



Plenary Session

Time: 18th, Sept., Wednesday

Venue: Function 1, Floor G, Wyndham Grand Xi'an South.

| | | |
|---------------|--|-----------------------------|
| 8:20 – 8:50 | Prof. Farhad Rachidi An Introduction to Electromagnetic Time Reversal | Host: William A. Radasky |
| 8:50 – 9:20 | Dr. Jin Soo Choi Methodology and Implementation of Automated HPEM Effects Testing | |
| 9:20 – 9:50 | Prof. Xueling Yao Development of Lightning Direct Effect Test and Simulation of Carbon Fiber Composites | |
| 9:50 – 10:10 | Coffee Break | |
| 10:10 – 10:40 | Dr. William A. Radasky From DC to Daylight: Let's look at the DC End! | Host: Chang-Su Huh |
| 10:40 – 11:10 | Prof. Jun Zhang Recent Progress in Narrowband High Power Microwave Sources | |
| 11:10 – 11:40 | Dr. Chaouki Kasmi EMSEC and InfoSec: differences, similarities and challenges | |
| 11:40 – 12:10 | Prof. Xiaoyun Lu Systematic Effects of acute Ka-HPM and L-HPM pulses exposure on KM mice | |



Plenary Talk 1: An Introduction to Electromagnetic Time Reversal

F. Rachidi¹, M. Rubinstein² and Y.-Z. Xie³

¹ Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland

² University of Applied Sciences of Western Switzerland, Yverdon-les-Bains, Switzerland

³ Xi'an Jiaotong University, Xi'an, China

Speaker: Prof. Farhad Rachidi

ABSTRACT

Time reversal has emerged as an interesting technique with potential applications in various fields of engineering. It first received a great deal of attention in the field of acoustics, in which it was first developed by Prof. Fink and his team in the 1990s. In the past decade, the technique has also been used in the field of electromagnetics and applied to various other areas of electrical and computer engineering. In particular, it has been successfully applied in the fields of electromagnetic compatibility (EMC) and power systems, leading to mature technologies in source-location identification with unprecedented performance compared to classical approaches.

In the first part of the talk, we will present the general theoretical basis of time reversal. An example from classical mechanics will be used to illustrate, in an intuitive manner, three approaches that can be used to effectively make a system go back in time, in the sense that it retraces the path it came from in the immediate past. The time reversal invariance of physics laws will then be described with special attention given to the time reversal invariance of Maxwell's equations. The concept of time reversal cavity, and the use of time reversal as a means of refocusing electromagnetic waves will then be introduced.

The second part of the talk will be devoted to a brief presentation of two application areas of electromagnetic time reversal: locating lightning strikes and locating faults in power networks.

Plenary Talk 2: Methodology and Implementation of Automated HPEM Effects Testing

Jin Soo Choi

Agency for Defense Development Daejeon, South Korea

Speaker: Dr. Jin Soo Choi

ABSTRACT

High power electromagnetic waves from antennas propagate in some distance and interact with electronic equipment or targets in



complex ways. These phenomena can be described as a sequential process of HPEM sources, antennas, propagation to targets, external and internal coupling with the targets, and vulnerability of interested circuitries. Many parameters from the sources to the targets affect this process, sometimes in probabilistic or nonlinear ways. So it's very important for the precise assessment of HPEM effects to use well-established numerical and experimental techniques. Especially HPEM effects testing is a time-consuming process and may contain some errors and uncertainties. In the Agency for Defense Development (ADD), many types of simulations and tests have been carried out to analyze and predict high power electromagnetic effects on electronic equipment. These studies range from vulnerability testing of simple devices or circuits to assessment testing of targets in system level such as complex buildings. Some interesting test results conducted in the ADD are first presented in this presentation. And a methodology to conduct HPEM vulnerability and susceptibility tests more effectively and systematically is proposed based on these studies. Based on the proposed methodology, a testing setup for systematic effect research was configured. Coupling and frequency-dependent vulnerability tests were performed by using this system, and these test results were analyzed in real-time and compared with the calculated predictions. Configurations of the testing setup and analysis of the test results are described in this presentation. Finally some recent issues for advanced testings and diagnostics of electromagnetic effects in real and complex environment are suggested.

