

The University of Maine
Department of Electrical and Computer Engineering
ECE 214 – Electrical Networks Lab

Spring 2018

Electrical Networks Lab

Course Number: ECE 214
Credits: 2
Lecture: 11:00 - 12:15 am, Tuesday; Barrows 119
Lab Sessions: 2:00 - 4:50 pm, Monday, Tuesday, Wednesday, and Thursday
Texas Instruments (TI) Lab, Barrows 221
Prerequisite: ECE 210 – Electrical Networks
Corequisite: ECP 214 – Engineering Communication Program I (Note: If ECE 214 is dropped, ECP 214 must also be dropped)
Course Web Site: <http://web.eece.maine.edu/kotecki/ECE214>

Instructor

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Office Hours

1:00 - 2:00 pm Monday, Tuesday, Wednesday, and Thursday
You are encouraged to drop by my office to ask questions and discuss labs related to this course.
If you are unable to meet with me during these times, e-mail me to set up an appointment.

Teaching/Lab Assistants

Teaching/Lab assistants will be available during the laboratory to help answer questions and sign-off on completed labs. To obtain credit for the lab, you must show both the working circuit and your completed laboratory notebooks (excluding any post-lab analysis) to the TA for sign-off no later than 5:00 pm one week after the lab due date. Late sign-offs will incur a 50% penalty.

Textbook

There is no required textbook for this course. The textbook used in ECE 210 should be used as a reference.

Course Goals

ECE 214 will prepare you for advanced courses in circuit analysis, electronics, and signals and systems. The five goals for this course are:

1. Become knowledgeable with the operation and use of electrical test equipment including the digital oscilloscope, waveform generator, DC power supply, spectrum analyzer, network analyzer, and voltage, current, resistance, capacitance, and inductance meters.
2. Become proficient with the use of computer simulations to predict and analyze circuit behavior at DC, in the time domain, and in the frequency domain. An open source SPICE (Simulation Program with Integrated Circuit Emphasis) simulator, NGSpice, along with Matlab® will be used for circuit simulation and analysis.
3. Become familiar with the properties of “real” circuit elements including the resistor, capacitor, inductor, transformer, and operational amplifier. The diode and transistor will be introduced and used to implement a voltage-controlled switch.
4. Learn how to maintain a proper “Engineering Notebook,” and in collaboration with ECP 214, produce a well written technical report.
5. Develop skills and techniques for debugging electrical circuits.

Digilent Electronic Test Equipment

The Digilent “Analog Discovery 2” 100 MS/sec oscilloscope, function generator, and logic analyzer, the BNC adapter board, a pair of BNC oscilloscope probes, and a dual-output 12 V (± 100 mA) PowerBrick are required for ECE 342 and are recommended for the laboratory portion of this course. Instructions for ordering the test equipment and obtaining the student discount are described at: http://davidkotecki.com/ECE214/docs/ECE214_2018_Digilent.pdf.

The “Waveforms” data acquisition software is used in conjunction with the Digilent “Analog Discovery 2” test equipment. The software is available for Windows, Mac OS X, and Linux. You can download the “Waveforms” software onto your laptop from the Digilent website: <https://reference.digilentinc.com/reference/software/waveforms/waveforms-3/start>.

Calculators

It is strongly recommended that you have a calculator capable of solving simultaneous linear equations with complex variables. Calculators may be used during the labs and when taking exams. The most popular calculators are TI-89 Titanium and the TI Nspire CX CAS. If you do not own one of these calculators, try to borrow one for use during the exams.

Circuit Simulation and Data Analysis

NGspice (http://www.cppsim.com/about_ngspice.html) will be used to perform circuit simulations. NGspice is an open source, multi-platform, circuit simulator. Everyone should install the NGspice circuit simulator, the Sue2 schematic capture program, and the NGspice Matlab® toolbox on their laptop before 29 January 2018. The easiest way to obtain the software is to install the bundled CppSim package from <http://www.cppsim.com/download.html>.

