Characterization of Underground Objects in UWB GPR by Range Profiling of Phase

Valeri Mikhnev[#1], Pertti Vainikainen[*2]

[#]*Institute of Applied Physics*
Akademicheskaya str., 16, Minsk, Belarus
[1]mikhnev@iaph.bas-net.by

[*]*SMARAD/Department of Radio Science and Engineering, Aalto University School of Science and Technology*
P.O. Box 13000, FI-00076 AALTO, Espoo, Finland
[2]pertti.vainikainen@tkk.fi

Abstract— **In this work, a new phase-based data processing method for UWB subsurface radar is presented. The method utilizes extraction of the phase information related to the signal reflected from the particular depth inside the medium under test. This phase depends on dielectric properties of reflecting targets and thus can be used for their discrimination. Both amplitude and phase data is combined further in common GPR image where brightness is related to the amplitude of reflection and the phase profile is represented by color. The phase-extraction algorithm does not employ heavy computations and therefore is well suited for practical applications. Advantages of the method as compared to other data processing methods are shown using simulated data. The method performance is demonstrated also in several experimental examples.**

I. Introduction

Versatile practical applications of UWB subsurface radar imaging such as detection of different objects in the ground, mapping of buried utilities, non-destructive inspection of roads, bridge decks and concrete structures in civil engineering stimulate researchers to the development of more effective methods of microwave visualization. Discrimination and classification of hidden reflectors is one of the most challenging tasks of the radar data processing. Typically, the approach involves first building of the subsurface image by one of the techniques such as SAR and migration [1-2] or inverse scattering [3-4]. Then, pattern recognition is utilized to discriminate targets by their shape and dielectric properties (in case of inverse scattering).

Another widely used approach is based on the extraction of features from the received signal using even a single snapshot of the ground [5].

The B-scan in the form of the impulse response in the case of pulse GPR of a Fourier transform of the frequency-swept radar can be also analyzed by experienced user to distinguish responses of buried targets. Unfortunately, typical GPR image lacks of clarity and contains a lot of undesired components caused by clutter and inhomogeneity of the ground and its surface.

However, some of observed oscillations in the microwave image are quite natural and follow from limited bandwidth of the radar. That is why the data processing techniques suppressing oscillations of real and synthesized pulses could improve quality of the subsurface image.

The approach proposed in this work is aimed at solution of this problem. This is done by separate evaluation of the amplitude and phase of reflected signal as a function of the depth. Then, the subsurface image is formed so that the amplitude is associated with the brightness and the phase is related to the color of the image. Such technique is expected to yield more understandable GPR image in which the targets can be detected as bright spots and moreover discriminated by color.

However, determination of the phase profile needed for described approach is a separate challenging task because the phase of received signal depends on the frequency and contains phase of propagation that is to be removed. A technique of evaluating the phase profile based on expanding the received signal into dominant components and their separate processing is presented, too.

II. Description of the Method

Consider performance of the method on the example of single A-scan and simulated input data. Let the dielectric half-space of interest be represented by layered medium with the permittivity profile shown in Fig. 1.

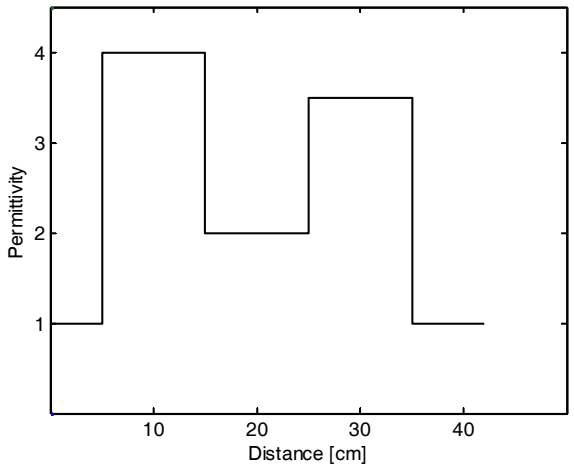

Fig. 1 Permittivity profile of the half-space