The EMI/ESD Environment of Large Server Installations

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Large installations of servers have become an important part of the infrastructure of our economy. Their reliability is of utmost concern. Results of an ongoing study of the EMI/ESD environment of server installations is reported herein and related to potential threats to equipment. The data to be presented shows a significant threat to the reliability of these installations.

I. Introduction

Large server farms, installations housing a large number of file servers, have become commonplace as the need to store information has mushroomed. This information explosion is partly fueled by the growth of the internet as well as traditional business. Physical security has been a major concern and is the focus of considerable effort. However, the threat posed by impulsive electromagnetic interference (EMI) is potentially as great or greater to the data stored in the servers. Although ESD environmental studies have been done in the past, published works on server installations are difficult to find[1].

II. Test Plan and Instrumentation

Data was taken in two ways. First, measurements were made of radiated fields that resulted from specific server maintenance operations. Measurements were then made of the electromagnetic environment in a location where many servers were located and maintenance operations were being performed

Figure 1 shows the antenna used for the measurements of specific maintenance operations. This type of antenna is called a TEM (**t**ransverse **e**lectro**m**agnetic) antenna. Its structure is essentially a tapered transmission line with one end open. The electric field strength measured is simply given by:

(1) $$E = \frac{1}{D} \bullet V_m$$

where D is the distance between the open ends of the plates in meters and V_m is the measured voltage at the antenna terminals. The vertical plates of the antenna shown in Figure 1 will respond to a horizontally polarized electric field.

Figure 1: TEM "Time Domain" Antenna

The advantage of this antenna is that it measures the true waveshape of the electric field of an electromagnetic wave. Most antennas have a resonant structure that has an oscillatory response to an impulse such as can be generated by an ESD event.

Figure 2 shows the antenna response to a coin charged to a low voltage colliding with another at 0.5 meter. If this measurement had been made with a dipole antenna (essentially just two wires), substantial ringing would have followed the initial event.

Since the separation of the antenna plates at the open end is 14.5 cm, the electric field strength given by (1) is ~6.90 times the voltage displayed on the oscilloscope or 27.6 Volts/meter for the 4 volt peak displayed in Figure 2. This antenna was not available for some of the measurements in multiple server environments so some oscillatory response will be seen in those results. In that case, an estimate of the electric field response can still be made.

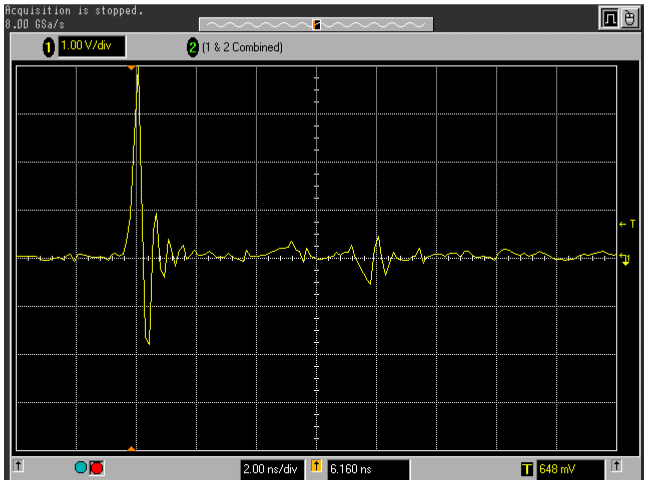

Figure 2: Response of TEM Antenna to Small Metal ESD

III. EMI Generated by Maintenance Operations

Measurements were taken using the facilities at Elliott Laboratories in Sunnyvale, California of specific maintenance operations using the TEM antenna of Figure 1. Measurements were made at a distance of 1.5 meters from the server, both in front of the server and to the side. The results were comparable for both the front and side, but slightly higher for the side readings. For all measurements, the person was charged to 500 Volts, a very low voltage that is far below the threshold of human perception of about 3500 Volts.

Figure 3 shows the field to the side generated by insertion of a power supply module. The peak voltage recorded of 3.2 volts translates to a field strength of ~22.1 Volts/meter, a value that is about 10 times the radiated immunity field strength required to put the CE mark on equipment sold in Europe.

Insertion of a disk drive produced the similar result shown in Figure 4 and having an electric field intensity of ~19.3 Volts/meter. The higher ringing frequency of the disk drive insertion was likely due to its smaller size and the structure it was mounted in. This structure held several drives and itself was then inserted into the server with the resulting ESD generated fields shown in Figure 5.

The peak value of the recorded waveform exceeded the ability of the scope (4 Volts full scale) to measure it. An estimate of the peak based upon the observed waveform is about 8 Volts. This yields a field strength of ~55.2 Volts/meter! This is an intense field strength especially considering the measurement was made at 1.5 meters.