Plenary Talk 3: From DC to Daylight: Let's look at the DC End!

Dr. William A. Radasky

Metatech Corporation, USA

Speaker: Dr. William A. Radasky

ABSTRACT

Early in my research career, I dealt with many interesting problems covering time ranges beginning from nanoseconds to seconds. In the early 1990s I had the opportunity to begin work on the problem of geomagnetic storms and the induction of "quasi-DC" currents known as Geomagnetically Induced Currents (GICs) into high voltage power grids and their transformers. This problem was initially raised by John Kappenman, who worked for Metatech at the time. He was a true expert in the behavior of bulk power grids when exposed to geomagnetic storms. With the help of Metatech's expertise in the field of numerical analysis of electromagnetics problems, we were able to solve the induction problem for specific cases of interest. Major contributions to this effort were also made by Drs. Jim Gilbert and Ed Savage.

This paper will describe the development of the complete model for evaluating the flow of "dc" currents in high voltage power grids in many countries throughout the world. The model includes the ability to use measured magnetic field data from past storms acquired at many observatories: to compute the induced electric fields in the time domain (using the local deep profiles of the ground conductivity), to model large numbers of transformers and power lines in an exposed grid, and to compute the currents flowing in those transformer neutrals. In addition, simple models for the generation of reactive power and possible hot-spot heating were also developed. The



emphasis in this paper will be to show the accuracy of the modeling when compared to measurements of GICs flowing through the neutrals of large transformers during specific geomagnetic storms of the recent past.

Plenary Talk 4: Recent Progress in Narrowband High Power Microwave Sources

Jun Zhang and Dian Zhang

College of Advanced Interdisciplinary Studies, National University of Defense Technology, Changsha 410072, China

Speaker: Prof. Jun Zhang

ABSTRACT

Motivated by some innovative applications, such as directed energy, space propulsion, and high power radars, narrowband high power microwave (HPM) sources technology is still under intense investigation after about 50 years of development. At present, enhancing the output power of a single HPM source to tens or hundreds of gigawatts (GWs) has encountered some physical limitations and it is no longer the main pursuit of HPM technology field. Phase locking and power combination, high power efficiency, compact sources with low/no external magnetic field, and high pulse energy are the four new development directions in this area. Recent progress of narrowband HPM sources in these four aspects in the last decade is summarized in this paper. PSSC based narrowband sources are also introduced because of their flexible parameter adjusting function and potential high power capability. A comprehensive evaluation of various kinds of narrowband HPM sources is presented.

Plenary Talk 5: EMSEC and InfoSec: differences, similarities and challenges

Chaouki Kasmi

Mobile and Telecom Lab, xen1thLabs, *DarkMatter Group*, Abu Dhabi, United Arab Emirates

Speaker: Dr. Chaouki Kasmi

ABSTRACT

Threats induced by Electromagnetic Compatibility and Electromagnetic interferences have been mainly studied with a focus on emanations and susceptibility testing. When dealing with the application in which the evaluated devices will be placed, the notion of risks become naturally of fundamental interest. Interestingly safety and information security have been dealing with risks management for a while. Unfortunately, the safety and security perspective is still at an early stage in EMC and EMI research communities when the work is performed by EMC experts. We propose in this plenary talk a comparison and the evolution of EMC/EMI-related work performed by the information security community and vis-versa with a focus on similarities and differences in the approaches of risks



management and possible solution to improve these.

