Stephen Halperin & Associates, Ltd.

The Truth About ESD Class 0

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The Truth About ESD Class 0

by

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The electronics industry is terribly confused by the term Class 0. Particularly when it comes to electrostatic discharge (ESD) device sensitivity and how the term applies to factory controls designed to mitigate ESD. The confusion manifests itself through the many companies and engineers seeking direction on how to “become qualified to handle Class 0 devices.” They are seeking this information because their equally confused customers have imposed requirements on them to meet this mythical level of performance. Not only is Class 0 as a factory level of performance a contrived ideal, it is not a realistic or useful goal. Our purpose here is to explain reality and what is necessary for understanding device ESD sensitivity and establishing control.

Currently, there is only one proper use of the term Class 0 and that is in the context of Human Body Model (HBM) component level testing. Developed over two decades ago and long outdated, Class 0 specifies components with a damage threshold sensitivity of <250 volts when tested using the HBM method. This is a component level test designation and has nothing to do with factory handling capability. Also, the device classification is only valid until the device is incorporated in a higher level assembly. For example, a device with a HBM classification of 250 volts may be damaged by lower voltages once that device is mounted on a printed circuit board.

Alphabet Soup

To further complicate the situation components are also classified with other testing models such as the Charged Device Model (CDM) and Machine Model (MM). Neither of the aforementioned testing models have a Class 0 designation. Class 1 CDM rated parts are <125 volts and Class 1 MM parts are <100 volts (with 3 subcategories M1A <25 volts, M1B 25 to <50 volts, and M1C 50 volts to <100 volts). Again, not any of these component levels test designations have anything to do with factory handling capability, or anything remotely associated with a Class 0 designation.

So what does Class 0 really mean?

In the grand scheme of ESD control in the factory, Class 0 has no purposeful meaning. Adopted and perpetrated by some companies as a marketing tool for their products or services, the term is being used to alert the electronics manufacturing industry about electronic devices that have lower damage thresholds than typical devices. Because of lower thresholds, the manufacturing company may need additional products or services from these companies in order to safely handle the “Class 0” devices. Since there is currently no industry accepted definition of Class 0 (other than the <250V HBM classification discussed above) the use of this term causes confusion as it means different things to many people. In fact some companies have expanded on the Class 0 marketing term to create Class 00 and even Class 000, which further confuses the situation beyond reason and technical validity.

Determining Device Sensitivity

Regardless of any device ESD classification (real or contrived), it is imperative that the factory ESD manager identify the failure thresholds and models (HBM, CDM and MM) for the most sensitive devices being processed in the factory. Only after obtaining this information can an ESD program manager effectively design an effective ESD program to protect their devices. Essentially, there are three options for determining device sensitivity:

1. Vendor information and test data
2. In-house testing
3. Third party device test laboratories

If device sensitivity information is not available, a reasonable approach would be to adopt the lower limits set by the "*ESD Technology Roadmap*," which is available at the ESD Association web site at www.esda.org . In the conclusion of the Roadmap document it is recommended that companies determine their ESD process capability and to limit HBM potential to <100 volts, MM to <10 volts and CDM potential to <50 volts. Once you know actual device sensitivity of critical components you can assess your process for suitable control levels and develop or enhance your ESD control program.

Device Sensitivity & Process Capability Analysis

Device damage voltage thresholds are indispensable when developing ESD control of critical or high value manufacturing and handling operations. Process capability analysis is a means of assessing the entire manufacturing process to determine its protective electrostatic thresholds to various failure models. This analysis technique defines the most sensitive device(s) that the process can safely handle without ESD damage. Properly conducted, a process capability analysis will define the maximum voltages exhibited in the manufacturing critical path as they relate to HBM, CDM and MM. This is why specific device failure voltage thresholds are essential guidelines to experienced ESD practitioners. General classification of devices without specific damage threshold detail is meaningless to the development of highly effective process ESD control.

Current Industry Standards

There are currently two widely accepted industry standards for ESD control programs. The standards are ANSI/ESD S20.20 and IEC 61340-5-1.

HBM Device Sensitivity & Body Resistance to Ground

In an ANSI/ESD or IEC certified or compliant facility, there is confidence in the process to safely handle devices with HBM thresholds of >100 volts. But what do you do if you handle a device that has an HBM sensitivity threshold of *less than* 100 volts? In this case, fundamental modifications may be required, such as reduction of your ESD control limits and modification of measurement procedures and/or frequency.

Industry ESD control program standards specify grounding requirements for personnel. One of the specifications is a resistance to ground for personnel of <35 megohms (<3.5 x 107 Ω). One aspect of this specification applies to personnel using wrist straps. At this resistance to ground level, it has been shown experimentally that a person will not be able to generate or accumulate greater than 100 volts of static electricity on their body regardless of how fast they move as shown in Table 1.

Body Resistance to Ground (Megohms)	Approximate Peak Body Voltage (Volts)
1	<10
10	40
16	50
28	75
35	93

Table 1: Body Resistance to Ground versus Approximate Peak Body Voltage (Gibson et al)

For a 100 volt HBM rated ESD Control Program, the <35 megohm specification provides an adequate safety margin. Obviously, the resistance to ground specification for personnel should be set to a lower level when handling parts with sensitivities below 100 volts HBM.

- In North America, normally a resistance to ground level of <10 megohms is used since the maximum voltage level on personnel will be under 40 volts even with very rapid movement.
- A person sitting down while wearing a wrist strap will be held to less than a few volts with a resistance to ground of one megohm or less.

Thus, it is obvious that by knowing the HBM threshold of the most sensitive device in the process, one would know the maximum body resistance to ground requirement for their process. More information on this subject is in the "*ESD Technology Roadmap*."

