TPD2E007 2-Channel ESD-Protection Array for AC-Coupled/Negative-Rail Data Interfaces

1 Features

- IEC 61000-4-2 Level 4 ESD Protection
  - ±8-kV IEC 61000-4-2 Contact Discharge
  - ±15-kV IEC 61000-4-2 Air-Gap Discharge
- IEC 61000-4-5 Surge Protection
  - 4.5-A Peak Pulse Current (8/20 µs Pulse)
- IO Capacitance 15pF (max)
- Low 50-nA Leakage Current
- Space-Saving PicoStar™ and SOT Package

2 Applications

- Cell Phones
- Audio Interface Connections
- Consumer Electronics (DVR, Set-Top Box, TV)
- Industrial Interfaces (RS-232, RS-485, RS-422, LVDS)

3 Description

This device is a Transient Voltage Suppressor (TVS) based Electrostatic Discharge (ESD) protection device designed to offer system level ESD solutions for wide range of portable and industrial applications. The back-to-back diode array allows AC-coupled or negative-going data transmission (audio interface, LVDS, RS-485, RS-232, etc.) without compromising signal integrity. This device exceeds the IEC 61000-4-2 (Level 4) ESD protection and is ideal for providing system level ESD protection for the internal ICs when placed near the connector.

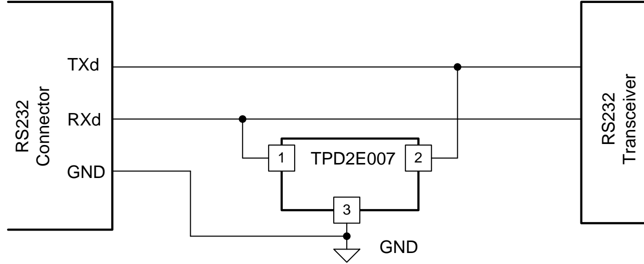
The TPD2E007 is offered in a 4-bump PicoStar and 3-pin SOT (DGK) packages. The PicoStar package (YFMG4), with only 0.15 mm (Max) package height, is recommended for ultra space saving application where the package height is a key concern. The PicoStar package can be used in either embedded PCB board applications or in surface mount applications. The industry standard SOT package offers straightforward board layout option in legacy designs.

Device Information(1)

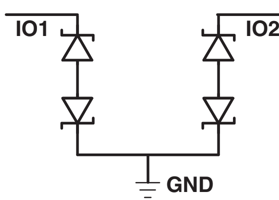
PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPD2E007	SOT (3)	2.00 mm x 1.25 mm
	PicoStar (4)	0.77 mm x 0.77 mm

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

Example Schematic



Equivalent Schematic Representation



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 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision E (August 2010) to Revision F — **Page**

- Added *Pin Configuration and Functions* section, *Handling Rating* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1

Changes from Revision D (October 2009) to Revision E — **Page**

- Added max continuous power dissipation value for DCK package 3

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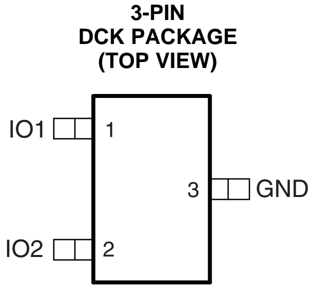
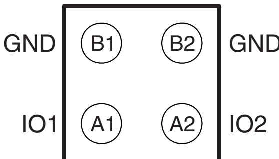
5 Pin Configuration and Functions





0.8 mm × 0.8 mm (0.4 mm pitch)

Pin Functions

PIN			I/O	DESCRIPTION
NAME	DCK NO.	YFMG4 NO.		
IO1	1	A1	IO	ESD protected channel
IO2	2	A2	IO	ESD protected channel
GND	3	B1, B2	G	Ground

