

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 mindfulness. **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

The primary importance of the laboratory report is to serve as a reference for the student in the future. The lab report 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).

The students must submit an electronics version of your weekly lab report to Compass 2G by the due date. We strongly recommend you to generate the report electronically, meaning to use a typeset software (Latex, Word), flowcharts, graphs, tables etc. should also be generated electronically instead of hand-drawing then included in the report as photographed pictures.

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 reuse or duplicate pictures in the lab manual). The procedure should not be over- or under-detailed. Include enough information so that the lab report 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 handed in immediately after the section begins will be automatically assessed a 10 point penalty. If you are not finished with the lab report, just hand it in and suffer a few point loss. We

stress that lab attendance and tardiness are important factors in deciding grades. **Please arrive on time.**

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.

In Spring 2021, the lab is conducted via teleconference, you are required to attend the whole lab by calling in using information provided to you by your TA and must connect to the meeting on time. Your lab report will not be counted if you were absent from the lab online meeting except for aforementioned situations or different arrangement between you and your TA.

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!