Broadband Measurement Method for Complex Permittivity and Permeability of Materials Using Hybrid Numerical Calculations

Hayato Miyagawa

An accurate evaluation of complex permittivity and permeability of the materials is essential for the design of broadband microwave devices and equipment. In the past few decades, many evaluation methods have been reported for the electromagnetic properties of lossy materials using waveguides or coaxial lines. However, these conventional measurement methods based on a simple transmission-line theory require that the cross-section of guiding structure has to be filled up by the sample closely to eliminate the influence of the air gap between the conductor and the sample. As a result, it makes the measured amplitude of S21 too week and degrades the accuracy of measurement data, when the sample is a lossy and/or high permittivity or permeability material

This study intends to introduce a new evaluation method of complex permittivity and permeability of the materials. The method is based on the hybrid electromagnetic analysis, which combines the extended spectral domain approach with the mode matching method (ESDMM). The EM analytical method can treat the scattering problems in waveguide even for the high dielectric and/or lossy obstacles of electrically small or large size. A suitably thinner and smaller sample, which occupies only a small portion of the cross-section, can be used to get the adequate amount of S parameters. In this method, only S21 parameters of a piece of sample are measured, and the measurements of reflection parameter S11, more difficult-to-calibrate than S21 parameters, are not required. The method measures two S21 parameters for the same sample placed at two different positions in the waveguide cross-section to evaluate and of materials simultaneously.

The numerical computations in the present method are efficient and are suitable for the iterative calculations to extract the material characteristics. The arbitrarily-shaped samples can be estimated by dividing the sample into thin slab regions.

This method realizes the evaluation of the frequency dependent characteristics of various materials.