

## Teaching Electronic Circuits Using Altium Designer

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**Abstract**—Majority of engineering colleges, universities and the technical institutions are undertaking all initiatives to stay competitive. Efforts are exerted to continuously improve the curriculum in order to provide quality and relevant education for the students in response to global call for outcomes-based education. This paper presents the procedures, techniques, methods, and advantages of using Altium Designer software in teaching electronic circuits. Altium Designer is a schematic capture, simulation, and PCB design software, dedicated to analyzing electronic circuits which is based on interconnected icons of electronic components. The approach makes it easier for the students to visualize the system they are attempting to design, model, and study. Likewise, it makes debugging and error correction simpler. Moreover, an example has been provided also to show how to use the software for teaching and research in electronic circuits.

**Keywords**—Altium designer, Computer simulation, Electronic circuit analysis, PCB, Schematic circuit, Teaching strategy

### I. Introduction

Developments in electronics have provided the designer with the tools of increasing power and also sophistication, which have significant implications for the use and the role of the computer simulation in practice. Computers and microprocessors have changed a lot in the field of traditional electronics engineering. Therefore, traditional teaching styles also need to be upgraded. Recent system hardware modules and software program tools for electronics, microprocessors, microelectronics, etc. are now being used in classrooms and laboratories to provide effective and efficient way of teaching the technical courses in electronics engineering. These tools are considerably of great help for lecturers whose purpose is to get the message across the students in an accurate and precise manner. These tools give the students a sense of awareness of what to use when they go out and work in their respective fields. Electronics is a major program of students taking B.S. Electronics Engineering, B.S. Electrical Engineering, and B.S. Computer Engineering. It offers several difficulties to teach electronics subjects due to some of the following reasons: (a) the electrical and electronics laboratory experiments have been difficult to devise because an actual laboratory exercise operates at dangerous level of voltage and the problem of electric shock is well known. Fatalities from shock can occur at voltages for as low as 24V AC. Accidents can happen anytime if the students are not being careful, (b) Also, some laboratory experiments like RL, RC, and RLC circuits and even operational amplifiers is modeled by first and second order differential equations. If it is done manually during the laboratory experiments, the process is long and it takes

time to solve; the students are trying to avoid mistakes of calculations and also the arithmetical errors. Thus, losing the momentum of what they are doing, (c) and if just in case, that the problem in (b) has been solved manually using analytical method or numerical analysis, to solve the given problem; Students may still find it difficult to interpret and make visualization of the results. This is because the theories of electrical and also the electronic circuitry do belong in the category of differential equations and in some cases, systems of non-linear differential equations, of which most of the students finds it difficult area of study. Complex electronics design has led to greater use of modelling and software simulation as the basis for analysis and design. For example, the RLC circuit, that is a circuit combination of resistance, inductance and capacitance. RLC circuits are the basis of frequency selectivity. Resonance in electrical circuits is very important to the operation of many types of electronic systems particularly in the communications, like for example the ability of a radio or television receiver to select a certain frequency transmitted by a certain station and to eliminate the frequencies from other stations is based on the principle of resonance. The operation of low pass, high pass, band pass and band stop filters are based on resonance of circuits containing resistance, inductance and capacitance. Manual designing of resonance and obtaining the frequency response accurately and in precision is a difficult and complicated job for the students. Hence, the Altium Designer software tool will be a powerful aid in electronic circuit design, electronic circuit simulation, and printed circuit board (PCB) design for the students, as well as teaching the course of electronics for lecturers. This software tool can be use to introduce with the students the concept of the electronic circuit design and simulation, and as well as the PCB design. The concept of Altium Designer for electronic circuit design is use to move through the analysis stage more efficiently. The general objective of this paper is primarily to incorporate Altium Designer software tool in electronic circuits as a teaching strategy. The demand for the software program for solutions in engineering education is being recognized worldwide. Moreover, Altium Designer software is commonly used by the electronics engineers, educators, and also the embedded designers in universities, and electronics industry worldwide for conducting research, design, and experiments. The study focuses on the proposed integration of Altium Designer software for electronic circuit design, simulation, and the PCB design in teaching the electronic circuits. It is directed towards the improvement of the existing learning styles, methods, and provides the students a clear understanding for the significance of the software in the design and analysis of

