



## TPD3F303 ESD Protection and EMI Filter for SIM Card Interface

### 1 Features

- Bidirectional EMI Filtering and Line Termination With Integrated ESD Protection
  - –3-dB Bandwidth 300 MHz
- IEC 61000-4-2 Level 4 ESD Protection
  - $\pm 15$ -kV Contact Discharge
  - $\pm 15$ -kV Air Gap Discharge
- DC Breakdown Voltage: 6 V (Minimum)
- Low Leakage Current: 0.1  $\mu$ A (Maximum)
- Low Noise C-R-C Filter Topology
- Integrated  $V_{CC}$  Clamp Eliminates the Need for External ESD Protection
- Space-Saving DPV (0.5-mm Pitch), DQD Packages (0.4-mm Pitch)

### 2 Applications

- End Equipment
  - Cell Phones
  - Tablets
  - PDAs
  - Hotspots
- Interfaces
  - SIM Cards

### 3 Description

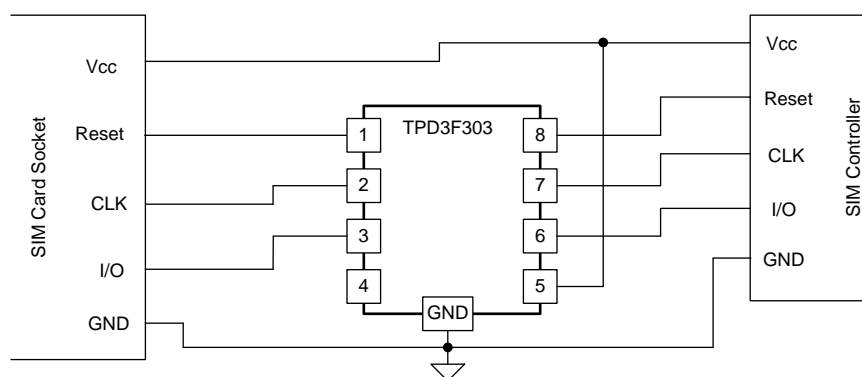
The TPD3F303 device is a highly-integrated device that provides a three-channel Electromagnetic Interference (EMI) filter and a Transient Voltage Suppressor (TVS) based ESD protection diode array. The C-R-C based low-pass filter provides EMI protection for the data, clock, and reset lines of a SIM Card interface. Furthermore, the four-channel TVS Diode array provides IEC 61000-4-2 level 4 ESD protection for the previously mentioned signals (data, clock, reset) and the  $V_{CC}$  power line. The TPD3F303 contains a 47- $\Omega$  termination resistor for the clock line and 100- $\Omega$  termination resistor for both the data and reset lines. The high level of integration offered by the TPD3F303 makes the device well-suited for applications like cell phones, tablets, hotspots, and PDAs.

**Device Information<sup>(1)</sup>**

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPD3F303	WSON (8)	1.35 mm x 1.70 mm
	USON (8)	1.60 mm x 2.10 mm

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

**Typical Application Schematic**



Copyright © 2016, Texas Instruments Incorporated



## Table of Contents

<b>1 Features</b> .....	<b>1</b>	7.3 Feature Description .....	<b>6</b>
<b>2 Applications</b> .....	<b>1</b>	7.4 Device Functional Modes .....	<b>6</b>
<b>3 Description</b> .....	<b>1</b>	<b>8 Application and Implementation</b> .....	<b>7</b>
<b>4 Revision History</b> .....	<b>2</b>	8.1 Application Information .....	<b>7</b>
<b>5 Pin Configuration and Functions</b> .....	<b>3</b>	8.2 Typical Application .....	<b>7</b>
<b>6 Specifications</b> .....	<b>3</b>	<b>9 Power Supply Recommendations</b> .....	<b>9</b>
6.1 Absolute Maximum Ratings .....	<b>3</b>	<b>10 Layout</b> .....	<b>9</b>
6.2 ESD Ratings .....	<b>3</b>	10.1 Layout Guidelines .....	<b>9</b>
6.3 ESD Ratings – Surge Protection .....	<b>4</b>	10.2 Layout Example .....	<b>9</b>
6.4 Recommended Operating Conditions .....	<b>4</b>	<b>11 Device and Documentation Support</b> .....	<b>10</b>
6.5 Thermal Information .....	<b>4</b>	11.1 Documentation Support .....	<b>10</b>
6.6 Electrical Characteristics .....	<b>4</b>	11.2 Community Resources .....	<b>10</b>
6.7 Typical Characteristics .....	<b>5</b>	11.3 Trademarks .....	<b>10</b>
<b>7 Detailed Description</b> .....	<b>6</b>	11.4 Electrostatic Discharge Caution .....	<b>10</b>
7.1 Overview .....	<b>6</b>	11.5 Glossary .....	<b>10</b>
7.2 Functional Block Diagram .....	<b>6</b>	<b>12 Mechanical, Packaging, and Orderable Information</b> .....	<b>10</b>

