



Never stop thinking



# ESD Protection Solutions

Consumer and wireless communication

[ [www.infineon.com/tvsdiodes](http://www.infineon.com/tvsdiodes) ]

## The ESD threat

In today's electronics, being faster, smaller and smarter creates profitability by enabling new and better applications. The race to pack even more high-speed functions in a smaller space accelerates miniaturization roadmaps.

However, the downscale of semiconductor chips together with the increase of doping levels results in a dramatic reduction of the thin gate oxide layer and the width of the pn-junction in semiconductor chips. This, in combination with greater circuit population, increases the susceptibility of the semiconductor chip to ESD.

The subsequent failures of the electronic equipment can be noticed as hard failures, latent damage or temporary malfunction. Hard failures are easier to spot, and in general require the failed device to be replaced. In the best case the failure will be detected before the equipment leaves the factory and customers will never receive it. Failures leading to temporary malfunction of equipment or latent failures are quite common and very difficult to detect or trace in the field. Temporary malfunctions may go unreported but can result in negative customer impressions as the user may need to reset the equipment. A product recall for swapping or repairing due to ESD failures may cause the company a cost several times higher than the cost of the device itself.

An efficient system design normally includes the implementation of a shielded chassis in order to minimize ESD risks. Nevertheless, ESD strikes represent a permanent threat to device reliability as they can easily find a way to bypass the shielded chassis and be injected into the IC/ASICs. Connectors and antennas exposed to the outside world are possible entry points of electrostatic discharges generated by end users.

### ESD PROTECTION FOR FASTER, SMALLER AND SMARTER APPLICATIONS

The only way to ensure stable operation and maximum reliability at the system level is to ensure that equipment is properly protected against electrostatic discharge and transients by an external protection device.

### INFINEON'S VALUE PROPOSITION

- Improve ESD immunity at system level by providing first-class protection beyond IEC61000-4-2 level 4 standard.
- Superior multi-strike absorption capability.
- Safe and stable clamping voltages to protect even the most sensitive electronic equipment.
- Protection devices that fully comply with high-speed signal quality requirements.
- Array solutions that boost space saving in the board and reduce part count.
- Easy-to-use single devices for space-constrained applications.
- Discrete components that drain extremely low leakage currents and help to extend battery duration.
- Packages enabling easy PCB layout.

### INFINEON TVS DIODE SERIES COVERED BY THIS BROCHURE

- Ultralow-capacitance series
- Low-capacitance series
- RF antenna series
- General-purpose series

### APPLICATION SEGMENTS

- Mobile communication
- Consumer
- Data processing
- Car infotainment

### FASCINATION FOR HIGH SPEED

Fine tuning of transmission lines in high-speed interfaces is not a trivial issue. Even the most negligible parasitic capacitance or inductance loading of an ESD protection device has impact on impedance requirements. This will degrade signal quality, and can make the difference between pass and failure of high-speed signal requirements. In applications implementing differential pairs like HDMI, not only the intrinsic capacitance of each single protection element but also the capacitance matching between the individual elements on data pairs plays a decisive role in signal integrity.

For many years, manufacturers of transient voltage suppression devices were confronted with technology and performance limitations to achieve low-capacitance devices. Today, efforts still focus on reducing capacitance while keeping ESD performance at an optimum. Infineon TVS diodes are the pioneers for ultralow-capacitance devices. Infineon's newest TVS diode generations set the standard for ESD protection in high-speed applications. Offering unique low-capacitance features down to 0.2 pF and at the same time providing superior protection to sensitive electronic equipment, Infineon TVS diodes set a benchmark in the protection arena.

# Ultralow-capacitance series

BEST IN MARKET SOLUTION FOR USB 2.0, HDMI 1.3, DISPLAYPORT, ETHERNET, S-ATA AND MANY MORE

The ESD5V3 and ESD3V3 series are specially designed for ESD and transient protection of the latest generation of high-speed interfaces with baud rates up to 8 Gb/s and beyond. The core features of these products are their ultralow parasitic capacitance combined with low clamping voltage and fast response time. This, in combination with dedicated package options, make these parts an ideal choice for high-speed transmission lines with the most stringent performance requirements.

### FEATURES AND BENEFITS

- Superior ESD and transient absorption capability beyond IEC market standards.
- Ultralow parasitic capacitance down to 0.2 pF to minimize signal attenuation at high frequencies.
- Very low clamping voltages to protect very susceptible IC/ASICs.
- Ultrasmall form factor and slimmest package designs.
- Special devices with leakage current reduced to less than 1 nA to ensure long battery duration in portable devices.
- Optimized flow-through array designs for easy lines routing.
- Unidirectional or bidirectional ESD protection.
- For maximum operating voltages of 3.3 V or 5.3 V.

TVS diode	Package	$V_{RWM}$ [V]	ESD [kV] <sup>(1)</sup>	EFT [A] <sup>(2)</sup>	$I_{pp\ max}$ [A] <sup>(3)</sup>	$I_R$ [nA]	$V_c$ [V] @ $I_{pp\ max}$	$V_f$ [V] @ $I_{pp\ max}$	$C_t$ [pF] @1 MHz, OV
ESD5V3U1U-02LS	TSSLP-2	5.3	20	40	3	< 10	12	4	0.4
ESD5V3U1U-02LRH	TSLP-2	5.3	20	40	3	< 10	12	4	0.4
ESD3V3U1U-02LS	TSSLP-2	3.3	20	40	3	< 1	12	4	0.4
ESD3V3U1U-02LRH	TSLP-2	3.3	20	40	3	< 1	12	4	0.4
ESD5V3U2U-03RLH	TSLP-3	5.3	20	40	3	< 1	12	4	0.2/0.4 <sup>(4)</sup>
ESD5V3U2U-03F	TSFP-3	5.3	20	40	3	< 1	12	4	0.2/0.4 <sup>(4)</sup>
ESD5V3U4RRS	SOT363	5.3	15	50	3	< 10	12	4	0.4
ESD5V3U4U-HDMI	TSLP-9	5.3	20	40	3	< 1	12	4	0.45