electronic circuits. Throughout the course, students shall be learning by doing, while they perform each exercise at their own computer. This will also give them the opportunity to deal with the electronic devices and other technological advances being used in some of the electronics, and semiconductor firms, giving them the confidence to face the challenges that they may encounter, after they graduate from the academe. This paper provides the confidence for the students of using the software in schematic circuit design, simulation, PCB design for electronic circuits. It is also significant for the lecturers in teaching the course; since, this software tool can help their students come up with the demands of their profession. This paper also emphasizes on the functionalities, usage, and encourages the use of the Altium Designer software in teaching electronic circuits. This paper shall not be able to work on the mathematical model of electronics, for example the partial differential equations, quantum analysis, and stochastic model of electronic circuits for which the researchers find it a difficult area of study. Although the researchers believe that adequate analysis of the linear tasks of the electronic circuitry will help students understand the non linear behavior of electronic circuits. Since we are dealing with electronic devices, one could possibly expect that the circuit shall be susceptible to noise, and problems may arise as the number of electronic devices to be used in the circuit design increases. Increasing the number of elements in the circuit shall also mean increasing its complexity and any mistake committed in assembly resemble minutes lost, and even hours of troubleshooting the schematic circuit diagram. Therefore, the study shall be limited only to a fair number of electronic devices for the sample design. The sample design demonstration is intended to illustrate the capability of Altium Designer software as a good teaching tool in electronic circuits. This paper is organized as follows. Section II presents integrating Altium Designer in teaching electronic circuits. Results and discussions are described in Section III. A conclusion and recommendation is finally given in Section IV.

## II. Methodology

Altium Designer software is designed for the purpose of changing the attitude of the students in learning electronic circuits. It is a challenge for the students and effective in preparation for their career in R&D field in electronics. The lecturer has several ways to restrict the student's actions, and it can be adopted in a progressive way for the student necessity and capability. Altium Designer is icon-based software that allows the user to develop executable programs using pictorial icons, and have been enhanced as user-friendly software; this allows the students to inject total freedom of interaction with the problems at runtime. This software consists of interconnected icons that represent the electronic circuits. The lecturer can declare conditions and variables to be solved, and the students can make changes to the variables and conditions during the simulation process in a real time environment without interrupting the flow of ideas. These possibilities make it necessary to integrate Altium Designer software tool in teaching electronic circuits. The major advantage of this software to computer programming is the whole system can be easily visualized and debugging is similar to the actual electronic circuit design of the system. The software tool does not contain lines of computer codes and therefore, it will not offer

difficulties in relating it to the physical electronic circuit system being analyzed. Altium Designer icons make it easy to change or debug the program, and electronic icons can be added in electronic circuit network during the real time simulation process. The study uses a computer desktop and the instrument used is electronics design program carried out by the Altium Designer software for windows environment. The Altium Designer is a software package tool rather than computer program language. It is a program dedicated for analyzing electrical and electronics circuits. The user designs and describes the circuit to the computer, following some rules and instructions, the computer then performs the circuit analysis, and prints out the requested voltage, current, graphical waveform, and so on. The use of Altium Designer software shall greatly reduced unnecessary tasks in setting up and performing circuit analysis without suffering too much for the accuracy and correctness of the output. In many cases, the advantage of using the software is that electrical and electronics circuits are easy to assemble, and voltages, currents, transients, and steady state response, DC/AC are easy to measure and analyze; whereas, in the construction of the electrical, and electronic circuit model can be complicated, expensive, time consuming, and also less accurate than using the software. Below is the sample flowchart in Fig. 1. that illustrates a problem solving related to frequency response in electronic circuits. The use of Altium Designer software will eliminate all the unnecessary tasks in electronic circuit analysis without suffering the accuracy and correctness of the data. As shown in Fig. 1. The whole flow chart process is a closed loop design. The simulation model of the whole system can be built by using the Altium Designer software. Students can start designing the whole system using the software, and invoke the schematic circuitry. Analysis and critical thinking takes place during the development process of the electronic circuitry, checking the performance, and behavior of the whole system.