Matlab® by MathWorks (<http://www.mathworks.com/>) will be used to control the NGspice circuit simulator and analyze and graph the simulation results. It is also used with the “Waveforms” data acquisition software to analysis and graph experimental results. Matlab® is a multi-platform numerical computing environment and a programming language used for technical computing. The University of Maine provides a free Matlab® license to all students. Everyone should install version 2017b of Matlab® on their laptop before 29 January 2018. Download Matlab® from <https://umaine.edu/it/software/matlab>.

Engineering Notebook

All students must maintain a proper “Engineering Notebook.” The engineering notebook should be used to record all calculations, preliminary and final designs, circuit simulation schematics and results, measured data, graphs, and analysis pertaining to the laboratory experiments. Basically, everything you do in this class should be recorded in the notebook. Guidelines for maintaining an engineering notebook are provided on pages 8–11.

Laboratory Teams

Students should partner with another student and work as a two person team. If there is an odd number of students in a laboratory session, a team of three students will be allowed. Each student must maintain a their own engineering notebook. If you and your laboratory partner have irreconcilable differences, you will have the opportunity to change laboratory partners at the mid-semester break.

Technical Report

Each laboratory team is required to submit a final technical report describing the DC-DC converter covered in Labs 7–9. The report must describe the theory of operation of the DC-DC converter, design considerations for the final DC-DC converter, a description of how the circuits function, circuit simulation results, experimental test results and a cost analysis. Details of the report will be provided in ECP 214. The report must be submitted electronically, in PDF format, to kotecki@maine.edu no later than 2200 UTC (6:00 pm EDT) on Friday, 4 May 2018. Late reports are **NOT accepted**.

Laboratory Periods

There are a total of ten graded labs. The first day of lab is the Wednesday proceeding the Tuesday lecture.

Labs are divided into three parts:

- “Pre-Lab” – Design calculations and simulations. The “Pre-Lab” should be completed and recorded in your engineering notebook **before** the laboratory period.
- “Laboratory Procedure” – Implementation and measurements of circuit performance. The “Laboratory Procedure” should be completed **during** the laboratory period.
- “Post-Lab” – Analysis and comparison of theory, simulations and measurement results. The “Post-Lab” should be completed **after** the laboratory period.

You should bring the following to each laboratory period: (1) engineering notebook, (2) laptop computer containing Matlab[®] and NGspice, (3) breadboard and wires, (4) digital volt meter (DVM), and (5) calculator. Electrical components (resistors, capacitors, inductors, diodes, and transistors) and test equipment cables will be provided.

To receive the maximum laboratory credit, your implemented circuit along with your Engineering Notebook, with a completed “Pre-Lab” and “Laboratory Procedure,” must be examined and signed-off by one of the TAs no later than one week after the day of the lab. Late sign-offs will incur a 50% penalty. The post-labs are graded when Engineering Notebooks are collected during the mid-semester break and at the end of the semester.

Class/Lab Cancellations

In the event that the University closes due to inclement weather and a laboratory session is canceled, a make-up laboratory session will be available on Friday from 2:00 - 4:50. All canceled laboratory sessions will need to be completed during another laboratory session.

Laboratory Etiquette and Safety

- Food and beverages are not allowed in the lab at any time.
- The Texas Instruments (TI) lab is heavily used this semester. Please keep the lab neat, clean, and remove any trash from the tables before you leave.
- Please do not rearrange the furniture, remove furniture, or bring in other furniture.
- The lab is open between 2:00–4:50. Always be safe when working in the lab. Students are not allowed to work alone or with the doors closed. At least one TA or faculty member must be present at all times.
- Do not use or operate any test equipment unless you are familiar with its proper use and operation. Ask if you have any questions regarding a piece of test equipment.

