Integrating Lectures and Labs Using the Mobile Studio

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Abstract *– The Department of Electrical and Computer Engineering has traditionally offered courses in several areas by separating course and labs. This approach has always presented difficulties to the average student bridging the gap between the course and the related lab even though the objectives and Accreditation Board for Engineering and Technology (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 (such as analog and or digital courses). (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 that is connected to the Tablet PC. The instructor also has a similar set-up for demonstration. Examples will be presented. Presently, the mobile studio approach is being implemented in circuits, digital and electronics courses with success. It is anticipated that the mobile studio approach will be extended to most courses in the curriculum where applicable. The mobile studio has motivated the students' interest in the courses and performance has improved immensely. Examples will be provided using the mobile studio. 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, and perceptions of engineering and ABET assessment.*

Index Terms – circuits, digital, electronics, examples, mobile studio, tablet PC, I/O boards, survey

INTRODUCTION

The traditional medium of instruction of course with accompanied labs offered separately has always created problems for the student as well as the instructor. Both courses are seldom taught at the same time, almost always on different days and even sometimes both are taken in different semesters. Thus, the student finds it difficult to understand theory as well as the lab hands on. Generally, the lab and lectures may be offered by different instructors. Thus there is a great need to offer 'hybrid 'courses that consist of lectures, demonstrations and labs at the same time. Additionally, traditional labs are equipped with bulky work benches and large expensive instruments as well as large function generators and power supplies that consume a lot of electric energy for operation. Due to limitation of space and bulky equipment students work in overcrowded groups. Thus rather a few number in a group actually participate in performing the tasks required for the lab under investigation. The rest only act as 'reporters'. Give me the results.

Due to advances in technology and miniaturization, a great deal on work devices have been developed. Bulky instrumentations have been reduced to palm sized computer notebooks. The miniature instruments (Tablet PC) is interfaced with input out I/O boards that serve as source of power supply and function generators for analog and digital labs. The circuit under test is on a bread board is connected to I/O board. This unit (tablet PC, I/O board, bread board system) know as the mobile studio occupies rather a small portable space (less than a 0.2 cubic foot). The cost is rather low, less tan $1500 per station,, with prices going down gradually just like any other new product. Thus there is available mobile studio for each enrolled student as well as one for the instructor. The mobile studio provides the functionally of a traditional lab in a portable package. The instructor as well as students will be in synchronism to provide lecture and hands on at the same time. Data collection at the PC is a synch. The PC offers several instrumentation (ammeter, voltmeter, oscilloscope with basic two-channels).

The mobile studio-based classes have been introduced at the Department of Electrical and Computer Engineering for over four years now. Initially we started with 15 stations on experimental basis with networks (circuits) courses. It caught on and we got some more. Presently, we have over 45 stations enough to cover at least two different classes going

on at the same time. The mobile studio is now used in several classes at different levels freshman through senior levels. It is used by high school students participating in the departments' summer outreach engineering programs.

FIGURE 1: OLD FASHION TRADITIONAL LAB BULKY EQUIPMENT.

MOBILE STUDIO APPROACH

Studio teaching normally a practice of other departments (such as architecture, arts) has been adopted by engineering departments) due to advances in technology and miniaturization (palm-sized) electrical equipment) such as instrumentation and input/output I/O boards that serve as computer interface. Thus, the traditional laboratory setup, that includes oscilloscope, multi-meter, power supply, function generator and others (digital equipment) has been replaced with the 'portable' 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 much less space than a notebook would, and is shown in.

Use of the mobile studio has increased the students participation including question and answer time combined with hands on verification of what has been learnt at the same time. The package shown in figure 1 allows individual participation since it occupies a small space compared with bulky lab expensive lab equipment. The tota2 cost is also much less compared full lab with ten work stations that can handle four students comfortably at the same time. The mobile studio also consumes much less electric energy compared with the traditional lab. See Figure 1 for traditional bulky lab set up.

