Sources of Impulsive EMI in Large Server Farms

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Abstract: Further research is reported on EMI in large server installations.[1] Data is presented from both staged events and server environments. The data confirms the presence of strong fields in the vicinity of servers. One unexpected source of EMI is reported. However, human activity is strongly correlated with the generation of EMI in most cases.

I. Introduction

Data on the EMI/ESD environment found in large server installations was reported at the 2001 EOS/ESD Symposium[1], as well as noting that published work on ESD environments are few and far between.[2] Additional tests have been done and are reported here. Data presented reinforces the conclusions in the 2001 paper and adds significant new information including an unsuspected source of EMI.

II. Measurements

Tests were conducted at both recently constructed server installations and facilities several years old. In addition, measurements were made in an anechoic chamber of the EMI resulting from typical human activities, such as installing a hard drive and connecting a cable. A TEM antenna, described in our previous paper in 2001, was used for the measurements reported here.[1]

II.a. Anechoic Room Measurements

The anechoic room used for measurements was a 3 meter facility (3 meters from the equipment under test, EUT, to the normal measurement position of an EMC antenna). Absorbers on the walls prevent reflections thus enhancing measurement accuracy. This type of room is normally used to measure radiated emissions from equipment.

Our setup in the anechoic room placed the TEM antenna 1.5 meters from the source of ESD generated EMI.[3] This distance was chosen both to represent the distance between possible ESD events and nearby servers in an installation and to avoid having to remove the antenna and mast structure normally used in the room. The TEM antenna also fills the need for measuring radiation far from an ESD event.

The measurements made in this room were setup to simulate typical installation and maintenance activities by people in server installations. The setup in the room is shown in Figure 1. The structure at the lower left of the picture with the white frame is the TEM antenna positioned 1.5 meters from a small server, which is resting on the table.

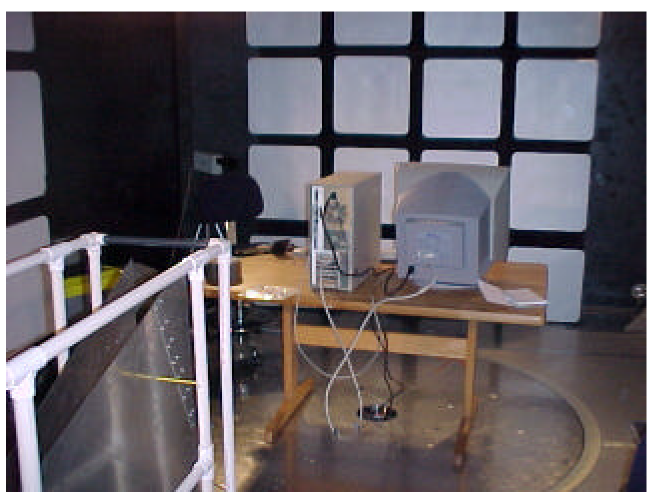

Figure 1: TEM Antenna and Small Server in Chamber

The white squares on the wall serve to protect the RF absorber material underneath and to reflect light to make the room easy to work in as the absorber is nearly black in color.

II.a.1. Cable Discharge and Maintenance Events

ESD events from charged cables have been reported to damage equipment as cables are plugged into equipment.[4] Our focus here was to measure the radiated EMI from such events and its possible effect on nearby equipment.

Figure 2 shows the discharge from the shield of a cable charged to +500 volts to the chassis of the server. Figure 2a shows how the event was produced. The peak voltage was about 2 volts. Multiplied by the antenna factor of ~6.9, the result is a field strength about 14 V/m, a substantial field.

