Miniaturized L-band Spiral Antenna Array with Optimum Aperture Usage

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Spiral antennas are of strong interest for both military and commercial applications due to its inherent wide band, circularly polarized nature. With careful design spiral antennas can be successfully miniaturized for conformal applications. Miniaturization of 55% in linear dimension has been reported. Also, the presence of ground plane and cavity backed configurations have been studied and shows good uni-direction radiation can still be achieved when proper loading strategies are employed. In this paper we present a novel spiral array design concept that combines aforementioned techniques with top-down, full-aperture-oriented design methodology.

It is shown in this study that a spiral antenna array composed of deformed spiral elements can achieve better low frequency gain as a result of fully utilized array aperture. With given aperture size and shape, deformed spiral elements were designed according to the elements number requirement and the aperture shape. It is observed that the more efficient usage of array aperture leads to significant size reduction. For example gain of 0 dBi can be achieved with spiral elements of size 0.13λ. Further, we show that by increasing the maximum linear dimension of the spiral elements a better low frequency gain can be obtained, even when its area size remains the same. However, it is also observed that aggressive deformation of the spiral has negative impact on axial ratio and may lead to dispersive behavior in pattern and impedance. We also characterize the coupling and phase center movement of spiral arrays designed with deformed elements.

We also explore the concept of aperture sharing in designing spiral arrays. This is achieved either by multi-layer configuration that allows partial overlapping of the elements, or by connecting elements with each other to form a larger antenna web. The impact of these strategies on coupling and radiation behavior will be presented.

We observe that both deformed spiral element concept and aperture sharing concept can lead to improved low frequency gain and thus allows for further miniaturization. Side effects of deteriorated axial ratio and coupling can be partially overcome with material and absorber loading, combined with proper termination. Specific array designs based on square and circular aperture shapes will be demonstrated.