

ESD441 采用 0201 封装的单通道 $\pm 30\text{kV}$ 单向 ESD 二极管

1 特性

- IEC 61000-4-2 4 级 ESD 保护
 - $\pm 30\text{kV}$ 接触放电
 - $\pm 30\text{kV}$ 空气间隙放电
- IEC 61000-4-5 浪涌保护
 - 6.2 A (8 μs /20 μs)
- IO 电容：
 - 1pF (典型值)
- 直流击穿电压：7 V (典型值)
- 超低漏电流：50nA (最大值)
- 极低 ESD 钳位电压
 - 16A TLP 时为 7.6 V
 - R_{DYN} ：0.1 Ω (I/O 至 GND)
- 低插入损耗：2GHz (- 3dB 带宽)
- 支持速率高达 4Gbps 的高速接口
- 工业温度范围：- 55°C 至 +150°C
- 节省空间的业界通用 0201 封装 (0.6mm $\times$ 0.3mm $\times$ 0.3mm)

2 应用

- 终端设备：
 - 扫地机器人
 - 可穿戴设备
 - 智能扬声器
 - 便携式电子产品
 - 小型电器
 - 零售自动化和支付
 - 便携式计算机和台式机
 - 电视和监视器
 - 扩展坞
- 接口：
 - USB 2.0
 - HDMI™ 1.4 和 2.0
 - DisplayPort™
 - SIM 卡
 - GPIO

3 说明

ESD441 是一款单向 ESD 保护二极管，用于保护数据线路和其他 I/O 端口。ESD441 的额定 ESD 冲击消散值高达 $\pm 30\text{kV}$ ，符合 IEC 61000-4-2 国际标准 (高于 4 级)。

该器件具有 1pF (典型值) IO 电容，可为 USB 2.0 等协议提供高速接口保护。指定了极低动态电阻 (0.1 Ω) 和钳位电压 (16A TLP 时为 7.6V)，可针对瞬态事件提供系统级保护。

30kV ESD 等级和 6.2 A 浪涌采用微型封装，可提供强大的瞬态保护，用于保护便携式电子产品和其他空间狭小应用 (如可穿戴设备) 中的 5.5 V 电源轨。

ESD441 采用业界通用的 0201 (DPL) 封装。

封装信息

器件型号	封装 ⁽¹⁾	封装尺寸 ⁽²⁾
ESD441	DPL (X2SON, 2)	0.6 mm $\times$ 0.3 mm

- (1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。
- (2) 封装尺寸 (长 $\times$ 宽) 为标称值，并包括引脚 (如适用)。



功能方框图



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4 Revision History

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision * (April 2023) to Revision A (June 2023)	Page
• 将数据表的状态从 预告信息 更改为 量产数据	1

5 Pin Configuration and Functions

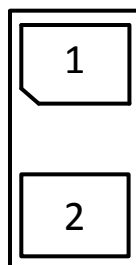


图 5-1. DPL Package, 2-Pin X2SON (Top View)

表 5-1. Pin Functions

PIN		TYPE ⁽¹⁾	DESCRIPTION
NAME	NO.		
IO	1	I/O	ESD protected channel
GND	2	GND	Ground. Connect to ground.

(1) I = input, O = output, GND = ground

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Peak Pulse ^{(2) (3)}	IEC 61000-4-5 power (t_p - 8/20 μ s)		45	W
	IEC 61000-4-5 Current (t_p - 8/20 μ 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

6.2 ESD Ratings—JEDEC Specification

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

- (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 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	

6.4 Recommended Operating Conditions

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

			MIN	NOM	MAX	UNIT
V_{IO}	Input pin voltage	Pin 1 to 2	0		5.5	V
T_A	Operating free-air temperature		-55		150	°C

6.5 Thermal Information

THERMAL METRIC ⁽¹⁾		ESD441	UNIT
		DPL (X2SON)	
		2 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	519.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	336.9	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	209.2	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	136.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	207.2	°C/W

