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The Microstrip Phased Array Antenna in The Centimeter Waves Range

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Abstract: In this paper a module of linear array antenna for a circular view with a single excitation point is proposed. With his module the structure of the phased array working in the range 8.9-9.1 GHz and consisting of 16 sub arrays was organized. The design of the phased array allows reducing the number of receiver and transceiver modules of the system and lowering the cost price, since one module provides the operational functionality of 16 transmitting and receiving elements. This makes it possible to simplify the lattice design, which leads to a reduction in the cost of the system. Such flat antenna arrays are used in survey terrestrial radars, in onboard radars with a synthetic aperture for monitoring the earth's surface.

Keywords: phased array antenna, survey terrestrial radar, synthetic aperture, rectangular stripline resonator.

1. Introduction

The appearance of microstrip antenna devices is caused by the need for lightweight, thin, comfortable and cheap antenna devices. Any microstrip antenna device is a thin dielectric sheet with a thin copper coating on both sides. On one side are made radiating element, circuits of feed, control and matching. The other metal side of the antenna board serves as a screen. Such flat antenna arrays are used in surveillance ground radars and on-board radars with synthesized aperture for earth's surface monitoring [7–9].

In this article, we propose a linear array for a circular scan with a single driving point. Such arrays are used as emitters of flat arrays, perpendicular to the line of emitters in a linear array. This allows you to simplify the design of the array, which leads to the array price cheap.

In this regard, to ensure high accuracy, you need to have a sufficiently narrow beam (in the horizontal plane), compared to the vertical plane. For implementation of the given array, have been carried out the researching with the follow initial data (the data were identified and improved by analyzing the parameters of similar radar): The operating bandwidth is $8.9-9.15GHz$, array beam width on the horizontal plane is 1.5^0, array beam width on the vertical plane is 20^0, array gain factor is $32dB$, side lobes level in the horizontal plane is $<-19dB.$

2. Theoretical calculations for the linear array implementation

As a radiator in this linear array, a rectangular stripline resonator is used (Fig. 1). The substrate material is RO4360G2, with $\varepsilon_r = 6.4$, dielectric width is $0.813mm.$

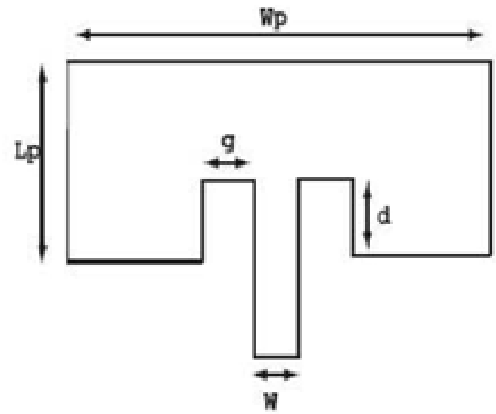

Fig.1 Geometrical view of resonator

Determination of the parameters of this resonator at a central frequency of $9GHz$ is carried out as follows.

The length of the resonator is determined by the formula:

$$L = \frac{\vartheta_0}{2 f_r \sqrt{\varepsilon_{reff}}} - 2\Delta L$$

where ϑ_0 – ght speed, f_r – esonance frequency, ε_{reff} – ffective dielectric constant, ΔL – ength correction. And the width of the resonator is determined by the formula:

$$W = \frac{\vartheta_0}{2 f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

where ε_r – ubstrate dielectric constant [1]. As a result of the calculations, we have the resonator length $L = 8mm$ and width $W = 6mm$.

In the next step, the theoretical distance between two elements of the given array is determined according to the formula

$$dx(y) = \frac{\lambda}{1 + |\sin\theta|} = 19mm\,.$$

Taking into account the initial data by the width of the DP(directional pattern) of the array in two planes, we obtain the number of elements along the horizontal plane $N_x = 64$, and along the vertical plane $N_y = 4$. Accordingly, the length of the array by the horizontal direction will be $L_x = N_x * 19 = 1300mm$, and by the vertical $L_y = N_x * 19 = 1300mm$. Then, the questions of the given array radiating elements power supply organization are considered [1,2]. For the radiating elements supply was chosen the tees circuit. This circuit allows feed a large number of radiating elements of the array from one point. The use of this circuit leads to the array design cheaper and simplified, which in turn will simplify the systems where it will be used [3].

