



AWERProcedia
Information Technology
&
Computer Science



1 (2012) 42-47

2nd World Conference on Information Technology (WCIT-2011)

Teaching microcontroller programming using “TINA” simulation

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Abstract

Electronic circuit simulation is very important in all branches of electrical and electronic engineering. In conventional laboratory experiments, it is required to purchase electronic components and instruments and use them to build circuits and then carry out experiments using these circuits. Usually it is difficult and costly to obtain the real components required for an experiment. This paper describes the use of a very popular circuit simulation software tool called TINA. With the help of this tool students can easily design and simulate their circuits and then implement their designs on a PCB, if desired. This paper describes the benefits of using TINA and gives an example microcontroller based system simulation using TINA. A short survey conducted by the author showed that students liked to learn microcontroller programming using TINA.

Keywords: Microcontroller teaching; Microcontroller simulation; Circuit simulation; Electronic simulation; Using TINA.

Selection and peer review under responsibility of Prof. Dr. Hafize Keser.

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1. Introduction

One of the major differences of engineering courses from many other courses is that the engineering courses are highly dependent on laboratories, and laboratories are a very important part of every engineering course. Students learn the complex engineering theories in classes and then apply these theories to practise by carrying out experiments in laboratories. For example, electronic engineering students learn the architecture and programming of microcontrollers in the class. They then carry out experiments in laboratories using real microcontroller hardware and programming tools, such as compilers, debuggers and so on.

Although real laboratory experiments are very useful, they have some problems associated with them:

- The purchase of real electronic components and instruments are costly. A large number of similar instruments are usually required for a class of students and this can be very costly.

- The characteristics of electronic components can change with aging and temperature.
- It is not always easy to find the required components and students may have to wait for long times before they can develop their projects.
- Real components can easily be damaged by improper use, for example by applying large voltages, or by passing large currents through them.
- Students can get electric shock in laboratories by not following the safety rules. Thus, an instructor should always be present in a laboratory to make sure that students connect the components correctly and follow the safety rules.
- Real laboratory instruments usually need calibration from time to time and this can be costly. Also the instruments are not available during the calibration process.

Computer simulation is an alternative to experiments using real hardware. A simulator is basically a computer program used to predict the behaviour of a real circuit. The software models (e.g. Spice models [1]) of real components and virtual instruments are used in a simulation. Typically in a simulation students run the simulator program and pick the required components and virtual instruments from a library. Then they join the components and the instruments to build the circuit. The simulation process is then activated and the A.C. and D.C. response, the transient response, noise response, Fourier analysis, and other responses of the circuit can easily be seen and recorded.

Although the simulation is an invaluable tool in designing and developing electronic circuits, it has the following advantages and disadvantages:

- Any component whatever the cost is, can be modelled and simulated using a simulator. The virtual instruments are computer programs and thus there are no cost issues.
- Simulation does not usually take into consideration the component tolerances, aging, or temperature effects. Students may think that all components are ideal at all times.
- Virtual instruments and components used in a simulation can not be damaged by connecting wrongly or by applying large voltages or currents.
- There is no calibration problems associated with virtual instruments. They are available at all times and operate with the same specifications.
- Simulation allows measurements of internal currents and voltages that in many cases are virtually impossible to do while using real components.
- Simulation can easily be used in distant education courses where students can be supplied with copies of the simulator program. Thus, students can carry out experiments in their own places of study and in their own times.

In this paper we shall be looking at the basic features and specifications of the TINA simulation package [2] and see how the simulator can be used to teach the principles and applications of microcontroller based systems. An example microcontroller based project is given in the paper.

2. The TINA simulator

TINA is a powerful integrated computer simulation program including schematic circuit design, analog and digital circuit simulation, PCB design, analog filter design, RF circuit design, microcontroller system design, and many more useful electronic design and simulation tools. The TINA software package is developed by DesignSoft, and the software is called *The Complete Electronic Lab*. TINA can be used by electrical and electronic engineering students, by professional engineers, and by people having hobbies in electrical and electronic engineering.

TINA is Windows based and provides a powerful user friendly interface for schematic design. Students can use the mouse to place electronic components and virtual instruments on a form. The circuit can then be simulated and the results observed by clicking a button. One of the nice things of TINA is that the simulated circuit can easily be implemented on a PCB with auto-placement and auto-routing. Students can also use the Gerber plotting and CNC drilling options of TINA to learn and design and implement a prototype of their projects.