## III. Results and Discussions

In this section, the researchers design a sample embedded electronic circuit design project to illustrate the potential of using the software in teaching electronic circuits. The PIC microcontroller-based electronic circuit design project is PICelab development board by the researchers. It provides quick access to the capability of the PIC MCU architecture, that enables evaluation and development to begin before the target hardware is available. This electronic circuit design board is developed using Altium Designer software and it offers a solid platform for both students, researchers, lecturers, engineers, and enthusiast, to use in evaluating and prototyping designs that closely parallel to their final applications. This will also give firmware development programmers a live target on which to begin developing and testing application code. Like all PIC development board, the PICelab development board system comes with the associated power supply, cables. This PICelab development

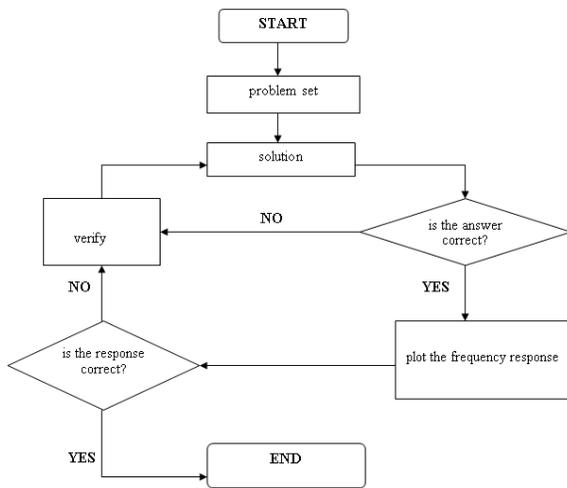


Fig. 1. Sample flowchart analysis for frequency response in electronic circuit.

board has been prepared and developed by the researchers using Altium Designer software.

#### A. Description of Electronic Circuit Design Using Altium Designer Software

The electronic circuit design developed in this research using Altium Designer is soldered with a PIC device (PIC16F877) which fit into all members of this product family.

Summary of electronic circuit design features:

- Microchip PIC16F877 in PDIP600-40 Package
- Interface for Serial Communications (UART)
- Interface for MPLAB ICD2 for debugger and as programmer
- 3 Low Power Status LEDs
- Headers for easy access to all MCU ports
- Push button switch which will reset the PIC16f877 electrically
- Power supply via Jack Cable
- Connectors

The PICelab board electronic circuit design using Altium Designer software offers a variety of connectors:

- Customized connector for RS-232C Interface (can possibly be extended to RS-422/RS-485)
- 3-pin header for easy access Port E
- 8-pin header for easy access Port C
- 8-pin header for easy access Port D
- 6-pin header for easy access Port B
- 6-pin header for easy access Port A
- Customized header for ICD2 interface components
- LED to validate power supply (5Volt)
- LED indicating hardware reset on active state
- Programmable on-board LED
- MAX232 (RS-232 driver)
- MC7805 (3 Terminal Positive Fixed Voltage Regulator)
- 3 general purpose LEDs

- Reset switch
- Low Voltage Power Supply Connector
- Surface Mount Crystal Oscillator
- General Purpose NPN Transistor
- General Purpose PNP Transistor

#### B. Electronic Board Design with PIC Microcontroller Using Altium Designer Software

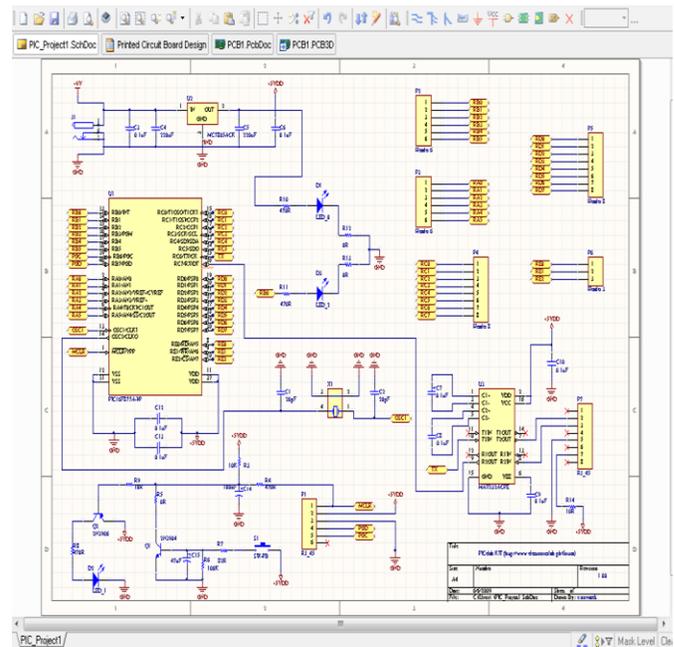


Fig. 2. PICelab development board electronic circuit design schematic.

