

ESD9101

ESD Protection Diode

Low Capacitance ESD Protection Diodes for High Speed Data Lines

The ESD9101 is designed to protect a single high speed data line from ESD. Ultra-low capacitance and low ESD clamping voltage via SCR technology make this device an ideal solution for protecting voltage sensitive high speed data lines. The SOD-923 micro-package allows for easy PCB layout and the ability to be placed in space constrained applications where board area comes at a premium.

Features

- Low Capacitance (0.5 pF Max, I/O to GND)
- Protection for the Following Standards:
IEC 61000-4-2 (Level 4) & ISO 10605
- Low ESD Clamping Voltage
- SZ Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

Typical Applications

- USB 3.0/3.1
- HDMI 1.3/1.4/2.0
- DisplayPort
- GPS Antenna

MAXIMUM RATINGS ($T_J = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Operating Junction Temperature Range	T_J	-55 to +150	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-55 to +150	$^\circ\text{C}$
Lead Solder Temperature - Maximum (10 Seconds)	T_L	260	$^\circ\text{C}$
IEC 61000-4-2 Contact IEC 61000-4-2 Air ISO 10605 150 pF/2 k Ω ISO 10605 330 pF/2 k Ω ISO 10605 330 pF/330 Ω	ESD	± 25 ± 25 ± 30 ± 30 ± 20	kV

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

See Application Note AND8308/D for further description of survivability specs.



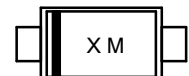
ON Semiconductor®

www.onsemi.com

MARKING DIAGRAM



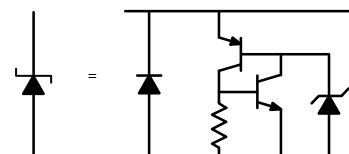
SOD-923
CASE 514AB



XX = Specific Device Code
M = Date Code
▪ = Pb-Free Package

(Note: Microdot may be in either location)

PIN CONFIGURATIONS AND SCHEMATICS



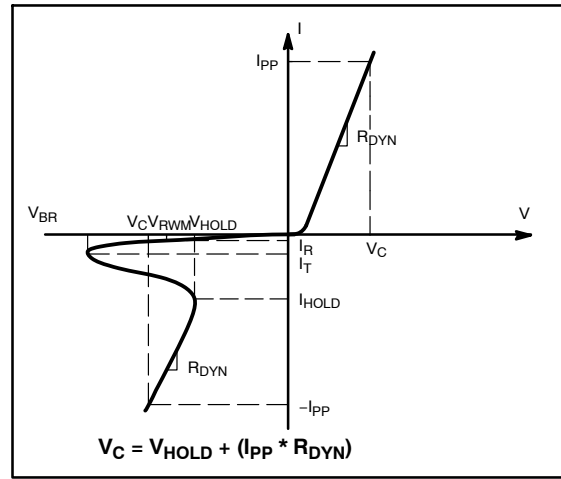
ORDERING INFORMATION

See detailed ordering and shipping information on page 6 of this data sheet.

ELECTRICAL CHARACTERISTICS

(T_A = 25°C unless otherwise noted)

Symbol	Parameter
V _{RWM}	Working Peak Voltage
I _R	Maximum Reverse Leakage Current @ V _{RWM}
V _{BR}	Breakdown Voltage @ I _T
I _T	Test Current
V _{HOLD}	Holding Reverse Voltage
I _{HOLD}	Holding Reverse Current
R _{DYN}	Dynamic Resistance
I _{PP}	Maximum Peak Pulse Current
V _C	Clamping Voltage @ I _{PP} V _C = V _{HOLD} + (I _{PP} * R _{DYN})



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Reverse Working Voltage	V _{RWM}	I/O Pin to GND			5.0	V
Breakdown Voltage	V _{BR}	I _T = 1 mA, I/O Pin to GND	5.3	7.0	8.0	V
Reverse Leakage Current	I _R	V _{RWM} = 5.0 V, I/O Pin to GND			1.0	μA
Holding Reverse Voltage	V _{HOLD}	I/O Pin to GND		2.2		V
Holding Reverse Current	I _{HOLD}	I/O Pin to GND	65	97		mA
Clamping Voltage	V _C	IEC61000-4-2, ±8 KV Contact	See Figures 1 and 2			V
Clamping Voltage TLP	V _C	I _{PP} = 8 A I _{PP} = -8 A I _{PP} = 16 A I _{PP} = -16 A		5.0 -4.0 7.0 -7.0		V
Dynamic Resistance	R _{DYN}	I/O Pin to GND GND to I/O Pin		0.30 0.38		Ω
Junction Capacitance	C _J	V _R = 0 V, f = 1 MHz between I/O Pins and GND V _R = 0 V, f = 2.5 GHz between I/O Pins and GND V _R = 0 V, f = 5.0 GHz between I/O Pins and GND		0.36 0.36 0.36	0.50 0.45 0.45	pF

