Software and Materials Support Antenna Design and Manufacturing

Antennas are an essential part of all systems that use radiated electromagnetic waves—communications, radar, sensing, and measurement. Antenna design and construction techniques have paralleled recent growth in all of these application areas. This report is a brief overview of the major advances in antenna engineering over the past several years. It is intended to provide background for electronics professionals who do not specialize in antennas, but who would benefit from some additional general knowledge.

Software for Simulation and Analysis

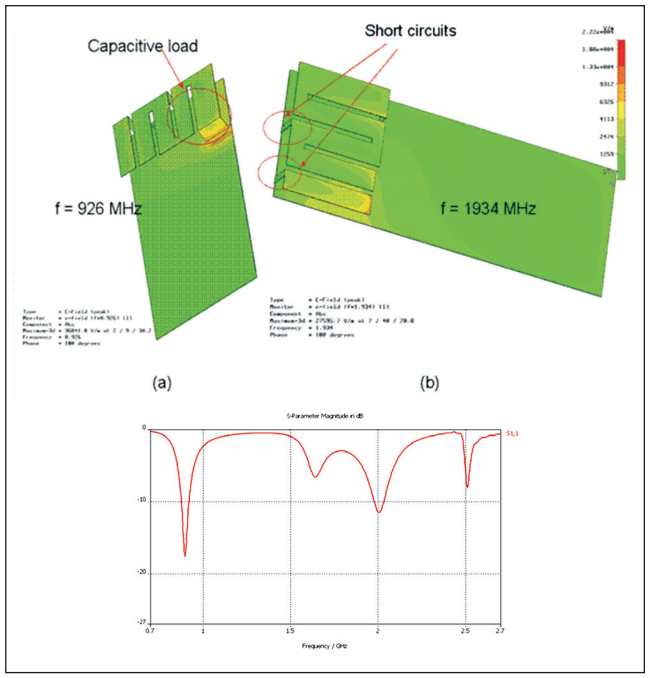
The single biggest advance in antenna engineering is the availability of multiple software tools that solve Maxwell's equations using various numerical methods. The first of these (from the 1980s) were Method of Moments programs such as the Numerical Electromagnetics Code (NEC), which has been regularly updated and is still an important part of antenna design. NEC uses segmented lines, determining current and phase of each segment, then integrating the entire structure. Near-field, far-field radiation, as well as response to an applied plane wave can all be accurately calculated.

Similar methods are used in other software that applies the segmentation of the structure in different ways: planar structures, including layers (e.g., for patch antennas), and three-dimensional tools for solid materials, conformal structures and other antenna configurations that cannot be analyzed as planar structures.

More recently, over the past ten years, finite difference time domain (FDTD) techniques have been refined, providing analysis that offers different insight into electromagnetic behavior. Time domain-based simulation allows the antenna designer to examine the flow of current in the antenna conductors, as well as the radiation characteristics. This insight is most important in traveling wave structures like transmission lines and waveguide that are part of an antenna's feed system.

These antenna tools are closely related to (in some cases identical to) electromagnetic tools for circuit design and analysis. Where there are differences, they are usually in the setup of physical parameters for simulation, and in the choice of data output for analysis.

Like all software tools, their accuracy is mathematical, not measured. They rely on precise characterization of the antenna structure and its environment. For example, a wireless base station antenna system should be analyzed along with neighboring antennas and the supporting tower structure. This is especially important for new smart antenna systems which must maintain predictable directive performance.



This dual-band patch antenna is an example of a structure developed for a specific application, using electromagnetic simulation and analysis software. *(Image courtesy CST)*

Many times, the surrounding environment is unpredictable or too complex to characterize completely. Examples include antennas close to earth, buildings and vegetation. The dielectric properties of the surrounding objects may not be known, or may be variable in the case of moving objects such as vehicles or aircraft. In cases like these, system design requires that idealized antenna models be supplemented with measurements, or with measurement-based statistical models.

Conductive and Dielectric Materials

The rapid growth in wireless systems has created new demands for size, performance, cost and manufacturability of antennas. To make smaller antennas, high dielectric