

## 4-CHANNEL ESD PROTECTION ARRAY WITH 1.5-pF IO CAPACITANCE

 Check for Samples: [TPD4E001](#)

### FEATURES

- 4-Channel ESD Clamp Array to Enhance System-Level ESD Protection
- Exceeds IEC61000-4-2 (Level 4) ESD Protection Requirements
  - ±8-kV IEC 61000-4-2 Contact Discharge
  - ±15-kV IEC 61000-4-2 Air-Gap Discharge
- ±15-kV Human-Body Model (HBM)
- 5.5-A Peak Pulse Current (8/20-us Pulse)
- Low 1.5-pF Input Capacitance
- Low 1-nA (Max) Leakage Current
- 0.9-V to 5.5-V Supply-Voltage Range
- Space-Saving DRL, DBV, DCK, and DRS Package Options
- Alternate 2-, 3-, 6-Channel Options Available: TPD2E001, TPD3E001, and TPD6E001

### APPLICATIONS

- USB 2.0
- Ethernet
- FireWire™
- Precision Analog Interface
- SVGA Connections

### DESCRIPTION/ORDERING INFORMATION

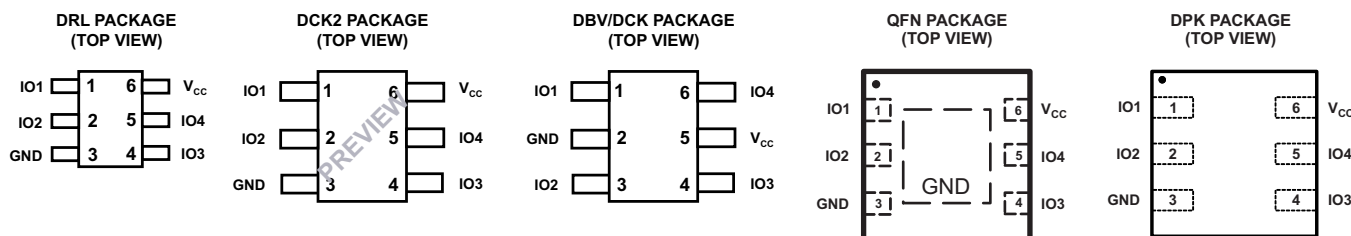
The TPD4E001 is a low-capacitance ±15-kV ESD-protection diode array designed to protect sensitive electronics attached to communication lines. Each channel consists of a pair of diodes that steer ESD current pulses to  $V_{CC}$  or GND. The TPD4E001 protects against ESD pulses up to ±15-kV Human-Body Model (HBM), ±8-kV Contact Discharge, and ±15-kV Air-Gap Discharge, as specified in IEC 61000-4-2. This device has a 1.5-pF IO capacitance per channel, making it ideal for use in high-speed data IO interfaces. The ultra low leakage current (<1 nA max) is suitable for precision analog measurements in applications like glucose meters, heart rate monitors, etc.

The TPD4E001 is available in DRL, DBV (SOT-23), DCK (SC-70), DRS (QFN), and DPK (PUSON) packages and is specified for –40°C to 85°C operation.

### ORDERING INFORMATION

$T_A$	PACKAGE <sup>(1)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	1.6 × 1.6 DRL	Reel of 4000	TPD4E001DRLR	2CR, 2C7
	2.9 × 2.8 DBV (SOT-23)	Reel of 3000	TPD4E001DBVR	NFY5
	DCK2	Reel of 3000	TPD4E001DCK2R	
	2.1 × 2.0 DCK (SC-70)	Reel of 3000	TPD4E001DCKR	2CF, 2CR
	3 × 3 DRS (QFN)	Reel of 1000	TPD4E001DRSR	ZWM
	1.6 × 1.6 DPK (PUSON)	Reel of 5000	TPD4E001DPKR	2C7

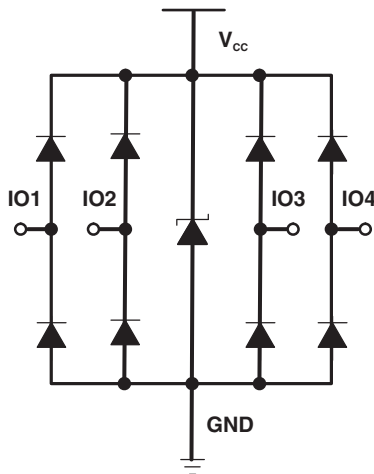
(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at [www.ti.com](http://www.ti.com).



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.

Figure 1. FUNCTIONAL BLOCK DIAGRAM



PIN DESCRIPTION

DRS/DRL/DPK NO.	DBV/DCK NO.	NAME	FUNCTION
1, 2, 4, 5	1, 3, 4, 6	IOx	ESD-protected channel
3	2	GND	Ground
6	5	V <sub>CC</sub>	Power-supply input. Bypass V <sub>CC</sub> to GND with a 0.1-μF ceramic capacitor.
Exposed Thermal Pad (DRS package only)		N/A	Exposed thermal pad. Connect to GND or leave floating.

Absolute Maximum Ratings<sup>(1)</sup>

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

		MIN	MAX	UNIT
V <sub>CC</sub>		-0.3	7	V
V <sub>I/O</sub>	IO voltage tolerance	-0.3	V <sub>CC</sub> + 0.3	V
T <sub>stg</sub>	Storage temperature range	-65	150	°C
T <sub>J</sub>	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	100	nA
$V_F$	Diode forward voltage	$I_F = 10\text{ mA}$	0.65		0.95	V
$V_{BR}$	Breakdown Voltage	$I_{BR} = 10\text{ mA}$	11			V
$V_C$	Channel clamp voltage	$T_A = 25^\circ\text{C}$ , $\pm 15\text{-kV HBM}$ , $I_F = 10\text{ A}$	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	
$V_{RWM}$	Reverse stand-off voltage	IO pin to GND pin			5.5	V
$I_{i/o}$	Channel leakage current	$V_{i/o} = \text{GND to } V_{CC}$			$\pm 1$	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  $T_A = 25^\circ\text{C}$ .

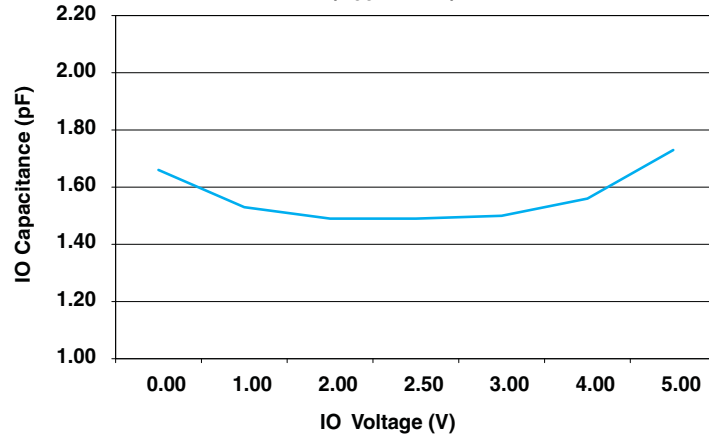
(2) Non-repetitive current pulse  $8/20\mu\text{s}$  exponentially decaying waveform according to ICE61000-4-5.

