1.0 ECE 3200 Electronics II Laboratory: Safety and Information

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Document Sections

1.1 SAFETY

Laboratory Physical Address
WMU/Floyd Hall
4601 Campus Drive
Room B-216, Second Floor, West Wing
Kalamazoo MI 49008

Safety when conducting electrical experiments, as well as any other activity, is a matter of knowing potential hazards, following safety precautions, and common sense. Electrical laboratory safety is an essential element of ECE 3200. There are strict standards for electrical system design, e.g. [1]. Just as you will find as an employee, safety is paramount, and there can be very serious consequences if rules and procedures are not followed.

There are a number of potential hazards present in any electrical engineering laboratory. Therefore, for your safety and the safety of those around you, as well as preventing damage to the laboratory equipment and facilities, it is **imperative** that you observe a number of basic precautions when working in this laboratory.

ANY EVIDENCE THAT SUGGESTS YOU HAVE FAILED TO OBSERVE ALL SAFETY RULES WILL RESULT IN YOUR IMMEDIATE FAILURE IN THE COURSE. THERE WILL BE NO EXCEPTIONS.

Current kills, not voltage. Currents above 100mA "can be considered lethal" while currents at one-fifth that value are "very dangerous" [2]. The current depends on body resistance, resistance between body and ground and the applied voltage. Even a 42V (constant) DC supply can be fatal [2]. **Therefore, never take a chance on a "low" voltage**.

Always observe the following safety rules.

SAFETY RULES

General

1. **CALL 911 in the event of an emergency.**
   Be sure that you know your physical address to report to the emergency dispatcher.

2. In an emergency the **MAIN AC** breaker on the main breaker panel located at the front of the lab removes **ALL LAB POWER**. *These controls are to be used in emergencies only.*

3. **WEAR YOUR SAFETY GLASSES WHILE IN THE LAB.**
   Always wear safety glasses! This is **critical**. One potential risk is ejected debris from a failing component or simply bits of expelled wire if you trim wires and component leads (not required). *You must wear safety glasses while in the lab even if you are done with your experiment!*

4. At the conclusion of working on your circuit and after putting your components away, **WASH YOUR HANDS**. Some components may contain hazardous substances, such as lead.

5. Closed-toe footwear is **required** when working on your circuits.
   (Flip-flops or sandals are therefore not adequate.)

6. Chairs and stools must be kept under laboratory benches when no one is sitting on them.

7. Students **MUST NOT** plug or unplug test equipment or computers (computers are plugged into blue outlets and all other equipment is plugged into black outlets).

8. Whenever possible avoid having two lab groups working back-to-back.
   Be extra careful when two groups must work back-to-back.

9. Never use water on an electrical fire. If possible first switch laboratory power off, then use a CO_2 or dry type extinguisher. There is a fire extinguisher in the hallway outside the lab.

   All dwellings are recommended to have a fire extinguisher.

10. In case of an electric shock, quickly remove the victim from the circuit without endangering yourself. If the victim is not breathing, administer CPR while someone else phones public safety (911) to call for an emergency vehicle. Continue CPR until the victim is revived.

11. No practical jokes of any kind are allowed.

Electrical Circuit Safety

12. Working on an electric circuit deserves your full and serious attention.

13. Do not work alone on energized electrical equipment.

14. Power must be switched off whenever an experiment or project is being assembled or disassembled. After power is removed discharge any high voltage points to ground through an adequately sized and well-insulated resistor.

15. Capacitors can store dangerous quantities of energy, perhaps at a high voltage, even after power is removed. After power is switched off, discharge capacitors through an adequately sized and well-insulated resistor. **ALWAYS OBSERVE THE POARITY WHEN CONNECTING POLARIZED CAPACITORS!**

16. Make measurements in energized circuits with well insulated probes and one hand behind your back. Do not allow any part of your body to contact any part of the circuit or equipment connected to the circuit. An added advantage of this essential safety practice is that it prevents you from adding an unexpected current path that could compromise the accuracy of your measurements.