Figure 2: Radiated Field, +500 Volt Cable Shield Discharge

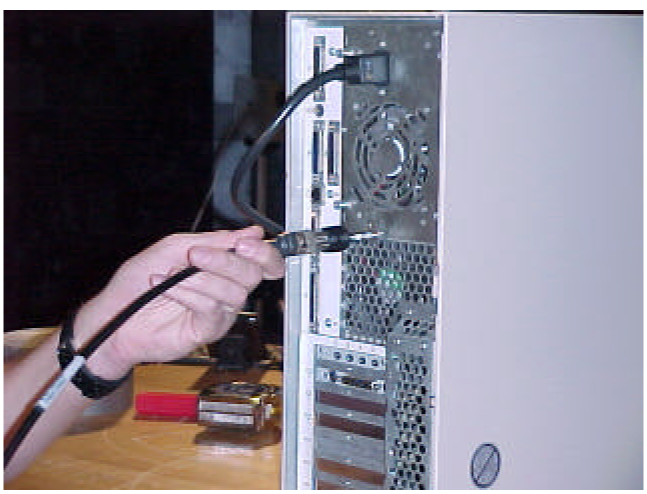

Figure 2a: Producing a Cable Shield Discharge

Figure 3 shows the discharge from an unshielded cable with an RJ45 plug, bundled up as shown in Figure 3a. The cable was charged to +1000 Volts and then inserted into a computer port. The peak amplitude and waveshape is similar to the discharge from a cable shield in Figure 2.

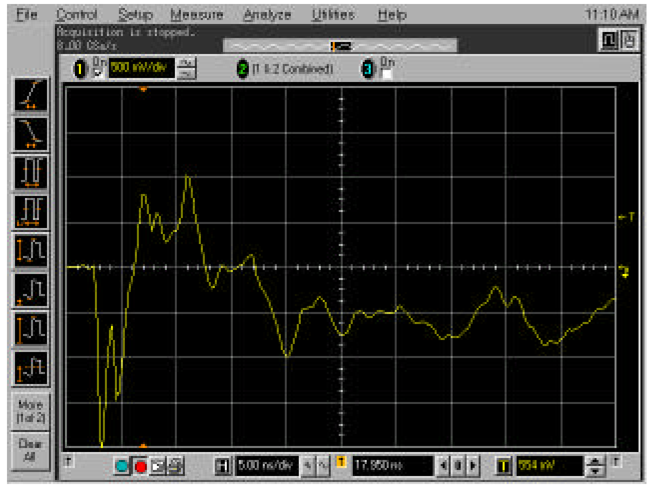

Figure 3: Radiated Field, +1000 Volt UTP RJ-45 Discharge

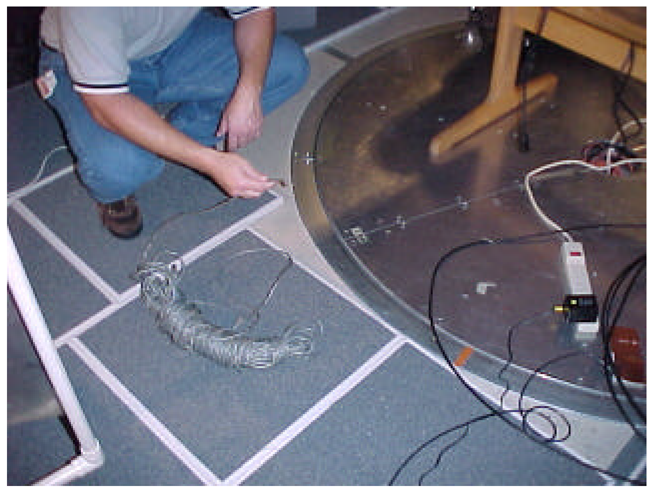

Figure 3a: Bundled Unshielded Cable Used in Discharge

However, longer cables give a different result. Figure 4 shows the discharge from a cable about 30 meters in length charged to +1000 volts and touched to the server chassis.

Figure 5 shows the rising edge of Figure 4 expanded to 5 ns/div.

Figures 4 and 5 show both strong field and fast edges. The amplitude was well beyond the scope upper limit of 4 Volts. Therefore, using the antenna factor of ~6.9, the resulting electric field strength was much greater than 28.6 V/m!

