

# Introduction to Electrical and Computer Engineering Using the Mobile Studio: An Outreach Program

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**Abstract** – The Department of Electrical and Computer Engineering has traditionally offered outreach programs to high school students nationwide. The effort is to motivate these young students to pursue electrical and or computer engineering profession. Under-represented groups generally have vague knowledge of the most important areas in engineering. The program introduces high school college bound students to several areas in engineering including college preparation such as SAT and basic required courses in mathematics and sciences. To date, it had been through classroom lectures, seminar and separate hands on projects. The Department has recently introduced the use of Mobile Studio to enhance integrated class lectures and labs. The approach has been extended to high school outreach programs that run in the summer months. The program covers, seminars, lectures in both electrical and computer engineering. Topics include lectures, hands-on coupled with the use of the mobile studio. It is well known that the world is facing energy crunch. Our resources are dwindling, Thus alternate energy sources and efficient energy use is discussed. They are also challenged with projects that require the use of the mobile studio. Typical examples include alternate energy sources and design, smart lighting (illuminations). Students are asked to design use smart lighting for illumination as well as communications. Participating students and teachers are presently recruited from the Washington Metropolitan High schools (Northern Virginia, Maryland and Washington DC). The mobile studio approach requires hands on and lectures simultaneously. It 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. The mobile studio has motivated the students interest in the electrical and computer engineering profession. A post-survey of the course is conducted at the end of the program that involves students, parents and the instructors.

**Index Terms** – electrical, computer, engineering, outreach, mobile studio, tablet PC, I/O boards, survey

## INTRODUCTION

The Department of Electrical; and Computer Engineering at Howard University, Washington, DC, offers an outreach summer program for high school students selected from, local schools that consist of Maryland, Washington DC and Virginia. The purpose of the program is to motivate students to pursue engineering profession in electrical and computer engineering. It introduces concepts and what it takes to be an engineer and various levels of the engineer at bachelor, masters and doctoral levels as well as special programs at the college level. This program consists of lecture series in mathematics, science and electrical/computer engineering basic. It is coupled with hands on approach since engineering involves data collection and analysis leading to evaluation. Hands on approach is introduced using the mobile studio that consists of tablet pc, input output, I/O board and the students bread board that contains the circuit to be tested. The i/o serves a power supply, function generator. It also contains digital portion for digital experiments. The computer serves as data storage as well as instrumentation (i.e. voltmeter, ammeter, and oscilloscope).

Topics cover definition of engineering and special areas, why engineering, branches of electrical and computer engineering, background preparation and expectations of the engineer, electrical units, symbols, circuits, and measurements, communications (report writing and oral presentations), basics designs and challenging designs with tests and data collection using the mobile studio. The importance and conservation of energy is introduced through renewable energy sources. The

program covers three weeks with closing ceremony on the last day when parents are invited to attend presentations of their kids. They learn team work. Presentations that consist of oral using power point, poster board preparation and hands on demonstration of the hardware of their designs. Awards and speeches are made at a luncheon after which the program comes to an end.

High school students (both males and females) have the slightest notion of what engineering is all about. There are several reasons for a freshman student to choose engineering major. However, the aspiring new engineering student has a lot to do (learn). The student must have basic foundations of engineering that requires mathematics, physics, chemistry and biology. The student is required to study specialized courses such as electrical circuits, electronics, digital systems, mechanics/structures and life long learning based on new technologies and need. The engineer must keep up with the competition since mathematics and engineering theory is so abstract to the new student, we have courses that introduce the new student to engineering principles and application using design through (hands on) approach and in a series of lectures/seminars. Engineering practice requires the ability to build real things for human needs. And it requires design.

The outreach program is designed to motivate the students participants to keep going in the chosen field. We want to increase the completion rate in the chosen field. They learn about the several areas in engineering such as: aerospace, mechanical, electrical, computer, civil, chemical, environmental, and industrial and systems engineering. They are also introduced to the existence of engineering societies/organizations (such as IEEE, AICHE), their functions and the engineering profession.

