ECR TUTORIALS

ET1	Lecturer name, affiliation
A Tutorial on Electromagnetic Inverse Scattering and Inverse Source Problems	Puyan Mojabi University of Manitoba, Winnipeg, Manitoba, Canada
This Tutorial is concerned with some of the fundamentals of electromagnetic inverse problems. The target audience for this Tutorial are those who are to begin their research in the area of electromagnetic inverse problems and would like to learn some of its basic considerations and fundamentals.1 Electromagnetic inverse problems deal with determining some properties of an investigation domain from its associated external electromagnetic data. The process of inferring (or, reconstructing) the properties of the investigation domain from its external electromagnetic data is referred to as electromagnetic inversion. In other words, electromagnetic inversion processes exterior electromagnetic effects to reconstruct their original cause. The computational aspect of this processing often involves different steps such as modelling, optimization, regularization, etc.	

ET2	Lecturer name, affiliation
RF Energy Harvesting for Internet of Things (IoT) Applications	Nosherwan Shoaib National University of Sciences and Technology (NUST), Islamabad, Pakistan
The RF energy harvesting is a “Green” self-sustainable operation which can potentially provide unlimited energy supply that can be used to remotely power up low power devices. In particular, it helps to eliminate the need for a battery, which not only increases the cost, weight, and size of the device but the battery replacement is also costly and time-consuming especially when a lot of devices are spread over wide or inaccessible areas. Furthermore, it improves the reliability, portability, and user and environment friendliness and reduces the size and cost of the device. In addition, the finite lifetime of the electrical batteries is encouraging the researchers to explore further solutions in the field of RF energy harvesting, as acknowledged by Nikola Tesla, who described the freedom to transfer energy between two points without the need for a physical connection to a power source as an “all-surpassing importance to man”. This talk will present an introduction to wireless power transfer (WPT) followed by a comparison between ambient energy sources and an overview of different components of rectennas that are used for RF energy harvesting. Being less costly and environment friendly, rectennas are used to provide potentially inexhaustible energy for powering up low IoT power sensors and portable devices that are installed in inaccessible areas where frequent battery replacement is difficult, if not impossible. The talk will also describe various stages of rectenna system including multiband/broadband antenna, matching network and rectifier. The current challenges in rectenna design & development and output power limitations will also be presented.	

ET3	Lecturer name, affiliation
High Power Electromagnetics: Effects on analogue and digital electronics	C. Kasmi, D. Martinez, F. Vega, N. Mora Directed Energy Research Center, Technology and Innovation Institute, Abu Dhabi, UAE

Electromagnetic interferences represent a non-negligible threat for the security and safety of critical infrastructures [1, 2]. The trend in society is to increase the number of autonomous systems [3, 4] which relies on the deployment of smart devices. Multiple sensors [5, 6] and actuators are enclosed within smart devices powered by complex software. Many studies have reported the susceptibility [7, 8, 9, 10, 11] to intentional electromagnetic interferences. Nevertheless, it is commonly accepted that the criticality of hardware and software failures induced by IEMI is difficult to assess especially for closed source devices where the detection of a failure remains a challenge. Few successful attempts [12, 13] have shown that once the possibility to instrument a device under test, the detection, the classification and the hardening process become natural.

We propose in this tutorial to review the different techniques applied to perform a deep analysis of the effects induced IEMI. We propose to go through different evaluation reports in order to highlight how the evaluation of IEMI effects on analogue and digital electronic functions have been performed and how they can be improved.

References: See *full abstract*

ET4	Lecturer name, affiliation
Latest research and future challenges for ionosphere-thermosphere data assimilation models	Sean Elvidge SERENE, University of Birmingham, UK

The upper atmosphere presents a distinct challenge for data assimilation. It is a rapidly changing environment with complex statistical properties. Nonetheless there are a wide range of data assimilation models in development and use across the globe.

Data assimilation is the science of combining different sources of information to estimate possible states of a system as it evolves in time. In general data assimilation can determine an evolving probability density function, which specifies the range of possible states and the probabilities that they represent. Data assimilation has many names, depending on the field of application (e.g. state estimation, history matching, filtering, smoothing), and it is often combined with so-called inverse methods to extract maximum information from observations. However the coupled ionosphere-thermosphere region is sparsely sampled by data, is strongly driven by solar inputs, and densities can vary by orders of magnitudes from day to night and in response to geomagnetic storms.

Since there are a lack of satisfactory covariance models for the ionosphere-thermosphere this provides the impetus to examine the use of ensemble methods of data assimilation. These ensemble approaches, for example the ensemble Kalman filter, also provide the opportunity for producing probabilistic forecasts.

This tutorial will describe the various approaches to mathematical modelling of the ionosphere-thermosphere system, derive the data assimilation theory, how ensemble output can be used for probabilistic forecasts and how this can all be combined to provide actionable space weather products and services into Government and industry. Whilst the examples in the tutorial will be based on the ionosphere-thermosphere, the techniques are applicable across a wide range of disciplines.