Examples of the Power Wave Theory of Antennas

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Last year we introduced the power wave theory of antennas, which provides a complete and simple description of antenna performance in both the frequency and time domains (E. G. Farr, "A Power Wave Theory of Antennas," FERMAT e-magazine, www.e-fermat.org, Vol. 7, 2015.) It expresses antenna performance in both transmission and reception, using the simplest possible expressions, with a minimal number of antenna descriptors. It fills a gap in frequency domain antenna theory, because it shows how to add a meaningful phase to both antenna gain and radar cross section.

To clarify the usefulness of power wave theory, we provide here a number of examples. We begin with a brief review of the theory. Next, we apply the theory to describe the performance of electrically small electric and magnetic dipoles; the so-called D-dot and B-dot sensors. We calculate the antenna transfer function and impulse response. From these, we calculate a number of standard antenna parameters, including gain, realized gain, effective length, and effective area.

We next show how to add a matching circuit to an antenna using the power wave formalism. In power wave theory, an antenna is represented by a 3X3 matrix designated as the Generalized Antenna Scattering Matrix. When adding a matching network, one generates a new 3X3 matrix that includes the S-parameters of the matching network. To derive the new result it is simplest to use the theory of signal flow graphs. Having derived the general form, we apply it to two commonly used matching networks. These include a splitter balun, which is commonly used with Impulse Radiating Antennas, and a quarter-wave balun, which is commonly used with narrowband antennas.

We continue to make the case that the antenna terms defined by power wave theory should be included in the next version of *IEEE Standard Definitions of Terms for Antennas*. (IEEE Std. 145™-2013, December 2013.) It may be surprising that this document includes no terms dealing with time domain antenna response, despite the high level of interest in UWB antennas in our community. Power wave theory shows the simplest approach to add these concepts.