## ESD Protection

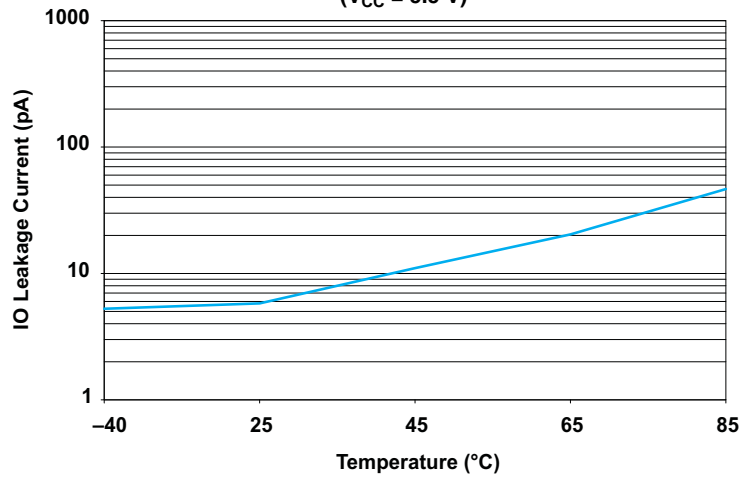
PARAMETER	TYP	UNIT
HBM	$\pm 15$	kV
IEC 61000-4-2 Contact Discharge	$\pm 8$	kV
IEC 61000-4-2 Air-Gap Discharge	$\pm 15$	kV
Peak Pulse Current, IPK ( $T_p = 8/20\ \mu\text{s}$ )	5.5	Amps
Peak Pulse Power, PPK ( $T_p = 8/20\ \mu\text{s}$ )	100	Watts

### TYPICAL OPERATING CHARACTERISTICS

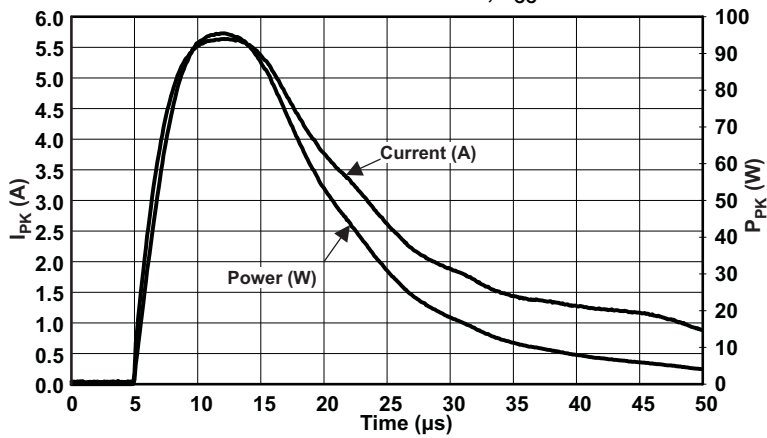
IO CAPACITANCE  
vs  
IO VOLTAGE  
( $V_{CC} = 5.0\text{ V}$ )



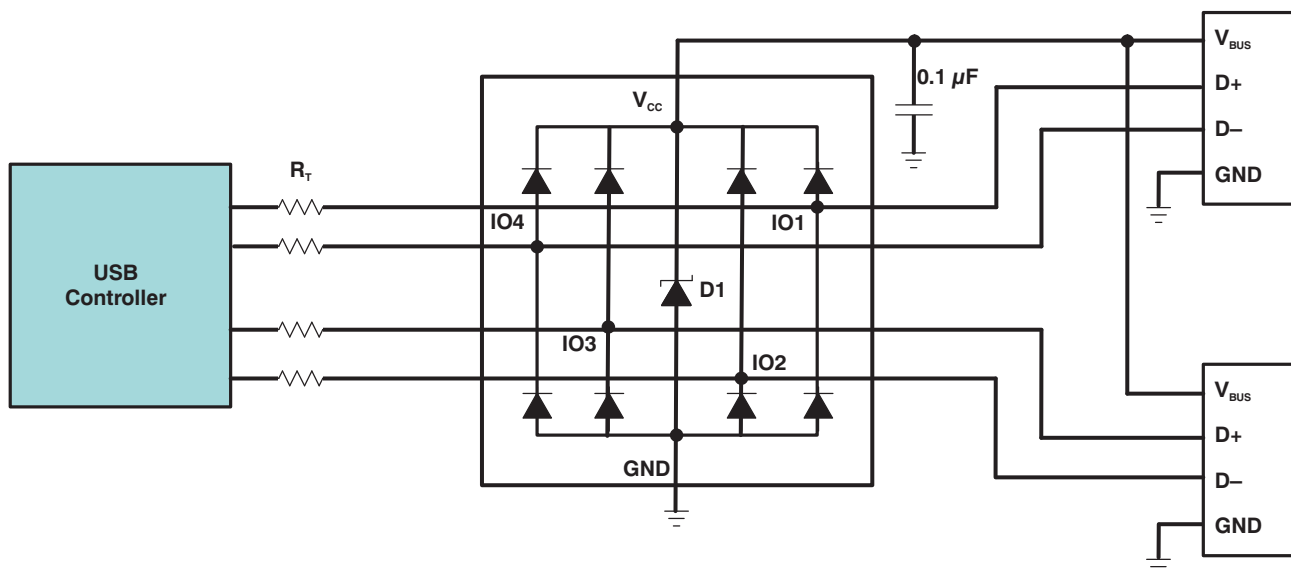
IO LEAKAGE CURRENT  
vs  
TEMPERATURE  
( $V_{CC} = 5.5\text{ V}$ )



PEAK PULSE WAVEFORM,  $V_{CC} = 5.5\text{ V}$



## APPLICATION INFORMATION



### Detailed Description

When placed near the connector, the TPD4E001 ESD solution offers little or no signal distortion during normal operation due to low IO capacitance and ultra-low leakage current specifications. The TPD4E001 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 TPD4E001 solution close to the connector. This allows the TPD4E001 to take away the energy associated with ESD strike before it reaches the internal circuitry of the system board.
2. Place a 0.1- $\mu$ 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. Ensure that there is enough metallization for the  $V_{CC}$  and GND loop. During normal operation, the TPD4E001 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 TPD4E001 works as a transient suppressor for any signal swing above  $V_{CC} + V_F$ . A 0.1- $\mu$ 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 TPD4E001 can tolerate higher signal swing in the range up to 10V. Please note that a 0.1 $\mu$ F capacitor is still recommended at the  $V_{CC}$  pin for ESD bypass.

