EET 2200/L: Electrical Systems I, Northern New Mexico College

Analysis and synthesis of electrical systems composed of diodes, transistors, operational amplifiers, comparators, timers, and voltage regulators.

Prerequisites: Algebra Based Physics II
Credits: 3
Instructor: Steve Cox, steve.cox@nnmc.edu
Textbook: Practical Electronics for Inventors by Paul Scherz and Simon Monk, McGraw-Hill, Fourth Edition. It will cover this course and EET 300L.
Software: We will start most of our work in the cloud, at tinkercad. We will make frequent use of python, so please download and install Anaconda. Chapter 1 of Problem Solving in Python steps you through the process. Chapter 2 shows you how to use jupyter notebooks. We will also use National Instruments Hardware and Virtual Instruments, so please download and install the NI-ELVISmx software and bookmark this NI-ELVIS II manual.
Time & Place: Tuesday and Thursday 1:00-3:05 in SERPA 115
Office Hours: On request
Grading Policy: 100% Weekly Labs. Due each Monday at midnight at Canvas.

Specific Outcomes of Instruction

- Knowledge of basic concepts of semiconductors, gain, impedance, phase, bandwidth and their mathematical representations.
- Graphical representation and physical construction of fundamental amplifier, oscillator and regulator circuits.
- Measurement of circuit response in tinkercad and NI with virtual instruments as well as physical instruments.
- Integration of components and fabrication of enclosure into a functioning solar charge controller.

Student Outcomes and Program Criteria Outcomes

- SO1. An ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined engineering problems appropriate to the discipline.
- SO2. An ability to design systems, components, or processes meeting specified needs for broadly-defined engineering problems appropriate to the discipline.
- PCO (d). Use appropriate computer programming languages for operating electromechanical systems.

Schedule

Week 1-4. Diodes & Transistors
Week 5-6. Operational Amplifiers
Week 7-8. Active Filters
Week 9-11. Oscillators & Timers

Week 12-14. Voltage Regulators and Charge Controllers

Week 1. Diodes Tinkercad
In tinkercad build and test and annotate these circuits from Practical Electronics for Inventors

- Voltage Dropper, Fig 4.15
- Voltage Regulator, Fig 4.16
- AND Gate, Fig 4.23 (use slide switches for inputs)
- OR Gate, Fig 4.23 (use slide switches for inputs)

Submit a word doc lab report where each circuit has an introduction, screenshot(s), and discussion/conclusion. **Due: Midnight Monday.**

Week 2. Diodes NI-ELVIS
Repeat the above lab in NI-ELVIS
Submit a word doc lab report where each circuit has an introduction, photos, screenshot(s), and discussion/conclusion. **Due: Midnight Monday.**

Week 3. Transistors Tinkercad
In tinkercad build on a breadboard and test and annotate

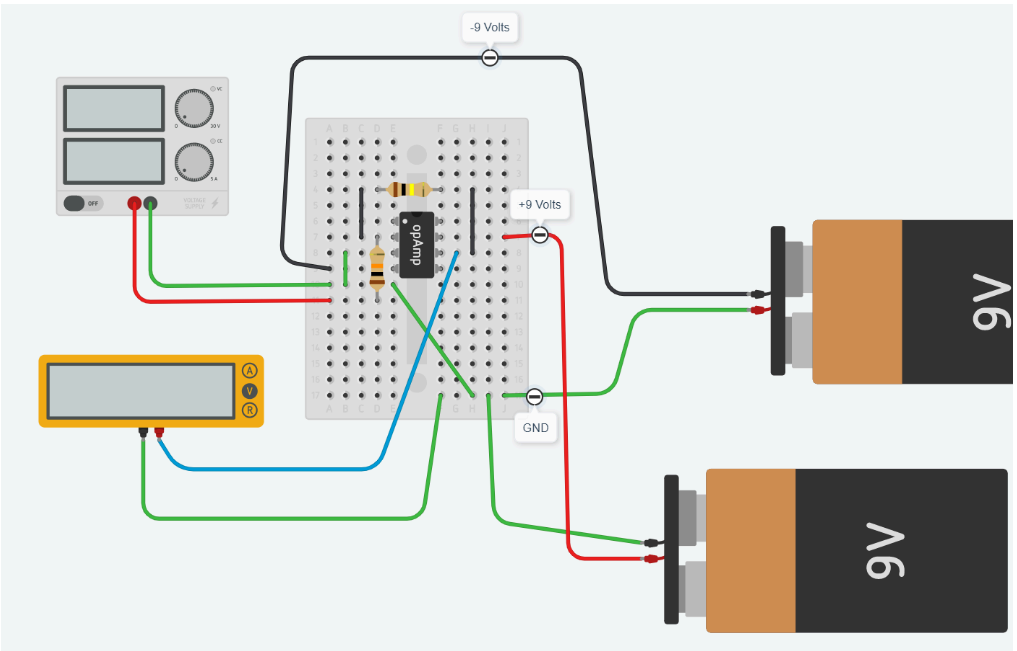
- the circuit in Figure 4.49. Measure the three currents and two voltages.
- the circuit in Figure 4.58. For Vin use a sine wave of frequency 100 Hz and Amplitude 0.1 V and use an oscilloscope to measure Vout and report the resulting gain, and discuss how close it comes to the predicted gain.
- the OR and AND gates in Figure 4.69.

