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Temperature Dependence of Complex Permittivity of Flame Retardant Circuit Boards

Sreedevi P. Chakyar · Sherin Thomas · Sikha K. Simon · Nees Paul · Joe Kizhakooden · Anju Sebastian · Jolly Andrews · Joseph V. P.

Abstract The temperature dependence of complex permittivity of flame retardant (FR) printed circuit board (PCB) samples is carried out using a resonance property of metamaterial split ring resonator structure. Different PCB laminates used for the study are placed in close contact with (SRR) test probe and is arranged inside a temperature controllable wooden chamber. The variation in the resonant frequency of the SRR with temperature in presence of the sample is measured by arranging it in between the transmitting and receiving probes of a vector network analyzer (VNA). Using theoretically developed equations the real and imaginary parts of permittivity at different temperature is calculated from the shift in resonance frequency and Q-factor. Results are verified by simulating the resonant frequencies from the calculated values of temperature dependent permittivity.

Keywords Metamaterial · Split Ring Resonator · Flame Retardent boards · Temperature dependent permittivity

Flame retardent (FR) Printed circuit boards (PCBs) are dielectric materials whose electrical properties strongly depend on their composites and fabrication procedure. One desirable condition for the faithful functioning of electromagnetic gadgets is to have thermal stability of the dielectric constant and loss tangent of the PCB laminates. In different electronic circuits the heat produced during operation can affect the performance of the FR board sub-

Sreedevi P. Chakyar, Sherin Thomas, Sikha K. Simon, Jolly Andrews & Joseph V. P.
Department of physics, Christ College (Autonomous), Irinjalakuda, University of calicut, Kerala, India
Nees Paul & Joe Kizhakooden
Department of physics, Christ College (Autonomous), Irinjalakuda, University of calicut, Kerala, India
Department of physics, St. Thomas College (Autonomous), University of Calicut, Kerala, India E-mail: vpjo@christcollegeijk.edu.in

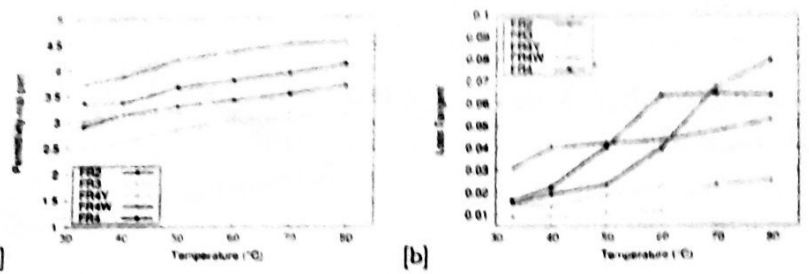

Fig. 1 Variation of (a) real part of permittivity and (b) loss tangent with temperature for five different FR board samples

strate which in turn adversely affect the operation of the circuit as a whole. Hence, the study of dependence of temperature on the electrical properties of the laminates is an important area in designing electronic circuits and antennas. Only a few attempts are found in literature in this regard [1],[2]. But, extensive sample preparation, bulky experimental setup and rigorous calculation methods make them less desirable. In this work we use the dependence of complex permittivity on resonant frequency and Q factor of metamaterial resonating structure SRR to measure the temperature dependent complex permittivity of FR board samples using the equations given in [3].

Five different types of FR boards samples are used for the study. SRR of resonant frequency 3.6 GHz is used as the test probe and is placed between two monopole antennas connected to transmitting and receiving probes of a vector network analyzer (VNA). For uniform heating of the sample, SRR test setup is placed inside a thermally insulated box, which is having an arrangement to increase the temperature using an infrared lamp and having provisions for accurate measurement of temperature.

Figures 1(a) and 1(b) show the variation of the real part of permittivity and loss tangent calculated using equations from the resonant frequencies and Q-factors obtained from the experiments for different temperature. Significant changes in real and imaginary parts are observed even for an experimental band of temperature difference 50 °C. From the experimentally obtained values of permittivity, the resonant frequencies for different temperatures are simulated and are found to be in agreement with experiment. In various fields employing circuit boards especially in microwave systems, this study may help in the detection and removal of undesirable noise effects which may be more prominent during sudden temperature changes in the environment due to various reasons.

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