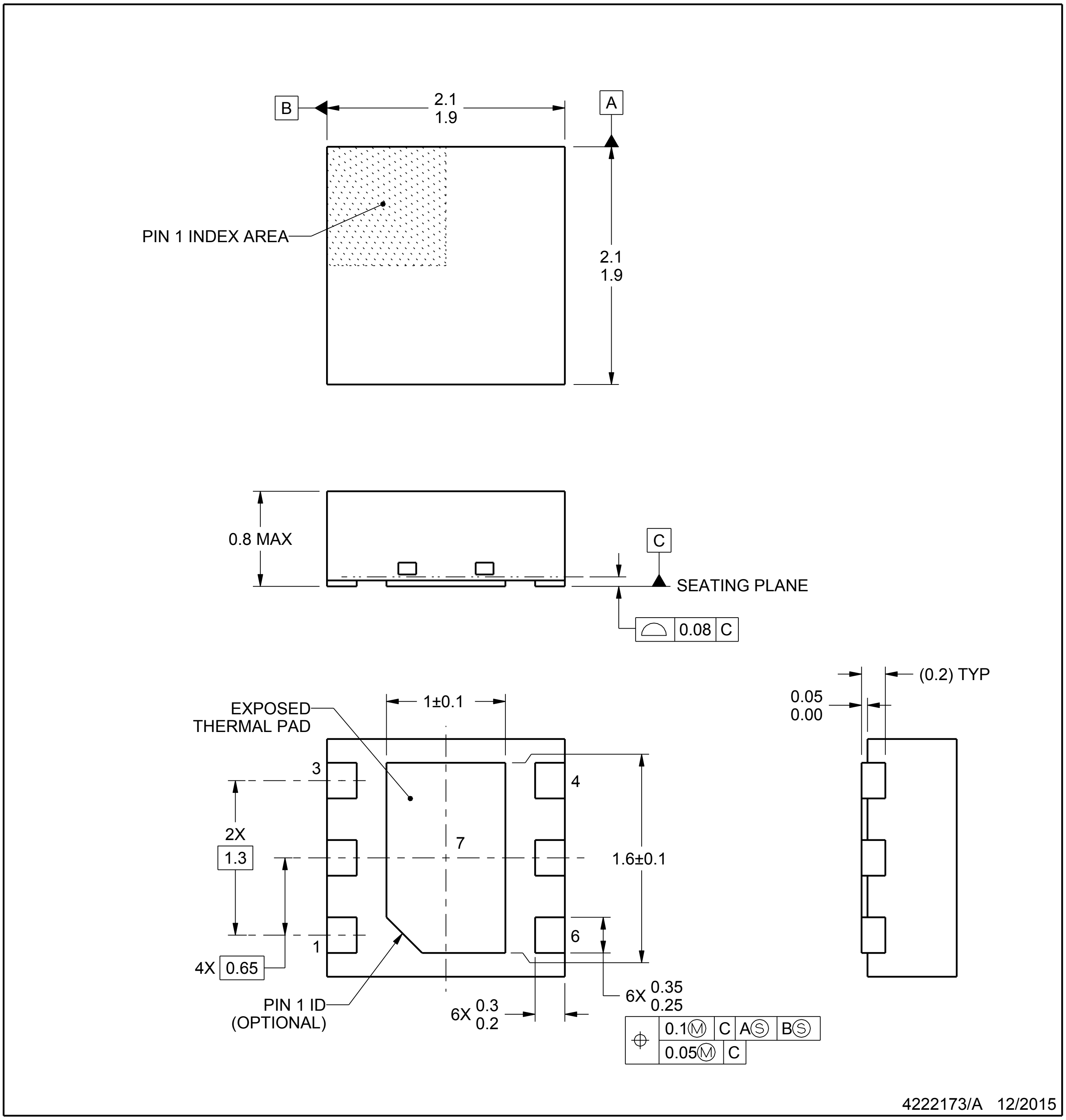
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.



