

# ESD Protection Diode

## Micro-Packaged Diodes for ESD Protection

### ESD5581

The ESD5581 is designed to protect voltage sensitive components that require low capacitance from ESD and transient voltage events. Excellent clamping capability, low capacitance, low leakage, and fast response time, make these parts ideal for ESD protection on designs where board space is at a premium.

#### Features

- Low Clamping Voltage
- Small Body Outline Dimensions: 0.62 mm x 0.32 mm
- Low Body Height: 0.3 mm
- Stand-off Voltage: 5 V
- IEC61000-4-2 Level 4 ESD Protection
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

#### Typical Applications

- $\mu$ SD Card Protection
- Audio Line Protection
- GPIO

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
IEC 61000-4-2 (ESD) Contact Air		$\pm 30$ $\pm 30$	kV
Total Power Dissipation on FR-5 Board (Note 1) @ $T_A = 25^\circ\text{C}$	$P_D$	250	mW
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	400	$^\circ\text{C/W}$
Junction and Storage Temperature Range	$T_J, T_{stg}$	-55 to +150	$^\circ\text{C}$
Lead Solder Temperature – Maximum (10 Second Duration)	$T_L$	260	$^\circ\text{C}$

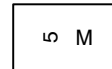
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. FR-5 = 1.0 x 0.75 x 0.62 in.

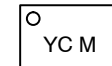


#### MARKING DIAGRAM

PIN 1


**X3DFN2**  
**CASE 152AF**


5 = Specific Device Code  
M = Date Code


**X2DFN2**  
**CASE 714AB**


YC = Specific Device Code  
M = Date Code

#### ORDERING INFORMATION

Device	Package	Shipping <sup>†</sup>
ESD5581MXT5G	X3DFN2 (Pb-Free)	10000 / Tape & Reel
ESD5581N2T5G	X2DFN2 (Pb-Free)	8000 / Tape & Reel

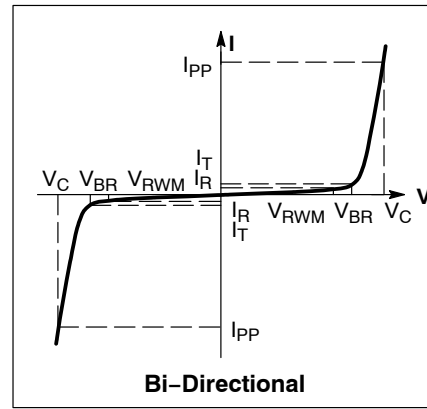
<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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

**ELECTRICAL CHARACTERISTICS**(T<sub>A</sub> = 25°C unless otherwise noted)

Symbol	Parameter
I <sub>PP</sub>	Maximum Reverse Peak Pulse Current
V <sub>C</sub>	Clamping Voltage @ I <sub>PP</sub>
V <sub>RWM</sub>	Working Peak Reverse Voltage
I <sub>R</sub>	Maximum Reverse Leakage Current @ V <sub>RWM</sub>
V <sub>BR</sub>	Breakdown Voltage @ I <sub>T</sub>
I <sub>T</sub>	Test Current

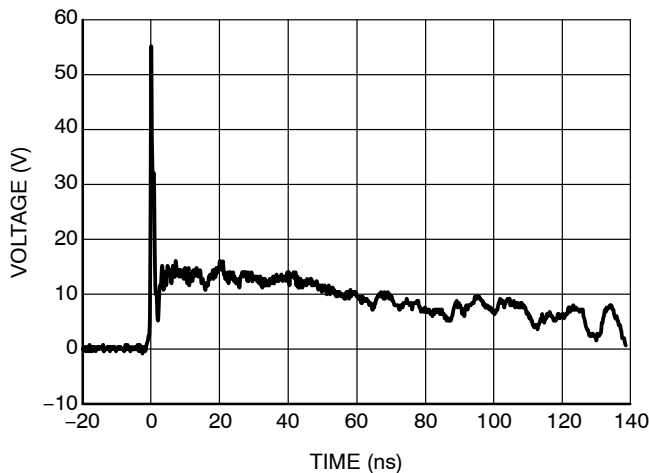
\*See Application Note AND8308/D for detailed explanations of datasheet parameters.