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

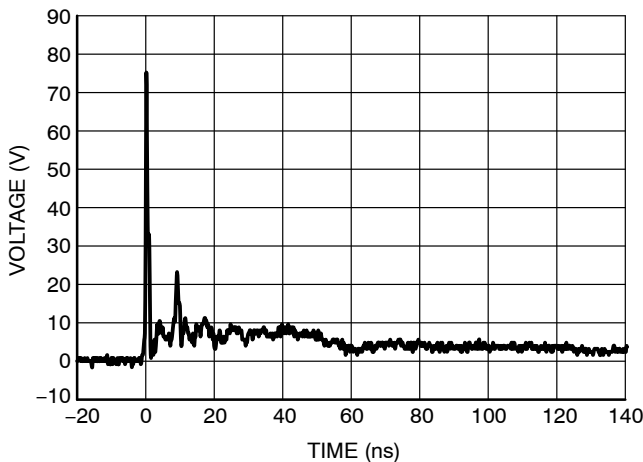


Figure 1. IEC61000-4-2 +8 kV Contact ESD Clamping Voltage

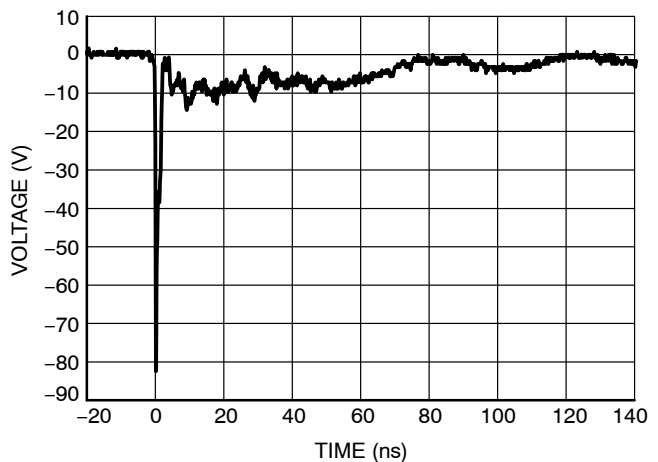


Figure 2. IEC61000-4-2 -8 kV Contact Clamping Voltage

ESD9101

IEC 61000-4-2 Spec.

Level	Test Voltage (kV)	First Peak Current (A)	Current at 30 ns (A)	Current at 60 ns (A)
1	2	7.5	4	2
2	4	15	8	4
3	6	22.5	12	6
4	8	30	16	8

