ESD Protection Diodes

Ultra Low Capacitance ESD Protection Diode for High Speed Data Line

ESD8011

The ESD8011 ESD protection diodes are designed to protect high speed data lines from ESD. Ultra−low capacitance and low ESD clamping voltage make this device an ideal solution for protecting voltage sensitive high speed data lines.

Features

- Ultra Low Capacitance (0.10 pF Typ, I/O to GND)
- Protection for the Following IEC Standards:
  IEC 61000−4−2 (Level 4)
- 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.x
- MHL 2.0
- SATA/SAS
- PCI Express

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

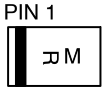
Rating	Symbol	Value	Unit
Operating Junction Temperature Range	T_J	−55 to +125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C
Lead Solder Temperature − Maximum (10 Seconds)	T_L	260	°C
IEC 61000−4−2 Contact (ESD) IEC 61000−4−2 Air (ESD)	ESD ESD	±20 ±20	kV kV
Maximum Peak Pulse Current 8/20 μs @ T_A = 25°C	I_{pp}	3.6	A
Maximum Peak Pulse Power 8/20 μs @ T_A = 25°C	P_{pk}	34	W

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.

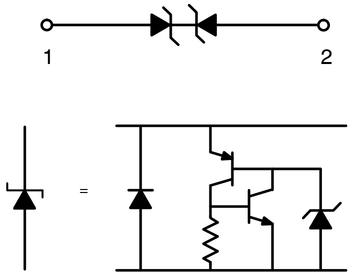
MARKING DIAGRAM

X3DFN2
CASE 152AF



R = Specific Device Code (Rotated 90° clockwise)
M = Date Code

PIN CONFIGURATION AND SCHEMATIC



ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 7 of this data sheet.

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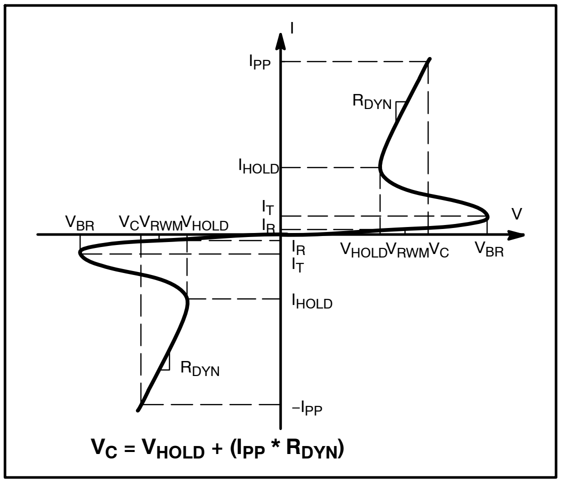
ELECTRICAL CHARACTERISTICS

(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} $V_C = V_{HOLD} + (I_{PP} * R_{DYN})$



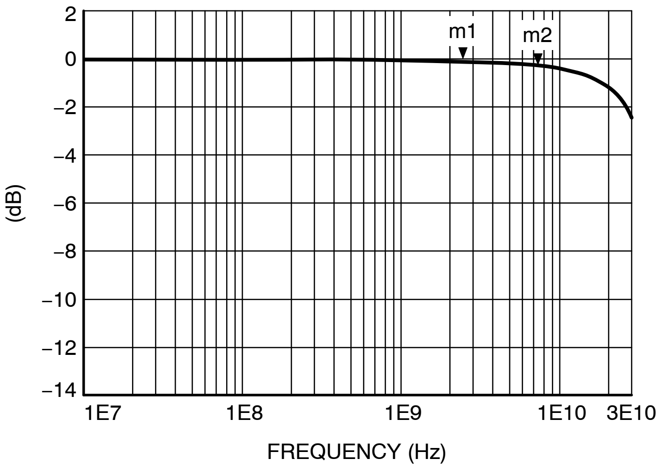
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Reverse Working Voltage	V_{RWM}	I/O Pin to GND			5.5	V
Breakdown Voltage	V_{BR}	I_T = 1 mA, I/O Pin to GND	6.5	7.3		V
Reverse Leakage Current	I_R	V_{RWM} = 5.5 V, I/O Pin to GND			1.0	μA
Reverse Holding Voltage	V_{HOLD}	I/O Pin to GND		2.05		V
Holding Reverse Current	I_{HOLD}	I/O Pin to GND		17		mA
Clamping Voltage TLP (Note 2)	V_C	I_{PP} = 8 A } IEC61000−4−2 Level 2 Equivalent (±4 kV Contact, ±8 kV Air) I_{PP} = 16 A } IEC61000−4−2 Level 2 Equivalent (±8 kV Contact, ±16 kV Air)		10.1 17.2		V
Dynamic Resistance	R_{DYN}	Pin1 to Pin2 Pin2 to Pin1		1.0 1.0		Ω
Junction Capacitance	C_J	V_R = 0 V, f = 1 MHz		0.10	0.20	pF
Series Inductance	L_S	V_R = 0 V		0.3		nH

