DESIGN OF A MINIATURE BROADBAND SATCOM ANTENNA USING TEXTURED DIELECTRIC LOADING VIA TOPOLOGY OPTIMIZATION

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Many military and commercial applications require smaller, light-weight antennas with broad-band and high gain performance. One such application is the UHF SATCOM antenna, which presents a significant advance in providing portable satellite communications technology for uses in the field. Although existing SATCOM antennas provide broad pattern coverage, they are still too large (15"-30"), heavy and bulky and therefore not quite portable. The goal of this paper is to propose a design which is much smaller in aperture (6") by modifying the dielectric loading applied to a slot spiral antenna. The bandwidth of interest is 240-318 MHz and the required gain is greater than 3dB. Also, circular polarization is expected for this SATCOM applications.

The challenge is to miniaturize the spiral and still retain its bandwidth with a satisfactory gain performance. Instead of the more traditional approaches to optimizing the shape or geometry of the antenna via reactive loading, parasitic coupling and etching, here we focus on the material substrate/superstrate of the slot spiral using high-contrast LTCC material. Recent efforts on metamaterials indicate that properly designed dielectrics or a combination of different materials can lead to designs which have greater bandwidth and small size (G. Kiziltas et al, IEEE T-AP, pp. 2732-2743, 2003). Nevertheless, the focus so far has been on narrowband antennas. Here, we present how to deliver the optimal SATCOM performance in terms of size, gain and impedance matching by optimizing the metamaterial profile of the broadband slot spiral antenna. The employed design method is the Solid Isotropic Material with Penalization (SIMP) technique (M. P. Bendsoe, Structural Optimization, 1, 193-202, 1989). Unlike conventional design methods, SIMP is a topology design method that draws from a broader class of design solutions. Through a simple continuous material model, geometrical and material configurations are effectively designed from 'scratch'. The continuous model allows for a design problem formulation in a non-linear optimization framework using the Finite Element–Boundary Integral method as the computational engine. Sequential Linear Programming (SLP) is then used to solve the optimization problem with sensitivity analysis based on the adjoint variable method for complex variables (G. Kiziltas et al, TAP, 51, 10, 2732-2743, 2003). The proposed design method allows for inhomogeneous material modeling and design to increase the bandwidth of a fixed size square slot spiral antenna using a high-contrast LTCC superstrate.