Another aspect of HBM damage prevention and body resistance limits is the use of ESD flooring and footwear systems to provide a ground path for personnel. If a person's *combined* resistance to ground using a floor and footwear system is less than 35 megohms then the same <100 volts requirement is met. If however, their flooring/footwear system resistance to ground is greater than 35 megohms, then additional walking tests must be performed to measure body voltage and qualify the personnel grounding system. The requirement in this case is to assure that a person, using the defined system, will not accumulate a body voltage of greater than 100 volts.

As discussed above, for more sensitive areas, the resistance to ground and body voltage accumulation specifications need to be set lower than the damage threshold voltage of most sensitive device. Using the outdated HBM Class 0 guideline of "*…less than 250 Volts*" is certainly not helpful in developing defined control to protect current technologies, nor does it correlate to standards that presently specify HBM control to 100 volts.

MM & HBM Device Threshold Concerns

The ESDA Standards device working groups agree that an acceptable general guideline for Machine Model (MM) device sensitivity is 10% of the device's HBM damage threshold. Device engineers have recently presented data to The Device Industry Council on ESD Target Levels (Industry Council) that indicates MM damage thresholds of new device technologies are as low as 3 to 5 percent of the device's HBM threshold. As a result, a device having an HBM damage threshold of 100 volts will have MM sensitivity in the area of 3 to 10 volts. Knowing the HBM damage voltage of device is important to understanding the level of control one must have for preventing MM damage.

To reduce the possibility of MM failures, all conductors in the process must be bonded or electrically connected and attached to ground. By grounding all conductors, the potential for MM discharges is mitigated. In process capability analysis direct voltage measurements are made on conductors that may contact devices and subassemblies to confirm that they are properly grounded *and* do not carry voltages higher than MM damage thresholds. Again, a general classification does not provide the detail one needs to determine MM damage thresholds and establish proper control levels.

CDM Trends

While the Industry Standards documents address control measures for CDM issues through the management of insulators, they have not identified a CDM threshold that can be used along with the previously established HBM thresholds.

The Industry Council, consisting of members across the electronics industry, published their White Paper 2 in April 2010 regarding component level CDM ESD specifications and related requirements. Based on an extensive study, the council reports that devices with CDM sensitivity thresholds of ≥250 volts can be handled safely with basic ESD control methods, including the grounding of conductors and the control of insulators as described in current industry ESD program standards. Devices with thresholds of less than 250 volts require additional measures to control the charging of the devices, including:

- **For devices 125 – 250 V_{CDM} requires implementation of "process specific measures** to reduce the charging of the device **OR** to avoid a hard discharge (high resistive material in contact with the device leads)."
- **For devices <125 V_{CDM} the Council specifies making "charging/discharging measurements at each process step"** in addition to the above requirements.

Again, simply saying that one has a Class 0 CDM device reveals nothing helpful in determining necessary ESD controls or suitable protective procedures.

At the time of this writing, standards bodies have not published a Standard Test Method or Standard Practice for determining process capability as it applies to CDM. However, case studies and detailed procedural papers have been presented at the EOS/ESD Symposium on this important topic. The ESDA and IEC standards organizations have plans to address process capability studies and related procedures in the near future.

Conclusion

While the term "Class 0" is being heavily propagated for ESD factory control, there is no formal definition for this term in the industry. It is not possible to be qualified or certified as a "Class 0" facility since specific and helpful guidelines have not been created by an accredited organization.

Instead, it is critical to know the actual damage thresholds for each model and to compare that information with the process capability of the facility. By determining your process capability to safely handle all failure model threshold voltages, you will determine the process ESD risks that require correction and establish quantifiable limits and control guidelines to protect your products.

AUTHORS

Stephen Halperin has over 30 years of industrial ESD experience and is known internationally for his work in process evaluation, control of sensitive environments, measurement and test innovations, and his many contributions to the electrostatics industry and ESD Association. He served two terms as ESDA president, and chaired Standards, Local Chapter Development, Education, and Professional Certification committees. Mr. Halperin is a recipient of the Symposium's Outstanding Paper Award, the Association's Outstanding Contribution Award for his work on behalf of industry and the Joel Weidendorf Memorial Award for his extensive contributions to ESD standards development. He formed Stephen Halperin & Associates (SH&A - 1983), an international electrostatic consulting firm, and established Prostat Corporation (1992) for design of high performance electrostatic instruments. Mr. Halperin has delivered several papers and authored over 100 articles on ESD related subjects.

David E. Swenson retired from 3M Company in 2003 after 35 years of service. Most of his career was involved with investigation and resolution of static electricity problems, development of new static control products and training of 3M and customer personnel globally. After retirement, David and his wife Geri established Affinity Static Control Consulting, LLC, to offer electrostatic solutions to industry. He has been a member of the ESD Association since 1984 and has served in many capacities including Sr. VP and president for a total of 4 years each. He is a four term elected member of the Board of Directors and currently serves as President Emeritus of the Board of Directors. He has served as Symposium General Chair, long term Standards Committee member and Working Group Chair of several committees and is the current chair of the Grounding WG. In addition, Dave was the ESD Association Technical Advisor and Chief Delegate of the US National Committee to IEC TC101 for 8 years and is currently a US Technical Expert. He was awarded the ESD Association Outstanding Contributions Award in 2002 and the Joel P. Weidendorf Memorial Award for service to Standards in 2004. A life member of the ESD Association, Dave has authored numerous technical papers covering ionization, grounding, packaging, triboelectrification, test methods for ESD materials and ESD control program implementation, presented around the world. He is Treasurer of the Texas Chapter of the ESD Association and a long term member of The Electrostatic Society of America. Dave can be reached at static2@swbell.net

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