Microwave and THz Imaging of the Stratified Media for Industrial and Biomedical Applications

Overview

The active electromagnetic imaging may be perceived as the retrieval of the spatial distribution of the permittivity function of the medium-under-test from the measurement of the scattered fields interacting with the medium. For carrying out the required sets of measurements, the test medium is illuminated with an electromagnetic wave of known characteristics. The determination of the permittivity profile provides the electrical image of the object-under-test, as different components or layers may be differentiated by their substantial difference in dielectric properties. The frequency of the illuminating electromagnetic wave may vary from GHz to THz range depending upon the required resolution of the image and the particular application. In recent years, the Microwave, Millimeter wave and THz imaging methodologies have been adopted for a number of real world applications including medical diagnostics, health monitoring of civil and aviation constructions (buildings, bridges, etc.), and security at airports and other restricted areas The electromagnetic imaging in the microwave and THz frequency bands is quite complicated process requiring expertise on various fronts such as basic electromagnetic scattering theory, mathematical reconstruction algorithms, microwave and THz measurement techniques etc. Moreover, the microwave imaging field is not very popular in the country due to the relatively weak pedagogy scheme for the electromagnetic courses in the undergraduate classes.

In this short course, the fundamentals of RF, microwave and THz imaging would be presented by the world renowned expert in the field of microwave imaging. The course will begin with the simple equations describing transmission-line wave propagation that are known to almost all electrical engineers. Based on the relations between intrinsic impedance, local reflection coefficient, local input impedance, and propagation speed, a nonlinear Riccati-type differential equation would be derived, which represents the fundamental equation of one-dimensional imaging. Exact and different approximations of this equation in both “direct” and “inverse” cases would be presented and discussed. The discussions would lead to a very clear, intuitive, and systematic way in order to conceptualize the practical issues characterizing the imaging process. These include the resolution degradation due to bandwidth limitations, the creation of what is called “artifacts” in imaging due to improper image reconstructions, as well as noise impact on imaging quality. The course moves then smoothly to two- and three-dimensional imaging schemes explaining the concept of “temporal” and “spatial” focusing and the role of antenna arrays for achieving the latter. The trade-off between wave penetrability (usually associated with low frequencies) and resolution needs (dictating bandwidth requirements) would be discussed. A number of imaging modalities and their medical, environmental, and industrial applications would finally be presented. These include “Synthetic Aperture Radar” (SAR), “Ground Penetrating Radar” (GPR), and

Terahertz Tomography. Laboratory prototypes of a SAR-based GPR imaging system implemented at the University of Magdeburg, Germany together with some of its imaging results would be presented and discussed.

This course would be quite instrumental in popularizing the practical aspects of the electromagnetic theory in general, and the microwave and THz imaging techniques in particular in the country. A series of lectures by the internationally renowned expert of the Microwave Imaging field in the framework of GIAN would certainly motivate and inspire many young researchers and professionals in the country to explore the microwave and THz imaging field.

Course participants will learn these topics through lectures and interactive discussions. A few case studies will also be shared to stimulate research motivation of participants.

Objective	• Providing participants a brief theoretical foundation of RF, microwave and THz techniques from the imaging and material testing perspective. • Explaining briefly the physics of microwave, millimeter-wave, and terahertz imaging. • Introducing the concept of electromagnetic inverse scattering and reconstruction algorithms for the microwave/THz imaging. • Introducing various analytical and numerical modelling schemes required for the microwave and THz imaging. • Explaining the fundamental difference between lateral and depth imaging, the achievable resolution in both cases, and the limits of their improvement, impact of higher penetrability on the achievable resolution. • Exposing the participants to the new emerging topics in the field of the microwave and THz for sub-surface and lateral imaging of test objects and media. • Showing the usage of microwave, mm-wave and Terahertz imaging techniques for various real world applications including the methodologies adopted for the same. • Motivating the young minds to the innovative research field of microwave and THz imaging by showing various RF imaging experimental modules for the biomedical, industrial and security applications.
Schedule	**December 05, 2017 –December 09, 2017** **Number of participants for the course would be limited to 70.**
Who Should Attend?	▪ Faculty members from academic institutions working in the field of electromagnetic theory and microwave engineering; ▪ Researchers, Scientists and Engineers from R&D organizations and Industry Professionals working in the RF domain. ▪ Students at all levels (B.Tech/MSc/M.Tech/Ph.D.)
Registration Fees	The registration fee for attending the course is as follows: **Industry/ Research Organizations: 20000** **Academic Institutions: 10000** **Students: 2000** **Participants from abroad : US $500** The above fee includes all instructional materials, Tea/Coffee Breaks, Lunch, and 24 hr free internet facility. The participants may be provided accommodation in the campus on payment basis depending upon availability.
Details	The details about the course including the registration procedures etc. would be available at following link: http://www.iitk.ac.in/web_mimt_lab/

The Faculty

Prof. A. S. Omar (Fellow, IEEE) has been professor of electrical engineering since 1990 and director of the Chair of Microwave and Communication Engineering at the University of Magdeburg, Germany since 1998. He joined the Petroleum Institute in Abu Dhabi as a Distinguished Professor in 2012 and 2013 as an organizer of the research activities for the Oil and Gas Industry in this area. In 2014 and 2015 he chaired the Electrical and Computer Engineering at the University of Akron, Ohio, USA. Dr. Omar has authored and co-authored more than 450 technical papers extending over a wide spectrum of research areas. His current research interests include Microwave, magnetic-resonance and acoustic imaging and their medical, security and environmental applications, Microwave and ultrasonic indoor positioning and tracking for logistic and health-care purposes, Electromagnetic material characterization for research and industrial applications, Ultra-wideband satellite, terrestrial and mobile communication and broadcasting, Field theoretical modeling of microwave systems and components, Antennas and RF-Filter design and optimization and Massive MIMO and its related 5G and IoT applications.

Dr. M. Jaleel Akhtar is Associate Professor in the Department of Electrical Engineering at the Indian Institute of Technology, Kanpur, India. He received the Ph.D. degree in electrical engineering from the Otto-von-Guericke University of Magdeburg, Magdeburg, Germany in 2003. From 2003 to 2009, he was a Post-Doctoral Research Scientist and a Project Leader with the Institute for Pulsed Power and Microwave Technology, Karlsruhe Institute of Technology, Karlsruhe, Germany. He has authored two books, two book chapters, and has authored or co-authored over 150 papers in various peer-reviewed international journals and conference proceedings. He holds two patents on RF sensors. His current research interests include RF, microwave and THz imaging, RF sensors, functional materials, wideband electromagnetic absorbers, UWB antennas for imaging, RF energy harvesting and design of RF filters using inverse scattering. Dr. Akhtar is a Fellow of the IETE and Senor Member of the IEEE.

Course Coordinator

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