Universidad Nacional de Colombia
Engineering Faculty
Electric and Electronics Engineering Department

Javier Leonardo Araque Quijano
jlaraqueq@unal.edu.co
Building 453 - office 204
Phone ext.: 14083

Transmission Lines and Antennas, 2012-1
Project 1: Experimental Characterization of dielectric substrates.
Bogotá, D.C., 7 May 2012

Objective

Apply the concepts of transmission line theory in the electromagnetic characterization of a dielectric substrate.

Specific objectives

1. Acquire experience in the design and fabrication of stripline systems and its coupling to coaxial lines.
2. Get acquainted with microwave measurement equipment.

Problem statement and specifications

It is required to implement and test a procedure to compute the dielectric constant and the loss tangent of a dielectric substrate from measurements performed on a stripline built with it.

The specifications are:

1. Frequency band of characterization: 2GHz-3GHz.
2. Allowable range for parameters: $2 \leq \epsilon_r \leq 20$, $0.001 \leq \tan\delta \leq 0.1$.
3. For the characterization students will have access to a Vector Network Analyzer (VNA), which allows measurement of the S-parameters of 2-ports.
4. Besides the ϵ_r and $\tan\delta$ values, it is required to provide the output relative uncertainty considering dimensional tolerances and noise with uniform phase distribution and maximum amplitude of 0.01, which affects all the S-parameters measured.

Grading

Examination will consider the following items:

1. (20%) Stripline system built. Note that stripline can be built easily from a microstrip line topped with a grounded substrate.
2. (50%) Final report (see below for details on format and contents).
3. (30%) Individual (oral/written) evaluation on the theory and practical aspects of the project.

Final Report

Final report must have the official format of the IEEE Transactions, there are templates available in LaTeX and MS-Word in this link (select "template for all Transactions"):

`http://www.ieee.org/publications_standards/publications/authors/authors_journals.html`

The final report must include these sections:

- Abstract
- Background: describes the relevant theory and equations citing the original sources. It is a plus to cite at least one article in literature that describes a technique to measure the dielectric constant of substrates describing the procedure and differences/similarities with the method proposed.
- Measurement technique: describes in detail the experimental and computational procedure to obtain the parameters sought. This must include validation via simulation and output tolerance analysis to assess robustness of the method against dimensional tolerances and measurement noise.
- Validation of the method with simulated data provided by the Professor. This point is important especially if results from experimental data below are not satisfactory, as it validates the algorithm used.
- Experimental results: Description of the procedure followed in the lab, the equipment and materials used and the results after processing the measured data. It contains also a discussion of the results, and possible explanations if some of these are unexpected.
- References.

The report is limited to an extent of five pages; note that additional pages will not be considered.

Schedule and products

- Prototypes will be measured on Saturday 2 June in turns to be defined. Note that you are required to have your system ready by the start of your time slot; failure to comply with this may make you loose altogether the opportunity to do measurements.
- Final report is due by Monday 4 June at midnight. This is to be sent in PDF format to the jlaraqueq@unal.edu.co. You can have a draft of your final report proofread by sending a PDF to this e-mail no later than Saturday 26 May.

Notes on Suggested Readings

The basic equations for the analysis of transmission lines (characteristic impedance, propagation constant, conduction and dielectric loss) can be found in [1, 2, 3]. Methods for dielectric characterization are presented in [4, 5, 6]. Note that reference [6] has errors in the formulas reported; the correct formulas are thus provided in [7] for your convenience.

References

[1] D. M. Pozar, *Microwave Engineering.* John Wiley & sons, 1998.

[2] R. E. Collin, *Foundations of Microwave Engineering.* IEEE press, 2001.

[3] B. C. Wadell, *Transmission Line Design Handbook.* Artech House, 1991.

[4] L. F. Chen, C. K. Ong, C. P. Neo, V. V. Varadan, and V. K. Varadan, *Microwave Electronics, Measurement and Materials Characterization.* John Wiley & Sons, Ltd, 2005.

[5] D. A.R., R. Biljie, V. Likar-Smiljanic, and T. Sarkar, "Wideband frequency-domain characterization of fr-4 and time-domain causality," *Electromagnetic Compatibility, IEEE Transactions on*, vol. 43, no. 4, pp. 662 –667, nov. 2001.

[6] C. Riedell, M. Steer, M. Kay, J. Kasten, M. Basel, and R. Pomerleau, "Dielectric characterization of printed circuit board substrates," *Instrumentation and Measurement, IEEE Transactions on*, vol. 39, no. 2, pp. 437 –440, apr 1990.

[7] J. L. Araque-Quijano, "Computation of transmission line parameters from complex reflection and transmission coefficients," October 2011.