A Power Wave Theory of Antennas

Everett G. Farr*
Farr Fields, LC, Albuquerque, NM, 87123, http://www.Farr-Research.com

We develop here a minimal set of parameters that fully characterizes all antennas in both the time and frequency domains. This is prompted by the need to characterize antennas in the time domain in a standard fashion, as gain does in the frequency domain. In doing so, we develop the concepts of antenna impulse response and the Generalized Antenna Scattering Matrix (GASM)

To implement this, we introduce the power wave theory of antenna radiation and scattering. This fully extends into the time domain a number of standard antenna terms, including gain, realized gain, antenna factor, antenna pattern, beamwidth, scattering cross section, and radar cross section. Power wave theory applies to antennas of all feed impedances and feed types, including waveguide feeds, and it applies to antennas embedded in any lossless medium. The theory also leads to a natural definition of mutual coupling coefficient in antenna arrays. The approach is analogous to that used to describe circuits with generalized scattering parameters, which permit different characteristic impedances at each port. We identify receiving and transmitting impulse responses, and prove that they always have a simple relationship to each other. We also identify a scattering impulse response that can be applied to either an antenna or an arbitrary scatterer. From these functions, we build a Generalized Antenna Scattering Matrix. This establishes a formalism that allows one to calculate antenna response under a variety of conditions, including, for example, a mismatched source or load. The approach simplifies and clarifies terminology for characterizing antenna performance in both the time and frequency domains.

Our ultimate goal is to incorporate the parameters developed here into the *IEEE Standard Definitions of Terms for Antennas*.