6 Specifications

6.1 Absolute Maximum Ratings(1)

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

			MIN	MAX	UNIT
V_{IO}			–13.5	13.5	V
	Continuous power dissipation (T_A = 70°C)	YFM package		270	mW
		DCK package		218	
	Operating temperature range		–40	85	°C
T_J	Junction temperature			150	°C
	Bump temperature (soldering)	Infrared (15 s)		220	°C
		Vapor phase (60 s)		215	
	Lead temperature (soldering, 10 s)			300	°C

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

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6.2 Handling Ratings

				MIN	MAX	UNIT
T_{stg}	Storage temperature range			–65	150	°C
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins[1]		–15	15	kV
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins[2]		–1.5	1.5	
		IEC 61000-4-2 ESD ratings	Contact	–8	8	
			Air gap	–15	15	

(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.

6.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
Operating temperature range		-40		85	°C
V_{IO}	Operating voltage range	–13		13	V

6.4 Thermal Information

THERMAL METRIC[1]		TPD2E007		UNIT
		DCK	YFMG4	
		3 PINS	4 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	251.9	175.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	115.4	39.2	
$R_{\theta JB}$	Junction-to-board thermal resistance	42.4	28.7	
ψ_{JT}	Junction-to-top characterization parameter	9.4	8.3	
ψ_{JB}	Junction-to-board characterization parameter	42.2	28.7	
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	n/a	n/a	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

6.5 Electrical Characteristics

T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP[1]	MAX	UNIT
V_{BR}	Break-down voltage	I_{IO} = 10 mA	–14		14	V
I_{IO}	Channel leakage current			20	50	nA
R_d	Dynamic resistance			3.5		Ω
C_{IN}	Channel input capacitance	V_{IO} = 2.5 V		10	15	pF

(1) Typical values are at V_{CC} = 5 V and T_A = 25°C.

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6.6 Typical Characteristics

IEC Clamping Waveforms (20 ns/div)

Figure 1. 8-kV Contact

Figure 2. –8-kV Contact

Figure 3. Capacitance vs Input Voltage at T_A = 27°C

Figure 4. Diode Breakdown Voltage Data at T_A = 27°C

7 Detailed Description

7.1 Overview

The TPD2E007 an ESD protection device designed to offer system level ESD solutions for wide range of portable and industrial applications. The back-to-back diode array allows AC-coupled or negative-going data transmission (audio interface, LVDS, RS-485, RS-232, etc.) without compromising signal integrity. The PicoStar package is intended to be embedded inside the printed circuit board which saves board space in portable applications. This device exceeds the IEC 61000-4-2 (Level 4) ESD protection and is ideal for providing system level ESD protection for the internal ICs when placed near the connector.

7.2 Functional Block Diagram

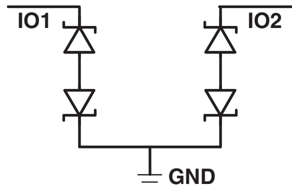

Figure 5. Equivalent Schematic Representation

7.3 Feature Description

The TPD2E007 an ESD protection device designed to offer system level ESD solutions for wide range of portable and industrial applications. The back-to-back diode array allows AC-coupled or negative-going data transmission (audio interface, LVDS, RS-485, RS-232, etc.) without compromising signal integrity. The PicoStar package is intended to be embedded inside the printed circuit board which saves board space in portable applications. This device exceeds the IEC 61000-4-2 (Level 4) ESD protection and is ideal for providing system level ESD protection for the internal ICs when placed near the connector.

7.3.1 IEC 61000-4-2 Level 4 ESD Protection

The I/O pins can withstand ESD events up to ±12-kV contact and ±15 kV-air. An ESD/surge clamp diverts the current to ground.

7.3.2 IEC 61000-4-5 Surge Protection

The I/O pins can withstand surge events up to 4.5 A (8/20 µs waveform). An ESD/surge clamp diverts this current to ground.

7.3.3 IO Capacitance

The capacitance between each I/O pin to ground is 15 pF.

