Broadband Printed Reflectarray Antenna

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Abstract

In this communication, we propose the design of a broadband reflectarray which resort to a non-conventional shape radiating element to assure a large gain bandwidth. The element shape presents sufficient degrees of freedom to compensate the frequency variation of the differential spatial phase delay even when single-layer printed patches are employed. In this way it is possible to manufacture planar reflector with a reduced cost, that are ideal candidates for the realization of portable and deployable reflectarrays.

1. Broadband Element for High-Gain Single-Layer Printed Reflectarray Antenna

Reflectarrays (RAs) present advantages as high gain, narrow beam with low side lobes, lightweight and smaller volume with respect to other types of antennas with comparable electromagnetic features, but also some drawbacks, the main of which is probably the poor bandwidth, due to two different reasons: the intrinsically poor bandwidth of printed radiated elements, usually no larger than the 3-6%, and the frequency dependence of the phase delay of the incident field. In particular this second aspect is quite critical and becomes dominant in large RAs [1]-[2], since it requires that the RA elements should be able to compensate different phase delays at different operating frequencies.

A possible way to enhance the RA bandwidth is that of adopting one of the techniques usually employed for printed antennas and arrays, i.e., using radiating elements that consist in two or more stacked printed single radiators. Examples of reflectarrays that employ stacked printed elements are shown in [3]-[5]. The resulting RA elements are quite complex, consisting in several dielectric layers and patches placed at the interface among the substrate layers: this increases the complexity of the whole reflectarray not only from the point of view of its design, but also from that of its manufacturing (higher costs), and of its handiness. For these reasons it would be better to use single layer RA also in applications in which a large bandwidth is required. Results on the attempt of design a single layer RA with a bandwidth greater than 10% are shown in [6], [7]

Here, we propose an alternative solution, in which the RA elements are single-layer printed patches of non conventional shape (original Malta Cross and modified one (Fig.1)). They present sufficient degrees of freedom to compensate the frequency variation of the differential spatial phase delay, allowing us to overcome the intrinsic RA narrow bandwidth limitation. Numerical analyses of structures designed using these elements show that it is possible to design high gain Ku band RAs with a bandwidth of more than 17% (i.e., working on the frequency interval 10.7-12.7 GHz), and with double polarization.

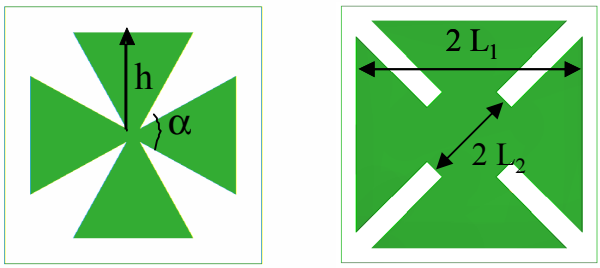

Fig. 1 - Original Malta Cross and modified Malta Cross

In order to validate these numerical results, a medium-size (about 16λ × 16λ at the central frequency of 11.7 GHz) RA has been designed and manufactured. In this particular case only two degree of freedom, i.e. the element size and the slot length of the modified Malta Cross have been used to provide the require phase delay in the considered frequency band. Moreover, in order to consider the worst situation, the feeding of this RA is off-set. Preliminary results on the measurements of this prototype (reported in [8]) shown that it guarantees a 1 dB bandwidth of the order of the 15 % for the worst polarization and an aperture efficiency of the 62 % at the central frequency.

More numerical and experimental results on this configuration will be presented at conference time. In the meantime the possibility a obtaining a reduced beam scanning without increasing too much the complexity of the planar reflector will also be investigated.

2. References

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