TINA is distributed in several forms to meet the needs of various individuals and companies. In order of price and the complexity, the available versions are:

- Industrial version

- Network version
- Educational version
- Classic version
- Student version
- Basic version

The Industrial version includes all of TINA's features and is the most expensive version. The Network version is slightly cheaper and has a few features removed. The Educational and Classic versions are for academic people interested in carrying out research in the design and development of electronic circuits. The Student version is low-cost and has been developed for students of higher education who are studying in the field of electrical and electronic engineering. The Basic version has limited functionality with the circuit size limited to 100 nodes, and the number of pads on the PCB limited to 100.

In addition to circuit simulation and PCB design, TINA supports a real multifunction PC instrument called TINALab II. With the help of TINALab II students can interface real hardware to TINA simulation package and observe the results on the oscilloscope, use signal analyzers, multimeters, and function generators in real time. The function generator can generate sine, square, ramp, triangle, and arbitrary waveforms from DC to 4MHz, with logarithmic and linear sweeps. Arbitrary waveforms can be programmed using TINA's easy to use built-in interpreter language.

TINA is currently at Version 9 and it can perform the following operations:

- Schematic capture
- Analog and digital simulation
- Schematic symbol editor
- PCB design
- Electrical rule check
- Live 3D breadboard
- Library manager
- Test and equation editor
- DC, Transient, and Fourier analysis
- Microcontroller based simulation
- Network analysis
- Optimization and noise analysis
- Virtual instruments

3. An Example microcontroller based project

In this section a very simple microcontroller based project design is given to show how TINA can be used to simulate a microcontroller project. In this example, a binary up counter is designed where the count is incremented by one and is then displayed on a virtual display of TINA. Fig 1 shows the circuit diagram of the project drawn using the TINA schematic editor. The project is based on a PIC16F887 type [3] 8-bit microcontroller, operated from 8MHz clock. PORT B of the microcontroller is connected to a virtual display instrument of TINA. Only the low byte of the display is used in this project, the higher byte being connected to ground. The code for this project was written using the mikroC language [4]. mikroC is a high-level C language, developed specially for the PIC series of microcontrollers. Students learn the architecture of PIC microcontrollers and the principles of C programming in classes. They can then use TINA to create microcontroller based projects and learn the practical aspects of using microcontrollers. Fig 2 shows listing of the mikroC program written for this project. At the beginning of the program PORT B is configured as digital output. Variable *cnt* is then declared and initialized to 0. The program then enters an endless loop where the value of *cnt* is incremented by one and sent to the display. This process is repeated with a small delay in the loop. Fig 3 shows the display counting up.

The program is first written in the mikroC environment and is compiled using the mikroC compiler. The generated "HEX" code is then loaded into the PIC microcontroller by double-clicking on the microcontroller in the TINA diagram and specifying the filename as shown in Fig 4.

4. Student opinions

A survey was conducted with the engineering students using TINA at the Near East University, in May 2011. 30 undergraduate students studying for the Degree of Computer Engineering who used TINA in their *microprocessors* course attended the survey. The survey consisted of 10 written questions with the answers in the 5-scale Likert, designed to find out the opinion of students after using TINA as part of their microprocessor laboratory exercises. While all the answers were positive, a majority of the students (M = 94.3%) said that they liked using TINA and they found it easy to use. A large proportion of students (M = 96.4%) said that they would be happy to see the use of TINA in the laboratory exercises of other courses as well.