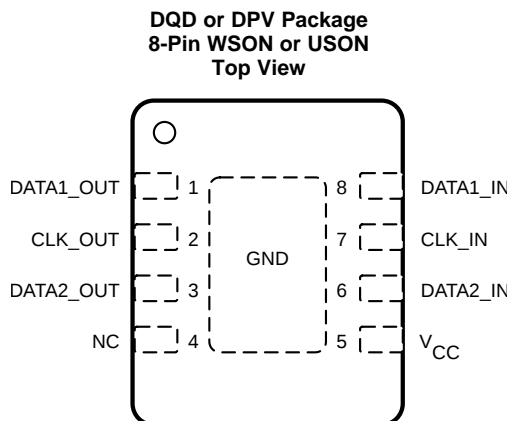
## 4 Revision History

### Changes from Original (January 2011) to Revision A

Page

- Added *Device Information* table, *ESD Ratings* 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**

## 5 Pin Configuration and Functions



**Pin Functions**

PIN		TYPE	DESCRIPTION
NAME	NO.		
CLK_OUT	2	Output	Clock Input and Output signals.
CLK_IN	7	Input	
DATA1_IN	8	Input	Data and Rest signals Input, Output pins. The DATA1 and DATA2 are symmetric circuits. They can be used interchangeably for either DATA or RESET pins based off board layout scheme.
DATA2_IN	6		
DATA1_OUT	1	Output	
DATA2_OUT	3		
GND	GND	Ground	Ground connection for the EMI filter. It is very important to connect the device GND to the printed circuit board ground plane through Vias directly under the package.
NC	4	No Connect	Not connected to any internal circuit. Leave this pin floating.
V <sub>CC</sub>	5	Power Clamp	ESD Clamp circuit for the V <sub>CC</sub> pin.

## 6 Specifications

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

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

		MIN	MAX	UNIT
	I/O voltage tolerance		5.5	V
T <sub>A</sub>	Operating free-air temperature	–40	85	°C
T <sub>stg</sub>	Storage temperature	–55	155	°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
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±15000
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	±1000

- (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.

## TPD3F303

SLVSAM5A – JANUARY 2011 – REVISED APRIL 2016

[www.ti.com](http://www.ti.com)

### 6.3 ESD Ratings – Surge Protection

			VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	IEC 61000-4-2 contact discharge	±15000	V
		IEC 61000-4-2 air-gap discharge	±15000	

### 6.4 Recommended Operating Conditions

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

	MIN	MAX	UNIT
V <sub>IO</sub> Input pin voltage	0	5.5	V
T <sub>A</sub> Operating free-air temperature	–40	85	°C

### 6.5 Thermal Information

THERMAL METRIC <sup>(1)</sup>		TPD3F303		UNIT
		DPV (USON)	DQD (WSN)	
		8 PINS	8 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	90	92.1	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	93.4	103.3	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	41.1	36	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	7.9	6.5	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	41	35.7	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	15.6	16.4	°C/W

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

### 6.6 Electrical Characteristics

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

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V <sub>clamp</sub> Clamp voltage	I <sub>IO</sub> = ±2 A I/O pin to ground			±10	V
I <sub>I</sub> Leakage current	R <sub>PU</sub> = Open I/O pin to ground			0.1	μA
R <sub>CLK</sub> CLK series resistors		40	47	55	Ω
R <sub>DAT_RST</sub> Data/RST series resistors		85	100	115	Ω
C <sub>Total</sub> IO Capacitance	V <sub>IO</sub> = 0 V I/O Pins to GND	16	20	24	pF
V <sub>BR</sub> Break-down Voltage	I <sub>IO</sub> = 1 mA	6			V
F <sub>–3dB</sub> –3-dB BW for DATA/RESET line	Z <sub>SOURCE</sub> = 50 Ω Z <sub>LOAD</sub> = 50 Ω		294		MHz
F <sub>–3dB</sub> –3-dB BW for CLK line	Z <sub>SOURCE</sub> = 50 Ω Z <sub>LOAD</sub> = 50 Ω		308		MHz

