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ERRORS IN THE MEASURER OF PHASE DIFFERENCE OF MICROWAVE SIGNALS

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The paper is devoted to analysis of operation of a phase detector of microwave signals. The operation is shown to be invariant to changes in phase shifts of the input and reference signal. An insignificant, within 2.4°, phase jump occurs due to operation in a wide range of signals. The theoretical results agree satisfactorily with experimental data.

The role of phase and frequency measurements, and of radio signal transformation is dominating in the theory of radio measurements and radio-measuring instruments. This stems from high metrological characteristics and informativeness of such parameters as phase shift and frequency of signals [1].

In [2] we suggested a phase detector of microwave signals using a new circuit element — ferromagnetic film (FMF). The device represents a parametric detector whose activation is effected both by the electric and magnetic component of microwave signals. All this permits to obtain rather easily the good decoupling between the input and reference signals. Such transducer performs the function of multiplication of two signals and can be used as a phase detector, which responds to a phase shift between the current in FMF and the magnetic field intensity of the reference source acting on the film. The detector can be appropriately used as a zero reader in an automatic phase control system.

To facilitate the design, the transducer operates without limiters of microwave amplitude. Because of this, due to undesirable secondary effects (additional “parasitic” components related to the self-detection effect), the system may exhibit overshoots of the output signal, which is equivalent to phase jumps. Moreover, we face inevitable errors related to the “range” properties of the transducer operation. Let us perform the assessment of the error of phase difference measurement caused by these factors.

The errors of phase setting arising from amplitude instability of microwave signals. In the case of ideal transformation, the output signal is proportional to the product of input signals and adheres to the relationship

$$e_0 = K_0 J_1 h_2 \cos\left(\arctan \xi + \psi_{ipl} - \pi/2\right) \tag{1}$$

where K_0 is the proportionality coefficient; J_1 is the current density in FMF; h_2 is the amplitude of alternating magnetic field; ξ is the integral detuning; and ψ_{ipl} is the total phase shift.

In the case of exact tuning to resonance, when $\xi = 0$,

$$e_0 = K_0 J_1 h_2 \sin \varphi \tag{2}$$

where φ is the error of phase setting of the measured and reference signals.

Apart from the legitimate signal, there are some undesirable (“parasitic”) components, arising from quadratic detection of input signals. The first one is related to J^2, occurring in the converter due to parametric detection in the availability of current flow in FMF, and is denoted as $e_{J^2} = K_1 J_1^2$. The second component, depending on h^2, is related to

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