Mobile Studio-Based Electronics Courses

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Abstract

The Department of Electrical and Computer Engineering offers courses in several areas including electronics. Traditionally, the Department had been offering two courses in electronics with two laboratories offered separately at the junior level. It was difficult for students to follow without physical feeling of the courses even though the objectives and ABET requirements were met. Recently, we have introduced the mobile studio approach that requires hands on and lectures simultaneously. The mobile studio is a lab on "wheels". Each student has his/her own work station that consists of: (a) A Tablet-PC (lap top) with special software that mimics instrumentation and other features. (b) Input/output I/O board that consists of dc power supplies, function generator and it can be used for analog or digital experiments. (c) A bread board that contains the hardware set up for the hands on approach. It is connected to the I/O board connected to the Tablet PC. The instructor also has a similar set-up for demonstration. Examples will be presented. The mobile studio has motivated the students' interest in the courses and performance has improved immensely. A post-survey of the course is conducted at the end of each semester. It covers use of the I/O boards, course content, format setting, perceptions of engineering and ABET assessment.

Index Terms – Electronics, mobile studio, tablet PC, I/O board, survey

I. Introduction

The Department of Electrical and Computer Engineering offers courses in several areas including electronics. Traditionally, the Department had been offering two courses in electronics accompanied by two electronics laboratories at the junior level. The laboratory and lecture sessions were often taught by different instructors at different times and it became difficult for students to follow the lectures without physical feeling of what was going on even though the Department met its objectives while satisfying ABET requirements. Recently, we have introduced the mobile studio approach that requires hands on and lectures simultaneously. The mobile studio is a lab on "wheels". Each student has his/her own working station that consists of: (a) A Tablet-PC (lap top) with special software that mimics instrumentation (voltmeters, ammeters, two channel oscilloscopes). (b) Input/output (I/O) board consists of dc power supplies, function generator and it can be used for analog or digital experiments. (c) A bread board that contains the hardware set up for the hands on approach. It is connected to the I/O board that is connected to the Tablet PC. The instructor, with the aid of a graduate teaching assistant, also has a similar set-up projected onto a screen for demonstration. Thus, the lectures also contain hands on approach.

II.Mobile Studio Approach

Electronics I is taught in the first semester of the third year of study in the Electrical and Computer Engineering program at Howard University. The aim of the course is to enable students to understand the basic physical concepts of electronic materials and solid state devices including one stage amplfiers; to prepare for the basic techniques of circuit design.

The original Electronics I theory course has been replaced by a course that entails both theory and practical hands on application. The traditional laboratory setup, which includes oscilloscope, multimeter, power supply, function generator and others has been replaced by the mobile studio setup that consists of a breadboard, Tablet PC (personal computer) and a Rensselaer I/O Board that is a small hardware platform. The entire setup occupies less space than a

traditional spiral notebook would, and is shown in Fig. 1 below.

