Low-Loss Circular Patch Array with Corporate Beam-Forming Network

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There is a requirement for extremely low-loss feeding networks for space-based applications, especially for satellite-to-satellite and satellite-to-ground communications. This topic will discuss methods of using air-loaded transmission lines to form a corporate beam-forming network. Also, it will discuss methods of employing a genetic algorithm to determine the spatial, power, and phase distributions to achieve the desired far-field pattern from a circular array. The motivation behind this research is to demonstrate a method for increasing radiation efficiency by reducing the accrued losses that are exhibited using conventional feeding methods. Another focus of research is to develop an innovative feeding mechanism to maintain pattern symmetry from circular-polarized patch antennas.

A common problem with beam-forming networks (BFN) is the loss that is exhibited when using conventional feeding methods. By mitigating these losses, efficiency of the radiating aperture is significantly improved. This allows for increased power radiation. For space-based applications, this improvement is highly beneficial since the link separation of these systems is very large. The main focus of this topic is to explore the extremely low-loss characteristics of air loaded transmission lines. Specifically, air loaded rectacoax and suspended stripline transmission lines will be examined. Using these types of transmission lines, a corporate BFN can be designed to feed a 19-element circular array. To shape the beam to user-defined specifications, a genetic algorithm is employed to determine spatial, amplitude, and phase distributions. For this research, the user specifications are a main beam of ±10° and sidelobes that are 30dBi down from the main lobe.

The elements that are used to make up the 19-element circular array are circular-polarized patch antennas. Patch antennas are used because they are low-profile, and manufacturable, and are therefore cost-effective. Conventionally, patch antennas are dual fed with a 0°-90° phase progression or with a single feed on the diagonal of the patch element to achieve circular polarization. However, this generally causes asymmetry in the far-field pattern. Because the asymmetry in the element pattern directly results in an asymmetry in the array pattern, the patch elements are fed with four probes with a 0°-90°-180°-270° phase progression. It is found that with the combination of the low-loss BFN parameterized by a genetic algorithm and the unconventionally fed patch element, a peak gain of 20dBi is achievable. Also, with an air-loaded transmission line there is a 6% increase in efficiency when compared to using standard coax cable and packaged power dividers.