A NOVEL MICROWAVE SENSOR WITH HIGH-Q RESONATOR FOR HIGH SENSITIVITY MATERIAL CHARACTERIZATION

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A NOVEL MICROWAVE SENSOR WITH HIGH-Q RESONATOR FOR HIGH SENSITIVITY MATERIAL CHARACTERIZATION

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DECLARATION

I declare that this thesis entitled “A Novel Microwave Sensor with High-Q Resonator for High Sensitivity Material Characterization” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering

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Supervisor Name : Associate Professor Dr. Zahriladha Zakaria

Date : .................................................................
DEDICATION

To my beloved mother and father
ABSTRACT

The use of novel microwave sensor on material characterization is an attractive idea. There are many applications that could benefit from this such as food industry, quality control and biomedical applications. The potential for highly accurate measurements of characterizing the material properties is offered by microwave resonant techniques at single or discrete set of frequencies. Conventionally, coaxial cavity, waveguide, and dielectric resonators have been used for characterizing the properties of materials. However, there are also challenges that arise from these resonators. One of them is the problem of fabricating the sensors which increase the cost and the other one they require large amount of circuit size and consequently require similar processing capability which restrict their use in many important applications. Thus, planar resonant techniques have gained a considerable interest over the past few years due to their advantages such as low cost, ease of fabrication and compact in circuit size. Conversely, these techniques suffer from low sensitivity and poor Q-factors which constrain their use and limit the range of materials characterizing applications. Therefore, this thesis presents novel structures of planar microwave sensors for detecting and characterizing the dielectric properties in common solids materials which produce high Q-factor with capability to suppress undesired harmonic spurious. These planar resonator structures are based on novel metamaterial symmetrical split ring resonator (SSRR) with and without spurlines filters by employing the perturbation theory, in which the dielectric properties of the resonator affect the Q-factor and resonance frequency. The sensors are designed at operating frequency of 2.2 GHz with resonant frequency ranging from 1 GHz to 10 GHz. As a results, the sensors achieve narrow resonance with low insertion loss and high Q sensitivity which peaked up to 652 at 2.2 GHz operating frequency. The circuit size of symmetrical split ring resonator is minimized about 30 % of total size by introducing spurlines filters. By using a specific experimental methodology, practical materials have been used as standards to validate the sensitivity of the sensors for permitting potentially material characterization and determination. In addition, a detailed sample thickness analysis has been carried out and accordingly the mathematical equation is derived to extract the materials with unknown properties. Experimentally, the measured and theoretical results are found in an excellent agreement with a 2 to 3 % possibility of typical error in the permittivity measurements. The average accuracy percentage of the measured results for all cases of the designed sensors is found within 97 to 98 % compared to those in literatures which has an average accuracy percentage of 91 to 92 % for the same tested standard materials. The most significant of using SSRR sensors with and without spurlines filters are to be used for various industrial applications such as food industry, quality control, bio-sensing medicine and pharmacy applications. It is believed that these techniques would lead for a promising solution of characterizing material particularly in determining material properties and quality.
ABSTRAK

Adalah dipercayai bahawa teknik-teknik ini akan membawa penyelesaian dalam pencirian sesuatu bahan terutamanya dalam menentukan sifat bahan dan kualitinya.
I would like to express my gratitude to all those who gave me the possibility to complete this thesis. I am deeply indebted to my main supervisor Associate Professor Dr. Zahriladha Zakaria from Faculty of Electronic and Computer Engineering, Universiti Teknikal Malaysia Melaka (UTeM), whose help, stimulating suggestions and encouragement helped me in all the time of research and writing of this thesis.

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