THE VIY-2 GROUND PENETRATING RADAR

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Abstract

The VIY-2 ground penetrating radar (GPR) with unique sounding possibilities and use simplicity is presented at this paper. The VIY-2 GPR combines all units (synchronizer, transmitting and receiving modules, power supply and antenna system) into single case. The VIY-2 GPR communicates with computer via standard interface RS232 or USB1.0. Utilized by the VIY-2 GPR technical solutions reduce deployment time and simplify survey process.

The VIY-2 GPR design features and its components interaction are considered. Some field results are also presented. The VIY-2 GPR design concept allows reducing the data acquisition time, optimizing the time-varying gain control function, applying depth-stacking dependence, controlling the survey window position and interference reducing by pulse repetition frequency randomizing.

Keywords: Ground penetrating radar, GPR, impulse radar.

1. INTRODUCTION

Ground penetrating radar (also known as earth sounding radar, ground probing radar, subsurface radar, or georadar) (GPR) uses radar principles to image, locate and quantitatively identify changes in electromagnetic properties under the ground. Information that can be obtained from GPR includes the depth, orientation, size and shape of buried objects, and the density and water content of soils. It can be utilized for various applications including utilities detection, civil engineering, archeology, hydrology, geological applications, sedimentology, concrete/pavement evaluation, unexploded ordnance (UXO) and mine detection, soil characterization, ice and permafrost examination.

There are known various GPR systems including pulsed, continuous wave (CW), frequency-modulated continuous wave (FMCW), stepped-frequency continuous wave (SF CW), chirp, noise and so on [1, 2]. The main idea of GPR sounding is acquisition of subsurface pulse responses in separate point of surveying surface and producing of media slice (called B-scan) by synthesized aperture method application. The pulse response (or A-scan) can be acquired either frequency or time domains.

The pulsed GPR systems acquire pulse response in time domain directly. It is the simplest and understandable method, that allows getting unique operation flexibility of the GPR system. To realize this method the following GPR components should be provided: powerful and stable nanosecond pulse generator, low-noise ultra wideband (UWB) receiver with overloaded preserving, UWB antenna system owning short pulse response and timing stability, timing circuits with low jitter and flexible adjustment abilities.

The main goal of the VIY-2 project was the GPR system development with improved energy and operation parameters. In order to realize the project all necessary GPR components were developed including synchronizing algorithm, GPR-PC transfer protocol, synchronizer with advanced capabilities, high efficient UWB transmitter module, low noise UWB sampling receiver module and unique antenna system. Appropriate software was developed also.

This paper describes the VIY-2 GPR owning unique sounding possibilities that differ it from other known pulsed GPR systems.

2. THE VIY-2 GPR

The VIY-2 GPR operation is based on a principle of sampling with arbitrary time sweeping. Applied algorithm assumes trace samples acquisition with arbitrary sequence and variable sounding pulse repetition frequency (PRF). The proposed attempt allows wide range varying such GPR parameters as survey window, sample numbers per trace, stacking number, time dependence of gain control, etc.

2.1. THE VIY-2 GPR HARDWARE

The VIY-2 GPR is assembled in single case (Fig. 1). The GPR panel contains interface and power connectors, power switch and three LED indicators. Owing to such technical solution reduces deployment time and simplifies survey process. The GPR hardware includes transmitting and receiver modules, synchronizer and power supply, that are placed on the rear side of antenna system.

Fig. 1 The VIY-2 GPR form

2.2.1. Transmitting Module

The VIY-2 GPR utilizes active transmitting module based on novel concept of kinetic energy accumulated antenna and drift step-recovery technology [3]. Bistatic antenna system is formed by exponential TEM horns adopted for operation in antenna current interruption mode. We developed a balanced current driver that provides specific conditions for drift step-recovery diode (DSRD) operation. Owing to used proposed concept the transmitting module combines powerful electromagnetic impulse radiation, high radiating efficiency and low jitter. The transmitting module generates 8 ns monocycle pulses with up to 1600-Watt peak power on the antenna terminal at 20 kHz pulse repetition frequency (PRF).

2.2.2. Receiving Module

The VIY-2 GPR utilizes active receiving module consisted of signal conditioner, differential variable gain sampling-and-hold amplifier and 10-bits analog-to-digital converter (ADC). The receiver is directly connected to the antenna terminal to provide required bandwidth and high sensitivity. Dynamic range of the receiver exceeds 110 dB with input noise factor less than 1 dB in frequency range from 10 MHz to 1 GHz.

2.2.3. Synchronizer

Synchronizer is a key element of the hardware that determines operation features of the GPR. It controls transmitting and receiving module, provides signal preprocessing and GPR-computer data interchange. We developed synchronizer that provides arbitrary sampling algorithm. It means that any point of signal waveform is acquired and digitized independently from another ones. Gain and stacking number of every sample is set independently and order of samples sequence can also be arbitrary. Owing to realized principle number of samples can be set from 2 to 1023 with arbitrary beginning and end of survey window. Stacking number can reach 78 for 128-point waveform. Variable gain control is also arbitrary and amplification can be varied from 0 dB to 48 dB.

2.2.4. Interface

To provide the VIY-2 GPR compatibility with commercially available computers (notebooks) the GPR control signals and acquired data are transferred via serial interface RS232 (or USB 1.0). Specially developed transfer data protocol is used to improve the GPR working efficiency. It allows acquiring of ten 512-point waveforms per second (without stacking) with 16-bit resolution.