THERMAL METRIC ⁽¹⁾		ESD441	UNIT
		DPL (X2SON)	
		2 PINS	
R _{θ JC(bot)}	Junction-to-case (bottom) thermal resistance	NA	°C/W

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

6.6 Electrical Characteristics

At TA=25°C (unless otherwise noted) ⁽¹⁾

PARAMETER		TEST CONDITION	MIN	TYP	MAX	UNIT
V _{RWM}	Reverse stand-off voltage	I _{IO} < 100 nA, across operating temperature range			5.5	V
I _{LEAK}	Reverse leakage current	V _{IO} = 5.5 V, IO to GND		1	50	nA
V _{BR}	Break-down voltage	I _{IO} = 1 mA, IO to GND	6	7	8	V
V _{FWD}	Forward voltage	I _{IO} = 1 mA, GND to IO		0.8		V
V _{HOLD}	Holding voltage ⁽²⁾	TLP, IO to GND		6.2		V
V _{CLAMP}	Clamping voltage with TLP ⁽²⁾	I _{PP} = 1 A, TLP, IO to GND		6.3		V
		I _{PP} = 5 A, TLP, IO to GND		6.5		V
		I _{PP} = 16 A, TLP, IO to GND		7.6		V
		I _{PP} = 16 A, TLP, GND to IO		3.8		V
	Clamping voltage with surge strike ⁽⁴⁾	I _{PP} = 6 A, t _p = 8/20 μs, IO to GND		7.6		V
R _{DYN}	Dynamic resistance ⁽³⁾	IO to GND		0.1		Ω
		GND to IO		0.16		
C _L	Line capacitance	V _{IO} = 0 V; f = 1 MHz, V _{pp} = 30 mV, IO to GND		1		pF

