Unusual Forms of ESD and Their Effects

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Abstract - Two unusual forms of ESD, internal chair discharges and multiple small metal-to-metal discharges from "jingling change," have caused severe field problems in electronic equipment. These forms of ESD are not covered by any current standard. A review of previous work, new measured data, and examples of problems that have occurred are presented.

Introduction

Electronic systems are routinely tested for compliance to international ESD standards, usually IEC 1000-4-2, to demonstrate immunity to ESD. However, ESD related problems can still occur that affect system performance. One of the problems not covered by the IEC test is for events with very fast risetimes or for mechanisms that can produce a large number of events in a short time. Two such sources of radiated interference from ESD are discharges internal to chairs and discharges between coins jingling in a pocket.

I. Background of Unusual ESD

I.a. ESD Internal to a Chair

When a person rises from a chair, charges are generated on both the surface of the chair seat and internally that can cause ESD events to occur inside of the chair. These discharges are between metal parts of the chair that are not electrically connected to each other. The discharges cause intense electromagnetic fields to be radiated from the metal parts of the chair, usually the legs. This radiation has been shown to be capable of disrupting the operation of nearby electronic equipment. This effect was reported in 1993 by Honda and Smith.[1][2]

The most common type of construction that can cause this effect has a central metal post with wheels on radial "spokes" at the bottom of the chair. I have observed that about 1/3 of all chairs with this type of construction exhibit the effect. Other types of construction can also cause this effect, but are less likely to do so.

This phenomena has several characteristics that cause its effects on electronic systems to be greater than one would think.

First: In my 1993 paper, it was shown that nearby conductors could experience an induction of 2 to 10 volts/cm. This is a relatively severe amplitude from a system point of view.

Second: Typically many discharges take place over a relatively short time. Most chairs I have observed with this effect produce about a dozen discharges over the first 10 to 15 seconds after a person rises from the chair. However, some office chairs are capable of producing several hundreds of discharges over as much as a minute after a person rises from the chair. The sheer number and close spacing of possible ESD events makes the probability of equipment failure more likely than the small number of widely spaced (one second) events (10 per polarity on each horizontal or vertical coupling plane) used in IEC 1000-4-2. A test of dozens of furniture discharges as per ANSI C63.16-1993 might be a good model of internal chair ESD.

Third: If a person delivers an ESD event to a piece of equipment through a 1 cm arc, the cause of the resultant malfunction is at least known. If one merely rises from a chair without even discharging to anything, and nearby equipment fails, it is unlikely that the association between rising from the chair and the equipment failure will be easily made. The ESD event is hidden inside of the chair and invisible to the person. Such a scenario can make it very difficult to learn the cause of a problem. In many cases, the cause may never be established or only after significant resources have been spent.

There is an urgent need for a standardized test so that procurement contracts can specify chairs that do not radiate this type of electromagnetic interference, EMI. Figures 1 and 2 show two examples of chairs that might be found in a commercial or office environment. Can you tell which one emits EMI from internal ESD? It turns out that the Gibo/Kodama chair does not emit internal ESD caused EMI and the conventional office chair does. At present there is no way for a purchaser to specify a chair for its EMI generation characteristics.

Figure 1. Standard Office Chair

Figure 2. ESD controlling chair by Gibo/Kodama

Just purchasing "ESD safe" chairs alone will not eliminate the problem. I have personally observed an "ESD safe" chair in a factory emitting this type interference.

Since 1993, many types of equipment have been affected by this phenomena including communications equipment, computer equipment, even critical equipment in the field of aviation.

I.b. Jingling Change ESD

Another unusual form of EMI generated by ESD is that of *jingling change*. When small pieces of metal, such as pocket change, move around inside of an insulating pouch, such as a pocket or plastic bag, the small pieces of metal generate different charges. When they touch, small ESD events are generated, for the most part too small to be seen.

I have measured risetimes of the fields to be smaller than 100 picoseconds which would indicate that the arc length is small and the voltage differential is also small. The pulse width is subnanosecond as well.

With the increasing speed of electronic circuits, many types of circuits have become susceptible to this form of interference. I have caused upset by shaking a plastic sandwich bag with a handful of pocket change near communications equipment, a 100 MHz PC, and some consumer electronics. In one case, shaking the bag of coins 3 feet from a rack of equipment resulted in dozens of red LEDs to light!

The problem is that people generate this type of interference all the time. If a plastic bag with a handful of change can cause upset from 2 feet away, then the product will experience random upsets in the field. These upsets will be very difficult to track down because the source is so unlikely.

The actual ESD event is well modeled by the *charged device model*. The difference is that there are hundreds of events in a matter of a few seconds raising the probability of a system "hit." There is a need to develop a standard test for this type of interference so that repeatable results can be obtained. The faster electronic equipment becomes, the more urgent the need for this test.

II. Measurements

II.a. ESD Internal to a Chair

Figure 3 shows a test setup to measure the number of events in an office chair that radiates EMI. The instrument used to count the events was a Lucent Technologies ESD Event Detector, model T-100.