## 6.7 Typical Characteristics

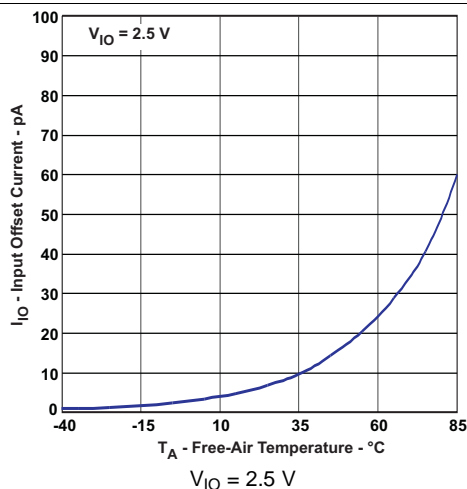


Figure 1.  $I_O$  vs Temperature

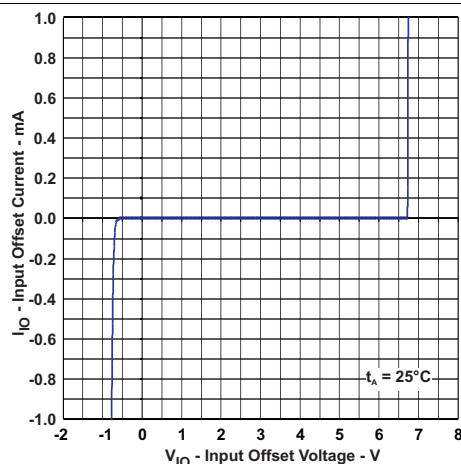


Figure 2.  $I_O$  vs  $V_{IO}$

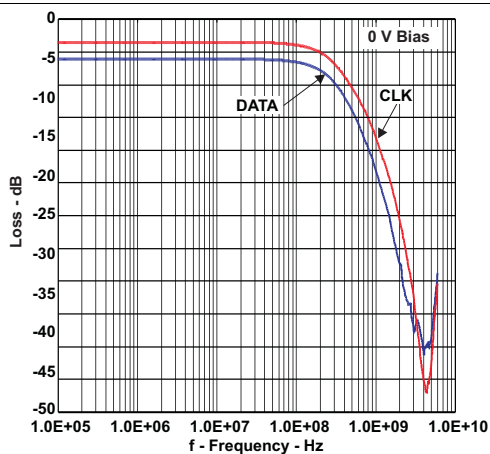


Figure 3. Frequency Response Data (0-V Bias)

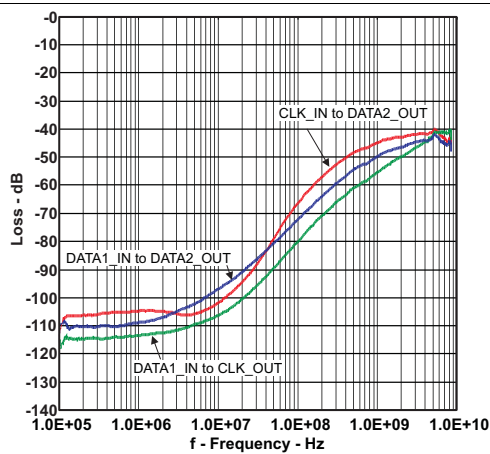


Figure 4. Channel-to-Channel Crosstalk

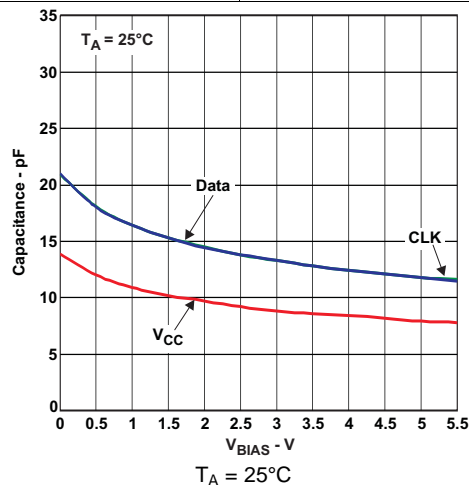


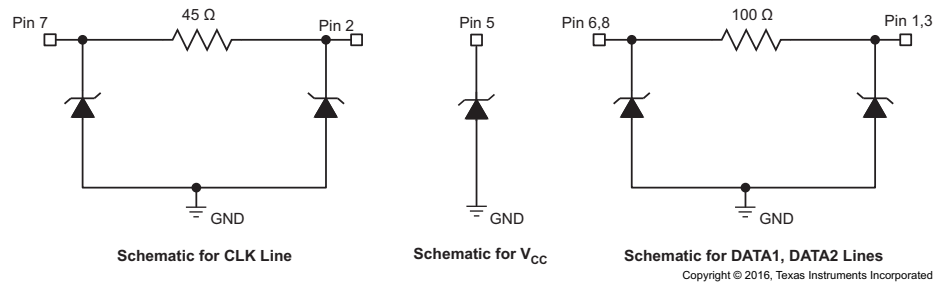
Figure 5. Capacitance vs  $V_{BIAS}$

## 7 Detailed Description

### 7.1 Overview

The TPD3F303 is a highly-integrated three-channel EMI filter and unidirectional TVS based protection diode array. This device can be used for a range of applications such as cell phones, tablets, hotspots, and PDAs.