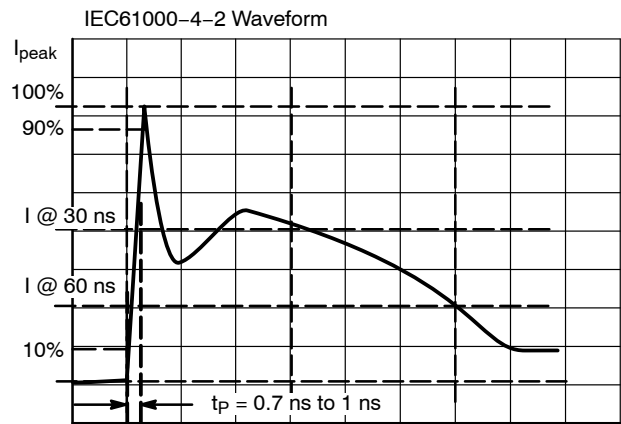


Figure 3. IEC61000-4-2 Spec

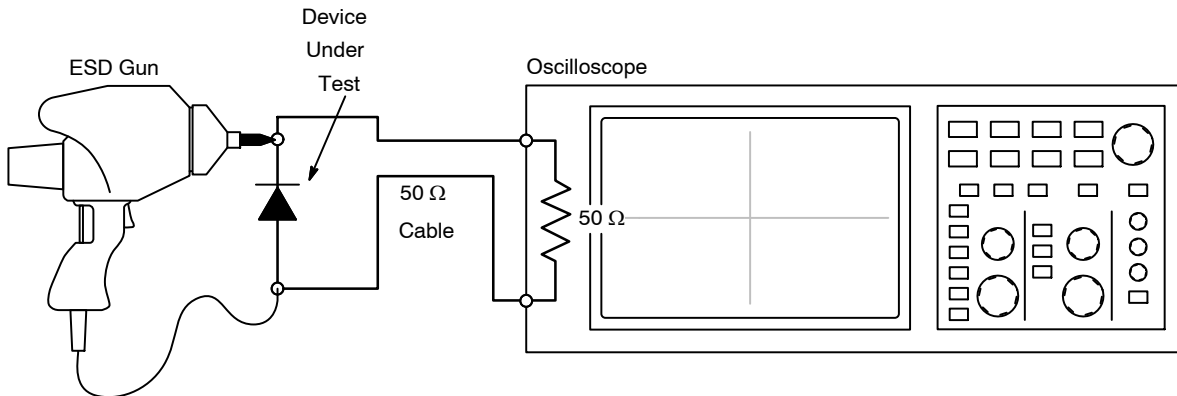


Figure 4. Diagram of ESD Clamping Voltage Test Setup

The following is taken from Application Note AND8307/D – Characterization of ESD Clamping Performance.

ESD Voltage Clamping

For sensitive circuit elements it is important to limit the voltage that an IC will be exposed to during an ESD event to as low a voltage as possible. The ESD clamping voltage is the voltage drop across the ESD protection diode during an ESD event per the IEC61000-4-2 waveform. Since the IEC61000-4-2 was written as a pass/fail spec for larger

systems such as cell phones or laptop computers it is not clearly defined in the spec how to specify a clamping voltage at the device level. ON Semiconductor has developed a way to examine the entire voltage waveform across the ESD protection diode over the time domain of an ESD pulse in the form of an oscilloscope screenshot, which can be found on the datasheets for all ESD protection diodes. For more information on how ON Semiconductor creates these screenshots and how to interpret them please refer to AND8307/D.

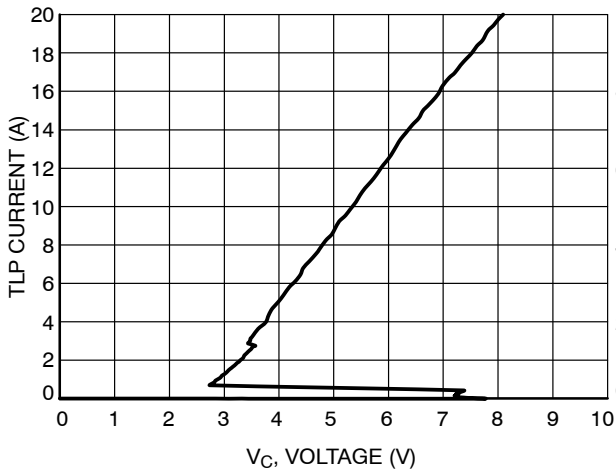


Figure 5. Positive TLP IV Curve

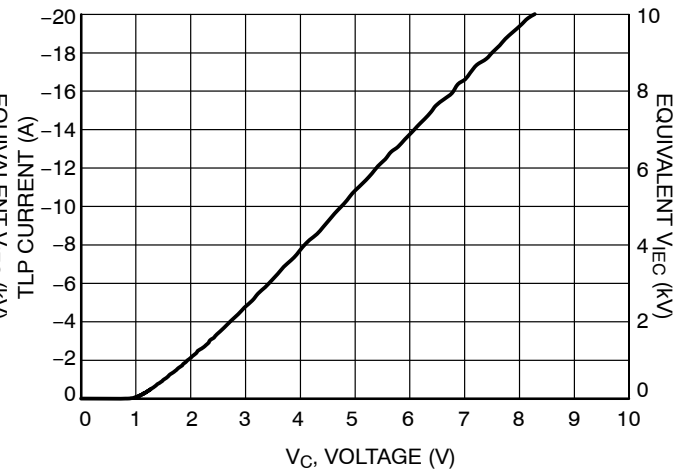


Figure 6. Negative TLP IV Curve

NOTE: TLP parameter: $Z_0 = 50 \Omega$, $t_p = 100 \text{ ns}$, $t_r = 300 \text{ ps}$, averaging window: $t_1 = 30 \text{ ns}$ to $t_2 = 60 \text{ ns}$. V_{IEC} is the equivalent voltage stress level calculated at the secondary peak of the IEC 61000-4-2 waveform at $t = 30 \text{ ns}$ with 2 A/kV . See TLP description below for more information.

