THE FREE SPACE TRANSMISSION-REFLECTION METHOD TO DETERMINE OF COMPLEX PERMITTIVITY AND COMPLEX PERMEABILITY OF THE DIFFERENT FILLERS RUBBER MATERIALS AT MICROWAVE FREQUENCIES

Thesis is presented in partial fulfillment for the award of the

Bachelor of Electrical Engineering (Hons)

Of

UNIVERSITI TEKNOLOGI MARA

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ACKNOWLEDGEMENT

All praises be to Mighty Allah S.W.T, the Most Gracious and Most Merciful for the strength and blessing me throughput the entire research and completion of this thesis. Peace is upon our prophet Muhammad S.A.W whose has given light to mankind.

I would like to express my gratitude towards my supervisor Associate Professor Dr. Deepak Kumar Ghodgaonkar for the following the chance to work under their guidance, ideas, comments, opinion and full support in complementing this thesis. Without him this work might not be done successfully.

Hereby, I would like to express my deepest thank to Associate Professor Dr. Azemi bin Mohamed for assisting and giving guidance for the rubber materials theory, materials and giving full cooperation towards the success of this project.

I also like to forward my special thanks to Master Student of the Electrical Engineering, Mr. Ermeey bin Abdul Kadir and Mrs. Norhasimah for their cooperation and support towards the success of the project.

Finally, my deepest appreciation goes to my beloved family for their moral and spiritual supports. Last but not least, I would like to take this opportunity to express my appreciation to those that have directly or indirectly contributed towards the progress of this thesis.

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ABSTRACT

The main objective of this project is to develop a free space measurement system at microwave frequencies in the frequency range of 7.5 to 12 GHz (X-band) for measured a reflection coefficient, S_{11} and transmission coefficient, S_{21} of the different filler composition for two major filler which is Carbon Black and China Clay (i.e. 20 part per hundred rubber (pphr) carbon black or 40pphr china clay) for natural rubber. The complex permittivity and complex permeability is calculated from the measured values of S_{11} and S_{21}.

Second objective is to proved that increasing a composition of filler will increased the complex permittivity or electrical constant (ε^*). Third is to proved that rubber is non magnetic material rubber which is gives a complex permeability (μ^*) equal to 1 for real and 0 for imaginary part. Finally, to prove that the carbon black rubbers have higher conductivity properties compared to the china clay rubbers.

The key components of the measurements system consist of transmit and receive spot-focusing horn lens antenna, and the vector network analyzer. For thin, flexible samples, the sample had to be sandwiched between two half-wavelength (at mid band) Teflon plate, to eliminate the effect of sagging. Because of the far-field focusing ability of horn lens antennas free-space measurement can be made at microwave frequency in a relatively compact and simple measurement setup.

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INTRODUCTION

1.1 The Electromagnetic Model

There are two approaches in the development of a scientific subject; the inductive approach and the deductive approach. Using the inductive approach, one follows the historical development of the subject, starting with the observations of some simple experiments and inferring from them laws and theorems. It is process of reasoning from particular phenomena to general principles. A deductive approach, on the other hand, postulates a few fundamental relations for an idealized model. The postulated relations are axioms, from which particular law theorems can be derived [1].

Three essential steps are involved in building a theory on an idealized model. First, some basic quantities germane to the subject of study are defined. Second, the rules of operations of these quantities are specified. Third, some fundamental relations are postulated. In this case the basis quantities are voltages (V), current (I), resistance (R), inductance (L) and capacitance (C). The rules of the operations are those of algebra, ordinary different equations, Laplace transformation, and the fundamental postulates are Kirchoff's voltage and current law [1].

The quantities in electromagnetic model can be divided roughly into two categories; source quantities and field quantities. The source of an electromagnetic filed is invariably electric charges at rest or in motion. However, an electromagnetic field may be cause a redistribution of charges, which will, in turn, change the field; hence the separation between the cause and the effect is not always so distinct.

We use the symbol q (sometimes Q) to denote electric charge. Electric charge is a fundamental property of matter and exists only in positive or negative integral multiples of the charges of an electron: