Relative Permittivity Extraction of Textile Materials Based on Ridge Gap Waveguide Technology

Shoukry I. Shams, Muhammad M. Tahseen, and Ahmed A. Kishk
ECE Department, Concordia University, Montreal, Quebec,
Canada, www.ece.concordia.ca

The Textile materials are widely used recently in microwave applications. The wearable antennas and the medical applications generate high potential to explore the electrical characteristics of the Textile materials. The mechanical properties of such materials are well known but the challenge is to determine the electric characteristics in an accurate way specially the relative permittivity. There are many traditional methods to identify the relative permittivity of an unknown material e.g. Coaxial probe method, the waveguide method, the free space method, and the cavity method. On the other hand, the Textile materials have relatively small standard thickness. This put some limitations on the used measurement technique. The objective is to select a suitable measurement technique for wide band operation and a small thickness for the sample under test.

The Ridge Gap Waveguide (RGW) is a guiding structures. Its basic idea is to carry the signal in the form of Quasi TEM mode inside a parallel plate like structure. The signal is prevented from escaping outside the required path by having periodic cells at the ridge level. These periodic cells form an Artificial Magnetic Conductor (AMC) surface. The Perfect Electric Conductor (PEC) on top with the AMC on bottom inhibit the wave propagation in all directions. Two main characteristics of this configuration are the main reason behind the idea of using it in the relative permittivity extraction procedure. The propagating mode inside this guiding structure is the Quasi TEM mode which will lead to straight forward calculations in finding the dielectric constant. The second characteristic is the small gap size of the RGWs which is suitable for the standard samples of the Textile materials.

The RGW is excited with a standard line and it is calibrated via TRL method. This process is performed to shift the reference plane to be exactly at the starting point of the sample under test. The second step is placing the Sample under test inside the gap of the RGW. The scattering parameters are obtained while the textile material is filling the gap. The overall insertion loss curve has a sinusoidal behavior related to the reflection at the interface surface between the sample under test and the air filling the rest of the RGW. This reflection coefficient is a function of the relative permittivity. A simple formula is derived to obtain the relation between the insertion loss and the relative permittivity, which is used to extract the required dielectric constant. This procedure is applied in the Ku-band with a sample of well known permittivity to perform a validity check. The relative permittivity is obtained with an average error of 3 % .