## REVISION HISTORY

<b>Changes from Revision C (April 2007) to Revision D</b>		<b>Page</b>
• Added DVB (SOT-23) package and package information. ....		1
<b>Changes from Revision D (December 2010) to Revision E</b>		<b>Page</b>
• Added DCK (SC-70) Package to Ordering Information table. ....		1
<b>Changes from Revision E (April 2011) to Revision F</b>		<b>Page</b>
• Added Peak Pulse current and power values to ESD Protection Table. ....		3
• Added Peak Pulse Waveform Graph to Typical Operating Characteristics. ....		4
<b>Changes from Revision F (May 2011) to Revision G</b>		<b>Page</b>
• Added DPK (PUSON) package and package information. ....		1
<b>Changes from Revision G (December 2011) to Revision H</b>		<b>Page</b>
• Updated TOP-SIDE MARKING column in ORDERING INFORMATION table. ....		1
<b>Changes from Revision H (August 2012) to Revision I</b>		<b>Page</b>
• Updated ORDERING INFORMATION table. ....		1
• Added DCK2 package to Pin Out drawings. ....		1
• Updated Electrical Characteristics table .....		3

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
TPD4E001DBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	NFY5	<a href="#">Samples</a>
TPD4E001DCKR	ACTIVE	SC70	DCK	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	(2CF ~ 2CR)	<a href="#">Samples</a>
TPD4E001DPKR	ACTIVE	USON	DPK	6	5000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	2C7	<a href="#">Samples</a>
TPD4E001DPKT	ACTIVE	USON	DPK	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	2C7	<a href="#">Samples</a>
TPD4E001DRLR	ACTIVE	SOT	DRL	6	4000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	(2C7 ~ 2CR)	<a href="#">Samples</a>
TPD4E001DRLRG4	ACTIVE	SOT	DRL	6	4000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	(2C7 ~ 2CR)	<a href="#">Samples</a>
TPD4E001DRSR	ACTIVE	SON	DRS	6	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZWM	<a href="#">Samples</a>

(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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side 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 Top-Side Marking for that device.

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**OTHER QUALIFIED VERSIONS OF TPD4E001 :**

- Automotive: [TPD4E001-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects



**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
TPD4E001DBVR	SOT-23	DBV	6	3000	178.0	9.2	3.3	3.2	1.55	4.0	8.0	Q3
TPD4E001DCKR	SC70	DCK	6	3000	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TPD4E001DPKR	USON	DPK	6	5000	180.0	9.5	1.75	1.75	0.7	4.0	8.0	Q2
TPD4E001DPKT	USON	DPK	6	250	180.0	9.5	1.75	1.75	0.7	4.0	8.0	Q2
TPD4E001DRLR	SOT	DRL	6	4000	180.0	9.5	1.78	1.78	0.69	4.0	8.0	Q3
TPD4E001DRLR	SOT	DRL	6	4000	180.0	8.4	1.98	1.78	0.69	4.0	8.0	Q3
TPD4E001DRSR	SON	DRS	6	1000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2

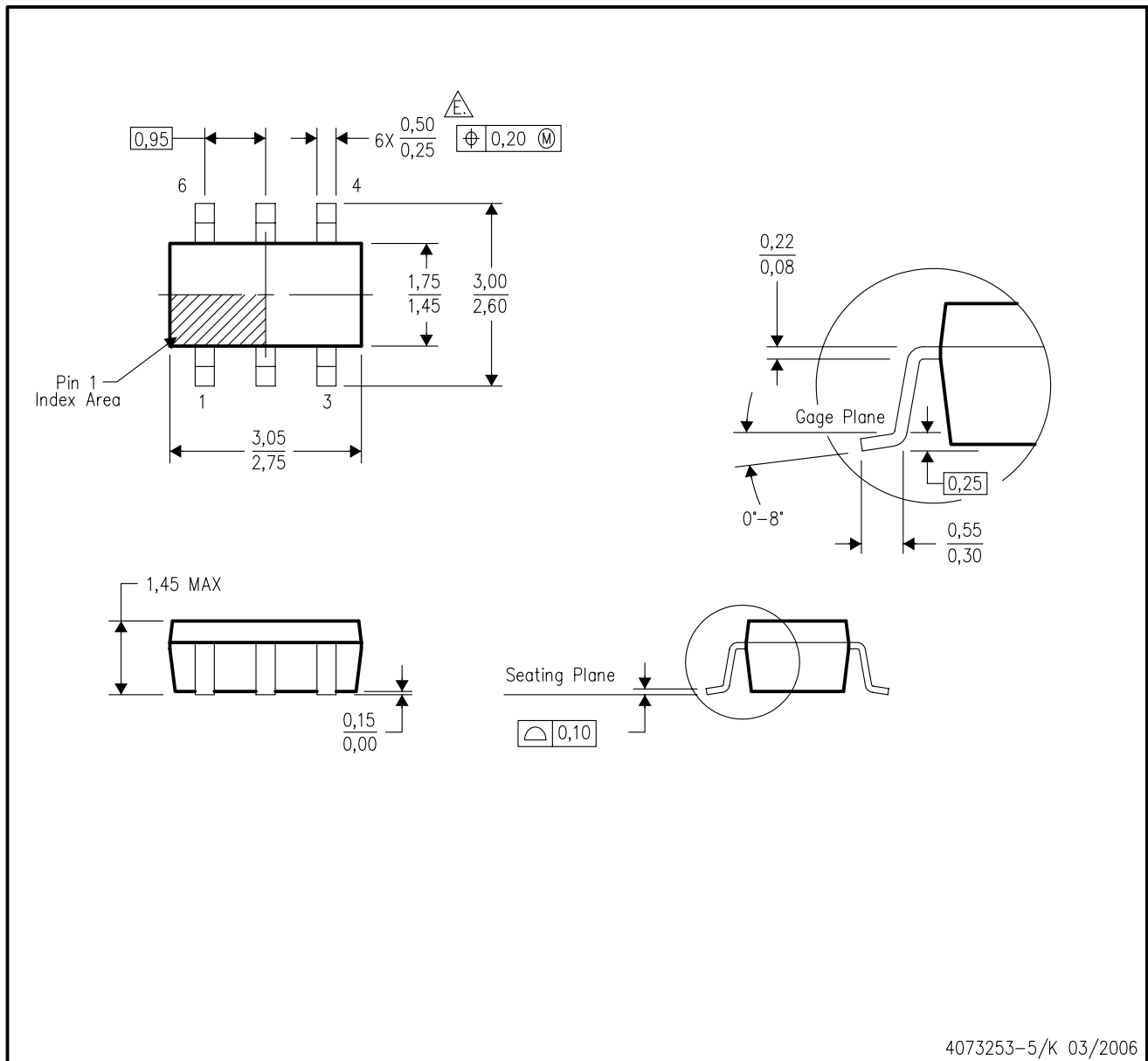
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPD4E001DBVR	SOT-23	DBV	6	3000	180.0	180.0	18.0
TPD4E001DCKR	SC70	DCK	6	3000	180.0	180.0	18.0
TPD4E001DPKR	USON	DPK	6	5000	180.0	180.0	30.0
TPD4E001DPKT	USON	DPK	6	250	180.0	180.0	30.0
TPD4E001DRLR	SOT	DRL	6	4000	180.0	180.0	30.0
TPD4E001DRLR	SOT	DRL	6	4000	202.0	201.0	28.0
TPD4E001DRSR	SON	DRS	6	1000	367.0	367.0	35.0

DBV (R-PDSO-G6)