Exams

There are two Preliminary Exams and a Final Exam. The preliminary exams will take place during the time allocated for the Tuesday morning lecture. You may use your Engineering Notebook and a hand held calculator during the exams. Laptops with Matlab® and NGspice may be needed for Preliminary Exam #2.

The exams will cover circuit theory, circuit simulation, the use of electrical test equipment, and the laboratory experiments. Poor presentation of your work will lower your grade – be neat! I will do my best to figure out what you meant to do on a problem, but if the work is poorly laid out or just a mess, your grade will suffer.

Grading

Circuit and Notebook (Pre-Lab and Laboratory Procedure) Sign-off	20%
Engineering Notebook (Post-Lab)	20%
Technical report	10%
Exam #1	15%
Exam #2	15%
Final Exam	20%
Total	<u>100%</u>

Letter Grade Assignment

$\geq 90\%$	A
88% – 89%	B +
80% – 87%	B
78% – 79%	C +
70% – 77%	C
68% – 69%	D +
60% – 67%	D
$< 60\%$	F

Tentative Schedule

Class	Date	Topic
Lab #0	23 Jan. 2018	Organize Teams, Software Issues, and Electrical Safety
Lab #1	30 Jan. 2018	Test Equipment Loading
Lab #2	6 Feb. 2018	First Order RC Circuits
Lab #3	13 Feb. 2018	RC Filter
Lab #4	20 Feb. 2018	Basic Operational Amplifier Circuits
Lab #5	27 Feb. 2018	Schmitt Trigger and Oscillator
Exam #1	6 Mar. 2018	Preliminary Examination #1
Lab #6	20 Mar. 2018	RLC Circuit
Lab #7	27 Mar. 2018	Boost Converter
Lab #8	3 Apr. 2018	Astable Multivibrator
Lab #9	10 Apr. 2018	DC–DC Converter
Lab #10	17 Apr. 2018	TBD
Exam #2	24 Apr. 2018	Preliminary Examination #2
Final Report	4 May 2018	Final report deadline: 6:00 pm EDT
Final Exam	10 May 2018	Final Exam (10:30–12:30 am) & Engineering Notebooks due

Academic Honesty Statement

Academic honesty is very important. It is dishonest to cheat on exams, to copy term papers, to submit papers written by another person, to fake experimental results, or to copy or reword parts of books or articles into your own papers without appropriately citing the source. Students committing or aiding in any of these violations may be given failing grades for an assignment or for an entire course, at the discretion of the instructor. In addition to any academic action taken by an instructor, these violations are also subject to action under the University of Maine Student Conduct Code. The maximum possible sanction under the student conduct code is dismissal from the University.

Students with Disabilities Statement

If you have a disability for which you may be requesting an accommodation, contact Student Accessibility Services, 121 East Annex, 581.2319, as early as possible. Students who have already been approved for accommodations by SAS and have a current accommodation letter should provide a copy of the letter to me as soon as possible.

Course Schedule Disclaimer (Disruption Clause)

In the event of an extended disruption of normal classroom activities, the format for this course may be modified to enable its completion within its programmed time frame. In that event, you will be provided an addendum to the syllabus that will supersede this version.

Sexual Violence Policy: Sexual Discrimination Reporting

The University of Maine is committed to making campus a safe place for students. Because of this commitment, if you tell a teacher about an experience of sexual assault, sexual harassment, stalking, relationship abuse (dating violence and domestic violence), sexual misconduct or any form of gender discrimination involving members of the campus, your teacher is required to report this information to the campus Office of Sexual Assault & Violence Prevention or the Office of Equal Opportunity.

If you want to talk in confidence to someone about an experience of sexual discrimination, please contact these resources:

For confidential resources on campus: Counseling Center: 207-581-1392 or Cutler Health Center: at 207-581-4000.

For confidential resources off campus: Rape Response Services: 1-800-310-0000 or Spruce Run: 1-800-863-9909.

