

# ESD451 1-Channel ±30kV Bidirectional ESD Diode in an 0201 and 0402 Package

## 1 Features

- IEC 61000-4-2 level 4 ESD protection:
  - ±30kV contact discharge
  - ±30kV air gap discharge
- IEC 61000-4-5 surge protection:
  - 6A (8/20µs)
- IO capacitance:
  - 0.5pF (typical)
- DC breakdown voltage: ±8V (typical)
- Ultra low leakage current: 50nA (maximum)
- Extremely low ESD clamping voltage
  - 10.4V at 16A TLP
  - $R_{DYN}$ : 0.19Ω
- Low insertion loss: 3.5GHz (-3dB bandwidth)
- Supports high speed interfaces up to 6Gbps
- Industrial temperature range: -55°C to +150°C
- Space saving industry standard 0201 (0.6mm x 0.3mm) and 0402 footprint (1.0mm x 0.6mm)

## 2 Applications

- End equipment:
  - Vacuum robots
  - Wearables
  - Smart speakers
  - Portable electronics
  - Small appliances
  - Retail automation and payment
  - Laptops and desktops
  - TV and monitors
  - Docking stations
- Interfaces:
  - USB 3.0
  - HDMI™ 1.4 and 2.0
  - DisplayPort™
  - SIM card

## 3 Description

The ESD451 is a bidirectional ESD protection diode for protecting data line and other I/O ports. The ESD451 is rated to dissipate ESD strikes up to ±30kV per the IEC 61000-4-2 international standard (greater than Level 4).

This device features a 0.5pF (typical) IO capacitance enabling high-speed interface protection for protocols such as USB 3.0. The extremely low dynamic resistance (0.19Ω) and clamping voltage (10.4V at 16A TLP) is specified for system-level protection against transient events.

The ±30kV ESD rating and 6A surge provides robust transient protection in a tiny package for protecting 5.5V power rails and data lines in portable electronics and other space constrained applications such as wearables.

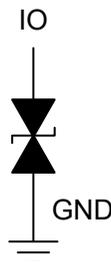
The ESD451 is offered in the industry standard 0201 and 0402 package.

### Package Information

PART NUMBER	PACKAGE <sup>(1)</sup>	PACKAGE SIZE <sup>(2)</sup>
ESD451	DPL (DFN0603, 2)	0.6mm × 0.3mm
	DPY (DFN1006, 2)	1.0mm × 0.6mm

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

(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Functional Block Diagram



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## 4 Pin Configuration and Functions

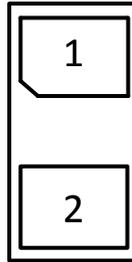


Figure 4-1. DPL Package, 2-Pin DFN0603 (Top View)

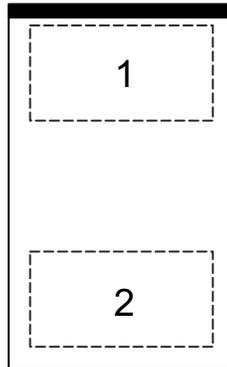


Figure 4-2. DPY Package, 2-Pin DFN1006 (Top View)

Table 4-1. Pin Functions

PIN		TYPE <sup>(1)</sup>	DESCRIPTION
NAME	NO.		
IO	1	I/O	ESD Protected Channel. If used as ESD IO, connect pin 2 to ground
IO	2	I/O	ESD Protected Channel. If used as ESD IO, connect pin 1 to ground

(1) I = input, O = output

## 5 Specifications

### 5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

		MIN	MAX	UNIT
Peak Pulse <sup>(2) (3)</sup>	IEC 61000-4-5 power ( $t_p$ - 8/20 $\mu$ s)		57	W
	IEC 61000-4-5 Current ( $t_p$ - 8/20 $\mu$ s)		6	A
$T_A$	Ambient Operating Temperature	-55	150	°C
$T_{stg}$	Storage Temperature	-65	155	°C

- (1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute maximum ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If briefly operating outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not sustain damage, but it may not be fully functional. Operating the device in this manner may affect device reliability, functionality, performance, and shorten the device lifetime.
- (2) Voltages are with respect to GND unless otherwise noted.
- (3) Measured at 25°C