Fig 1: Mobile Studio workstation

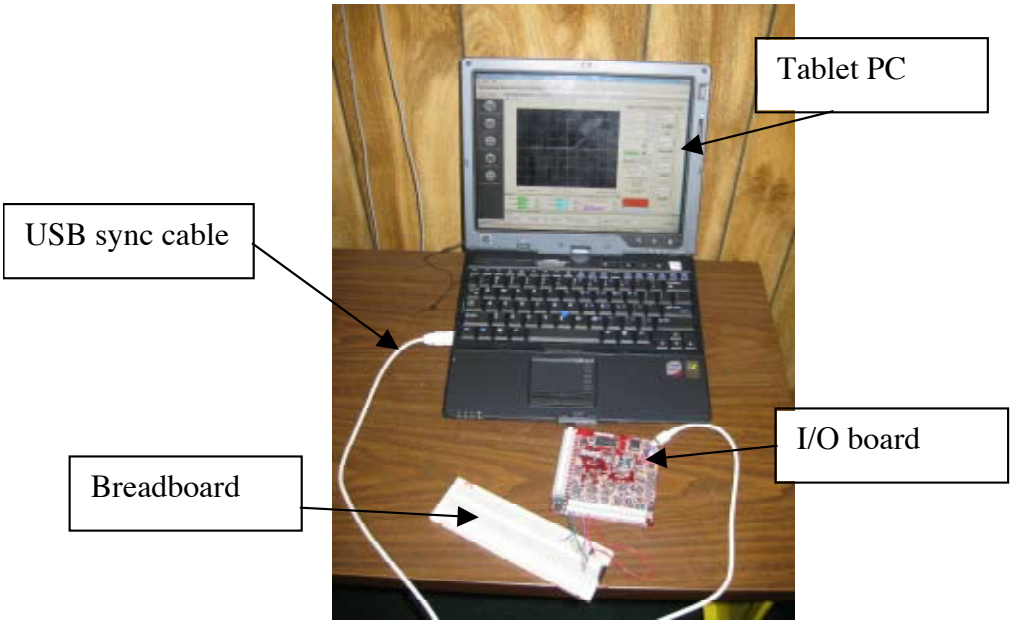
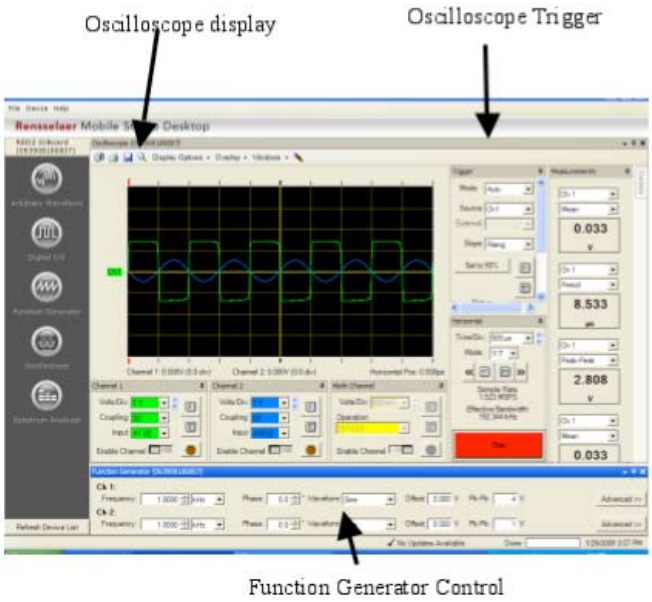


Fig. 2 below shows a screenshot of the I/O board instrumentation panel displayed on the tablet PC screen. The I/O board emulates a function generator, oscilloscope, voltmeter, Spectrum analyzer, ±4V DC power supply and is capable of digital operations. The board output dc power lies in the range -4V to +4V, and all of the experiments have been designed with voltage range (constraint) this in mind.

Fig 2: The I/O board instrumentation panel



The portable nature of this setup means that there is far greater student interaction with the equipment. In a small classroom, In this set up there is a workstation for each student. The instructor, the graduate assistant and each student are equipped with a mobile studio setup. Every topic taught in the class is punctuated by a practical example

that is demonstrated by a lab technician and or graduate assistant. The students are then encouraged to individually explore the characteristics of the demonstrated circuit. The instructor and the graduate student monitor students progress and offer assistance to ensure that all students understand the topic before resuming the lecture. Projects (homework) that involve the use of the studio are also assigned.

The topics covered in Electronics I course (offered in the Fall semester) include:

1. Course Introduction, Review of circuits and networks
2. Diodes, Circuits with Diodes
3. Amplifiers, Operational Amplifiers
4. MOS FET Transistors
5. Bipolar junction transistors
6. Single stage Amplifiers, frequency response

Electronics II is offered in the second semester of the academic year in Spring taken only by electrical engineering students. . Topics covered include:

1. Review of electronics I Topics
2. Differential and Multi-stage amplifiers
3. Feedback amplifiers
4. Integrated circuits (the operational amplifier)
5. Filters and tuned amplifiers
6. Signal generators (wave shaping)
7. Power amplifiers and output stages of amplifiers.

We combine lecture, recitations and laboratory experiments together in a minimum of six-hour periods per week. The mobile-studio approach has improved students performance and participation tremendously. Some selected examples follow.

III. Selected Examples of students' work

a.The operational amplifier (inverting mode)

The third unit is an introduction to linear and non-linear amplifier circuits. Op-amp, transistor, and other types of amplifiers are discussed. One of the Mobile Studio exercises related to this topic involve theoretical and experimental determination of op-amp output behavior. The circuit discussed is shown in Fig 3 (a). Fig 3 (b) below shows the voltage waveforms obtained using Mobile Studio.