## **THE OUTREACH SUMMER PROGRAM**

The program emphasizes electrical and computer engineering and it is designed to provide an exciting, hands-on, design-centered introduction to engineering design. It also provides information on engineering education, the engineering profession, and basic concepts and tools. Students are introduced to the engineering design process, and complete engineering design projects that require the use of the mobile studio. Howard University is committed to providing an educational environment that is accessible to all students. The School of Engineering at Howard University consists of the following main departments: Chemical Engineering, Civil Engineering, Electrical and Computer Engineering, Mechanical Engineering, and System and Computer Science. We explain what area does.

**Mechanical Engineering:** is a discipline that applies the principles of physics in the analysis, design, manufacturing, and maintenance of mechanical systems. It deals with power and the design of machines and processes used to generate power. Mechanical engineers are also expected to understand and be able to apply basic concepts from chemistry, chemical engineering, electrical engineering, and civil engineering. Modern software tools facilitate engineers to create a 3D computer models a structure and for analysis the design (to minimize cost) before a prototype is created.

**Systems and Computer Science:** Engineering design process involves analysis (need for calculus ,physics etc, etc), perform iterations, produce model, fabricate prototype,-full scale model, test and evaluate, integrate into manufacturing process, document and communicate.

**Electrical Engineering:** Electrical engineering is very broad. It encompasses all devices generating, control or using electricity. Examples are: power systems, communications, automobile electrical systems, radio, television, cell phones, video games, renewable energy (solar power, wind power), digital systems, nanotechnology. The departments' main areas of concentration are: energy systems and control, communication and signal processing, material science and electronics, digital systems, electromagnetics and microwaves A typical electrical engineer must have strong background in mathematics, physics and some chemistry and biology.

**Computer Engineering:** Computer engineering also encompasses several areas including digital systems (hardware) and software. Computer engineers also require strong background in mathematics and physics. They design and build computers as well as develop software to run them. A hardware computer engineer may combine microprocessors, memory chips, disk drives, display devices and drivers to produce computers.

## THE MOBILE STUDIO

The main purpose of the program is to introduce electrical and computer education and profession to high school students through, lecture, and hands-on using the mobile studio. The mobile studio consists of a table pc, with connected i/o board that serves as a function generator with other features for analog or digital work. The i/o board is coupled to a bread board that contains the students circuit. As shown on figure 1. It is a portable lab that saves space as well as allowing a studio for each student instead of crowding around a cumbersome traditional lab equipment. Figure 2 show the instrumentation panel and controls.