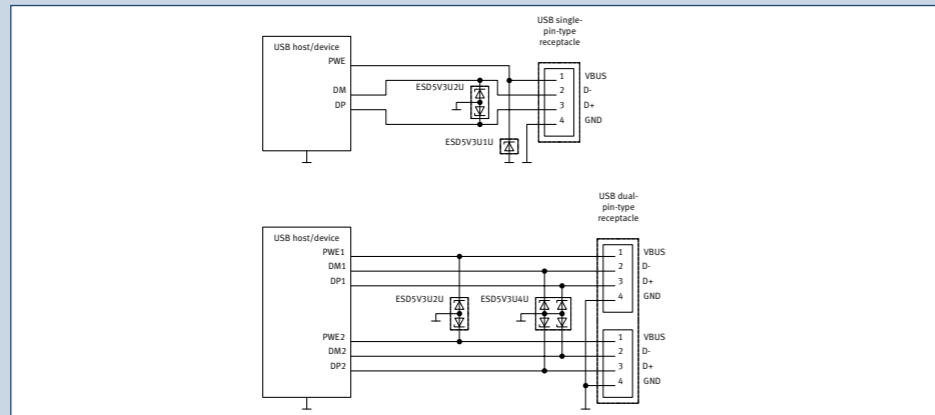
(1) Electrostatic discharge, contact discharge as per IEC61000-4-2.  
 (2) Electric fast transient according to IEC61000-4-4 (5/50 ns).  
 (3) Surge, according to IEC61000-4-5 (8/20  $\mu$ s).  
 (4) 0.2 pF for bidirectional configuration, 1-line protection and 0.4 pF for unidirectional configuration, 2-line protection.

### DIODE CONFIGURATIONS

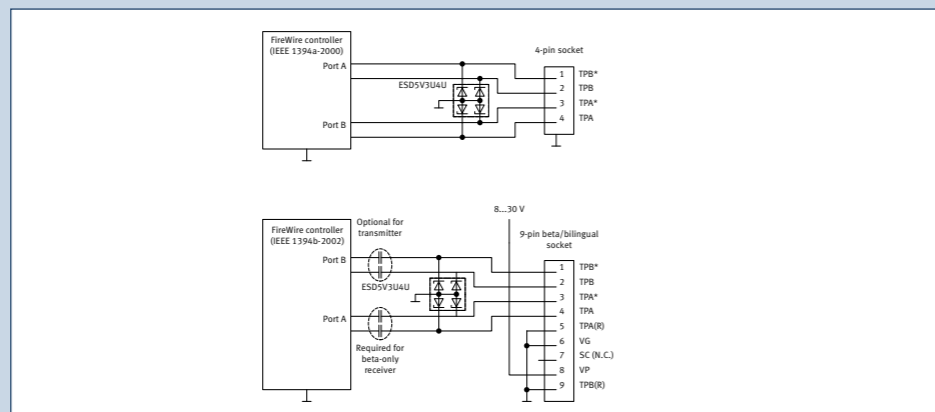
Part name	Configuration	Protection
ESD5V3U1U-ESD3V3U1U-	<p>Protected line, signal level up to <math>+V_{RWM}</math> (unidirectional)</p> <p>The protection diode should be placed very close to the location where the ESD or other transients can occur to keep loops and inductances as small as possible. Pin 2 should be connected directly to a ground plane on the board.</p>	1 line, unidirectional
ESD5V3U2U-	<p>2 protected high-speed I/O data lines</p> <p>The protection diode should be placed very close to the location where the ESD or other transients can occur to keep loops and inductances as small as possible. Pin 3 should be connected directly to a ground plane on the board.</p>	2 lines, unidirectional
	<p>1 protected high-speed I/O data lines</p> <p>The protection diode should be placed very close to the location where the ESD or other transients can occur to keep loops and inductances as small as possible. Pin 3 should not be connected to the board. 0.2 pF typ.</p>	1 line, bidirectional (pin 3 floating)
ESD5V3U4U-HDMI	<p>1 protected high-speed I/O data lines</p> <p>The protection diode should be placed very close to the location where the ESD or other transients can occur to keep loops and inductances as small as possible. Pin 3 should be connected directly to a ground plane on the board. Pins 6, 7, 8 and 9 are not connected.</p>	4 lines, unidirectional
ESD5V3U4RRS	<p>4 protected high-speed I/O data lines, 1 protected power supply line (+Vcc)</p> <p>Pin 2 is directly connected to the positive power supply line (+Vcc). Pin 5 should be connected directly to a ground plane on the board.</p>	4 data lines and 1 power supply line, unidirectional



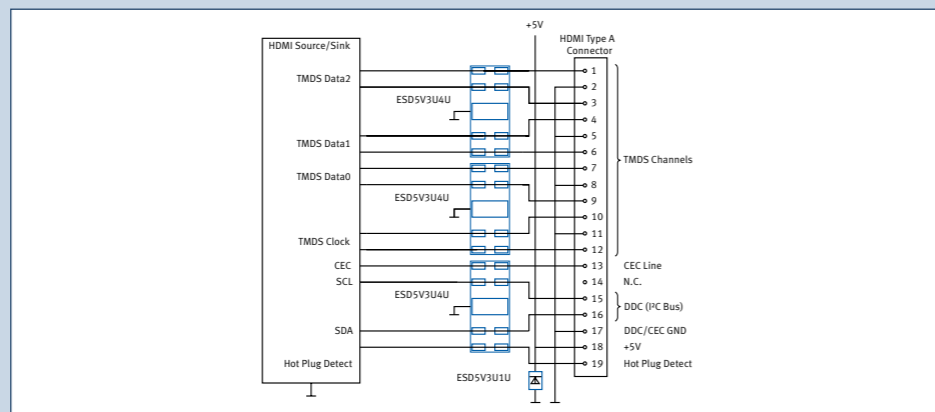
## TYPICAL APPLICATIONS



Application in USB 2.0: type "A" or "B" receptacle.



Application in FireWire interfaces (IEEE 1394a-2000 and IEEE 1394b-2002).



Application in HDMI 1.3 interfaces.

## Low-capacitance series

The bidirectional ESD8V0\*\*\* diode series is designed for use in a wide voltage range from  $-8\text{ V}$  to  $+14\text{ V}$ . With a typical capacitance down to  $4\text{ pF}$ , it ensures signal integrity on digital high-speed interfaces with baud rates of up to  $500\text{ MBd}$ . The key feature of this series is its low leakage current of less than  $1\text{ nA}$  which is guaranteed over repeated strikes, an important factor for battery-powered devices and a differentiating feature versus other forms of ESD protection.

