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Use of GPR method for contactless measuring of contact wire position in electrified railway

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ABSTRACT

This paper is devoted to studying the applicability of impulse radiolocation method in microwave range (1700 MHz) with the use of transmit and receive GPR antennas in order to measure contact wire position of electrified railways. Results showed that basing on triangulation principle of object distance measurement GPR method can be applied to identify contact wire geometric parameters: height, stagger, mast distance, line events (signals, crossings, points etc.).

1. Introduction

Keeping catenary in the state ensuring reliable interaction of collector bow and contact wire is an essential condition for safe and continuous operation of electrified railways, especially in the circumstances of high-speed and high-density traffic [1–3]. The important aspect of this task is timely and accurate control of geometric parameters contact wire position. Anyway, known systems for measuring of contact wire position that are based on application of laser and video technologies have some drawbacks [4,5]. The main of these drawbacks is measurement accuracy decrease under adverse weather conditions, for example, under direct sunbeams, when it's foggy, snowy, rainy or during hours of darkness.

Due considerably higher penetration ability of microwave radiation in comparison with optical ones, the method of impulse radiolocation which is widely applied for geophysical purposes [6], can be a possible way of reduction of the described restrictions. This paper is devoted to studying of GPR method applicability for measuring the parameters of contact wire position.

2. Method

Radar measurements were done with the use of radar antenna unit (RAU) of single-channel type with operational frequency 1700 MHz (produced by GEOTECH Company, Russia) using catenary system training hardware of actual dimension located in the building of Power Engineering Department of the Rostov State Transport University (Fig. 1a). Radar setting parameters: number of independent measurements for recording the traces – 16, sampling rate — 511 samples for each radar trace, scanning time discrimination – 24 ns. Recording and pre-processing of GPR data were performed by the GeoScan-32 software.

3. Results and conclusions

Fig. 1b shows the results of radargram processing obtained along the line of catenary system training hardware. The obtained radargram has got a blue line corresponding to the observed contact wire. It has also got red circles indicating the elements of catenary (Fig. 1b). High contrast of amplitude characteristics in this radargram area is determined by the reflection of waves on the environment boundary with different electrophysical properties (dielectric permittivity and conduction). Here with the accuracy of object position is determined by resolution ability of RAU (0.03 m for RAU operational frequency 1700 MHz). The possibility of identifying contact wire by changes of amplitude and phase characteristics of the reflected microwaves enables to determine its geometric parameters (height, stagger, mast distance, line events) on the basis of simple correlations (Fig. 1c). All that is possible basing on the principle of triangulation (Fig. 1c) that are widely used in laser and video diagnosis technologies [7]. In this case, the basis is the distance between two datum points – radar antenna units, and the top is the target object – contact wire. Further development of this method can be connected with

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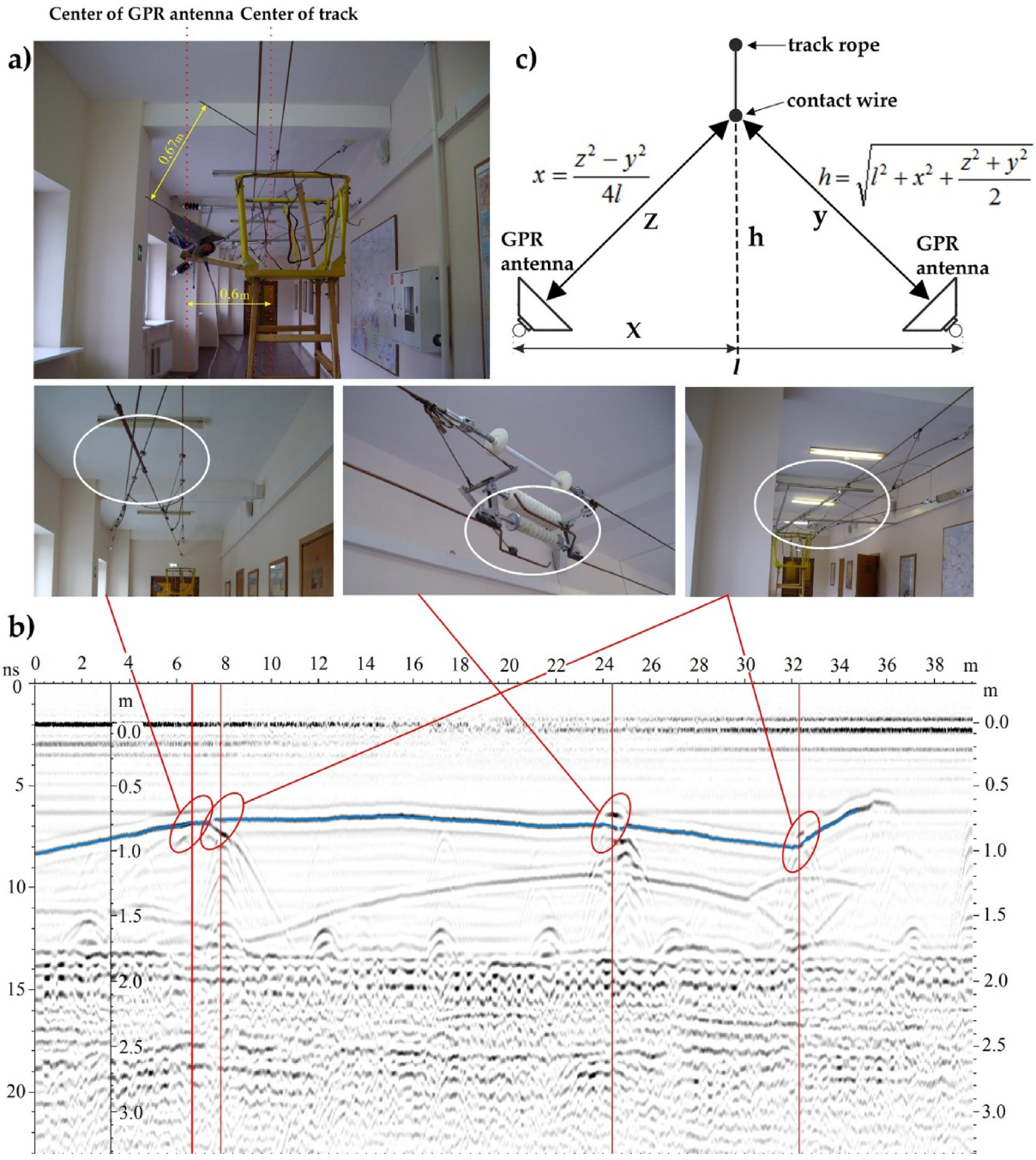

Fig. 1. Geometry of the measurement system (a), measurement results for wire locations (b) and concept of contactless GPR measurement method for localization of contact wires (c).

automation of processing and interpretation of data amassed in the process of measurement.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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