

PC- Based Microcontroller Programmer and Training Kit

A Thesis Project
Presented to
the Faculty of
STI College Rosario

In Partial Fulfillment
of the Requirements for the Degree of
Bachelor of Science in Computer Engineering

by

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Bachelor of Science in Computer Engineering degree has
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acceptance and approval



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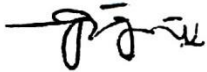
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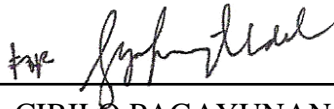
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ABSTRACT

This study was designed and developed as a PC- Based Microcontroller Programmer and Training Kit. The objective of this project is to guide and assist the learning of Electronics and Computer Engineering students regarding microcontroller programming and interfacing, especially those who are beginners in this essential topic. This project includes a microcontroller programming device and training kit modules containing basic electronic devices, along with a GUI (Graphical User Interface) software tailored for novices in microcontroller systems.

The developers used prototyping methodology that involved building a prototype repeatedly until it is accepted and implemented. Some of the procedures undertaken were data gathering through research and interviews, specifying the problem and formulating the objectives through analysis, designing the project through diagrams, developing the project through coding of software and construction of hardware, improving the project through modifications, and finalizing through testing and evaluation.

The project was evaluated by engineering students from STI College Rosario and CvSU-Rosario based on six criteria, namely: functionality, reliability, aesthetics, durability, economy, and safety. It rated an overall mean of 4.33 (Very Good).

The developers also gathered feedback from the faculty members of the schools through an essay-type form. The responses generally show that they are interested with the project, especially regarding its functionality in programming the MCU and how it is interfaced to the training kit modules.

PREFACE

Microcontrollers are intelligent electronic chips used to control and monitor devices in the real world. They are found in PCs, printers, cell phones, DVD players, hi-fi equipment, home appliances, robots, and in other electronic devices. Due to its prevalence, microcontroller programmers and development kits have always been a necessity for engineering students to accomplish their endeavors regarding microcontrollers. These students, especially those new in device interfacing and programming, need an easy-to-use training kit and software to quickly and easily learn about microcontrollers. Because of this, the proponents decided to develop a PC- Based Microcontroller Programmer and Training Kit.

This documentation is developed in a logical manner, with consideration to its content and length. The readers of this thesis document can find the topics clearly and concisely discussed.

Chapter 1 of this document includes the problem to be solved, the solution proposed, and the objectives undertaken to solve the problem. Chapter 2 discusses the theories and ideas that formed the framework of the project. Chapter 3 contains the project design and the procedures that were done to complete the project, as well as the discussion about the hardware and software used. Chapter 4 details the testing done to analyze the performance of the project, the modifications made to improve the project, and the results of the evaluation. Chapter 5 contains the conclusion and some recommendations.

Supplementary information and documents can be found in appendices A to H.

1.0 INTRODUCTION

Microcontroller units (MCU) are intelligent electronic devices used to control and monitor devices in the real world. They provide an essential component of larger systems, such as automobiles, robots, and industrial systems. About 40% of microcontroller applications are in office automation, such as PCs, laser printers, fax machines, intelligent telephones, and so forth. About one-third of microcontrollers are found in consumer electronics goods. Products such as cell phones, calculators, MP3 players, hi-fi equipment, video games, washing machines and cookers fall into this category. The communications market, automotive market, and the military share the rest of the application areas. [IBRA2008]

Among the competing microcontroller products, the PIC Microcontroller by Microchip Inc. has been very popular because of its wide availability, extensive references and user base, low cost, large variety, and its immense capability. [MCUL2009]

MCU programming has been a usual task for electronics students, hobbyists, and professionals. Thus, MCU programmers are in-demand today. Demo boards, or learning kits that accompany the MCU programming device also became significant especially for those new in MCU interfacing. Consequently, the developers intended to know if BSECE (Bachelor of Science in Electronics and Communications Engineering) and BSCoE (Bachelor of Science in Computer Engineering) students have MCU programmers and demo boards in their schools and if they are acquiring sufficient knowledge regarding MCUs.

