SCM01

High RF Power Critical Effects

Organisers
Jacques Sombrin, TESA Laboratory, France
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Abstract
This short course will present the state-of-the-art in understanding RF power phenomena that detrimentally affect space, aircraft and terrestrial communications. Dramatic increase in communications capacity, bandwidth, number of carriers and antennas poses new challenges in handling the high RF power. These problems become ever more acute and critical for emerging and future RF systems. The short course addresses the following aspects:

- Awareness of the diverse physical origins of RF power effects
- Context of RF power impact on the communications devices
- State-of-the-art in prediction (simulation), measurement and mitigation/correction of the high RF power effects
- Standardization and specifications
- Knowledge of existing means and actors in Europe
- Features of the RF power effects in the space, terrestrial and aircraft communications will be discussed.

Main parts of the short course cover:
- Multipactor theory and simulation methods, test and measurement methods
- Secondary electron theory and measurement, surface conditions and conditioning
- Corona theory and simulation methods, test and measurement methods
- RF breakdown and plasma, avalanche, effect of pressure
- Passive Intermodulation theory and simulation
- Passive Intermodulation theory of distributed non-linearity, modeling and measurements
- Standardization: present and future
- Measurement means and simulation software

Programme

8:30 - 8:40 Welcome

8:40 - 9:25 Multipactor theory
Eden Sorolla, XLIM, University of Limoges, France
→ Abstract

9:25 - 10:10 Secondary electron emission yield
Mohamed Belhaj, ONERA, France
→ Abstract

10:10 - 10:50 Coffee Break

10:50 - 11:35 Improvement of RF high power breakdown margins using numerical simulations
Carlos Vicente, and Vicente E. Boria, AURORASAT and Technical University of Valencia, Spain
→ Abstract

11:35 - 12:30 Corona theory and simulation
Vladimir Semenov, Russian Academy of Sciences, Russia
→ Abstract

12:30 - 13:50 Lunch Break

13:50 - 14:35 PIM theory and simulation
Jacques Sombrin, TESA Laboratory, France
→ Abstract

14:35 - 15:30 Intermodulation and Nonlinear Distortion in Passive Components and Distributed Circuits
Alexander Schuchinsky and Michael Steer, Queens University Belfast, UK, and North Caroline State University, USA
→ Abstract

15:30 - 16:10 Coffee Break

16:10 - 16:55 Standardization
David Raboso, ESA
→ Abstract

16:55 - 17:40 Measurement and simulation means
Jérôme Puech, CNES, France
→ Abstract

17:40 - 17:50 Open discussion and concluding remarks
8:40 - 9:25  Multipactor theory
Eden Sorolla, XLIM, University of Limoges, France

Abstract
Parallel-plate theory, waveguide theory, filters - Simulation Cases - Degradation of equipment
The lack of a unique multipactor onset criterion leads simulation tools to predict different values of the power breakdown threshold. Experimentally, the discharge is often witnessed by detecting the third harmonic of the radiated power spectrum emitted by the electron cloud. As the electron population saturates very quickly, the level of radiation is measured at the steady state, and this level depends on the number of electrons. Thus, studying the saturation mechanisms is crucial to find the electron population and link simulations with detection techniques in order to predict the radiation power levels accurately. This talk intends to show the relations between the radiation levels predicted by the simulation tools and the measurements in order to eventually propose a multipactor criterion.

9:25 - 10:10  Secondary electron emission yield
Mohamed Belhaj, ONERA, France

Abstract
The study of secondary electron emission (SEE) phenomenon and electron backscattering under low-energy electron impact (few eV to hundreds of eV) is of great importance in many branches of fundamental and applied science and in particular for multipactor modeling and mitigation. The electron emission is a complex phenomenon highly dependent on the material surface and subsurface properties such as composition, contamination, roughness, etc. This talk will be divided in three major parts. The first is intended to introduce some fundamental aspects of the electron emission process including:

(i) The secondary electron generation and transport
(ii) The most needed electron emission parameters (electron emission yield (EEY), backscattering yield, angular and energy distributions of the emitted electrons...).

The second part will be dedicated to describe the capabilities and the limits of the experimental facilities and models commonly used to extract the SEE key parameters. The final part of this talk will be focused on the environmental effects (temperature, radiation, air exposure and contamination) on the EEY.

