











TPD4E1U06 SLVSBQ9D - DECEMBER 2012 - REVISED APRIL 2017

TPD4E1U06 Quad-Channel, High-Speed ESD Protection Device

Features

- IEC 61000-4-2 Level 4 ESD Protection
 - ±15-kV Contact Discharge
 - ±15-kV Air-Gap Discharge
- IEC 61000-4-4 EFT Protection
 - 80 A (5/50 ns)
- IEC 61000-4-5 Surge Protection
 - 3 A (8/20 μ s)
- IO Capacitance 0.8 pF (Typical)
- DC Breakdown Voltage 6.5 V (Minimum)
- Ultra Low Leakage Current 10 nA (Maximum)
- Low ESD Clamping Voltage
- Industrial Temperature Range: -40°C to +125°C
- Small, Easy-to-Route DCK, and DBV Package

Applications

- **USB 2.0**
- Ethernet
- **HDMI Control Lines**
- MIPI Bus
- **LVDS**
- SATA

3 Description

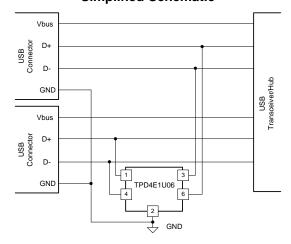
The TPD4E1U06 is a quad-channel unidirectional Voltage Suppressor (TVS) Electrostatic Discharge (ESD) protection diode with ultra low capacitance. This device can dissipate ESD strikes above the maximum level specified by the IEC 61000-4-2 international standard. Its 0.8-pF line capacitance makes it suitable for a wide range of applications. Typical application areas include HDMI, USB2.0, MHL, and DisplayPort.

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)		
TPD4E1U06DCK	SC70	2.00 mm x 1.25 mm		
TPD4E1U06DBV	SOT-23	2.90 mm × 1.60 mm		

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

Simplified Schematic



Circuit Schematic Diagram

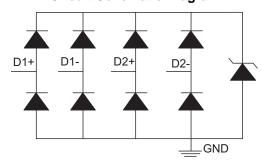




Table of Contents

1	Features 1		7.4 Device Functional Modes	9
2	Applications 1	8	Application and Implementation	10
3	Description 1		8.1 Application Information	. 10
4	Revision History2		8.2 Typical Application	. 10
5	Pin Configuration and Functions3	9	Power Supply Recommendations	12
6	Specifications4	10	Layout	12
Ū	6.1 Absolute Maximum Ratings		10.1 Layout Guidelines	. 12
	6.2 ESD Ratings		10.2 Layout Example	. 12
	6.3 ESD Ratings—IEC Specification	11	Device and Documentation Support	13
	6.4 Recommended Operating Conditions		11.1 Documentation Support	. 13
	6.5 Thermal Information		11.2 Receiving Notification of Documentation Updates	13
	6.6 Electrical Characteristics5		11.3 Community Resources	. 13
	6.7 Typical Characteristics		11.4 Trademarks	. 13
7	Detailed Description 8		11.5 Electrostatic Discharge Caution	. 13
	7.1 Overview 8		11.6 Glossary	. 13
	7.2 Functional Block Diagram 8	12	Mechanical, Packaging, and Orderable	
	7.3 Feature Description 8		Information	13
	-			

4 Revision History

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

CI	nanges from Revision C (October 2014) to Revision D	Page
•	Updated DCK and DBV Pinout image	3
•	Added 61000-4-5 spec to Absolute Maximum Ratings table	4
•	Added IEC 61000-4-5 Surge Protection section	8
•	Added IEC 61000-4-4 EFT Protection section	
CI	nanges from Revision B (February 2013) to Revision C	Page
CI	Added Pin Configuration and Functions section, Handling Rating table, Feature Description section, Device Functional Modes, Application and Implementation section, Power Supply Recommendations section, Layout	Page
CI	Added Pin Configuration and Functions section, Handling Rating table, Feature Description section, Device	
•	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	

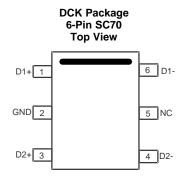
Added C_{CROSS} data for DBV package......5

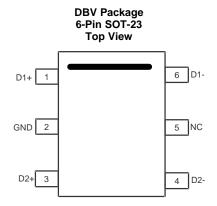
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5 Pin Configuration and Functions





Pin Functions

	PIN	I/O	DESCRIPTION			
NAME	NO.	1/0	DESCRIPTION			
D1+	1	I/O				
D1-	6	I/O	ESD protected channel. Connect to data line as close			
D2-	4	I/O	to the connector as possible			
D2+	3	I/O				
GND	2	GND	Ground. Connect to ground			
NC	5	I/O	No connect. Can be left floating, grounded, or connected to VCC			