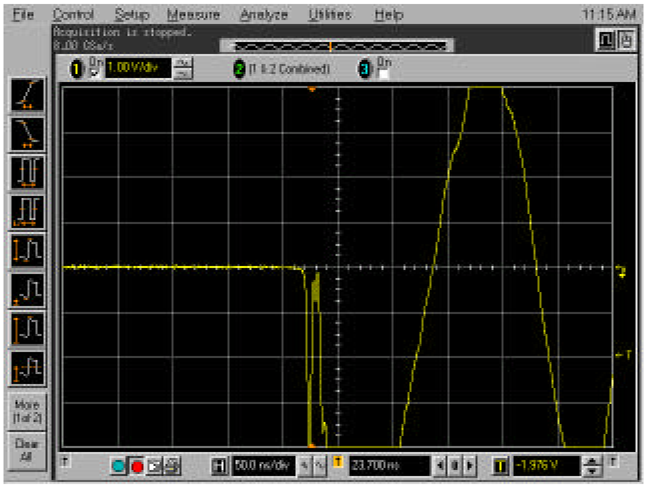

Figure 4: Radiated Field, +1000 Volt, 30 Meter UTP Discharge

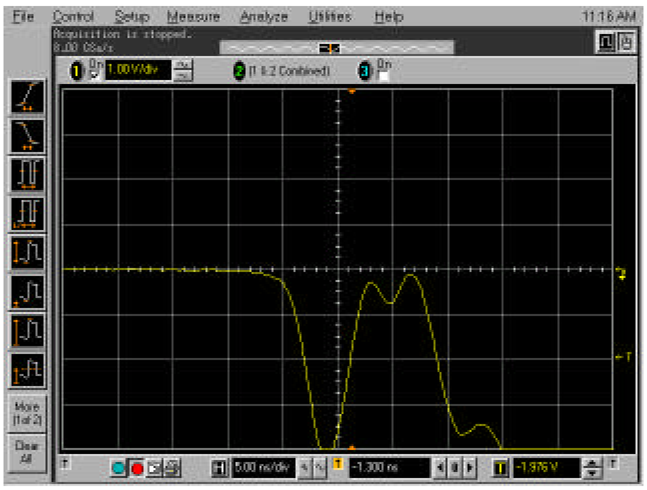

Figure 5: Rising Edge of Figure 4 Expanded

II.a.2. Radiation from Tool Discharges

Figure 6 shows the radiated field when a person charged to 1 kV and holding a screwdriver, touched the screwdriver to the server chassis. The result was nearly 30 V/m! Figure 6a shows how the event was produced.

So it can be seen from these tests that using tools and cables can generate substantial EMI at relatively low ESD voltages, in fact, substantially less than the level of human perception at 3 kV.

II.b. Server Room Measurements

Measurements were made in two locations. The first was a facility that was in service for a number of years and the second was a state of the art, new facility.

II.b.1. Existing Facility

The most significant events that were recorded involved human activity. Figure 7 shows the result of a person closing a door a few meters from the antenna. The charge on the person was measured at only 1000 Volts, yet still the recorded field reached about 15 V/m.