10:50 - 11:35 Improvement of RF high power breakdown margins using numerical simulations
Carlos Vicente, and Vicente E. Boria, AURORASAT and Technical University of Valencia, Spain

Abstract
In this talk we will show the benefits of using numerical tools in order to determine the RF breakdown (multipactor and corona) power levels of passive microwave components. In particular, for some specific cases, we will show the increase of the obtained margins when compared to traditional approaches based on simplified analytical models. These more realistic margins will be validated through comparisons with other techniques and available experimental data. These approaches (based on numerical simulations) are becoming crucial in the development of new high power components for space applications, where the saving of mass and volume is more critical. Also, the use of advanced numerical algorithms can result in a reduction of the time-to-market of the products and their cost reduction, thanks to the avoidance -in some cases- of additional high power validation tests.

11:35 - 12:30  Corona theory and simulation
Vladimir Semenov, Russian Academy of Sciences, Russia

Abstract
Basic theory; Dependence on frequency, pressure, temperature, and geometry; Threshold Simulations; Propagation of the ionization front. The simple theory of electron heating in microwave field will be applied to show a dependence of electron temperature on the field intensity and frequency as well as on the gas pressure and nature. On the base of this theory the similarity principle will be formulated to describe a dependence of the breakdown threshold on frequency, pressure and geometry. An influence of gas heating on a reduction of the breakdown threshold will be discussed. Software capable to predict the breakdown threshold inside RF filters will be demonstrated and applied to study the corona breakdown around metal corners. Particular attention will be paid to a discussion concerning possible stability of localized breakdown in the regions with high RF field (around metal corners and screws). Effects of the ionization front propagation will be discussed theoretically and demonstrated in numerical simulations. Some experimental results will be shown to demonstrate possible propagation of the ionization front into a region where RF field intensity is well below the breakdown threshold.

13:50 - 14:35  PIM theory and simulation
Jacques Sombrin, TESA Laboratory, France

Abstract
The differences between passive and active inter-modulation measurements that prevent to apply polynomial non-linearity theory to passive inter-modulation, will be presented. We will show that it is necessary to use discontinuous at origin non-linearity to be able to represent correctly the measured behavior of passive non-linearity. We will show that this can be used to relax the 2-carrier specifications and allows us to use less massive technologies for the same multicarrier PIM performance.

14:35 - 15:30 Intermodulation and Nonlinear Distortion in Passive Components and Distributed Circuits
Alexander Schuchinsky and Michael Steer, Queens University Belfast, UK, and North Caroline State University, USA

Abstract
The conceptual aspects of the phenomenology and characterisation of Passive Intermodulation (PIM), produced by localised and distributed nonlinearities of passive circuits and devices, will be presented. The distinctive features of PIM generation and their impact on signal integrity will be considered and illustrated by examples of printed circuits with distributed sources of nonlinearity. Specific physical mechanisms of PIM generation will be discussed, particularly, PIM production caused by the electro-thermal nonlinearity. The issues of PIM measurements, modelling and mitigation in passive RF components and devices with multiple localised and distributed sources of weak nonlinearity will be discussed.

16:10 - 16:55  Standardization
David Raboso, ESA

Abstract
Standardization present and future

16:55 - 17:40  Measurement and simulation means
Jérôme Puech, CNES, France

Abstract
Evaluation and Validation of Electromagnetic Software, Test Facilities and Test Standard in Europe to Predict and Test RF Breakdown and Passive Intermodulation: (EVEREST synthesis)
At the payload level, microwave components downstream microwave amplifiers must handle very high electric fields in vacuum. Risks of discharge such as
Multipactor or Gaseous Discharge triggered by Multipactor can become critical and must be taken into account at the system level, as well as at the equipment level. At platform level during launch, the whole range of pressure levels are imposed onto hardware and gaseous discharge (Corona effect) often determines the power-handling limit.

Cross-validations between measurements and simulations results were addressed in the ESA activity “Evaluation and validation of electromagnetic software, test facilities and test standards in Europe to predict and test RF breakdown and passive intermodulation (PIM)”, abbreviated “EVEREST”, coordinated by CNES. The objective of this activity performed by a consortium of 17 entities was to evaluate and validate electromagnetic software, test facilities and test standards in Europe used to predict and test RF breakdown.

The final aim was to synthesize all results in order to prepare outputs for the standardization purposes. The activity consisted in updating the test plans and assessment of test samples and in evaluating the common test procedure that were used in the different test facilities. It also consisted in evaluating the prediction tools, which were cross-validated with measurements.