EE283 Electrical Measurement Laboratory Syllabus, Fall 2017

General Information: Required course for EE, EGM, and ME Majors
Text: Engineering Laboratory Reports Manual, Handouts for lab exercises, other materials
Instructors: Dr. John B. Gilmer Jr. (A, D, E1, G), Mr. William (Bill) Schlosser (B, C, F, H)
Sections: Thursday: A: 9a.m., B: 1p.m., C: 3:10p.m., E1: 6p.m,
Friday: D: 9a.m., G: 11 a.m., F: 1p.m., H: 3p.m.
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Catalog Description:
EE 283. Electrical Measurements Lab Credits: 1
A laboratory for the development of measurement techniques and use of electrical instruments for the measurement of various electrical quantities. One two-hour lab per week.
Co-Requisites: EE 211

Introduction:

Measurement Lab, EE 283, is the first formal exposure to electrical measurement instruments and electronic circuits for most students in our engineering programs. The course introduces common instruments such as DC power supplies, analog and digital multi-meters, function generators, and oscilloscopes, that are used to investigate principles of circuits presented in EE 211. Initial work focuses on Direct Current (DC) circuits and basic circuit principles. The course then progresses into Alternating Current (AC) circuits, including AC components and their behavior in circuits of increasing complexity.

This is an engineering course. There is some overlap with Physics, in that both in Physics and in this course, we are dealing with many of the same fundamental components, such as resistors, capacitors, and inductors. The difference is that in Physics is a science. The emphasis is on understanding the components, and the theory behind them. In contrast, engineering is about application, using those same components in increasingly complex circuits for some specific useful purpose. As an example, in Physics you study AC components and consider resonant circuits, typically looking at dynamics such as frequency and damping factor. In engineering, that same resonant circuit may be used as a filter, for example, to isolate a particular frequency for the desired station to be received by a radio. Yes, the frequency matters, but an engineer would focus on things like bandwidth, to be sure the radio will receive the full signal, and avoid receiving adjacent stations. An engineer might also use those resonant circuits as a notch filter, for example, to remove 60 cycle AC hum, or as a low pass filter, to avoid aliasing in digitally transmitted telephone systems. Typically, an engineer distinguishes between a signal (which carries information) and power sources. In physics, you usually don't.

So, as this course progresses, you will increasingly see things like complex AC circuits, rectifier circuits, operational amplifiers (op-amps), and digital logic, all of which are beyond the scope of your physics classes. In particular, the Op-amp circuits are the simplest, and earliest, experience that students will have with using feedback. Use of feedback is pervasive in engineering systems. For example, if a motor is to be driven at a particular speed, a sensor monitoring the speed can produce a signal that can be compared to the desired speed. If the speed is too low, the motor is given more energy by a larger Voltage, more gasoline in the fuel mixture, or raising the control rods in the nuclear reactor.

The course introduces students to basic digital circuits. This is important because computers have become pervasive in practical systems engineers must design. Most computers are “embedded” and not even identified as such. How many computers are in your car? By now, likely dozens, with the individual computers often costing less than $1 to the manufacturer. Fully understanding computers and their technology is beyond the reach of what we can do, but this course does offer an introduction to digital basics. The course includes two projects that are completed and demonstrated by a team. The first is “combinational logic”, a project to display, on a seven-segment display device, a three-bit binary number, having the value 0 to 7. A second project is to build a digital counter, which can be used to count events, measure frequency, or even possibly measure a Voltage. These project circuits require a large number of electrical connections, so the student has the opportunity to learn about dealing with complexity. These circuits will not function as designed with any misplaced connections or design errors. Attention to detail is needed to minimize such errors. The need to do “debugging” is almost inevitable. Troubleshooting skills are difficult to teach in theory; real understanding comes from practice, the experience of doing it. Typically, a circuit is set up in a manner which gives a wrong behavior. Then, the erroneous signal needs to be followed to locate the problem, and determine whether the error is caused by a malfunctioning component, an incorrect circuit connection, or some other source. This analysis experience transfers to other types of engineering systems.

