MINIATURIZATION OF PLANAR TWO-ARM SPIRAL ANTENNAS USING SLOW-WAVE ENHANCEMENTS

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The size of a spiral antenna depends on the lowest operating frequency. The radius from the center feed to the outer boundary of the spiral antenna is normally about quarter wavelength of the lowest operating frequency. Basically, fundamental limit theory on antenna size shows that the size, efficiency, gain, and bandwidth are trade- offs. Thus, the reduction of antenna size while retaining the same bandwidth causes both lower radiation efficiency and lower antenna gain. Typical approaches to reduce the antenna size are dielectric loading, slow-wave structural patterns on the radiating element, and capacitive/inductive loading. The dielectric loading method is direct and very effective for shrinking antenna size. Typically, non- magnetic dielectric materials are used with the antenna size related to the inverse of the dielectric constant. However, this loading increases the Q of the antenna structure dramatically and causes severe reflection between the boundary of the antenna structure and air, having a negative impact on the impedance bandwidth. Thus, frequency independent antennas constructed on high electrical dielectric-constant materials usually are found to be narrow band. Dielectric loading with magnetic materials can be considered, but those are generally heavy, expensive, and very lossy. Methods other than dielectric loading also increase the Q, but not as significantly. Thus, size reduction using these other methods is not as dramatically affected. The bandwidth can be maintained at a slight cost in efficiency.

In this study, we explore size reduction methods using zigzag spiral arms for the Archimedean, equiangular, and stacked equiangular spirals (the stacked equiangular having arms located in different planes in order to maximize the zigzag). Preliminary simulation results show that the zigzag Archimedean has a smaller size reduction than found with the equiangular structure. The stacked zigzag equiangular spiral shows a significant on reducing the lower end of operating frequency, though having an overall efficiency lower than the other structures.

The detail influence of size-reduction methods on return loss, antenna input impedance, radiation directivity, and axial ratio will be compared. The impact of the size reduction on the peak amplitude of the transient response for various wrapping rates and configurations of slow-wave structures will also be discussed and compared to other classic UWB antennas.

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