



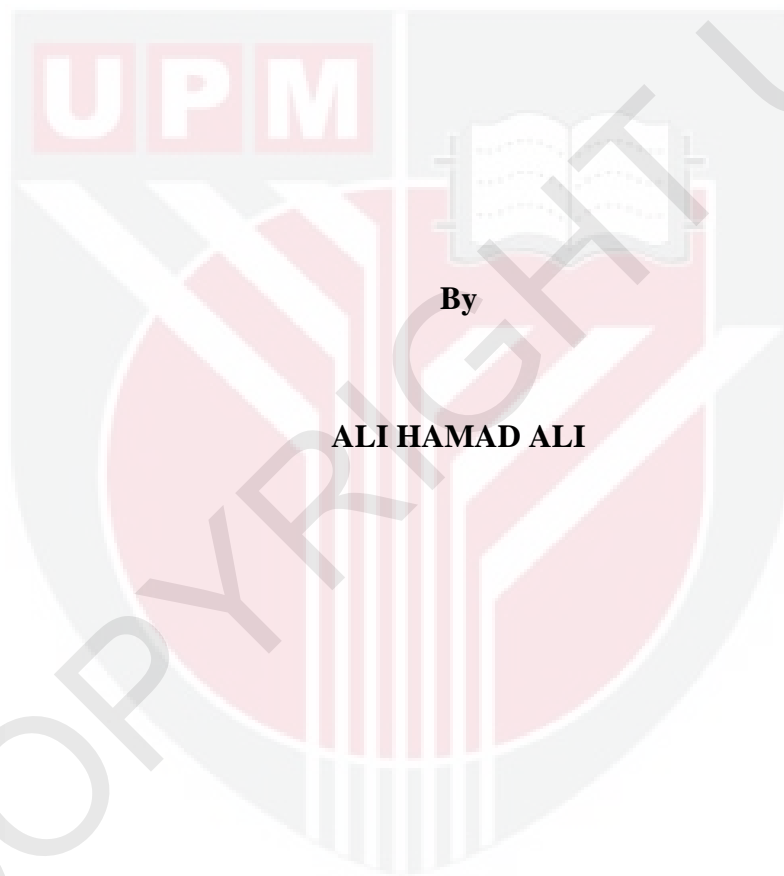
**UNIVERSITI PUTRA MALAYSIA**

**NOVEL MONOPOLE ANTENNA TECHNIQUE FOR DETERMINATION  
OF MOISTURE CONTENT IN HEVEA RUBBER LATEX**

**ALI HAMAD ALI**

**FS 2011 86**

**NOVEL MONOPOLE ANTENNA TECHNIQUE FOR DETERMINATION  
OF MOISTURE CONTENT IN HEVEA RUBBER LATEX**



**By**

**ALI HAMAD ALI**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in Fulfilment of the Requirements for the Degree of Master of Science**

**July 2011**

**DEDICATION**

*Specially dedicated to my beloved Parents*



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UPM

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment  
of the requirement for the degree of Master of Science

**NOVEL MONOPOLE ANTENNA TECHNIQUE FOR DETERMINATION  
OF MOISTURE CONTENT IN HEVEA RUBBER LATEX**

By

**ALI HAMAD ALI**

**July 2011**

**Chairperson: Zulkifly Abbas, PhD**

**Faculty: Science**

In this thesis the determination of moisture content in hevea latex using novel monopole antenna technique is described. The measurement set-up includes a computer controlled Professional Network Analyzer (PNA) of model N5230A and monopole antenna. The antenna was connected to the PNA using a low-loss coaxial cable to measure magnitude of reflection coefficient from 2.2 GHz to 2.7 GHz. Measurement of complex relative permittivity of hevea latex was done by using coaxial line probes (HP 85070B) coupled with the PNA. The actual moisture content was found by using standard oven drying method.

Data analysis has been carried out to establish optimal operating frequency based on the relationship between the magnitude of reflection coefficient and moisture content from 20% to 80% for all frequencies where minimum reflections took place and other selected frequencies. Functional relationships have been developed between

magnitude of reflection coefficient, frequency shifts and moisture content. The magnitude of reflection coefficient was found to increase linearly as moisture content increasing from 2.2 GHz to 2.3 GHz. A linear relationship between frequency shifts ( $\Delta f$ ) and moisture content from 2.2 GHz to 2.7 GHz was also obtained. The performance characteristic of monopole antenna as a hevea latex moisture sensor was given as well as comparison between measured and calculated values of impedance at 2.30 GHz, results was found decreasing with increasing moisture content. The results obtained in this aspect are in good agreement at low moisture content (i.e.  $\leq 40\%$ ). The relationship between the reflection coefficient magnitude and measurement data at low moisture content section was more linear with higher sensitivity compared to those at high moisture content sections. Furthermore, the mean linearity error at low moisture content section was large than at high moisture content sections. The probability distribution of error was normal and almost symmetric with value of skewness equal to zero.

