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THE PROPERTIES OF RESONANT PERTURBING FORCES IN PARAMETRIC LOOPS

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The paper gives critical analysis of the present-day theory of resonance of parametric circuits. A new insight in this theory is suggested. The principle of linear connection makes it possible to link the parametric loop with nonlinear ones.

Let us establish a strict line of demarcation between two concepts, almost coincident in their names but quite different in essence — the “parametric resonance” and “resonance of a parametric loop”. It is well known that the free (transient) process of an ordinary circuit (loop) composed of positive components is attenuating — with a single exception — if we deal with a circuit without loss, when the free process is neither attenuating nor growing. The free process of a parametric loop may be attenuating, non-attenuating and non-growing, or growing. To discriminate between the three cases is a rather complex task. The “parametric resonance” notion refers to the case when the free process of the parametric loop is ascending. This phenomenon is the distinctive property of the parametric loop and cannot be realized in an ordinary circuit.

A quite different phenomenon is resonance of the parametric loop. Here we deal with generalization of resonance of an ordinary loop. This effect falls in the category of forced oscillations, whose intensity during resonance is maximal. The ordinary loop responds in the form of resonance to the harmonic function of a certain frequency, the forced oscillations represent harmonic functions of the same frequency, and the amplitudes of the forced oscillation during resonance are maximal.

Just in the same manner, the parametric loop responds in the form of resonance to a certain forcing function of time. It is not harmonic and even non-periodic. Its spectrum has the form $\omega \pm k\Omega$, $k = 0, \pm 1, \pm 2, ...$, where $\Omega = 2\pi/T$ is the circular frequency of variation of the loop’s parameters (here T is the period), ω is some constant quantity with dimensionality of circular frequency, and its calculation is the subject of our analysis. This function belongs to quasiperiodic functions with the basis equal to two (its spectrum represents a particular case of combinative spectrum of at least two frequencies — ω and Ω, i.e., $l\omega + m\Omega$, m, $l = 0, \pm 1, \pm 2, ...$). In radiophysical literature these functions are sometimes referred to as Hill’s functions. In the case of resonance, the parametric loop responds in the form of forced oscillations with a maximum of intensity (the concept of amplitude cannot be applied to this type of oscillations), which represent the Hill functions with a peculiar frequency ω.

The theory of resonance of parametric loops was developed by radio physicists belonging to the Soviet school of nonlinear oscillations. The ideas put forward by Academician L. I. Mandel’shtam [1] were extended and described in more detail by G. S. Gorelik [2] in his theory of resonance of parametric loops. More recently, Academician N. D. Papaleksi [3] published an overview of development of the resonance theory, where he gave high appreciation to the scientific contribution made by G. S. Gorelik. Subsequently, for reasons not well understood, the work in this field was suspended, although the theory, started so successfully, was far from its completion. One of possible explanations of this strange situation can be found in periodicals. As a matter of fact, during thirties of the 20th century, many countries were involved

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