**ELECTRICAL CHARACTERISTICS** (T<sub>A</sub> = 25°C unless otherwise specified)

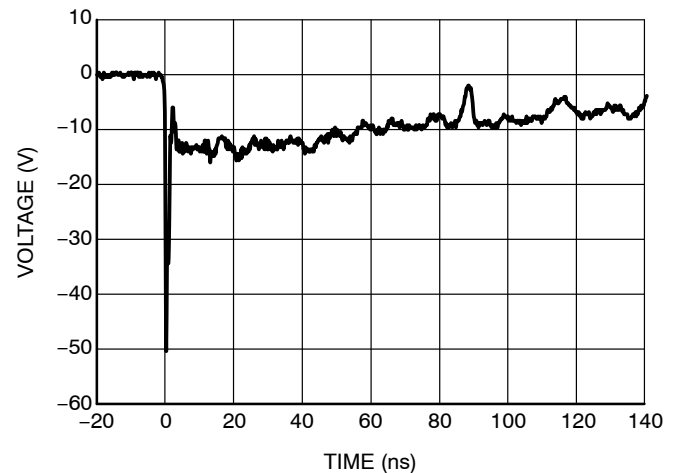
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Reverse Working Voltage	V <sub>RWM</sub>				5.0	V
Breakdown Voltage (Note 2)	V <sub>BR</sub>	I <sub>T</sub> = 1 mA	5.2	6.2	7.5	V
Reverse Leakage Current	I <sub>R</sub>	V <sub>RWM</sub> = 5 V			0.1	μA
Clamping Voltage (Note 3)	V <sub>C</sub>	I <sub>PP</sub> = 1 A			8.0	V
Clamping Voltage (Note 3)	V <sub>C</sub>	I <sub>PP</sub> = 4 A			10	V
Clamping Voltage (Note 3)	V <sub>C</sub>	I <sub>PP</sub> = 6 A		10.3	12	V
Clamping Voltage (Note 4)	V <sub>C</sub>	IEC61000-4-2, ±8 kV Contact	See Figures 1 & 2			V
Peak Pulse Current (Note 3)	I <sub>PP</sub>	t <sub>p</sub> = 8/20 μs	6.0			A
Clamping Voltage TLP (Note 5)	V <sub>C</sub>	I <sub>PP</sub> = 16 A } IEC 61000-4-2 Level 4 equivalent (±8 kV Contact, ±15 kV Air)		11		V
Dynamic Resistance	R <sub>DYN</sub>	TLP Pulse		0.22		Ω
Junction Capacitance	C <sub>J</sub>	V <sub>R</sub> = 0 V, f = 1 MHz			10	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.

- Breakdown voltage is tested from pin 1 to 2 and pin 2 to 1.
- Non-repetitive current pulse at T<sub>A</sub> = 25°C, per IEC61000-4-5 waveform. (See Figure 12)
- For test procedure see Figure 10 and application note AND8307/D.
- ANSI/ESD STM5.5.1 – Electrostatic Discharge Sensitivity Testing using Transmission Line Pulse (TLP) Model.  
TLP conditions: Z<sub>0</sub> = 50 Ω, t<sub>p</sub> = 100 ns, t<sub>r</sub> = 4 ns, averaging window; t<sub>1</sub> = 30 ns to t<sub>2</sub> = 60 ns.