7.3.4 Low 50-nA Leakage Current

The I/O pins feature a low 50-nA (max) leakage current.

7.3.5 Space-Saving PicoStar and SOT Package

This device is offered in both a space-saving PicoStar package, as well as a standard DCK package.

7.4 Device Functional Modes

TPD2E007 is a passive integrated circuit that triggers when voltages are above or below V_{BR}. During ESD events, voltages as high as ±15 kV (air) can be directed to ground via the internal diode network. Once the voltages on the protected line fall below the trigger levels of TPD2E007 (usually within 10’s of nano-seconds) the device reverts to passive.

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8 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.

8.1 Application Information

TPD2E007 is a diode type TVS which is typically used to provide a path to ground for dissipating ESD events on signal lines between a human interface connector and a system. As the current from ESD passes through the TVS, only a small voltage drop is present across the diode. This is the voltage presented to the protected IC.

8.2 Typical Application

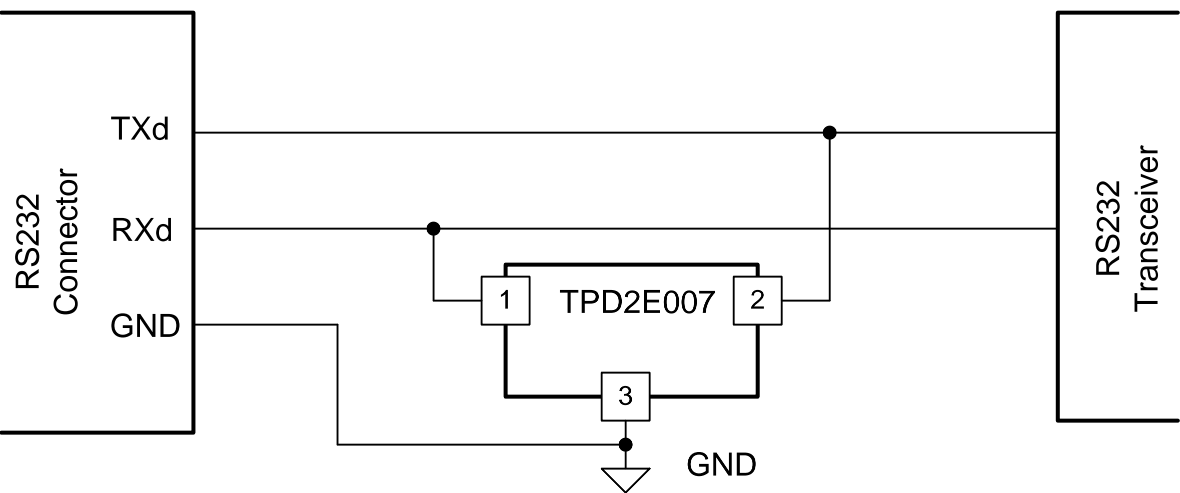

Figure 6. Example Schematic

8.2.1 Design Requirements

For this design example, a single TPD2E007 is used to protect an RS232 3-wire connector.

Given the application, the following parameters are known.

DESIGN PARAMETER	VALUE
Signal range on all pins except GND	–12 V to 12V
Surge Withstand - IEC 61000-4-5	150 W

8.2.2 Detailed Design Procedure

To begin the design process, some parameters must be decided upon; the designer needs to know the following:

- Signal voltage range on all protected lines
- Surge Withstand

8.2.2.1 Signal range on IO1 and IO2 pins

The TPD2E007 has 2 IO pins which can support up to ±13 V.

8.2.2.2 Surge Withstand

The TPD2E007 can withstand up to 170W of IEC 61000-4-5 8/20μs surge.

