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An Ultra-Wideband Log-Periodic Vibrator of the Mirror Antenna

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Abstract—The paper is devoted to investigation of ultra-wideband logarithmically periodic vibrators of mirror antennas. The vibrators have the form of cophasal antenna arrays consisting of two log-periodic dipole radiators, comprising a pyramid arranged in the *H*-plane. The asymmetric and symmetric types of excitation of these dipoles are considered, with their calculated and measured characteristics included.

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The advance of the last decade in the sphere of new wireless technologies of high-speed transmission of data flows and ultra-wideband radiolocation is closely related to creation of ultra-wideband active and passive microwave components and antennas. Among ultra-wideband radiators, of particular interest are log-periodic dipole antennas (LPDA) showing comparatively high and stable gain factor, good matching properties, and stable polarization characteristics. The idea of a frequency-independent LPDA was put forward in 1957 [1]. The first detailed mathematical analysis of LPDA [2] was performed based on the prerequisite that the feeding line structure is negligibly small compared to the length of the radiating dipoles and makes no effect of the radiation pattern, while the electromagnetic field in it can be adequately described by currents and voltages. All the dipoles are characterized with symmetric sinusoidal distribution of the current along their length. Despite a large number of simplifications, calculations in [2] permitted to obtain the dependence of the gain factor on LPDA parameters (σ, τ) and to outline the properties and type of variation of the "active zone" parameters in the operation range of frequencies. All this made it possible to synthesize LPDA in the close form. In the course of further investigation in LPDA, the above theory was modified due to application of the method of moments based on piecewise constant or piecewise sinusoidal approximation of current in the dipole, and representing it as the sum of currents of a system of elementary dipoles with electromagnetic coupling (NEC is one of the successful computer programs able to take the finite radius of dipoles into account). All this made it possible to analyze more complex configurations of the radiating dipoles such as LPDA, whose main part represented the V-shaped dipoles and frames. It should be noted, however, that effectiveness and practical importance of the analysis techniques suggested in [2], decline in the case of LPDA optimization at frequencies exceeding 5 GHz, when dimensions of the feeding lines become commensurable with the dimensions of dipoles' cross-sections.

In [4, 5] we can find description a new printed log-periodic radiator designed for operation in the centimeter range of wavelengths. The LPDA was arranged on a dielectric substrate. The structure used a symmetric strip line and printed dipoles. In [5] the feeder system (but not the whole antenna) was analyzed by the finite element method. Obviously, the intricacy of the electrodynamic problem of LPDA analysis and the lack of high-speed computational facilities compelled the researchers to resort to some simplifications. As a result, many properties of LPDA were not studied in full measure, since they were not considered in this simplified analysis.

In the work below we present new results of inquiries in two-element cophasal antenna arrays for a range of frequencies from 0.7 to 12 GHz. The arrays use more than one LPDA comprising a pyramid arranged in the *H*-plane. In order to estimate the characteristics of the wide-band log-periodic structure, the authors performed electrodynamic analysis of LPDA by the method of finite differences in the time domain.

According to the classical definition, LPDA consists of a number of parallel linear vibrators fabricated of metal pipes and symmetrically fed with the aid of a two-wire line (Fig. 1). The lengths l_n of the radiating dipoles vary in geometric progression with its factor $\tau < 1$ along the feeder. The distance between two