A Vertical Differential Configuration in GPR prospecting

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The rejection of the direct coupling between the antennas is an issue of interest in several GPR applications, especially when it is important to distinguish the targets of interest from the clutter and the signal reflected from the air soil interface. Therefore, in this framework several hardware and software strategies have been proposed. Among the software strategies, probably the most common one is the background removal [1], whereas as an hardware strategy the differential configuration has been introduced in [2-3] and then further on studied in [4] with respect to the spatial filtering properties of the relevant mathematical operator. In particular, the studies proposed in [1] and [4] have shown that, in general, all the strategies for the rejection of the direct coupling have necessarily some drawback, essentially because it is not possible to erase all and only the undesired contributions leaving "untouched" the contributions of the targets of interest to the gathered signal.

With specific regard to the differential configuration, in [2-3], the differential configuration consisted in a couple of receiving antennas symmetrically placed around the transmitting one, being the three antennas placed along the same horizontal segment. Therefore, we might define that configuration as a "horizontal differential configuration".

Here, we propose a novel differential GPR configuration, where the two receiving antennas are still symmetrically located with respect to the transmitting one, but are placed piled on each other at different heights from the air-soil interface, whereas the transmitting antenna is at the medium height between the two receiving one (however, it is not at the same abscissa but at a fixed horizontal offset from the receiving antennas). Such a differential configuration has been previously presented in [5-6] and allows a good isolation between the antennas, while preserving the possibility to collect backscattered signals from both electrically small objects and interfaces. This configuration can be labeled as a vertical differential configuration.

At the conference, the reconstruction capabilities of this differential GPR configuration system will be discussed by means of an analysis of the problem based on a properly designed microwave tomographic inversion approach. The proposed approach exploits the Born approximation and faces the imaging as the solution of a linear inverse scattering problem. In this way, the problem of the local minima is avoided [7] and it is possible to impose some regularization to the problem in an easy way problem [8-9]. At the conference, a theoretical analysis of the mathematical propserties of the scattering operator under the vertical differential configuration will be presented showing that, with respect to the horizontal differential configuration, the vertical one allows to reject the direct coupling between the antennas but not the coupling of the antennas occurring through the air-soil interface. On the other hand, the filtering properties of the operator at hand con be considered, let say, less severe in some cases. At the conference, both some numerical and experimental results will be shown.

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