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A FREQUENCY DETECTOR WITH A BALANCE AMPLITUDE MODULATOR AND WITH A SHIFT GENERATOR

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The paper describes a new single-channel microwave frequency detector equipped with a balance amplitude modulator and a shift generator. Analysis of operation of the frequency detector shows that it is able to compensate the intrinsic phase noise of the mixer and of the intermediate-frequency amplifier.

Severe requirements to the phase noise level, imposed on phase noise measurers and on devices for frequency and phase control of frequency, predetermine the importance of creation of highly sensitive microwave frequency detectors. This work is devoted to analysis of operation of a new single-channel microwave frequency detector with a balance amplitude modulator and a quarts shift generator. Analysis of fluctuations of the FM (PM) detector will be performed by the quasiatatic method [1].

The simplified block diagram of the single-channel frequency detector with a balance amplitude modulator and a quarts shift generator is shown in Fig. 1.

The main elements of the network are as follows: SO is the self-oscillator under test; FG — ferrite gate; SG — quartz shift generator; TR — transformer with tapped zero point; BAM — balance amplitude modulator; R — resonator; Amp — low-noise microwave amplifier; VA — variable attenuator; VPS — variable phase shifter; MIX — mixer; IFA — intermediate frequency amplifier; PhD — phase detector; LFA — low-frequency amplifier; and SA — spectrum analyzer.

Consider first the principle of operation of the frequency detector with regard for only the frequency (phase) noise of oscillation of the microwave self-oscillator. After that, perform analysis of impact of the phase and amplitude noise of the frequency detector elements on the final result of detection. In the frequency detector analysis, the mixer is modeled by a multiplying device MD1 added by a band-pass filter BPF at its output. The phase detector is simulated by a multiplying device MD2 with a low-pass filter LPF at its output.

Assume that the inputs of the measuring resonator and of the balance amplitude modulator are driven by voltages from the microwave self-oscillator under test:

$$u(t) = \overline{U}\cos\left[\overline{\omega}t + \int_{-\infty}^{t} \nu(t)\mathrm{d}t\right] = \overline{U}\cos[\overline{\omega}t + \varphi(t)],$$

where $\overline{U}$ and $\overline{\omega}$ are mean values of the amplitude and circular frequency of the voltage $u(t)$, while $\nu(t)$ and $\varphi(t)$ are fluctuations of the angular frequency and phase of the SO.

The low-frequency inputs of the balance amplitude modulator and the reference input of the phase detector are activated by the voltage from the quartz shift generator $u_q(t) = \overline{U}_q \cos\overline{\omega}_q t$ where $\overline{U}_q$ and $\overline{\omega}_q$ are mean values of the amplitude and of circular frequency of the voltage $u_q(t)$.

The voltages $u_1(t)$ and $u_2(t)$, acting at the phase shifter and amplifier outputs, can be written in the form

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