Two-channel power dividers (tees) are used for junction (summing) of microwave signals (Fig. 2).

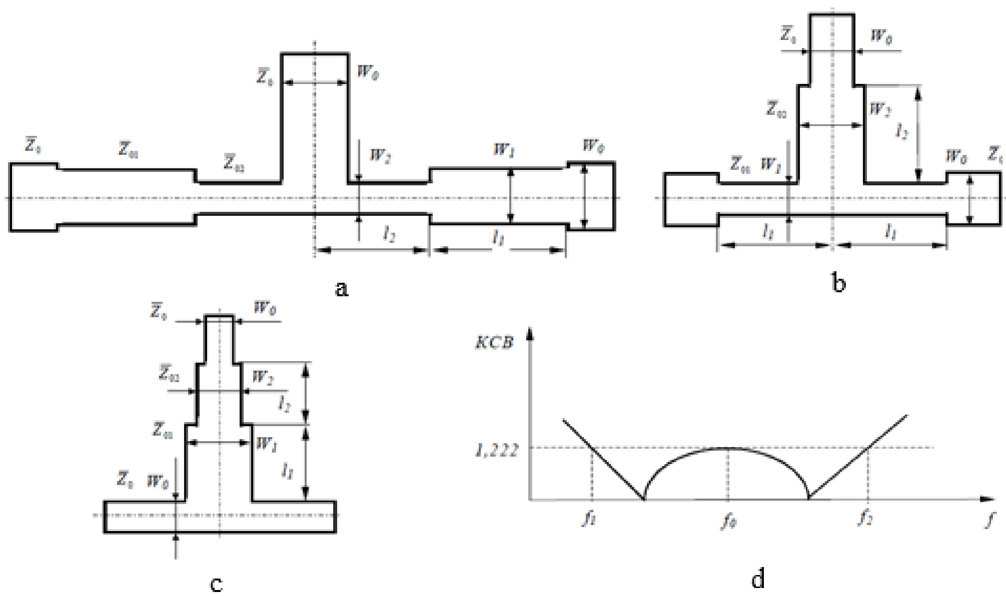

Fig. 2. Types of broadband tees having a two-stage crossing:
(a) - with two-stage matching transformers in the output shoulders;
(b) - with matching transformers in the input and output shoulders;
(c) - with two-stage matching transformers in the input shoulder;
(d) -frequency response of two-stage tee

The main electrical characteristic of the unit is the frequency response of the SWR from the shoulders. Allowable maximum level of $\mathrm{SWR}_{\mathrm{MAX}}$ in the operating range with the required ceiling of the boundary frequencies is $k = \frac{f_0}{f_1}$ The calculation of the power divider is carried out as follows. The first step is to determine the material of ε and h substrate thickness. Then, is set the wave resistance of the path Z_0 ; the band center of the operating range $f_0 = \sqrt{f_1 f_2}$; he boundary frequencies of the working band f_1 d f_2 the maximum allowed value of the standing-wave ratio of the divider shoulders in the $\mathrm{SWR}_{\mathrm{MAX}}$ range; contact ratio of the working band k. Then, is determined the number of matching steps of the n divider; wave resistance of matching stages Z_i; the geometric dimensions of the divider structure $(W_i; I_i)$.

3. Numerical simulation of a linear array in the 8.9-9.15GHz range

Based on the input requirements of our task, it is advisable to divide the linear array into subarray, which will be powered from one point (Fig. 3). In this case, a numerical simulation of this subarray was performed using the CADFEKO program [4].

