Six Antenna Theory Puzzles That Are Solved by the Antenna Equation

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Abstract— The antenna equation as developed by Farr [1,2,3] describes antenna performance in a manner that is both compact and elegant. It works in both the time and frequency domains, and in both transmission and reception. It provides the obvious way to standardize antenna characteristics in the time domain. It also adds a meaningful phase to antenna gain. In addition to these remarkable accomplishments, the antenna equation also solves six problems in antenna theory that previously seemed intractable.

Keywords-antenna equation, antenna impulse response, antenna transfer function, antenna gain, effective length, bandwidth, coupling to complex systems, transient antenna pattern, mutual impedance.

I. GAIN OR REALIZED GAIN–WHICH TO USE?

Because space is limited in publications, it is common to publish only antenna gain and reflection coefficient, leaving out realized gain. While one can calculate realized gain from the other two quantities, most readers cannot do so in their heads! The antenna equation shows that realized gain is far more fundamental to antenna performance, and should always be preferred to simple gain.

II. COUPLING INTO AND RADIATION FROM SHIELDED COMPLEX SYSTEMS

A longstanding problem in the EMC community has been how to describe coupling into and radiation from shielded complex systems, with the simplest possible parameters. These parameters must be consistent in both transmission and reception, and must work in both the frequency and time domains. If we treat this as an antenna problem, then the parameters of the antenna equation provide the simplest solution, with the simplest equations.

III. HOW TO DEFINE TRANSIENT ANTENNA PATTERNS?

Various authors use a variety of definitions of antenna frequency range and bandwidth. But the choice becomes obvious from the antenna equation, using the 3-dB frequency range of the antenna impulse response.

IV. HOW TO DEFINE ANTENNA FREQUENCY RANGE AND BANDWIDTH?

Antenna frequency range and bandwidth are also defined differently by various authors. But the choice becomes obvious from the antenna equation, using the 3-dB frequency range of the antenna impulse response.

V. HOW TO GENERALIZE EFFECTIVE LENGTH?

The effective length of an antenna is the ratio of the received open circuit voltage to the incident electric field [4]. It is often used in place of antenna gain in applications, such as phased antenna arrays, that require phase information. However, effective length is undefined for waveguide feeds, because one cannot measure an open circuit voltage. One can avoid the problem by adding waveguide-to-coax adapters, but the adapter response is then mixed in with the antenna response. The antenna equation shows how to isolate the antenna response from the waveguide-to-coax adapter, using simpler equations than those currently used.

VI. HOW TO GENERALIZE MUTUAL IMPEDANCE IN AN ANTENNA ARRAYS?

Mutual impedance in an antenna array is the ratio of the open-circuit voltage produced at one terminal to the current supplied to a second terminal, when all other terminal pairs are open-circuited [4]. This concept is undefined for waveguide feeds, because one cannot measure an open-circuit voltage. One can add waveguide-to-coax adapters to all the ports, but the adapter response is then mixed in with the antenna response. The antenna equation allows one to isolate the mutual coupling response from the waveguide-to-coax adapter, using simpler equations than those currently used.

REFERENCES

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