Axial Ratio Optimization of a Circularly Polarized 2x2 Microstrip Antenna Array for a Reflectarray Feed Application

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Due to their numerous advantages relative to classical parabolic reflectors and phased arrays, reflectarrays have found increasing application in satellite communication systems. One critical issue in the design of planar microstrip reflectarrays is the feed.

This paper describes a circularly polarized 2x2 microstrip antenna array for operating at K-Band (18.95 GHz), more precisely in the frequency range 18.7-19.2GHz, to be used as a feed of a satellite communications reflectarray antenna. The proposed configuration is based on the well-known microstrip square patch with two truncated corners fed by a microstrip line quarter wave transformer.

The design of the corporate feed network is based on the sequential rotation technique of four circularly polarized square patches and by advancing the phase of each successive patch element by 90° when compared to the adjacent element. The sequential rotation technique has been chosen because it provides an improvement of the axial ratio, bandwidth, and radiation pattern symmetry. In addition, much research has been accomplished on coplanar corporate feed network that consist of sequentially rotated circularly polarized elements and an improvement have been achieved in the axial ratio bandwidth.

However, it has been observed that using a feed system in a coplanar configuration to the patches provides performance degradation of the axial ratio due to spurious radiation of the feed system. In order to solve this problem a scaling technique was used to modify the truncated corners of the patches and the dimension of the patch side edge and provide improvement of the array axial ratio. This technique consists of two steps. 1) to change the truncated corners dimensions to find the best axial ratio value. Consequently the variation of this parameter causes a shift in the design frequency; 2) to move the best point of the axial ratio to the desired frequency. This is solved by a scaling factor which consists of ratio between the frequency with the lowest axial ratio and the design frequency. Therefore the frequency offset is given by the multiplication of the patch side edge and truncation dimension by the scaling factor. For this project no more than two iterations were needed.

To validate the proposed design approach the proposed geometry has been manufactured and the experimental results are compared with the numerical simulations. The laminate RT/Duroid5880 was employed to fabricate the array antenna prototype. It has a thickness of 0.787 mm, with relative permittivity of 2.2 and loss tangent of 0.001. The experimental result show that the axial ratio remains below 2.5 dB in the whole frequency band of interest. Moreover, the reflection coefficient remains below -15 dB within the operating band. It is worthwhile to note that measurement results show that the antenna exhibits good performance in terms of radiation pattern. These results demonstrate that the proposed antenna is a good candidate for feeding of a reflectarray antenna.