Design of an Electrically Small Planar Antenna Using Multiple Foldings

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It is well known that as the size of an antenna is reduced, its radiation resistance drops drastically. As a result, the loss resistance becomes a predominant portion of the total input resistance and the efficiency of the antenna is poor. Previously, we reported on the use an inductively coupled feed to boost up the input resistance of the antenna for improved matching (S. Lim et al, *Electron. Lett.*, **40**, 1388 –1389, 2004). However, the inductively coupled feed steps up the radiation resistance and the loss resistance by the same ratio and does not improve the efficiency of the antenna. The achievable efficiency of a 3-dimensional, inductively-coupled wire antenna (with a kr of 0.2, where k is the wave number and r is the radius of the enclosing sphere) built with 18-gauge wire is under 70% at 30 MHz.

Another useful approach to step up the radiation resistance is the use of the folding concept. When N multiple folded arms are used, the radiation resistance scales approximately as N^2 while the loss resistance scales approximately as N. This results in an increase of the radiation efficiency. In this paper, we present the design of a small planar antenna using multiple foldings. The antenna is designed to operate at 150MHz. The height and the width of the antenna are confined to a maximum dimension of 9cm. Each antenna arm is comprised of a planar rectangular spiral and the arms are stacked and connected at the end to make the folding geometry. A genetic algorithm is used to optimize the antenna dimensions within the confined size, including the the width and the number of turns of the spiral, the number of arms and the distance between the arms. The cost function is chosen to be the realized gain. It is found that 3 arms are sufficient to achieve good matching to 50Ω. The simulated return loss of the antenna has a minimum of -10dB at 150MHz. The simulated efficiency is 86.3% using 18-gauge wire. This three-layered planar design is fairly easy to fabricate, and is a good candidate for an electrically-small, highly efficient antenna in HF/VHF applications.