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A Method for Controlling Polarization Structure of a Field Generated by a Spiral Cone Antenna

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Abstract—A method of controlling the radiation's polarization structure, allowing to decrease the losses due to the mismatch in antennas polarization by 3 dB, is suggested on the example of a four-turn spiral antenna. The experimental research results of a switching device allowing to realize the necessary amplitude-phase excitation of each spiral turn within the radiator are presented.

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For the state of information and multimedia messages transmission over radio channels theory and technology it is typical to solve problems of synthesizing the corresponding radio systems taking into account their real operation conditions. A trend to account for radio channel's state changes which is primarily noticeable in case of movable radio communications leads to an urgent problem of vector space-time radio signal's processing. One of the promising ways of solving the mentioned problem expects performing the radio signal's preliminary polarization processing accomplished with the corresponding choice of antenna-feeder path's antenna systems and microwave devices. A set of such antennas is limited that is probably due to the theoretical research complexity, the absence of the necessary experimental results and methods of designing such antenna types respectively.

Due to low weight-dimension characteristics, the possibility of generating the field with linear and circular polarization and the simplicity of excitation a radiator in the form of a spiral structure performed on a cone surface (CSR) may be considered the most promising ones that can be used for such antennas creation. The known research results of small-size antennas based on CSR and of the possibility to form the desired first of all polarization and frequency characteristics are rather limited. This fact makes a reasonable choice and optimization of antenna's geometric structure, its excitation circuit, calculation and analysis of its main radiation characteristics and, finally, the creation of efficient antennas with new possibilities and ultimately achievable characteristics rather difficult.

In order to create an antenna with controlled polarization structure of the radiated field first of all it is necessary to choose the appropriate geometric parameters of the radiator.

Mathematical models describing geometric configuration of multiturn spiral radiator built on a cone (Fig. 1) allowing to generalize the known variants of regular (equal-step and equal-angle) spirals for the case of non-regular spirals located on a cone with elliptic generatrix are suggested by us. As a result the relations for geometric description of spirals in the Cartesian coordinate system with respect to variable α are obtained. Particularly for one of the equal-step and equal-angle spiral's turns based on elliptic cone the corresponding expressions have the following form:

$$\begin{cases} x(\alpha)=(\rho_0+2\pi^{-1}h\sin\theta_0\alpha)\cos\alpha; \\ y(\alpha)=\sqrt{1-e^2}(\rho_0+2\pi^{-1}h\sin\theta_0\alpha)\sin\alpha; \\ z(\alpha)=2\pi^{-1}h\cos\theta_0\alpha; \end{cases} \quad \begin{cases} x(\alpha)=\rho_0 C(\theta,\beta)^{\alpha\pi^{-1}}\cos\alpha; \\ y(\alpha)=\rho_0\sqrt{1-e^2}C(\theta,\beta)^{\alpha\pi^{-1}}\sin\alpha; \\ z(\alpha)=\rho_0\operatorname{ctg}\theta_0(C(\theta,\beta)^{\alpha\pi^{-1}}-1), \end{cases} \tag{1}$$

where $C(\theta,\beta)=\cos(\beta-\theta)/\cos(\beta+\theta)$; h and β are correspondingly step and angle of spirals; ρ_0 represents the projection of the spiral initial radius on the cross-section plane; θ_0 stands for half-angle at the cone