Submit a word doc lab report where each circuit has an introduction, screenshot, and discussion/conclusion. **Due: Midnight Monday.**

Week 4. Transistors NI-ELVIS
Repeat the above lab in NI-ELVIS, with the addition of the IV curve in Fig. 4.46 (page 432) using the 3-wire analyzer in NI-ELVIS. Regarding the input voltages in Fig. 4.49, use the +15V for Vcc and VPS for 5.6V.
Submit a word doc lab report where each circuit has an introduction, photos, screenshot(s), and discussion/conclusion. **Due: Midnight Monday.**

Week 5. Operational Amplifiers Tinkercad

Use python to graph Vout vs. Vin for both the non-inverting **and** inverting amplifiers in figures 8.11 and 8.12 of our text. Here is a tinkercad build of the inverting amplifier. The first thing to note is that we have used the circuit of Figure 8.23 to power our opamp with a pair of 9 volt batteries.



Use the Variable Power Supply (VPS) for Vin. Measure Vout with the Digital Multimeter (DMM). I recommend input current at 0.1 A

and input voltages of 0.2, 0.4, 0.6 and 0.8 Volts

Submit your completed jupyter notebook with a graphic showing

(1) the pinout of our 741 op-amp, (https://www.base64-image.de/)

(2) a screenshot of each circuit and a well labeled python plot, using this jupyter notebook, and (optionally please coax schemdraw into drawing your inverting amplifier circuit) - and please include the circuit analysis that establishes its gain.

(3) theoretical and experimental calculations and comparison of their gains.

Due Monday at midnight.

Week 6. Operational Amplifiers NI-ELVIS

Repeat the above lab in NI-ELVIS

Submit a word doc lab report where each circuit has an introduction, screenshot of each built circuit, and Vout vs. Vin for each amplifier comparing ELVIS recordings to last week's results (graph tinkercad and ELVIS data on same figure, with distinct colors and use of legend) and discussion/conclusion. **Due: Midnight Monday.**

Week 7. Active Filters Tinkercad

Build and test Circuit in Final Low Pass Filter Figure 9.15, get gain plot in Figure 9.14 (top left) by recording Vout_pp at 10 frequencies, and plotting gain (20*log10(Vout_pp/Vin_pp))

Build and test Circuit in Final High Pass Filter Figure 9.17, get gain plot in Figure 9.16 (top left) by recording Vout_pp at 10 frequencies, and plotting gain (20*log10(Vout_pp/Vin_pp))
C values are 10 times too large, please use 16 nF.

Build and test Circuit in Final Band Pass Filter Figure 9.18, get gain plot as described in words in sentence following Wide-Band Example (bold heading)

Build and test Improved Notch Filter in Figure 9.22 and demonstrate the notch at 2000 Hz with a -3 dB bandwidth of 100 Hz by plotting gain as described above.

Submit one word.doc or jupyter notebook with intro, and R and C vals plus screen shot of tinkercad simulation, and python gain plot, for each filter over the right frequency range, and conclusion. **Due Monday at midnight.**

Week 8. Active Filters NI-ELVIS

Repeat the above lab in NI-ELVIS, using the Bode Analyzer to take care of ALL of your frequency needs.
Submit a word doc lab report where each circuit has an introduction, photos, screenshot(s), and discussion/conclusion. **Due: Midnight Monday.**

Week 9: Oscillators & Timers in CircuitLab and Tinkercad

Basic Oscillators
Build the circuits in Figures 10.2 and 10.4.
These are easy to build but impossible to simulate in tinkercad (why?).
Instead I **highly recommend** https://www.circuitlab.com/ You can create an account and build a circuit (and take a screenshot) but you can't simulate it without paying $24/year
Check out my screenshots of the circuit and simulated response.

Timer Circuits
Use the 555 chip to build and study the circuits in Fig 10.7 and the metronome in Fig 10.13
Include tinkercad screen shots of oscilloscope traces for the two circuits.
Gather your plots into a single word doc with copious documentation.

Due Midnight Monday.

Week 10: Oscillators & Timers in NI-ELVIS

Repeat the above lab in NI-ELVIS. Submit a word doc lab report where each circuit has an introduction, photos, screenshot(s), and discussion/conclusion. **Due: Midnight Monday October 24.**

Week 11: Voltage Regulators and Charge Controllers in Tinkercad

Voltage Regulators
Read Chapter 11 through section 11.2
Build and test the top circuit in figure 11.4 with 7805 . Use VPS for Vin, and vary it from 10 V down to 4V in steps of 1V and create a well labeled graph, via python, of Vout vs. Vin . Include this graph in your word doc with a figure of your circuit along with your precise capacitor values.

Solar Charge Controller
Build and test this Solar Charge Controller in tinkercad.
To confirm your test, record a video demonstrating that your relay "trips" when your "battery" voltage goes below the lower threshold or above the upper threshold.

Due: Midnight Monday.

Week 12: Voltage Regulators and Charge Controllers in NI-ELVIS

Repeat the above lab in NI-ELVIS. Submit a word doc lab report where each circuit has an introduction, photos, screenshot(s), and discussion/conclusion.

Due: Midnight Monday.

Week 13-15: Voltage Regulators and Charge Controllers for Real.

Repeat the above lab on a soldered breadboard and 3d designed box.
I have chosen to go with this voltmeter. Please use its dimensions.
Design your box in tinkercad and print it via flashprint
Layout your components before soldering.
Great solder demo.
Practice soldering before doing the real thing.

Due: Midnight Monday.