Transmission Line Pulse (TLP) Measurement

Transmission Line Pulse (TLP) provides current versus voltage (I-V) curves in which each data point is obtained from a 100 ns long rectangular pulse from a charged transmission line. A simplified schematic of a typical TLP system is shown in Figure 7. TLP I-V curves of ESD protection devices accurately demonstrate the product's ESD capability because the 10s of amps current levels and under 100 ns time scale match those of an ESD event. This is illustrated in Figure 8 where an 8 kV IEC 61000-4-2 current waveform is compared with TLP current pulses at 8 A and 16 A. A TLP I-V curve shows the voltage at which the device turns on as well as how well the device clamps voltage over a range of current levels. For more information on TLP measurements and how to interpret them please refer to AND9007/D.

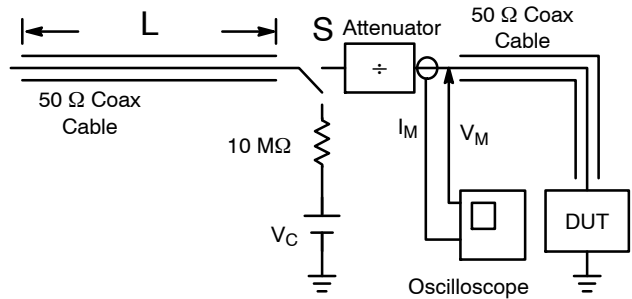


Figure 7. Simplified Schematic of a Typical TLP System

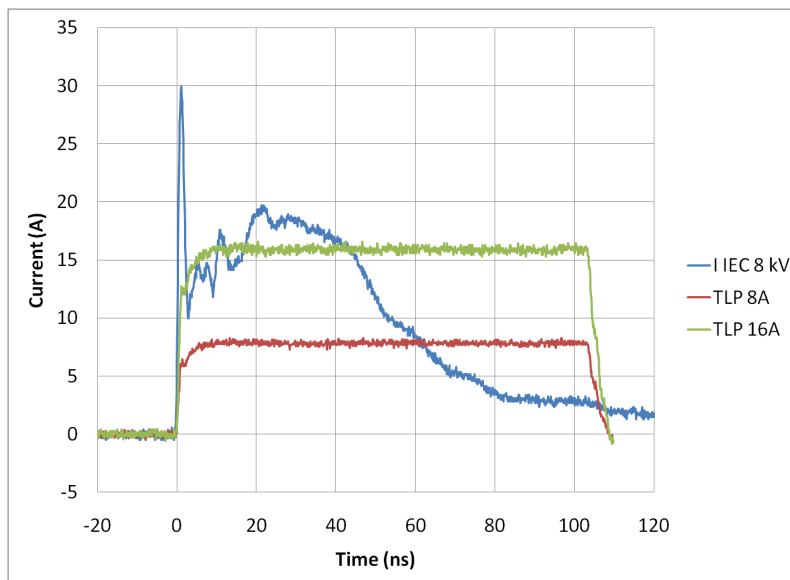


Figure 8. Comparison Between 8 kV IEC 61000-4-2 and 8 A and 16 A TLP Waveforms

ESD9101

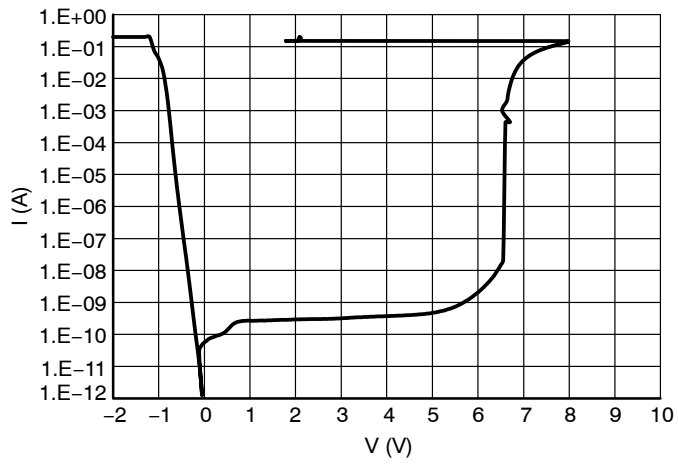


Figure 9. IV Characteristics

Latch-Up Considerations

ON Semiconductor’s 9100 series of ESD protection devices utilize a snap-back, SCR type structure. By using this technology, the potential for a latch-up condition was taken into account by performing load line analyses of common high speed serial interfaces. Example load lines for latch-up free applications and applications with the potential for latch-up are shown below with a generic IV characteristic of a snapback, SCR type structured device overlaid on each. In the latch-up free load line case, the IV characteristic of the snapback protection device intersects the load-line in one unique point (V_{OP} , I_{OP}). This is the only stable operating point of the circuit and the system is