**TYPICAL CHARACTERISTICS**

**Figure 1. ESD Clamping Voltage Screenshot**  
Positive 8 kV Contact per IEC61000-4-2



**Figure 2. ESD Clamping Voltage Screenshot**  
Negative 8 kV Contact per IEC61000-4-2

TYPICAL CHARACTERISTICS

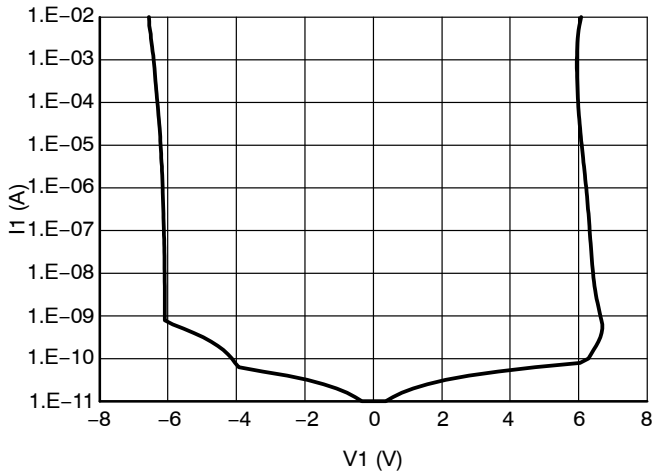


Figure 3. IV Characteristics

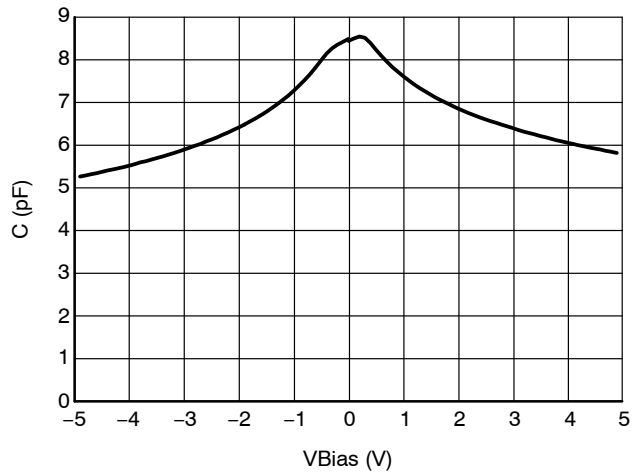