The design of PICelab development board using Altium Designer software generates internally +5V via the designed power supply. A stable supply voltage causes the power-on to reset for a short period. The LED (+5V) indicates the status of the on-board generated voltage. There is a fixed crystal clock on the PICelab development board. There are 3 LEDs on board

- D1 +5V power supply indication
- D2 indicates the reset state of the board
- D3 programmable on board LED

The header is customized purposely to work with RS-232C; hence, a special connector shall be customized such that proper communication via serial interface port takes place. The board can possibly be extended for RS-422, RS-485 communication, via transmitter receiver (Tx/Rx) port of the PIC microcontroller. The communication (COM) port shall be used to communicate with the board via asynchronous (ASC) of the device. The header is customized purposely to work with ICD2 interface. Normally, it is RJ-45; however, specialized connector can be design in customization such that wiring communication via ICD2 that will take place properly. For all other peripherals, there are no special plugs on the board. However, all of the MCU signals including all peripheral signals are available on the different connectors

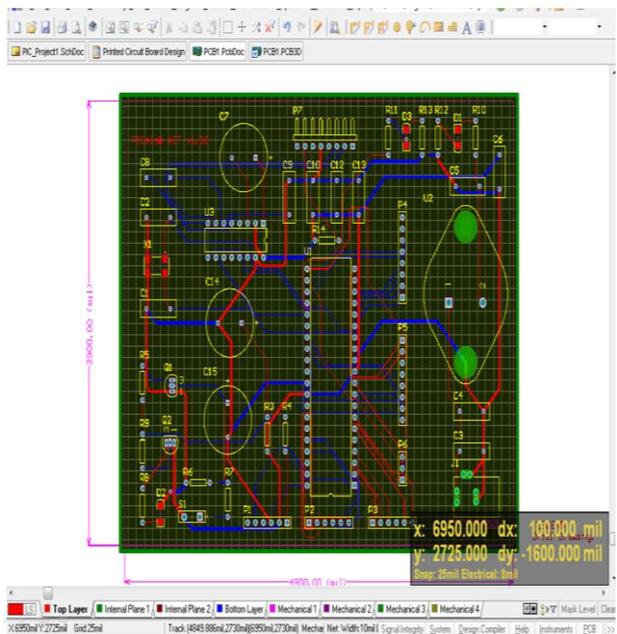


Fig. 3. PCB design.

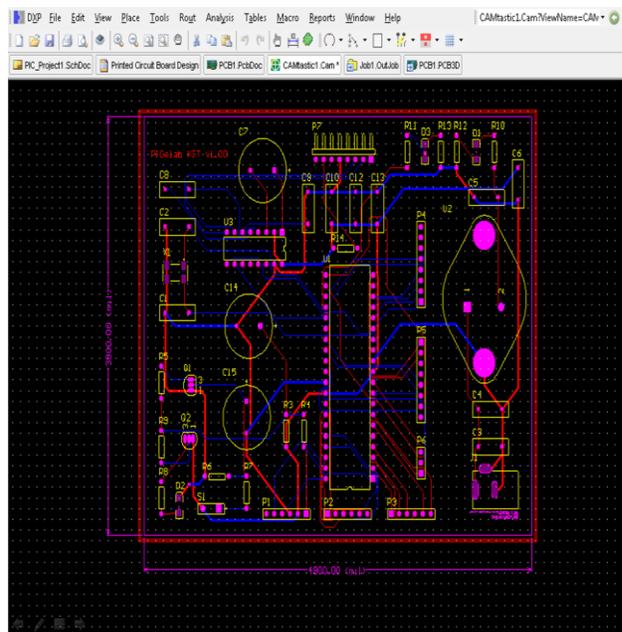


Fig. 5. PCB layout camtastic.

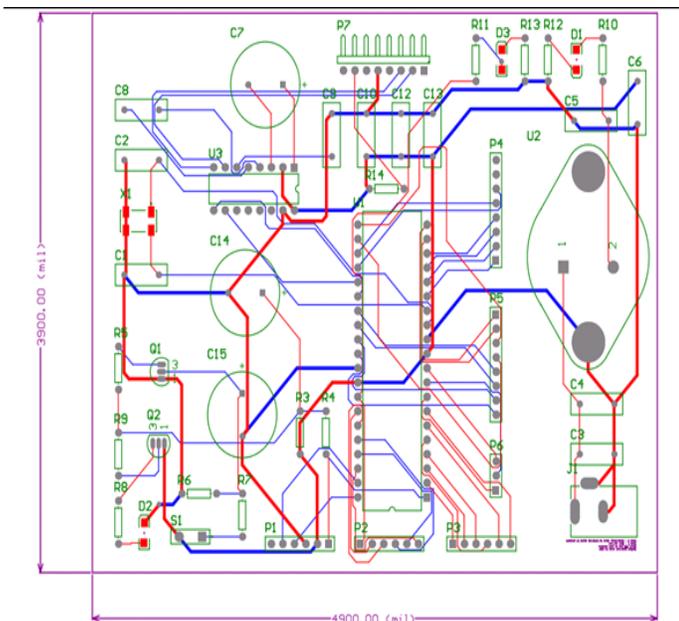


Fig. 4. PCB layout and routing.