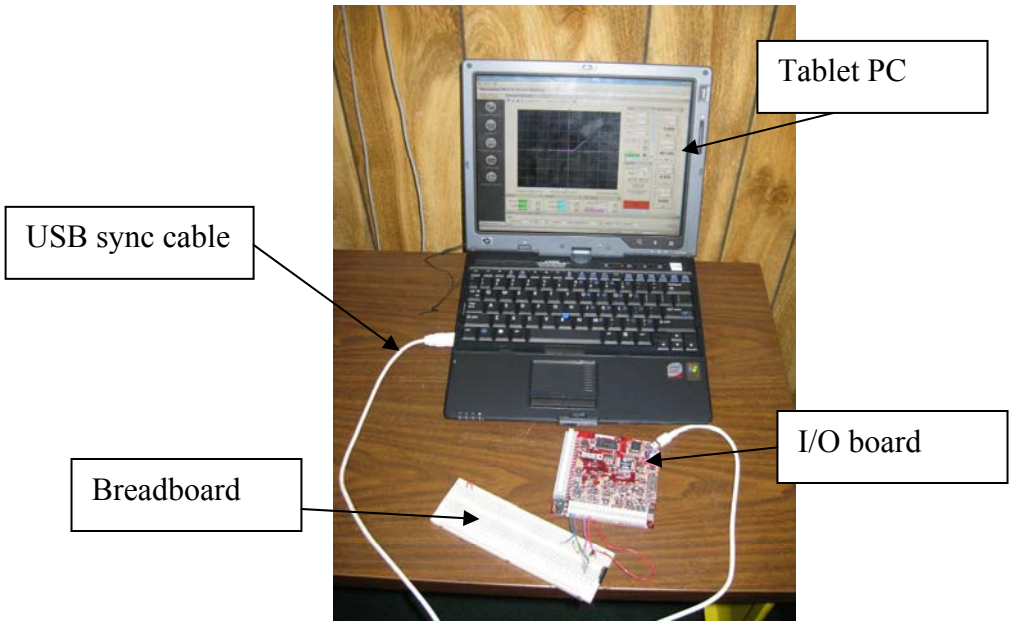

FIGURE 2: MOBILE STUDIO STATION.

Figure. 3 below shows the I/O board instrumentation panel displayed on the tablet PC screen. The I/O board emulates a function generator, oscilloscope, voltmeter, Spectrum analyzer, ±4.5V DC power supply and is capable of digital operations. Thus the board output dc power supply lies within the range of -4.5V to +4.5V, and all of the experiments or designs have been built with this voltage range (constraint) in mind.

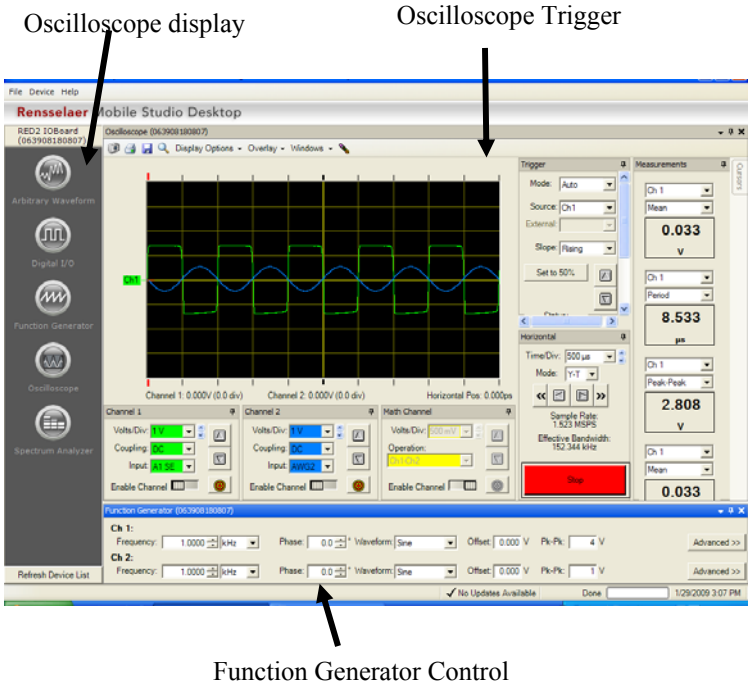

FIGURE 3: THE I/O BOARD INSTRUMENTATION PANEL.

The portable nature of this setup means that there is far greater student interaction with the equipment. 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. Most topics taught in the lecture is demonstrated by the instructor to the students. They encouraged to individually explore the characteristics of the demonstrated circuit under several conditions. Occasionally, a graduate teaching assistant may contribute to monitoring the students progress and offer assistance to ensure that all students understand the topic before resuming the lecture. Students use the studio for projects, homework, labs, and designs.