### 5.2 ESD Ratings—JEDEC Specification

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±2500	V
		Charged device model (CDM), per JEDEC specification JS-002 <sup>(2)</sup>	±1000	V

- (1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

### 5.3 ESD Ratings—IEC Specification

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	IEC 61000-4-2 contact discharge	±30000	V
		IEC 61000-4-2 air-gap discharge	±30000	

### 5.4 Recommended Operating Conditions

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

			MIN	NOM	MAX	UNIT
$V_{IO}$	Input pin voltage	IO to GND	-5.5		5.5	V
$T_A$	Operating free-air temperature		-55		150	°C

### 5.5 Thermal Information

THERMAL METRIC <sup>(1)</sup>		ESD451		UNIT
		DPL (DFN0603)	DPY (DFN1006)	
		2 PINS	2 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	356.9	305.0	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	201.2	179.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	136.4	121.4	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	2.6	16.5	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	135.9	120.3	°C/W

THERMAL METRIC <sup>(1)</sup>		ESD451		UNIT
		DPL (DFN0603)	DPY (DFN1006)	
		2 PINS	2 PINS	
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	NA	NA	°C/W

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

## 5.6 Electrical Characteristics

At TA=25°C (unless otherwise noted) <sup>(1)</sup>

PARAMETER		PACKAGE	TEST CONDITION	MIN	TYP	MAX	UNIT	
V <sub>RWM</sub>	Reverse stand-off voltage	DPL & DPY package	I <sub>IO</sub> < 100nA, across operating temperature range	-5.5		5.5	V	
I <sub>LEAK</sub>	Reverse leakage current		V <sub>IO</sub> = 5.5V, IO to GND or GND to IO		5	50	nA	
V <sub>BR</sub>	Break-down voltage		I <sub>IO</sub> = 1mA, IO to GND	7	8	9	V	
V <sub>CLAMP</sub>	Clamping voltage with TLP	DPL Package	I <sub>PP</sub> = 1A, TLP, IO to GND		7.6		V	
			I <sub>PP</sub> = 5A, TLP, IO to GND		8.2			
			I <sub>PP</sub> = 16A, TLP, IO to GND		10.4			
			I <sub>PP</sub> = 1A, TLP, GND to IO		7.6			
			I <sub>PP</sub> = 5A, TLP, GND to IO		8.2			
			I <sub>PP</sub> = 16A, TLP, GND to IO		10.4			
	Clamping voltage with surge strike <sup>(3)</sup>		I <sub>PP</sub> = 6A, t <sub>p</sub> = 8/20μs, IO to GND		9.5			
			I <sub>PP</sub> = 6A, t <sub>p</sub> = 8/20μs, GND to IO		9.5			
R <sub>DYN</sub>	Dynamic resistance <sup>(2)</sup>	DPY Package	IO to GND		0.19		Ω	
			GND to IO		0.19			
V <sub>CLAMP</sub>	Clamping voltage with TLP		DPY Package	I <sub>PP</sub> = 1A, TLP, IO to GND		8.2		V
				I <sub>PP</sub> = 5A, TLP, IO to GND		9.2		
				I <sub>PP</sub> = 16A, TLP, IO to GND		11.5		
				I <sub>PP</sub> = 1A, TLP, GND to IO		8.2		
				I <sub>PP</sub> = 5A, TLP, GND to IO		9.2		
				I <sub>PP</sub> = 16A, TLP, GND to IO		11.5		
	Clamping voltage with surge strike <sup>(3)</sup>	I <sub>PP</sub> = 6A, t <sub>p</sub> = 8/20μs, IO to GND			10			
		I <sub>PP</sub> = 6A, t <sub>p</sub> = 8/20μs, GND to IO			10			
R <sub>DYN</sub>	Dynamic resistance <sup>(2)</sup>	DPL & DPY Package	IO to GND		0.24		Ω	
			GND to IO		0.24			
C <sub>L</sub>	Line capacitance			V <sub>IO</sub> = 0V; f = 1MHz, V <sub>pp</sub> = 30mV, IO to GND or IO to GND		0.5		pF

(1) Typical parameters are measured at 25°C

(2) Extraction of R<sub>DYN</sub> using least squares fit of TLP characteristics between I = 10A and I = 20A

