



## Interpretation of Datasheet Parameters for ESD Devices

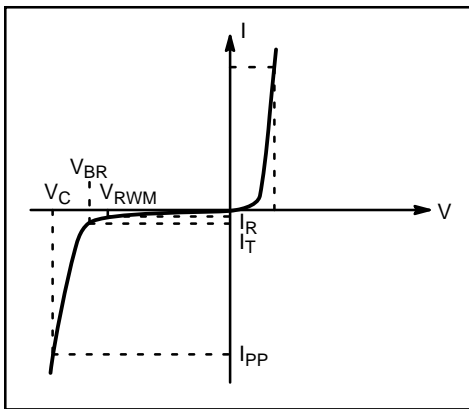
### Introduction

Electrostatic Discharge (ESD) protection devices play an important role in protecting electronic products from surges and ESD events. The selection of the proper ESD device for a given application requires an understanding of both the system that needs protection as well as an understanding of the properties of the ESD diode. The ESD device must not disrupt the functionality of the system it is protecting during normal operation but also must react quickly to shunt dangerous current and voltage spikes to ground during surge and ESD events.

This application note will define the parameters that can be found on ESD/TVS protection diodes' datasheets and explain the relevance of each parameter.

### DC Parameters

The key DC parameters of an ESD diode are presented below. A typical IV characteristic curve for a unidirectional ESD diode is shown in Figure 1.



$V_{BR}$  = Breakdown Voltage @  $I_T$      $I_{PP}$  = Maximum Reverse Peak Pulse Current (Typically Specified with either the 8x20  $\mu$ s or 10x1000  $\mu$ s Surge Pulse)  
 $V_{RWM}$  = Reverse Working Voltage @  $I_R$  ( $V_{RWM}$  (typ) = 0.8 x  $V_{BR}$ )  
 $I_T$  = Test Current  
 $V_C$  = Clamping Voltage @  $I_{PP}$

**Figure 1. Unidirectional IV Characteristic Curve of an ESD and TVS**

**Reverse Working Voltage,  $V_{RWM}$ :** Maximum nominal working voltage for which the ESD device is intended for use. At this voltage, the ESD diode will appear in the “off” state as a high impedance element that will have very low leakage current. The  $V_{RWM}$  is below the reverse breakdown voltage,  $V_{BR}$ .

## APPLICATION NOTE

**Reverse Breakdown Voltage,  $V_{BR}$ :** At this voltage, the ESD diode starts to conduct, or turn “on”. The breakdown is measured at a test current,  $I_T$ , typically from 1mA to 10 mA.  $V_{BR}$  is specified as a minimum value for ESD applications and usually is 10% to 15% above the  $V_{RWM}$ . When selecting an ESD protection diode a designer must ensure that this voltage is higher than the maximum working voltage of the system it is protecting.

**Forward Voltage,  $V_F$ :** Voltage in the forward direction at the test current,  $I_F$ .

**Capacitance, C:** Capacitance is a parameter that becomes a concern for applications that operate at high data rates. High capacitance will degrade signals, compromising high speed applications. A device with low capacitance is preferred for high speed applications. HDMI and USB connections are examples of high speed applications where low capacitance is needed.

### ESD and Surge Parameters

Interpretation of clamping specs during ESD or transient events is commonly misunderstood on ESD protection datasheets. There is no industry recognized standard for specifying clamping performance of ESD protection diodes and it is highly dependant on the testing conditions and input waveforms.

### Survivability Specs

**Peak Pulse Current,  $I_{PP}$ :** Maximum surge current which the device can withstand without damage. Most low power TVS diodes are specified with the 8  $\mu$ s x 20  $\mu$ s current surge pulse. Higher power TVS diodes are measured with the 10  $\mu$ s x 1000  $\mu$ s current surge pulse. See Figures 2 and 3 for definitions of these waveforms. This parameter plays an important role to determine the robustness for high power transient voltage suppression (TVS) applications such as lightning or inductive switching applications, but is not as crucial for applications that are predominantly concerned with ESD events such as portables applications.