MOBILE STUDIO-BASED COURSES

The mobile studio concept has in use for the past four years. The Department initially started with a few tablet-pcs with circuits courses (by combining lecture with labs at the sophomore level). It became in instant 'hit'. Students interest in electrical/computer engineering increased. Lab and lecture could be handled at the same time. Data gathering time was saved using the mobile studio. Students could obtain plots instant (instead of traditional write down data, and plot graphs on paper by hand or other means).

The following year, more tablet pcs were obtained, and the limit I/O board voltage supply had been improved from rather low voltage to +- 5.0 volts and more features had been added to the I/O by Rensselaer Polytechnic Institute, RPI. Thus due to flexibility of the mobile studio, the approach was extend to electronics courses at the junior level. Now, in addition to above course, the Mobile studio is being used in digital, circuits, and electronics courses, as well as in senior capstone designs. It has also be introduce in freshman introduction to electrical and computer engineering courses. We plan to extend the mobile studio system to other applications in other course such as electromagnetics. Not also that students can take home 'studio' to complete assignments since the unit occupies a very small space in backpack

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EXPERIENCE WITH THE MOBILE STUDIO

Combining lectures and labs has greatly improved the attention of our students through hands on approach. Learning by doing makes it possible for the students experiential learning process that reflects the students capabilities in retention of knowledge. Student are able to discuss results with either students instantaneously. They correct each other. Figure 4 below shows a a student working on an assignment with the mobile studio. One can observe her serious concentration.

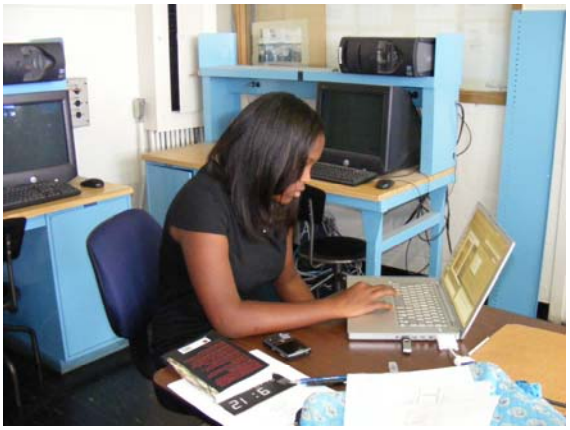


FIGURE 4: A STUDENT AT THE MOBILE STUDIO LAB.

The students obtain concrete experience in experimentation, measurements (data collection) also obtain direct plots instead using paper and pencil for plot later when the experiment is completed. Instant plots allow for instant correction just in case a of a wrong data set. The experiment can be repeated. Students' mobile studio work coupled with on the spot comments from the instructor enhances the individual's understanding of the subject both theory and practice (through experimentation) during lecture. The mobile studio experience makes the theory jump out of a circuit and impact on the student great appreciation of theory and the happiness of hands on. Figures 5 and 6 show students projects (demos) using the mobile studio. All are happy.

FIGURE 5: LIGHT CONTROLLED ROBOT (FRESHMEN).

ENERGY MANAGEMENT (SENIORS)
FIGURE 6: STUDENTS' PROJECT.

SAMPLE OF STUDENTS APPLICATIONS OF MOBILE STUDIO

FeedBack Amplifiers

Abstract: Feedback exists when some fraction on the output of systems is recombined with the input. There are two types of feedback circuits. If the output signal feedback opposes the original signal, the feedback circuit is known as negative feedback. If the output signal feedback increases the input signal, it is known as positive feedback. Negative feedback is one of the most important feedback configurations. This is because it improves frequency response by increasing bandwidth, and it also increases stability in the system. It also reduces the effect of inherent flaws in the systems which cause instability.

Introduction:

Most physical systems incorporate some form of feedback. The theory of negative feedback has been developed by electronics engineers. In his search for methods for the design of amplifiers with stable gain for use in telephone repeaters, Harold Black, an electronics engineer with the Western Electric Company invented the feedback amplifier in 1928. Since then the technique has been so widely used that it is impossible to think of electronic circuits without some form of feedback, either implicit or explicit. Furthermore, the concept of feedback and its associated theory are currently used in areas other than engineering, such as in the modeling of biological systems.