### 7.2 Functional Block Diagram



### 7.3 Feature Description

#### 7.3.1 Bidirectional EMI Filtering and Line Termination With Integrated ESD Protection

This device provides bidirectional EMI filtering, integrated line-termination resistors, and integrated ESD protection.

#### 7.3.2 IEC 61000-4-2 ESD Protection

The ESD protection on all pins exceeds the IEC 61000-4-2 level 4 standard. Contact and air-gap ESD is rated at  $\pm 15$  kV.

#### 7.3.3 DC Breakdown Voltage

The DC breakdown voltage of this device is 6 V minimum.

#### 7.3.4 Low Leakage Current

The I/O pins of this device feature a low leakage current of 0.1-μA maximum.

#### 7.3.5 Low Noise C-R-C Filter Topology

This device has a C-R-C filter topology composed of a series resistor with two capacitors in parallel with the I/O pins. The typical resistor value for the DATA1 and DATA2 pins is 100 Ω and 45 Ω for the CLK pins. The typical capacitance on all lines is 20 pF when biased at 0 V.

#### 7.3.6 Integrated V<sub>CC</sub> Clamp

This device integrates an ESD clamp for the V<sub>CC</sub> pin, which eliminates the need for additional components.

#### 7.3.7 Space-Saving Packages

The layout of this device makes it easy to add protection to existing layouts. The packages offer flow-through routing which requires minimal changes to existing layout for addition of these devices. Additionally, the device is offered in two small space-saving packages that take up minimal footprint on the board.

### 7.4 Device Functional Modes

The TPD3F303 is a passive integrated circuit that triggers when voltages are above  $V_{BR}$  or below  $V_f$  (–0.7 V). During ESD events, voltages as high as  $\pm 15$  kV (air or contact) can be directed to ground through the internal diode network. When the voltages on the protected line fall below the trigger levels of TPD3F303 (usually within 10s of nanoseconds) the device reverts to passive.

## 8 Application and Implementation

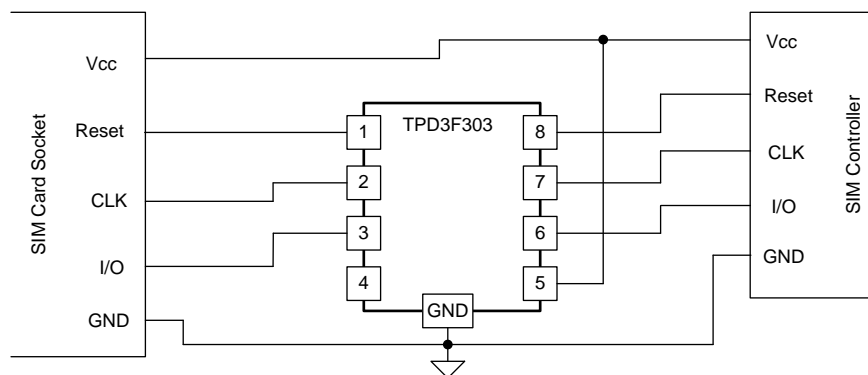
### NOTE

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 TPD3F303 is a diode type TVS + EMI filter which is used to provide a path to ground for dissipating ESD events on signal lines between a SIM card slot 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 across the termination resistors.

### 8.2 Typical Application



Copyright © 2016, Texas Instruments Incorporated

**Figure 6. Typical SIM Card Application**

#### 8.2.1 Design Requirements

For this design example, one TPD3F303 is used to protect a SIM card interface. [Table 1](#) lists the parameters for [Figure 6](#).

**Table 1. Design Parameters**

PARAMETER	VALUE
Signal Range on Protected Lines	0 V to 5 V
Required Level of IEC ESD Protection	±15-kV Contact, ±15-kV Air Gap

#### 8.2.2 Detailed Design Procedure

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

- Voltage range of the signal on all protected lines
- Required ESD protection needed

## TPD3F303

SLVSAM5A – JANUARY 2011 – REVISED APRIL 2016

[www.ti.com](http://www.ti.com)

### 8.2.2.1 Signal Range

The TPD3F303 supports signal ranges from 0 V to 5.5 V, which supports the SIM card application

### 8.2.2.2 Required ESD Protection

The TPD3F303 is rated to withstand up to  $\pm 15$ -kV contact and  $\pm 15$ -kV air gap IEC ESD. This meets the IEC ESD design target.

