Inclusion of PCB Fabrication and Testing within Lab experiments

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Extended Abstract:

It is essential for practicing engineers to know the printed circuit techniques to design and analyze the PCB boards within electronic devices. Circuit tracing and troubleshooting experience are also essential for engineers to maintain electronic circuits. To facilitate this training, this paper proposes to include PCB fabrication and testing as the final part of the laboratory experiment associated with junior/senior-level electrical and computer engineering courses. In this paper, the PCB design process is included on the lab with title "BJT Common Emitter (CE) Amplifier" and belong to a junior electrical engineering course on "Analog Circuit Design". Some of the reasons for this selection are as follows: (1) This experimental circuit uses a lower number of electrical components, which may lead to lower errors during the PCB design, fabrication and testing process; (2) The input/output of the amplifier can be connected to physical devices (microphone/speaker) in addition to comparing the input and the output signals using an oscilloscope; (3) Since this was the 4th lab, the students can focus on the PCB design as they are already trained on the simulating software and the measurement setup from the previous experiments.

The lab work was divided into two parts. Part-1 required the whole duration of the lab session to successfully build and simulate the Ltspice/Pspice model of the amplifier. Note that the design of the amplifier with required parameters was a pre-lab assignments for students. On the 2nd 2-hour long lab, students used a breadboard to constract the amplifier circuit and experimentally verify the simulated results. The measurement process required DC and AC signal sources, a digital multimeter and a multi-channel digital oscilloscope. Figure 1 shows the setup, the simulated results on the laptop screen, the experimental setup and the measured signal on the oscilloscope screen.

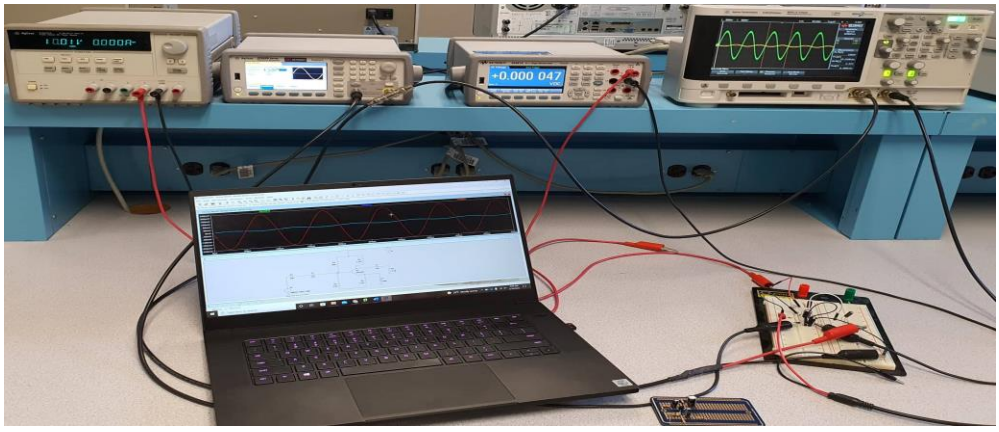

Figure 1: Simulated and measured output of the designed BJT CE amplifier circuit.

Once the experimental verification is complete, students were trained on the process of generating PCB layout manually and using the software. Since most of the students did not have any PCB design/fabrication experiences, the instructor provided them with a customized PCB board shown in figure 2(a). Once the students are confident about their PCB layout, they were asked to place the components on the PCB board and start the soldering process. For normal PCB boards, this process can be considerably improved by using an automated layout generator and printing them LPKF PCB plotter.

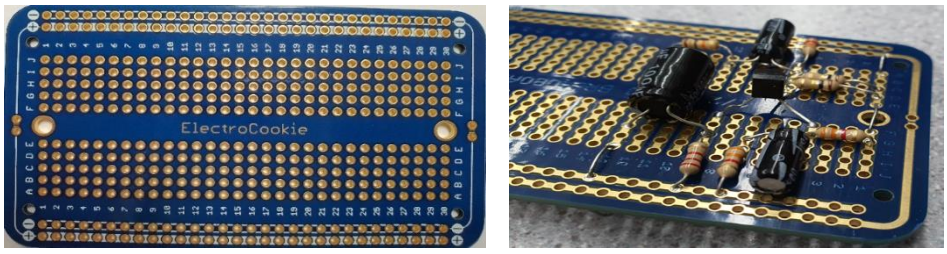

Figure 2(a) PCB board (b) PCB of a BJT amplifier

The most challenging part was the soldering of the components to the PCB board. Due to remote learning in previous semesters, the majority of students had never used the PCB fabrication facility of the lab and the student/instructor had to remain very careful to avoid injury. The final product of one group is shown in figure 2(b). Note that most of the two-students groups successfully completed the PCB board and were able to measure the amplified output signal during their 1st trial. The unsuccessful groups debugged the PCB board using circuit tracing technique and eventually measured the outputs. Even though students were disappointed due to initial errors in the PCB fabrication process, they were eager to find the fix the faults. Students feedback demonstrated that they were more satisfied with this lab compared to other labs without the PCB fabrication part.

Conclusion:

The purpose of this exercise is to better prepare the engineering students for industry, where they may need to produce a practical prototype of the designed circuit. To make this process more efficient, the instructors plan to use the simulator software to generate the PCB layout and use PCB plotters to fabricate the PCB circuit. Although it may take considerably longer time to print circuits for all the groups, these steps will introduce professional techniques to fabricate an accurate prototype. All the student groups successfully implemented the PCB-based amplifier circuit and demonstrated the amplified output signal. Several groups needed multiple attempts to get the correct output and needed to trace their PCB layout to find the fault with their initial PCB design. But excitement replaced the initial disappointment when they saw the correct output on the oscilloscope. Finally, as a lab instructor, I have noticed students enjoyed the PCB fabrication and testing process.