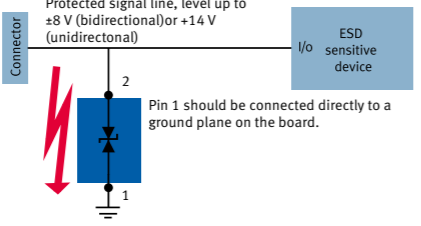
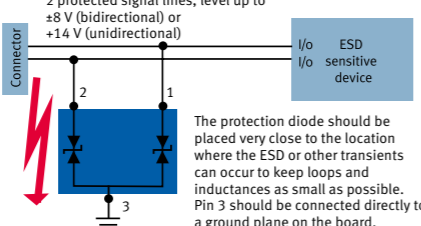
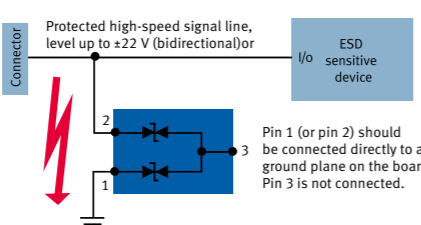
### FEATURES AND BENEFITS

- Outstanding ESD absorption capability exceeding IEC61000-4-2 level 4.
- Very low clamping voltages to protect susceptible IC/ASICs.
- Capacitance down to  $4\text{ pF}$ .
- Ultrasmall form factor down to  $0.6 \times 0.3 \times 0.3\text{ mm}$ .
- Bidirectional protection of 1 or 2 lines.
- Leakage current reduced to less than  $1\text{ nA}$  to ensure long battery duration in portable devices.

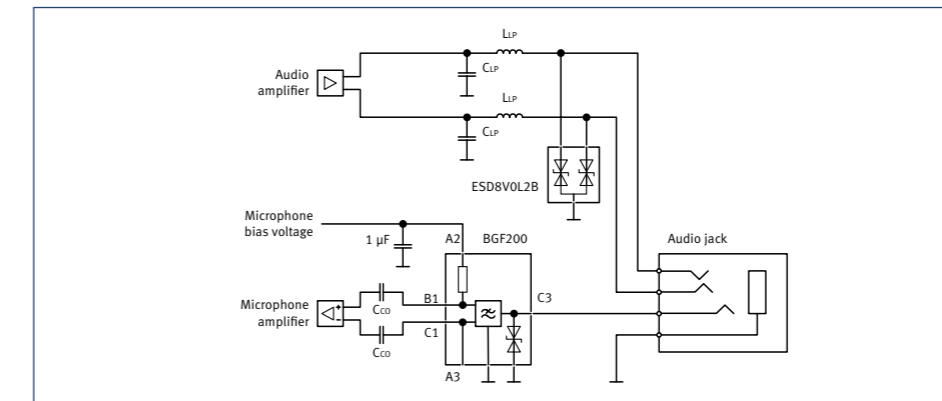
TVS diode	Package	$V_{RWM}$ [V]	ESD [kV] <sup>(1)</sup>	EFT [A] <sup>(2)</sup>	$I_{pp\ max}$ [A] <sup>(3)</sup>	$I_R$ [nA]	$V_C$ [V] @ $I_{pp\ max}$	$V_F$ [V] @ $I_{pp\ max}$	$C_t$ [pF] @ $1\text{ MHz, OV}$
ESD8V0L1B-02LRH	TSLP-2	-8/14	25	40	2.5	< 1	26	20	8.5
ESD8V0L2B-03L	TSLP-3-1	-8/14	15	40	1	< 1	26	20	4
ESD8V0L2B-03LRH <sup>(4)</sup>	TSLP-3-7	-8/14	15	40	1	< 1	26	20	4
ESD8V0R1B-02LRH	TSLP-2	-8/14	14	40	1	< 1	23	17	4
ESD8V0R1B-02LS	TSSLP-2	-8/14	14	40	1	< 1	23	17	4

- (1) Electrostatic discharge, contact discharge as per IEC61000-4-2.  
 (2) Electric fast transient according to IEC61000-4-4 (5/50 ns).  
 (3) Surge, according to IEC61000-4-5 (8/20  $\mu\text{s}$ ).  
 (4) Product on request.

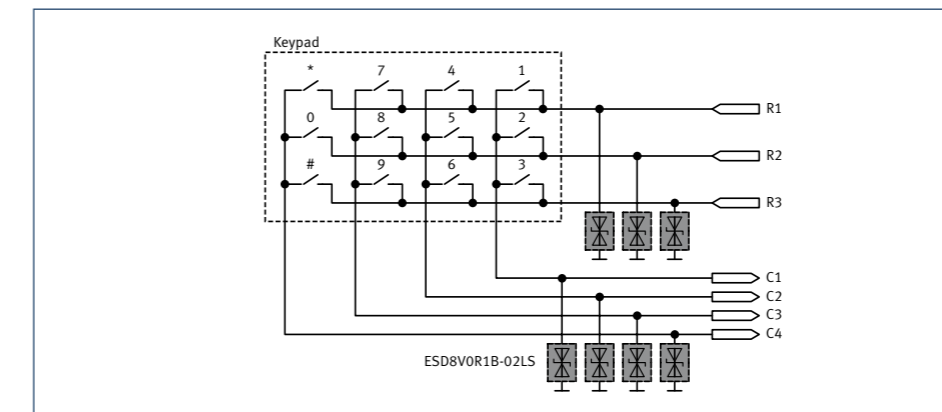
## DIODE CONFIGURATIONS

Part name	Configuration	Protection
ESD8V0R1B- ESD8V0L1B-	 <p>Protected signal line, level up to <math>\pm 8</math> V (bidirectional) or +14 V (unidirectional)</p> <p>Pin 1 should be connected directly to a ground plane on the board.</p>	1 line, bidirectional for voltage level up to $\pm 8$ V or unidirectional up to +14 V.
ESD8V0L2B-	 <p>2 protected signal lines, level up to <math>\pm 8</math> V (bidirectional) or +14 V (unidirectional)</p> <p>The protection diode should be placed very close to the location where the ESD or other transients can occur to keep loops and inductances as small as possible. Pin 3 should be connected directly to a ground plane on the board.</p>	2 lines, bidirectional for voltage level up to $\pm 8$ V or unidirectional up to +14 V.
ESD8V0L2B-	 <p>Protected high-speed signal line, level up to <math>\pm 22</math> V (bidirectional) or</p> <p>Pin 1 (or pin 2) should be connected directly to a ground plane on the board. Pin 3 is not connected.</p>	1 line, pin 3 non-connected, bidirectional for voltage level up to $\pm 22$ V.