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6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
	IEC 61000-4-4 EFT protection (5/50 ns)		80	Α
I _{PP}	IEC 61000-4-5 surge protection (8/20 μs) peak pulse current		3	Α
P _{PP}	IEC 61000-4-5 surge protection (8/20 μs) peak pulse power		45	W
	Operating temperature	-40	125	°C
T _{stg}	Storage temperature	-65	115	°C

⁽¹⁾ Stresses beyond those listed under Absolute Maximum Ratings 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 Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 ESD Ratings

			VALUE	UNIT
.,	Clastrostatia disebarga	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins (1)	±4000	V
V _{(ESE}	Electrostatic discharge	Charged device model (CDM), per JEDEC specification JESD22-C101, all pins (2)	±1500	V

⁽¹⁾ JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 ESD Ratings—IEC Specification

			VALUE	UNIT
V	Electrostatio discharge	IEC 61000-4-2 contact ESD	±15000	V
V(ESD)	V _(ESD) Electrostatic discharge	IEC 61000-4-2 air-gap ESD	±15000	V

6.4 Recommended Operating Conditions

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

		MIN	MAX	UNIT
V_{IO}	Input pin voltage	0	5.5	V
T _A	Operating free-air temperature	-40	125	°C

6.5 Thermal Information

		TPD4		
	THERMAL METRIC ⁽¹⁾	DBV (SOT-23)	DCK (SC-70)	UNIT
		6 PINS	6 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	224.3	274.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	166.1	113.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	68.4	76.7	°C/W
ΨЈТ	Junction-to-top characterization parameter	57.3	3.6	°C/W
ΨЈВ	Junction-to-board characterization parameter	67.9	75.9	°C/W

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

Product Folder Links: TPD4E1U06

⁽²⁾ JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.



6.6 Electrical Characteristics

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

	PARAMETER	TEST CONDITIONS			TYP	MAX	UNIT
V _{RWM}	Reverse stand-off voltage	I _{IO} = 10 μA			5.5	٧	
	Clamp voltage with ESD	$I_{PP} = 1 \text{ A, tp} = 8/20 \ \mu\text{s, from I/O to GND}^{(1)}$			11		V
V_{CLAMP}	strike	$I_{PP} = 3 \text{ A, tp} = 8/20 \ \mu\text{s, from I/O to GND}^{(1)}$			15		V
D	D	Pin x to GND pin ⁽²⁾			1.0		
R_{DYN}	Dynamic resistance	GND to pin x		0.6		Ω	
C _L	Line capacitance	f = 1 MHz, V _{BIAS} = 2.5 V, 25°C			0.8	1	pF
0	Channel to channel input	Pin 2 = 0 V, f = 1 MHz, V _{BIAS} = 2.5 V, between	DCK package		0.006	0.015	-
C _{CROSS}	capacitance	channel pins	DBV package		0.01	0.025	pF
$\Delta C_{\text{IO-TO-GND}}$	Variation of channel input capacitance	Pin 2 = 0 V , f = 1 MHz, V_{BIAS} = 2.5 V, channel_x pin to ground – channel_y pin to ground			0.025	0.07	pF
V_{BR}	Break-down voltage, IO to GND	I _{IO} = 1 mA	6.5		8.5	٧	
I _{LEAK}	Leakage current	V _{IO} = 2.5 V			1	10	nA

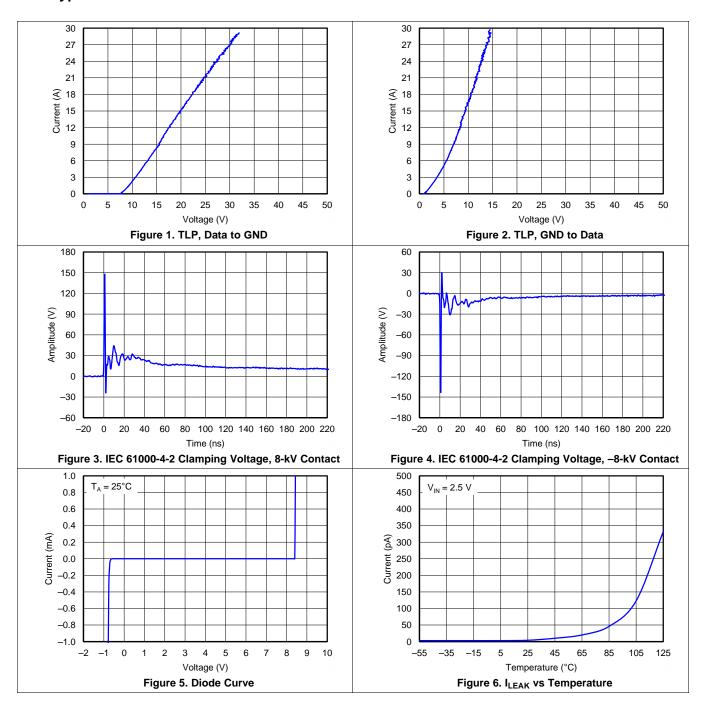
⁽¹⁾ Non-repetitive current pulse 8/20 μs exponentially decaying waveform according to IEC61000-4-5.

