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Design of resonator cavity for liquid material characterization

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ABSTRACT

Dielectric characterization is very essential before the material can be utilized in designing microwave networks. Circular cylindrical resonators have been widely used for material characterization, but it is not a preferable design during the measurement of liquid samples as the sample placement requires repetitive process of opening and closing the lid of the cavity. This repetition procedure easily affects the accuracy of measurement and may lead to a measurement error. In this study, a rapid and less measurement procedure of liquid material characterization is proposed. The proposed rectangular resonator design is far more convenient and easier to handle as it does not require complex sample preparation. Considering electric field leakage, a hole is designed at the top of the cavity to ease the inserting process of sample. A 5-GHz prototype of a rectangular resonator is designed and fabricated to measure a liquid sample. Complex scattering parameters are measured using a vector network analyzer before the dielectric properties are estimated using an inverse technique. The dielectric properties of distilled water are measured to demonstrate the practicality of the proposed measurement technique. As a result, the measured dielectric properties of distilled water show a reasonable agreement with the values from other literature.

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1. INTRODUCTION

The rapid expansion of wireless networking, communication [1], radar, and medical systems [2], [3] necessitated the development of novel materials in radio frequency (RF) and microwave engineering. Apart from the geometry and design of devices, microwave design is heavily influenced by the dielectric characteristics of materials. Consequently, accurate measurement in material characterization is critical for RF/microwave engineering as well as for low frequency applications such as insulator development.

Many researchers have developed microwave sensors and measurement techniques for material characterization that are based on free-space, transmission line and resonant methods. The free-space method is grouped under the non-destructive and non-contact dielectric measurement methods that are applicable in material characterization [4]-[6]. A sample is placed between the transmitting and receiving antennas, which are typically horn antennas. Scattering parameters can be measured using a vector network analyzer (VNA). This method does not require sample machining but is easily affected by the noise due to the open system. Another closed system technique used in material characterization is the transmission line. The benefit of this