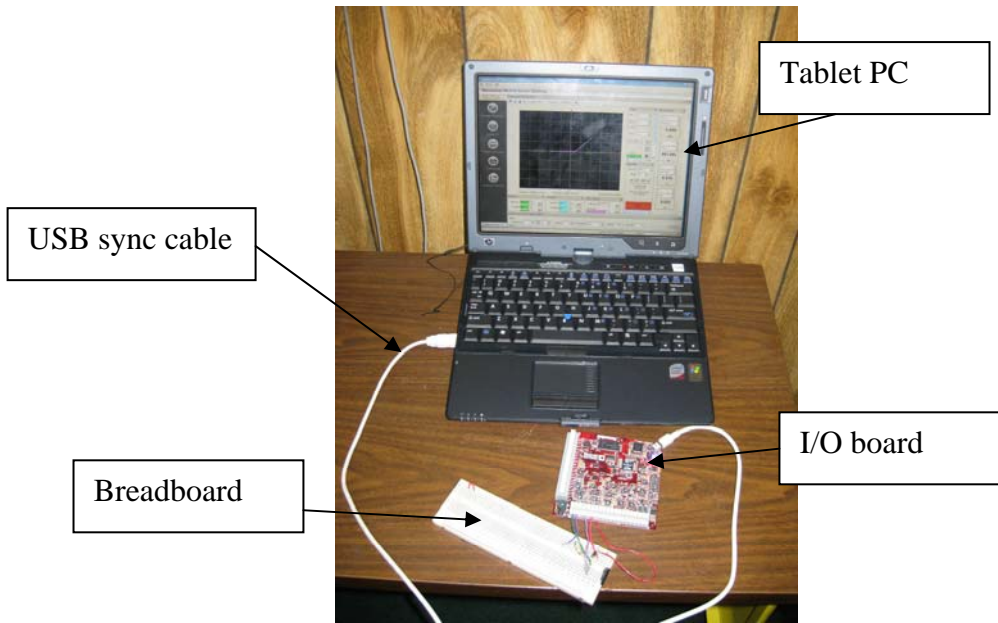
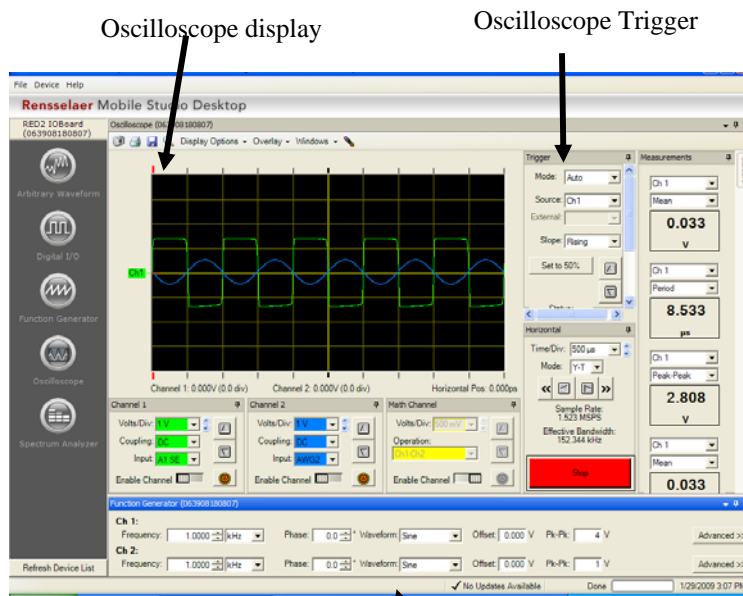


FIGURE 1: MOBILE STUDIO SET UP.



Function Generator Control

## FIGURE 2. I/O BOARD INSTRUMENTATION PANEL.

Students are introduced to concepts of electrical and computer engineering using basic analog and digital circuit theory. system of units, symbols, color codes, measurement techniques using the mobile studio. series and parallel connections, safety issues to make it more interesting. Students use the studio with a little introduction right away. Minimal mathematics is used here. Electronic devices such as diodes and transistors are introduced. The student is also made aware of magnetic circuits and how they are used construction of electric machines such as motors, generators and loudspeakers.

## PROJECTS

Project one students are challenged to applications of the lectures to design an electronic system, electromagnet structure, and a digital system.

Team A: Designs an audio amplifier using two stages, components consists of resistors, BJTs, npn, pnp transistors, coupling capacitors, dc power supply, load is a loudspeaker, input voice through a microphone transducer. It works. They learn about dc and ac sine waves, frequency. They find out the audio amplifier was invented by Lee De Forest in 1906.

Team B: Designs an electric fan using an electric motor... They learn ho it operates with variable speed control by changing the voltage using a variable resistors, potentiometer. They also study various load operations on the motor and measure speed in rpm.

Team C: Designs a digital clock. They study digital circuits using the 7490 integrated circuit (ic) counter, connected to 7447 decoder. They learn to under leds and how they work to vied numbers They also learn how to convent a 60 Hz time base sine wave to 1 Hz square wav using divide by 10 counter, and divide by 6 counter.