    - *To measure voltage or current, connect your multimeter to the circuit prior to applying power.*
    - *Remember that a multimeter configured as an ammeter is a short.*
    - *Never use an ohmmeter in an energized circuit.*
    - *After using a multimeter as an ammeter or ohmmeter, return the multimeter to a voltage measurement configuration.*

17. Never touch electrical equipment while standing on a damp or metal floor.

18. Never touch two pieces of equipment simultaneously.

19. Never handle wet, damp or ungrounded electrical equipment.

20. Wearing a ring or watch can be hazardous in an electrical laboratory since such items make good electrodes for the human body.

    a. *Remove all conductive jewelry and watches during your experiments.*

21. Never lunge for a falling part of an energized circuit, such as leads or measuring instruments.

22. Never touch heat dissipating surfaces of high wattage resistors and loads because they can cause severe burns.

23. Never touch even one wire or component of an energized circuit; it may be electrically "hot" (i.e. capable of delivering an electric shock) or hot enough to cause severe burns. Note that even low-voltage small components can become very hot.

24. If your circuit becomes hot (often detected by an odor), immediately turn off and/or disconnect power if it is safe to do so.

25. Some components (particularly large wattage resistors) have exposed metal that is electrically "hot." Take extra care when working with these components.

26. **NEVER SHORT A BATTERY** as a large dangerous current can flow and the battery can overheat**.** Insure battery terminals will not touch each other; for example, a piece of non-conductive electrical tape should be placed over 9 V battery terminals during storage. Measure the resistance between battery connection points *before connecting the battery* to be sure that there is a substantial resistance.

27. **NEVER SHORT A POWER SOURCE** as a large dangerous current can flow. If your power supply has an adjustable current limit, set that control to the lowest setting that provides sufficient current for your correctly-operating circuit.

28. Ask the instructor to check out your constructed circuit before applying power.

29. ***If you have ANY concerns about a lab procedure, contact your instructor before proceeding!***

High Power and Machinery Safety

30. When using rotating machinery, remove neckties or necklaces.
    Tie-up long hair to prevent hair from becoming entangled in machinery.

31. Keep clear of rotating machinery. Do not be fooled by stroboscopic effects.

32. Never open field circuits of DC motors since the resulting dangerously high speeds may cause a "mechanical explosion".

33. Keep your eyes well away from arcing points. High intensity arcs may seriously impair your vision and a shower of molten copper may permanently injure your eyes.

Laboratory Instrument Safety

34. Fuse circuits to protect ammeters and wattmeters for the current range being used.

35. Do not drop or bang instruments. They are delicate.

36. Never short circuit a power source.

37. When using instruments connected to the power line, connect all ground leads to the same point. Otherwise, a short circuit may result.

38. When using a voltmeter or ammeter, begin with the highest range and work your way down to a suitable range.

39. When using an ohmmeter, never measure resistance in an energized circuit.

40. Keep instruments away from the edge of the work bench.

OTHER RULES

41. Use safe laboratory practices at all times.

42. No food or drink is allowed in the laboratory.

43. Do not write on bench surfaces or equipment.

44. Report defective equipment and blown fuses to the instructor.

45. Students **must not** replace blown fuses, move instruments from one station to another, or turn on the main or secondary circuit breakers.

46. Put all wastepaper, newspapers, etc. in the wastebasket.

47. Return all equipment and supplies to proper storage locations as applicable.

References

1. A. L. Clapp, *NESC Handbook: A Discussion of the National Electrical Safety Code*. New York: IEEE 2006. Online resource: https://ieeexplore-ieee-org.libproxy.library.wmich.edu/servlet/opac?bknumber=5769541
2. "How much current is fatal?" *Popular Electronics*, p. 31, January 1972. Available at https://www.americanradiohistory.com/Archive-Poptronics/70s/1972/Pop-1972-01.pdf

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Adapted from material developed by current and former ECE faculty, including S. Durbin, J. Kelemen, and D. Miller. S. Masihi contributed to this document.

1.2 TYPICAL LABORATORY SEQUENCE

This section outlines the steps needed for completion of a typical ECE 3200 laboratory.