(3) Nonrepetitive current pulse 8 to 20μs exponentially decaying waveform according to IEC 61000-4-5

### 5.7 Typical Characteristics

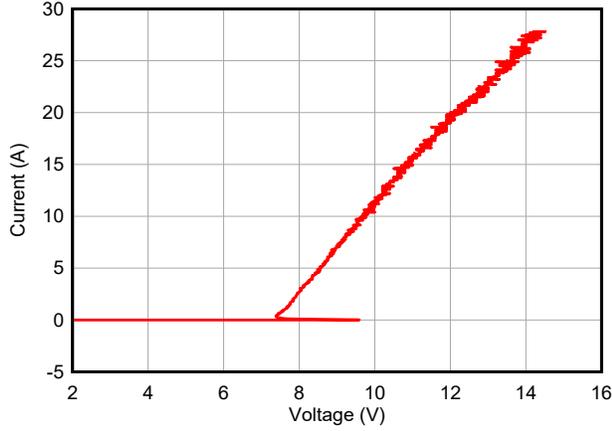


Figure 5-1. Positive TLP Curve (DPL)

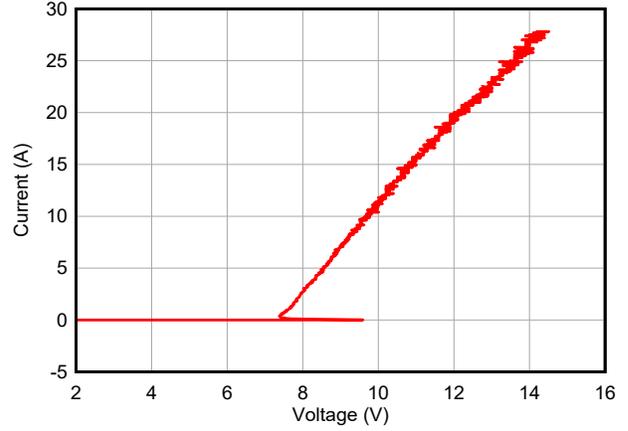


Figure 5-2. Negative TLP Curve (DPL)

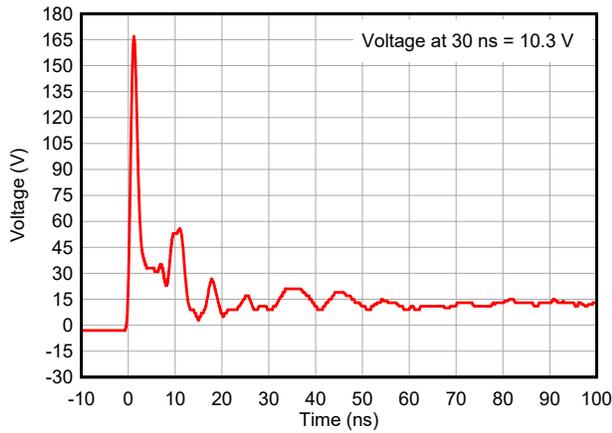


Figure 5-3. +8kV Clamped IEC Waveform (DPL)

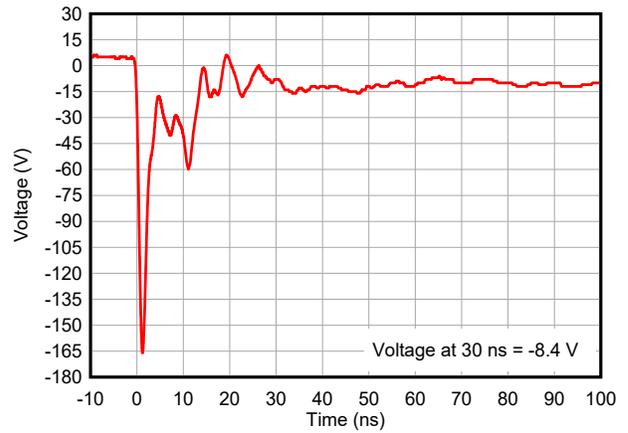


Figure 5-4. -8kV Clamped IEC Waveform (DPL)

