LINER ANTENNA ARRAY WITH CIRCULAR POLARIZATION AND WIDE-ANGLE SCANNING

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Abstract

Ultra wideband linear circularly polarized antenna array with wide angle beam scanning consisting of conical helical radiators is described. The Results of calculation characteristics and parametrs using method of integral equations in the thin-wire approximation are presented. The beam scanning regularity when scanning sector is $0…50^0$ on example of array with operating band 120-180 MHz are researched.

Keywords: Conical helical antenna, wideband antenna array, circular polarization.

1. INTRODUCTION

For circular polarized field radiation over a wide frequency range helical antennas have been applied [1-4]. The use of such radiators as element of phased antenna arrays almost not considered in the literature.

Purpose of the work is to research the possibility of application of conical helix antennas as element of planar antenna arrays with wide angle beam scanning.

For antenna characteristic research a mathematical model using Pocklington's integral equation for current in thin wire [5] is designed. The integral equation is solved by the method of moments with using pulse function as a basis and weights subdomain functions. On the basis of mathematical model the numerical simulation program allowing to calculate characteristics and parameters single antenna and antenna array is developed. The mathematical model was verified by comparing the results obtained from the developed program with the results obtained from the program MMANA [6]. Unlike the program MMANA the developed program has the editor where creation of models with any number of wires in the antenna is possible.

2. SIMULATION OF ANTENNA ARRAY ELEMENT

The construction of the antenna array element is shown in Fig. 1. Antenna array element is a two-arm spiral conical antenna. The antenna length is 2300 mm, the maximum diameter of the spiral - 700 mm, the minimum diameter - 200 mm, the number of turns is 6, the winding angle is 10^0, made of tubes 20 mm diameter. The antenna is designed for feeding by feeder with characteristic impedance of 200 Ohms. The dependence of standing wave ratio (SWR) on frequency is shown in Fig.2. Figures 3-5 show the antenna patterns for the total field in the principal planes at frequencies of 120, 150, 180 MHz. Antenna beam width at mentioned frequencies is 74^0, 88^0 and 90^0; directive gain D is 6, 5.7 and 5 dB. The dependence of axial ratio (AR) on observation angle at frequency of 150 MHz is shown in Fig.6. From the Fig. 6 it is visible that the antenna radiates the field with circular polarization.

The possibility of simplification of the design of antenna, by its winding on six-sided cone is checked (Fig. 7). The dependence of SWR on frequency for this design is shown in Fig.8. The dimensions correspond to the dimensions of the radiator considered above; the helix diameters correspond to the diameters of circles, circumscribed around hexagons. From the Fig. 8 it is visible that matching of the radiator in comparison with the previous design has practically not worsened. Far-fields calculation had shown that they are almost the same as the far-fields of previous radiator version.

From the results of modeling it is visible that the radiator parameters is weakly depend on frequency that allows to use it as a part of broadband antenna arrays.

3. SIMULATION OF LINEAR ANTENNA ARRAY

The possibility of application of the radiator described above (Fig.1) as a part of a linear phased antenna array is checked by the example of the linear antenna array consisting of 16 radiators located along the X-axis with a step of 800 mm. The possibility of the phased array beam steering in a sector with a width of 100^0 is realized. The amplitude excitation of radiating elements in array is uniform. The specified step provides condition for no grating lobes of the radiation pattern [4] at the maximum frequency of 180 MHz at the scan angle of 50^0.

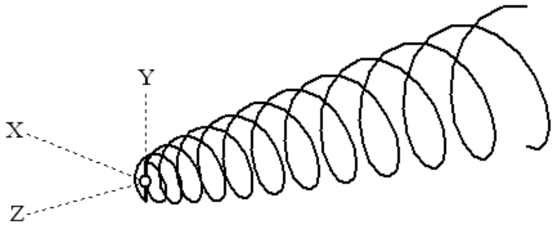

Fig. 1. Design of array radiator

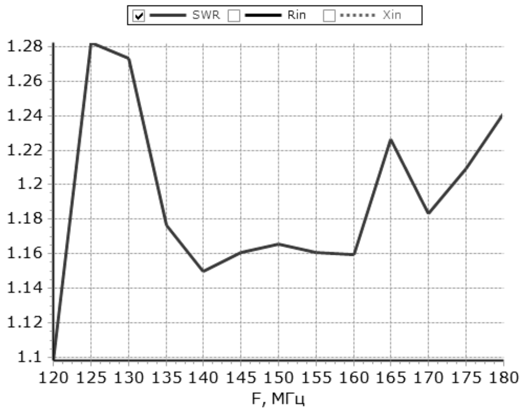

Fig. 2. Dependence of SWR on frequency for spiral antenna

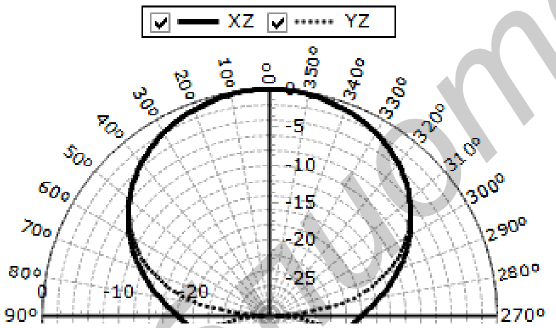

Fig. 3. Antenna pattern of array radiator for the total field in the principal planes at frequency of 120 MHz