1. YOU MUST BE CLEARED TO COME TO CAMPUS BEFORE ATTENDING IN-PERSON LABS VIA THE ONLINE COVID SURVEY.

2. Well in advance of the lab, students complete any pre-laboratory exercises. Pre-labs must meet the requirements for submitted assignments as described in section 1.3 and are due as indicated in the syllabus. Frequently information in the pre-lab is needed during the experiment, such as simulation results, theoretical analyses, formulas, etc. HENCE YOU MUST PLACE A COPY OF SUCH INFORMATION IN YOUR LAB NOTEBOOK BEFORE LAB. This will enable you to verify that your experimental results are consistent with your pre-lab analysis.

3. The lab instructor may lecture on the lab. This information, as with all information gained from the lab, goes in the lab notebook.

4. After the lecture by the lab instructor, students work alone on the experiment. Experimental data MUST be compared to the theoretical analysis/simulation results WHILE YOU ARE IN THE LAB. All work is recorded in the laboratory notebook (refer to section 1.4). Plot your experimental values on your simulation results. This provides you with a high degree of confidence that you conducted the experiment properly or indicates a problem with either your theoretical and/or experimental results.

5. The due dates of the report and any other assignments is listed in the course syllabus.

1.3 Pre-Laboratory Assignments

Pre-laboratory assignments must be stand-alone documents.
Arrange your pre-lab assignments in the following order:

1. Cover Sheet
2. Summary - concisely describe what was done in the pre-lab and provide important
3. Results (e. g. component values used in your design, key circuit parameters, etc.). Use tables whenever possible. Some SPICE output might appear here (e. g. important figures).
4. Calculations, SPICE results, etc.

Be sure to include schematics as an APPENDIX. Simply turning in SPICE results will earn no credit. If the pre-lab includes a design problem, demonstrate how closely your design meets the specifications (do not blindly trust SPICE — find a way to verify the results!). Also use the check list included in section 1.6.

1.4 The Laboratory Notebook

Laboratory notebooks provide a convenient tool to maintain a permanent and accurate record of your laboratory work. Such a record is essential and is often required by employers. Remember

that the person most likely to refer back to these notebooks several weeks or even years later will most likely be you! A notebook is invaluable in documenting and organizing research. You may find that using a notebook is also useful in other personal and professional activities
.

ECE 3200 LABORATORY NOTEBOOK REQUIREMENTS AND GUIDELINES

1. The notebook must be permanently bound (not loose-leaf) with a minimum of 60 sheets. Each sheet should have a square grid (4 or 5 divisions/inch is convenient) and be of 8.5 x 11 inch size. A spiral bound notebook is preferred since it will easily lie open on the lab tables. If the pages are not numbered, number them. Be sure to reserve several pages at the beginning for "global" information and a table of contents which may be entered as you fill the notebook.

2. The table of contents must consist of three columns: (1) date(s) that the work was performed, (2) title of the laboratory, and (3) space for the instructor to initial your notebook data for that lab.

3. Use a PEN for ALL entries in the notebook.

4. Put your name, course number, and section number both on the cover and on the first page.

5. Each page of the notebook must be numbered and contain material pertaining to only one experiment. Entry dates must be indicated.

6. If additional materials such as graphs and computer outputs are entered into the notebook, fasten them (e.g. tape or paste) securely and trim edges to prevent their protrusion from the notebook.

7. Enter data and calculations into the notebook **AS YOU WORK**. **DO NOT** take data on loose sheets or scraps of paper and later copy it into the notebook. Erasure of notebook entries is bad practice and is discouraged. Simply cross out mistakes, do not obliterate them. Often what appears at first to be a mistake will later be found to contain useful information.

8. Laboratory instruction sheets may be attached to pages of the notebook, however the sheets should be trimmed so that they do not protrude from the notebook.

9. Neatness and legibility are **VERY** important.

10. The following is a list of items that would appear in a well planned and executed laboratory notebook for **EACH** laboratory exercise. Use this list as a guide for your entries:
    a. Pre-lab calculations
    b. Measurement preparations and circuit diagrams
    c. Lab lecture notes
    d. Original data
    e. Calculation of theoretical values and data analysis

f. Data presentation clearly showing discrepancies between experimental and theoretical values
g. Answers to questions and conclusions, i.e. discuss discrepancies between experimental and theoretical values and on this basis clearly assess whether the objectives of the experiment were attained.

1.5 The Laboratory Report

The laboratory report is often the primary means of communicating the results of your work to your peers and superiors. A well-organized report permits them to easily and quickly understand your work and it is also a reflection of **YOUR** ability to accomplish objectives and communicate information.

The technical level of a report should be varied depending on the background of the reader. Assume that you are writing the report for a junior electrical engineering student at another university. The reader **SHOULD BE ABLE TO DUPLICATE THE ENTIRE EXPERIMENT USING ONLY YOUR REPORT**.

Reports will be arranged as follows:

1. TITLE PAGE
2. TABLE OF CONTENTS
3. TABLE OF FIGURES
4. LIST OF TABLES
5. SUMMARY
   A summary must concisely state at least the following:
   a. What the author has done
   b. How it was done (if that is important)
   c. The principle results
   d. The significance of the results
6. RESULTS
   This is the main body of the report. Describe your results, how you obtained your data, theoretical analyses, simulation results, etc.
7. CONCLUSIONS
   Present conclusions supported by the results of the laboratory.
8. REFERENCES
   DO NOT PLAGIARIZE! Be sure to cite any references used in the preparation of your report. Number each reference and use this number to identify the source of paraphrased information, direct quotes, and figures as they are introduced in the report.

The report must be typed and "reproducible" using conventional (black and white) photocopying means. Note that color coding is lost in black and white copying. Use only one side of the sheet and **DOUBLE SPACE ALL TEXT**. Always leave sufficient room for binding. DO NOT "hide" text in the binding of punch binding holes in the text. These problems frequently occur when hard copy from computer programs is included in reports.

We will otherwise follow the guidelines in your technical writing reference for preparation of the laboratory reports. Use the list of section 1.6 to check your report before turning it in.

A RULE THAT SOMETIMES HELPS PRODUCE EXCELLENT RESULTS IS AS FOLLOWS:

Write your reports such that a student at a different university who is at the same stage in their education as you but who is not familiar with the details of the experiment, could, from your report alone, repeat the experiment, obtain similar results (both experimental and theoretical) and arrive at the same conclusions you did. As you write, modify and review what you've written, frequently place yourself in your reader 'shoes' and make your modifications to best serve your reader.

1.6 Partial Checklist for ANY Submitted Laboratory Assignment

1. The first page of any assignment must include:
    a. Author's name
    b. Due date
    c. Date of submission if different than due date
    d. Lab partner's name if there was a lab partner for the assignment
    e. Name/title of the assignment
2. Include references used.
3. All text must be DOUBLE SPACED.
4. All pages must be numbered.
5. All graphs, charts, computer hard copy, etc. must have:
    a. a figure number (Arabic numeral) and a caption (DON'T group all figures together at some point in the report, disperse them appropriately throughout).
    b. a title
    c. labeled and enumerated axes
    d. a symbols key for multiple curve graphs
    e. notes of explanation
6. Do not "connect the dots" when plotting experimental values on graphs. Instead, plot each point using a suitable symbol. Use distinct symbols for experimental points obtained under different conditions. Provide a symbol legend.
7. All tables must have:
    a. a title
    b. a Roman numeral table number, e.g. "TABLE III"
8. Define symbols, parameters, and variables.
9. Show sample calculations where appropriate.
10. When instructed to compare numerical results, always calculate % difference or % error or some such numerical quantity making sure to indicate the reference parameter for calculation.
11. Write in the third person passive voice, not in the first person active voice.
12. If the report is to be bound along a complete edge, leave sufficient binding margin on each page. Avoid this problem by stapling only in upper left corner.

13. Don't color code information that may be lost in a black and white copy. Geometric symbols can be used instead of colors for coding.
14. Briefly but clearly annotate your document in a way which will provide the document reader with information such as:
    a. which part of the assignment is this?
    b. what is being done and why?
    c. how was it done and what are the results?
    d. how was this equation obtained and how was it used?
    e. sample calculations and definitions of symbols and parameters.
    f. judging from the professional manner of information presentation in this document, this author obviously has a keen sense of professional pride.

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