Geophysical Research Abstracts
Vol. 16, EGU2014-12971, 2014
EGU General Assembly 2014

Characterisation and optimisation of Ground Penetrating Radar antennas

Craig Warren (1) and Antonios Giannopoulos (2)

(1) School of Engineering and the Built Environment, Edinburgh Napier University, United Kingdom (C.Warren@napier.ac.uk), (2) Institute for Infrastructure and Environment, University of Edinburgh, United Kingdom (Antonis.Giannopoulos@ed.ac.uk)

Research on the characterisation and optimisation of Ground Penetrating Radar (GPR) antennas will be presented as part of COST Action TU1208 “Civil Engineering Applications of Ground Penetrating Radar”. This work falls within the remit of Working Group 1 – “Novel GPR instrumentation” which focuses on the design of innovative GPR equipment for Civil Engineering (CE) applications, on the building of prototypes and on the testing and optimisation of new systems.

The diversity of applications of GPR has meant there are a number of different GPR antenna designs available to the end-user as well as those being used in the research community. The type and size of a GPR antenna is usually dependent on the application, e.g. low frequency antennas, which are physically larger, are used where significant depth of penetration is important, whereas high frequency antennas, which are physically smaller, are used where less penetration and better resolution are required. Understanding how energy is transmitted and received by a particular GPR antenna has many benefits: it could lead to more informed usage of the antenna in GPR surveys; improvements in antenna design; and better interpretation of GPR signal returns from the ground/structure. The radiation characteristics of a particular antenna are usually investigated by studying the radiation patterns and directivity. For GPR antennas it is also important to study these characteristics when the antenna is in different environments that would typically be encountered in GPR surveys.

In this work Finite-Difference Time-Domain (FDTD) numerical models of GPR antennas have been developed. These antenna models replicate all the detailed geometry and main components of the real antennas. The models are representative of typical high-frequency, high-resolution GPR antennas primarily used in CE for the evaluation of structural features in concrete: the location of rebar, conduits, and post-tensioned cables, as well as the estimation of material thickness on bridge decks and pavements. Radiation patterns obtained using the antenna models as well as physical measurements have been used to investigate the radiation characteristics of high-frequency GPR antennas. Studies were conducted with homogeneous materials of different dielectric constants (Er=3, 10, 30, & 72) and at a range of observation distances. The first objective was to compare, using the FDTD antenna model, ‘traditional’ transmitted field patterns with field patterns obtained using responses from a target spaced at regular intervals around the circumference of a circle, i.e. received energy. Our initial results show, for the same dielectric and observation distance, E- and H-field patterns obtained using the received energy approach have a significantly narrower main lobe than the traditional transmitted patterns. This raises the question of which approach is more beneficial for the characterisation of GPR antennas, and hence better interpretation of GPR responses. The second objective was to compare modelled field patterns with measured patterns obtained from a commercial high-frequency GPR antenna using the received energy approach. The measurements were made in different oil-in-water emulsions which were used to simulate materials with different permittivities and conductivities. Initial comparisons of the measured and modelled data show a very good correlation, which validates use of the antenna model for further studies.