ECE 451

Automated Microwave Measurements Laboratory

Introduction

Welcome to the ECE 451 Automated Microwave Measurements Laboratory! The purpose of this course is to introduce senior and graduate students to the fundamentals of high-frequency measurements and the latest techniques for accuracy-enhanced automated microwave measurements. We start the course in the "dark ages" of microwave measurements and then move into modern measurement and calibration techniques. This progression provides the student with a deeper understanding of what is happening inside the modern network analyzer. As microwave measurement technology matures, the companies who build this equipment are attempting to simplify the process of making a microwave measurement down to a few button presses. While this can improve and speed up the measurement experience, the engineer who depends on this in favor of a deeper understanding is stuck when problems arise. Students leaving this class will not only know how to use a vector network analyzer, but will also be able to understand how this device makes its measurements so as to be able to use it to its full capability and handle possible errors when they arise. Students will also gain experience with some of the software packages that are commonly used in industry today to automate microwave measurements or process the microwave data after they are collected. The goal of these experiences is to give the students familiarity with the software in order to help them find employment and jump start more extensive use of the software in later efforts.

Laboratory Procedure

We expect you to follow the lab manual closely, take notes and observations during your experiments so that you have enough information to write your lab report. You must follow the instructions from the TA in your section, handle lab equipment with care and mindfullness. **Return all equipment, accessories and lab bench to where and how they were before you start your section** unless your TA specifies otherwise. Either in this class or in your future job, you will have to share the same lab space with your classmates/colleagues. It is always a good practice to clean up after yourself when you are done with your measurements. Keeping equipments in order will save you and others a lot of time when any of you wants to perform a measurement.

Laboratory Report Format

We recommend students to have laboratory notebook. The primary importance of the laboratory notebook is to serve as a reference for the student in the future. The lab notebook will be largely graded on its ability to convey the purpose, measurements, sticking points, and conclusions of a laboratory project to someone who is familiar with the concept of the project but who has forgotten the intricacies of it (e.g. you in five years). Here is one way to prepare your labotary notebook that ECE451 students have been using for a long time to serve the mentioned purpose:

- Each student would have 02 laboratory notebooks, to be used in alternating weeks. This allows the TAs to grade one notebook while the other is being using for the current lab. We do not require that you purchase a specific type of notebook, but it might be easier to have one that can comfortably fit a standard sheet of printer paper (8.5"x11").

- The first two pages of each lab notebook should be reserved for a table of contents, which is to be updated with the number and name of each additional lab along with its starting and ending pages. All lab notebook pages should be numbered as lab-page. For example, the third page of lab six should be labeled 6-3. Any scratch pages before the formal lab report should be numbered with roman numerals (e.g., 2-iv for the fourth page of scratch work).
- The lab notebooks must be legible and presentable. All attachments should be securely glued or taped to the notebook. It is recommended that as much of the lab report as possible be generated electronically.

The students could also submit an electronics version of your weekly lab report to Canvas by the due date. This is up to the agreement between you and your laboratory instructors to decide which lab notebook format is most convenient and effective for your study.

Parts of the Lab Report

All lab reports must include the following sections and section labels:

1. TITLE PAGE. Each lab report should include the following information on the first page: experiment number, experiment title, date of experiment, your name, and your partner's name (no section label is necessary).
2. OBJECTIVE. State the purpose of the lab in a brief sentence or two.
3. PRE-LAB. Discuss relevant theory and background information pertaining to the experiment (not required). This includes information given in class, the lab manual, or by the TAs. Answer the TAs' assigned questions **which have to be done before you enter a new lab session**.
4. PROCEDURE. Make a list of the equipment, identifying the equipment by name, model, so that at a later date you or someone else can duplicate the experiment using the original equipment. After the equipment list, outline the steps followed in performing the experiment. Include block diagrams, showing hardware and connections (it is allowed to redraw or duplicate pictures in the lab book). The procedure should not be over- or under-detailed. Include enough information so that the lab notebook is a useful reference, now and in the future, but do not just copy the procedure from the lab manual.
5. RESULTS and OBSERVATIONS. Use this section to record data, show plots, make observations, show any important sample calculations, etc. It is always better to generate the plots or tables of your data electronically in the final report for clarity purposes. The original measurements can always be recorded on a scratch page before the formal report or on a separate piece of paper. Be sure to use the appropriate number of significant figures (neither too many nor too few) for a measurement to be meaningful and accurate. Explain what you have observed or learned. Comment on the measurements, explaining why the results were good or bad in terms of the underlying theory. This means going beyond simply recording observations; demonstrate your knowledge of the theory and how this knowledge confirms or denies the confidence in the accuracy of a measurement. Always relate the results to previous labs where possible.
6. CONCLUSIONS. The conclusion section should consist of answering the TA-assigned questions in a clear, thorough, and thoughtful manner. Also, resolve the purpose of the lab. If your data do not support a conclusion that you are sure is true, try to discern why.
7. SIGN AND DATE. The last part of the lab report includes your signature and the date completed. This signature indicates that the work is yours (unless where indicated else) and that you can defend the assertions made in the report. Signing and dating your work is an important practice so do not forget to do it. Each one of these sections will be graded separately to generate the

total number of points in a lab report. Because most of the independent work done in lab resides in the conclusion and theory sections, grades are disproportionately based on performance in those sections. Save time by not stating the obvious, such as "In this lab we learned how to use the HP8510...". Since this is a class in measurement techniques, try to make explicit the assumptions and systematic errors inherent in the technique you are studying. Also, a device you are using might malfunction or give incorrect data. When this occurs, consult with your TA. If neither of you are able to resolve the malfunction, please note it in your report and label which data were affected by it.

Due Dates Lab

Write-ups are due at the beginning of the next lab section following the completion of a lab. Any lab report not submitted to Canvas before the section begins will be automatically assessed a 10 point penalty. We stress that lab attendance and tardiness are important factors in deciding grades. **Please arrive on time**. If you are not finished with the lab report, just submit it and suffer a few point loss.

Lab Absence

We realize that you may have to miss lab for job interviews, conferences, and other non-emergency events. In this case, it is your responsibility to inform the TAs (and your lab partner as a courtesy) of your absence at least one week prior to your lab and to make arrangements to attend another lab section. If this is not possible, we can offer no guarantees of a substitute lab. Obviously sickness, injury, family emergency, etc. are exceptions.

Last but not least, do not forget to have fun, this is where you get all the hands-on experience and testify the theory you have known. Happy studying!