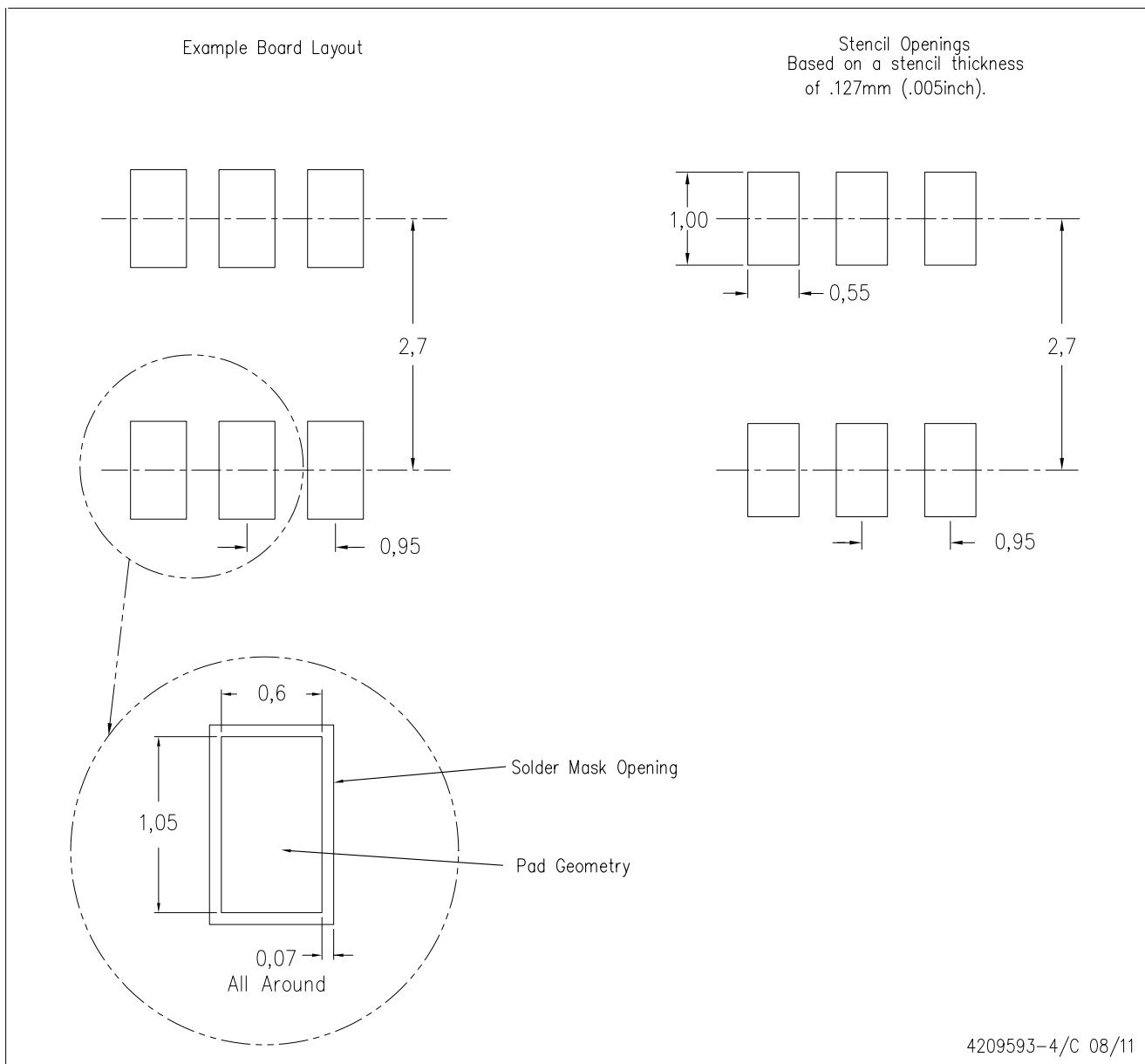
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- $\triangle E$  Falls within JEDEC MO-178 Variation AB, except minimum lead width.

DBV (R-PDSO-G6)

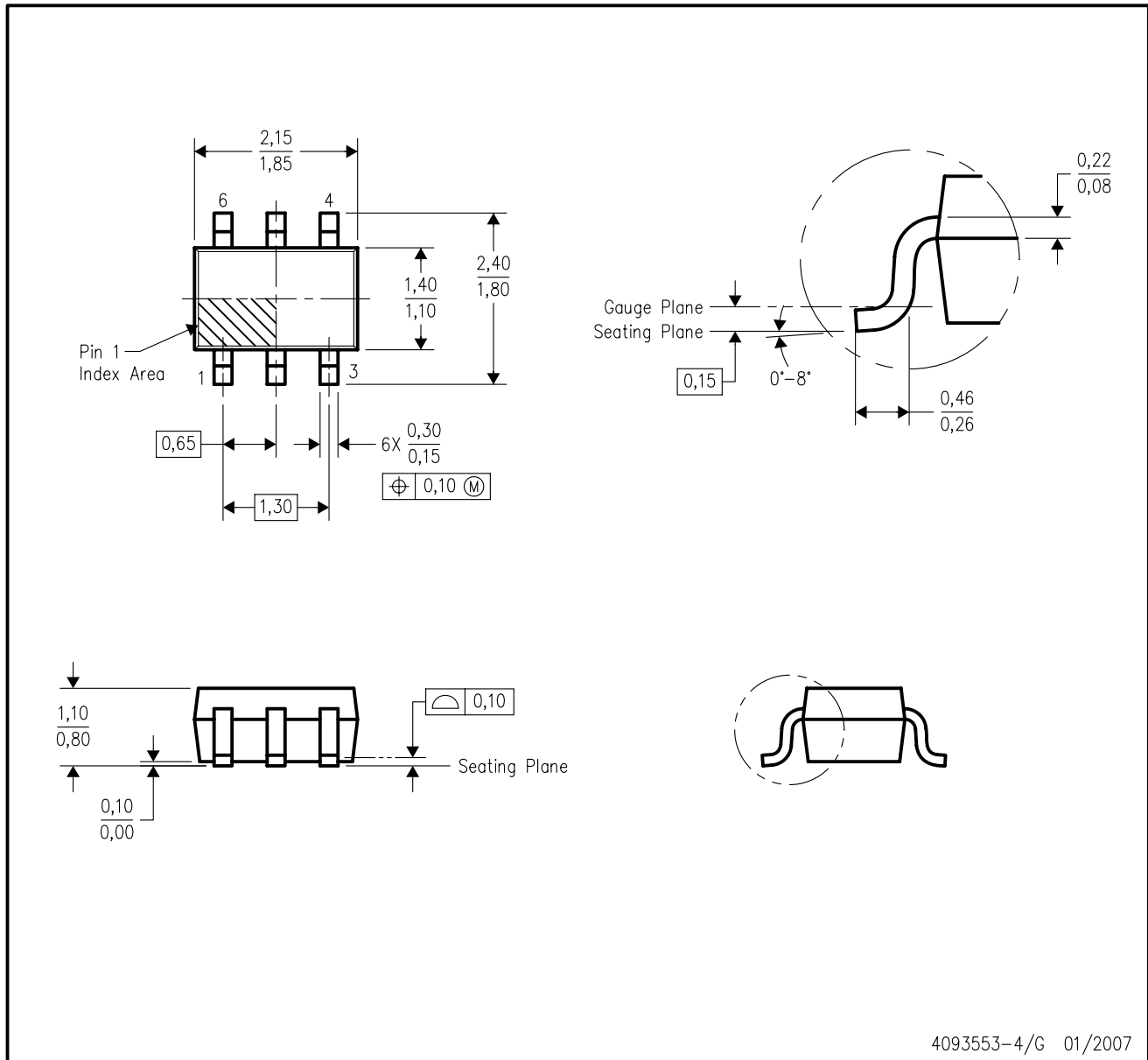
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

DCK (R-PDSO-G6)

