Dual Frequency and Dual Circular Polarization Microstrip Nonresonant Array Pin-Fed From a Radial Line

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Abstract—A new type of a dual frequency and dual circular polarization multilayer microstrip nonresonant antenna array for satellite communication is presented. The microstrip radiating elements in the array are arranged in concentric circles and fed through pins embedded in a radial line. The radial line is excited through a probe at its center. The microstrip array exhibits a dual frequency band of operation, low side-lobes in the radiation pattern, and high radiation efficiency (more than 65%) for both polarizations. The microstrip element has been designed using commercial software based on the method of finite integral time domain algorithm, and the feed network has been designed by a theoretical analysis. A prototype of the array has been built and tested. The agreement between the measured and numerical results is satisfactory.

Index Terms—Circular polarization, dual frequency, nonresonant microstrip antenna, radial line.

I. INTRODUCTION

The rapid growth of satellite communication has stimulated intensive research concerning medium and high gain planar antennas. Microstrip nonresonant antennas are considered as an obvious choice for such an application due to their low cost, low weight and low profile. However, large microstrip antennas for mid and high gain applications encounter a major deficiency in their performance, due to their high loss experienced in the feed network. These losses reduce the achievable radiation efficiency to less than 40%. A possible solution to this problem is to replace the standard microstrip feed network with a radial line (radial waveguide) feed network. A radial line feed network is subject to much lower losses. Hence, it is an attractive alternative. This type of network was first conceptualized and built by Goebels and Kelly [1] to feed a flat antenna with annular slots as radiators, also called radial line slot antenna (RLSA). A derivative from RLSA concept was studied by Carver [2] and Nakano [3], in which the radiating elements in the array are helices fed from a radial line through small wire pins to obtain circular polarization. The radial line was excited at its center by a probe and the helices were distributed circularly on the top surface of the radial line on concentric circles. In 1991, Haneishi et al. [4] replaced the helices with circular polarized microstrip elements to obtain a high efficiency (90%) antenna in Ku band. These elements were used also by Yamamoto et al. [5] to design a circular array antenna with shaped beam. In the circular polarization antennas described in [2]–[5], the arrays are nonresonant and uniformly excited. Hence, the outer circle of radiating elements in these arrays is strongly coupled to the waveguide and serves also as an effective termination (load of the waveguide). Other types of the radial line planar microstrip array antennas are described in [6], [7].

In this paper, a new type Ku band, dual frequency and dual circular polarization multilayer microstrip array antenna with low side-lobes fed from a radial line through wire pins is presented. The motivation is the design of a two-way terminal antenna for low earth orbit (LEO) satellite communication from a mobile platform. The radiating element is composed from two stacked circular patches fed by a single feeding pin. The circular polarization is achieved for each circular patch by introducing two indents as described in [8]. The uniqueness of the proposed element is that it enables to control independently the radiated phase of each of the patches by turning the two patches around their common feeding point. The computation of the radiation parameters of the radiating element was conducted using the MWS commercial software from CST, which is based on a finite integral time domain (FITD) algorithm. The radiating elements are distributed on concentric circles and the radial line is fed through a wire probe at its center. The lengths and coupling to the wire pins inserted in the radial line have been determined through an analytical procedure outlined in [9], [10]. A prototype of an array with 8 rings operating in two frequency ranges 11.7–12.2 GHz (low frequency band) with right hand circular polarization (RHCP) and 14–14.5 GHz (high frequency band) with left hand circular polarization (LHCP) has been build and tested. The agreement between the computed and the test results is satisfactory.

II. THE RADIATING ELEMENT

The basic structure of the proposed element operating in two Ku frequency bands and two orthogonal circular polarizations is shown in Fig. 1. Two stacked circular patches are fed in tandem by a single pin. Each patch is coupled eccentrically to the feeding pin through an annular gap [11], [12]. This unique type of feeding is necessary in order to introduce a capacitive effect to counterbalance the inductive effect of the feeding pin. The feeding pin is top loaded with a little circular pad as an