Figure 4. CV Characteristics

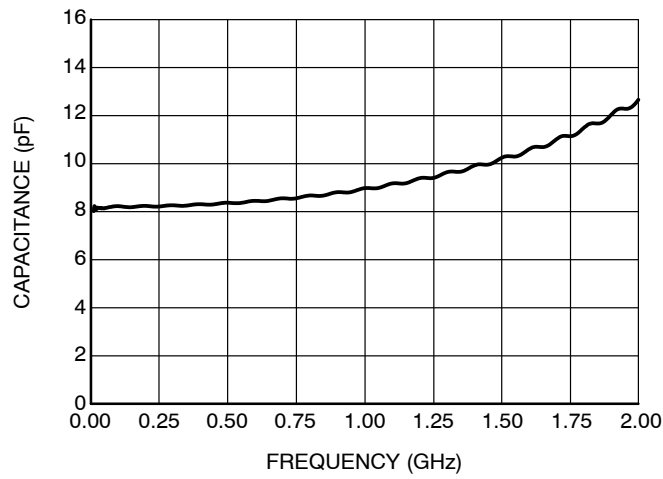


Figure 5. Capacitance over Frequency

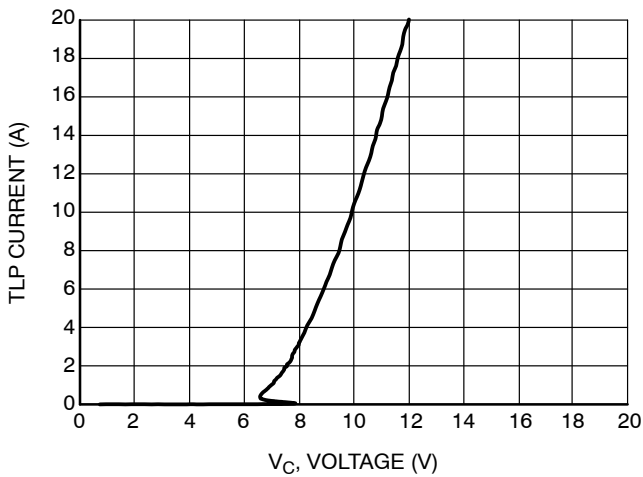


Figure 6. Positive TLP I-V Curve

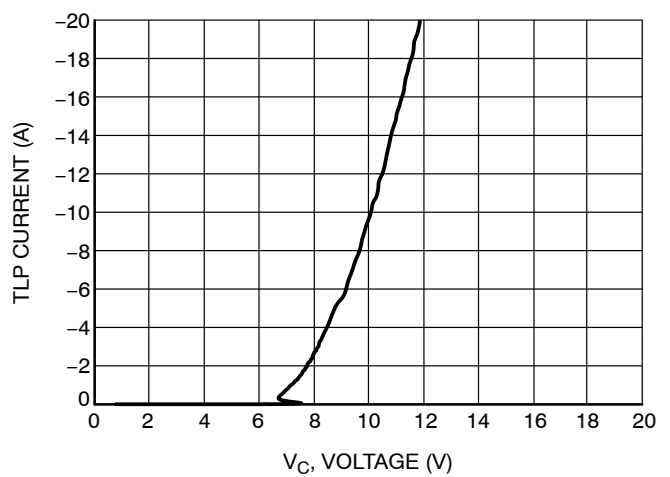
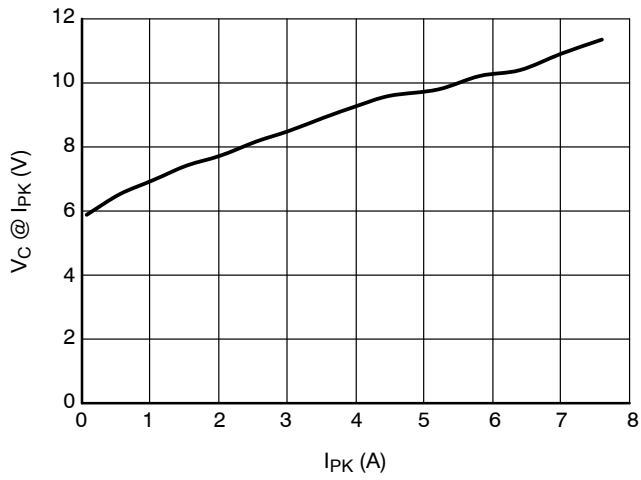
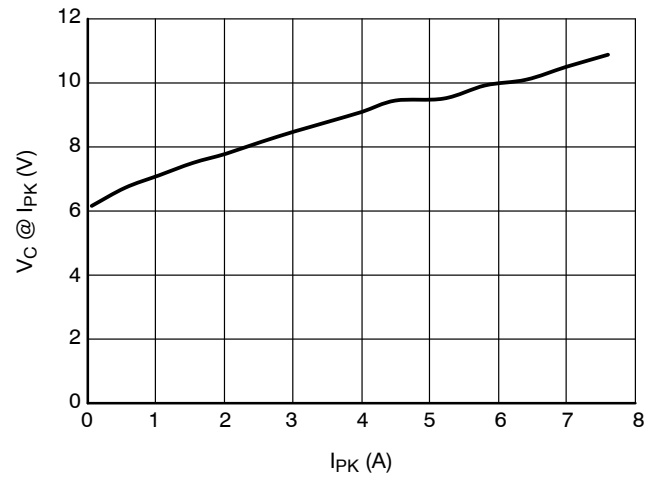