Since electrical signals and electronic instrumentation are widely used in the engineering discipline, EE 283 is a required course for EE, EGM, and ME majors at Wilkes University. The Mechatronics course, EGR222, for which EE283 is a prerequisite, directly builds on the principles and skills developed in EE283. (Indeed, you will need to keep your lab kit to use in that course, to which additional components like motors and sensors will be added.) EE283 is also a required prerequisite for EE252 Electronics 2.

The formal objectives of EE 283, Electrical Measurements Lab, are that the students will:

1. Develop competency in the use of common electrical measurement instrumentation.
2. Be able to construct circuits as represented on a circuit diagram.
3. Use common methods of signal conditioning.
4. Document laboratory activities and observations and analyze laboratory data.
5. Construct and analyze (troubleshoot) model engineering systems (projects).
6. Use teamwork to amplify the learning experience and expedite the learning process.
7. Apply statistical methods.
8. Use simulation (either LTSpice or PSpice) for circuit analysis.

Schedule:

Week	Dates	Lab exercise	Report/Test
1.	Aug 31, Sept 1	#1 Introduction, Power supply, Meters, Resistors	Form
2.	Sept 7, 8	#2 DC Circuit Analysis (Kirchoff, Thevenin)	Form,(graph from #1)
3.	Sept 14, 15	#3 Digital devices, get Lab Kit	(Report from #2)
4.	Sept 21, 22	#4 AC Components, characterization	Form
5.	Sept 28, 29	Practical Examination	Exam,(graph from #4)
6.	Oct 5, 6	Demonstrate Digital Project #1	Form,demo
7.	Oct 19, 20	#5 AC Filters, resonance	Form, attach graph

8.	Oct 26, 27	#6 AC Circuit Analysis (Kirchoff, Thevenin)	Form, attach graph
9.	Nov 2, 3	#7 Start Digital Project #2	
10.	Nov 9, 11	#8 Transformers, Diodes, Power supplies	Form
11.	Nov 16, 17	#9 Op-Amp circuits, feedback	Form
12.	Nov 21	Make-up day for Thursday section	
13.	Nov 30, Dec1	Demonstrate Digital Project #2	Form, demo
14.	Dec 7, 8	Preparation for Practical Final Examination	(Extras if any)
15.	Dec 11	Make-up day for Friday section	
16.	Exam Week	Practical Examination (AC, digital)	Exam

Grading:

Graded material will include form reports that are handed in at the end of the laboratory session in which the laboratory exercise is performed. These are to be neatly hand-written, and will usually include figures for circuits, and graphs for results. Values given are to have appropriate units, and are to be presented with an appropriate number of significant digits. Graphs and figures are to be properly annotated. For some of the later laboratory exercises, students are to construct a graph in Excel using the lab station computer, using the lab exercise results, and the printed graph is to be attached to the form report.

In some cases, a part of the laboratory report is to be handed in at the beginning of the next laboratory session. That is true when the students perform analysis, build graphs, or do simulation that cannot be done during the laboratory exercise proper.

For the two projects, a form report is to be filled in and turned in on the date on which the project is due to be demonstrated. The instructor or an assistant will visit your station, observe the correct (or incorrect) operation of your project circuit, and add notations on your report. You are to turn in a schematic (circuit diagram) that was prepared ahead of time with the form report.

There will be two practical examination. The first is before mid-term, concerning DC circuits. The second is at the time of final examinations, concerning AC circuits. These are done by individual students in two shifts of 50 minutes each.

Graded material (in order collected), with grade weightings toward the course grade are listed:

Lab #1 form (Includes hand drawn graph) team grade	4%
Lab #1 graph (Excel prepared graph) individual grade	2%
Lab #2 form (Includes series and parallel parts, measurements for network) team grade	3%
Lab #2 report (Includes analysis, simulation of network) team grade	4%
Lab #4 form (Includes form, hand drawn or Excel printed graphs) team grade	4%
Lab #4 graph (Excel prepared graph) team grade	2%
Practical Mid-Term Examination: individual grade	20%
Lab #3 form, demonstration (working circuit graded) team grade	8%
Lab #5 form (includes attached Excel graph) team grade	6%
Lab #6 form (includes attached Excel graph) team grade	7%
Lab #8 form: team grade	6%
Lab #9 form: team grade	6%
Lab #7 form, demonstration (working circuit graded) team grade	8%
Practical Final Examination: individual grade	20%
Total	100%