For this test, a short test clip was attached to the input of the event detector and positioned a few feet from the office chair. The counter was reset and a person then rose from the chair. After about 10 to 15 seconds, the count stabilized at 15 counts as shown in Figure 4.

Figure 3. Test Setup to Measure Number of ESD Events

Figure 4. Event Count After Rising From Chair

To measure the possible induction into nearby conductors, a small dipole antenna 30 cm in length was positioned about a foot from the chair shown in Figure 1. The dipole is shown in Figure 5. It is one half wavelength at 500 MHz, the bandwidth of the oscilloscope used.[3]

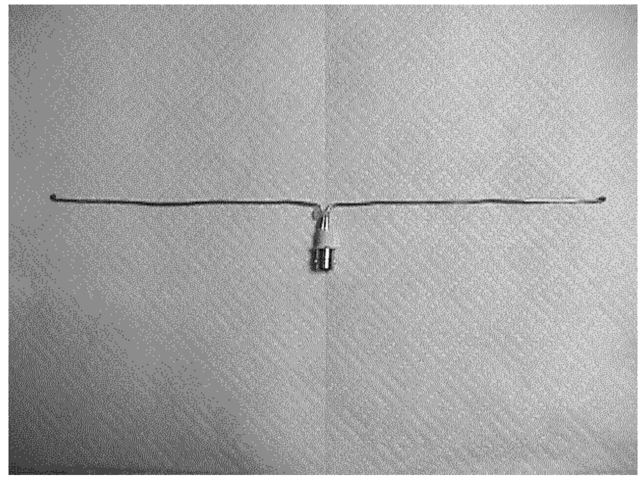

Figure 5. 30 cm Dipole

The resultant signal shown in Figure 6 represents the result of one out of many ESD events that took place in the chair after a person rose from it.[3] Note that the signal achieves more than 4 volts peak-to-peak amplitude in one nanosecond, near the bandwidth limit of the oscilloscope.

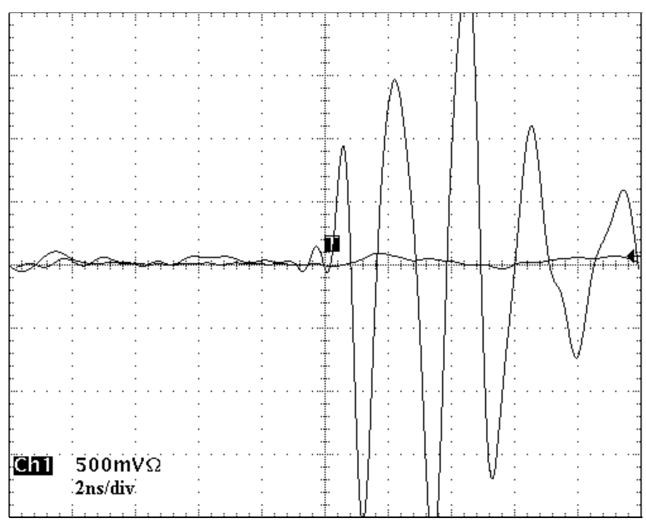

Figure 6. EMI Picked up by a 30 cm Dipole Near Chair

II.b. Jingling Change ESD

Measurements on jingling change were made with an HP54542A 2 GSa, 500 MHz oscilloscope and a plastic sandwich bag with some pocket change thrown in. Figure 7 shows the bag of change and Figure 8 shows the first measurement configuration using the large EMCO 7405 magnetic field probe. The oscilloscope bandwidth was not adequate for an accurate representation of the voltage output of the loop, but nonetheless useful information was obtained. In general, the amplitude shown on the scope was significantly lower than the signal amplitude actually present.

Figure 7. Plastic Bag with Change

Figure 8. Jingling Change Test Setup

Figures 9 and 10 show two representative waveforms of those that were captured by the scope. The peaks shown on these waveforms represent a single sample by the oscilloscope. The real amplitude is much higher than the 6 volts peak shown. However, even 6 volts into a 5 cm loop is a significant signal. This signal is capable of causing interference to many types of circuits.

