ISSN 0735-2727, Radioelectronics and Communications Systems, 2013, Vol. 56, No. 4, pp. 207–211. © Allerton Press, Inc., 2013.
Original Russian Text © K.S. Drozdenko, 2013, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2013, Vol. 56, No. 4, pp. 62–67.

Single-Channel Focusable Acoustothermometer for Measuring the Internal Temperature of Biological Object

K. S. Drozdenko

National Technical University of Ukraine "Kyiv Polytechnic Institute" (NTUU KPI), Kyiv, Ukraine

Received in final form March 21, 2013

Abstract—A new method of voltage modulation at the piezoelectric receiver output using a noise reference and electronic switch has been proposed. The functional block diagram of a focusable acoustothermometer has been developed. The specified acoustothermometer enables us to perform measurements of the internal temperature of biological object using the single-frequency single-channel method with the measurement characteristics adequate for medical applications.

DOI: 10.3103/S0735272713040067

Among modern medical technologies focused on prevention and treatment of various diseases an important place belongs to a new direction in the early disease detection that involves the determination of the space-time distribution of internal temperature of biological object by using its thermal self-radiation.

The thermal electromagnetic radiation is a source of physical self-fields in the range of microwave frequencies, infrared emission and also the acoustic radiation in the ultrasonic range. The following methods of measuring the internal temperature are distinguished: infrared thermovision, radio- and acousto-thermometry [1]. In this case acoustothermometry is characterized by a better spatial resolution, larger depth of probing, lower damping, and, in addition, by simpler technical implementation that indicates a good promise for its applications [2].

The intensity of ultrasonic waves determining the absolute temperature of a body can be measured by using an acoustothermometer (AT).

Modulation AT are now of the main interest. They consist of the following elements (Fig. 1): receiver of acoustic radiation (RAR), matching transformer (MT), broad-band high frequency amplifier (HFA), quadratic detector (QD), synchronous detector (SD), low-pass filter (LPF), temperature meter of the modulator chamber (TM), and recording unit (RU). RAR consists of a chamber with mechanical modulator (CMM) filled with liquid for thermal stabilization and a piezoelectric transducer (PT).

Up to date an effective solution of the problem of constructing AT for measuring the internal temperature of biological objects that possess adequate characteristics in terms of the spatial resolution, sensitivity, and the probing depth has not been found. This is related to the fact that Western researchers link the prospects of creating AT with the issues of exploring the World Ocean and develop the active acoustothermometry, while the scientists in the former Soviet republics made a series of inaccuracies in conducting their investigations in this field.

In particular, they did not take into account the peculiarities of boundary conditions on the active and passive antenna surfaces, in solving the inverse problem they used "narrow-band approximation", calculated the voltage at the piezo receiver output in accordance with the Nyquist theorem, and took account of the HFA self-noises incorrectly that resulted in errors of theoretical calculations of the accuracy of temperature determination and the erroneous interpretation of results of experimental measurements.

In this connection the development of AT possessing the adequate characteristics for medical application is an urgent task.

The blocks of the AT diagram implementing zero modulation method were investigated in detail in papers [3–5]. These papers considered possible techniques of their upgrade and formulated the requirements making it possible to increase the accuracy of determining the internal temperature up to the level determined by object's threshold fluctuation accuracy. The authors of the specified papers indicated the need of replacing or changing QD performing the separation of information signal from the modulated