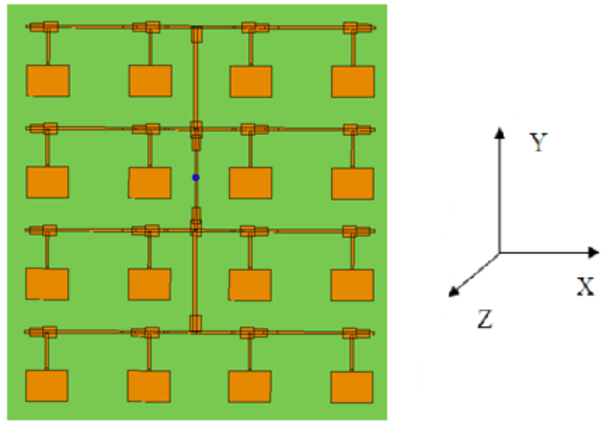

Fig.3. General view of subarray in CADFEKO interface

The result of subarray's directional pattern simulation in the horizontal and vertical planes, accordingly are shown below.

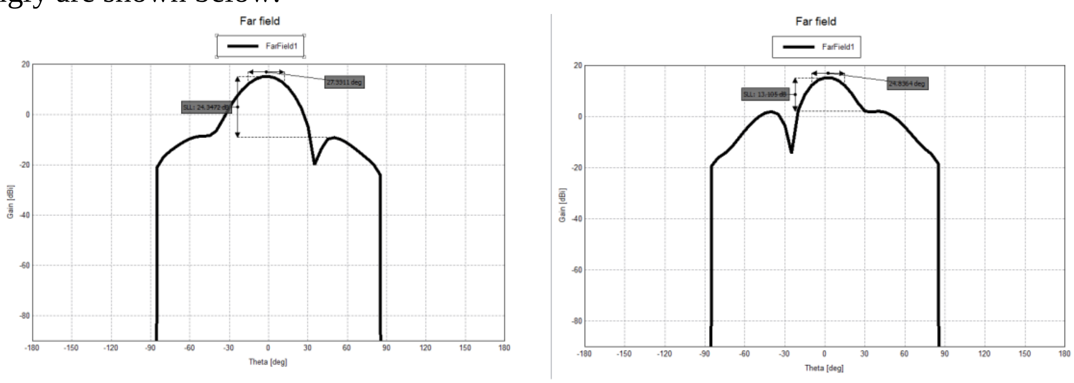

Fig.4: The simulation DP in the horizontal and vertical planes accordingly

After researching the results of array simulation, the production of module was carried out. (Fig.5).

Fig.5. General view of the manufactured module

After the module production the actual measurement of the parameters of this subarray was carried out. In fig. the DP of the subarray is shown on the horizontal and vertical planes (Fig.6).

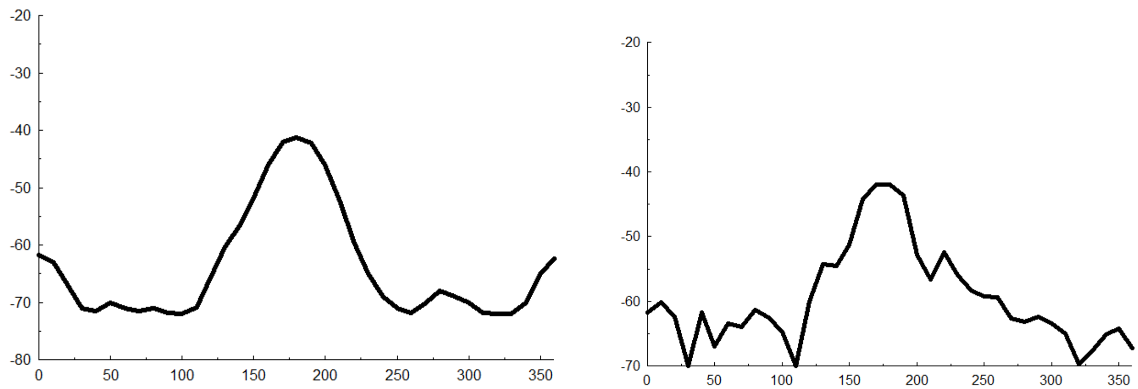

Fig.6. The DP of the subarray on the horizontal and vertical planes respectively

Researching the measurement results, we have deduced that the gain factor of subarray is $11.5dB$, and the width of the DP in two planes is about 25^0.

In generally the given results repeat the results deduced by computer simulation. The results of modeling of array consisting of 16 subarrays was carried out and is given below.

Fig. 6 shows the obtained result of the array DP modeling consisting of 16 subarrays in the vertical and horizontal planes respectively.

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