## TYPICAL APPLICATIONS



Application in Audio jack. Two audio lines can be simultaneously protected with one dual-channel TVS diode.



Application in keypad. If the ESD problem is localized on a certain number of lines in a given application, the miniature TVS in TSSLP offers great design flexibility.



## RF antenna TVS diodes

### OPTIMAL ESD PROTECTION WITHOUT SACRIFICING RF SIGNAL QUALITY

The ESDxPyRFz family of transient voltage suppressor diodes from Infineon overcomes the ESD (electrostatic discharge) problem in RF antenna and high-speed data transmission lines by providing outstanding protection in a very small form factor.

For any antenna system, electrostatic discharges are a continuous threat to device reliability. These antennas are often exposed to direct ESD events as they are externally connected or installed in ESD-sensitive locations. For these reasons it is mandatory for the elements located right after the antenna to be protected against ESD threats. This is true despite the fact that some RF front-end technologies that are connected to the antenna now have built-in ESD protection. This internal protection is primarily intended to safeguard the semiconductor chip from electrostatic discharges during manufacture, not from system level (end user) use. ESD robustness at the system level can only be achieved by implementing an external protection device.

When applied to high-frequency circuits, the parasitic capacitance of the protection device must be kept at a minimum in order not to interfere with the signal performance. Designers should also choose devices providing low trigger and appropriate clamping voltages for the application.

### FEATURES AND BENEFITS

- ESD absorption capability up to  $\pm 15$  kV (contact) exceeding IEC 61000-4-2 standard level 4.
- No degradation even after multiple strikes.
- Extremely low and stable forward clamping voltage of 6 V at 5 A as per IEC 61000-4-5.
- Ultralow capacitance of only 0.2 pF at 1 GHz.
- Very small form of  $0.6 \times 0.3 \times 0.3$  mm<sup>3</sup> for space-constrained applications.
- Packages with ultralow series inductance down to only 0.2 nH (TSSLP) or 0.4 nH (TSLP).
- Optimized devices with very low noise figure and high-return loss for protection of ESD-sensitive low noise amplifiers (LNA) operating in the gigahertz range.
- Continuous expansion of TVS diode portfolio for RF antenna applications.

TVS diodes	Package	$V_{RWM}$ [V]	$V_{ESD}$ [kV] <sup>(1)</sup>	$I_{pp\ max}$ [A] <sup>(2)</sup>	$V_{cl@I_{pp\ max}}$ [V]	Insertion loss <sup>(3)</sup> [dB]	Return loss <sup>(3)</sup> [dB]	Noise figure <sup>(3)</sup> [dB]	$C_t$ @0V [pF]
ESD3V3U1U-02LS	TSSLP-2	3.3	20	3	12	0.22	19	0.16	0.4@1 MHz
ESD3V3U1U-02LRH	TSLP-2	3.3	20	3	12	0.23	19	0.17	0.4@1 MHz
ESD5V3U1U-02LS	TSSLP-2	5.3	20	3	12	0.22	19	0.16	0.4@1 MHz
ESD5V3U1U-02LRH	TSLP-2	5.3	20	3	12	0.23	19	0.17	0.4@1 MHz
ESD1P0RFS	SOT363	70	20	10	12	on request			1@1 MHz
ESD1P0RFW	SOT323	70	20	10	12	on request			1@1 MHz
ESD0P8RFL	TSLP-4	50	20	10	12	0.44	11	0.08	0.8@1 GHz
ESD0P4RFL	TSLP-4	50	15	5	6	0.12	18	0.06	0.4@1 GHz
ESD0P2RF-02LRH <sup>(4)</sup>	TSLP-2	5.3	20	3	16	0.13	23	0.11	0.2@1 GHz
ESD0P2RF-02LS <sup>(4)</sup>	TSSLP-2	5.3	20	3	16	0.12	23	0.10	0.2@1 GHz

(1) Contact discharge as per IEC61000-4-2.

(2) According to IEC61000-4-5.

(3)  $T_A = 25^\circ\text{C}$ ,  $V_R = 0$  V,  $f = 2$  GHz,  $Z_S = Z_L = 50 \Omega$ .

(4) Preliminary data.

### DIODE CONFIGURATIONS

Part name	Configuration
ESD1P0RFS	<p>2 protected signal lines, superimposed DC voltage up to <math>\pm V_F</math> (diode forward voltage)</p> <p>Line capacitance to ground = 1 pF</p> <p>2 lines antiparallel</p>
ESD1P0RFW	<p>1 protected signal line, superimposed DC voltage up to <math>\pm V_F</math> (diode forward voltage)</p> <p>Line capacitance to ground = 1 pF</p> <p>1 line, antiparallel</p>
	<p>1 protected signal line, superimposed DC voltage up to <math>\pm 2 \times V_F</math> (diode forward voltage)</p> <p>Line capacitance to ground = 0.5 pF</p> <p>1 line low capacitance, antiparallel</p>
	<p>1 protected signal line, superimposed DC voltage up to +Vcc (voltage supply)</p> <p>Line capacitance to ground = 1 pF</p> <p>1 line, rail to rail</p>



Part name	Configuration	
ESD0P8RFL		
ESD0P2RF-02LS ESD0P2RF-02LRH		

### RF CHARACTERISTICS

With a capacitance of only 0.2 pF, the ESD0P2RF- diode series can be applied to RF circuits up to 4 GHz without any additional compensation technique. With an inductive transmission line of less than 2 mm, the frequency range can easily be extended to ultrawide-band applications up to 8 GHz and beyond.

The extremely high 3 dB bandwidth of more than 11 GHz for the 0.4 pF diode ESD5V3U1U-02LS is due to the super-small package with parasitic inductance of only 0.2 nH. The ESD0P4RFL results in a total parasitic inductance of again only 0.2 nH. Due to its very low parasitic capacitance of only 0.4 pF and a 3 dB bandwidth beyond 11 GHz, there is no need for compensation of the diode's capacitance up to 2 GHz. Beyond 2 GHz the capacitance can be easily compensated by a short inductive transmission line surrounding the diode (see Figure 4). In the case of ESD0P8RFL with 0.8 pF capacitance, this diode can be implemented without the need for any compensation technique up to 1 GHz.

