A Geo-Radar Intended for Detection, Control and Identification of Subsurface Objects

S. P. Lukjanov, O. V. Stoukatch, V. E. Semenchuk, A. S. Karaush, V. V. Zagoskin, and R. V. Potemin
Tomsk State University of Control Systems and Radioelectronics, TUCSR
40 Lenin Avenue, Tomsk, 634050, Russia

The geo-radar methods are based on analysis of medium and object reaction on ultra-wideband electromagnetic radiation. The spectrum involves frequencies up to hundreds of MHz. And its impact causes the excitation of practically all-possible types of intrinsic oscillations of the object or medium. This leads to an increase of the information content in radar diagnostics and control of disorders in natural and technogenic media.

In many tasks, the geo-radar methods are the only possible means for the problem solution, while for others, it is more effective. The factors limiting the functional capability of developed geo-radars are the following: (a) the influence of medium's electrophysical characteristics on the signal level; (b) the influence of electrophysical characteristics of different underlying media on the ultra-wideband signals used for target classification; (c) the influence of radiating and receiving antennas patterns on the accuracy of ultra-wideband geo-radar.

At present authors accumulate sufficient theoretical and practical experience on creation both separate functional units, and geo-radars. Principles of construction of main functional units of geo-radar and their original circuit decisions are investigated. For extraction of information of vector characteristics of scattering signals the experimental prototype of geo-radar system has been created. Geo-radar consists of two-channel path on radiation and receiving. Functionally it consists of three independent parts: a transmitting part, receiving part and microprocessor controller block for data processing.

Designed software package allows to make secondary data processing and to present the information kind convenient for operator. To describe the concentration and temperature dependence of dielectric characteristics and electric conductivity, the mathematical method of flowing theory is used. The modern algorithms of electrodynamics and thermo-humidity problems for investigating the electrophysical and structural parameters of semiconducting substances, which compound the subsurface media and objects of control, are used.

For increase of reliability of signal interpretation the data of researches of electrodynamics characteristics of natural and technogenic media and their components for wide (from 0 up to 10 GHz) frequency range of electromagnetic radiation are used. Available data bank includes real investigations data, which concerns the electrodynamics characteristics of soil, rock, construction material and article samples.

In the paper it is supposed to consider the problems of high informing geo-radar creation, based on the use of the vector characteristics of ultra-wideband pulse signals, and problem of processing of such signals. Results of complex researches of factors on the geo-radar characteristics marked above, as means of engineering investigation of subsurface objects and media will be indicated. Offered algorithms of data processing provide higher informing of engineering exploring of subsurface objects and media both in step of detection, and in stage of recognition. The efficiency increase of system for diagnostics and control in comparison with known systems is achieved by using the models of relation between spatial-temporal structure of the signals and radiophysical properties of subsurface medium and objects, their dimensions and spatial position.

Advancement of the approach could allow to use the subsurface radar methods as for well-known problems (determination of the thickness, state and properties of extended objects in different media), and for new problems connected with detection and identification of objects (including small-sized and small-contrast ones) in media while prognosing and controlling the emergency situations.