Figure 6: Radiated Field, +1000 Volt, Screwdriver Discharge

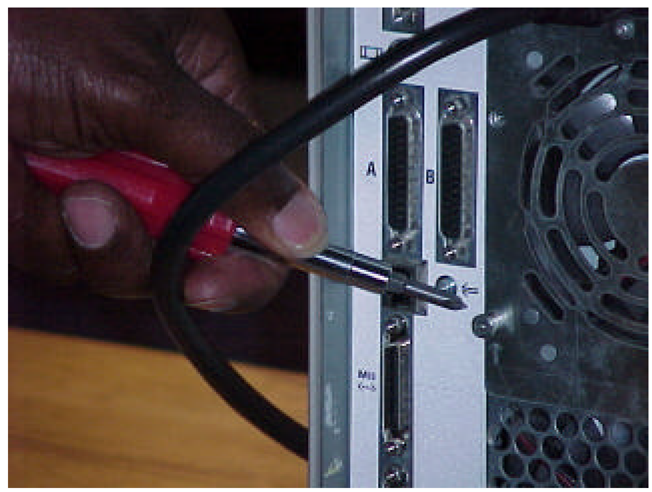

Figure 6a: Screwdriver Discharge

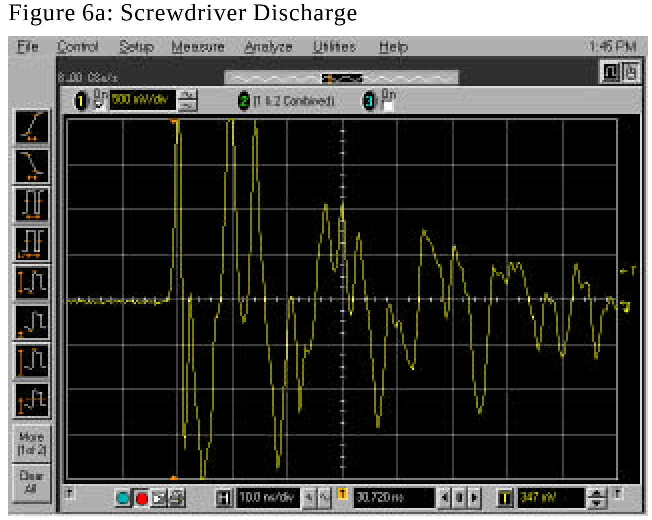

Figure 7: Radiated Field, Door Closure

Perhaps the most surprising measurement of an ESD event came from an unlikely source. Floor resistivity measurements were made at each location where radiated EMI measurements were taken near servers in actual service. At this location, as the floor measurement kit was being repacked after a measurement had been made, the kit itself caused a significant ESD event as metal pieces of the kit contacted each other as they were being packed. Figure 8 shows the result. The antenna was about a meter or two from the event.

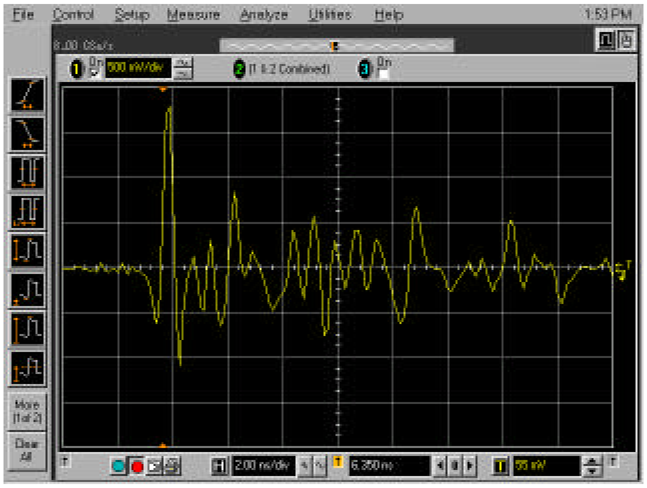

Figure 8: Radiated Field, Repacking Restivity Measuring Kit

The waveform in Figure 8 shows about a 12 V/m peak, but possibly more important, a very fast dv/dt with a change from the highest peak to the lowest peak of about 300-400 picoseconds and pulsewidth of less than 500 picoseconds. Previously, one of our authors has personally observed similar fields causing data transmission test equipment to malfunction.

II.b.2 New Facility

The new facility was a state of the art server installation. The facility was designed for the purpose of housing a large number of servers. The main server room was very quiet with respect to ESD generated EMI. We did not detect significant events over a few hour period when people were not doing work in the room.

During work on a server, from a distance of about 3 meters, we recorded EMI caused by that work. Figure 9 shows one of the oscilloscope traces.

Figure 9 indicates a peak field strength of about 3 V/m, substantial in that the antenna was 3 meters away. At a one meter distance, nearby servers would experience much greater field strength. The engineer was using a wrist strap at the time, but the chassis he was working on was not grounded and likely had developed some charge.

Another event that occurred during the maintenance work when Figure 9 was recorded is shown in Figure 10. We were not able to correlate the event in Figure 10 to actions of people in the area and so it may have come from some greater distance away. However, as can be seen in Figure 10, the fields were substantial, especially since the antenna frequency response falls off significantly below a few hundred MHz. The signal displayed in Figure 10 is actually much larger than shown..

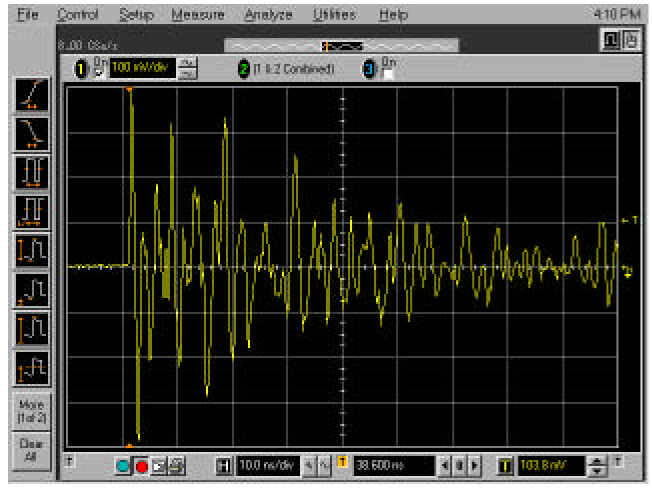

Figure 9: Radiated Field, Equipment Maintenance

The low ringing frequency in Figure 10, between 15 and 20 MHz was likely due to the source involving a large structure. The observed frequency was the natural resonant frequency of that structure. One wavelength in free space at 15 MHz is 20 meters so the structure might be comparable to a significant fraction of that size. Possibly a whole bank of racks was involved. One of our authors has personally observed a similar case where such an event caused interference with optical transmission circuits within a large equipment installation.