### RF CHARACTERISTICS

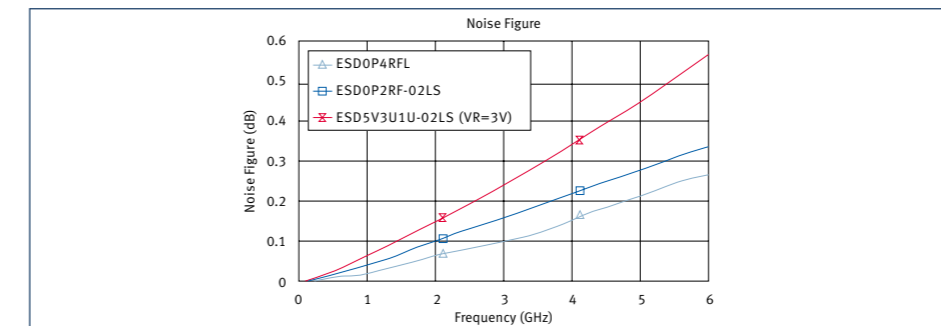


Figure 1: Noise figure for RF antenna TVS diodes.

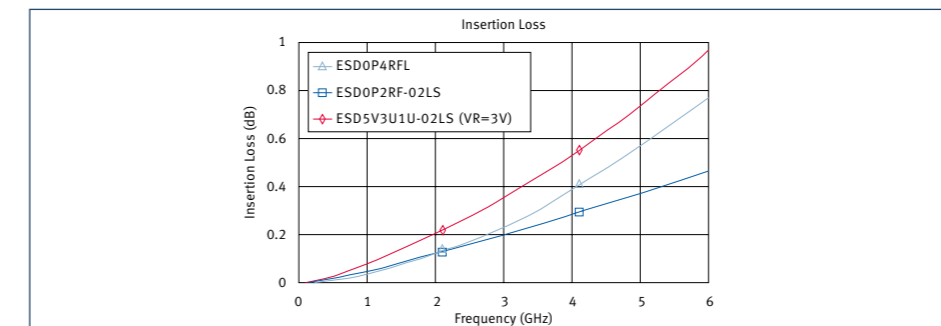


Figure 2: Insertion loss for RF antenna TVS diodes.

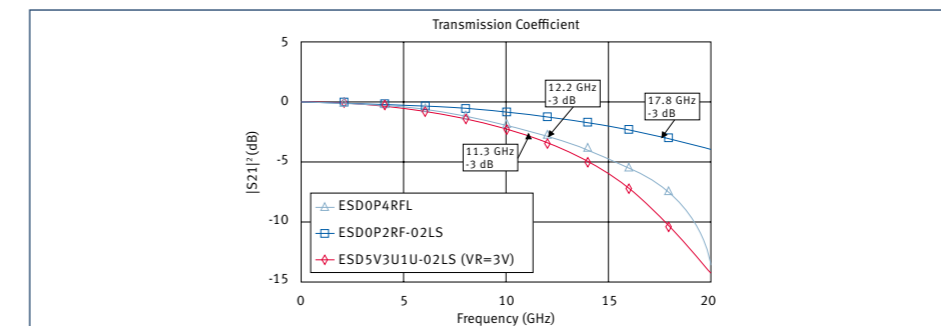


Figure 3: Wide span transmission coefficient ( $|S_{21}|^2$ ) for RF antenna TVS diodes.

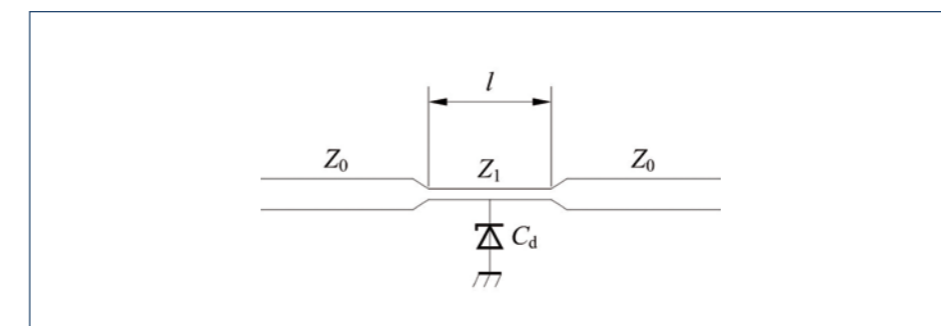
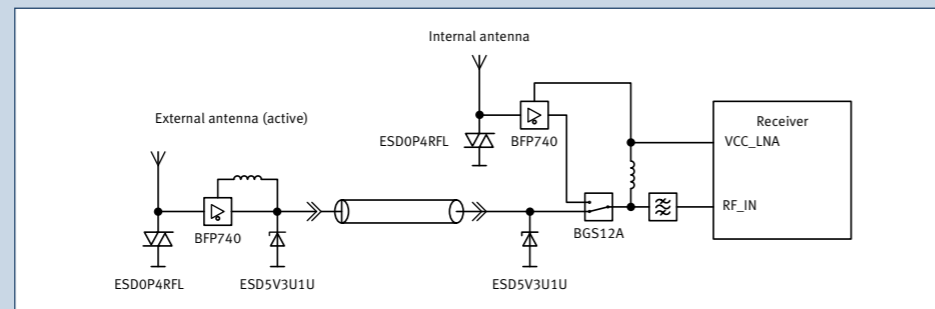


Figure 4: Example of compensation schema by a skinny trace.