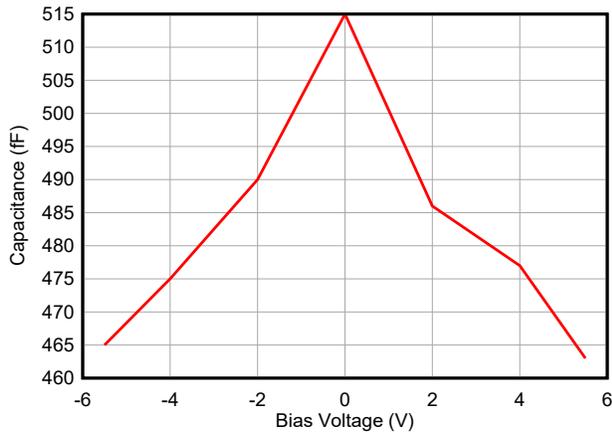


Figure 5-5. Bias Voltage vs. Capacitance (DPL)

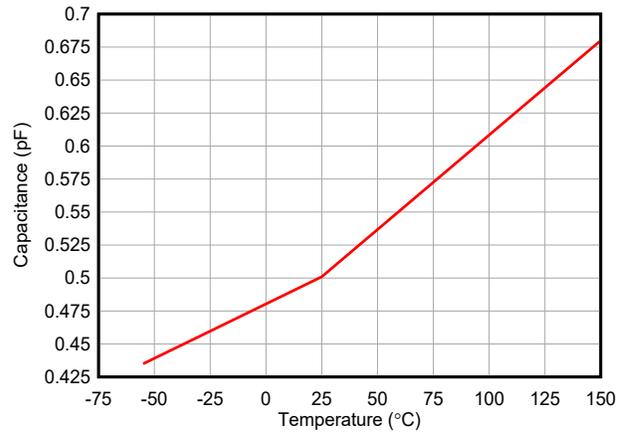


Figure 5-6. Temperature vs. Capacitance (DPL)

### 5.7 Typical Characteristics (continued)

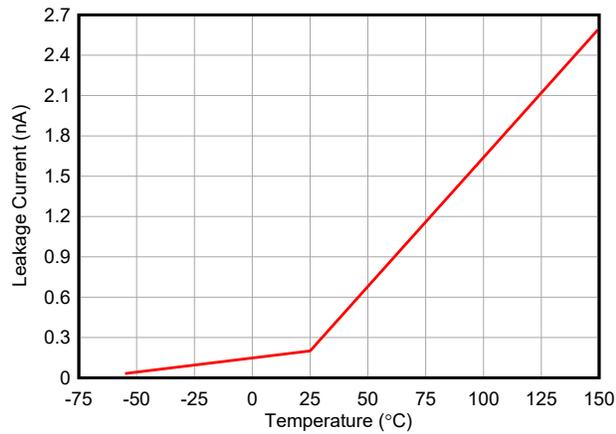


Figure 5-7. Temperature vs. Leakage Current (DPL)

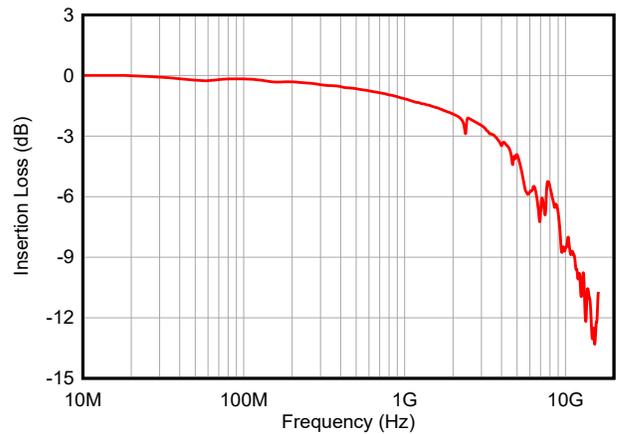


Figure 5-8. Insertion Loss (DPL)