Each team writes a report and make oral presentation with hardware demonstrating coupled with questions by following the format below.

### Written Report format

Cover Sheet, Acknowledgements, Summary/abstract, Table of contents, Introduction, Problem Statement Method of Solution , Analysis/Design stages, Results: Hand calculation, simulation, experimental, tables, graphs, pictures/sketches of hardware, Conclusion/ recommendations, References,, Appendix,

### Poster Preparation and Poster board format:

Use Power Point, any fonts and colors, Title and team members, Problem statement, Analysis, Results, Conclusion

**Demonstration :** a. Rationale and Approach. Your team should be able to explain what you did and why you chose your particular problem. b. Creativity and Relevance. Your solution must be a cost effective, sustainable solution. Creative solutions are preferred. c. Operability (does it work?), d. Aesthetics , e. Questions and Answers

### Sample: Major Design

#### Smart Lighting Design of LED Based Traffic Lights



### Abstract:

In this project, we create 3 functional light emitting diodes (LEDs) to resemble a traffic light based system. These LED's light up at different intervals when given a supply of about 5 volts. Each LED needs a resistor in order for it to light up in the circuit. A timer is used to send pulses, a counter is used count the pulses from the timer, and a

NOR gate is used to implement the logic in the design of the system. The light system mimics a real traffic light system with red and green lights on for the longer periods of time and the yellow light on for a shorter time.

**Introduction:**

The main idea of this project is to construct a traffic light system based on LED's. For this, we use a 555 timer, a 7490 counter, and a NOR gate. This traffic light system consists of three colors: red, yellow, and green. Our traffic light controller has three colors on and off at different time intervals. This project simulates a real traffic light system with minor time interval alterations. An LED is a semiconductor diode. It works when the LED is switched on, electrons are able to recombine with electron holes and energy is released in the form of light. This effect is called electroluminescence, light produced by electric current.

**Explanation of the devices:**

The 555 timer used is not a typical timer used as stop watches, but rather a device it generates consistent pulses at certain intervals. These pulses will be sent to the counter, that counts the pulses at intervals of 9. (Ex: 0,1,2,3,4,5,6,7,8,9, and then back to 0). The counter counts the pulses up in 4 digit binary notation format. This format stores each number from 0-9 using 0's and 1's. (Ex: 0 is 0000 and 9 is 1001). This 4 digit binary number is then separated by digits through the different pins in the counter (Qa, Qb, Qc, and Qd). Each pin will either be on or off, determined by the digits 0 or 1. (0 being off and 1 being on). We divide red, green and yellow lights into a 4:4:2 ratio because red and green light tend to be on a lot longer than yellow lights. Yellow lights turn on when Qd is on and green lights turn on when Qc is on. Red lights, however, needs both Qc and Qd to be linked to the NOR gate and will only turn on when both of them are "off".