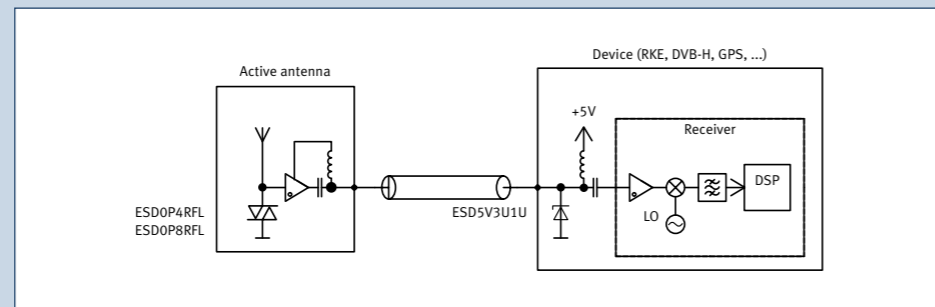


### TYPICAL APPLICATIONS

- Applications in antiparallel configuration: for low RF-signal levels without superimposed DC voltage, such as: GPS, FM Antenna, XM-Radio, Sirius, DVB (Digital Video Broadcasting), DMB (Digital Multimedia Broadcasting), DAB (Digital Audio Broadcasting), and remote keyless entry.
- Also for applications in rail-to-rail configuration including DC-biased lines where the RF signal levels do not approach the clamping reference voltages, such as: LNB interfaces, HDMI, S-ATA, and Gbit Ethernet.



Application in internal and external antenna.



Application in GPS, RKE, DVB-H.

## General-purpose diodes

INFINEON general-purpose TVS diodes are designed to handle high-peak transient currents far beyond market standards and to remain unchanged after repetitive strikes. These devices are especially well suited for ESD and transient protection of low-speed data and power lines in applications with a maximum operating voltage of 5.3 V.

### FEATURES AND BENEFITS

- ESD (electrostatic discharge), EFT (electric fast transient) and surge protection exceeding market standards.
- Excellent high current absorption capability.
- Uni- or bidirectional operation possible.
- Very low clamping voltage.
- Arrays for multiline protection.

TVS diode	Package	$V_{RWM}$ [V]	ESD [kV] <sup>(1)</sup>	EFT [A] <sup>(2)</sup>	$I_{pp,max}$ [A] <sup>(3)</sup>	$I_B$ [nA]	$V_C$ [V] @ $I_{PP,max}$	$V_F$ [V] @ $I_{PP,max}$	$C_t$ [pF] @ 1 MHz, 0V
ESD5V0S1U-03W	SOD323	5.0	30	80	40	20	11	4	430
ESD5V0S2U-06	SOT23	5.0	30	80	40	20	11	4	430
ESD5V0S4US	SOT363	5.3	30	80	10	5	10.5	3.5	70
ESD5V0S5US	SOT363	5.3	30	80	10	5	10.5	3.5	70

(1) Electrostatic discharge, contact discharge as per IEC61000-4-2.

(2) Electric fast transient according to IEC61000-4-4 (5/50 ns).

(3) Surge, according to IEC61000-4-5 (8/20  $\mu$ s).

### DIODE CONFIGURATIONS

Part name	Configuration	Protection
ESD5V01U-03W	<p>The protection diode should be placed very close to the location where the ESD can occur to keep loops and inductances as small as possible.</p>	1 line, unidirectional
ESD5V0S2U-06	<p>The protection diode should be placed very close to the location where the ESD or other transients can occur to keep loops and inductances as small as possible. Pin 3 should be connected directly to a ground plane on the board.</p>	2 lines, unidirectional



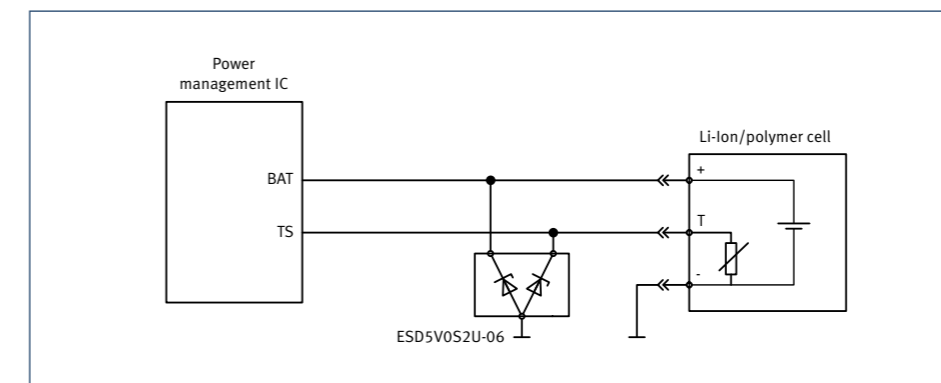


Part name	Configuration	Protection
ESD5V0S2-U6	<p>Protected signal line</p> <p>ESD sensitive device</p> <p>Pin 2 should be connected directly to a ground plane on the board. Pin 3 is not connected.</p>	1 line, bidirectional
ESD5V0S4US	<p>4 protected signal lines, level 0...+5.3 V</p> <p>ESD sensitive device</p> <p>Pin 2 and pin 5 should be connected directly to a ground plane on the board.</p>	4 lines, unidirectional
ESD5V0S5US	<p>4 protected signal lines, level -5.3 V...+5.3 V</p> <p>ESD sensitive device</p> <p>For bidirectional protection pin 2 (or any other pin except pin 5) should be connected directly to a ground plane on the board. Pin 5 is not connected. Total clamping voltage is the sum of <math>V_{CL} + V_{FC}</math> (see table on page 2).</p>	4 lines, bidirectional
	<p>5 protected signal lines, level 0...+5.3 V</p> <p>ESD sensitive device</p> <p>The protection diode should be placed very close to the location where the ESD or other transients can occur to keep loops and inductances as small as possible. Pin 5 should be connected directly to a ground plane on the board.</p>	5 lines, unidirectional

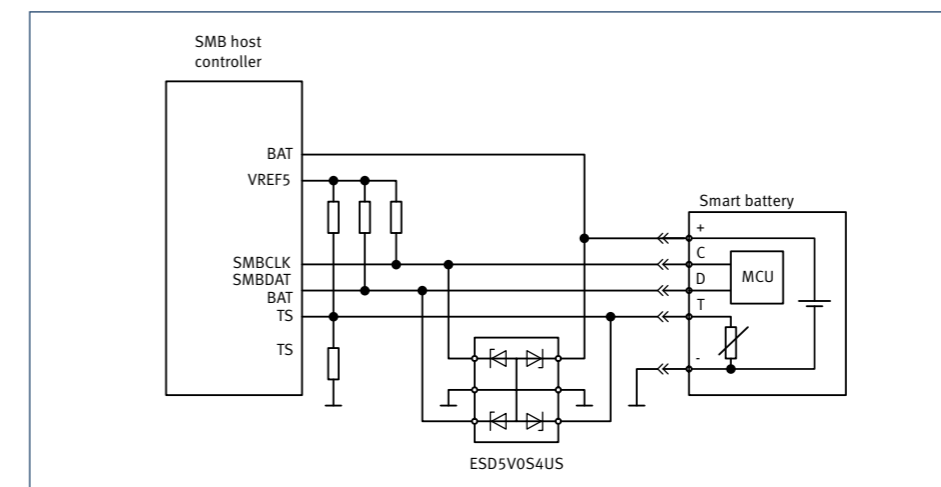
## TYPICAL APPLICATIONS

The general-purpose diode series is recommended for protection of sensitive lines that have low data rates such as:

- Power inputs line
- Keypad/keyboard interfaces
- Microphone and speaker interfaces
- Headset
- Flash card



Application in a Li-ion polymer battery.



