

Cable Discharge Events (Part I) What is a CDE?

Q: What is a Cable Discharge Event?

A Cable Discharge Event, or CDE, is a discharge that occurs when a cable is connected to a piece of electronic equipment – it occurs because there is a differential between the charge on a cable to be connected and the equipment that it's being plugged into. It doesn't matter if the cable is charged or if the equipment to which it will be connected is charged – same event; different polarity. It's the differential that causes the discharge.



A: How does charging take place?

Cables can easily become charged during installation as it is pulled through the walls or ceiling of a facility¹. This Triboelectric charging causes a charge on the cable sheath which is transferred to the conductors in the cable. Result: a static voltage just waiting to be discharged when the cable is connected to your computer or the company server!

But that's not the only threat – what about the other way around? As you probably know, while walking around in a normal office environment a person will often become charged. You may be familiar with the “door knob effect”, especially in the winter – the extreme case being in a cold climate where people learn to touch the door knob with a key or other metal object before opening the door! And if this person happens to be carrying a computer? The result is clear: the computer also gets charged up so that when it's time to reconnect to the network via an Ethernet cable a discharge is likely.

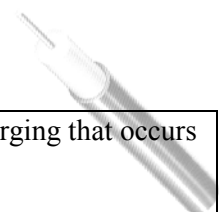
Ethernet cables aren't the only problem. Discharges will also occur when connecting USB, power, audio and other interconnecting cables. The difference with shorter cables is only the amount of charge the cable can hold and therefore the amount of energy that can be transferred during a discharge.

What kind of a discharge can be expected?

The static voltage that appears on the cable is determined by the triboelectric charging that occurs and the capacitance of the cable to everything around it:

V (voltage) is equal to the charge (Q) divided by the capacitance (C): $V = Q/C$.

The longer the cable, the higher the capacitance; the further the cable is pulled through the building, the more rubbing and therefore, more charging, and therefore, more voltage.

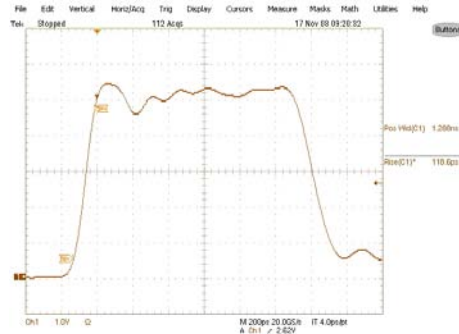


¹ Data taken by myself and Jon Stephen of Intel at Thermo Fisher Scientifics' Lowell facility showed that dragging 100 feet of insulated Cat 5 Ethernet cable approximately 280 feet across a tile floor developed a voltage of -580V.

Any engineering student will tell you that when a charged cable is discharged, a nice rectangular current pulse will result. That's true, assuming you have a perfectly clean switching operation at the output of the cable the termination of the cable is controlled.

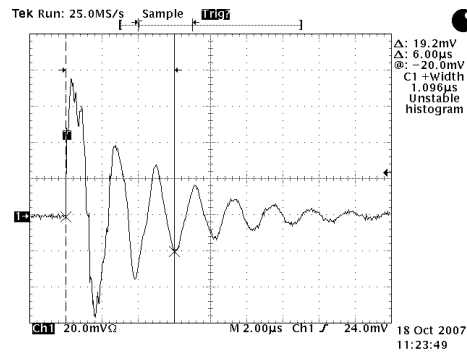
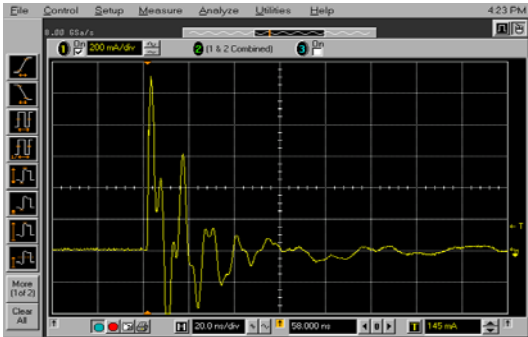
Commercial Transmission Line Pulse (TLP) testers operate on this principal and produce very clean rectangular pulses with controlled parameters; however, cable discharge events to electronic products are not so well controlled.

Typical TLP Pulse, courtesy of Thermo Fisher Scientific



In practice, an air breakdown between the cable and its mating connector is likely prior to a hard contact being made; an arc occurs resulting in a fast transient current spike being injected.