Materials for the design

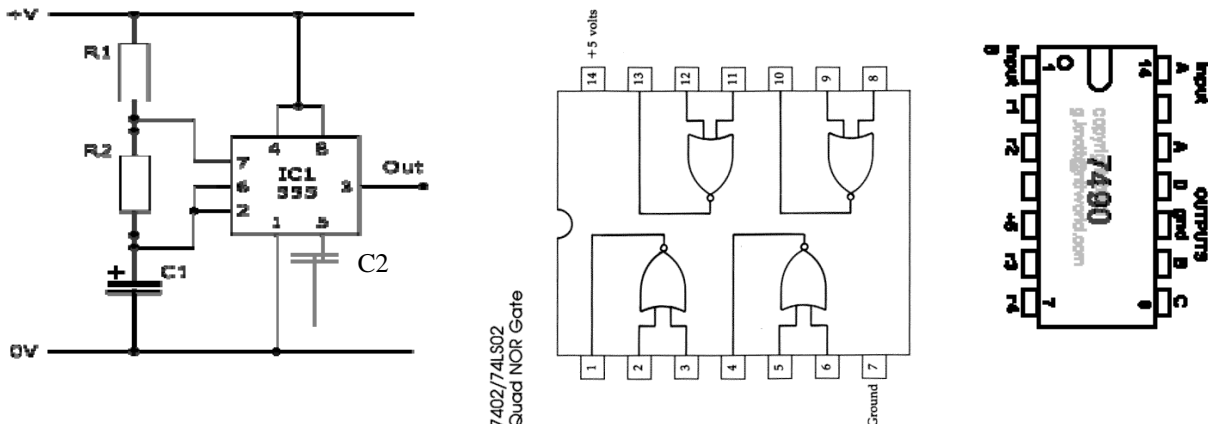
- 5 Volts needed to power the board, Bread Board, Wire Jumpers (20)
- LEDs (3 red, green, and yellow), 1mF (micro farad) Capacitor, 3.3mF Capacitor
- 560k Resistor, 270k Resistor, 150 Resistor, 15 Resistor
- 555 Timer, 74LS90 Counter, 74LS02 NOR Gate, Mobile Studio (Tablet PC)

**Problem Statement:**

The experiment was to design a traffic light system based on 3 LEDs operating as the red, yellow, and green lights. The voltage supply is 5 volts.

Procedure: We connect each of the 3 LED's to a 1K resistor on one side and ground on the other. Next, we use a wire jumper to link the resistor side to a dc power source. It allows us to test and make sure that the LED's work and the circuit is functional. Next, we put together the circuit for the 555 timer. On our first attempt, we build the monostable model and have to restart to build the astable model instead. The monostable model requires a trigger to initiate and sends off pulses with the width depending on a time constant in the(R-C) circuit. The astable model, however, sends of a continuous stream of pulses at a fixed interval. A traffic light system requires a change of lights at a fixed interval rate and thus, we need to use the astable model. Next, we add the 7490 counter. We get the pins confusing, we use trial and error to get the Qa, Qb, Qc, Qd pins. Next we get the NOR gate, and link it up to the 7490 counter. We link them up the LED lights, but the lights did not work. Only the green and sometimes yellow lights are functional. We realize that we mix up Qd with Qa and Qb with Qc, so we went back and changed the sequence in our circuit. We also linked up 2,3,6 and 7 to ground and 5 to the power supply. It took a long time for us to figure out that Qc was not linked to the LED correctly and finally when we fixed it, our circuit worked.

555 Timer: For our 555 timer, we build this astable circuitry: (We choose the astable circuitry because we need a timer to produce a continuous stream of pulses at certain intervals.)



### L-R: 555 Timer, NOR GATE, COUNTER

This is the diagram/key for the 7490 counter. Each pin is labeled with its function. Pins 1 and 14 are the input pins. In this project, those pins receive constant pulses from the 555 timer and are interconnected between each other. Pins 2,3,6 and 7 are reset pins and so they are all grounded. Pin 10 is grounded and pin 12,11,9 and 8 represent Qa, Qd, Qb, and Qc respectively. Pin 1 is connected to pin 13 by design so that the counter will count in series of 9.

The NOR gate has 4 possible output lines. In this project, we used only one (pin1). Pins 2 and 3 are the inputs and both feed into the output line (1). Pins 2 and 3 receive an “on” or “off” signal from Qd and Qc respectively from the 7490 counter. Only when both 2 and 3 are “off”, will 1 generate some power. This output line is then used to light up the red LED light, which only turns on when both Qd and Qc are off. A NOR gate basically has an output when there is no input.