The closed-loop gain for a feedback amplifier is given by: $A_f = \frac{A}{1+\beta A}$, Miller equivalent circuit makes the analysis of the feedback circuit easier. If Z is the original feedback resistor, the transformation is given by:

$$Z_1 = \frac{Z}{1-k} = \frac{R_s}{1+\mu}, \qquad Z_2 = \frac{Z}{1-\frac{1}{k}} = \frac{Z}{1+\frac{1}{\mu}}$$

Problem Statement:

1) To build a shunt-shunt feedback amplifier circuit, with open-loop gain A= -μ.
2) To obtain the small signal characteristics for the circuit, through theoretical analysis, and PSPICE simulation.
3) To obtain the gains (both theoretical, and experimental) for the open loop and closed-loop configurations using several values of the feedback resistor, and to verify the effect of feedback on bandwidth.

Equipment/Parts:

1) 1* Q2N2222A BJT transistor
2) Resistors: 1*5.1k, 1*2.4k, 1* 3.3k, 1*1.6k, 1*330, 1*1k, 1*10k, 1*100k, 1*1M
3) Capacitors: 1*10u, 2*4.7u, 1 bread board, Connecting wires
4) Input/Output board, Mobile studio, PSPICE

Analysis:
Dc bias analysis gives:

$$I_C = \alpha I_E,\ I_C 0.531mA,\ g_m = \frac{I_C}{V_T} = \frac{0.531mA}{0.025V} = 21.27mA/V,\ r_\pi = 4.7K,\qquad \mu = \frac{V_o}{V_i}$$

Small signal analysis:

$Avo = -gmRc$, $= -21.27mA/V * 2.4k$, , $Av = -gm(R||Rc)$

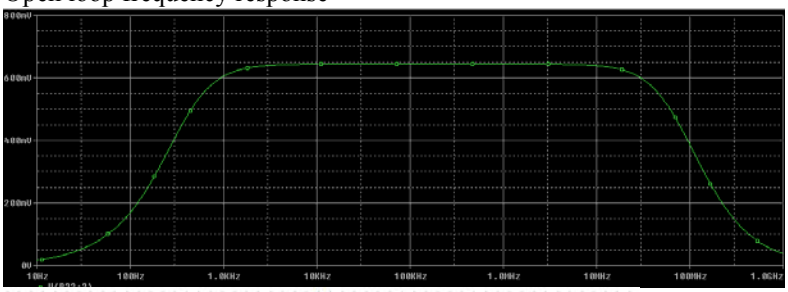
$K = -\mu$, $R_f = 10K, 100K, 1MK$, When Rf=10k

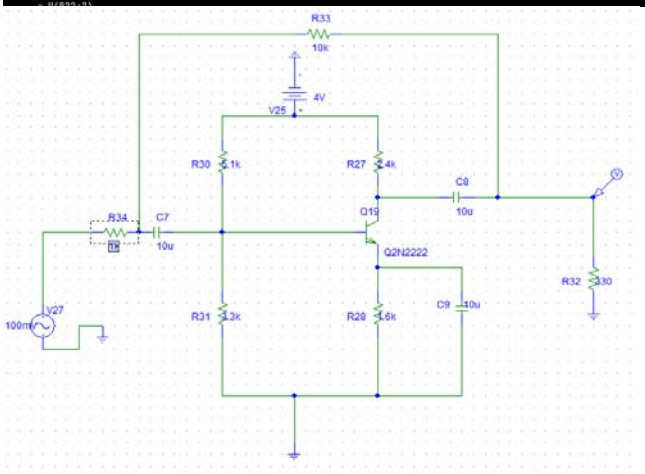
$$Z_1 = \frac{Z}{1-k} = \frac{R_f}{1+\mu} = \frac{10K}{1+6.17} = 1.39K$$

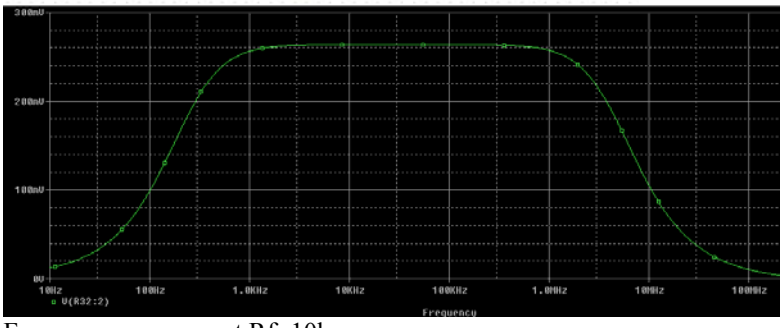
$$Z_2 = \frac{Z}{1-\frac{1}{k}} = \frac{R_f}{1+\frac{1}{\mu}}$$, closed=loop gain $A_f = -\mu\frac{R_C}{R_L}$