A white paper published by Intel² and Doug Smith's Technical Tidbits³ show cable discharge events beginning with a current spike and followed by an oscillatory decay. Data published in a white paper by IEEE⁴ seems to be along the same lines as Intel and Doug Smith with the initial current spike and ringing decay, but goes further to show that the ringing frequency is dependant on the length of the cable being discharged, i.e, the shorter the cable, the higher the ringing frequency and the longer the cable, the lower the ringing frequency.



Discharge from a 1 meter cable charged to about 300V.
Courtesy of Doug Smith's Technical Tidbit of January 2002

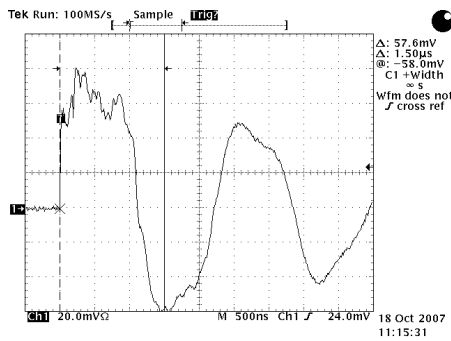
Waveform taken from a 100m Cat 5 cable charged to 200V. Note that compared to Doug Smith's waveform the ringing frequency is much lower due to the longer cable length.

² Cable Discharge Event in the Local Area Network Environment, White Paper, Intel Order Number 249812-001, July 2001

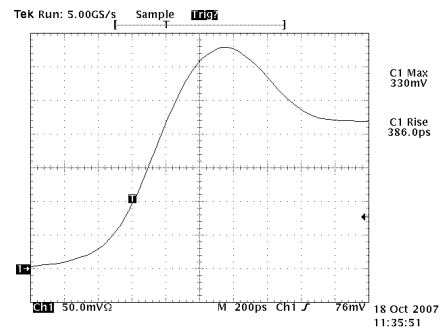
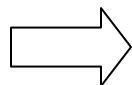
³ Cable Effects Part 1: Cable Discharge Events, Technical Tidbit – January 2002, High Frequency Measurements Web Page, Douglas C. Smith

⁴ A Simple Model For a "Cable Discharge Event", Rich Brooks, IEEE802.3 Cable Discharge Ad-hoc, March 2001

Doug Smith's "Technical Tidbit" does describe the metrology he used to gather discharge current waveforms, but none of the other papers or reports mentioned here provide such information. Without a defined metrology for measuring CDE currents, we can't quantify such parameters as rise times or peak amplitudes of a CDE event. We know that real ESD events from people tend to have risetimes in the picosecond to nanosecond regions, and this requires high bandwidth measurement equipment and techniques to obtain realistic data. Once the metrology is defined and accepted, we should start to see good data that will describe the event adequately.



The first cycle of a Cable Discharge Event from a 100m cable....



And the rise time of the initial pulse – limited to 386ps by the 1GHz bandwidth of the scope!

Okay, so what does this mean in terms of the threat level? We don't know for sure, but we do know the rise times can be very fast and the energy is dependant on the length of the cable and its ability to store charge. In order to get better data, Working Group 14 of the Electrostatic Discharge Association (ESDA) has developed a metrology for measuring these events in a way that is both repeatable and reproducible (it's in a final draft form as of this writing). lap-top if it reset, re-boots, or otherwise misbehaves when you re-connect to an Ethernet cable or plugged in a USB device hanging on a cable.

Upset of system operation and/or damage to devices is certainly possible and is of great concern to both equipment manufacturers and device manufacturers. Imagine how much Ethernet cable has been charged up while being strung through buildings in the last few years, and how much is still to be done. Perhaps this threat will be mitigated somewhat with the advent of wireless networks, but there's still some time before that completely takes over.



Besides, even though the cable is installed and any charges built up during installation have long been removed, the threat of connecting a charged product to the cable still exists. As mentioned in the introduction, it probably doesn't matter if the cable is charged or if the product connecting to the cable is charged, the result is the same: a cable discharge event. Meanwhile, cables will continue to be installed and whatever charge exists on the cable will be equalized rather quickly when connected to a piece of electronic equipment, whether it's your PC, laptop or server.