### 8.2.3 Application Curves

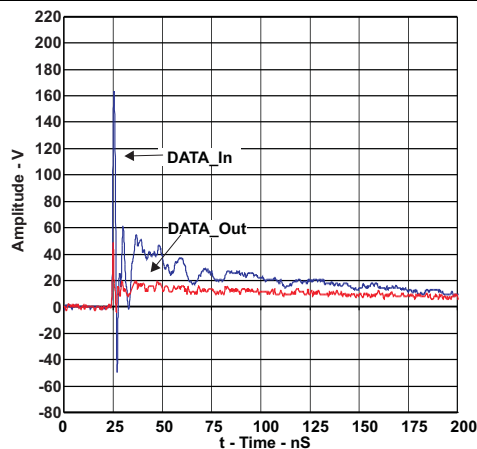


Figure 7. +15-kV IEC Contact, DATA1\_In Stressed

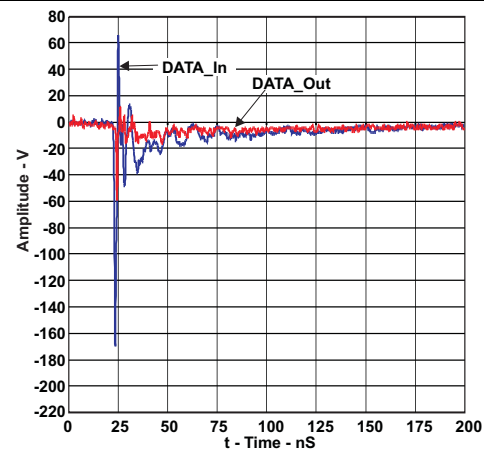


Figure 8. -15-kV IEC Contact, DATA1\_In Stressed

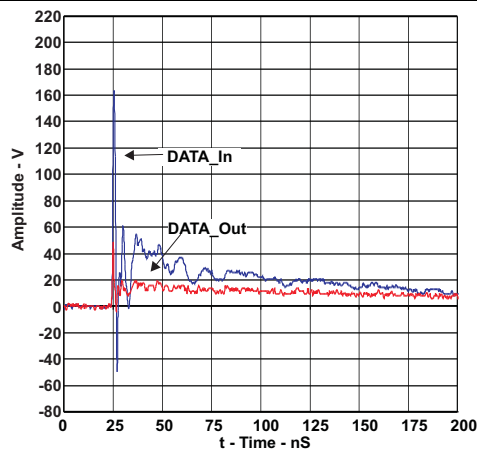


Figure 9. +15-kV IEC Contact, CLK\_In Stressed

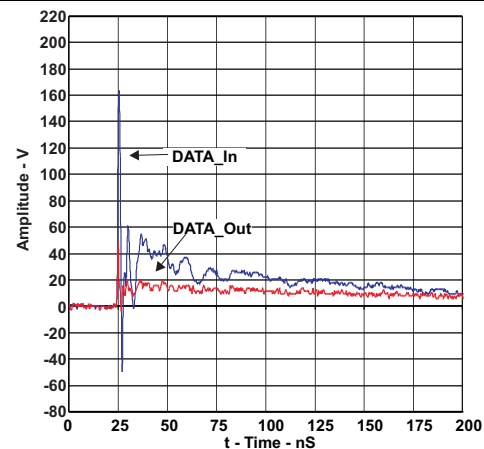


Figure 10. -15-kV IEC Contact, CLK\_In Stressed



## 9 Power Supply Recommendations

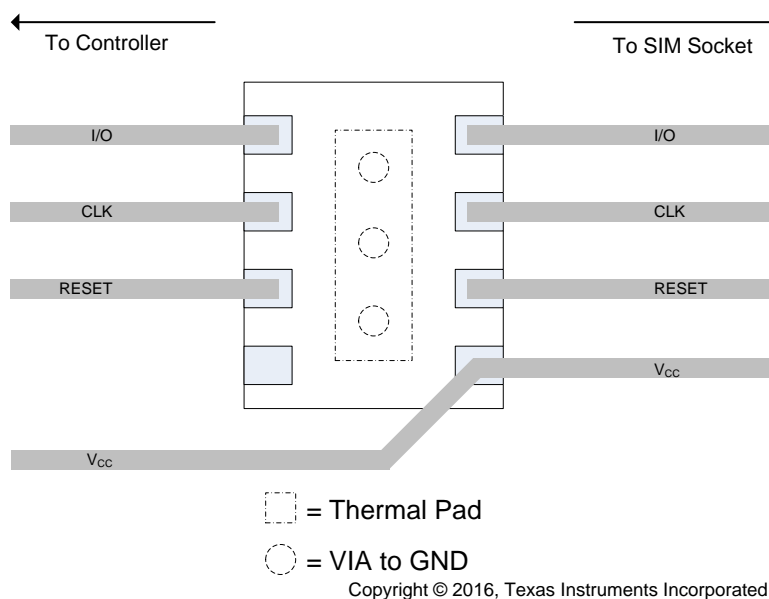
This device is a passive ESD device, so there is no need to power it. Take care not to violate the recommended I/O specification (0 V to 5.5 V) to ensure the device functions properly.