Figure 7. Negative TLP I-V Curve

## TYPICAL CHARACTERISTICS



**Figure 8. Pin 1-2 Clamping Voltage vs. Peak Pulse Current ( $t_p = 8/20 \mu s$ )**



**Figure 9. Pin 2-1 Clamping Voltage vs. Peak Pulse Current ( $t_p = 8/20 \mu s$ )**

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

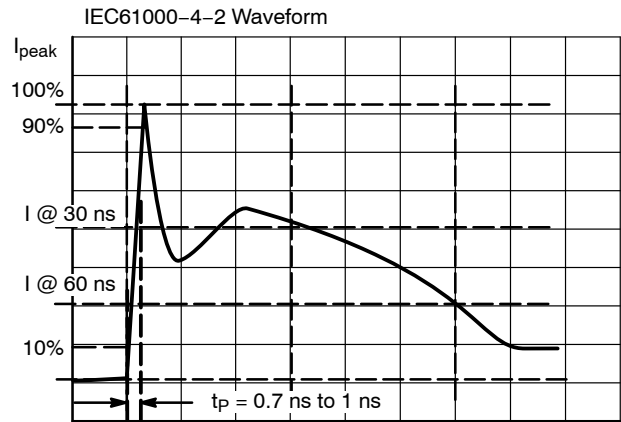


Figure 10. IEC61000-4-2 Spec

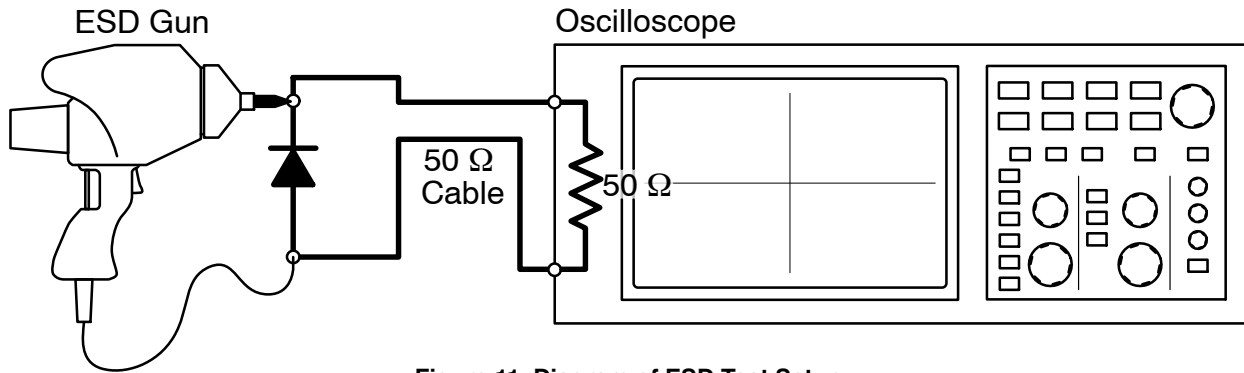


Figure 11. Diagram of ESD Test Setup

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. **onsemi** 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 **onsemi** creates these screenshots and how to interpret them please refer to AND8307/D.

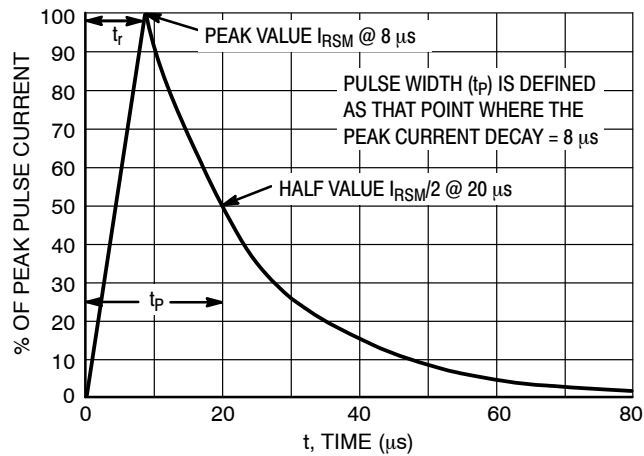
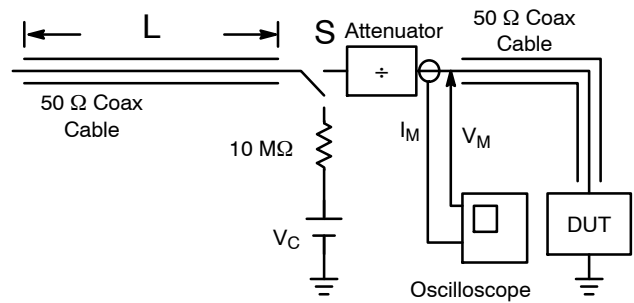