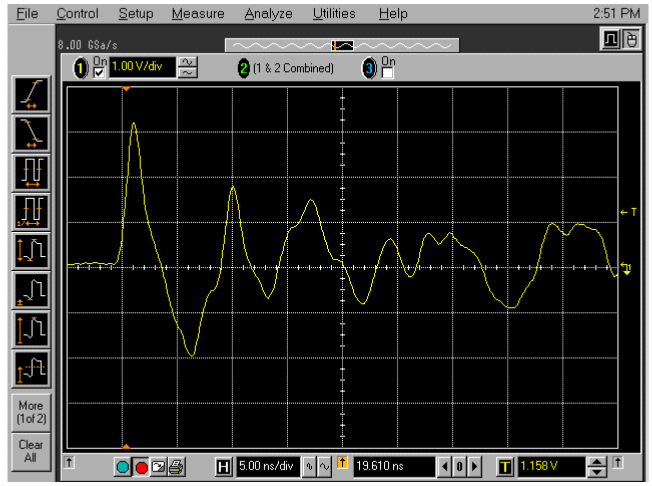

Figure 3: Field Strength Resulting From Power Supply Insertion

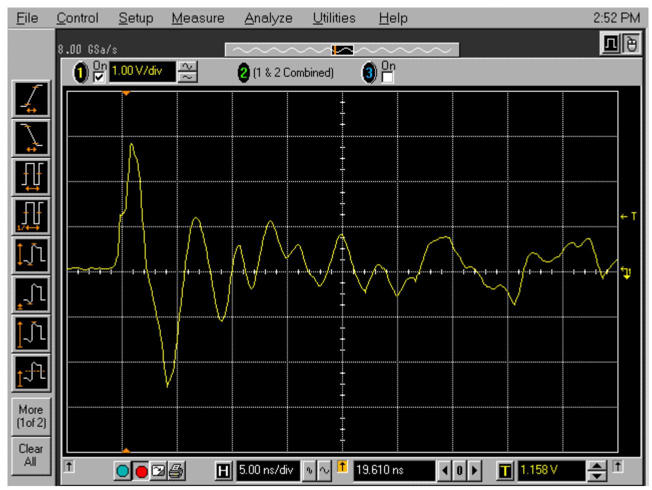

Figure 4: Field Strength Resulting From Disk Drive Insertion

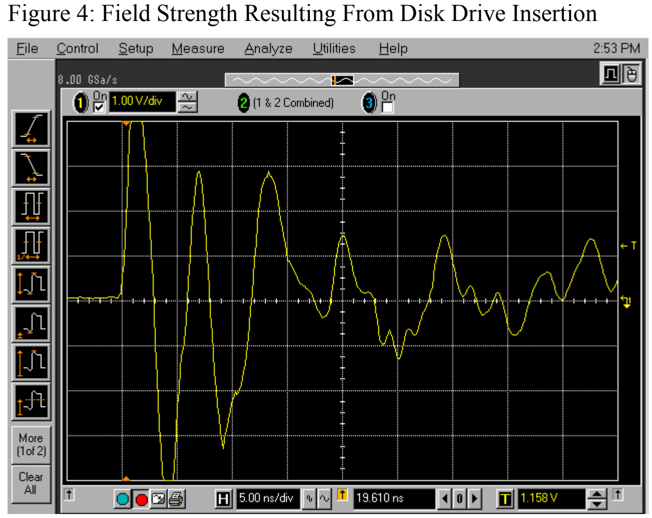

Figure 5: Field Strength Resulting From Disk Array Insertion

Space is usually at a premium in server farms and servers are usually mounted close to each other, not 1.5 meters apart. Imagine what the field strength would be at an adjacent server or to components of the server into which the drive array was inserted!

One feature to note on the data presented is that most of the measured fields had an oscillatory nature. This is due to resonance in the metal of the server or the parts being inserted and is a function of their physical size. The TEM antenna accurately reproduces the time domain field including the oscillatory nature noted above. The oscillatory nature increases stress on nearby equipment in that the greater the number of fast edges, the more likely an equipment problem will result.

IV. On-Site Measurements

Measurements were made using the TEM antenna at site where a large number of servers were located. During the measurement session, maintenance and testing operations were being performed on some of the servers.

Figure 6 shows a typical measurement that was taken at a distance of 10 meters from a server that was being power cycled. The peak voltage of ~460 mV translates to a field strength of ~ 3.2 Volts/meter. That is a high strength to be measured at such a distance. Servers in the vicinity of this one would experience much higher fields comparable to the fields measured for specific maintenance operations above.

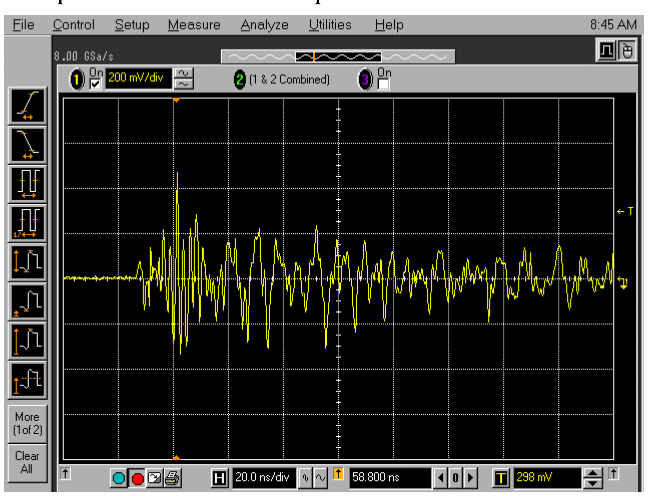

Figure 6: On-Site Field Measurement at 10 Meters

Figure 7 shows the data of Figure 6 expanded from 20 ns/div to 2 ns/div. Note the relatively fast 1 ns edges and ~500 MHz ringing frequency. This represents relatively intense **e**lectro**m**agnetic **i**nterference (EMI). Upset in nearby equipment is a definite possibility as a result of this event

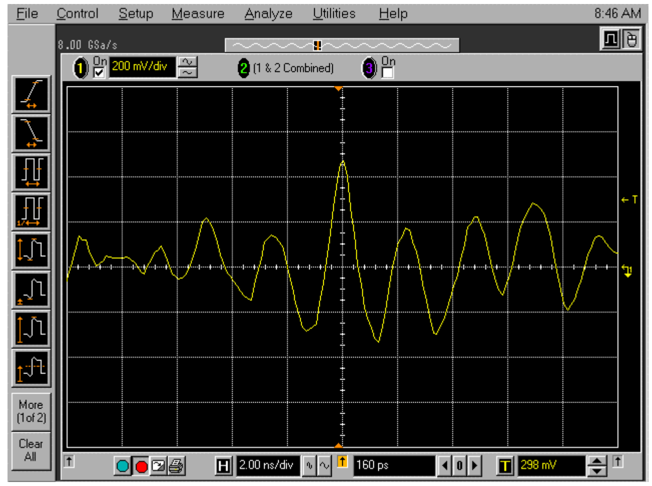

Figure 7: Expansion of Figure 6 to 2ns/div

In Figure 6, the high frequency energy at the start of the plot, shown in Figure 7, is associated with the original impulse of the event being measured (possibly an electrical fast transient on the power line). The lower frequency oscillations later in the plot have more to do with resonance in the equipment and its connecting cables.

Figure 8 shows an event with different characteristics. In this case, the peak amplitude is about the same value but occurs during the lower frequency, later, part of the waveform, not the high frequency early parts of the waveform as in Figure 7. Apparently the original high frequency energy excited a system or cable resonance causing the peak amplitude to occur later in the received EMI and at a lower frequency.

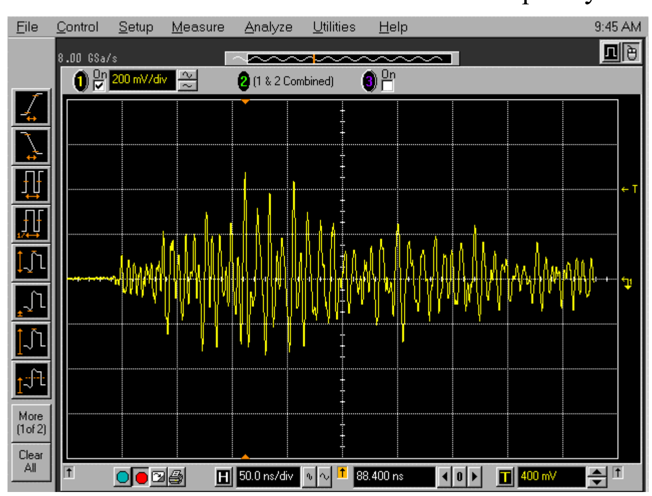

Figure 8: A Second On-Site Field Measurement at 10 Meters

Also note that Figure 8 is plotted at 50 ns/div instead of the 20 ns/div used in Figure 6. The event of Figure 8 lasted a long time, close to 0.5 microsecond! This relatively long time coupled with high intensity and many oscillations poses a definite threat to nearby electronic equipment including other servers.

Figure 9 expands the peak of Figure 8 to 5 ns/div. The lower frequency of oscillation and slower 2 ns edges associated with the peak are clearly shown.