Application in a smart battery.



## THE RISKS OF INSUFFICIENT ESD PROTECTION

What are the risks of insufficient ESD protection?

- The high-peak voltage within the first nanoseconds, which can result in dielectric breakdown of downstream devices.
- The electrical energy of the ESD pulse can damage or disrupt downstream devices as a result of their ultrafast high energy signature.

Therefore it is important that an ESD protection device keeps both the peak voltage at the ESD sensitive device and the electrical energy that is absorbed by the sensitive equipment as low as possible. Some ESD protection devices specify that they will survive an 8 kV strike. However, their trigger and clamping voltages are beyond the maximum voltage level that the downstream protected device can withstand. As a result, the protected chip is subjected to a high voltage and energy stress that increase the risk of future malfunctions, or directly destroy it.

## PERFORMANCE COMPARISON

A comparison between a polymer-based ESD protection device, a low-capacitance varistor and Infineon's low-capacitance ESD protection diode ESD0P8RFL is shown in Figure 5. Figure 6 points out the peak voltage ( $V_{PEAK}$ ), the clamping voltage ( $V_{cl}$ ) after 30 ns and the dissipated thermal energy ( $W_{cl}$ ) at a 50  $\Omega$  load. The ESD tests were performed at 8 kV contact discharge according to IEC 61000-4-2 standard (Figure 6).

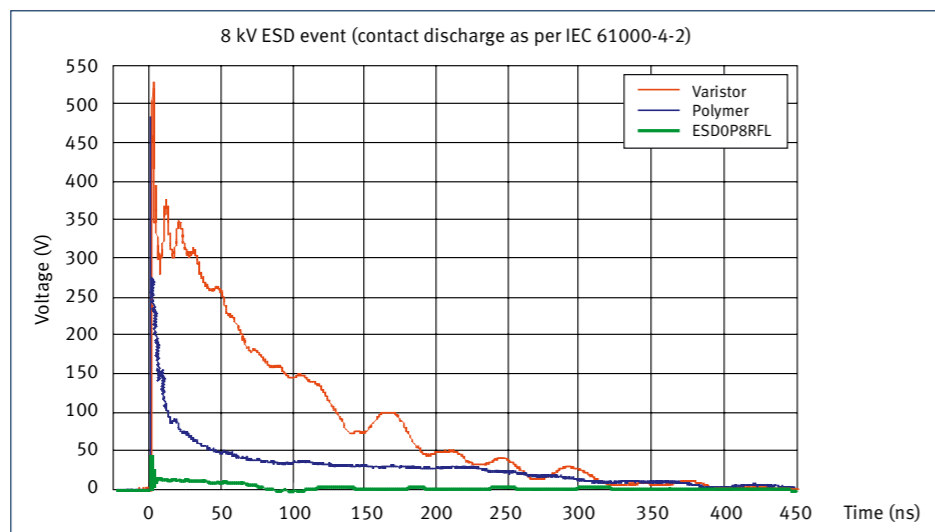


Figure 5: Clamping voltage comparison with Infineon TVS diode, polymer and varistor devices.

ESD protection device	ESD test voltage [kV]	$V_{PEAK}$ [V]	$V_{cl}$ at 30 ns [V]	$W_{cl}$ at 50 $\Omega$ (nWs)
INFINEON ESD0P8RFL	2	23	3	20
	8	43	10	200
Polymer-based protection device	2	306	150	33,200
	8	486	64	17,000
Multilayer varistor (0.5pF)	2	245	120	22,700
	8	528	300	151,000

Figure 6: Comparison between different ESD protection devices and ESD test voltages.

- A typical polymer device breaks down only after a high trigger voltage is reached. Designers should consider this aspect because the overall energy delivered to the protected equipment after clamping can be above its tolerable level and destroy it. Even in the cases where ESD events are absorbed by the polymer, it takes a long time before the polymer recovers to face a new ESD strike again. Polymers show aging due to degradation effects that can be triggered on multiple ESD strikes.
- The evaluated varistors reflect the typical trade-off between low capacitance and low clamping voltage that exist in some kinds of devices. Low-capacitance varistors have very high clamping voltages (for example, measured after 30 ns) far in excess of 100 V.
- When using varistors or polymer protection devices the system may appear protected but the energy dissipated into the downstream devices is still high enough to cause damage or disruption.

The subsequent failure of the electronic equipment as a consequence of deficient protection can be seen as hard failures, latent damage or temporary malfunction (see "ESD threat" section). In the end, customers will perceive this as poor quality.

In summary, the only way to ensure stable operation and maximum reliability at the system level is to ensure that the equipment is properly protected against electrostatic discharge and transients by adding an external TVS diode protection device:

- In this case with Infineon's ESD0P8RFL protection diode, both peak voltage and clamping voltage and therefore also the thermal energy dissipated in the load is much lower than for a polymer-based ESD protection device or a low-capacitance varistor.
- In addition, Infineon TVS diodes are characterized by a faster turn-on time, lower dynamic resistance and long-time reliability.
- Laboratory tests have shown no degradation of Infineon TVS diodes tested under extreme scenarios, i.e. 5,000 ESD pulses at the highest IEC 61000-4-2 level 4. Once the ESD strike is absorbed by the TVS diode, the protection device returns to its high-impedance state very quickly.



