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Dynamics of Autodyne Response Formation in Microwave Generators[1]

V. Ya. Noskov and K. A. Ignatkov
Ural Federal University, Yekaterinburg, Russia
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Abstract—The paper presents results of studying the dynamics of autodyne response formation when switching on a radio-pulse microwave generator which is subject to the influence of its own reflection radiation. Basic relations for a step-wise calculation of autodyne response as a function of time delay, autodyne response time constant, distortion parameter and intrinsic parameters of the self-oscillating system are obtained. Calculation and analysis of peculiarities of autodyne signal generation by radio-pulse oscillator are conducted for the cases of motionless and moving reflecting object under relatively low, medium and high inertia properties of the oscillator if compared to the propagation time of the reflected radiation. Experimental research results that confirm conclusions of theoretical analysis are obtained for a common hybrid-integrated autodyne TIGEL-08 module of the 8-mm frequency-range implemented on a planar two-meza Gunn diodes and the same module stabilized by the external high-Q resonator.

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Radio-engineering systems that use autodyne principle have a simple structure of transceiving module which contains only single antenna and autodyne oscillator (a.k.a. autodyne) combining functions of receiver and transmitter. Hence autodynes are attractive to a wide range of applications including various purpose short-range radars (SRR), equipment for controlling parameters of technological processes, radio-spectroscopy, communications and measuring equipment where the mentioned quality indicators are of essential importance [1–5].

The operation principle of these devices is based on autodyne effect that consists in changes of auto-generator's oscillation parameters, such as amplitude and frequency as well as auto-bias voltage, caused by the impact of its own reflected radiation. Any of the mentioned low-frequency components of autodyne response may be used as a useful signal given the possibility to extract them in a number of different ways [1, 4–6].

The use of pulse modulation of autodyne probing signal significantly broadens functional capabilities of systems as well as improves their parameters and characteristics [7].

Consider a case when the delay of the reflected from the target signal τ is less than the radio-pulse duration t_p ($\tau < t_p$), so reception takes place simultaneously with the probing pulse transmission. In this case radiated and reflected oscillations are coherent and the process of extracting useful signal is based on registering changes in their interference picture inside the oscillator itself, i.e. on the autodyne effect.

Given the condition $\tau > t_p$ radiated and reflected radio-pulses do not overlap in time, hence during reception of reflected probing pulse there is no output autodyne signal.

The mentioned property of autodynes provides improvement of a system's interference immunity as well as possibilities to define the far border of target discovery based on distance, register appearance of moving targets in the observation region, measure their velocity and estimate range to a single target. Besides discontinuous nature of oscillator's operation improves stealthiness of autodyne radar and essentially decreases energy consumption.

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