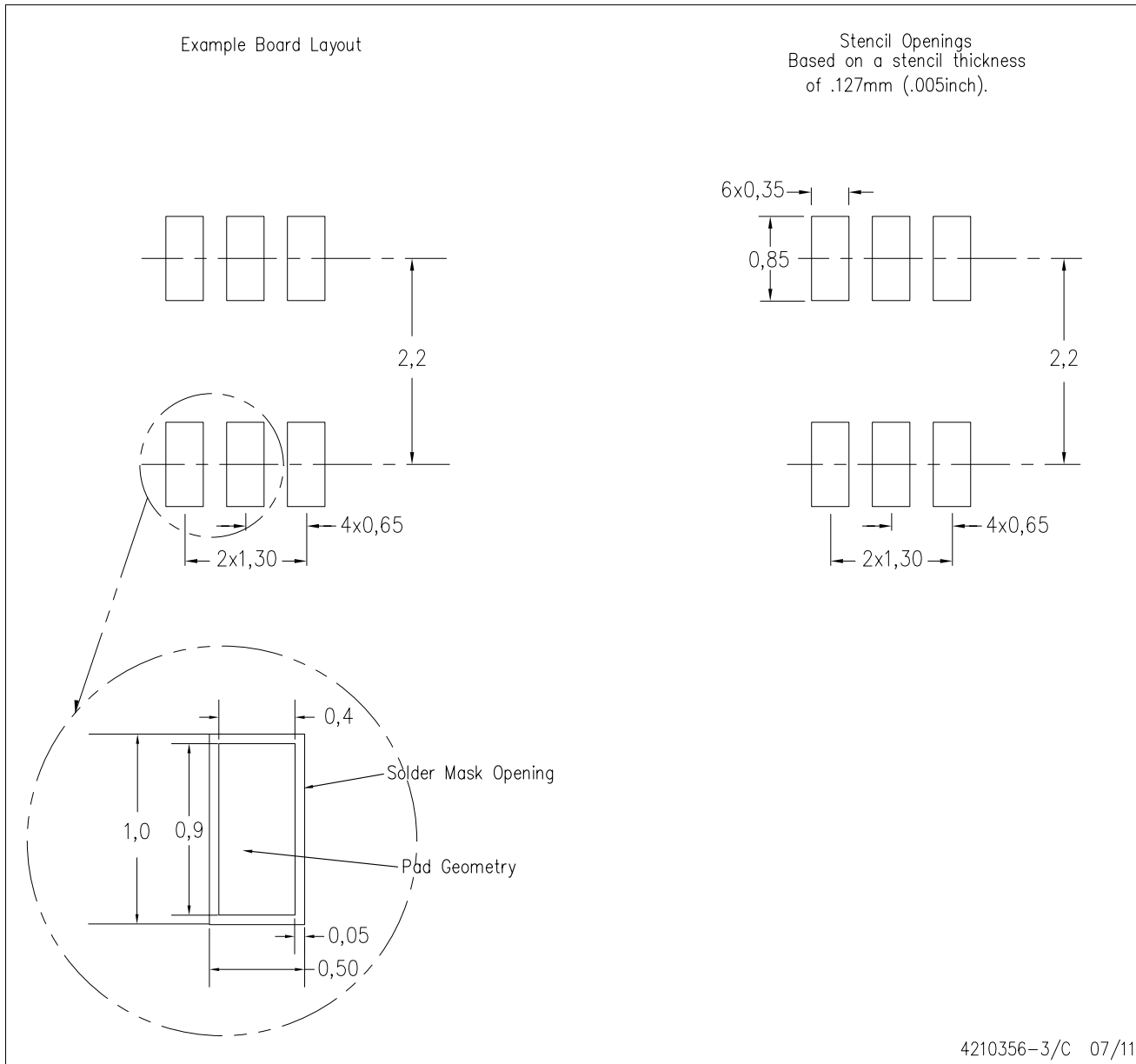
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Falls within JEDEC MO-203 variation AB.

DCK (R-PDSO-G6)