The developers conducted a survey to 140 respondents composed of 3rd year

and 4th year BSECE and BSCoE Students. Majority of the respondents (91%) do not have a subject about microcontrollers, as well as 70% of them do not know what a microcontroller is. Likewise, 78% of them do not have MCU device at school. Lastly, most of them (58%) do not have hardware interfacing in their programming subject.

In addition, the developers also arranged interviews with a BSCoE and a BSECE student. Generally, the responses show that engineering students have to deal with MCUs in their projects and thesis proposals despite of the deficiency of related knowledge and resources. Thus, the students struggle with their endeavors regarding MCU programming and device interfacing.

If the students have a MCU programming device and training kit, they can gain the necessary knowledge and experiences about MCUs through experiments. A GUI (Graphical User Interface) software that can guide them in performing such experiments would also help them significantly.

Various microcontroller programmers and training kits are available in the market today. Although these devices have advanced features, some of them has limited support for MCU types and are lacking some electronic devices for interfacing. One of them is the Microchip PIC kit 1 which has limited support for 8 and 14-pin PIC MCUs and only has LEDs for interfacing.

A MCU programmer with multiple MCU type support and a training kit with more electronic devices for interfacing would not only make the device flexible and efficient, but can also provide more experimentation and learning for the user.

1.1 Statement of the Problem

1.1.1 General Problem

How to design and develop a PC- Based Microcontroller Programmer and Training Kit that will help Engineering students, particularly BSECE and BSCoE, to have better understanding about MCU programming and device interfacing?

1.1.2 Specific Problems

1. How to develop a microcontroller programmer for a variety of PIC Microcontrollers?

The MCU programming device is necessary for the user program to be transferred to the MCU. Some existing MCU programming device has limited MCU socket which only supports one or two types, such as the Microchip PIC kit 1. Furthermore, ordinary socket included in these existing devices can introduce problems, such as pin bending and Electrostatic Discharge (ESD).

2. How to develop a MCU training kit with a variety of electronic devices for interfacing?

The MCU training kit is needed for the user to test and see the output of his code in the actual devices. Some existing training kit has limited devices for interfacing, such as the Microchip PIC kit 1 which only includes LEDs. The user cannot easily experiment with other electronic devices not included in the kit.

3. How to develop a beginner- oriented software?

The software is essential for the user to create his program for the MCU. Aside from a code editor, the software must also feature predefined experiments with visual emulator and helpful guides to assist the users in programming.

4. How to develop an efficient communication link between the host PC and the device?

The interface between the device and the host PC determines the specification for the device and its convenience for the user. The interface to be used must be compatible with the user's computer, or even a laptop

1.1.3 Project Rationale

This research will not only be beneficial to students, but also to various groups of people who want to gain knowledge and experience regarding MCUs.

- Electronics and Computer Engineering Students

This study will provide them with the actual hardware for them to program and test, as well as the support software to simplify such tasks. As a result, they would acquire sufficient knowledge and experience regarding the MCUs. They can pursue advanced learning of the topic, experimentation on various electronic projects, and innovation of systems and even industrial devices involving MCUs.

- Hobbyists and other Electronics Enthusiasts

Brought about by its importance in the industry today, microcontrollers gained the interest of hobbyists, enthusiasts and professionals in the field of Electronics. This project would be their quick start into the world of MCUs.

- Future Researchers

This project can be an initial reference to the succeeding researchers who would consider using a microcontroller in their endeavors, and to those who would intend to make innovations related to this project.

- STI College Rosario

This project can be useful to STI College Rosario, particularly for the engineering department. It can be integrated into subjects such as Logic Design and Circuit Theory, Advanced Logic Circuits, Microprocessor Systems, Control Systems, and certain electives such as Robotics. The project can assist the instructors in discussing knowledge about microcontrollers, and in giving activities and experiments to students.

