

Matthew Xiong

In the [first installment of this series](#), I argued for the need for discrete electrostatic discharge (ESD) protection. The different factors you need to consider when selecting an ESD protection diode for your system will be discussed.

Most circuit components do offer some kind of device-level ESD protection in compliance with charge device model (CDM) or human body model (HBM) standards. If you were to look at the data sheet spec shown in [Figure 1](#), it would be tempting to assume that this component would be robust enough to survive ESD strikes. Perfect! Done! No discrete ESD protection required, right?

6.2 ESD Ratings

		VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±3500
		Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±1000

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Figure 1. Example Data Sheet with HBM and CDM ESD Ratings

Well ...not so fast. The CDM simulates an integrated circuit (IC) charging and discharging, while the HBM simulates a human being discharging onto the IC in a controlled ESD environment. These standards are useful in ensuring that components will survive manufacturing and assembly in factories where there are protocols to minimize ESD exposure. However, they do not accurately represent what a component will experience in an end-user scenario. I don't know about you, but I don't wear an ESD strap when I use my toaster in the morning.

To accurately model ESD strikes in real user scenarios, the International Electrotechnical Commission (IEC) created a more rigorous standard called IEC 61000-4-2. As you can see in [Figure 2](#), this IEC pulse has a faster rise time, a longer duration, a higher peak pulse current and significantly more energy than the CDM and HBM pulses.

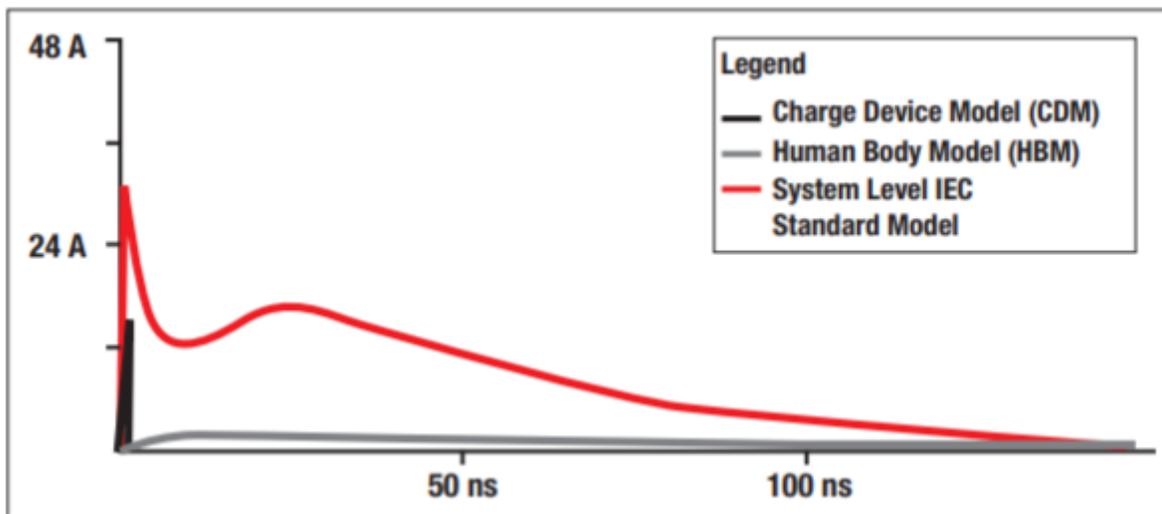


Figure 2. Comparison of Different ESD Models

The IEC 61000-4-2 standard includes two different ratings for ESD that you can generally find on data sheets: contact voltage discharge (ESD directly discharged onto the device) and air-gap voltage discharge (ESD discharged onto the device through a gap of air). The IEC 61000-4-2 standard specifies four levels of voltage ratings, with level 4 being the highest (see [Table 1](#)).

Table 1. IEC 61000-4-2 Standard Levels

IEC 61000-4-2 Level	Contact Voltage	Air Gap Voltage
1	2 kV	2 kV
2	4 kV	4 kV
3	6 kV	8 kV
4	8 kV	15 kV

For most applications, level 4 IEC ESD protection (8 kV contact/15 kV air gap) is sufficient. However, applications or environments where ESD strikes are expected to have stronger voltages or may occur more frequently require higher contact-voltage and air-gap voltage ratings ([Table 2](#)). TI's [TPD1E1B04](#), for example, has an IEC 61000-4-2 rating of 30kV/30kV.

Table 2. Typical Examples of ESD Generation (Source: Phil Storrs PC Hardware)

Source of ESD Voltage	Typical ESD Voltage at 20% Relative Humidity
Triggering a vacuum solder remover	8 kV
Walking across vinyl floor	12 kV
Removing plastic tape for a PC board	12 kV
Removing shrink film from PC board	12 kV
Spraying aerosol freezer spray	15 kV
Arising from a foam cushion	18 kV
Sliding plastic box on carpet	18 kV
Opening a plastic bag	20 kV

If a device is only rated for HBM and CDM ESD, it most likely does not have enough robustness to survive continued normal operation in real-world scenarios. Therefore, when selecting ESD protection diodes to protect these devices, it is critical to select a diode that has a sufficient IEC 61000-4-2 rating to ensure that the diode itself will survive repeated exposure to ESD.

Now that you know how to compare the robustness of ESD protection diodes, in part three of this series, "[ESD fundamentals, part 3: clamping voltage](#)," I explore clamping voltage, which indicates how well a diode can protect sensitive circuitry.

Additional Resources

- View all articles in the [ESD Fundamentals technical article series](#).
- For more information about the ISO 10605 automotive standard, see [ISO 10605 Road Vehicles Test Methods for Electrical Disturbances from Electrostatic Discharge](#).

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated