WEST VIRGINIA UNIVERSITY **COLLEGE OF ENGINEERING**

Lane Department of Computer Science and Electrical Engineering

EE 356: Analog Electronics Lab

Fall 2013

Instructor: Rehan Fazal

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Office: 901 ESB, Desk 11

Office Hours: Wednesday 3:00 -5:00 PM

Prerequisites: EE 224 (Electrical Circuits) and EE 252 (Digital Electronics).

Co-Requisite: EE 355 (Analog Electronics)

Section: 003 R 5:30-8:20

Text: Permanently bound lab notebook. Lab notebooks will be checked regularly and points will be taken off when the students fail to show the notebook to the Instructor.

Lab kits are mandatory. It is a good habit to carry your text book along with you to the lab as most labs are design oriented and you might need to refer to the text for the equations.

Course Description:

Analog Electronics Laboratory. 1 Hr. Design, fabrication, and measurement of analog electronic circuits. Use of discrete devices, integrated circuits, operational amplifiers, and power electronic devices. Study of biasing and stability, frequency response, filters. **(3 Hr. lab**)

This course will consist of a series of laboratory exercises coordinated with EE 355, the parent course. Students will investigate characteristics of several devices: diodes, MOSFETs, BJTs, operational amplifiers, and power transistors. These devices will be used in circuits designed by the student to meet specified performance. Lab reports are required and design work prior to lab attendance is required.

Notes on Lab Operation:

The majority of the lab exercises in this lab will consist of two parts: first you will be asked to investigate the characteristics of components or circuits and then you will be asked to design a circuit to meet performance requirements. Most of these exercises will take place over two weeks or two lab periods. The first lab period will be used to investigate the characteristics and take data. Between the two lab periods you will apply the theory you learned from the class lectures and the data you took during your investigations to design the circuits. In the second lab period, you will construct the circuit, demonstrate it, and measure its actual performance.

The remaining lab exercises will consist primarily of the design component, but for more complex systems. These exercises typically will be allowed two weeks. Most of this time will be taken up with design and analysis outside the lab setting.

Lab Reports:

Engineering lab reports for this class involve little prose with most of the information conveyed through lists, tables, graphs, and drawings.

Part 1. Aim of the Experiment and the apparatus used should be specified. Specify the part numbers of the Transistors or the MOSFETs used and also the values of resistances and other parts you might have used in your design.

Part 2. Results of your lab investigations on the characteristics of devices or circuits. These results are usually conveyed in lists or tables. There should be a one or two paragraph discussion how these characteristics were obtained and will be used.

Part 3. Circuit diagram for the design part of the exercise. All components should be specified. This circuit should be on a page by itself. This circuit may not be hand drawn, we prefer computer drawn.

Part 4. Results of your simulation. Models must be shown and computer generated results must be annotated. Crucial information must be clearly marked and specified.

Part 5. Predicted performance and measured results. In this section, performance predicted by analysis and simulation must both be summarized in a table along with measured results.

Part 6. Conclusions: There should be a one or two paragraph discussion of conclusions. These conclusions should state things of interest in the design or results, unexpected results, and/or how this function could better be done. This should also include a discussion on how or why your results differ from expected. This discussion must be specific.

The Design Process:

Design is the essence of engineering. It is in this process that we convert components and ideas into a workable plan for a device that will perform the required functions. During the class lectures we learn the theory of how devices and circuits work, and in lab we investigate the characteristics of specific devices or circuits. These form the basis for the designs. Because we are working with real components that have limitations and characteristics that we have not investigated, we also have to look at the manufacturer’s specification sheets to verify that the devices are indeed intended to work as we have designed for them.

During the design process, we first have to select circuits and devices that will perform the required function and then select component values that will allow the circuit to perform the function to the required performance level. This selection of component values is the crux of the design process, but not the complete process. This design step is usually done by “analysis” and is often done in steps in cases where several components are to be selected. For example, when designing a transistor amplifier, you must first select the operating point, which will determine some of the component values and then follow up by selecting other components that will control the gain. This process is often iterative in that your first selections for bias will not allow the required gain or dynamic range, but the analysis will lead you in the right direction.

Once component values have been selected, there are several more steps for a complete design.

First, you completely analyze your final circuit for its predicted performance, which may be somewhat different than you intended, but must still meet required performance. (For example, the predicted bandwidth might be wider than required.)

Second, while you have chosen specific resistor values, you must check that they are operating within their power limitations, transistors are operating within allowed voltage, current, and temperature ratings, etc., and specify appropriate power and current ratings and heat sinks, etc.

Third, you must perform simulations that verify your calculations and predicted performance levels. Fourth, you can then make a final copy of your circuit design with all components completely specified.

The design process does not involve tinkering with a circuit nor involve tinkering during simulations to make it meet performance requirements. Rather, it is a deliberate process based on theory and analysis. To be sure, tinkering is often done to decide on device or circuit characteristics, but not during the design process. If a design fails, it is usually because of faulty analysis or faulty information on device characteristics. Another cause of failure to meet requirements is that all components are manufactured with a range of values, called tolerance.

The resistors in the lab have a 5% tolerance and your design should take that into account. Hand selecting resistor values or using multiple resistors in series or parallel is poor design practice and is frowned upon. In other words, design for standard values of resistors and take their tolerance into account during the design.

Please note that you will not be allowed to proceed with constructing the circuit in the lab for demonstration until the final circuit design, the predicted performance, and simulations are turned in to the lab instructor. This process means that all calculations and simulations should be complete before coming to lab. The lab instructor will sign these papers and return them to you so you can include them in the lab report upon demonstration and verification of performance.

Collaboration:

You are encouraged to learn from other students, but the design aspect of the exercises is to be your own. The design process must be carried out in your lab notebook as much as possible.

Obviously, multiple runs of a simulation to get it right would clutter up the book beyond all possible value. Lab partners are required to be full partners in each design, each contributing fully to the design. Evidence of these contributions will be shown in the lab notebooks and referencing each other. For example, if partner A does a calculation, the process will be given in A's notebook, but only the result will be shown in B's notebook and referenced to A. Be aware that designs without documentation of the process will be seriously downgraded. Designs and/or analyses and simulations copied from another group will not be accepted. All persons involved in plagiarized work will receive zeros on that exercise; including both those that copy and those that provide the original work. Both members of each group will be presumed involved. One area where people get in trouble here is in leaving their lab report or PSPICE files on a public computer.

Troubleshooting Circuits:

Troubleshooting is just problem solving in a specific situation. It is an intellectual exercise rather than a physical exercise. Typically, the engineer observes the symptoms of the failure by noting voltages or currents at specific points in the circuit, develops a hypothesis of where the fault lies, and takes more data to verify or disprove the hypothesis. Typical faults are: misplaced wire or connection, missing signal (power, ground, or input signal), wrong component value or type, or failed component (typically in that order). Students found to be switching components without first proving that is the problem or rewiring circuits without finding the specific fault will fail the instructor's evaluation.

When a circuit is not working and the student is getting frustrated, there is a tendency for the student to simply tinker until it works. This technique demonstrates poor troubleshooting skills and is to be avoided. Instead, it is usually advisable to take a break to allow your mind to focus on the symptoms rather than on your frustrations. Leave the lab for a few minutes or work on some other aspect of the current exercise.

Please note that the lab instructor will not troubleshoot your circuits for you but will help lead you through it. The instructor should not touch your circuit or take measurements for you.

Instead, the instructor will ask for a circuit diagram and ask you to take the measurements and what those measurements should be based on your design. Then the instructor will work with you to develop a hypothesis of the trouble and follow through to verify.

The Role of the Lab Instructor:

By now you have completed at least four EE/CpE labs and should be capable of using most of the laboratory instruments and taking good measurements. You should also be capable of doing the minimal technician work required for the lab exercises. You should also be capable of designing your own experiments to take most of the data required. You will not be given explicit directions except in a few cases where specific action is required or to mention pitfalls to be avoided.

Consequently, there will be very little lecture done in the lab. However, your lab instructor will answer specific questions; often with another question to help you understand the situation rather than just give you something else to memorize.

Grading:

Grades will be assigned on a standard scale:

≥ 90%	**A**
80 - 90	**B**
70 - 80	**C**
60 - 70	**D**
<60%	**F**

List of Experiments:

Lab 1 - Introduction to P-SPICE	(1 week)
Lab 2 - Operational Amplifiers	(2 weeks)
Lab 3 - MOSFET Amplifier	(3 weeks)
Lab 4 – Photodiodes	(2 weeks)
Lab 5 - Frequency Response	(2 weeks)

ACADEMIC INTEGRITY:

The integrity of the classes offered by any academic institution solidifies the foundation of its mission and cannot be sacrificed to expediency, ignorance, or blatant fraud. Therefore, I will enforce rigorous standards of academic integrity in all aspects and assignments of this course. For the detailed policy of West Virginia University regarding the definitions of acts considered to fall under academic dishonesty and possible ensuing sanctions, please see the Student Conduct Code at http://www.arc.wvu.edu/admissions/integrity.html. Should you have any questions about possibly improper research citations or references, or any other activity that may be interpreted as an attempt at academic dishonesty, please see me before the assignment is due to discuss the matter.

SOCIAL JUSTICE STATEMENT:

West Virginia University is committed to social justice. I concur with that commitment and expect to foster a nurturing learning environment, based upon open communication, mutual respect, and nondiscrimination. Any suggestions as to how to further such a positive and open environment in this class will be appreciated and given serious consideration. If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with Disability Services (293-6700). If you feel that you are being treated inappropriately or unfairly in any way, please feel free to bring your concerns to my attention. Please be assured that doing so will not prejudice the grading process. In return, I expect you to behave professionally and ethically. Grades will be based on performance, but will be lowered for unethical or unprofessional conduct