Other resources: The resources listed below can offer support but may have to report the incident to others who can help: For support services on campus: Office of Sexual Assault & Violence Prevention: 207-581-1406, Office of Community Standards: 207-581-1409, University of Maine Police: 207-581-4040 or 911. Or see the OSASP website for a complete list of services at <http://www.umaine.edu/osavp/>

Engineering Notebook Guidelines

An engineering, or laboratory, notebook serves several functions. In industry it can serve as a legal document to establish priority of invention in patent disputes. While we do not expect many patentable discoveries to come out of the ECE 214 labs and the U.S. has moved to a first-to-file patent system, you should still develop good engineering notebook habits. It will serve you well when you go to work for a company that has such expectations. In scientific research, an engineering notebook provides a record that allows you to duplicate your work if you succeed at your endeavor (or if you achieve some unexpected but significant result). It's also useful in identifying what might have gone wrong if you achieve neither your desired result nor a miraculous discovery.

You will also collect and generate a number of pages of printed material that are related to the lab work. These will include lab handouts, data sheets, and Computer Simulation and Matlab® printouts to name a few. These handouts should be taped into your engineering notebook. Copies of all important results and conclusions should be included in your engineering notebook.

Since we will not have weekly lab reports, your engineering notebook provides a mechanism for evaluating your performance. Furthermore, you will need your engineering notebook during exams. Some exam questions will require information gathered during lab sessions. Engineering notebooks will be collected and graded at the mid-semester break and at the final exam.

Every student will maintain an engineering notebook. The notebook must be a bound book with consecutively numbered pages. Do not tear pages out of your notebook. Composition books having quadrille ruled sheets make good lab notebooks; they allow tables, graphs, and circuit diagrams to be laid out neatly. Notebooks with duplicate pages and carbon paper are impressive, but messy and not really necessary. Spiral notebooks without pre-numbered pages, loose leaf binders and electronic notebooks are not acceptable.

Format:

- Reserve the first few pages for a table of contents. Each time you use your notebook (pre-lab calculations, during lab, or post-lab summary) draw a line, write the date, title of the new section, lab number and name of your team member (if working as part of a team), and make an entry in the table of contents along with the date.
- Date each page. Each page should have at least one date. All pages should be dated consecutively.
- Do not skip any pages or leave blank spaces in a page.
- Always use ink (not pencil). If you make a mistake, draw a single line through it, leaving it legible. Some of the greatest advances in modern technology began life as mistakes. Use all pages consecutively; leave no blank pages and do not remove pages.
- All entries should be made by hand except for computer printouts of schematic diagrams or computer printouts of plots. All printouts should be trimmed to fit one page of the notebook, and should be glued or taped into the book. Do not use staples.
- A summary of each laboratory experiment should be included in the notebook.

Contents:

Your notebook will contain a record of each of the phases of your weekly lab. The notebook should be limited to work related to the ECE 214 labs. Do not include notes from the classroom unless they directly apply to the assigned lab. Here are a few guidelines:

- **Before the Lab:** Before you come to lab, you should have a plan for what you are going to do. As you formulate this plan, put any calculations, designs, ideas, questions, etc. in your notebook. The lab handout will often include a Pre-Lab work section. This work should be done before you come to lab. It may require calculations or graphs that must be added to your lab notebook or the assembly of a circuit.
- **During the Lab:**
 1. The notebook should contain a written description of each laboratory procedure. The description should be sufficient so that a reader given the lab handout could follow the work done and identify the results requested in the handout. The Lab procedures are numbered in the handouts. Make sure you indicate in your notebook how the notebook entries correspond to the procedure steps.
 2. Describe the experimental setup completely but succinctly. Include the equipment and model numbers but do not include equipment serial numbers.
 3. Include a complete diagram for each circuit you design or construct. Label the values of each component, including units if there might be a question.
 4. Indicate clearly the points in the circuit where voltage or current measurements were taken.
 5. All data should be recorded directly in to the notebook at the time it is taken. Never write data on scrap paper.
 6. Multiple or sequential measurements should be recorded in a table. Table headings should include the name of the variable and the units. The table should also have a title and description of what it is; make sure to include the procedure step and number from the class handout.
 7. You may be asked to draw a waveform as seen on the oscilloscope or to plot measured data points from a table. These drawings should be done by hand during the lab session.
 8. Label each axis of a graph, including units, and give each graph a title and description of what it is; make sure to include the procedure step and number from the class handout.
 9. If something does not work or behaves unexpectedly, make a note of it. When you fix something, describe what was wrong and how you fixed it.
 10. The lab handouts will contain a procedure section describing what you should do in lab. You may, for example, be asked to take certain measurements or to describe the behavior of a circuit. Make sure that you do all the procedures and answer all the questions. It should be easy to find the results in your notebook and associate them with the procedure step and number.

