ESD Open Forum

Conformity—2009

Provided by the ESD Association

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.

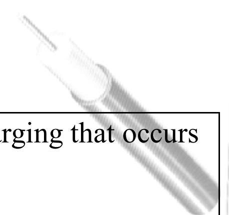
A: How does charging take place?

Cables can easily become charged during installation as it is pulled through the walls or ceiling of a facility[1]. 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): $V = Q/C$.

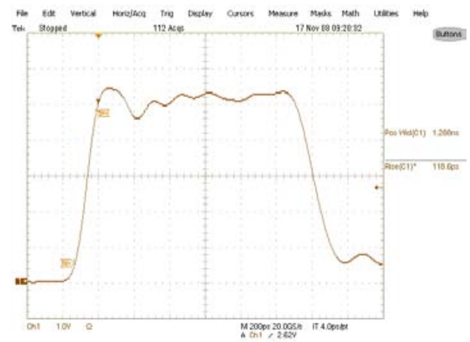
The longer the cable, the higher the capacitance; the further the cable is pulled through the building, the more rubbing and therefore, more charging, and therefore, more voltage.

[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.

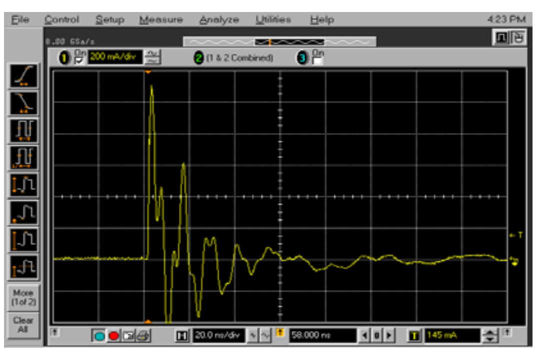
Commercial Transmission Line Pulse (TLP) testers operate on this principal and produce very clean rectangular pulses with controlled parameters; however, cable discharge events to electronic products are not so well controlled.

Typical TLP Pulse, courtesy of Thermo Fisher Scientific

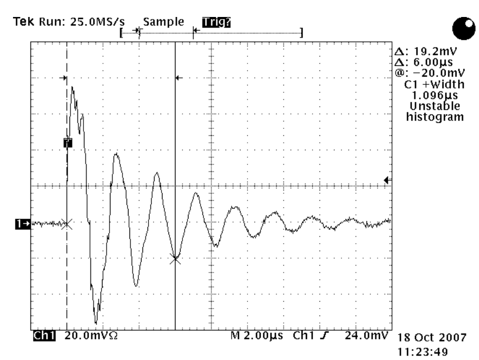


In practice, an air breakdown between the cable and its mating connector is likely prior to a hard contact being made; an arc occurs resulting in a fast transient current spike being injected.

A white paper published by Intel[2] and Doug Smith's Technical Tidbits[3] show cable discharge events beginning with a current spike and followed by an oscillatory decay. Data published in a white paper by IEEE[4] 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



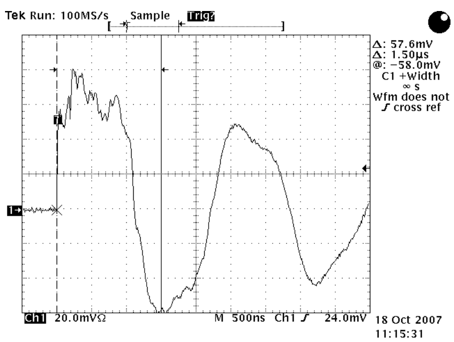
Waveform taken from a 100m Cat 5 cable charged to 200V. Note that compared to Doug Smiths waveform the ringing frequency is much lower due to the longer cable length.

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

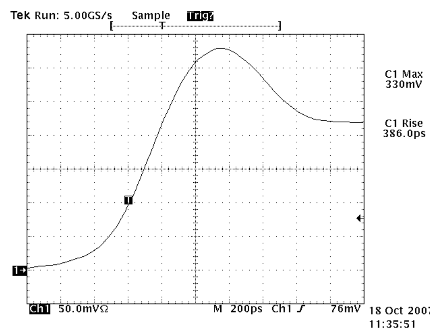
[3] Cable Effects Part 1: Cable Discharge Events, Technical Tidbit – January 2002, High Frequency Measurements Web Page, Douglas C. Smith

[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.
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