(1) Typical parameters are measured at 25°C

(2) Transition line pulse with 100 ns width and 10 ns rise and fall time

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

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

6.7 Typical Characteristics

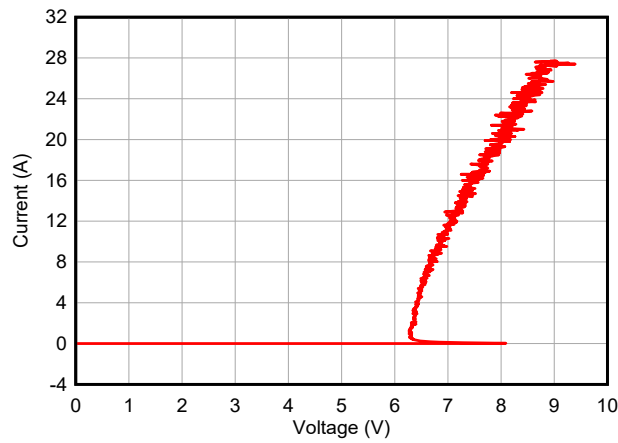


图 6-1. Positive TLP Curve

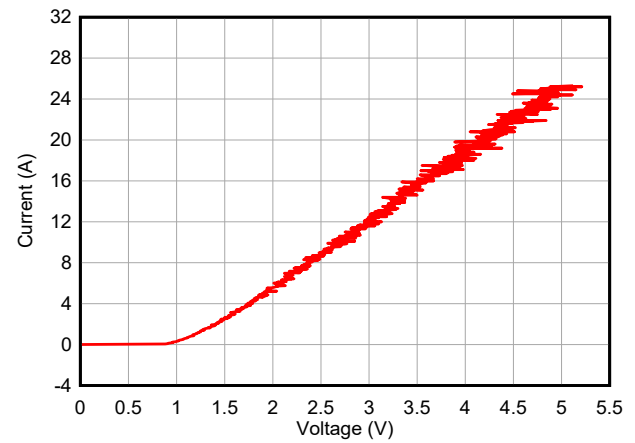


图 6-2. Negative TLP Curve

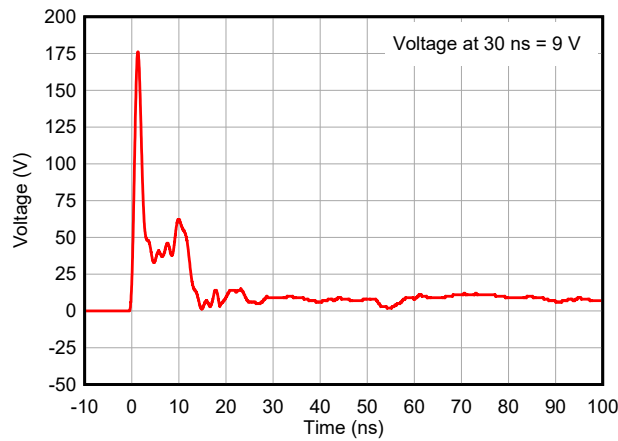


图 6-3. +8-kV Clamped IEC Waveform

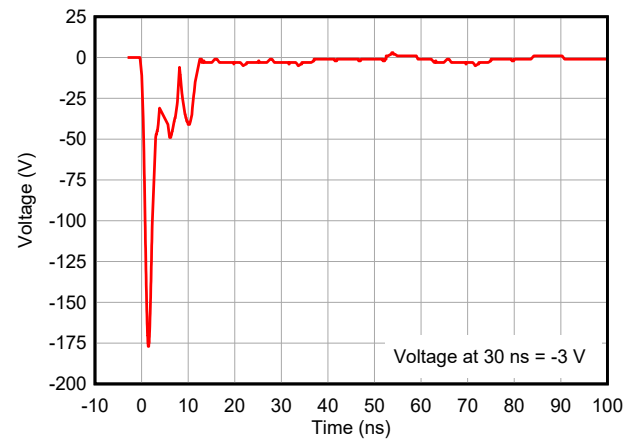


图 6-4. -8-kV Clamped IEC Waveform

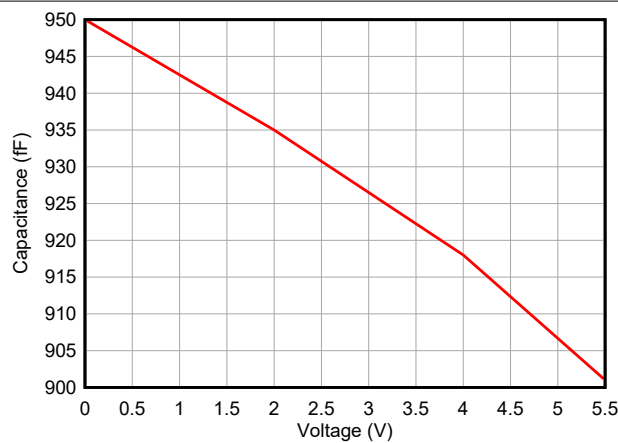


图 6-5. Bias Voltage vs. Capacitance

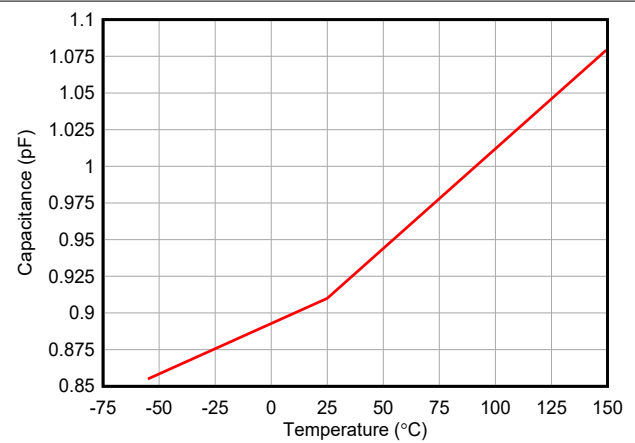


图 6-6. Temperature vs. Capacitance

6.7 Typical Characteristics (continued)

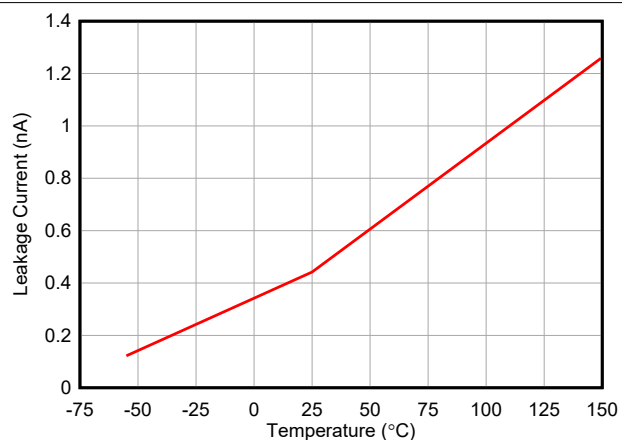


图 6-7. Temperature vs. Leakage Current

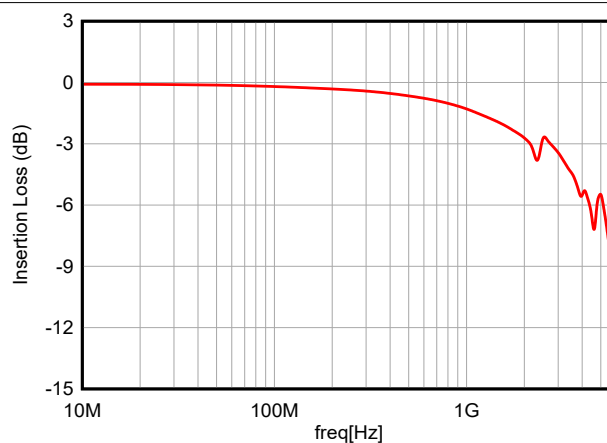


图 6-8. Insertion Loss

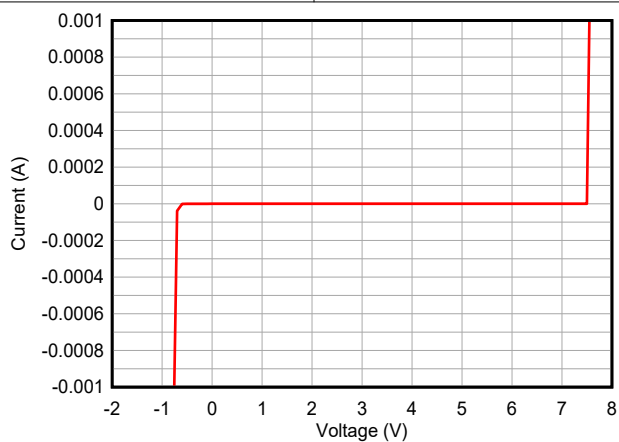


图 6-9. DC I-V Curve

7 Application and Implementation

备注

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.

7.1 Application Information

The ESD441 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.

8 Device and Documentation Support

8.1 Documentation Support

8.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [ESD Packaging and Layout Guide](#)
- 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](#)

8.2 接收文档更新通知

要接收文档更新通知，请导航至 [ti.com](https://www.ti.com) 上的器件产品文件夹。点击 [订阅更新](#) 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

8.3 支持资源

[TI E2E™ 支持论坛](#) 是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的 [《使用条款》](#)。

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TI E2E™ is a trademark of Texas Instruments.

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8.5 静电放电警告



静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

8.6 术语表

TI 术语表

本术语表列出并解释了术语、首字母缩略词和定义。

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)
ESD441DPLR	Active	Production	X2SON (DPL) 2	15000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	E
ESD441DPLR.B	Active	Production	X2SON (DPL) 2	15000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	E

⁽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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