Encouraging Female High-School Students towards a Career in Electrical Engineering via In-Lab Participatory Learning: An Audio Electronics based Hands-On Example

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Introduction

Despite continued and numerous efforts by many, women remain underrepresented in electrical engineering[1]. To help address this issue, an experimental summer program of a one-week duration was designed and implemented with the goal of encouraging young female high school students to enter undergraduate engineering programs. The program fits into a larger program organized by the College of Engineering and Women in Engineering and specifically was built around hobbyist electronics. The goal of this short summer program was to provide hands-on lab experience that can be accomplished at the high school level, leading to enthusiasm and confidence among female high school students. This work has been carried out as part of the community outreach educational activities at the Advanced Signal Processing Circuits (ASPC) lab and we summarize our experience in planning and delivering this workshop as follows.

Learning Objectives

The programmed was structured to achieve the following learning objectives.

- Familiarize with basic electrical engineering terminology such as voltage, current, signals, frequency, resistance, capacitance, amplitude, amplification.
- Familiarize with simple electrical laboratory equipment such as oscilloscope, function generator, power supply and digital multi-meter.
- Learn how to assemble an electronic circuit on a prototyping board (bread board) using discrete components such as resistors, capacitors.
- Learn how to test and troubleshoot a simple electronic circuit.
- Enhance team-work and presentation skills

Hands on Project Description

As shown in Fig. 1(a), the particular audio amplifier circuit that we chose contains the LM384 power amplifier[2] integrated circuit (IC) and few passive components such as resistors and capacitors. The IC approach was chosen to let the students appreciate the concept of very large scale integration of electronic devices inside a single silicon chip. A prototyping board was used to construct the circuit using the IC, resistors, capacitors and connecting wires. Basic tools such as wire strippers and pliers were used during the circuit assembling process. Fig. 1(b) shows the assembled circuit on the prototyping board, where an input signal is provided using an iPod and the amplified sound is heard back from the speaker. A 22V DC power supply was used to provide the power. Function generator was used to provide test input signals such as sine waves with known amplitude and frequency, and the oscilloscope was used to observe the amplified output. The equipments are shown in Fig. 1(c). Soldering was not used during the project and operating voltage of the DC power supply was kept within the 22V limit

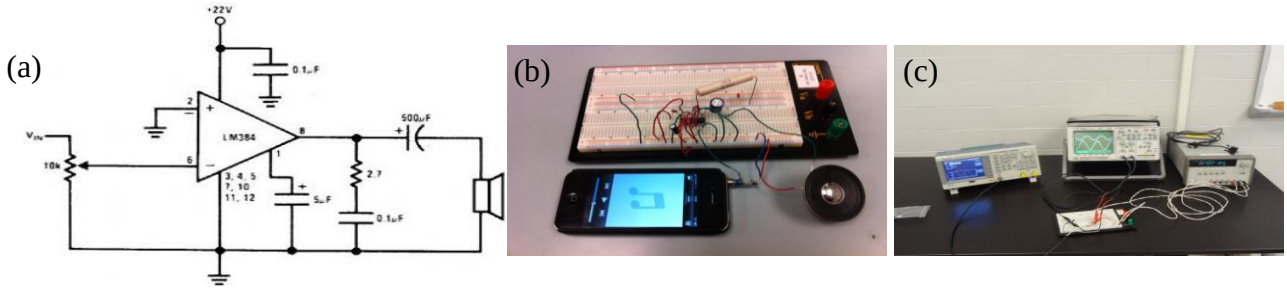

Fig.1: (a) Circuit diagram of the audio amplifier. (b) Assembled circuit on the prototyping board with an iPod connected to provide the audio input. (c) DC power supply, oscilloscope and function generator used to operate and test the circuit.

List of components/equipments

1. Integrated circuit(IC) LM384
2 (a). Resistors: one 10 KΩ and one 2.7 KΩ
   (b). Capacitors: one 5 μF, two 0.1 μF and one 500 μF
3. Prototyping board.
4. Connecting wires.
5. Lab equipment – oscilloscope, signal generator and DC power supply.
6. Speaker (8W/8Ω).

Specific Methods of Delivery

In order to achieve the learning objectives mentioned above we adopted the following outline during the 1-week program. Fig.2 depicts selected activities in each day.

Day 1: Program overview with motivation towards audio amplifiers

During this introductory session students were introduced to various applications of electrical engineering in day to day lives. Significance of audio amplification was explained in particular, by taking examples ranging from iPods, TVs to high end audio systems. An example senior design project related to audio amplification was demonstrated by one of the female graduate student. Students were involved in a group discussion on the project that they are going to complete. Also, the students had to practice time management by having the circuit done and tested by a certain time so that the last 30 minutes of the day was devoted to working on the poster with the team.