All materials will be collected and graded on the basis of 100 points. Graded material will be averaged with the weightings given above, then converted to Wilkes's 4.0 scale as follows:

90-100	4.0	70-74	2.0
85-89	3.5	65-69	1.5
80-84	3.0	60-64	1.0
75-79	2.5	below 60	0.0

Laboratory reports, graphs, simulation results, and other submitted graded material is to be the work only of the individual student or the team, as appropriate for the particular assignment. You may get help of a general nature from other students, such as the general approach to solving a problem, but not any data, text, figures, or other material specific to the problem. If a student has been found to have inappropriately copied from another student, or has furnished another student with material from which a copy was made, a grade of zero will be awarded for that exercise or perhaps the entire course if that seems to be warranted. If the work in question is an obvious copy of another student's work, that violation of academic integrity is flagrant enough to earn a zero in the course.

Attendance is mandatory. Missing two lab sessions, unless excused, will result in a failing grade for the course. Missed lab sessions must be made up, or will be given a zero grade. That may require the student who missed the session to perform the entire laboratory exercise by himself without the benefit of having a partner.

Practical Examinations:

The anticipated contents of the two practical examinations are:

Mid-term Practical Exam (DC): (50 minutes)
1. Reading and measuring resistor values
2. Construct a given resistive DC circuit and measure several Voltages and Currents
3. Find the Thevenin Voltage and Resistance for the circuit, taking one resistor as the load.

Final Practical Exam (AC): (50 minutes, so only a few of these. Content not yet decided.)
Possible suggested components:
1. Have student measure unknown capacitor (or inductor) value. (Use RL or RC to find it?)
2. Find resonant frequency and bandwidth / Bandpass for RLC circuit using oscilloscope.
3. Given AC network, freq., measure Voltage amplitude and phase across a component or two
4. Construct an op-amp circuit and give gain as measured (incl. phase) at given frequency.
5. Given a 14 pin 4 gate digital gate device (number hidden), find truth table, function

Component values, frequencies, and other circuit details will vary from section to section.

It is important that both students in each team participate fully in doing the laboratory exercises. One student should not monopolize the instruments. Both need the experience. If a student takes a passive approach, letting his partner do all the work, that student will be seriously exposed during the practical examinations. Partners should help each other out so that both gain a full understanding of the laboratory exercises, how to use the equipment, and how to build and troubleshoot circuits.

The Lab Kits:

Each team of students will receive a "lab kit" which consists of an assortment of tools, components, an inexpensive digital meter, a power supply, and a solderless breadboard. The kits will be distributed during the 3rd lab session (Sept. 14 or 15). While doing laboratory exercises in the laboratory, you will often use the solderless breadboard and instruments belonging to the laboratory. You will first need the kit and its components to do the first digital project. However, having the kit available, especially the tools (wire cutters, pliers, alligator clip wires) and the extra meter, will be very helpful in later lab exercises. Often it helps to have two or even three meters, so that two or more measurements can be made simultaneously without having to move the meter leads.

You should bring some sort of box to lab session 3 for your kit components. (Often students purchase plastic tackle boxes or tool boxes for this purpose. Initially what you need can be as simple as a cardboard box, with assorted smaller boxes for different kinds of components.)

The lab kit includes some potentiometers. You should make a point of soldering leads to these, as well as to the SPST pushbutton. (Great care is needed with the pushbutton since the plastic can melt, ruining it. Use your pliers as a heat sink and use as little heat as you can.) There will be two soldering stations at the rear of the laboratory for doing this. You must wear the eye protection provided while doing soldering, and wear clothing that provides protection from solder spills.

The wire to be used for your projects and for general wiring is available in spools at the back of the laboratory. During Lab 3, you should help yourself to generous portions, perhaps 4 feet or so, of each color to be used for wiring of the first project. In addition, boxes containing wire scraps from previous projects are available in the lab. You may be able to find suitably trimmed and stripped wires there, thus recycling wire and saving resources as well as reducing the labor to cut and strip wires.

