Complex Permittivity Determination from Measured Scattering Parameters of TEM Waveguides

Geophysical Research Abstracts
Vol. 13, EGU2011-13103, 2011
EGU General Assembly 2011

Complex Permittivity Determination from Measured Scattering Parameters of TEM Waveguide

Stefano Ferraris (1), Patrizia Savi (2), and Ivan Maio (2)

(1) Universita degli Studi di Torino, Dipartimento di Economia e Ingegneria Agraria, Forestale e Ambientale (D.E.I.A.F.A.), Sezione di Idraulica Agraria,Via Leonardo da Vinci - 10095 - Grugliasco (TO), Italy, stefano.ferraris@unito.it, (2) Politecnico di Torino, Dipartimento di Elettronica, Corso Duca degli Abruzzi 24, Torino, 10129 Italy, patrizia.savi@polito.it

An important method to estimate the permittivity of dielectric materials is based on the measurement of the scattering parameters of a TEM (Transverse Electro-Magnetic) waveguide filled by the dielectric to be characterized and on the inversion of the scattering response for the unknown permittivity. This approach is exploited in many applications where the estimation of the permittivity over wide frequency bands is required, as in the characterization of dielectric materials for electronics packaging and in the measurement of the permittivity of soils in soil science. In a uniform TEM waveguide the relation between the permittivity of the filling dielectric and the propagation function is simple, and the resulting inversion problem is readily solved. In order to connect a uniform TEM waveguide to a Network Analyzer for the measurement of the scattering parameters, however, the waveguide must be completed by suitable launchers at its ends. Depending on the specific application, the launchers can introduce a significant discontinuity, and can lead to a transmission response of the waveguide plus launchers quite different from the propagation function of the waveguide alone. The problem then becomes how to eliminate the effects of launchers from the measured scattering responses of the waveguide and its launchers (de-embedding), obtaining the transmission response of the waveguide alone. For this problem, several method have been developed, *e.g.*, see [1,2,3]. The double-delay method of [2], in particular, seems well suited to the de-embedding of the propagation function of a waveguide terminated by arbitrary launchers.

In this paper, we apply the double-delay method to estimate the complex dielectric permittivities from the measured scattering responses of TEM waveguides. The double-delay method is based on the scattering responses of a pair of test structures composed of a segment of the waveguide being characterized and its launchers. The two test structures must differ for the length of the waveguide segment only. Furthermore, the shortest waveguide segment must be long enough to guarantee that a pure TEM propagation takes place for a part of the segment. Two coaxial probes of different lengths have been used in this study (Maury Microwave Airline, model no. 2653S10, length $\ell_1 = 10.5\,\mathrm{cm}$ and $\ell_2 = 20\,\mathrm{cm}$, load shield and inner conductor radii $3.5\,\mathrm{mm}$ and $1.5\,\mathrm{mm}$, respectively, dc-resistance of inner conductor $9.4\,\mathrm{m}\Omega/\,\mathrm{m}$). The ability of the double-delay method to de-embed the effect of the launchers and to correctly estimates the complex dielectric permittivity is verified on various sandy soil with different water contents rates.

References

[1] A. M. Nicolson and G. F. Ross. Measurement of the intrinsic properties of materials by time-domain techniques. *IEEE Trans. on Instr. and Measurement*, IM-19(4):377–402, Nov. 1970.

[2] J. C. Rautio. A de-embedding algorithm for electromagnetics. *International Journal of Microwave and Millimeter-Wave Computer-Aided Engineering*, 1(3):282–2S7, 1991.

[3] M. Farina, A. Morini, and T. Rozzi. A calibration approach for the segmentation and analysis of microwave circuits. *, IEEE Trans. on Microwave Theory and Techniques*, 55(10):2124–2134, 2007.