DESIGN AND ANALYSIS OF DUAL BAND T-RESONATOR MICROWAVE SENSOR FOR MATERIAL CHARACTERIZATION

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

I dedicated this thesis to my beloved parents, Md Kamal Bin Abdul Manaf and Roslinda Binti Ramli for always be my backbone to complete the research.

ABSTRACT

Microwave sensor which is known as resonant sensor are design that is the most popular for sensor application in detecting material characterization. This design can be seen in food industry, biomedical and material industrial application. Measurement of dielectric constant on any material is important in those respective industry by using microwave resonant technique which is used at single or discrete frequency. Conventionally, there are many kinds of resonant sensor, and has been realized in the respective industry such as waveguide, coaxial and dielectric resonator. Nevertheless, their traditional technique produces them in bulky size and high cost for manufacturing the resonator. Thus, past research conclude that planar resonant technique has the advantages due to their size comparably smaller resulting low costs manufacturing process. However, by comparing the most important perspective which is sensitivity and Q-factor, the planar technique is definitely lower than the others and limited by the range of resonant it produced. Therefore, this thesis introduces a different implementation of the same planar technique which is dual band metamaterial to overcome the disadvantages of sensitivity. The dual band sensor operates in two different frequencies in range of 1GHz to 5 GHz. It can be used with either solid, liquid, gas or powder, depends on the sensor structure and design with

Polydimethylsiloxane (PDMS) as a container for the material under test (MUT). The design will be simulated in computer simulation technology (CST) and as a result, produces narrow resonance and high Q-factor comparable to previous researchers' thesis. This proof that the proposed sensor can be one of the solutions to characterize material dielectric constant for determining its properties and quality level.

ABSTRAK

Penderia gelombang mikro yang dikenali sebagai penderia resonan adalah reka bentuk yang paling popular untuk aplikasi penderia dalam mengesan pencirian bahan. Reka bentuk ini boleh dilihat dalam industri makanan, aplikasi industri bio-perubatan dan bahan. Pengukuran pemalar dielektrik pada sebarang bahan adalah penting dalam industri masing-masing dengan menggunakan teknik resonan gelombang mikro yang digunakan pada frekuensi tunggal atau diskret. Secara konvensional, terdapat pelbagai jenis sensor resonan, dan telah direalisasikan dalam industri masing-masing seperti pandu gelombang, sepaksi dan resonator dielektrik. Namun begitu, teknik tradisional mereka menghasilkannya dalam saiz yang besar dan kos yang tinggi untuk pembuatan resonator. Oleh itu, kajian lepas menyimpulkan bahawa teknik resonan satah mempunyai kelebihan kerana saiznya yang lebih kecil menyebabkan proses pembuatan kos rendah. Walau bagaimanapun, dengan membandingkan perspektif yang paling penting iaitu kepekaan dan faktor Q, teknik planar pastinya lebih rendah daripada yang lain dan dihadkan oleh julat resonan yang dihasilkannya. Oleh itu, tesis ini memperkenalkan pelaksanaan berbeza bagi teknik planar yang sama iaitu dua jalur metamaterial untuk mengatasi kelemahan sensitiviti. Penderia jalur dwi beroperasi dalam dua frekuensi berbeza dalam julat

1GHz hingga 5 GHz. Ia boleh digunakan dengan sama ada pepejal, cecair, gas atau serbuk, bergantung pada struktur penderia dan reka bentuk dengan Polydimethylsiloxane (PDMS) sebagai bekas untuk bahan dalam ujian (MUT). Reka bentuk akan disimulasikan dalam teknologi simulasi komputer (CST) dan hasilnya, menghasilkan resonans sempit dan faktor Q yang tinggi setanding dengan tesis penyelidik terdahulu. Bukti ini bahawa sensor yang dicadangkan boleh menjadi salah satu penyelesaian untuk mencirikan pemalar dielektrik bahan untuk menentukan sifat dan tahap kualitinya.

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LIST OF SYMBOLS AND ABBREVIATIONS

PDMS	:	Polydimethylsiloxane
DUT	:	Device Under Test
MUT	:	Material Under Test
FR-4	:	Flame Retardant 4 (UL94V-0 Standard) (Glass Name)
CST	:	Computer Simulation Technology
VNA	:	Vector Network Analyzer
PCB	:	Printed Circuit Board
PM	:	Perturbation Method
TM	:	Transverse Magnetic
TE	:	Transverse Electric
VC	:	Empty Cavity
GHz	:	Giga Hertz
MHz	:	Mega Hertz
Hz	:	Hertz
CSSR	:	Complementary Split Ring Resonator
SMA	:	Sub Miniature Version A
EM	:	Electromagnetic
S21(dB)	:	Insertion Loss
S11(dB)	:	Return Loss

μ_0	:	Permeability
BW	:	Bandwidth
f_c	:	Resonant Frequency Without Sample
f_s	:	Resonant Frequency With Sample
Q	:	Quality Factor
f_r	:	Resonance Frequency
Δf_r	:	Resonance Frequency Shifting
$\Delta \mu$	:	Permeability Changes
$\Delta \varepsilon$	:	Permittivity Changes
V	:	Perturbed Volume
E_0, H_0	:	Field Distribution Without Perturbation
E_1, H_1	:	Field Distribution With Perturbation
ε_r	:	Dielectric Constant
ε'_r	:	Actual Permittivity
ε''_r	:	Imaginary Part of Permittivity
μm	:	Micrometer
Zo	:	Input Impedance
εeff	:	Effective Dielectric Constant
h	:	Height of Substrate
Lf	:	Microstrip Line
Lfeed	:	½ Microstrip Line
fo	:	Resonant Frequency
Wp	:	Width of Patch
Lp	:	Length of Patch

Lstub	:	Length of Patch (stub)
Ls	:	Length of Substrate
Ws	:	Width of Substrate

LIST OF APPENDICES