1.2 Current State of Technology

A variety of MCU programming devices with their corresponding development kits and software are available in the market. To start with, Zilog's Z8 Encore! XP® Family of MCU Development Kits features a Serial/USB Smart interface, ZDS II-Z8 Encore! ® IDE with ANSI C-Compiler, and hardware components including a Z8 Encore! XP MCU, LEDs, pushbuttons (RESET and TEST), IrDA transceiver (U4), oscillator (Y1), External interface connectors (JP1 and JP2), headers (J2), and On-Chip Debugger interface (P2). An In-Circuit Emulator (ICE) is also integrated for the Z8 Encore! XP® F64xx Series. [ZILO2008]

Although the kits are of advanced functionality, the interface connectors are not populated, and these do not include any other basic electronic device other than the LEDs and pushbuttons. The MCU chip also cannot be removed or replaced from the board.

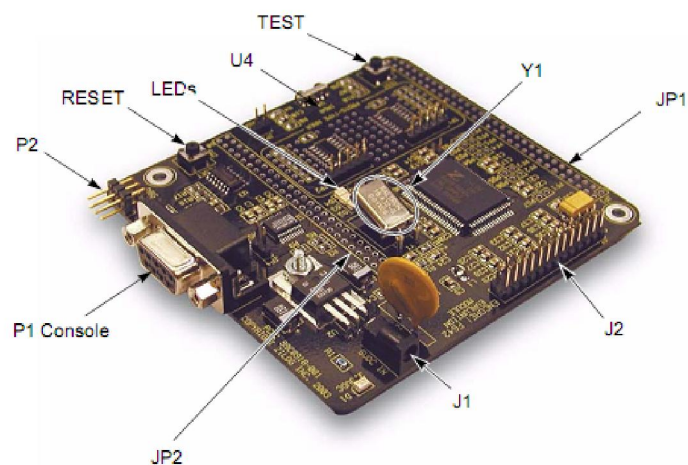


Figure 1.1 Z8 Encore! XP F64XX Series Development Board

Next, Microchip's PicKit™ 1 Flash Starter Kit has In-Circuit Serial Programming™ (ICSP™), USB interface, and a board including 8/14 pin PIC MCU slot and 8 LEDs. Then, Microchip also released PicKit™ 2 Starter Kit that features Full-Speed USB, support for 8/14/20-pin MCUs, Low Pin Count Demo Board containing a 20-pin PIC MCU, 4 LEDs, a pushbutton and a pot. Meanwhile, the PicKit 2™ Debug Express allows ICD (In-Circuit Debugging), and a 40-pin PIC MCU and a prototyping area. Microchip's next release is the PicKit3 In-Circuit Debugger that highlights the Programmer-To-Go function and includes a 44-pin demo board with a 40-pin PIC MCU. All of these kits by Microchip come with the MPLAB® IDE and an optional HI-TECH PICC™ LITE C Compiler. [MICR2011]

Though these kits highlight advanced programming and debugging, the electronic devices included for testing are limited. The kits also do not include a ZIF (Zero Insertion Force) socket for easy removal of PIC MCUs.

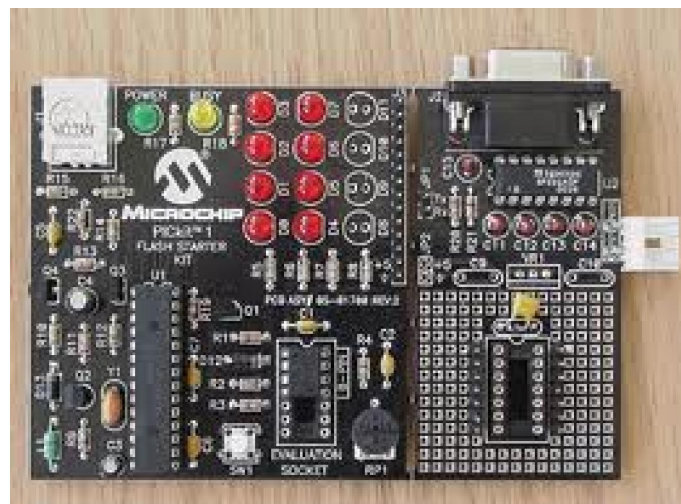


Figure 1.2 Microchip PIC Kit 1

Microchip also offered demo boards sold separately to maximize the functionality of the kits cited above. One of the most notable is the PIC DEM 4 that includes an LCD, 8 LEDs, an active RS-232 port, 3 push buttons and reset, 8/14/18-pin sockets, transceiver header, and a prototyping area. [MICR2007]

The board only includes connectors, without the additional electronic devices. It also has no socket for 28-pin and 40-pin PIC MCUs.