therefore latch-up free. In the non-latch up free load line case, the IV characteristic of the snapback protection device intersects the load-line in two points (V_{OPA} , I_{OPA}) and (V_{OPB} , I_{OPB}). Therefore in this case, the potential for latch-up exists if the system settles at (V_{OPB} , I_{OPB}) after a transient. Due to its high holding current, the ESD9101 is suitable for HDMI and 5 V active antenna applications where previous ESD8000 series devices were not. *When designing this part into the application, please note the latch-up considerations by performing a loadline analysis corresponding to the data line and ESD9101’s SCR characteristics.* For a more in-depth explanation of latch-up considerations please refer to Application Note AND9116/D.

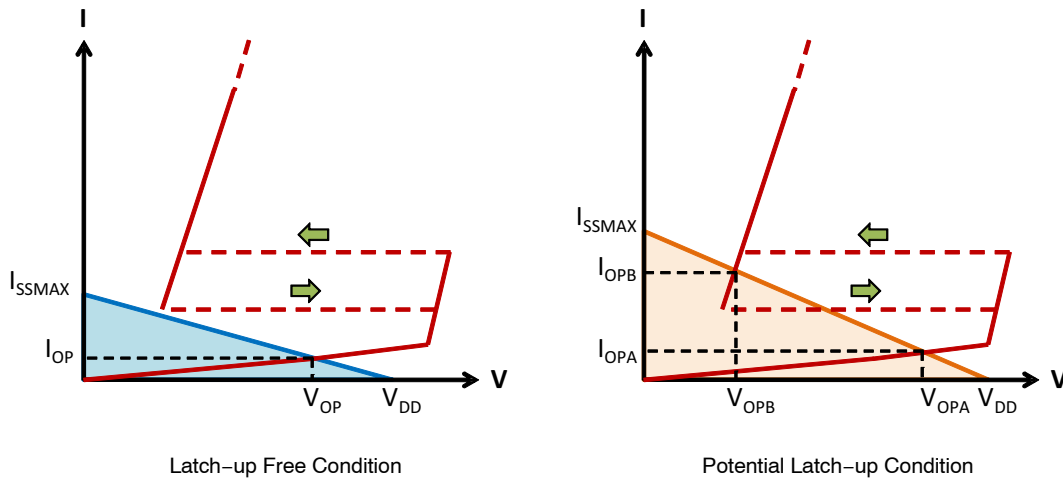


Figure 10. Example Load Lines for Latch-up Free Applications and Applications with the Potential for Latch-up

Table 1. SUMMARY OF SCR REQUIREMENTS FOR LATCH-UP FREE APPLICATIONS

Application	VBR (min) (V)	IH (min) (mA)	VH (min) (V)
HDMI 1.4/1.3a TMDS	3.465	54.78	1.0
USB 2.0 LS/FS	3.301	1.76	1.0
USB 2.0 HS	0.482	N/A	1.0
USB 3.0/3.1 SS	2.800	N/A	1.0
DisplayPort	3.600	25.00	1.0
GPS (Active)	5.200	80.00	1.0

ORDERING INFORMATION

Device	Package	Shipping†
ESD9101P2T5G	SOD-923 (Pb-Free)	8000 / Tape & Reel
SZESD9101P2T5G		

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

onsemi, **Onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:

Email Requests to: orderlit@onsemi.com

onsemi Website: www.onsemi.com

TECHNICAL SUPPORT

North American Technical Support:

Voice Mail: 1 800-282-9855 Toll Free USA/Canada

Phone: 011 421 33 790 2910

Europe, Middle East and Africa Technical Support:

Phone: 00421 33 790 2910

For additional information, please contact your local Sales Representative