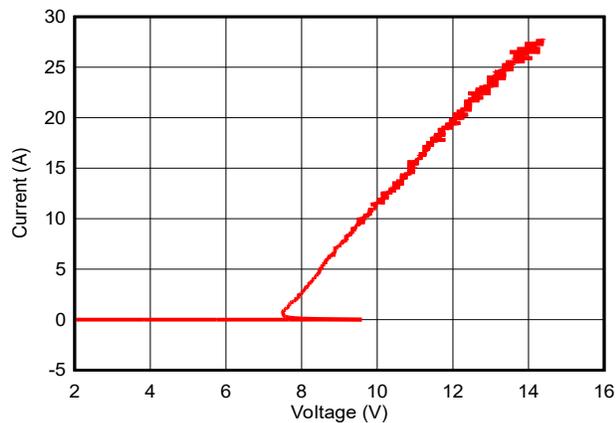


Figure 5-9. Positive TLP Curve (DPY)

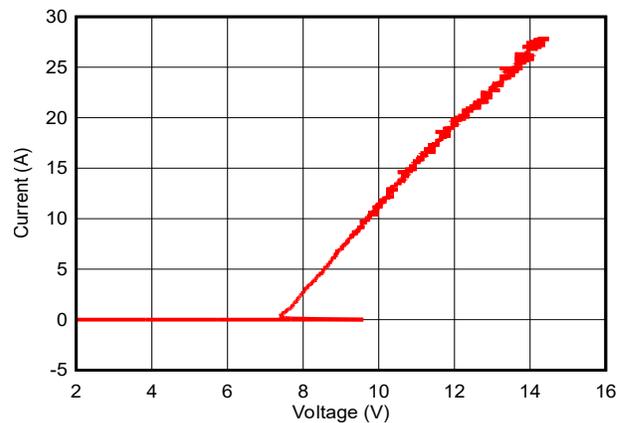


Figure 5-10. Negative TLP Curve (DPY)

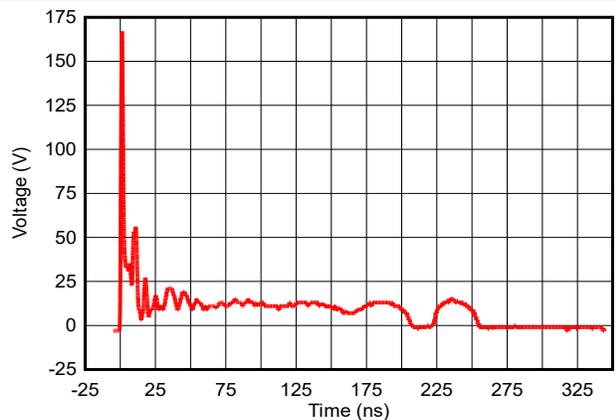


Figure 5-11. +8kV Clamped IEC Waveform (DPY)

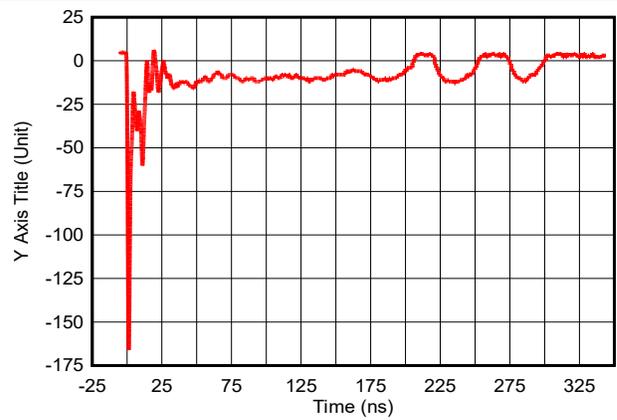
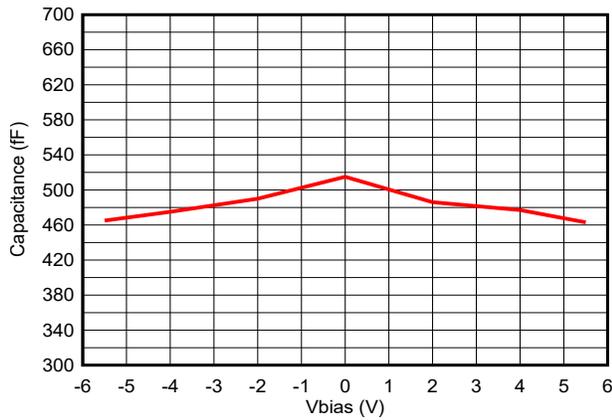
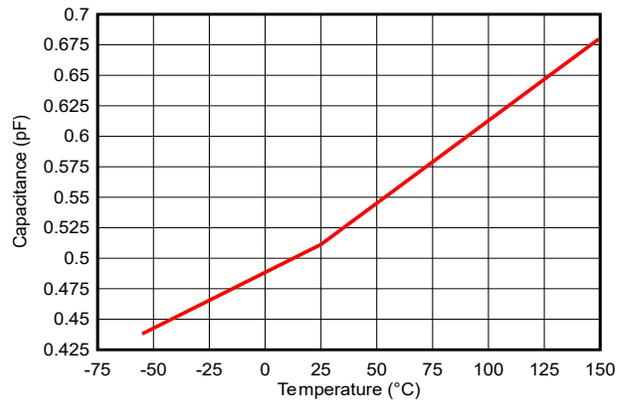