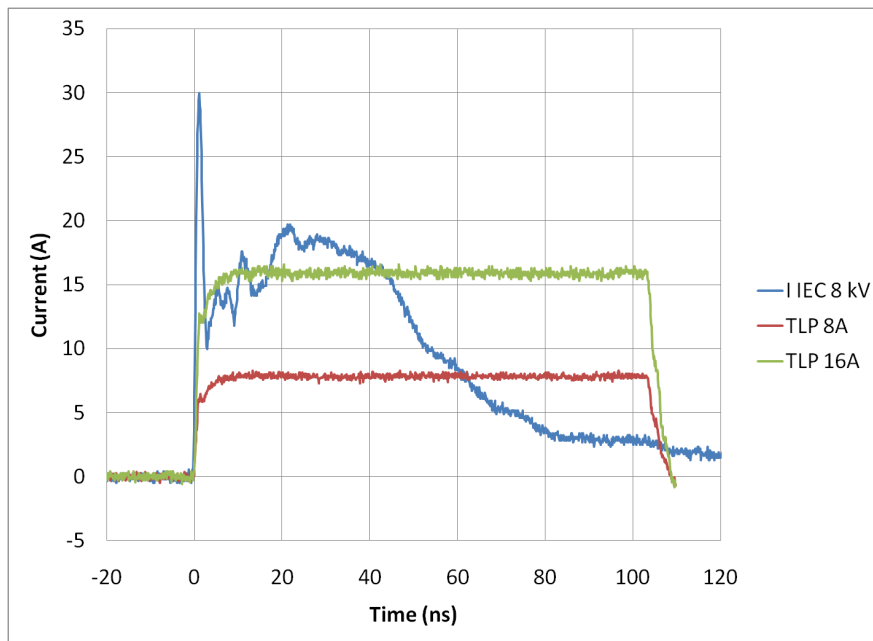
Figure 12. 8 X 20  $\mu$ s Pulse Waveform

### Transmission Line Pulse (TLP) Measurement

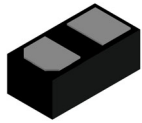
Transmission Line Pulse (TLP) provides current versus voltage (I-V) curves in which each data point is obtained from a 100 ns long rectangular pulse from a charged transmission line. A simplified schematic of a typical TLP system is shown in Figure 13. TLP I-V curves of ESD protection devices accurately 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 14 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 requirements, and how to interrupt them, please refer to AND9007/D.