Fig 3 (a) : Schematic of op-amp circuit used in practical exercise

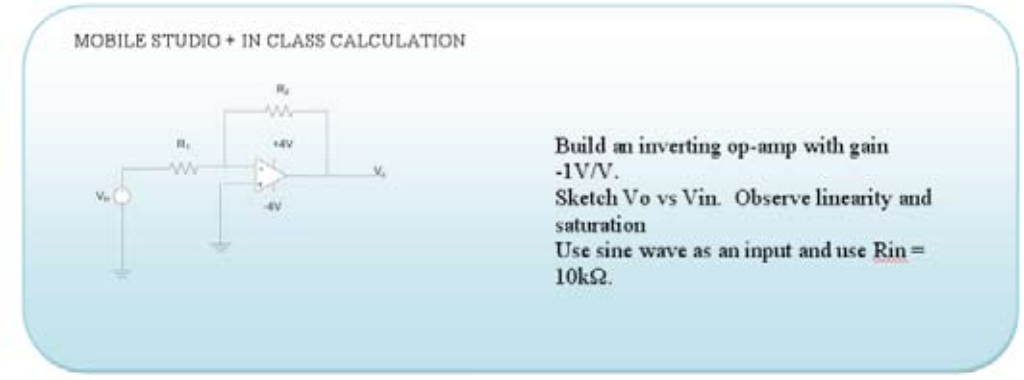
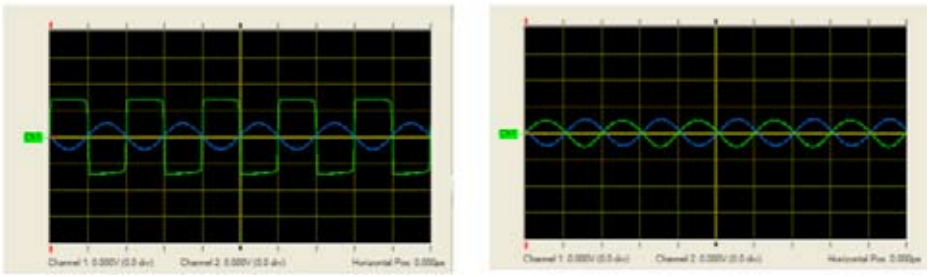


Fig 3 (b) : Voltage waveforms obtained using Mobile Studio
One with distortion and the other with no distortion. Inversion mode results.



The students are able to observe immediate practical hand on application of the lecture material and are, therefore, able to actively participate in the discussion.

b. Laboratory Examples – NMOS amplifiers

The second laboratory experiment involved the design, construction and analysis of NMOS amplifiers. The responses of common source, common gate and common drain amplifiers are compared. The schematic diagram of the common source amplifier circuit is shown in Fig 4 (a) below and the output is shown in Fig 4 (b). The students measured the gain at different frequency values to obtain the frequency characteristics.

Fig 4a: Schematic diagram of common source amplifier

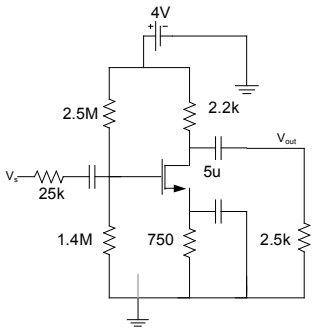
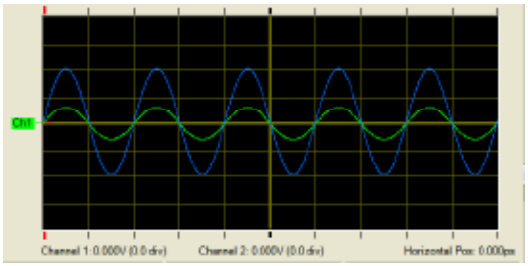


Fig 4b: C-S amplifier input/output



c. Compound amplifiers

The third laboratory exercise involved the construction of several compound amplifiers. Fig 5 below shows the schematic diagram and voltage waveforms of the amplifier with a Darlington pair at the output.

Fig 5a: Schematic diagram of Darlington pair

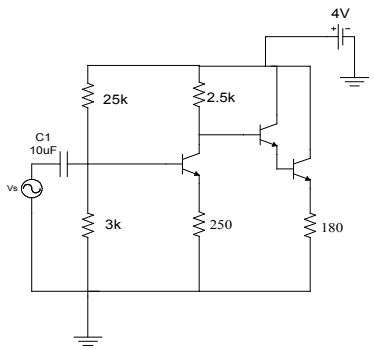
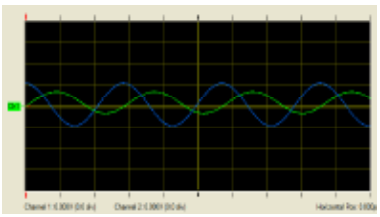


Fig 5b: Mobile Studio Output



d. Diode Characteristics

The students investigate diode characteristics during the diode.. The input and output voltage waveforms and the I-V characteristics are shown in Fig 6 below. They also demonstrate its rectification characteristics and use in logic circuits.

