Harvesting the Energy of the Electromagnetic Wave—From Tesla to THz and Beyond

Date: Tue. 26th Mar.
Time: 1:30 pm
Location: Building 59, Room 2016

Speaker:

Prof. Omar Ramahi,
Fellow IEEE,
University of Waterloo, Ontario, Canada

Abstract:

Freely available historical records show that Nicola Tesla was the first to experiment with the idea of transporting energy between two distant points. Tesla's ingenuity, however, was not only ahead of its time but also ahead of its practical relevance. In the 1960s, W. C. Brown proposed wireless power transfer using microwaves, and in the 1970s, R. Bailey was on the record to be the first to propose harvesting the energy of the solar spectrum directly using nano-antennas. The world's energy crises have undoubtedly ignited interest in these earlier extraordinary and highly important works.

By far, the most abundant and clean energy source is solar radiation. Converting solar energy into usable DC with efficiencies much higher than the 160-year old photovoltaic-based technology would be based on understanding the electromagnetic radiation and reception phenomena in general and the concept of antenna in particular. In this talk, I will re-examine the concept of electromagnetic energy reception and its evolution from transmission between tightly coupled systems, namely inductive and/or capacitive (near-field) coupling, to very loosely coupled system (far-field coupling). To receive electromagnetic energy, one needs an energy collector, namely an antenna. Classical antenna metrics were conceived for the antenna as a communication device. In energy harvesting systems, however, the "energy transfer" modality is distinct and different from information transmission, which calls for revisiting the classical antenna metrics and determining their suitability for the energy harvesting paradigm.

Focusing on the efficiency as the most important parameter, I will discuss several design paradigms for energy absorption and channeling developed by my group that span the microwaves to the infrared frequency range. I will show important accomplishments that enabled us to achieve near-unity power harvesting and channeling efficiency while at the same time highlighting the important challenges that we anticipate as we inch closer to the holy grail of high solar energy absorption in the infrared frequency regime and beyond.

Bio:

Omar M. Ramahi was born in Jerusalem, Palestine. He received the B.S. degree (Hons.) in mathematics and electrical and computer engineering from Oregon State University, Corvallis, OR, USA, and the Ph.D. degree in electrical and computer engineering from the University of Illinois at Urbana–Champaign, IL, USA. He was with Digital Equipment Corporation (currently, HP), MI, USA, where he was a member of the Alpha Server Product Development Group. In 2000, he joined the faculty of the James Clark School of Engineering, University of Maryland at College Park, College Park, MD, USA, as an Assistant Professor, where he was a faculty member with the CALCE Electronic Products and Systems Center and later a tenured Associate Professor. He is currently a Professor with the Electrical and Computer Engineering Department, University of Waterloo, Waterloo, ON, Canada. He has authored or co-authored over 400 journal and conference technical papers on topics related to the electromagnetic phenomena and computational techniques to understand the same. He has co-authored EMI/EMC Computational Modeling Handbook, (Kluwer, first edition, 1998, and Springer–Verlag, second edition, 2001, and Japanese edition, 2005). Prof. Ramahi was the recipient of the 2004 University of Maryland Pi Tau Sigma Purple Cam Shaft Award. He was also the recipient of the Excellent Paper Award of the 2004 International Symposium on Electromagnetic Compatibility, Sendai, Japan, the 2010 University of Waterloo Award for Excellence in Graduate Supervision, and the IEEE Electromagnetic Compatibility Society Technical Achievement Award in 2012.