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⁽²⁾ Extraction of R_{DYN} using least squares fit of TLP characteristics between I = 10 A and I = 20 A.

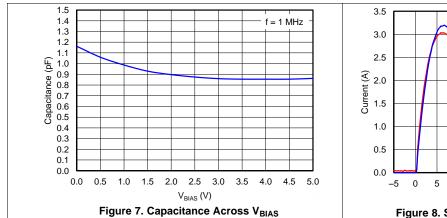


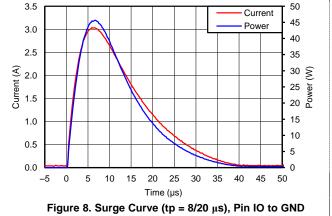
6.7 Typical Characteristics





Typical Characteristics (continued)





7 Detailed Description

7.1 Overview

The TPD4E1U06 is a quad channel unidirectional TVS ESD protection diode with ultra low capacitance. This device can dissipate ESD strikes above the maximum level specified by the IEC 61000-4-2 international standard. Typical application areas include HDMI, USB2.0, MHL, and DisplayPort. Its 0.8-pF line capacitance makes it suitable for a wide range of applications.

7.2 Functional Block Diagram

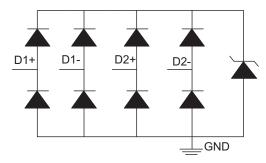


Figure 9. Circuit Schematic Diagram

7.3 Feature Description

7.3.1 IEC 61000-4-2 Level 4 ESD Protection

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

7.3.2 IEC 61000-4-5 Surge Protection

The IO pins can withstand surge events up to 3 A and 45 W (8/20- μ s waveform). An ESD-surge clamp diverts this current to ground.

7.3.3 IEC 61000-4-4 EFT Protection

The IO pins can withstand an electrical fast transient burst of up to 80 A (5/50-ns waveform, 4 kV with $50-\Omega$ impedance). An ESD-surge clamp diverts the current to ground.

7.3.4 IO Capacitance

The capacitance between each I/O pin to ground is 0.8 pF.

7.3.5 DC Breakdown Voltage

The DC breakdown voltage of each I/O pin is a minimum of 6.5 V. This ensures that sensitive equipment is protected from surges above the reverse standoff voltage of 5.5 V.

7.3.6 Ultra Low Leakage Current

The I/O pins feature an ultra-low leakage current of 10 nA (Maximum) with a bias of 2.5 V.

7.3.7 Low ESD Clamping Voltage

The I/O pins feature an ESD clamp that is capable of clamping the voltage to 11 V (IPP = 1 A).

7.3.8 Industrial Temperature Range

This device features an industrial operating range of -40°C to +125°C.

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Feature Description (continued)

7.3.9 Small, Easy-to-Route Packages

The layout of this device makes it simple to add protection to the design. Industry standard packages allow for easy additions to the board and easy layout.

7.4 Device Functional Modes

The TPD4E1U06 is a passive integrated circuit that triggers when voltages are above V_{BR} or below the forward diode drop. During ESD events, voltages as high as ± 15 kV can be directed to ground via the internal diode network. Once the voltages on the protected line fall below the trigger levels of TPD4E1U06 (usually within 10s of nano-seconds) the device reverts to passive.

Product Folder Links: TPD4E1U06



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

The TPD4E1U06 is a TVS diode array which is typically used to provide a path to ground for dissipating ESD events on hi-speed 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. The low R_{DYN} of the triggered TVS holds this voltage, V_{CLAMP} , to a safe level for the protected IC.

8.2 Typical Application

For this design example, one TPD4E1U06 device is being used in a dual USB 2.0 application. This provides a complete port protection scheme.

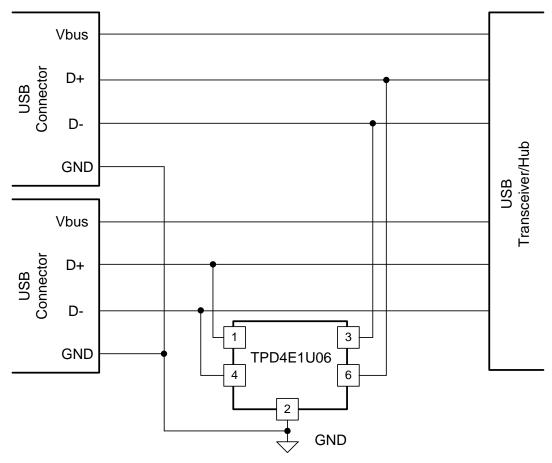


Figure 10. Dual USB 2.0 Application



Typical Application (continued)

8.2.1 Design Requirements

Given the USB 2.0 application, the parameters in Table 1 are known.

