Low Profile Metaferrite Belt Antenna for Fixed Wing Aircraft at HF

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Airborne radar applications require low profile antennas that conform to the surface of the supporting structure whenever possible in order to decrease weight and increase in-flight aerodynamics. Low profile antenna solutions reduce drag on the aircraft resulting in reduced fuel costs and/or longer flight durations. Whenever applicable, the antenna aperture is approximated by a plane with the requirement that the dimension normal to the surface of the fuselage be minimized. Low profile antennas are of special importance within the high frequency (HF) band where electrical lengths in terms of wavelength are very large. For SAR applications, these antennas also require wide bandwidths, in addition to low profiles, for higher resolution. Meeting both requirements at the long wavelengths involved poses special difficulties. In order to lower the operational frequency of an antenna in a given space, loop antennas are intriguing because they resonate at frequency multiples of the circumference of the loop as opposed to the half wavelength resonance of a typical dipole.

The availability of magnetic metamaterials that are much lighter than traditional ferrites has widened the range of possible design approaches. Of particular interest are anisotropic magnetic substrates that allow engineers to control the direction of the magnetic field surface waves on the surface of the substrate. This paper presents preliminary simulation results of an antenna model from 2 to 10 MHz, known as the "belt" antenna, where a metallic loop antenna is wrapped around the circumference of a metal elliptical fuselage. In order to reduce the profile of the antenna, we place an anisotropic magneto-dielectric substrate between the loop antenna and the surface of the fuselage. The model utilizes an elliptical shell that mimics the dimensions of a DCH-8/300 aircraft. The wings and other finer details of the aircraft are neglected to simplify the model and reduce simulation time.

Simulations show comparisons of directivity and radiation patterns of a loop antenna in free space versus the belt antenna loaded with an anisotropic magneto-dielectric medium. In all cases, the medium is predominantly magnetic ($\mu > \varepsilon$), and I will show the effect of increased uniaxial permeability on radiation pattern in the presence of the fuselage for profiles of 10 inches and 5 inches. As a comparison I will also show the performance of the belt antenna for different profile depths with no substrate. All simulations have been run using the time domain solver of CST Studio Suite 2015, and adaptive meshing has been used to verify convergence in the far field results.