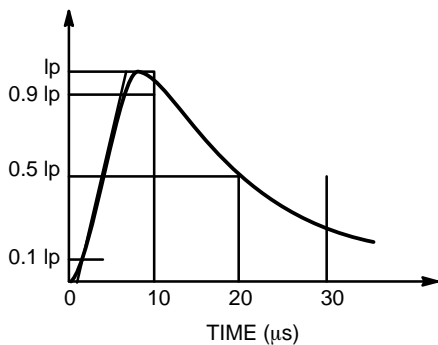


Figure 2. 8  $\mu$ s x 20  $\mu$ s Pulse Waveform

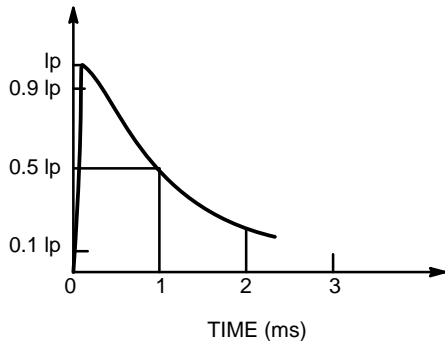


Figure 3. 10  $\mu$ s x 1000  $\mu$ s Pulse Waveform

**ESD Rating:** This is the survivability rating of an ESD protection diode. The most common waveform that is specified is the IEC61000–4–2 system level ESD test which is distinguished by its fast rise time and high current levels (see Figure 4). The survivability rating is typically specified by a level or input voltage level per the table below. Most system designers are required to test up to level 4 which is  $\pm 8$  kV contact or 15 kV air discharge. This rating on an ESD diode datasheet is incomplete, however, since it only tells the designer what the protection diode can survive, but does not give any information as to what voltage level the ESD diode will clamp the ESD pulse to.

**IEC 61000–4–2 CURRENT WAVEFORM**

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

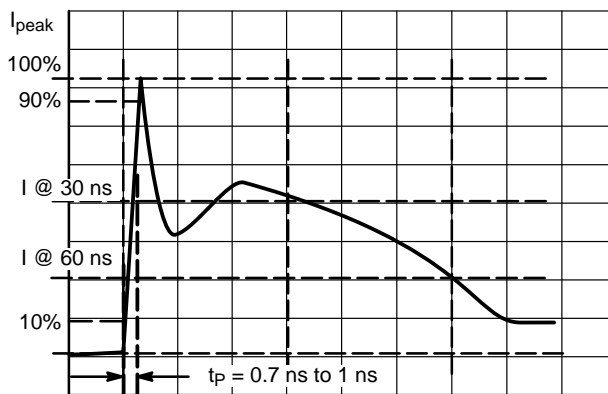


Figure 4. IEC 61000–4–2 Current Waveform

**Clamping Voltage Specs:**

For an ESD protection application the clamping voltage is a key parameter as it will determine the voltage that the integrated circuit (IC) that is being protected will get exposed to. As new IC's are becoming more sensitive to ESD voltage (see [AND8309/D](#)) ESD clamping voltage is becoming a crucial parameter. Since clamping voltage is directly related to the waveform and current level of the surge event being specified it is crucial to examine the conditions of the test for which a clamping voltage is specified. To determine the protection diode with the best clamping performance for an application it is important to look at the clamping performance of the appropriate surge event for that application.

**Transient Surge Clamping Voltage:**


This spec is a key concern for high power TVS diodes. The clamping voltage is the maximum voltage drop across the TVS diode for a particular peak pulse current,  $I_{PP}$ . Since there is no standard  $I_{PP}$  or surge waveform for specifying a clamping voltage for ESD protection diodes there is a lot of variance from vendor to vendor. Some vendors will specify a clamping voltage per the 8  $\mu$ s x 20  $\mu$ s waveform at a given  $I_{PP}$ , but this is inappropriate for ESD. The 8  $\mu$ s x 20  $\mu$ s waveform has a longer rise time and duration than an ESD event by orders of magnitude. TVS waveforms like the 8  $\mu$ s x 20  $\mu$ s are intended for applications exposed to high power surge events like lightning surges and inductive switching that may be seen in networking or automotive applications.

## AND8308/D

### ESD Voltage Clamping

This property is key for determining the level of protection the protection diode will guarantee against ESD. 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](#).

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