Plenary Talk 6: Development of Lightning Direct Effect Test and Simulation of Carbon Fiber Composites

Xueling Yao

State Key Laboratory of Electrical Insulation and Power Equipment, Xi'an Jiaotong University, Xi'an, 710049, China

Speaker: Prof. Xueling Yao

ABSTRACT

As a natural discharge phenomenon with high voltage and high current, lightning strike seriously affects the safe operation of aircrafts. With the improvement of aircraft design and the advancement of carbon fiber reinforced polymer (CFRP) composite manufacture technology, the proportion of the CFRP continues to grow in commercial aircraft, military aircraft, unmanned aircraft and stealth aircraft due to its mechanical advantages of superior static strength, low density, high durability and excellent workability [1]. However, the weak electrical and thermal conductivity of CFRP composite compared to those of traditional metallic materials [2]. Thus, the large amounts of charge and heat associated with a lightning strike cannot be transferred and dissipated effectively, causing a sharp increase in local temperature and serious damage, such as fiber sublimation, resin pyrolysis and deep delamination, in CFRP laminates [3, 4]. The lightning protection ability of CFRP has become a technical bottleneck restricting the wild application of CFRP materials in aerospace manufacturing. Therefore, the experimental research and computational simulation on lightning damage properties and lightning protection methods in CFRPs has important scientific and practical value. Based on the research background of the direct lightning strike effect of carbon fiber reinforced composites, the present situation and problems of experimental research, theoretical analysis and simulation modeling were analyzed. The lightning damage characteristics and damage modes of CFRP laminates were obtained by means of ultrasonic scanning imaging, three-dimensional X-ray scanning and scanning electron microscopy observation, and the forming process of lightning damage were analyzed. Based on the analysis of the lightning damage expansion process, the characteristics of lightning current conducting and diversion and the mechanism of lightning damage were explored. A series of studies of carbon fiber lightning direct damage modeling and simulation calculation methods was carried out, and the influence relation of dynamic impedance characteristics of CFRP material on its corresponding lightning damage area and depth was found. The dynamic conductivity characteristics was suggested to be introduced into the coupled thermal-electrical FE model of CFRP to improve the calculation accuracy and decrease the deviation between calculation and experimental results. The lightning damage effect of multiple continuous lightning current strikes was analyzed and compared with that of the single lightning current strike. The experimental results showed that the lightning damage effect of the single lightning current component was significantly different from its damage effect in multiple continuous lightning strike sequence [5]. Therefore, the multiple continuous sequential lightning current components was supposed to be used in the lightning strike test to simulate the actual damage situation of composite materials subjected to natural lightning strike. In



addition, the lightning damage experimental results of CFRP laminates with copper mesh protection layer also support this conclusion. The research results can provide theoretical basis for the modification and structural design of CFRP. At the same time, it will also build a theoretical foundation and experimental data support for the formulation of test waveforms, test methods and test standards of direct lightning effect of CFRP materials used in aircraft industries.

Plenary Talk 7: Systematic Effects of acute Ka-HPM and L-HPM pulses exposure on KM mice

X.-Y. Lu¹, H.-H. Yang and Y. Zhou²

1. Key Laboratory of Biomedical Information Engineering of Ministry of Education, School of Life Science and Technology, Xi'an Jiaotong University, Xi'an 710049, Shaanxi, China.
2. State Key Laboratory of Electrical Insulation and Power Equipment, School of Electrical Engineering, Xi'an Jiaotong University, Xi'an 710049, Shaanxi, China.

Speaker: Prof. Xiaoyun Lu

ABSTRACT

Many researches have been done to investigate the biological safety of electromagnetic fields either in the extremely low frequency range e.g. HVAC and the radio frequency range e.g. cell phone, etc. While, still much should be done concerning the biosafety of high-power electromagnetic fields. Recently, we investigated the effects of acute Ka-HPM and L-HPM pulses exposure on mice, carrying out the high throughput biological analysis to reveal the systematic responses of mice exposed to Ka-HPM pulses and L-HPM pulses. The data demonstrated that although no obvious histo-morphological alterations could be observed, blood biochemical examination, hepatic metabolomics analysis and white blood cells transcriptome analysis results all revealed the significant change in the molecular level, especially in the immunological and metabolic processes. Specifically, the fatty acid metabolism pathway and the cytokine secretion pathway were most significantly affected. The data provided a comprehensive understand on the bioeffects of HPM pulses exposure. These results also implied the potential health risk of HPM pulses exposure and therefore highlight the necessity for study of long-term effects.