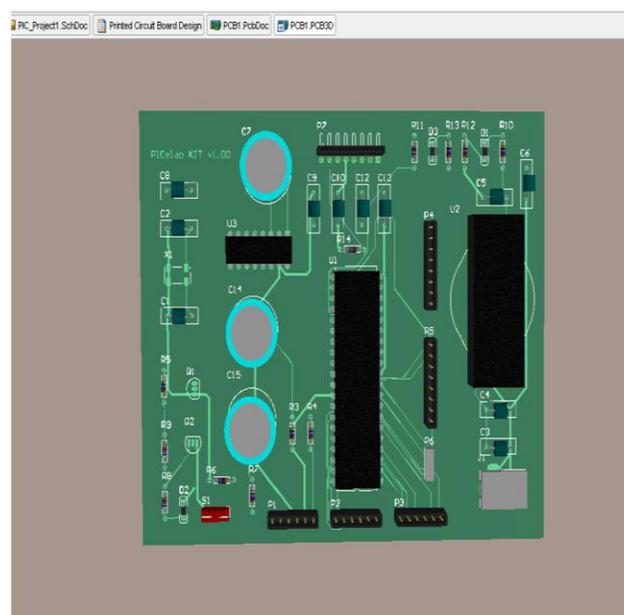


Fig. 6. 3D board (bird's view).

and headers. Some exercises in the developed PICelab board can be suggested as follows:

- (1) *Hello world*, A simple exercise to produce an output with the classical "hello, world" application.
- (2) *LED blink*, An exercise guides that the user to program the on-board LED (D3).
- (3) *Saturation*, An exercise that will show you how to use key features of the instruction set by using C language extensions. The system timer can be used to measure the execution speed.
- (4) *Interrupts*, Exercises that will guide the user to program interrupt service routines.
- (5) *Serial Communication*, An exercise that will guide the user to

program the communication interface via hyper-terminal using the ASC peripheral of PIC microcontroller.

- (6) *PWM*, A simple application that generates a PWM using the Timer Array of PIC microcontroller

The researchers have presented the features of the Altium Designer software for integrating the software in teaching electronic circuits, and created a sample electronic circuit design to illustrate the potential of using the software as a teaching strategy. This paper also provides some illustrations to show the usage, and features of Altium Designer software for invoking the electronic circuit schematic, PCB layout, and others.

## IV. Conclusion

In this paper, the proposed program integrating Altium Designer in teaching electronic circuits is presented. Altium Designer software provides complete electronic circuit analysis laboratory experiment, research and design environment, which includes fourier analysis, the sensitivity, waveform analysis with cross-probing and the bias results display on schematics, monte carlo, etc. The software also offers good access to the many libraries models, developed by different electronics manufacturers. It also allows the mixing of digital and analog parts without problems and learning the software is easy. The use of Altium Designer software shall be of help managing all aspects of important electronics engineering core topics such as the power electronics, digital and analog electronics, the frequency analysis and response, feedback and oscillations, simulations, schematic circuit diagram, PCB design, FPGA field programmable gate array, and others. Altium designer software is widely used in universities and industry worldwide. This paper illustrates an example to comprehend the features of using the software; thus, motivating the students to create, design and learn more on electronic circuits. The researchers have shown that a complex electronic circuit can be taught in a meaningful way by using the software. More time shall then be dedicated to interpreting, and explaining the results, and rather than doing arithmetic; hence, providing complete visualization of a complex circuit network. The Integrating Altium Designer in teaching electronic circuits is further recommended for the following reasons: (a) The high computational speed of the computers offers great saving in time, and is especially when feedback systems and frequency response are analyzed in electronic circuits; (b) Hand calculations that can easily commit errors, the computer software produces an accurate answers, and viable information about the electronic circuit specified; (c) the Altium Designer software is designed to be user friendly software, one can get acquainted with its usage by simply trying it out; (d) Altium Designer software runs on the PC under the standard windows environment.

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