Simulation of a switched electrically small antenna using FDTD-XSPICE
USNC-URSI National Radio Science Meeting

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The demand for electrically small antennas continues, particularly at frequencies below 100 MHz, where efficient and broadband antennas are too large to be accommodated by handheld mobile devices. Over approximately the last decade, switched electrically small antennas and RF circuits have been reported to outperform their static counterparts due to time variance (H. C. Jing and Y. E. Wang, “A UWB Pulse Transmission Scheme - Switched Resonant Antenna,” 2006 IEEE Int. Conf. Ultra-Wideband, pp. 551–555, Sep. 2006). In practical communications, details of transients, harmonic generation, etc. must be considered carefully. FDTD techniques are appropriate because they operate on the time basis and sample at short durations varying nature and sample at short intervals, broadband transients and harmonic generation, nonlinear mixing, etc.

A simple and intuitive test case involves a monopole antenna with a single switch embedded toward the end. The switch is used to form a time varying trap at the end of the monopole. A pulse train is fed into the monopole, and the switch is actuated synchronously with the input waveform but with a phase offset such that pulses pass into the end segment as they arrive, but pulses reflected from the tip are then trapped between the open switch and the tip.

Prior work noted a need for better models, specifically ones that capture realistic switch properties (finite rise time, on and off state resistances, parasitic capacitance, etc.). FDTD-SPICE enables use of manufacturer circuit models, and XSPICE enables code-based behavioral models to represent arbitrary nonlinear and time varying devices. The spice code used in this work provides adaptive time stepping to ensure convergence within each FDTD time step. Simulation results for a switched antenna show modest decrease of the antenna reflection coefficient, which improves with tuning of the switch delay relative to the input waveform.

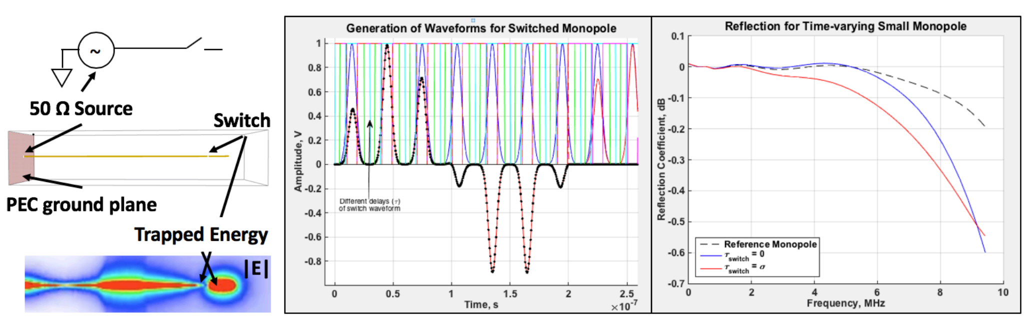

Figure 1. Model equivalent circuit, FDTD geometry, and fields captured during simulation (left), waveforms used for input signal and switch control signal (center), and reflection coefficient of the unswitched reference monopole vs. two tunings of the switch phase (right).