Antenna and current optimization for antennas in lossy media

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Antennas are often placed close to or inside lossy media (Wheeler 1958, Skrivervik 2013). Characterization of antennas in a lossy background medium is challenging as the electromagnetic fields decay exponentially away from the antenna and the radiation patterns are coordinate dependent (Moore 1963). The performance of small antennas is constrained by the bandwidth and efficiency. Bandwidth limitations dominate for low loss media and the efficiency for higher losses. The bandwidth is quantified by the Q-factor that is defined as the quotient between the stored and dissipated energies.

Stored energy is classically defined by subtraction of the energy in the far field from the total energy density. This technique is difficult to generalize to lossy media due to the exponential decay of the far field. Here, we follow the approach by Harrington (1972), Geyi (Geyi2003), and Vandenbosch (2010) and express the stored energy and Q-factors in terms of the current density on the antenna structure. The derivation is based on frequency differentiation of the method of moments (MoM) impedance matrix (Gustafsson etal 2014).

Optimization is a useful antenna design tool (Rahmat-Samii & Michielssen 1999). Most antenna design problems require global search-based optimization algorithms such as genetic algorithms, particle swarm, etc. The drawbacks of these global optimization algorithms include stopping criteria and lack of knowledge if the final result is converged. The current distribution on a radiating structure is an antenna parameter that can be formulated as a convex problem (Gustafsson & Nordebo 2013). The optimal current distribution can be used to determine physical bounds on antenna performance in terms of *e.g.*, gain over Q (G/Q), Q for prescribed radiation patterns, etc.

Here, we combine current optimization with global optimization for automated optimal antenna design (Cismasu & Gustafsson 2014). The stored energy is generalized to lossy and temporally dispersive media. We illustrate the approach for several antenna types.