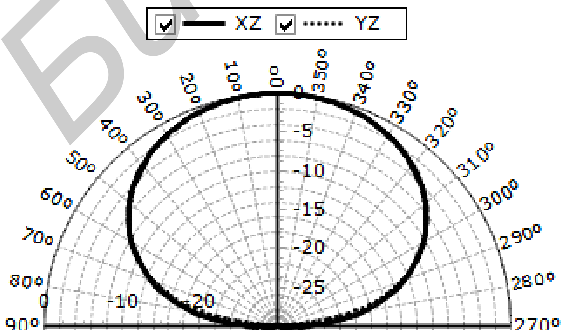

Fig. 4. Antenna pattern of array radiator for the total field in the principal planes at frequency of 150 MHz

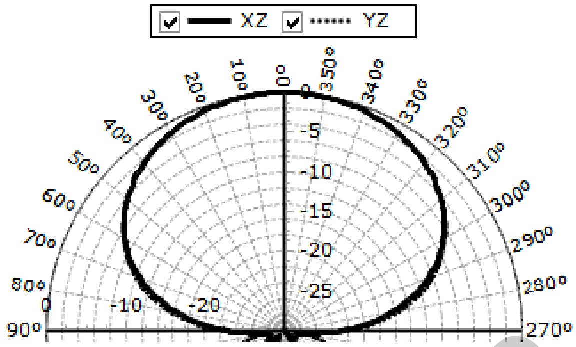

Fig. 5. Antenna pattern of array radiator for the total field in the principal planes at frequency of 180 MHz

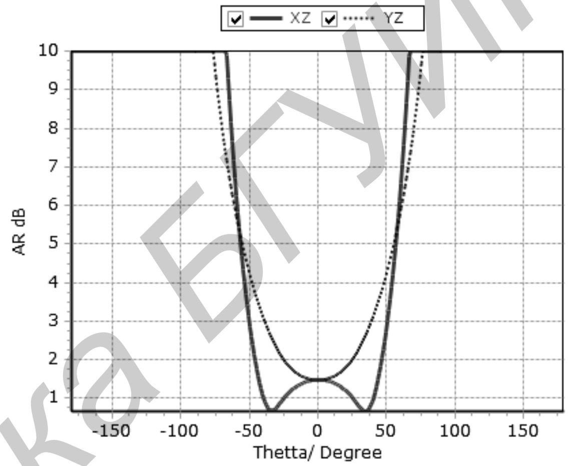

Fig. 6. Dependence of axial ratio AR on observation angle at frequency of 150 MHz

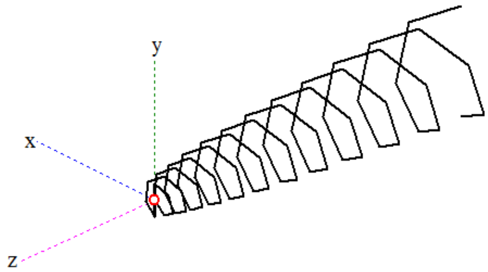

Fig. 7. Six-sided spiral conical antenna

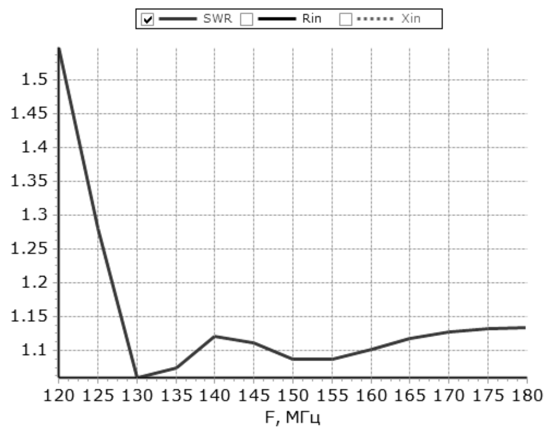

Fig. 8. Dependence of SWR on frequency for six-sided spiral conical antenna

Figures 9-14 show the antenna array patterns for the total field at the scan angles (Θscan) of 0^0 and 50^0 at frequencies of 120, 150 and 180 MHz. The array parameters (directive gain (D), beam width ($2\Theta_{0.5}$), maximum SWR in array radiators (SWR_{max})) at different scan angles presented in (Table 1).

