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Design and fabrication of a wideband reflectarray antenna in Ku and K bands

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ABSTRACT

The purpose of this paper is design of a wide band single layer reflectarray antenna using a new broadband cell. The proposed cell consists of two parts. The first part is a circular patch and the second one is a ring with some additional stubs, which are attached to the patch and ring in a symmetrical form. The circular patch and ring elements are designed at frequencies of 20 GHz and 15 GHz respectively. In order to increase the reflectarray antenna bandwidth, at first the dimensions of the patch, ring and stubs are optimized to attain uniform phase response in the frequency range from 11 GHz to 20 GHz. Then an air layer is considered under the dielectric substrate. The reflectarray antenna is designed based on this optimized wideband unit cell. A wideband horn antenna is also designed as a feed antenna for the proposed reflectarray structure. The reflectarray antenna with horn are simulated. The 1 dB gain-bandwidth of 4.66 GHz is obtained (27.4% fractional bandwidth) in the frequency band of 14.72 GHz to19.38 GHz. Finally, the reflectarray antenna is fabricated and tested. It can be seen that there is a good agreement between simulation and measurement results.

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1. Introduction

Due to high gain and efficiency of the conventional reflector antennas, these antennas are widely used in communication systems. However, because of the large size and non-planar structures, they are not suitable for many applications especially for satellite communication.

Non planar antenna, such as dish antennas, cannot be fixed properly on the satellite surface. Thus, due to shock that is caused by launching of the satellite, the antenna vibration causes serious problems on satellite mission. It might be thought that the phased-array antenna could be a good alternative for the dish antenna [1]. But, phased-array antennas also have a lot of complexity in design and fabrication. Reflectarray antenna is the combination of the both of reflector and phased-array antennas, which has the advantages of the both of antennas. Due to the advantages of microstrip structure, they are commonly used in the design of the reflectarray antennas [2]. However, low bandwidth and spatial phase difference due to the different distances of the position of the reflector elements from the antenna feed, are the main disadvantages of microstrip reflectarray antennas [3]. By decreasing the effective aperture area of the reflectarray antenna and increasing F/D parameter, the problem caused by spatial phase difference can be resolved. In addition, there are several ways to increase the bandwidth of microstrip antennas [4,5]. In order to increase the bandwidth of a reflectarray antenna, the reflector elements must be able to create at least a phase difference of 360° in the desired frequency range [6]. Doing this, we need to design the patch elements with some variable physical parameters in such a way that the required phases may be achieved through the changes of these parameters [7]. In the design process of a wideband reflectarray antenna, two important points should be considered. First, the phase response of the reflected wave from the reflectarray elements should be uniformly linear in a wide frequency band. Second, the slope of phase diagrams in terms of variable cell parameters should be low enough. The sharp slope of the phase diagrams leads to narrow bandwidth of the reflectarray antenna [8].

As it is indicated in some references, circular patch elements with variable size produce a small linear phase region. In order to maximize the phase variations over a wide frequency range, an air layer should be considered between the substrate and the ground plane [9]. Circular patch with an additional ring around it can provide a linear phase range of more than 360° [10]. In some previously reported works, the variation of the phase response was larger than 360° but the amount of phase variations could

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