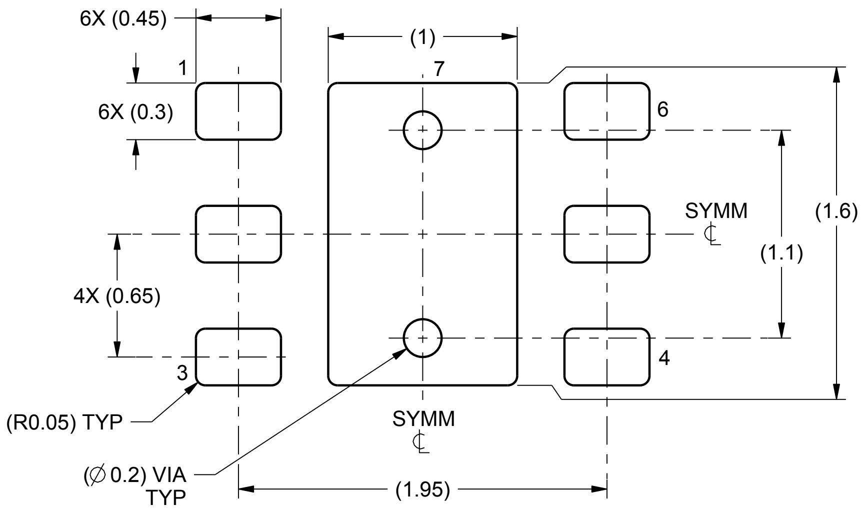
Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4206925/F

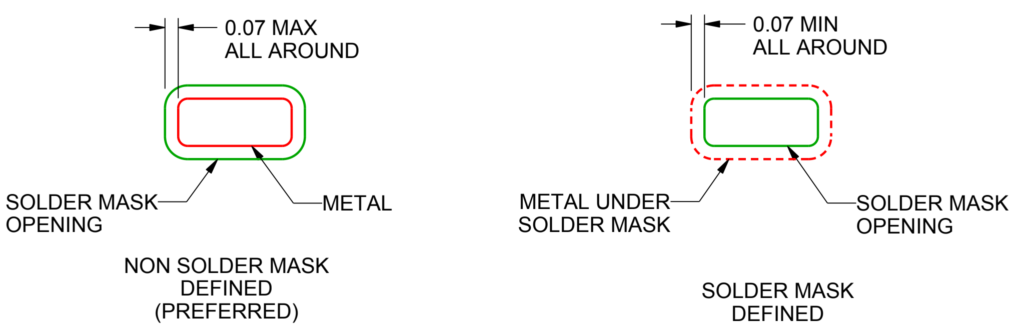


NOTES:

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.



LAND PATTERN EXAMPLE
SCALE:25X



SOLDER MASK DETAILS

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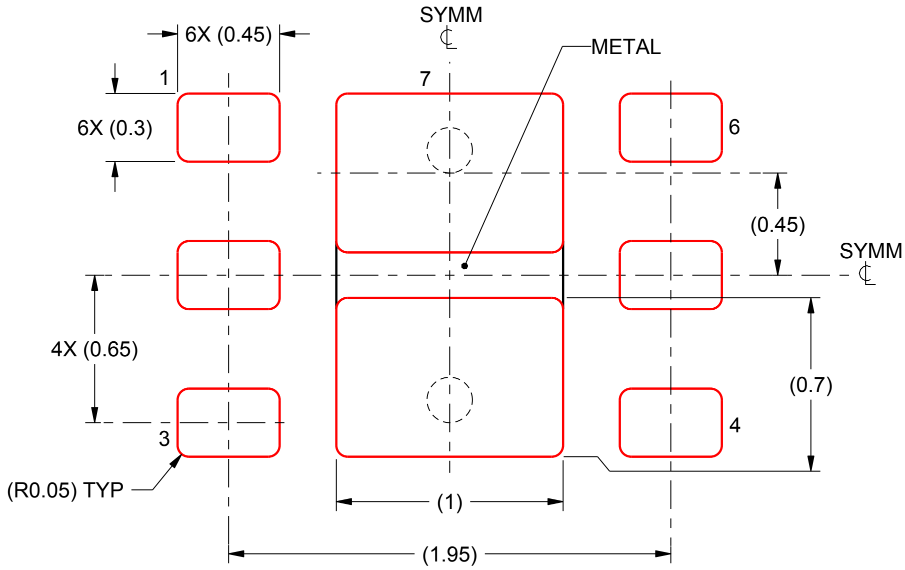
NOTES: (continued)

4. 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).
5. 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)

6. 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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