## 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 must 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 11. Typical SIM Card Layout**

## 11 Device and Documentation Support

### 11.1 Documentation Support

#### 11.1.1 Related Documentation

For related documentation, see the following:

- *ESD Protection Layout Guide*, [SLVA680](#)
- *Reading and Understanding an ESD Protection Datasheet*, [SLLA305](#)
- *Design Considerations for System-Level ESD Circuit Protection*, [SLYT492](#)

### 11.2 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.

### 11.3 Trademarks

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

### 11.4 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.

### 11.5 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.

## 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)
<a href="#">TPD3F303DPVR</a>	Active	Production	USON (DPV)   8	3000   LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	6SS
TPD3F303DPVR.A	Active	Production	USON (DPV)   8	3000   LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	6SS
<a href="#">TPD3F303DQDR</a>	Active	Production	WSON (DQD)   8	3000   LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	6SS
TPD3F303DQDR.A	Active	Production	WSON (DQD)   8	3000   LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	6SS

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **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.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **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.

<sup>(5)</sup> **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.

<sup>(6)</sup> **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**


\*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
TPD3F303DPVR	USON	DPV	8	3000	180.0	8.4	1.84	2.32	0.78	4.0	8.0	Q1
TPD3F303DQDR	WSO	DQD	8	3000	180.0	8.4	1.65	2.0	0.95	4.0	8.0	Q1

## TAPE AND REEL BOX DIMENSIONS

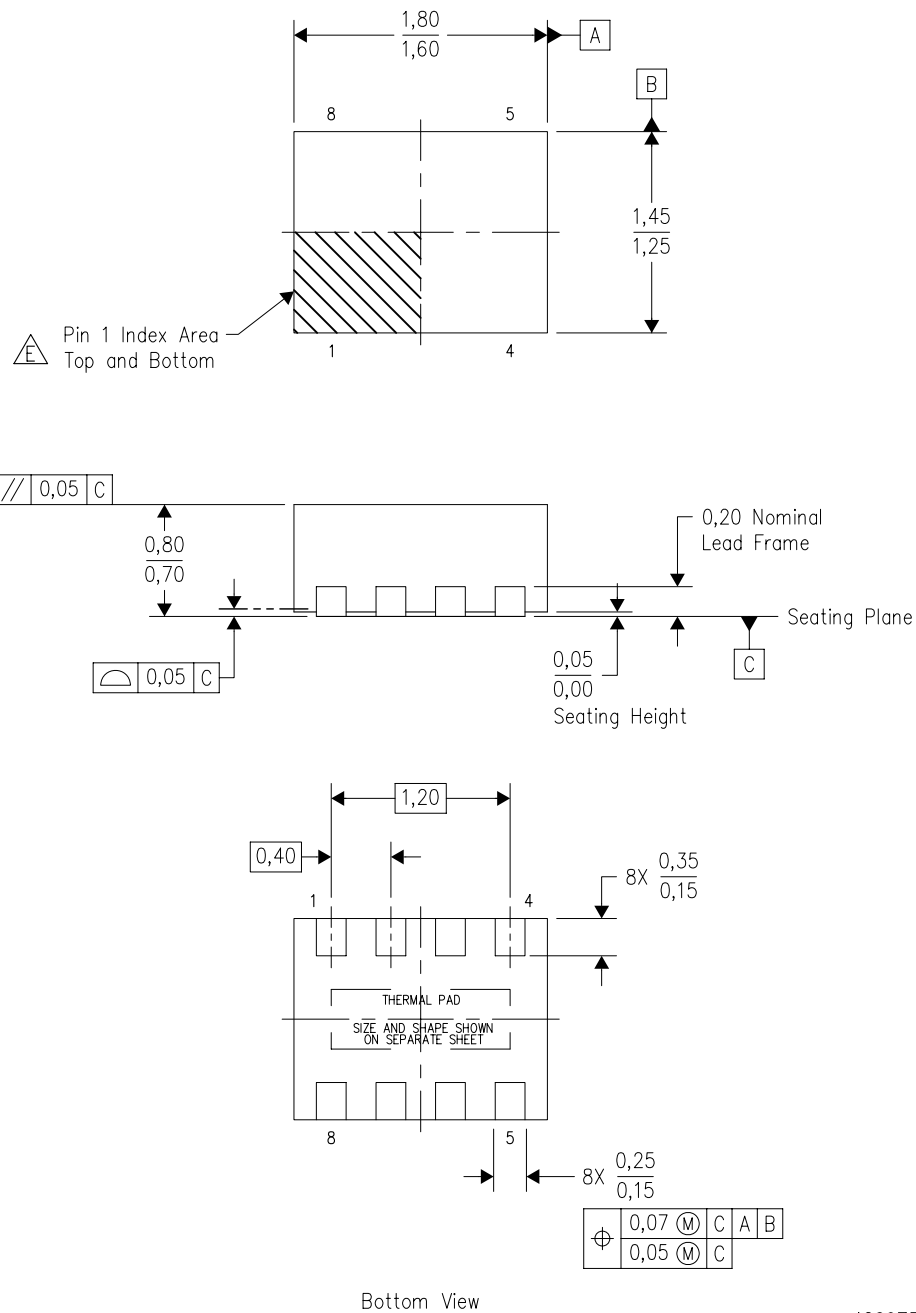


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPD3F303DPVR	USON	DPV	8	3000	183.0	183.0	20.0
TPD3F303DQDR	WSO	DQD	8	3000	183.0	183.0	20.0