Figure 5-12. -8kV Clamped IEC Waveform (DPY)

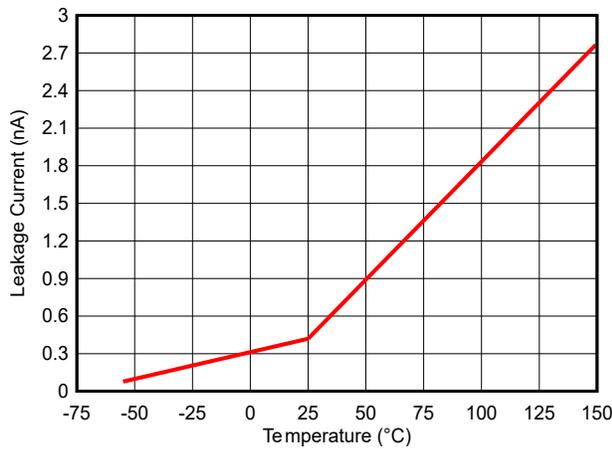
### 5.7 Typical Characteristics (continued)



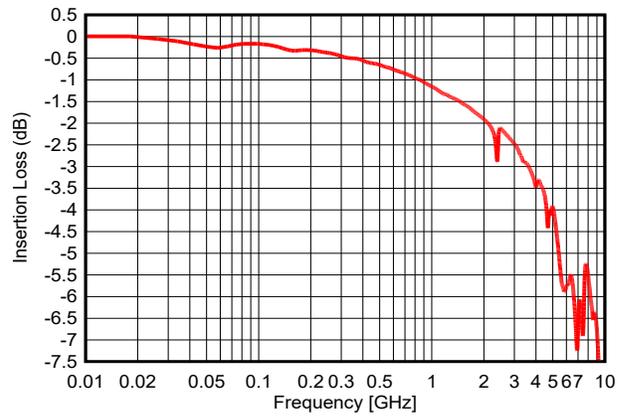
**Figure 5-13. Bias Voltage vs. Capacitance (DPY)**



**Figure 5-14. Temperature vs. Capacitance (DPY)**



**Figure 5-15. Temperature vs. Leakage Current (DPY)**



**Figure 5-16. Insertion Loss (DPY)**

## 6 Application and Implementation

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### 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, as well as validating and testing their design implementation to confirm system functionality.

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### 6.1 Application Information

The ESD451 is a diode type TVS which provides a path to ground for dissipating transient voltage spikes, such as ESD or surge, on signal lines and power lines. The device should be connected in parallel to the down stream circuitry it is protecting. As the current from the transient 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. For more information on how to properly use this device, please refer to the [ESD Packaging and Layout Guide](#) for details.

## 7 Device and Documentation Support

### 7.1 Documentation Support

#### 7.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [ESD Layout Guide application reports](#)
- Texas Instruments, [Generic ESD Evaluation Module user's guide](#)
- Texas Instruments, [Picking ESD Diodes for Ultra High-Speed Data Lines application reports](#)
- Texas Instruments, [Reading and Understanding an ESD Protection data sheet](#)

### 7.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](http://ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 7.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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### 7.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 7.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 8 Revision History

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

<b>Changes from Revision A (June 2023) to Revision B (December 2025)</b>	<b>Page</b>
• Added DPY package throughout the data sheet.....	1
• Updated surge value in <i>Features</i> to match surge value in <i>Electrical Characteristics</i> table.....	1

<b>Changes from Revision * (April 2023) to Revision A (June 2023)</b>	<b>Page</b>
• Changed the status of the data sheet from: <i>Advanced Information</i> to: <i>Production Data</i> .....	1

## 9 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="#">ESD451DPLR</a>	Active	Production	X2SON (DPL)   2	15000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	G
ESD451DPLR.B	Active	Production	X2SON (DPL)   2	15000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	G

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

(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.