2.1. THE VIY-2 GPR SOFTWARE

The VIY-2 GPR basic software package is compatible with any computers with Win9X and higher operation system. It allows making the GPR adjustment, carrying out the field surveying and executing the acquired data processing.

Setup window provides adjustment of survey window, stacking number, step increment and time-varying gain control (TVGC) shape. The tuning results are reflected by received waveform (A-scan) in online (Fig. 2).

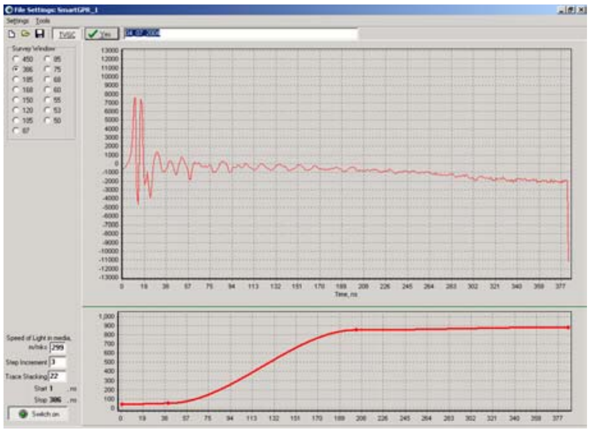

Fig. 2 Setup window with A-scan and TVGC

During the survey the acquired data are displayed on the computer screen as B-scan in online. Size of the B-scan document may be as much as 2 GBytes.

Acquired data can be processed by appropriate tools, including signal normalizing, low and high pass filtering, median filtering, correlation, color coding, averaging, rectifying and so on. The B-scan processing tools are arranged by tree configuration. The tools can be added, deleted, adjusted and rearranged. Result of the tools applying is immediately reflected by the B-scan. Recalculation is made from the redefined tool, that allows reducing the processing time.

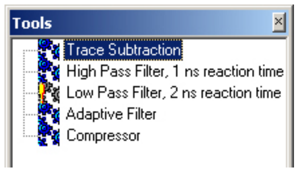

Fig. 3 Tree with various processing tools

3. EXPERIMENTAL RESULTS

The VIY-2 GRR was tested for searching of utility lines in Dneprovskiy region, Kiev, Ukraine. Area is sandy soil (approximate electromagnetic wave velocity in the media was fixed as 15 cm/ns). The B-scan (Fig. 4) presents one of the concrete tubes that was detected on a depth about 4 meters.

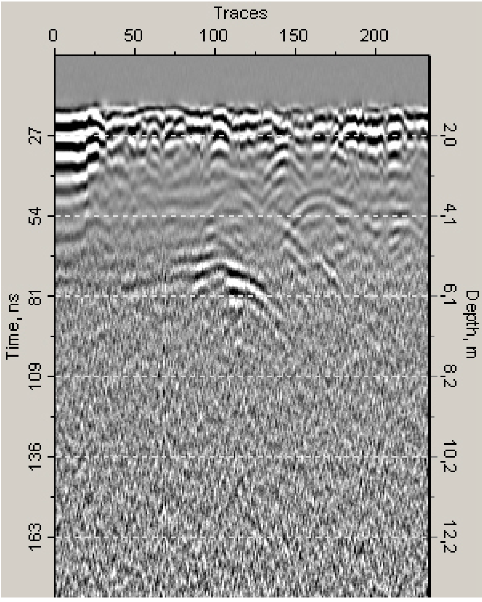

Fig. 4 Vertical slice (B-scan) of the survey area

Excavation has confirmed the survey results (Fig. 5).

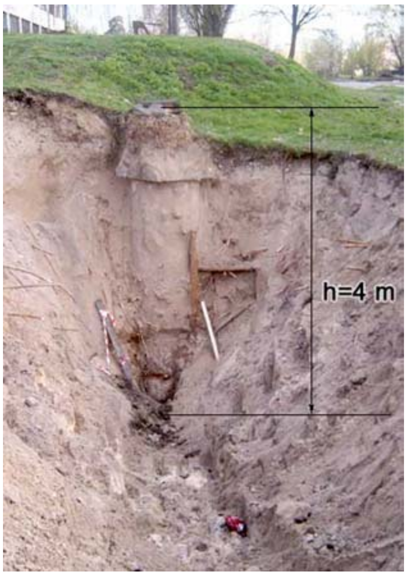

Fig. 5 Excavation of nearby survey place

4. CONCLUSIONS

The VIY-2 ground penetrating radar (GPR) with unique sounding possibilities and use simplicity is presented at this paper. The VIY-2 GPR combines all units (synchronizer, transmitting and receiving modules, powering and antenna system) into single case. The VIY-2 GPR communicates with computer via standard interface RS232 or USB1.0. Technical solutions utilized by the VIY-2 GPR reduce deployment time and simplify survey process.

The VIY-2 GPR design features and its components interaction are considered. Field result is also presented. The VIY-2 GPR design concept allows reducing the data acquisition time, optimizing the time-varying gain control function, applying depth-stacking dependence, controlling the survey window position and reducing of interference by providing the pulse repetition frequency randomizing.

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