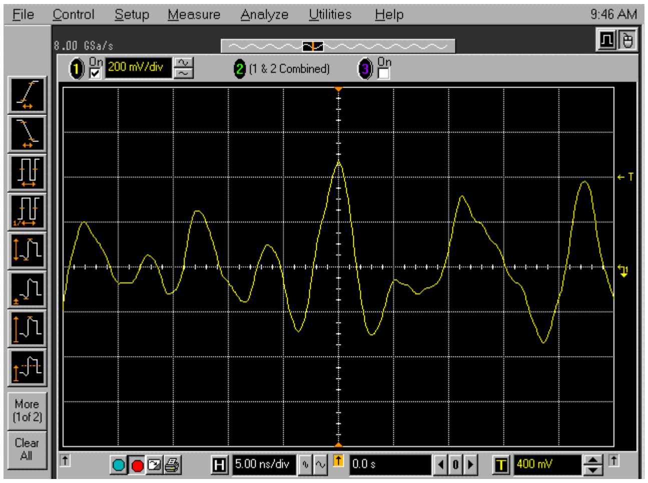

Figure 9: Expansion of Figure 8 to 5 ns/div

Additional data was taken at a second location with a large number of servers. A bi-conical antenna used for electromagnetic compliance measurements in the frequency domain was used as the TEM antenna was not available for these measurements. Because of this, the actual waveform shape may not be accurate but useful information was obtained.

Figure 10 shows a relatively long view (20 µsec/div) of an event. We are not sure of the location of this event, but notice that it was really three events (or more). The first event was greater than 4 Volts!

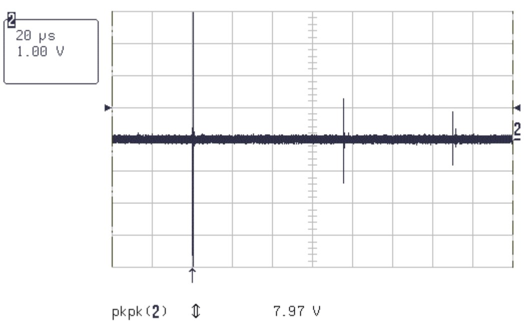

Figure 10: Long Time View of EMI Event

Figure 11 expands the first event of Figure 10 out to 50 ns/div to see greater detail. The plot shows an exponentially decaying oscillatory waveform. The decaying oscillatory nature of the waveform is at least partly due to the characteristics of the antenna.

However, note the high amplitude of over 4 Volts peak. Figure 12 expands Figure 11 to 5 ns/div. Here we see that the amplitude is somewhat greater than 4 Volts peak, possibly in the 6 to 8 volt range.

The antenna factor of the bi-conical antenna used was in the range of 20 dB, a factor of 10, so the real field strengths were on the order of 60 to 80 Volts/meter, an intense field indeed!

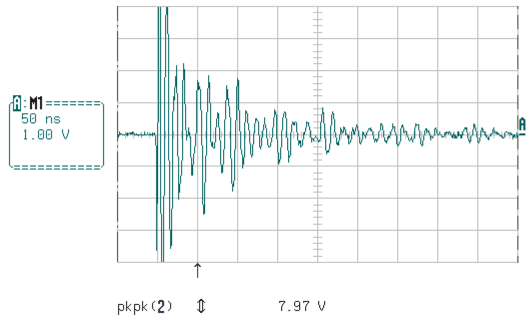

Figure 11: Expansion of Figure 10 to 50 ns/div

The data from this location shows not only intense EMI, but also closely spaced (tens of microseconds) multiple events as well.

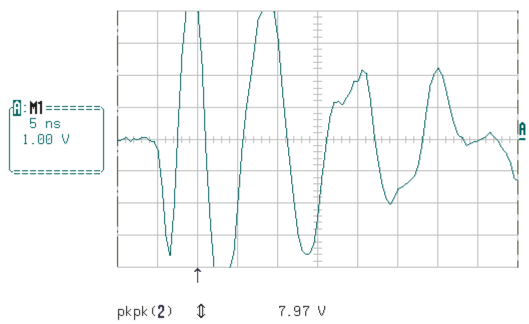

Figure 12: Expansion of Figure 11 to 5 ns/div

V. Conclusions

The data presented in this paper show that levels of EMI are present in the vicinity of servers at such a magnitude as to present a potential threat to those servers. Even with proper design for immunity of the servers, it is not a good idea to continue to test the limits of immunity of equipment on an everyday basis. Operators of such mission critical equipment should monitor and control the EMI environment of their equipment just as they do the physical premises.

Given the value of the stored data, the EMI environment of server farms should be further studied so that enough data is available to allow statistical analysis. Such an analysis would provide a more accurate picture of the threat level to server farms.

References

[1] M. Honda, "ESD Events in Aircraft Cabin Environment", Proceedings of the 1998 EOS/ESD Symposium, Reno, Nevada, October 6-8, 1998, pp. 22-28.

Acknowledgements

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