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Improvement of the energetic properties of the GPR

Gennadiy P. Pochanin, Vadim P. Ruban, Pavlo V. Kholod, Alexander A. Shuba, Alexander G. Pochanin, and Alexander A. Orlenko

O.Ya.Usikov Institute for Radiophysics and Electronics of the National Academy of Science of Ukraine, Kharkov, Ukraine (gpp@ire.kharkov.ua)

The necessary condition for the expansion of the impulse Ground Penetrating Radar (GPR) applications is to improve the GPR energy performance for the detection of signals on the background of noise. Digital signal processing techniques allow suppressing the noise largely, but they work only when the GPR is able to register the reflected signals.

The majority of the modern GPRs use sampling receivers. They allow recording signals of a very short duration. However, very large energy losses are inherent to this method.
To improve the signal to noise ratio it is possible to increase the power of the probing signal and to de- crease the noise level of the receiver.

In GPR, the transmitting and receiving antennas are usually electrodynamically coupled because they are situated quite close to each other. The sensitive input circuit of the receiver does not allow the excess of the signal amplitude typically more than 1 V. Thus, the increase of the intensity of the probing signal is possible only up to a certain level. To overcome this limitation, it was proposed to design an antenna in such a way that the coupling between the transmitting and receiving sections was absent or minimal. A special method that provided the decoupling below -64 dB was invented (theoretically the isolation is absolute and frequency independent).

In order to register as short as possible signals, researchers strive to make sample duration of the sampling converter as short as possible. However, the shorter the sample duration, the smaller the energy of the signal that can be received and the larger the noise.

Due to the dispersive absorption of electromagnetic waves in the ground, the high-frequency part of the signal spectrum is attenuated faster than the low-frequency part. It makes no sense to expect the arrival of very short pulses from deep reflectors. Thus, it is possible to increase the duration of the samples at reception of the signals from the deep objects. The authors proposed to increase the duration of the samples with the distance. In this way, a smoothing of the noise and an increase of the recorded energy at each subsequent sampling were achieved.

The next opportunity to improve the signal to noise ratio is the coherent accumulation of the signal that can be carried out both in digital and analog forms. Due to the fast ADC, it became possible to accumulate a large number of signals in an acceptable survey period.

In practice, the amount of accumulated signals is limited by jitter. Thus, to achieve accumulation and reception of signals without distortion the authors have suggested and implemented GPR improvements allowing to get the instability of sampling below 3.5 ps.

Owing to increase of the pulse-repetition frequency up to 1 MHz and data transmission via Ethernet, it was also possible to provide a fast GPR survey.

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