Triple-Layer Transmitarray Antenna Designs

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The goal of this work is to reduce the complexity and cost of transmitarray antennas by decreasing the number of layers. Three different methods are used to design triple-layer transmitarray antennas, while maintaining the overall performance with full transmission coefficient phase range of 360° and avoiding the reduction of the element transmission coefficient magnitude.

The first method aims to reduce the contribution of the elements, which have low transmission coefficient magnitudes, on the overall antenna loss. The transmission coefficient phase of the center element of the transmitarray aperture is optimized, such that the transmission coefficient magnitudes of this element and the elements closer to the aperture center equal 1 (0 dB), while keeping the elements with smaller transmission coefficients away as much as possible from the aperture center. This is because the radiation pattern of the feed antenna is directed with its maximum power to the center of the transmitarray aperture, while the feed illumination decreases away from the aperture center. Based on this method a prototype of high gain transmitarray antenna is designed, fabricated, and tested.

The second method is based on the use of transmitarray elements with non-identical layers to cover the transmission coefficient phase region that has degradation in the transmission coefficient magnitude when using identical layers. For the unit cells with non-identical layers, either the element has different conductor layer shape, or they have the same shape but different dimensions. This method has been analytically studied and verified through numerical simulations. Moreover, the sensitivity of the unit cell to manufacturing accuracy has been clarified, and different ways to minimize this impact have been determined.

The third method relies on using two groups of double-layer unit cells, which have different thicknesses. Each unit cell group has a transmission coefficient phase range differ from that of the other group. A full transmission coefficient phase range of 360° is obtained when combining the transmission coefficient phase ranges of the two groups of unit cells. Each unit cell group has been analytically studied and verified through numerical simulations. However, there is a challenge for accurate use of periodic boundary conditions in the numerical simulations of combined two different unit cells. The analysis and results of the three methods presented here will be detailed in the presentation.