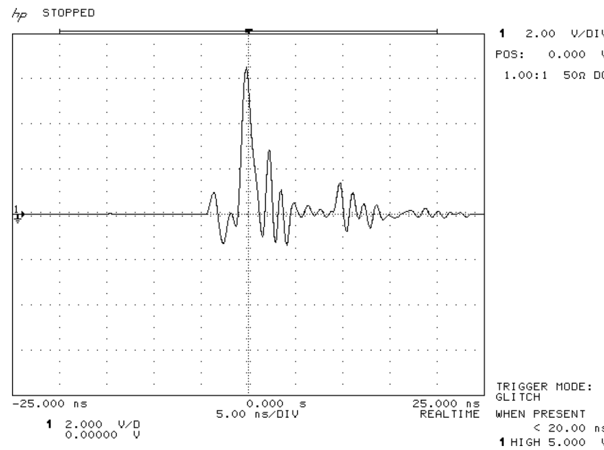

Figure 9. Loop Output Caused by Jingling Change

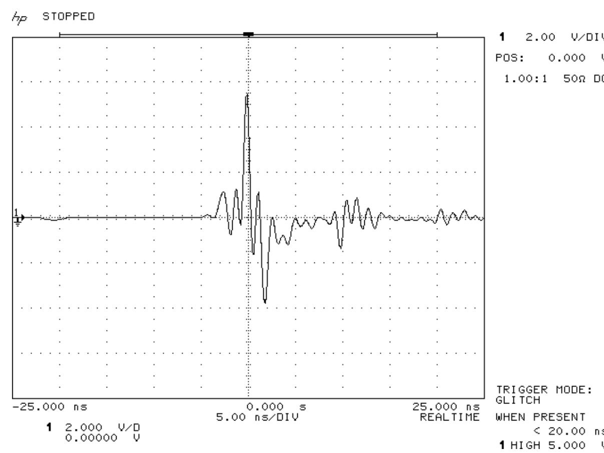

Figure 10. Loop Output Caused by Jingling Change

A second test was done using a broad band antenna normally used for EMC emissions measurements. The test setup is shown in Figure 11. The bag of change was about 2 meters in front of the antenna. Figure 12 shows the antenna signal delivered to the oscilloscope.

The antenna factor of an antenna relates the electric field impinging on the antenna to the voltage delivered to the coaxial output from the antenna. Since the antenna factor of this antenna is not constant with frequency it is difficult to calculate the field strengths from the data in Figure 12. However, it is instructive to note that from 2 meters away, the jingling change was able to produce an antenna output of nearly a volt. That is consistent with the data above that shows there is an interference potential from this phenomena.

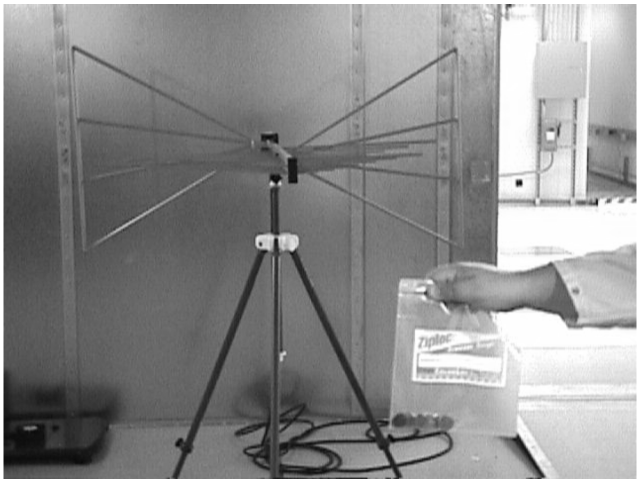

Figure 11. Pickup of Jingling Change EMI by Broadband Antenna

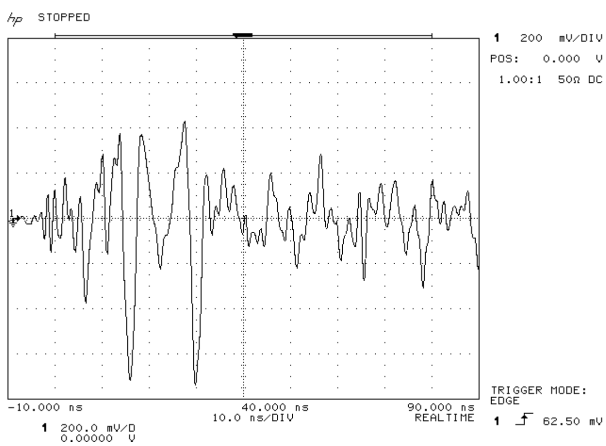

Figure 12. Antenna Output Caused by Jingling Change

A simple test to obtain a feeling for the large number of ESD events that jingling change can cause is to shake a bag of loose change near an inexpensive AM radio. Static like noise will be heard in the radio. The ESD events are so rapid as to cause an almost audio rate of pops in the radio.

III. Conclusions and Summary

Two unusual forms of ESD, internal chair ESD and jingling change ESD, were presented. Although each event is similar to an existing model for an ESD event, furniture and charged device model respectively, the mechanisms presented differ in the large number of events likely and in their hidden nature. It is the hidden nature of these forms of ESD that can cause much wasted effort in tracking down problems when they occur in electronic equipment and are due to these mechanisms.

There is a need to develop a standardized test for these events. Such a test will allow providers of critical services, such as communications, medical, and air traffic control, the ability to specify an environment that will minimize potential problems.

IV. Credits

I would like to thank Glen Dutrow of Auspex Systems for help in taking data for this paper. I would also like to thank Masamitsu Honda for insightful discussions about these phenomena.

V. References

[1] "A New Type of Furniture ESD and Its Implications," Douglas C. Smith, *Electrical Overstress/Electrostatic Discharge Symposium Proceedings*, 1993, pp.3-7.

[2] "Impulsive ESD Noise Occurred From an Office Chair," Yasuo Tonoya, Masashi Ono, Masamitsu Honda, *Electrical Overstress/Electrostatic Discharge Symposium Proceedings*, 1993, pp. 9-16.

[3] "Electrostatic Discharges Internal to Chairs, a Hidden Threat to Electronic Equipment," Douglas C. Smith, *Air Traffic Technology International '99*, UIP UK and International Press.