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Statistical Synthesis and Analysis of the Additive Noise Microwave Radiometer with Optimal Structure

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Abstract—An optimal algorithm for estimation of the brightness temperature of intrinsic thermal radio radiation of objects having different physical nature in additive noise microwave radiometer has been synthesized. A functional block diagram implementing this algorithm was developed. The limiting error of estimating the desired parameter was calculated, and the potential fluctuation sensitivity of the proposed radiometer was investigated.

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INTRODUCTION

Additive noise microwave radiometer is referred to the instrumentation and intended for measuring the parameters of intrinsic thermal radio radiation of objects having different physical nature in systems of radiolocation, Earth's remote probing, radio astronomy, radiophysics and medicine.

This type of radiometers as compared to the other known single-channel radiometric receivers possesses a number of advantages [1, 2] including the invariance of measurement results with respect to the gain instability, and the high fluctuation sensitivity.

Despite advantages of this circuit, its structure has been developed by heuristic technique. It does not use fully enough the circuit potential capabilities. The application of modern methods of statistical optimization of reception and processing of radio thermal signals makes it possible to refine the structure of additive noise radiometer and enhance its performance.

STATEMENT OF OPTIMIZATION PROBLEM

The optimal estimate of brightness temperature $T_s^{\circ}(\vec{\lambda})$ of radiation source observed against the background of intrinsic noises of predetection part of radiometer should be found on the interval of observation time [0, T] under conditions that the receiver gain is unstable in time and the noise of reference source is periodically added to the useful signal in the input channel.

INITIAL RELATIONSHIPS

It is assumed that the signal of noise radio thermal radiation $s(t,\vec{\lambda})$ with unknown parameters $\vec{\lambda}$ subject to estimation is registered by antenna. The main unknown parameter requiring the optimal estimation and construction of appropriate structure of optimal radiometer is the brightness temperature of useful radiation source $T_s^{\circ}(\vec{\lambda})$. However, parameters $\vec{\lambda}$ entering the estimate $T_s^{\circ}(\vec{\lambda})$ can be the coordinate parameters in infrared detection problems, electrophysical parameters of investigated media in problems of remote probing, radio astronomy, etc.

Antenna output signal $s(t,\vec{\lambda})$ is periodically mixed with the noise signal of reference generator $s_{\text{ref}}(t)$ with the frequency of modulating function $m(t)$ and fed to the receiver input channel. The pulse-response characteristic of the linear part of receiver (LPR) consists of the sum of constant and fluctuating parts

$$h(t,\tau) = h(t-\tau) + h_{\xi}(t,\tau) = h(t-\tau)[1+\xi(t)], \quad (1)$$

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