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Time-Frequency Transform Techniques Applied to Ultra-wideband Ground-Penetrating Radar

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Background

Recently, Dauvignac et al [1] utilized a ground penetrating radar unit consisting of an exponentially tapered slot antenna (ETSA) of the Vivaldi type, connected to an Agilent vector network analyzer to obtain a densely-sampled profile in the anti-blast tunnel of LSBB (Low-Noise inter-Disciplinary Underground Science & Technology Laboratory) located in Rustrel, France. The frequency data, from 150 MHz to 2 GHz, was inverse Fourier-transformed to obtain the time dependent data. Simultaneously, the same profile was obtained using a RAMAC 500 MHz ground-penetrating radar unit. Initial comparison of both data sets was done in the time-domain. Data obtained from the ETSA will be inverted using a constrained least squares algorithm, in order that the depth-dependent permittivity can be inferred. As a quality control, the RAMAC data will also be inverted. The resulting permittivity profiles obtained in both inversions will be used to image water content over a depth of several meters.

Proposed Research

It is well-known, qualitatively in the ground penetrating radar literature that high frequencies appear at early times, but generally are attenuated at later times, essentially due to the skin effect. However, a signal-processing verification of this well-known result is needed. We propose to use the Stockwell or S transform [2] to determine the temporal location of frequencies in both of the foregoing datasets. The S transform, a short-time Fourier transform with a frequency-dependent window, will be described and applied to synthetic data. Then the application of the S transform to the RAMAC and ETSA data will be presented, after each data set has undergone the same pre-processing. The S transform is completely linear and preserves the phase of the data, which allows for easy interpretation of the operations of filtering, due to the linear inverse of the forward S transform. Thus the S transform is ideal for comparing the temporal distribution of frequency in these two datasets.

BIBLIOGRAPHY

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