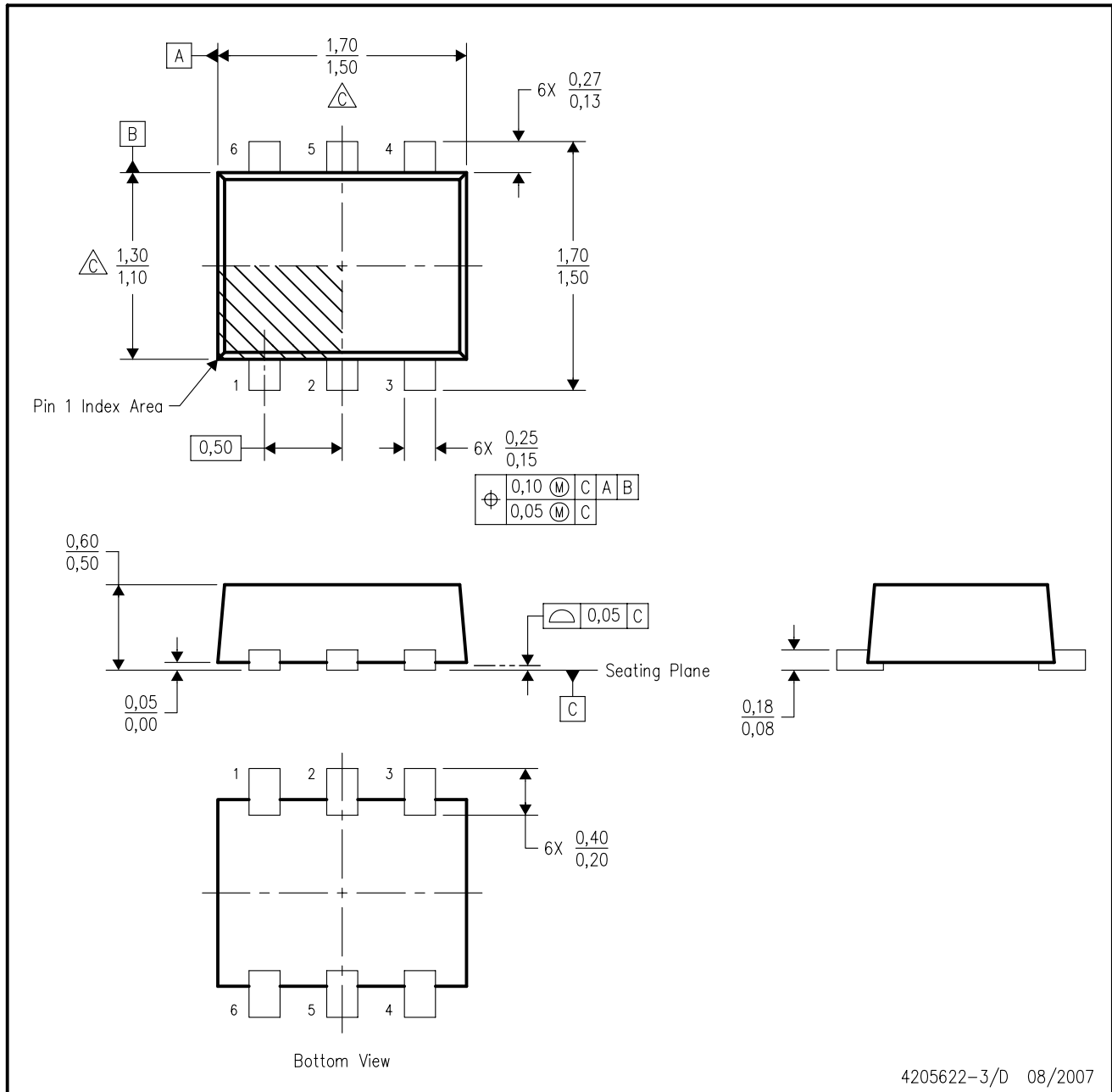
PLASTIC SMALL OUTLINE

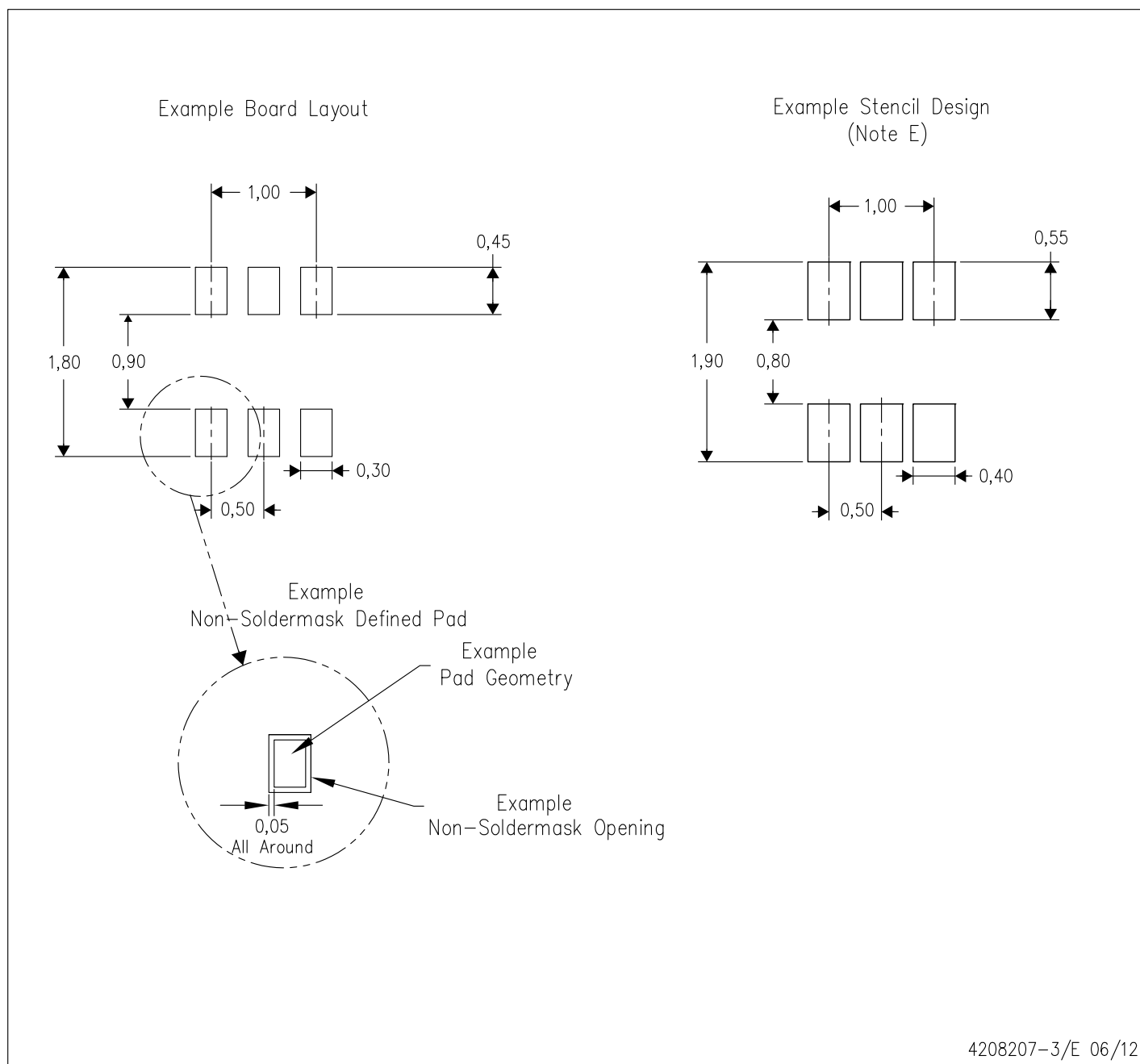


- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

DRL (R-PDSO-N6)

PLASTIC SMALL OUTLINE



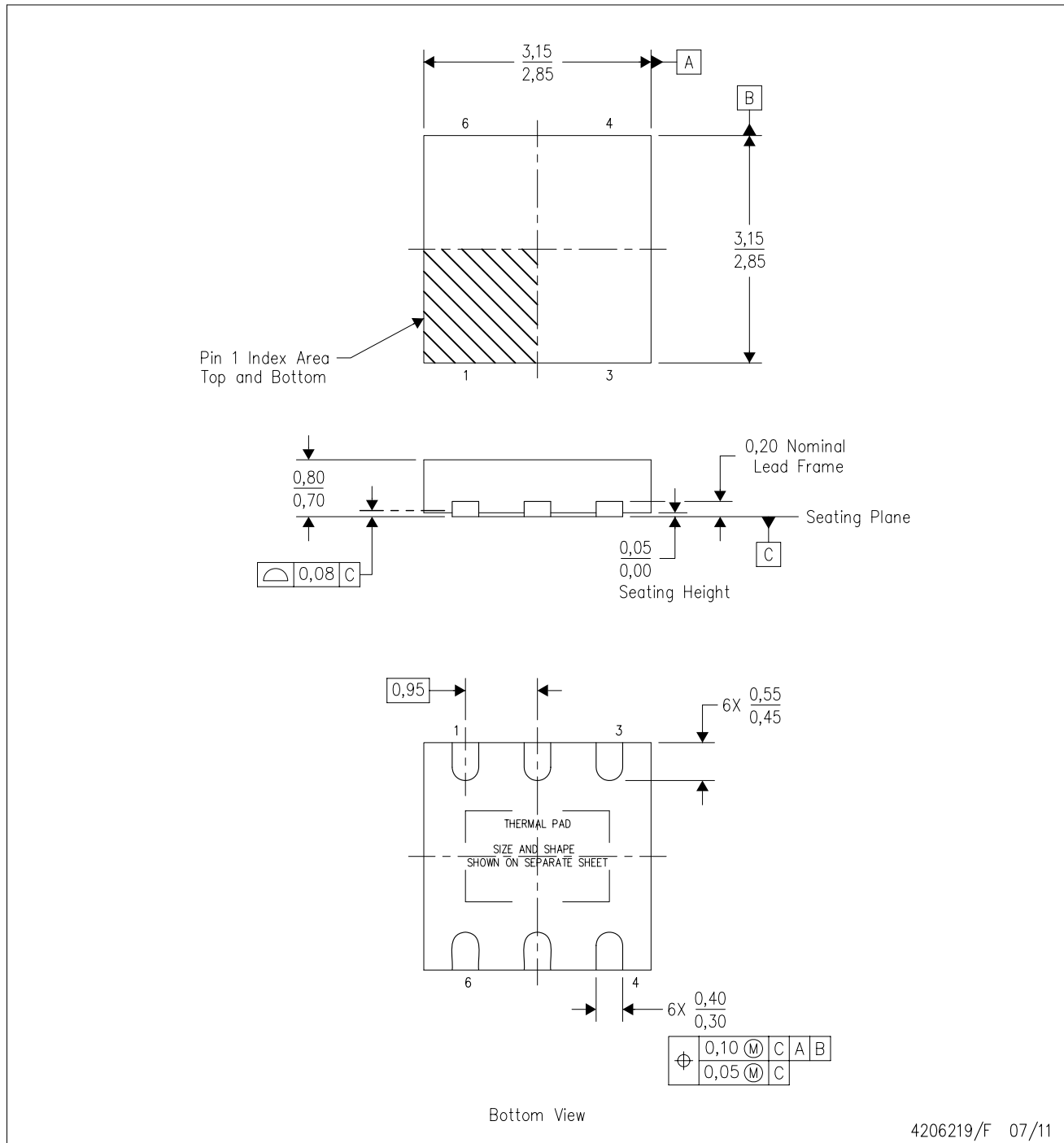


- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.
  - E. Maximum stencil thickness 0,127 mm (5 mils). All linear dimensions are in millimeters.
  - F. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
  - G. Side aperture dimensions over-print land for acceptable area ratio > 0.66. Customer may reduce side aperture dimensions if stencil manufacturing process allows for sufficient release at smaller opening.