By comparing the results from other microwave methods with the results obtained from this study, this technique is very potential and successfully determined the amount of moisture content in hevea latex from 20% to 80% at a frequency of 2.3 GHz. This technique is non-destructive and the sensor is very cheap which cost only two dollars and since there is no chemical reagent needed there will be no daily expenditure. This method is accurate and rapid because it does not requires laborious sample preparation and the whole operation only takes few minutes. The antenna can be used to measure specified range of moisture content in hevea latex based on measured magnitude of reflection coefficient alone at 2.30 GHz within  $\pm 1.5595\%$  of error.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**TEKNIK BARU ANTENA SEKUTUB UNTUK MENENTUKAN  
KANDUNGAN KELEMBAPAN DALAM SUSU GETAH**

Oleh

**ALI HAMAD ALI**

**Julai 2011**

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Tesis ini menerangkan penentuan kandungan kelembapan dalam susu getah dengan menggunakan teknik baru antena sekutub. Set ujikaji pengukuran merangkumi Penganalisa Rangkaian Profesional N5230A atau Professional Network Analyzer (PNA) dengan kawalan komputer dan antena sekutub. Antena disambungkan ke PNA untuk mengukur pekali pantulan magnitud menggunakan kabel sepaksi kehilangan-rendah dari 2.2 GHz hingga 2.7 GHz. Pengukuran bagi ketelusan relatif kompleks bagi susu getah telah diukur menggunakan proba sepaksi hujung-terbuka (HP 85070B) yang disambungkan dengan PNA. Jumlah kandungan kelembapan sebenar diperolehi dengan menggunakan teknik pengeringan ketuhar. Analisis data telah dijalankan untuk mengukuhkan frekuensi operasi optimum berdasarkan hubungan antara pekali pantulan magnitud dan kandungan kelembapan dari 20% hingga 80 % untuk semua frekuensi, di mana pantulan minimum berlaku pada frekuensi-frekuensi tertentu. Hubungan antara pekali pantulan magnitud, anjakan

frekuensi dan kandungan kelembapan telah dibina. Pekali pantulan magnitud didapati meningkat secara linear dengan kandungan kelembapan dari 2.2 GHz hingga 2.3 GHz. Hubungan antara anjakan frekuensi ( $\Delta f$ ) juga didapati berkadar terus dengan kandungan kelembapan dari 2.2 GHz hingga 2.7 GHz. Ciri-ciri pencapaian bagi antenna sebagai pengesan kelembapan susu getah telah diperolehi dengan membandingkan nilai-nilai impedans yang diukur dan dikira pada 2.3 GHz, keputusan menunjukkan ianya berkurang dengan kandungan kelembapan. Keputusan yang baik diperolehi dalam aspek ini pada kandungan kelembapan yang rendah (iaitu  $\leq 40\%$ ). Hubungan data pengukuran antara pekali pantulan magnitud dan peratus kandungan kelembapan yang rendah adalah lebih berkadar terus dengan nilai kepekaan yang tinggi berbanding bahagian kandungan kelembapan tinggi. Tambahan pula, ralat purata linear pada kawasan kandungan kelembapan rendah didapati lebih besar berbanding pada kawasan kandungan kelembapan tinggi. Taburan kebarangkalian bagi ralat ini adalah lazim dan hampir simetri dengan nilai sifar. Dengan membandingkan keputusan ini dengan kaedah gelombang mikro yang lain bagi kajian ini, teknik ini sangat berpotensi dan berjaya menentukan kandungan kelembapan susu getah dari 20% hingga 80% pada frekuensi 2.3 GHz. Teknik ini adalah tidak-musnah dan kos pengesan ini sangat murah iaitu dua dollar sahaja dan didapati ianya juga tidak memerlukan bahan kimia yang melibatkan perbelanjaan harian. Kaedah ini adalah cepat dan tepat kerana ianya tidak memerlukan penyediaan bahan yang membebaskan dan keseluruhan operasi hanya mengambil masa beberapa minit sahaja. Antena ini boleh digunakan untuk mengukur julat kandungan kelembapan susu getah yang tertentu berdasarkan pekali pantulan magnitud pada 2.3 GHz dalam lingkungan ralat  $\pm 1.5595\%$ .

## ACKNOWLEDGEMENTS

Alhamdulillah, praise only to the almighty Allah (S.W), without His blessing I could not achieve my goals.

Putting this study together into a thesis is a long and difficult task. In this respect I would like to thank and express my sincere gratitude to my supervisor Dr. Zulkifly Abbas who continued to give me every support and encouragement to go forward. With his persistent guidance, friendship, and humour, I was able to achieve my academic goals and therefore produce this piece of work. Successful completion of this work would not have been possible without his constant support. I would like also to express my sincere gratitude to Associate Professor. Dr. Jumiah Hassan, my co-supervisor, for her guidance, encouragement and instruction during this research. In a special way, I am also grateful to the staff members and entire community of the university for the cooperation and assistance that I received throughout the course. I am touched with the way in which the faculty of science and school of graduate study staffs in general handled our academic issues throughout the course.

This study is financial supported by Scholarship Division of Ministry of Higher Education in Malaysia whom I would like to thank as well. In this line, I also thank Ministry of Education and Vocational Training in Zanzibar for giving me permission to attend the course.

I would like to extend my special thanks to my family for their patience and continuous support. I would not possibly do this work without them.

Appreciation also given to all my fellow students in RF and Microwaves Laboratory in Department of Physics, friends and all other individuals who have supported and encouraged me throughout my academic journey.



I certify that a Thesis Examination Committee has met on 8<sup>th</sup> July, 2011 to conduct the final examination of ALI HAMAD ALI on his Master of Science thesis entitled “**Novel Monopole Antenna Technique for Determination of Moisture Content in Hevea Rubber Latex**” in accordance with the Universities and University Colleges Act 1971 and the Constitutional of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The committee recommends that the student be awarded the degree of Master of Science.

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## DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been dully acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.



\_\_\_\_\_  
**ALI HAMAD ALI**

Date:

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