8.2.3 Application Curves

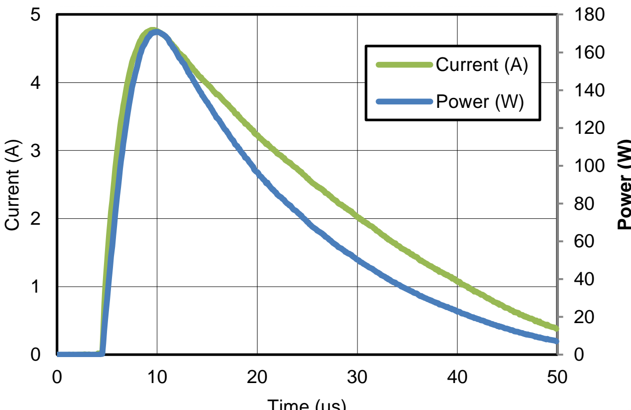

Figure 7. Surge Pulse Waveform

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9 Power Supply Recommendations

This device is a passive ESD device so there is no need to power it. Care should be taken to not violate the recommended I/O specification (±13 V) to ensure the device functions properly.

10 Layout

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

10.2 Layout Example

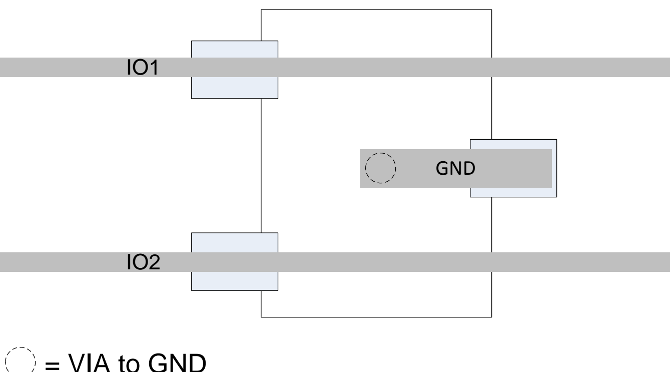

Figure 8. Layout Example

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11 Device and Documentation Support

11.1 Trademarks

PicoStar is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.2 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.3 Glossary

SLYZ022 — *TI Glossary*.

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

12 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.

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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
TPD2E007DCKR	ACTIVE	SC70	DCK	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	45U	Samples
TPD2E007YFMR	PREVIEW	DSLGA	YFM	4		TBD	Call TI	Call TI	-40 to 85		
TPD2E007YFMRG4	ACTIVE	DSLGA	YFM	4	3000	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM	-40 to 85	45 T	Samples
TPD2E007YFMTG4	ACTIVE	DSLGA	YFM	4	250	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM	-40 to 85	45 T	Samples

(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) 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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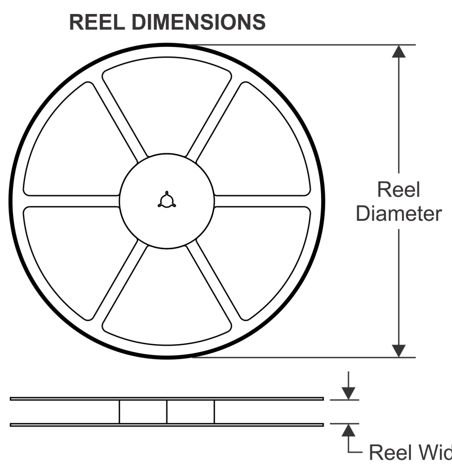
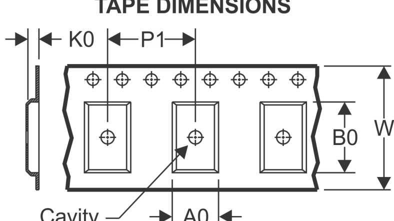
TAPE AND REEL INFORMATION