Table 1. Design Parameters

DESIGN PARAMETER	VALUE
Signal range on pins 1, 3, 4, or 6	0 V to 5 V
Operating frequency	240 MHz

8.2.2 Detailed Design Procedure

8.2.2.1 Signal Range on Pins 1, 3, 4, or 6

The TPD4E1U06 has 4 identical protection channels for signal lines. The symmetry of the device provides flexibility when selecting which of the 4 I/O channels protect which signal lines. Any I/O supports a signal range of 0 to 5.5 V.

8.2.2.2 Operating Frequency

The TPD4E1U06 has a capacitance of 0.8 pF (typical), supporting USB 2.0 data rates.

8.2.3 Application Curve

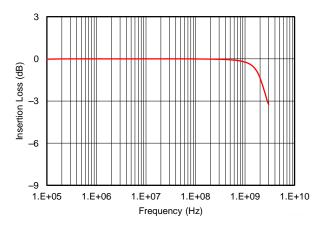


Figure 11. Insertion Loss Graph

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9 Power Supply Recommendations

This device is a passive ESD device so there is no need to power it. Take care not to violate the recommended I/O specification (0 V to 5.5 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

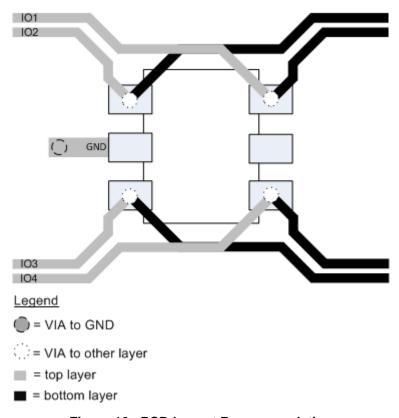


Figure 12. PCB Layout Recommendation



11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation see the following:

- Reading and Understanding an ESD Protection Datasheet
- ESD Layout Guide
- TTPD4E1U06DCK EVM User's Guide
- TPD4E1U06DBV EVM Userf's Guide

11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates—including silicon errata—go to the product folder for your device on ti.com. In the upper right-hand corner, click the *Alert me* button. This registers you to receive a weekly digest of product information that has changed (if any). For change details, check the revision history of any revised document.

11.3 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.

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

11.4 Trademarks

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11.5 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.

11.6 Glossary

SLYZ022 — TI Glossarv.

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.

Product Folder Links: TPD4E1U06

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PACKAGING INFORMATION

Orderable part number	Status	Material type	Package Pins	Package qty Carrier	RoHS	Lead finish/	MSL rating/	Op temp (°C)	Part marking
	(1)	(2)			(3)	Ball material	Peak reflow		(6)
						(4)	(5)		
TPD4E1U06DBVR	Active	Production	SOT-23 (DBV) 6	3000 LARGE T&R	Yes	NIPDAU SN	Level-1-260C-UNLIM	-40 to 125	(NG4, NG4P)
TPD4E1U06DBVR.B	Active	Production	SOT-23 (DBV) 6	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	(NG4, NG4P)
TPD4E1U06DCKR	Active	Production	SC70 (DCK) 6	3000 LARGE T&R	Yes	NIPDAU SN	Level-1-260C-UNLIM	-40 to 125	(BP6, BP8, BPI)
									(BPP, BPP, BPS)
TPD4E1U06DCKR.B	Active	Production	SC70 (DCK) 6	3000 LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	(BP6, BP8, BPI)
									(BPP, BPP, BPS)

⁽¹⁾ Status: For more details on status, see our product life cycle.

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

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⁽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.

PACKAGE MATERIALS INFORMATION

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TAPE AND REEL INFORMATION





	-
A0	Dimension designed to accommodate the component width
В0	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		SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPD4E1U06DBVR	SOT-23	DBV	6	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPD4E1U06DCKR	SC70	DCK	6	3000	180.0	8.4	2.3	2.5	1.2	4.0	8.0	Q3

PACKAGE MATERIALS INFORMATION

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*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPD4E1U06DBVR	SOT-23	DBV	6	3000	210.0	185.0	35.0
TPD4E1U06DCKR	SC70	DCK	6	3000	210.0	185.0	35.0





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. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.25 per side.

- 4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- 5. Refernce JEDEC MO-178.





NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.





NOTES: (continued)

- 8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
- 9. Board assembly site may have different recommendations for stencil design.







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. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.

 4. Falls within JEDEC MO-203 variation AB.





NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.

6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.





NOTES: (continued)

- 7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
- 8. Board assembly site may have different recommendations for stencil design.



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