Day 2: Introduction to basic terminology, discrete components and laboratory equipment

Basic electrical engineering terms such as voltage, current, resistance, capacitance, signal, amplitude, and frequency were introduced. Each term was introduced with their definition together with a real word analogy for better understandability. For instance the analogy of water pressure and the flow rate for voltage a current, the blockage in pipes and values for resistance, the ability to store/absorb water into a particular medium for capacitance. The concept such as amplitude and frequency were illustrated using the oscilloscope. Ohm's law was introduced using an in-circuit demonstration and the Ohm's law triangle was introduced to remember the law.

Day 3: Learning different kinds of connections to be made on the prototyping board

The series and parallel connections in a circuit were explained using analogies based on various connections of water pipes. The prototyping board was introduced and students were given the change to construct random connections on the board and have some practice.

Day 4: Building up the circuit on the prototyping board

With the experience from day-3 students were provided with step-by-step instructions to assemble the circuit on the prototyping board.

Day 5: Testing the circuit and Preparation of a poster

The circuit was first tested by providing test input signals by the function generator and observe the output in the oscilloscope, where student were able to visually see the amplification of the output signal. After that, an iPod was used to provide an audio signal (one of their favorite songs) and the connected speaker gave the amplified sound. After testing, students prepared for the poster presentation.

Day 6: Present the poster

The students were asked to present their work using the poster.

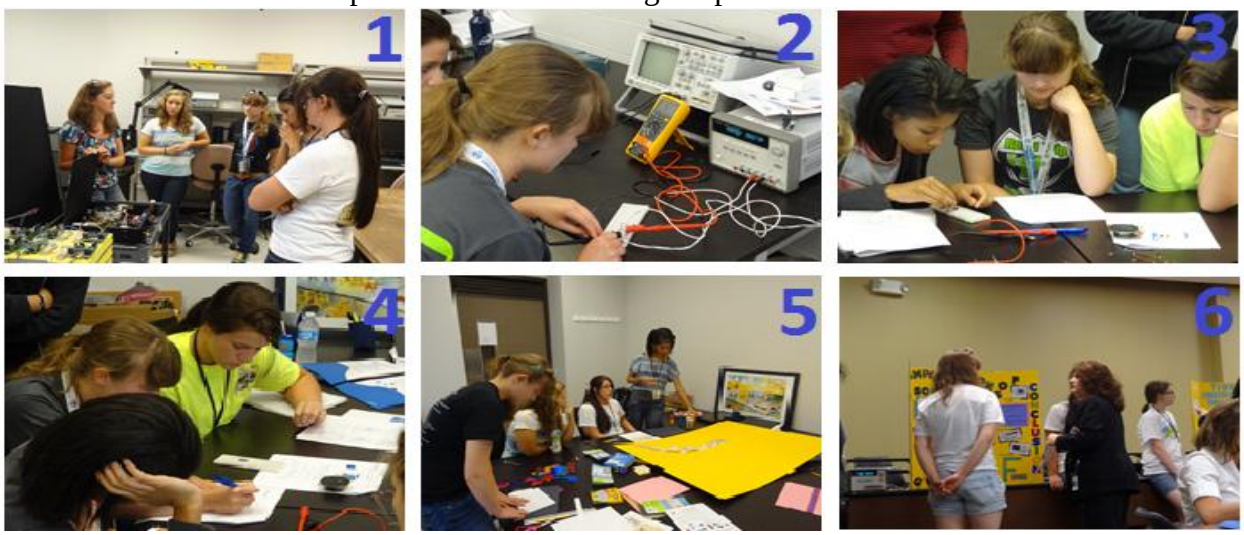

Fig.2: Photos depicting each day of the program.

Conclusions

Initially, the students had a notion that engineering was boring and tedious. During the week, they had exciting and energetic experience with the concepts learnt and tools used. After the program, they had better understanding of electrical engineering and were well-determined to pursue an engineering degree. Students were able to successfully present their work and were able to secure the second place during the poster competition.

1. David Knight, Lisa R. Lattuca, Alexander Yin, Gul Kremer, Travis York and Hyun Kyoung Ro, "An exploration of gender diversity in engineering programs: a curriculum and instruction-based perspective", journal of Women and Minorities in Science and Engineering, vol.18, pp.55-78, 2012.

2. "LM384 5W Audio Power Amplifier", [online] http://www.datasheetcatalog.org/ datasheet/ nationalsemiconductor / DS007843.PDF