DQD (R-PWSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD



Bottom View

4209732-2/C 12/11

- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - SON (Small Outline No-Lead) package configuration.
  - The package thermal pad must be soldered to the board for thermal and mechanical performance.
  - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
- E** Pin 1 identifiers are located on both top and bottom of the package and within the zone indicated. The Pin 1 identifiers are either a molded, marked, or metal feature.

DQD (R-PWSON-N8)

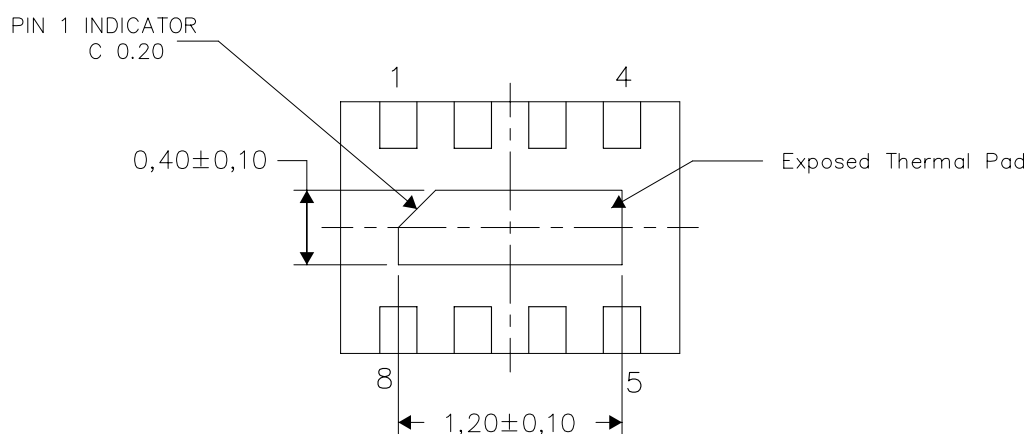
PLASTIC SMALL OUTLINE NO-LEAD

## 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

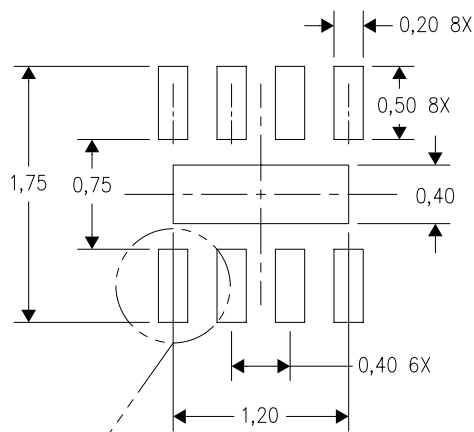
4209733-2/C 12/11

NOTE: All linear dimensions are in millimeters

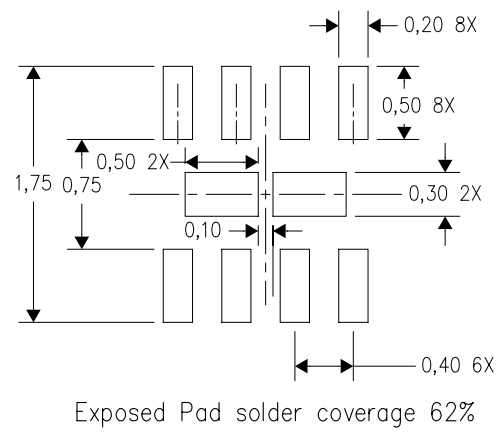
DQD (R-PWSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD