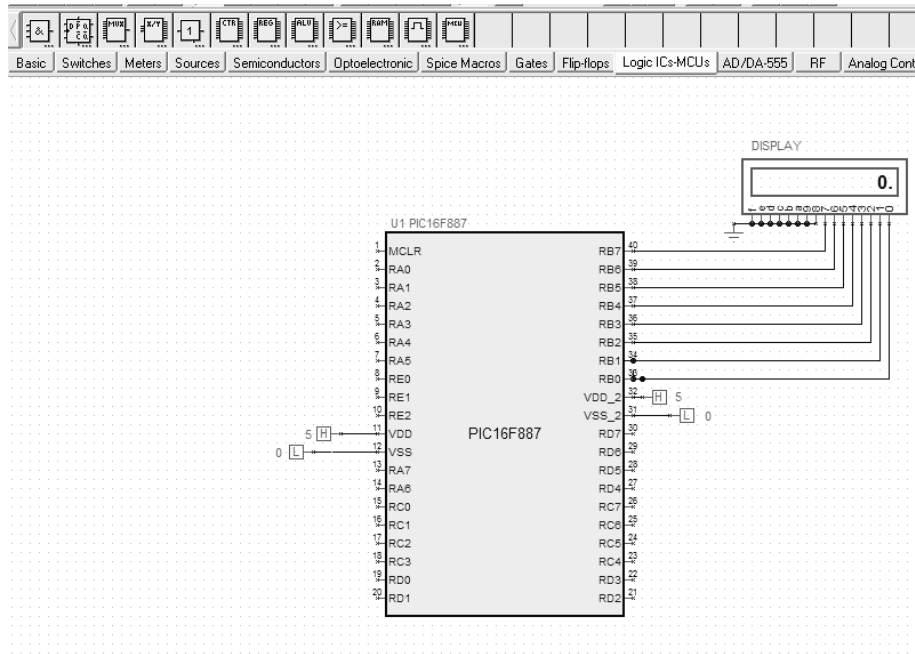


Fig. 1. Circuit diagram of the project implemented in TINA

```

/*****
                                UP COUNTER PROJECT
                                =====

This is a digital counter project. A PIC16F887 microcontroller is used in this project with an 8-bit display.
The program counts up by one and displays the result on the display.

The counter is connected to PORT B of the microcontroller.

The program is written using the mikroC language.

Programmer: Dogan Ibrahim
File:      Counter.C
Date:     May, 2011
*****/

```

```

unsigned char cnt;

void main()
{
    ANSELH = 0;                // Configure PORT B as digital

```

```

TRISB = 0;                                // PORT B is output
cnt = 0;                                   // Clear count

for(;;)
{
    PORTB=cnt;                             // Send count to PORTB
    cnt++;                                  // Increment count
    Delay_Ms(1);                           // Wait a bit
}
    
```

Fig. 2. Program listing of the project

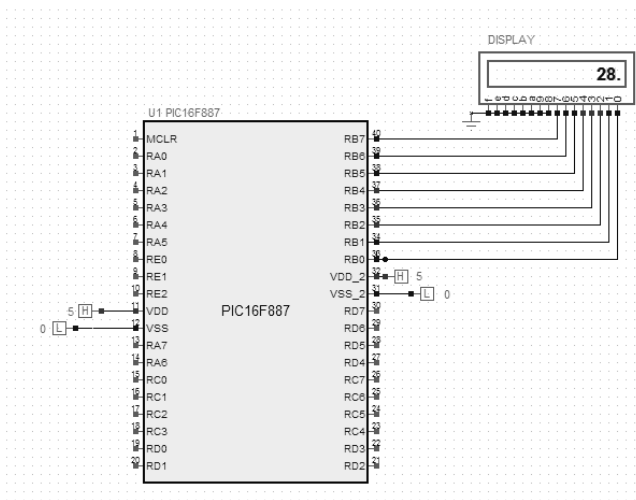


Fig. 3. The display counting up

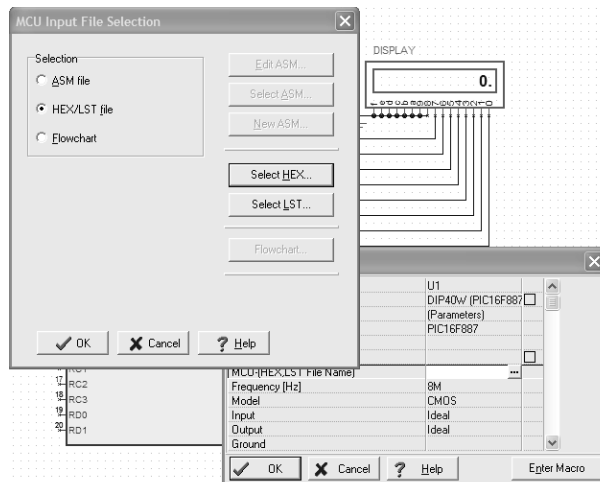


Fig. 4. Loading the "HEX" file into the microcontroller

5. Conclusions

The use of the TINA simulator package for teaching microcontroller based system design has been presented. Using TINA helps students to quickly build a microcontroller based system and then simulate it. A student survey showed that the students liked using TINA as part of their microcontroller learning.

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