DRS (S-PWSON-N6)

PLASTIC SMALL OUTLINE NO-LEAD



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. SON (Small Outline No-Lead) package configuration.
  - D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
  - E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.

## THERMAL PAD MECHANICAL DATA

DRS (S-PWSON-N6)

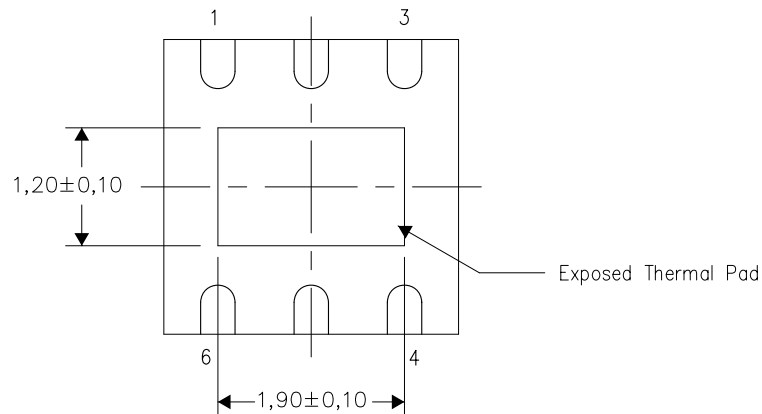
PLASTIC SMALL OUTLINE NO-LEAD

### THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

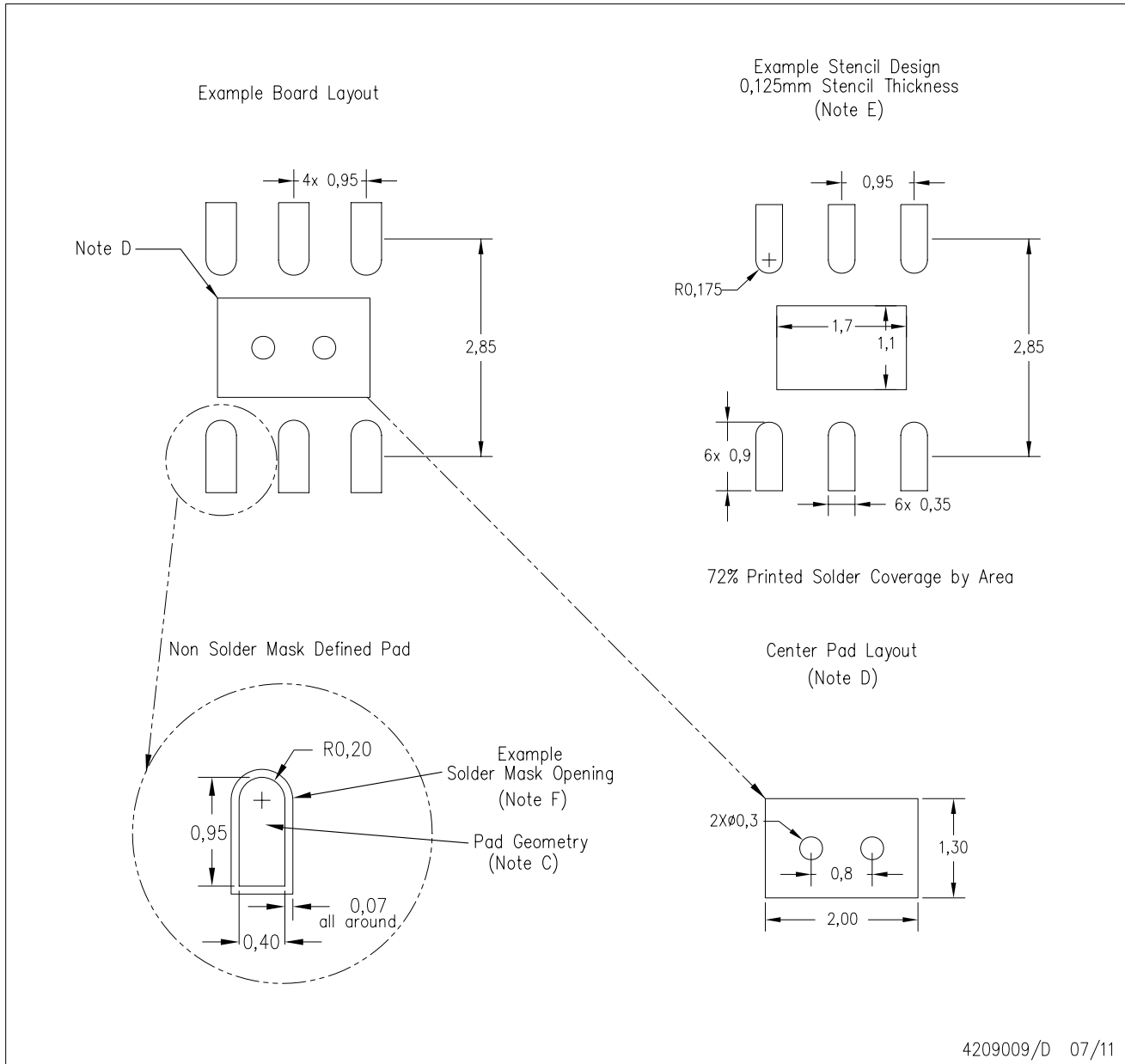
Exposed Thermal Pad Dimensions

4207663/E 07/11

NOTE: All linear dimensions are in millimeters

DRS (S-PWSON-N6)