REEL DIMENSIONS

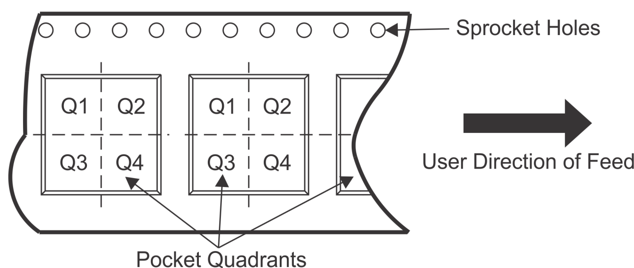


TAPE DIMENSIONS



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

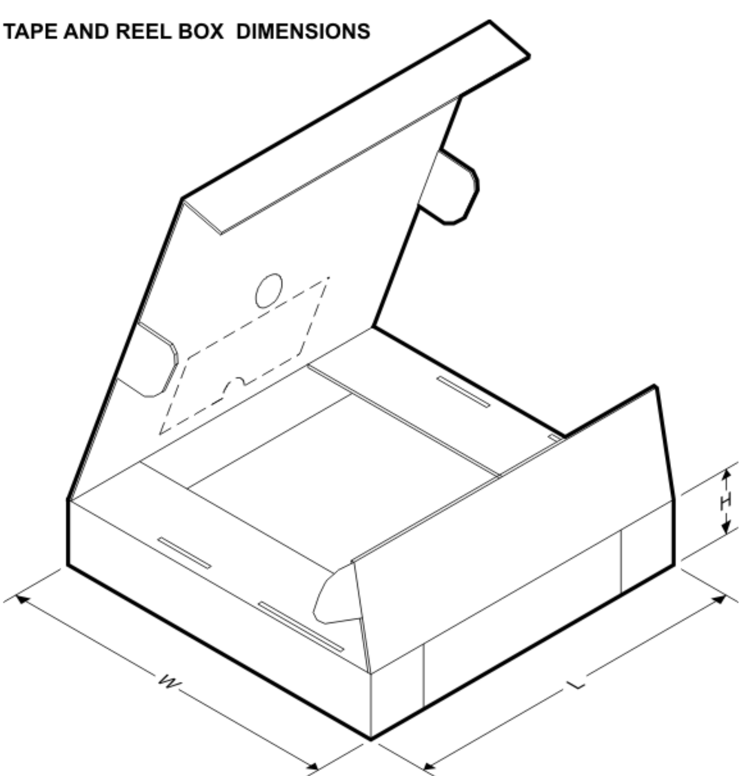
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPD2E007DCKR	SC70	DCK	3	3000	179.0	8.4	2.4	2.4	1.19	4.0	8.0	Q3
TPD2E007YFMRG4	DSLGA	YFM	4	3000	178.0	9.2	0.83	0.83	0.19	4.0	8.0	Q1
TPD2E007YFMTG4	DSLGA	YFM	4	250	178.0	9.2	0.83	0.83	0.19	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPD2E007DCKR	SC70	DCK	3	3000	195.0	200.0	45.0
TPD2E007YFMRG4	DSLGA	YFM	4	3000	220.0	220.0	35.0
TPD2E007YFMTG4	DSLGA	YFM	4	250	220.0	220.0	35.0

DCK (R-PDSO-G3) PLASTIC SMALL-OUTLINE PACKAGE

2,15
1,85
3
2,40
1,80
1,40
1,10
Pin 1
Index Area
1 2
0,65
3X 0,30
0,15
0,10 Ⓜ
1,30
0,22
0,08
Gauge Plane
Seating Plane
0,15
0°–8°
0,46
0,26
1,10
0,80
0,10
0,00
0,10
Seating Plane

4093553-2/G 01/2007

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.

YFM (S–pSTAR–N4) PicoStar™

4209106–2/L 02/14

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. PicoStar™ package configuration.
D. The package size (Dimension D and E) of a particular device is specified in the device Product Data Sheet version of this drawing, in case it cannot be found in the product data sheet please contact a local TI representative.
E. Reference Product Data Sheet for array population. 2 x 2 matrix pattern is shown for illustration only.
F. This package is a Pb–free solder land design.

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