About the Author

Michael Hopkins has nearly 30 years experience in EMC as an independent consultant, an employee of Thermo Fisher Scientific working with the KeyTek product lines, and now working

with Amber Precision Instruments. He has worked closely with manufacturers and laboratories world-wide providing training, applications help, and assistance with the development of interpretation of test standards, is the author of several papers and articles on Pulsed EMI phenomena, and has participated in numerous national and international seminars as author, speaker, and panelist. Michael has been an active member of several committees developing standards for industry including the ESD Association, IEC Technical Committees 77A and B for the development and maintenance of Basic EMC Standards (US Delegate to Maintenance Team 12 for all pulsed phenomena), IEEE/ANSI, SAE, and RTCA.

About the ESD Association

Founded in 1982, the ESD Association is a not for profit, professional organization directed by volunteers dedicated to furthering the technology and understanding of electrostatic discharge. The Association sponsors educational programs, develops ESD Standards, holds an annual technical symposium, and fosters the exchange of technical information among its members and others. Additional information may be obtained by contacting the ESD Association, 7900 Turin Rd., Bldg. 3 Rome, NY 13440-2069 USA, Phone 315-339-6937, Fax 315-339-6793. Email info@esda.org.
Website://www.esda.org.

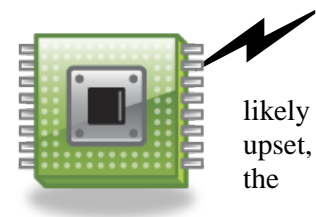
Cable Discharge Events (Part II) CDEs Place in Testing

Where does CDE testing fit in the realm of ESD and EMC in general?

CDE *is* an ESD event. We know that the CDE has an initial rise and spike very much like other ESD events. Testing at the system level is done with a current waveform that has an initial rise time of 0.7ns to 1ns and we know that many real ESD events are much faster. The big difference is that at the system level, testing of input pins is not required for compliance to international standards but CDE is exactly that – a discharge to an input pin of a connector.

Because the ESD discharge current is directly into the pin of a connector, some kind of ESD protection directly at the input pins of a system is necessary to protect semiconductor devices that are likely to be directly connected to those pins. Some manufacturers may try to rely on the semiconductor manufacturer to provide this kind of protection, but there's a problem: semiconductors are tested for failure but systems are tested for upset.

A typical semiconductor device is tested to withstand ESD stress during handling. Pins are zapped at some voltage, the device is tested in a functional tester and if it passes, it can be rated to withstand that voltage. This is important, of course, and the higher the withstand level of the device, the less it will fail in operation; however, its ability to continue to function without loss of data, or simply shutting down is completely unknown – and *these* are criteria necessary to pass compliance testing! Although pin testing is not a *requirement* for some international standards, you wouldn't be happy with your



Standards

There are no industry wide standards for testing for the effects of CDE. TIA recommends using system level methods described in IEC 61000-4-2, and that's exactly what some manufacturers are now doing. Part of the threat really is the ESD like transient that occurs as the charged cable approaches its mating connector. (Note: To get a discharge, the mating connector pins don't need

to be at ground potential, but only at a potential that is different that of the charged cable – the two will try and equalize through a discharge.)

There's really no published information at this time to show exactly how manufacturers are testing their products, but there is enough anecdotal information to say that at least some manufacturers are simply using ESD simulators, such as those described in IEC 61000-4-2.

Others are charging up lengths of cable (probably using an ESD simulator of some kind) and then discharging the end of the cable directly into a connector. Still others might try using something like a TLP tester to produce a clean rectangular pulse.

One could make arguments for any of these methods, but if comparisons are to be made concerning the ability of a product to withstand such an event, a standardized method of performing the test and evaluating the results is necessary.

At the device level, semiconductor manufacturers have also expressed an interest in a test to determine if their devices will survive a CDE event, and the same thing applies here as with systems or finished products: no current standard method of testing exists, but to be able to compare the performance of one device to another, standards will need to be developed. As is the case with ESD events, the tests applicable to the semiconductor device directly may not be the same as those used at the equipment level.

Summary

It's clear that a problem exists in industry that requires some attention. Cable Discharge Events do occur and they do cause upset and device failure in equipment and systems. The problem is that there is no good data to quantify the event characteristics, and therefore no agreed upon process for evaluating products for the effects of CDE. In order to get to the point of a well defined test method, we first need an accepted metrology so that we can capture the events, then record and evaluate the data. After that come test standards, without which comparison of product performance to CDE events just isn't possible.

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