This is a table of the key taken from a TTL data book. The counter counts from 0 to 9 that are indicated by the numbers in the first column. Each of these numbers are converted to 4 digit binary notation that is shown in the corresponding row to that specific number. Qd, Qc, Qb and Qa each records a single digit of the 4 digit binary number, with 0 representing “off” and 1 representing “on”. The yellow LED will be on when Qd is on, and so it will turn on when the counter counts 8 and 9. The green LED is on when Qc is on (or reads 1), and so it turns on when the counter counts 4,5,6 and 7. The red LED only turns on when Qd and Qc are both off, so it will be on when the counter counts from 0 to 3. This way, the red and green lights each turns on for 4 pulses, while the yellow light only turn on for 2 pulses. This creates a 4:4:2 ratio and correctly simulates an actual traffic lights system with the yellow light being much shorter than the green and red lights.

### Final Circuit:

Here is a picture of our final circuitry of the traffic light system. The top 3 LEDs represent the 3 traffic lights, while the bottom 4 LEDs are used to represent Qa, Qb, Qc, and Qd. These lights were mainly used for debugging purposes so that we can check our circuitry as we build it.

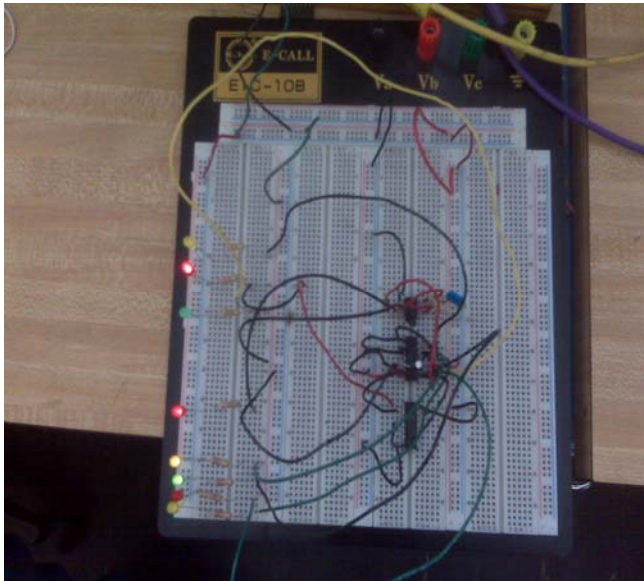


Table 1. Qd Qc, Qb, and Qa:

	Q d	Q c	Q b	Q a
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

### Results:

We are successful in this project. We are able to link the 555 timer to the counter, the NOR gate and the LED lights accurately and create a functional circuit. We learn how to identify the pin numbering system of chips (ingrate circuits). Use of the MOBILE studio is rather fun.

### Conclusion:

In this project, We learn about a NOR gate, its logic and how to incorporate it into a circuit. We also learn about a timer and how it gives off pulses to the counter that counts them in binary notation. We learn about Qd, Qc, Qb, and Qa and how each represents a single binary digit (where 0 represents “off” and 1 represents “on”). We learn how to use the oscilloscope



(on the Tablet PC) to detect where the problem in the circuit may be. We learn that a capacitor can sometimes be used to reduce the voltage fluctuations in a circuit by connecting the capacitor to ground. We learn about the differences between the monostable mode and the astable modes, where the monostable mode gives off a pulse for a certain period of time with a changing pulse width and the astable mode gives off a continuous stream of pulses with a specific frequency.

Other project we use lights (LEDs) as a communication systems to transmit information.

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## CONCLUSION

In this high school outreach program (known as Smart Lighting Institute) we demonstrate how students can be exposed to several areas of engineering profession and practice through hands on approach and using pen-ended projects. They also get to use the mobile studio to participate in lectures and testing circuits (analog and digital). It is anticipated that they choose electrical and computer engineering as their college majors. parents are also thrilled to see their 'children' participate in the program and make presentations.

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## 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, electronics and 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.

## ACKNOWLEDGEMENT

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**Highlights of the Outreach Program**

Top-row: L-R Students demonstrate their projects, demo to an instructor

Middle row: L-R Invited guest lectures from industry, Students and family member on closing days

