Analysis and Optimization of Miniaturized Broadband Conical Helical Antennas

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Conical helical antennas exhibit wide band operation and circular polarization operation. Of interest in this paper is its miniaturization or operation to lower frequencies. Initial simulations show that one can achieve significantly lower frequency of operation if the helix is loaded with inductive coiling as shown in Fig. 1. Specifically, we demonstrate that the coiled conical helical antenna can operate at 40% to 60% lower frequencies leading a similar degree of minimization (see Fig. 1). However, the diameter and step distance of the coils have a significant influence on performance in addition to affecting the gain. Therefore, the coiling design must be optimally adjusted to achieve optimum performance.

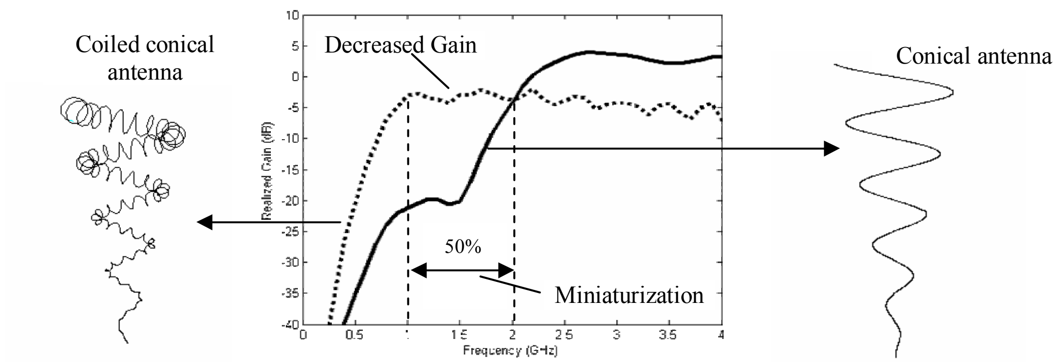

Figure 1: Realized RHCP boresight gain for a conical helical antenna with or without coils.

In pursuing an optimization of the proposed coiled helical antenna, one is faced with significant computational challenges due to geometry complexity, very high discretization rates and integration of the formal optimization tools. As an alternative, we propose an equivalent model to replace the coils on the conical helical structure with an equivalent circuit involving a combination of resistive, inductive and capacitive elements. This new model is then used within the context of a formal optimization algorithm to determine the appropriate RLC values for achieving the best possible operation.

Further minimization can be also achieved by embedding the loaded helical antenna within a dielectric volume. The insertion of this helix inside a dielectric is considered using our novel technique for fabricating flexible polymer ceramic composites. These substrates have a dielectric constant in the range of 1 to 25 and low losses. They are effortlessly fabricated with the procedure requiring the following steps: a) inserting wires (or other structures) inside the substrate and b) designing of a patterned or textured region for high contrast ceramic material loading. Thus, instead of using a uniform substrate for the coiled conical helical antennas, we can effectively apply a patterned substrate to realize different permittivities along the length of helix. Again, the height and permittivity of the polymer-ceramic layers can be determined by employing suitable optimization techniques to yield the polymer pattern for optimum performance in terms of gain, impedance matching and size.