Land Pattern



Stencil Pattern



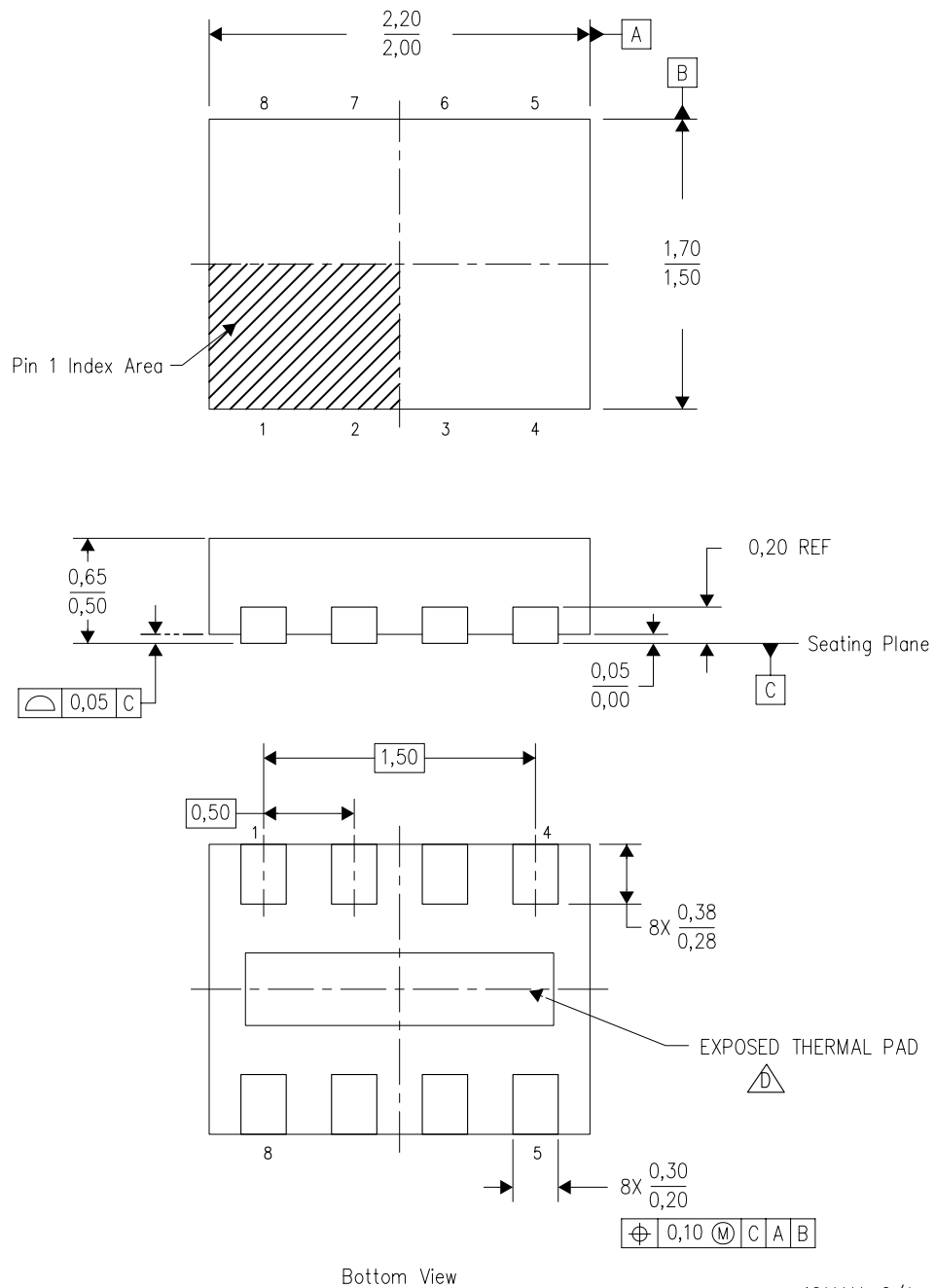
4211174-2/B 01/12

- 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 0,1016 mm (4 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.



DPV (R-PUSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD



4211111-2/A 06/2010

- 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.
  - The package thermal pad must be soldered to the board for thermal and mechanical performance.

DPV (R-PUSON-N8)

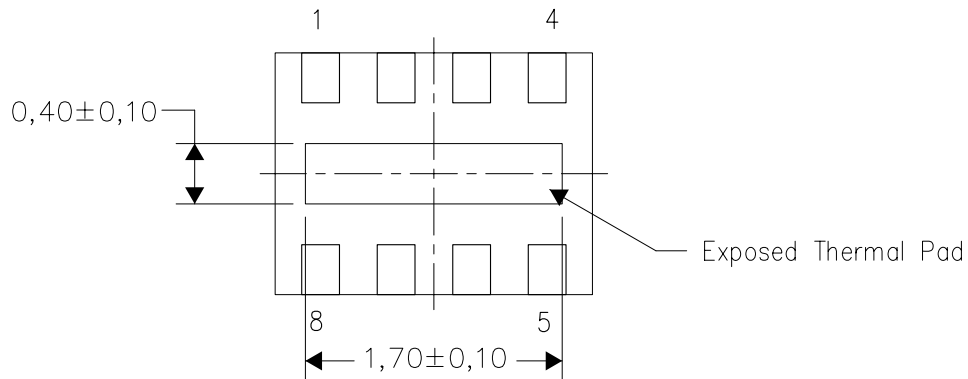
PLASTIC SMALL OUTLINE NO-LEAD

## 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

4211680/A 04/11

NOTE: A. All linear dimensions are in millimeters

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2025, Texas Instruments Incorporated

Last updated 10/2025