Dielectric Measurements and Sensors: The Excitement and Challenges Ahead

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The field of electromagnetics has experienced a dramatic growth during the past 50 years. Driven largely by military-related factors since the inception of the radar until the recent innovations in stealth technology. The revolution in communications was also, in part, made possible by the remarkable innovations in antennas and transmissions systems. It is perhaps safe to assert that the paradigm of electromagnetic problems of “how can I solve for or predict the field-matter interaction” is approaching its classical stage. Leaving efficiency considerations aside, it is possible now to find electromagnetic field solvers that can address the most challenging field-matter interaction. Does this maturity imply stagnation in the field of electromagnetics? While for many selfish reasons, many would predict and hope otherwise, the good news is that a new paradigm is emerging. How can we leverage the high maturity and advances in the field of electromagnetics to create advances in other fields. How can the field of electromagnetics play and be an integral part in the new age of information that will most likely characterize the 21st century. The answer lies in *electromagnetic-field-based sensors*.

Sensors are the link between information and electromagnetics. Microwave based sensors (and possibly millimeter wave based sensors) are becoming a highly desirable, mobile, versatile, and highly-reliable tools to gather information from afar as in the example of remote sensing, to very close proximity of the sensed object, as in mine and tissue detection or even near-field microscopy. Microwave-based sensors can even be placed on “small” objects to be sent for detection of harmful substances and events. Clearly, sensors represent an integral part of an information gathering system. However, sensors need to know what they are sensing. Electromagnetic fields are color-blind. They can only discriminate based on dielectric properties. If these properties are not understood correctly, the sensing system is rendered useless (as the old saying goes, garbage-in-garbage-out). This is no more important than in the area of microwave-based cancer detection where determining accurate benign and malignant tissue properties presents a challenge that is, arguably, greater than the formidable task of designing the sensor in the first place. Another area that has recently witnessed significant activities is multi-function sensing where multi-parameter calibration becomes essential. Multi-function microwave sensing is expected to play a strong role in a wide range of technologies from grain moisture and temperature sensing to detection of impurities in pharmaceutical products.

In this presentation, we present an overview of current applications of microwave-based sensors. We discuss current research trends in dielectric measurements and address some of the system integration challenges that are critical to making robust and reliable sensors.