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.

1. For test procedure see Figure 5 and application note AND8307/D.
2. ANSI/ESD STM5.5.1 − Electrostatic Discharge Sensitivity Testing using Transmission Line Pulse (TLP) Model.
   TLP conditions: Z_0 = 50 Ω, t_p = 100 ns, t_r = 0.6 ns, averaging window; t_1 = 70 ns to t_2 = 90 ns.

TYPICAL CHARACTERISTICS



Interface	Data Rate (Gb/s)	Fundamental Frequency (GHz)	3rd Harmonic Frequency (GHz)	ESD8011 Insertion Loss (dB)
USB 3.0	5	2.5 (m1)	7.5 (m2)	m1 = 0.087 m2 = 0.256

Figure 1. ESD8011 Insertion Loss

TYPICAL CHARACTERISTICS

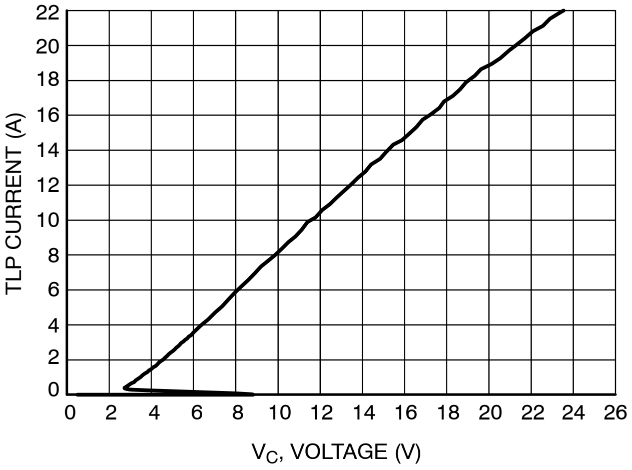


Figure 2. Positive TLP IV Curve

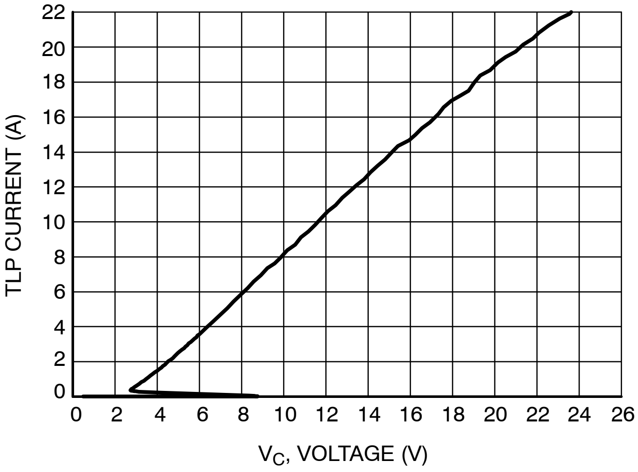
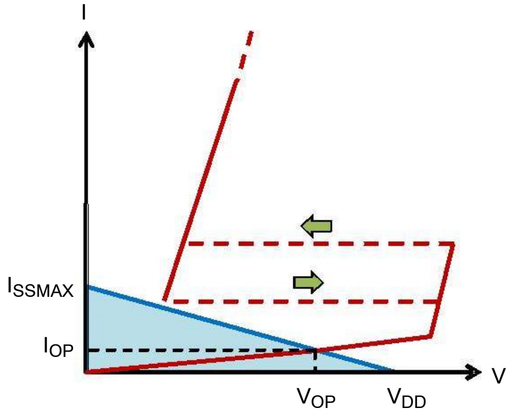