**Figure 13. Simplified Schematic of a Typical TLP System**

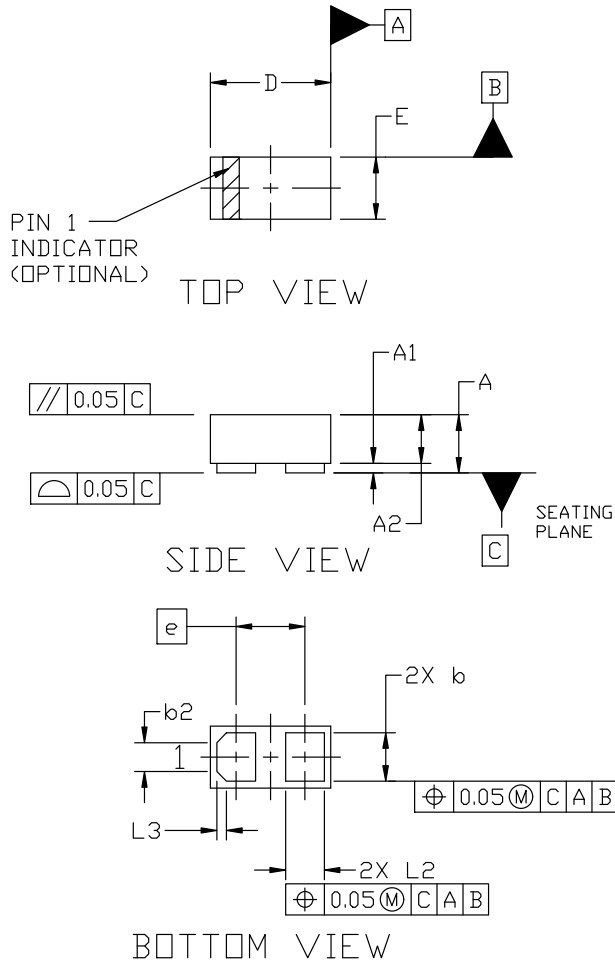


**Figure 14. Comparison Between 8 kV IEC 61000-4-2 and 8 A and 16 A TLP Waveforms**



**X3DFN2 0.62x0.32x0.24, 0.35P**  
CASE 152AF  
ISSUE C

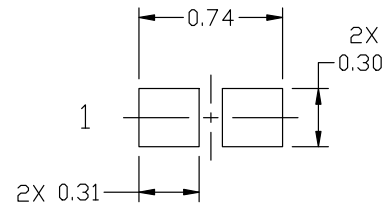
DATE 08 AUG 2023



### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS
3. 0201

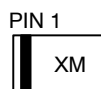
MILLIMETERS			
DIM	MIN.	NOM.	MAX.
A	0.25	0.29	0.33
A1	0.00	---	0.05
A2	0.14	0.24	0.34
b	0.22	0.25	0.28
b2	0.150 REF		
D	0.58	0.62	0.66
E	0.28	0.32	0.36
e	0.355 BSC		
L2	0.17	0.20	0.23
L3	0.050 REF		



**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.

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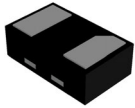
X = Specific Device Code  
M = Date Code

\*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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<b>DESCRIPTION:</b>	<b>X3DFN2 0.62x0.32x0.24, 0.35P</b>	<b>PAGE 1 OF 1</b>

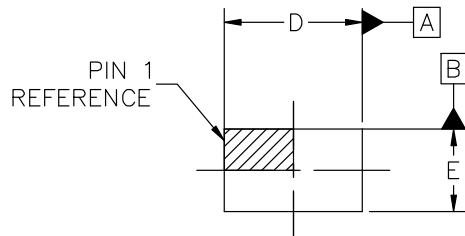
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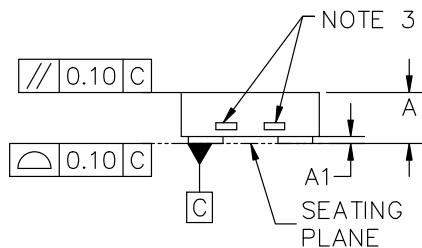


**X2DFN2 1.00x0.60x0.37, 0.65P**  
**CASE 714AB**  
**ISSUE C**

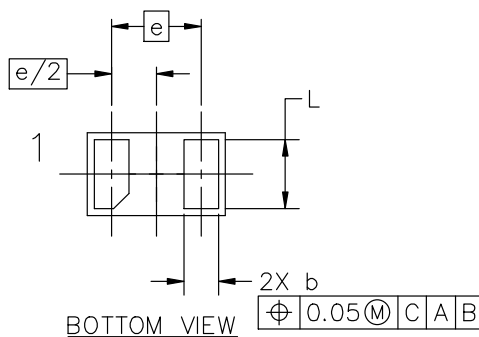
DATE 21 FEB 2024



TOP VIEW



SIDE VIEW

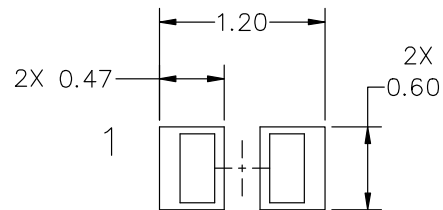


BOTTOM VIEW

## NOTES:

1. DIMENSIONING AND TOLERANCING CONFORM TO ASME Y14.5-2018.
2. ALL DIMENSION ARE IN MILLIMETERS.
3. EXPOSED COPPER ALLOWED AS SHOW.

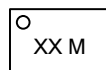
DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	0.34	0.37	0.40
A1	---	0.03	0.050
b	0.20	0.25	0.30
D	0.95	1.00	1.05
E	0.55	0.60	0.65
e	0.65 BSC		
L	0.45	0.50	0.55



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\*



XX = 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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<b>DESCRIPTION:</b>	<b>X2DFN2 1.00x0.60x0.37, 0.65P</b>	<b>PAGE 1 OF 1</b>

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