From the results of modeling it is visible that it is possible to build ultra wideband antenna arrays with wide angle scan, when using conic spiral antennas as a radiator.

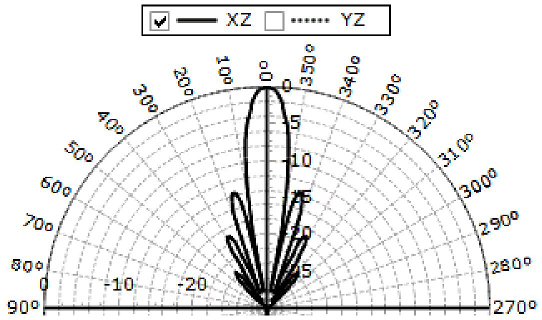

Fig. 9. Antenna pattern of antenna array for the total field at frequency of 120 MHz

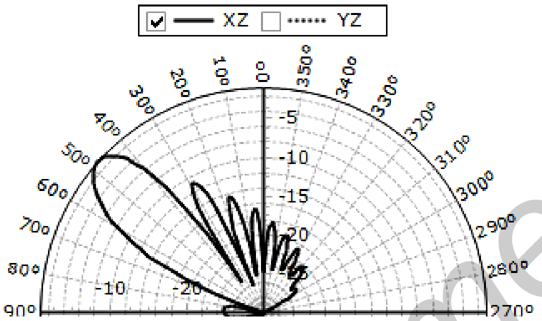

Fig. 10. Antenna pattern of antenna array for the total field at frequency of 120 MHz

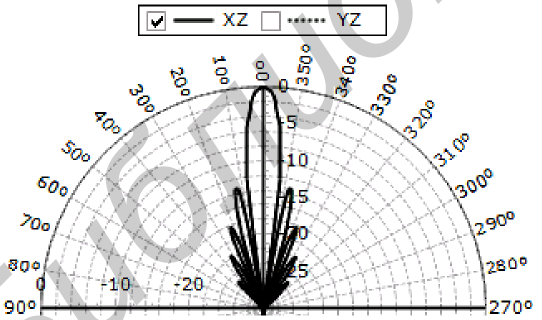

Fig. 11. Antenna pattern of antenna array for the total field at frequency of 150 MHz

Table 1. The array parameters at different scan angles and frequencies

F, MHz	Θscan = 0^0			Θscan = 50^0.		
	D, dB	$2\Theta_{0.5}$	SWR_{max}	D, dB	$2\Theta_{0.5}$	SWR_{max}
120	15.2	10	1.3	13.6	16	1.6
150	15.4	8	1.3	14.9	13	1.4
180	15.6	8	1.3	15.2	11	1.3

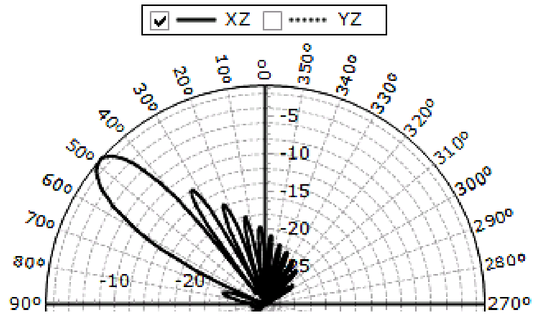

Fig. 12. Antenna pattern of antenna array for the total field at frequency of 150 MHz

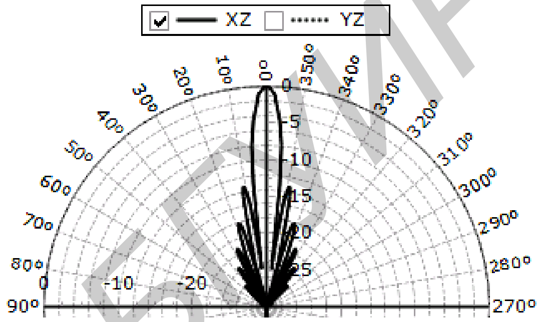

Fig. 13. Antenna pattern of antenna array for the total field at frequency of 180 MHz

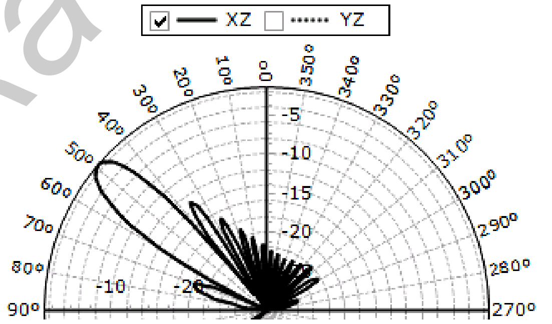

Fig. 14. Antenna pattern of antenna array for the total field at frequency of 180 MHz

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