- **After the lab:** After most labs you will answer a series of questions and perform tasks described in the post-lab section. You will use the data generated during the lab and recorded in your notebook to complete the post-lab. This is another reason to develop good habits with your notebook. All of the information needed to complete the work sheet should be added to your engineering notebook.

Basic Presentation Guidelines

These guidelines will set down some basic tips that will help you present your work in the best possible way. The way you present your work is important in your academic life as well as your future career as an engineer. Good presentation will:

- Help you clearly demonstrate your understanding of the material to those who will review it
- Train you to use the correct format and concise wording when you create your work
- Emphasize the importance of the process used to obtain an answer
- Make it easier to revise and correct what you have done

Use the following list of tips whenever you create work to be handed in for this class. Another way to think about what is expected of you is to consider the question: Would the class understand your work if it was photocopied and distributed but not given any accompanying verbal explanation? If the class would find your work difficult to follow, then your work is unacceptable.

1. Identify the answer to each problem by drawing a box or circle around it.
2. If the steps required to solve a problem are not clear from the layout of the problem, identify in writing what steps you have used.
3. Draw schematics for all circuits under consideration, and redraw them when the circuit is collapsed, expanded, or modified. Do not draw circuits on top of other circuits.
4. If you define a new variable (e.g. V_0 , R_1) be sure to identify it on your drawing.
5. Define all variables in a circuit and use consistent notation. For example, V_a is not equal to v_a nor is it equal to VA .
6. Equations should have an expression on both sides of the equal sign.
7. Voltages are usually defined by a value and two measurement points (nodes) labeled with a “+” and “-” respectively. If a voltage at a single point (node) in a circuit is defined, it will be assumed that the second node is the ground node (zero volts) of the circuit.
8. Currents are defined by a value and a direction in a circuit branch.
9. Use the notation “||” to denote components added in parallel. For example: $40\Omega || 10\Omega = 8\Omega$.
10. ~~Cross out~~ things you do not want considered toward your grade.

11. Your work should proceed left-to-right and top-to-bottom. If you must alter this scheme, use arrows to indicate the flow.
12. Use at least four significant digits for preliminary results on a problem. Doing so will guarantee that the final result is accurate to three significant digits.
13. Express your final answer in three significant digits using scientific notation. For example: $20/3$ is written as 6.67; $10/3 \times 10^{-3}$ is written: 3.33×10^{-3} . The number 0.003 has only one significant digit. Do not express variables with more than three initial or trailing zeros. For example, do not express $4.20\mu F$ as $0.0000042F$ or express 25×10^4 as 250,000 when it should be expressed as: 2.50×10^5 .
14. When your work leads to a set of simultaneous linear equations, place the fundamental equations in a column and draw a box around them. Then proceed to solve them by hand, using Matlab, or with a calculator. You do not need to show the steps used to solve the simultaneous equations unless they are being solved by hand.
15. Complex numbers are written in the form of: $3 + j4$ or $6\angle 30^\circ$, where $j = \sqrt{-1}$. Complex numbers are not written as (4,3), a popular calculator format, or as $4 + i3$ (i denotes current).