Results

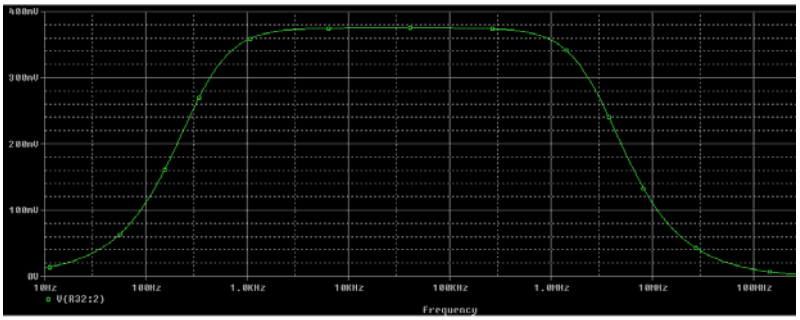
Open loop frequency response







Frequency response at Rf=10k



Frequency response at Rf=100k

Comment: We are unable to get the required experimental frequency response range due to limitation of the mobile studio.

Conclusion: The feedback resistor reduces the overall gain. Larger feedback resistor values reduce the overall gain to values closer to the open loop gain, but at the same time, larger resistor feedback reduced the bandwidth when compared to the values for smaller feedback resistors. This result is expected as it is consistent with the Bandwidth-Gain tradeoff for amplifier.

Reference: Adel S. Sedra and Kenneth C. Smith, adapted by Arun N. Chandorkar *Microelectronics Circuits*, 5th edition New York: Oxford University Press, 2004.

SURVEY ON USE OF THE MOBILE STUDIO

A survey of the students reaction to the use of the mobile studio that involves a combination of lectures and labs is conducted every semester based on the outline listed below.

- Frequent use of I/O boards in class, lab and homework, I/O Board usage in course content, instructor and teaching assistant, 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.

Response: Students unanimously approve the use of the mobile studio concept. Students view the experience hands on environment, practical application of subject matter under peer interaction. They easily overcome the difficulties around hardware and software. Students attendance, attention and grades have also improved.. 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. They want to see the I/O board with improvements in the voltage supply increased above the available 4.5 volts, and the frequency from the function generator be increased to the MHz range.

Accreditation Board for Engineering and Technology (ABET) Program outcomes and assessment Sample

(a) An ability to apply knowledge of mathematics, science, and engineering
Demonstrated competence in course work undertaken to learn materials and concepts of analog/digital systems-based on selected problems.

(e) An ability to identify, formulate, and solve engineering problems
Design project– 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. .

(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.

(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.

(c) An ability to design a system component, or process to meet desired needs
Design project–students are required to consider the design goals are multifaceted, dynamic, and sometimes contradictory; the design process from concep to prototype is multi-dimensional, team-working, multidisciplinary as well as iterative and synthetic. .

CONCLUSION

The department has successfully implemented the mobile studio approach (while satisfying ABET requirements) in teaching circuits, electronics and digital courses including laboratory hands on by combining lectures, labs, recitation and homework projects. The new approach has improved students' understanding of the material and perform assigned tasks with great success. Their teamwork skills have also gone up. Students participating in the high school summer engineering outreach programs show great interest and appreciation in the use of the mobile studio. Typical students' examples using the mobile studio has been discussed. Their confidence levels have increased unlike the earlier traditional methods that require bulky confusing wiring (class lectures separate from labs). The department plans to extend the use of the mobile studio in teaching other courses. The survey for assessment of the mobile studio concept by the students is very overwhelming and encouraging .

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BIOGRAPHY

Peter Bofah obtained his BSEE and MSEE both in electrical engineering from the University of Nebraska, and PhD in controls from Howard University. He is on the faculty Areas of interest include: modeling and control of large structures, energy conversion, power electronics, 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.

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