The relatively slow risetime of nearly 20 nanoseconds in Figure 10 indicates the event was either a close-by high voltage event and therefore had slow risetime or was a fast risetime event, but further away. In either case, a significant amount of energy was involved. We did not observe a cause of the event, so the likely case was a distant event. So the registering of about 5 V/m in Figure 10 is of concern. Servers near this event were subjected to a high level of EMI.

The room was equipped with mobile furnishings such as ladders and hoists that were used to position servers in their mounting racks. As could happen during work on the facility, we caused various of these mobile furnishings to move about and then come in contact with racks or other moveable furnishings.

Figure 10: Radiated Field, Unknown Origin, During Maintenance

One significant case is shown in Figure 11. A mobile hoist used to lift servers onto shelves touched the large metal cabinet of some environmental control equipment. The hoist was about the size of a small fork lift but optimized for lifting servers.

Figure 11: Radiated Field, Mobile Hoist, During Maintenance

The antenna was more than 3 meters from the hoist when Figure 11 was recorded. Notice the very high and fast initial spike. This could pose a problem when the hoist is near operating servers where the field would be much the greater than 5 V/m at close range. Note that the waveform is off screen on positive edge in Figure 11.

Figure 12 shows the result when the hoist traveled across a floor joint. No actual collision between objects occurred, as was the case for most of the earlier waveforms.

A waveform similar to Figure 11 was recorded in Figure 12. This may have been due to parts of the hoist discharging to each other. The problem here is that such an event may happen regularly as the hoist travels down the rows of servers! The distance to the servers would be less than 1 meter in such a case leading to much higher field strengths that the ~5 V/m shown in Figure 12.

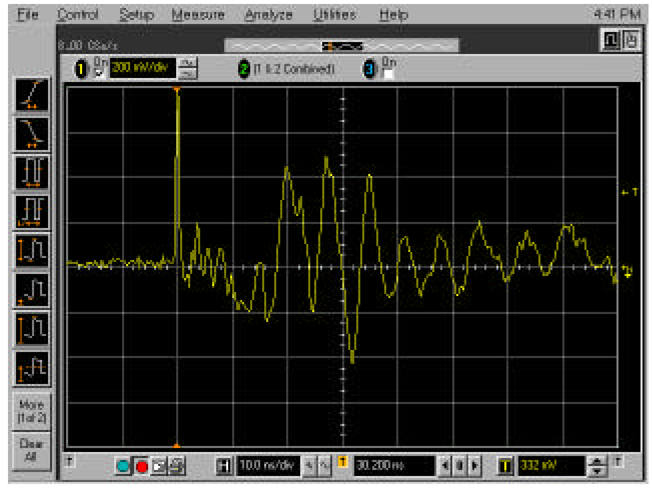

Figure 12: Radiated Field, Mobile Hoist, Crossing Floor Joint

III. Conclusions

Significant EMI was recorded in server installations. Most was produced by human activity, but at least one event had unknown origin. Tests in an anechoic chamber show that normal operations such as plugging cables and using tools can produce significant EMI from ESD events. This further confirms the preliminary data published earlier in the open literature.[5]

Because most of the problems we found were related to staff activities and materials handling, an Electrostatic Management Program for large server centers might be in order. Such a program should consist of facility audit to review design issues that might be related to grounding, ESD/EMI control procedures, staff training, and appropriate ESD control measures. The Electrostatic Management Program should be folded into an ISO process for companies where appropriate.

Since many data centers involve mission critical corporate or government activities, Information Technology personnel should look into the development of ESD/EMI sensor networks to monitor for ESD/EMI and help prevent catastrophic and latent ESD/EMI induced server failure.

Our recommendation is that the ESD/EMI environment of server installations should be monitored and if necessary, mitigation of ESD and EMI should be carried out. In addition, standard ESD precautions should be taken.

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[5] D. C. Smith and M. Hogsett, "The EMI/ESD Environment of Larger Server Installations," Conformity, October 2001, Vol 6, #9, pp. 38-46, Publ. Co., Curtis-Stauss, Littletown, MA.