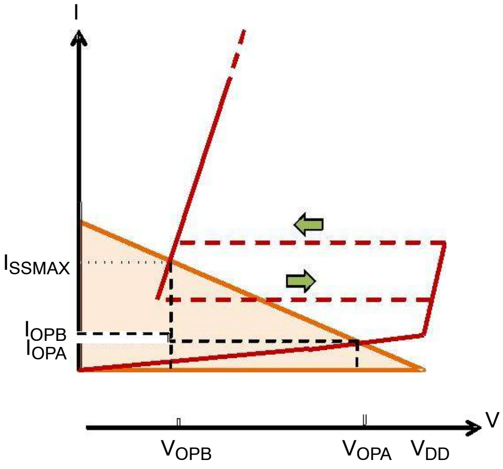
Figure 3. Negative TLP IV Curve

Latch−Up Considerations

ON Semiconductor's 8000 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. Because of this, ESD8011 should not be used for HDMI applications − ESD8104 or ESD8040 have been designed to be acceptable for HDMI applications without latch−up. Please refer to Application Note AND9116/D for a more in-depth explanation of latch−up considerations using ESD8000 series devices.



ESD8011 Latch−up free:
USB 2.0 LS/FS, USB 2.0 HS, USB 3.0 SS,
DisplayPort



ESD8011 Potential Latch−up:
HDMI 1.4/1.3a TMDS

Figure 4. 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

	VBR (min)	IH (min)	VH (min)	ON Semiconductor ESD8000 Series
Application	(V)	(mA)	(V)	Recommended PN
HDMI 1.4/1.3a TMDS	3.465	54.78	1.0	ESD8104, ESD8040
USB 2.0 LS/FS	3.301	1.76	1.0	ESD8004, ESD8011
USB 2.0 HS	0.482	N/A	1.0	ESD8004, ESD8011
USB 3.0 SS	2.800	N/A	1.0	ESD8004, ESD8006, ESD8011
DisplayPort	3.600	25.00	1.0	ESD8004, ESD8006, ESD8011

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

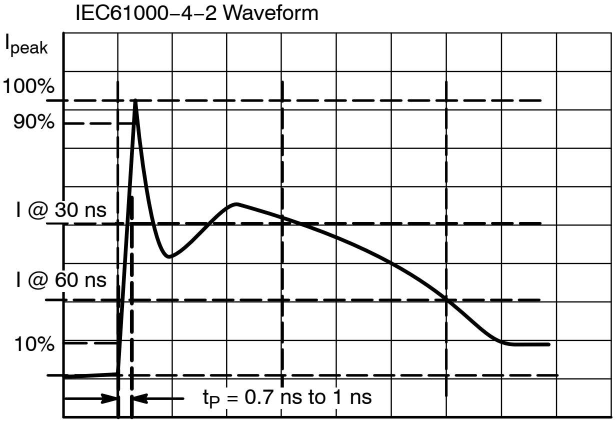


Figure 5. IEC61000−4−2 Spec

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 6. 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 7 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.