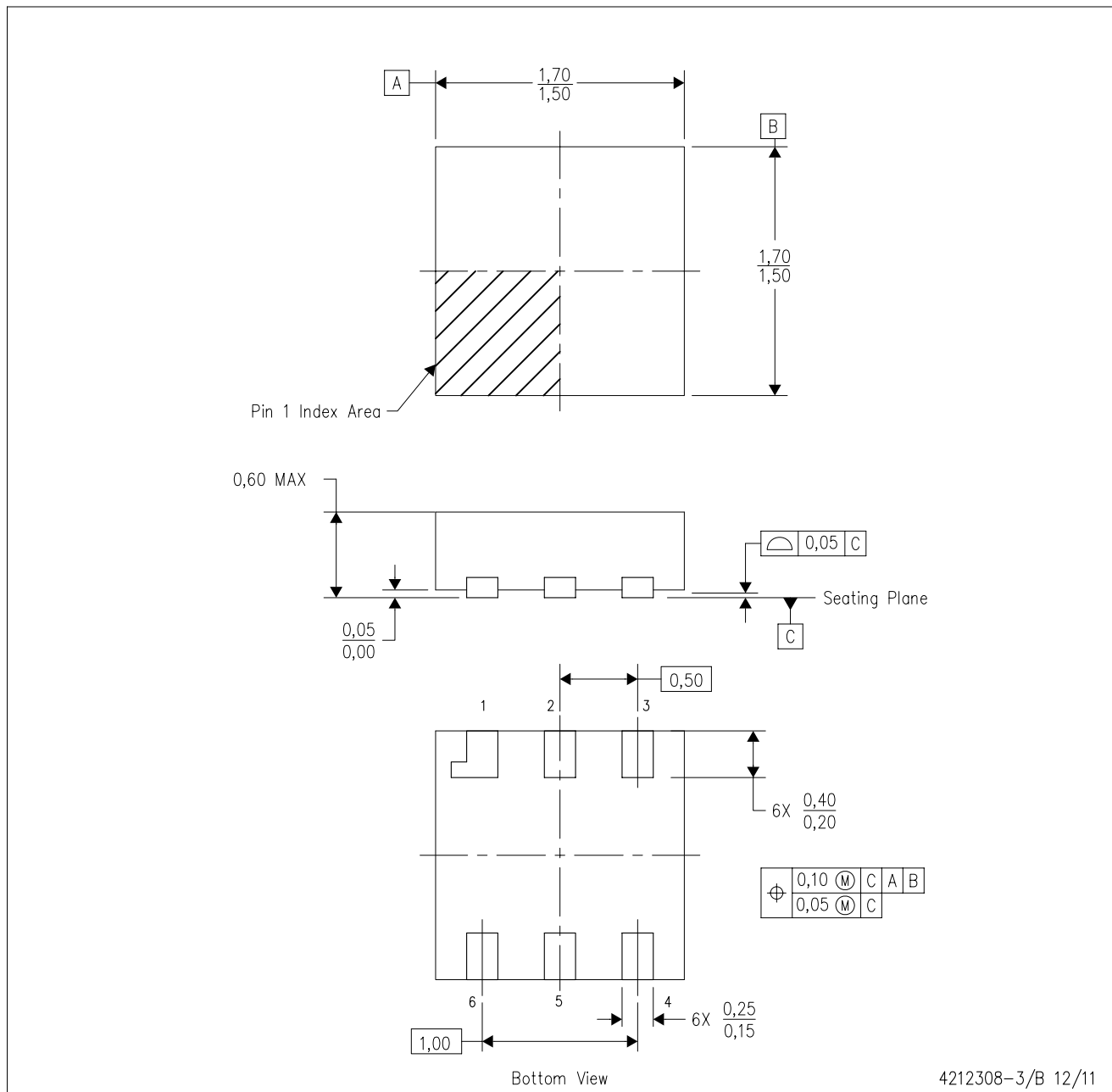
PLASTIC SMALL OUTLINE NO-LEAD



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
  - Customers should contact their board fabrication site for solder mask tolerances.

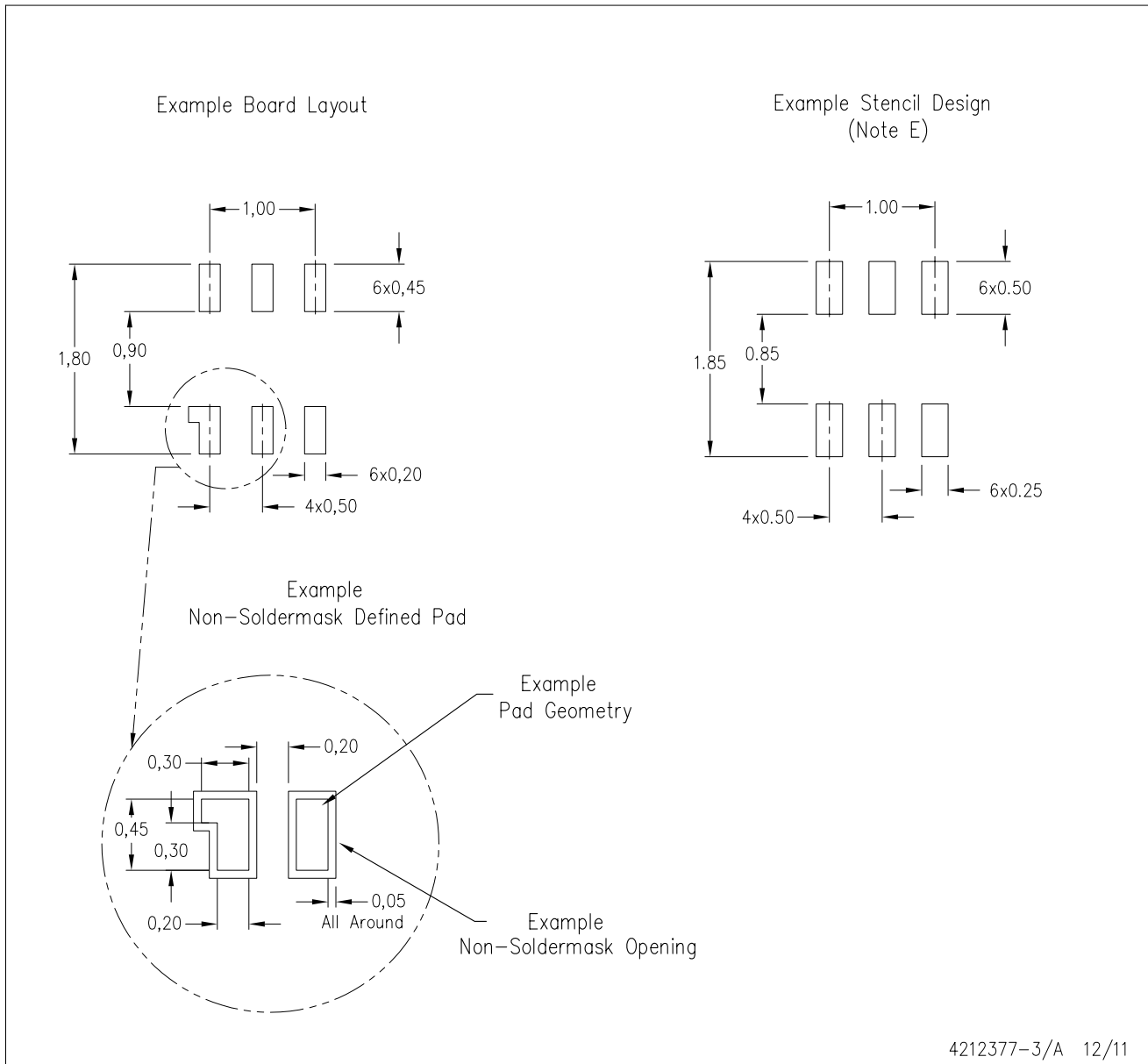
DPK (S-PUSON-N6)

PLASTIC SMALL OUTLINE NO-LEAD



4212308-3/B 12/11

NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.  
 B. This drawing is subject to change without notice.



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.
  - Maximum stencil thickness 0,127 mm (5 mils). All linear dimensions are in millimeters.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
  - Side aperture dimensions over-print land for acceptable area ratio > 0.66. Customer may reduce side aperture dimensions if stencil manufacturing process allows for sufficient release at smaller opening.

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