You may want to consider supplementing your kit with an Exacto knife (a sharp pointed one) or equivalent. Occasionally a wire may break off leaving a very short stub in your breadboard. This can usually be avoided by being careful not to nick the wire when stripping. But, if you do have a break, the small fragment can usually be coaxed up out of the hole with a sharp knife. A knife can also be useful for stripping wire, though that does have more danger of nicking the wire than other methods. Having your own soldering iron might be useful.

The solderless breadboards in the kit come with a small plastic box that includes pieces of wire, rubber feet, and binding posts. You should put the rubber feet on the corners under your board, so the breadboard won't scratch your grandmother's priceless walnut table. The wire assortment isn't terribly useful because it is color coded by length. What you need is color coding by function. For example, you always want to use black wire for ground and red wire for power, then use other colors for various signals. The wire kit colors don't help you with that.

The binding posts are junk. They are fragile, and often the plastic insulation doesn't fit properly, so they wiggle around, and cause shorts and intermittent open faults. If you tighten the nut that secures the binding post adequately, it will often snap the shaft. You are welcome to use the binding posts, but be aware of this peril. You are probably better off to directly connect signals and power directly to your breadboard strips. The alligator clip wires are handy in going from the banana connector wires in the lab to a small piece of hook-up wire that can be inserted into the breadboard holes.

A handout describing various parts in the lab kit will be distributed. It may be a bit out of date on the power supplies and a few other devices, but most of it is still applicable.

Laboratory Computers:

The computers in the laboratory at each station are there to be used for purposes appropriate to the laboratory exercises. They are not there to play music or run games. You will need the computers specifically to use Excel for graphing, and to run circuit simulation programs (LTSpice or PSpice). You may use other applications on the computer for purposes of preparing reports or other material associated with the course. A printer at the back of the laboratory can be used to print the graphs to be included in some reports. (It is a monochrome printer. Be sure that you select colors and other options appropriate to the medium.)

If you find that a computer or the printer is not operating properly, please bring that to the instructor's attention immediately, so that corrective action can be initiated.

You may find it convenient and useful to bring a laptop computer to the laboratory to be used instead of or in addition to the lab computer. That is allowed.

Laboratory Stations:

The laboratory stations are numbered starting with number one adjacent to the window side of the laboratory at the front, counting back on that side to station 4 in the back, then on around with station 5 on the interior wall at the back to station 8 in the front next to the door. You will need to identify your lab station on your reports.

If you find that some part of the laboratory equipment is not operating properly, please bring that to the instructor's attention immediately, so that corrective action can be initiated. We do have spare equipment that can be deployed if such a problem comes up.

At the end of each laboratory session, you are responsible for cleaning up your lab station and putting the cables back into their normal appropriate positions. That means specifically:

1. T connector on channel 1 of the signal generator
2. BNC-BNC cable from T connector to Channel 1 of the oscilloscope
3. BNC-banana cable from T connector, to loose on the table
4. BNV-banana cable from Channel 2 of the oscilloscope, to loose on the table
5. Red and black alligator to banana cables to the positive V/Ohms terminal (red)of the Digital Multi-meter and the common (black) terminal, to loose on the table
6. Mouse and keyboard placed to the side, out of the way
7. Other banana cables returned to the holders found on the equipment racks.
8. Scraps of wire and insulation placed in the wire scrap box or trash as appropriate, and any loose components (typically resistors) placed in the "junk" components box
9. Loose papers and trash picked up and either put away appropriately or thrown away.

(There may be appropriate reason to deviate from this, but if so, notify the instructor.)

Engineering Laboratory Reports Manual:

Copies of this manual will be distributed to every student in the course. While the primary concern of the manual is preparation of formal laboratory reports, much of the contents are applicable to this course as well. In particular, students should read the material on preparing graphs using Excel and drawing schematics. The manual can be found at the following web site:

< http://www.jbgilmer.com/LabManual/LabManual.htm>

Course web site:

Materials including the syllabus, lab exercises, handouts and tutorial material will be posted at: < http://www.jbgilmer.com/EE283/EE283.htm>.