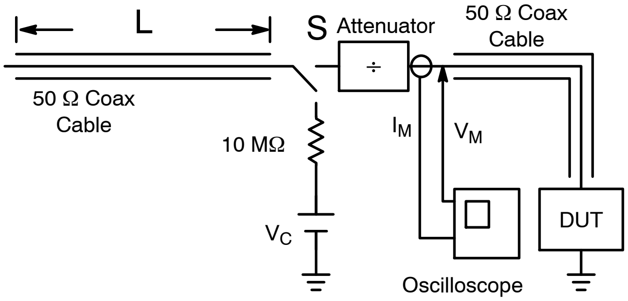


Figure 6. Simplified Schematic of a Typical TLP System

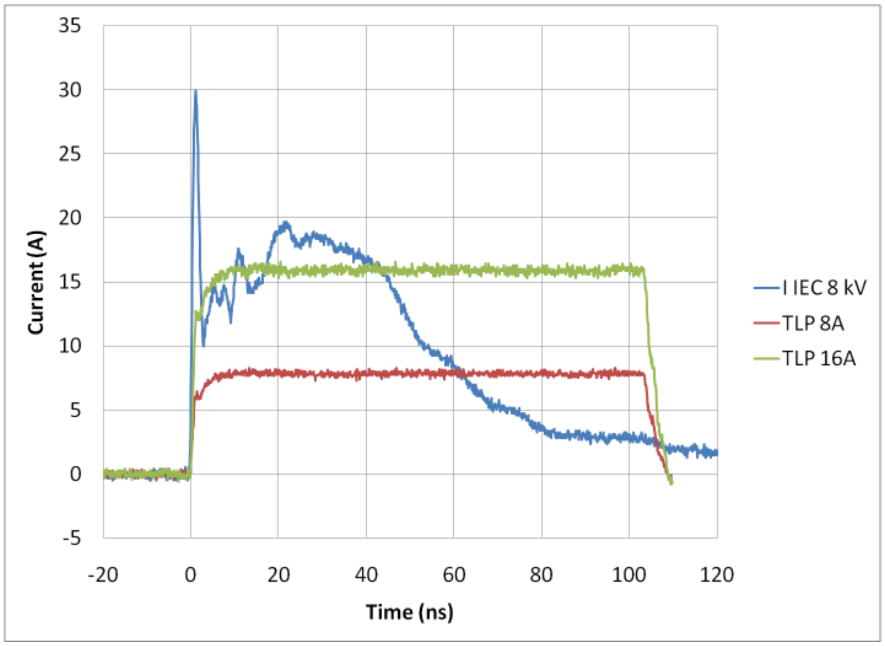


Figure 7. Comparison Between 8 kV IEC 61000−4−2 and 8 A and 16 A TLP Waveforms

ORDERING INFORMATION

Device	Package	Shipping†
ESD8011MUT5G	X3DFN2 (Pb−Free)	10000 / Tape & Reel
SZESD8011MUT5G*	X3DFN2 (Pb−Free)	10000 / Tape & Reel

†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.

*SZ Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q101 Qualified and PPAP Capable.

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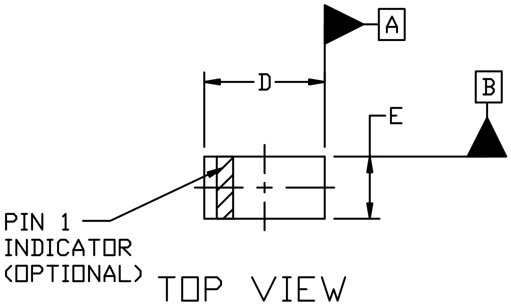
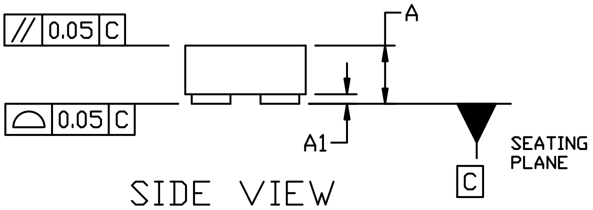
SCALE 8:1

X3DFN2, 0.62x0.32, 0.355P, (0201)
CASE 152AF
ISSUE B

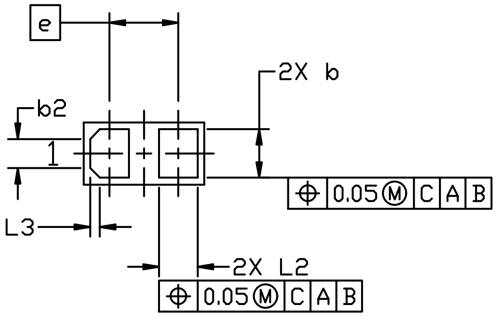
DATE 13 JAN 2023



TOP VIEW



SIDE VIEW

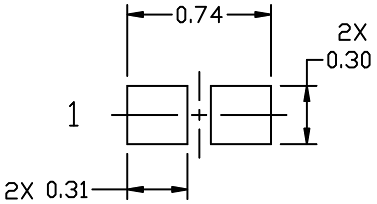


BOTTOM VIEW

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS

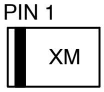
	MILLIMETERS		
DIM	MIN.	NOM.	MAX.
A	0.25	0.29	0.33
A1	0.00	---	0.05
b	0.22	0.25	0.28
b2	0.150 REF		
D	0.58	0.62	0.66
E	0.28	0.32	0.36
e	0.355 BSC		
L2	0.17	0.20	0.23
L3	0.050 REF		



RECOMMENDED
MOUNTING FOOTPRINT*

* For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

GENERIC MARKING DIAGRAM*



X = Specific Device Code
M = Date Code

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, “G” or microdot “▪”, may or may not be present. Some products may not follow the Generic Marking.

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