## Flatter, thinner, smaller

### STAY ONE STEP AHEAD WITH INFINEON TVS PACKAGES

Infineon TVS diodes support our customers' roadmaps with package solutions that boost both space and cost savings, resulting in the following benefits:

- Low parasitic inductance.
- Flexibility of single and array solutions.
- Ultralow height and size of thin (super) small leadless package (TS(S)LP) result in dramatic reduction of footprint and height requirements.
- Smallest and flattest size leaded packages (TSFP) for easy optical control on soldering.
- Packages suited for all variations in pick-and-place assembly including miniature gullwing leaded packages (SOTx) and small outline diode packages (SODx).
- All parts are suited for lead-free soldering according to JEDEC J-STD-020 standard.
- All parts are fully compliant with RoHs directive.
- Active package development ongoing to expand TVS portfolio.

### THE WORLD'S SMALLEST TVS DIODES

At just 0.62 x 0.32 x 0.31 mm for TSSLP-2 (thin super-small leadless) or 1.00 x 0.60 x 0.39 mm for TSLP-2,-3,-4 (thin small leadless), Infineon packages are the smallest in the world for a TVS diode. These packages enable the creation of smaller and slimmer designs in applications where PCB space is usually a concern. Specially designed for mobile phones, laptops, PDAs, digital still cameras, mobile TV and other portable applications, they support designers by generating additional space for added functionality.

The TSLP and TSSLP packages are leadless. They can be used as drop-in replacement of passive ceramic or polymer suppressors.

### SPACE SAVING WITH ARRAY SOLUTIONS

Array solutions can free-up space in the board by combining two, four or more elements in a single package. Infineon offers a comprehensive portfolio of leaded and leadless devices for protection of up to 5 lines with a single device. For example, a solution integrating protection on both the high-speed data lines (x4) and their related power line is available (see ESD5V3U4RRS).

### HOW TO READ THE TABLES

Package (JEITA)	
Scale 1:1	SAMPLE (Scale)
Pins	
Dimensions [mm]	

#### LEADLESS PACKAGES

TSSLP-2-1		TSLP-2-7	
	5:1		5:1
2		2	
0.62 x 0.32 x 0.31		1.0 x 0.6 x 0.39	
TSLP-3-1		TSLP-3-7	
	5:1		5:1
2		3	
1.0 x 0.6 x 0.4		1.0 x 0.6 x 0.39	
TSLP-4-7		TSLP-9-1	
	5:1		5:1
4		9	
1.2 x 0.8 x 0.39		2.3 x 1.0 x 0.31	

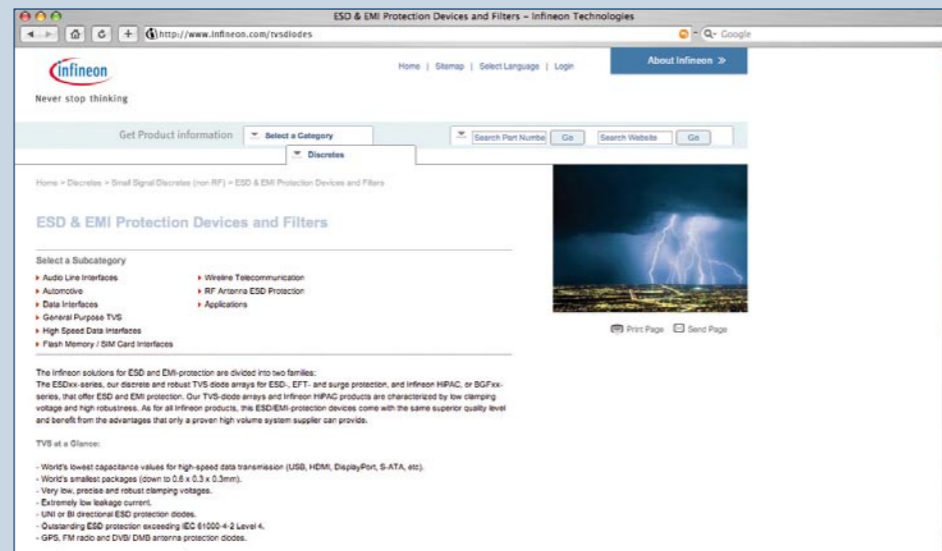
#### TSFPx / SODx / SOTx PACKAGES

TSFP-3		SOT323 (SC70)	
	2:1		2:1
3		3	
1.2 x 1.2 x 0.55		2.0 x 2.1 x 0.9	
SOD323 (SC76)		SOT143 (SC61)	
	2:1		2:1
2		4	
2.5 x 1.25 x 0.9		2.9 x 2.4 x 1.0	
SOT23 (SC59)		SOT363 (SC88)	
	2:1		2:1
3		6	
2.9 x 2.4 x <1.1		2.0 x 2.1 x 0.9	



## FIND OUT MORE ABOUT ESD PROTECTION

[WWW.INFINEON.COM/TVSDIODES](http://www.infineon.com/tvsdiodes)



## APPLICATION NOTES

- AN079: ESD tests according to the human body model.
- AN086: ESD protection in RF circuits.
- AN100: ESD protection for high-speed applications: 1- & 2-channel low-capacitance bidirectional ESD diode in ultrasmall TSLP package.
- AN103: ESD and antenna protection using Infineon ESD0P8RFL.
- AN104: 2-channel bi/unidirectional TVS diodes for ESD protection in CAN/LIN bus applications ESD24VS2B, ESD24VS2U.
- AN140: ESD protection for digital high-speed interfaces (HDMI, FireWire, etc.) using ESD5V3U1U.
- AN167: ESD protection for broadband low noise amplifier BGA728L7 for portable and mobile TV applications.

## REPORTS

- ESD protection for GPS antenna using Infineon ESD5V3U1U and ESD0P4RFL (upon request).
- Recommendations for printed circuit board assembly of Infineon TSLP/TSSLP packages.

## BROCHURES

- Small signal discretes selection guide
- Small signal discretes product and application guide
- Evaluation boards for automotive, industrial and multimarket applications
- GPS front-end components for mobile and portable applications

## SAMPLE KITS

- KIT TVS DIODE 1: TVS diodes for ultrahigh-speed applications
- KIT TVS DIODE 2: Diodes for RF antenna protection
- KIT TVS DIODE 3: ESD8V0L series for ESD protection
- KIT TVS DIODE 4: ESD24VS series for ESD protection
- KIT GPS: GPS receive front-end

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