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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**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
ESD451DPLR	X2SON	DPL	2	15000	178.0	8.4	0.36	0.66	0.33	2.0	8.0	Q1

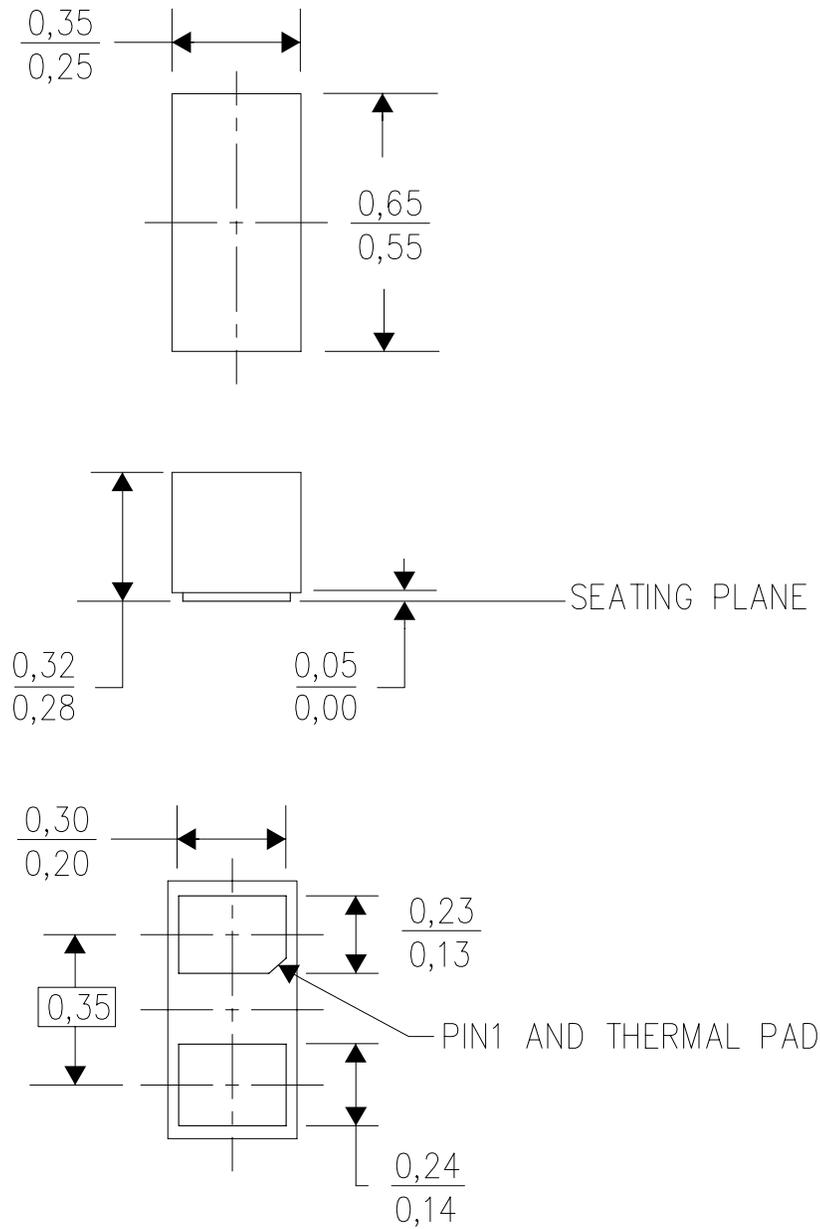
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
ESD451DPLR	X2SON	DPL	2	15000	205.0	200.0	33.0

DPL (R-PX2SON-N2)

PLASTIC SMALL OUTLINE NO-LEAD



4212149/B 10/11

- 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.
  - C. Small Outline No-Lead (SON) package configuration.
  - D. The package thermal pad must be soldered to the board for thermal and mechanical performance.

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