Fig 6a: Schematic diagram of diode circuit

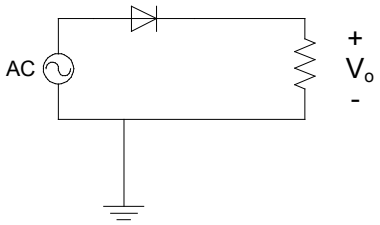
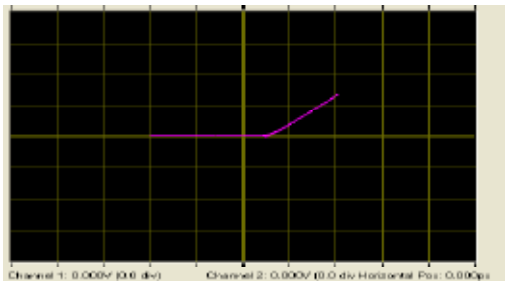


Fig 6b: Diode I-V characteristics



IV. Survey

The purpose of the survey is to use the results to enhance the electronics program and proposed use in other courses.. The responses are confidential and are not released in a way that identifies the student. The mobile studio electronics courses surveys are conducted to get feedback/reaction from students. The data is analyzed and the results are use for class improvement.

Summary of course survey outline:

- Frequent use of I/O boards in class, lab and homework
- I/O Board usage in course content, instructor and teaching assitsnt, format setting, supplementary material
- Use of I/O boards integration on students- development of students confidence
- Students perceptions of engineering- interest in the engineering profession
- Engineering knowledge (follows closely ABET outcomes)-application of mathematics and science in solving/ designing engineering problems, effective communications.

Students also respond to effective use of the I/O board and confidence in engineering and whether it is useful in studying the courses. What changes need to be made and additional comments.

V. ABET Program outcomes and assessment

(a) An ability to apply knowledge of mathematics, science, and engineering

Demonstrated competence in course work undertaken to learn materials and concepts of analog electronics.. Tests and homework will demonstrate such competence. Minimum competence is defined to be 70% average on all tests and homework assigned during the semester.

(e)An ability to identify, formulate, and solve engineering problems

Design project work – for each design project, students are required to discuss at least two possible ways in which to fulfill the design specifications and give substantive reasons for their own choices. Minimum competence – grade of C on written design reports where alternative solutions are required for evaluation.

(g) An ability to communicate effectively

Design project work – communication/writing skill are required in the written report detailing requested work, information, and in the oral presentation. Minimum competence – grades of C on written design reports, and average communication skill.

(b) An ability to design and conduct experiments, as well as to analyze and interpret data

Design project work - for students to build and test a hardware prototype or its simulation. Students must determine the appropriate type of data to acquire and analyze them in order to show proper functionality of circuit. Minimum competence – working prototype or its simulation as demonstration to instructor, grade of C on subsequent written design reports.

(c) An ability to design a system component, or process to meet desired needs

Design project work – for each design project students are required to consider the design goals are multifaceted, dynamic, and sometimes contradictory; the design process from conceptual to prototype is multi-dimensional, team-working, multidisciplinary as well as iterative and synthetic. The design solutions must be multiple and open-ended. Minimum competence is a grade of C in each design project.

Under the Americans with Disabilities Act of 1990, if you want to be identified as a person with a disability and need accommodations, please advise me by making an appointment.

VI. Conclusion

The department has successfully implemented the mobile studio approach (while satisfying ABET requirements) in teaching electronics courses including laboratory hands on by combining lecture, labs, recitation and homework projects. The new approach has tremendously improved students understanding of the material and perform assigned tasks. Typical students examples through the use of the mobile studio have been presented. Their confidence levels have increased unlike the earlier traditional methods (class lectures separate from labs). The department plans to extend the use of the mobile studio in teaching other course and eventually traditional lab instrumentation will be phased out.

VII. References

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VIII. Biography

Peter Bofah obtained his BSEE and MSEE both in electrical engineering from the University of Nebraska-Lincoln. He obtained his PhD in controls from Howard University. He is a faculty member at Howard University in the Department of Electrical and Computer Engineering. His areas of interest include: modeling and control of large structures, energy conversion, power electronics, and design and engineering education.

Mohamed Chouikha obtained his MS and PhD degrees in electrical engineering from the University of Colorado. His areas of interest include image and signal processing, and electrical and computer engineering education. He is the Chair of the Department of Electrical and Computer Engineering.

Jan Jerry received a BSEE degree in Electrical Engineering in May 2007 at Howard University, where she is currently studying for her Masters degree. Her research interests include nonlinear and adaptive control of electromechanical systems-based ac industrial drives, signal processing, and DSP-based control architectures.

IX. Acknowledgment

Thanks to the students and the faculty who have contributed to the success and continuous improvement of the mobile studio based hands on electronics courses..