IEEE Antennas and Propagation Society Distinguished Lecture Title:

Fundamental quantity and equations for electromagnetics, implicit FDTD computation and enhanced learning

Abstract:

It has been more than 160 years since Maxwell presented his equations of electromagnetics (EM) in 1864. Today, these equations have been written in the beautiful form in terms of fields (E and B). Besides the fields, there are also potentials (A and phi) and their corresponding wave equations. Since Maxwell-Hertz-Heaviside era, there have been longstanding dilemma to use either fields or potentials (or both) for EM, and for the potentials, which gauge condition should be imposed, e.g. Lorenz gauge, Coulomb gauge, etc. The present talk will introduce new gauge-invariant physical quantity of field-impulse for new fundamental equations of electromagnetics. Unlike the potentials that are gauge-dependent and may not be physical nor causal, the field-impulses are gauge-independent, physically real, causal and measurable. Moreover, the single electric field-impulse can unify not only electrodynamics, but also electrostatics and magnetostatics, which otherwise remain independent and left separated all this while. It can completely embed all fields and potentials attributed to static, dynamic, steady or nonsteady charge and/or current distributions. Using the single wave equation in terms of electric field-impulse, one can obtain the complete description of electrostatics, magnetostatics and electrodynamics. The field-impulses facilitate the development of finite-difference time-domain (FDTD) method for EM simulations including electrostatics (recall that the traditional Yee's FDTD is not meant for electrostatics for dealing with Maxwell curl equations with only current and no charge.). The field-impulses not only resolve the century-old field-potential/gauge dilemma, but also aptly describe quantum-EM interactions. Apart from theoretical formulations, efficient computation using fundamental implicit schemes of FDTD methods will be presented. Several mobile apps for technology-enhanced-learning of electromagnetics will also be demonstrated if time permits.