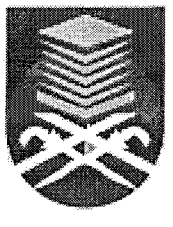
# FREE SPACE MEASUREMENT OF COMPLEX PERMITTIVITY AND COMPLEX PERMEABILITY OF FERRITES MATERIALS USING TRANSMISSION REFLECTION METHOD AT MICROWAVE FREQUENCIES

Thesis is presented in partial fulfillment for the award of the
Bachelor of Electrical Engineering (Honours) (Communication)
UNIVERSITI TEKNOLOGI MARA



HASBULLAH BIN HASSAN
Faculty of Electrical Engineering
UNIVERSITI TEKNOLOGI MARA
40450 SHAH ALAM, SELANGOR

# ACKNOWLEDGEMENT

In the name of Allah, the Beneficent and Merciful. It is with the deepest sense of gratitude to Allah who has given the strength and ability to complete this project and the thesis as it is today.

With this opportunity, I would like to express my gratitude to my project supervisor, Dr Deepak Kumar Ghodgaonkar for his continued guidance and invaluable advice, which has helped me tremendously in completing this project.

I also like give my sincere thanks to my family who have sacrificed so much of all that was theirs to give me a good education and for their never ending prayers. I would like to thank them for being supportive and understanding.

Last but not least, a thousand of thanks to all my friends who gave me all the moral support and encouragement in completing this project.

Hasbullah Bin Hassan
Faculty of Electrical Engineering
UNIVERSITI TEKNOLOGI MARA
40450 Shah Alam.

# ABSTRACT

Measurement of complex permittivity ($\varepsilon^*$) and complex permeability ($\mu^*$) at frequency range 7.5 to 12.5 GHz using transmission reflection method are presented for ferrites material. In this method, the complex permittivity and complex permeability will be calculated from the measured value of reflection coefficient ($S_{11}$) and transmission coefficient ($S_{21}$).

The key components of measurement systems are a pair of spot-focusing horn lens antennas, vector network analyzer and the computer. Because of the far field focusing ability of horn lens antennas, the free space measurement can be made at microwave frequency in a relatively compact and simple measurement set up. The free space line reflects line (LRL) calibration technique is using to eliminate the errors due to multiple reflections between antennas via the surface of the sample. For ferrite that is have high complex permittivity, the sample need to be sandwiched between two quarter wavelength (at mid-band) teflon plates, to eliminate the effect of non-matching problem.

# LIST OF CHAPTERS


| CHAPTER | | PAGE |
|---|---|---|
| 1. | **INTRODUCTION** | |
| | 1.1 Microwave Nondestructive Testing (MNDT) | 1-3 |
| | 1.2 Scope of the Thesis | 4 |
| | 1.3 Complex Permittivity | |
| | 1.3.1 Dielectric Constant | 5 |
| | 1.3.2 Polarization of Dielectric | 5-6 |
| | 1.3.3 Loss Factor | 7 |
| | 1.3.4 Loss Tangent | 7 |
| | 1.4 Complex Permeability | 8-9 |
| 2. | **ELECTROMAGNETICS AND MICROWAVES** | |
| | 2.1 Electric and Magnetic Fields | 10-12 |
| | 2.2 Electromagnetic waves | 12-14 |
| | 2.3 Microwave | |
| | 2.3.1 What are Microwave | 14 |
| | 2.3.2 Characteristic Feature of Microwave | 14-15 |
| | 2.3.3 Application of Microwave | 16-18 |
| 3. | **FERRITES MATERIALS** | |
| | 3.1 Ferrite Material | 19 |
| | 3.2 Preparation of Ferrite | 19-22 |
| | 3.3 Electrical Property of Ferrite | 22 |
| | 3.4 Permeability of Ferrite | 22-23 |
| | 3.5 Microwave Ferrite | 23-26 |

4. **THEORY**

4.1 Calculation for Complex Permittivity and Complex Permeability 27-30

4.2 Calculation of S-Parameter of the sample from measured S-Parameter of the Teflon Plate – Sample – Teflon Plate Assembly. 31-33

5. **EQUIPMENT**

5.1 Vector Network Analyzer 34-36

5.1.1 Network Analyzer Measurement 37-39

5.2 Antenna 39

5.2.1 Requirement 40-43

5.3 Spot Focusing Horn Lens Antenna 44

5.3.1 Lenses 44-45

6. **SET UP MEASUREMENT**

6.1 Experimental work

6.1.1 Objective 46

6.1.2 Measurement Systems 46-47

6.2 Free Space Measurements of S-Parameter 48

6.2.1 Error of Measurement Using Free Space Technique 49

6.3 Transmission Reflection Method Measurement 50-51

6.3.1 Quarter wavelength Line 51-52

6.3.2 Quarter wavelength inside the Teflon. 52-53

7. **RESULTS**

7.1 Experiment Results 54-56

8. **DISCUSSION AND CONCLUSION**

8.1 Discussion 57-58

8.2 Conclusion 59