Progress in the Field of Intentional Electromagnetic Interference (IEMI) Since the New Delhi General Assembly in 2005

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Abstract

Since the New Delhi General Assembly in 2005, there has been significant progress reported in the field of intentional electromagnetic interference (IEMI) through papers published at EMC conferences, workshops and tutorials. Most of this new research has dealt with the susceptibility of handheld electronics, interference with networks, threats to transportation systems and additional information concerning the susceptibility of modern PCs. This new work will be summarized in this paper, and conclusions will be drawn concerning the state of understanding of the threat of IEMI to civil systems and equipment.

1. Introduction

Over the past three years there have been a significant number of workshops, tutorials and EMC conferences in which new research has been presented in the area of intentional electromagnetic interference (IEMI). This work has focused on understanding the impacts of wideband and narrowband electromagnetic threat waveforms on commercial equipment in order to understand the threat to commerce and to develop protection methods against these types of electromagnetic fields. At the New Delhi URSI General Meeting in October 2005, progress in both IEMI and high-altitude electromagnetic pulse (HEMP) protection was discussed with an overview of the progress up to early 2005, when the submitted papers were due [1]. In addition the International Electrotechnical Commission (IEC) has continued its work in standardizing the threat of IEMI and ways to deal with it. These efforts will be reviewed in this paper.

It is noted that many EMC conferences deal with the subject of HPEM and sometimes have one or two papers dealing with IEMI. For this paper only conferences with major IEMI activates are discussed:
- EMC Zurich Symposium – Zurich in February 2005 (Special Session on HEMP, plus selected papers on IEMI)
- EMC Europe Workshop – Rome in June 2005 (Special Session on IEMI)
- IEEE EMC Symposium – Chicago in August 2005 (Tutorial on IEMI)
- URSI General Meeting – New Delhi in October 2005 (Papers in invited sessions on IEMI and Standards)
- EMC Zurich Symposium – Singapore in February 2006 (Special Session on IEMI)
- AMEREM2006 – Albuquerque in July 2006 (Special Session on IEMI)
- EMC Europe Workshop – Paris in June 2007 (Special Session on IEMI)
- EMC Zurich Symposium – Munich in September 2007 (Tutorial on IEMI)
- EMC Zurich Symposium – Singapore in May 2008 (Special Session on HPEM including IEMI)

2. Definitions of IEMI and HPEM

As described in the 2005 URSI General Meeting [1], it is important to understand how IEMI is related to high-power electromagnetics (HPEM). The term HPEM has been employed for many years and is used to describe different types of phenomena that generate significant electromagnetic fields from the standpoint of high peak power. Although there is not a precise definition of “high power”, the IEC Subcommittee 77C has suggested that high-power conditions are achieved when the peak electric field is 100 V/m or higher [2].

Given this definition, the following phenomena are included as part of HPEM:
- Lightning electromagnetic pulse (fields produced near a cloud-to-ground stroke)
- Radar fields
- Fields produced near an electrostatic discharge (ESD) arc
- Electromagnetic Pulse (EMP) produced by a nuclear detonation at any altitude
Electromagnetic fields that can produce IEMI, including narrowband threats such as high-power microwaves (HPM) and wideband threats such as ultrawideband (UWB) fields.

It should be noted that the above list includes both natural and intentional threats to electronic equipment and systems. In a resolution published by URSI in 1999 [3], the use of EM tools (or sources) by criminals was defined as a threat to be considered by the electronics community as an intentional threat. The term IEMI was discussed over several years and was later accepted by the IEC with the following definition: “Intentional malicious generation of electromagnetic energy introducing noise or signals into electrical and electronic systems, thus disrupting, confusing or damaging these systems for terrorist or criminal purposes” [2].

3. Discussion

As there are 9 conferences to be discussed in this paper, emphasis will be placed on those with the largest impact on our understanding of IEMI.

3.1 EMC Zurich Symposium – Zurich in February 2005

While there was no special session dealing with IEMI during this conference, there were two important papers dealing with the subject:
• C. Baum, D. Nitsch, “Band Ratio and Frequency-Domain Norms.”

3.2 EMC Europe Workshop – Rome in June 2005

This workshop dealt mainly with communications, and a special session on IEMI dealing with wireless networks was convened with the following papers. It is noted that many of these papers were preliminary in nature, and several of the research efforts were continued with full papers in the Singapore Conference in February 2006.
• W. Radasky, M. Backstrom, “Overview of the Threat of Intentional EMI to Civil Wireless Systems.”
• T. Nilsson, O. Lunden, M. Backstrom, “HPM Susceptibility Measurements on WLAN and GPS Systems.”
• J. Delsing, J. Ekman, J. Johansson, “Intentional EMI Considerations for Sensor Networks.”
• I. Kohlberg, R. Boling, “Mathematical Structure of Ad-hoc Wireless Networks and Their Tolerance Against IEMI Attacks.”

The issue of networks and interference was discussed in the context of IEMI for the first time at this workshop. It was important to observe that while jamming of operating signals for wireless systems is easily accomplished, it was a surprise to observe problems with GPS receivers at frequencies above the operational frequency.

3.3 IEEE EMC Symposium – Chicago in August 2005

A one-half day tutorial on IEMI was presented by William Radasky and Richard Hoad introducing the topic of IEMI and examining the effects, mitigation approaches and standardization activities underway.

3.4 URSI General Meeting – New Delhi in October 2005

During the URSI General Meeting there was an invited session on IEMI (E03) that included the following four papers. In addition a related paper on UWB standardization was also presented.
• W. Radasky, “New Developments in Intentional Electromagnetic Interference (IEMI) and High-Altitude Electromagnetic Pulse (HEMP).”
• D. Didier, “Potential IEMI Threats Against Civilian Air Traffic.”
• L. Siniy, “Electromagnetic Threats to the Civil Infrastructure.”
3.5 EMC Zurich Symposium – Singapore in February 2006

This special session on IEMI concentrated on networks and how IEMI could affect their performance. There were also several papers that extended efforts beyond the EMC Europe Workshop in Paris in 2005.

- R. Hoad, A. Lambourne, A. Wraight, “HPEM and HEMP Susceptibility Assessments of Computer Equipment.”
- H. Potrykus, I. Kohlberg, “Resistance to Extended IEMI by Physical/Correlated Wireless Random and Non-random Networks.”

Additional data were presented at this symposium with respect to hand-held devices and their vulnerability to hyperband pulses at relatively low field levels. In addition the work dealing with non-random networks indicated that problems could occur if IEMI was used to interfere with many nodes in a wireless network.

3.6 AMEREM2006 – Albuquerque in July 2006

This conference dealt entirely with the subject of HPEM, although there was a special session dealing with IEMI. This conference only publishes abstracts, so many of these papers are usually extended and found fully published in other symposia.

- W. Radasky, R. Hoad, “Progress in the Development of HEMP and IEMI Standards by the International Electrotechnical Commission (IEC).”
- F. Sabath, M. Backstrom, “Intentional Electromagnetic Interference (IEMI) Simulator Compendium.”
- W. Radasky, K. Smith, “Coupling Calculations of Narrowband, Mesoband, and Hyperband Electric Field Waveforms to Network Cable Systems.”
- R. Hoad, “Detection of Disruptive Intentional Electromagnetic Interference (IEMI) to Information Systems and Processes.”
- Kohlberg, “Theory of Resilience of Modern Large Communication Networks to Intentional EMI.”

3.7 EMC Europe Workshop – Paris in June 2007

During this workshop, another special session on IEMI was presented that focused on transportation, communications and security.


At this workshop, IEMI impacts on railway systems were discussed with regard to future plans for using wireless signaling on European trains. In addition, new work dealing with IEMI detectors was presented.

3.8 EMC Zurich Symposium – Munich in September 2007

A one-half day tutorial on IEMI was presented by William Radasky and Richard Hoad updating the tutorial presented in August 2005 at the IEEE EMC Symposium.

3.9 EMC Zurich Symposium – Singapore in May 2008

At this conference a special session on HPEM and IEMI is planned, and the following papers dealing with IEMI aspects have been accepted:

- M. Ianoz, “A Comparison Between HEMP and HPEM Parameters, Effects and Mitigation Methods.”
- E. Savage, et al., “Pulse Testing of Network Interface Cards for Upset and Damage.”
- W. Radasky, “High-Power Transient Phenomena and Standardization.”

While this conference has not yet been held at the time this paper was written, there are several accepted papers dealing with wired systems (such as Ethernet) and the problems of interference in terms of data quality, propagation of interference signals in cables, and upsets/damage to the Ethernet cards in computers. In addition, more work has been performed on railway systems and the critical infrastructures.

4. Conclusions

Over the past three years since the last URSI GM, continued progress has been made in the area of intentional electromagnetic interference. While research into the susceptibility of electronic equipment due to different types of narrowband and wideband threats has continued, authors have extended their research into the areas of wired and wireless networks, transportation system vulnerabilities, vulnerabilities of sensor networks, and the design and uses of IEMI detectors. In addition there has been continued progress in the area of standardization, mainly in IEC SC 77C to understand the threat of IEMI and to protect against it.

Readers who are interested in this topic are invited to examine the proceedings of these conferences to learn more about this subject and the progress of the research.

5. References