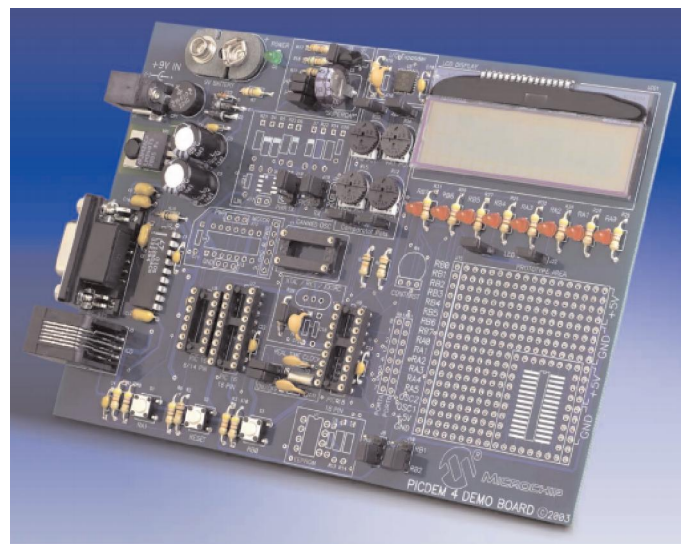


Figure 1.3 Microchip PIC Dem 4

Alexan Philippines also have a number of training modules available. The Alexan 8051 Training Module 1 using ATMEL 89C2051/89C4051 incorporates switches, 7-segment display, buzzer, LEDs, and Relay. It is succeeded by the Alexan 8051 Training Module 2 using ATMEL 89C2051/89C4051 that integrates an LCD, Dot Matrix, Matrix Keypad, and serial EEPROM. Another product sold by Alexan is the PICMe™ Microcontroller Starter Kit that makes use of a 40-pin PIC MCU, I/O headers, 8 LEDs, pots, and pushbuttons. [ACEE2008]

These kits sold by Alexan uses only RS232 serial interface without a USB connection. The board also does not have a ZIF socket for easy removal of PIC MCUs.

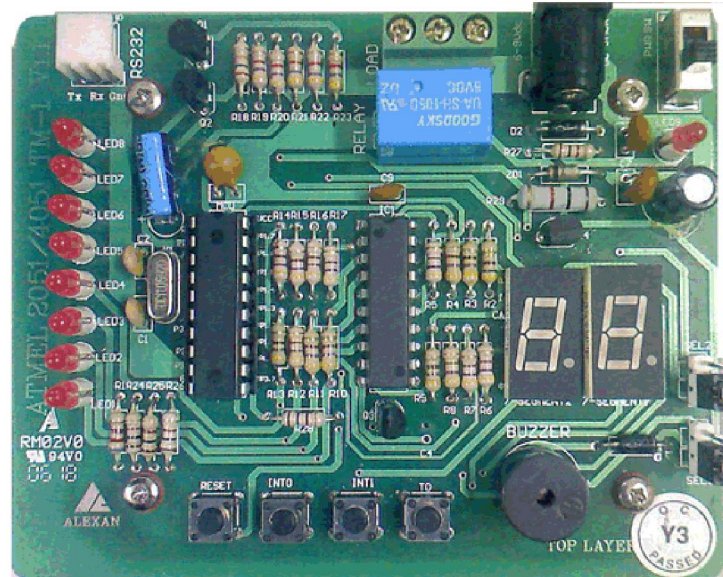


Figure 1.4 8051 Training Module

Another one of the popular boards today is the Arduino, which contains the Atmel ATMEGA8 and ATMEGA168 microcontrollers. The Arduino boards feature USB connectivity and a software environment. The headers surrounding the board provide easy access to the MCU pins and features. Due to its popularity, Arduino boards are cloned here in the Philippines as Gizduino (E-gizmo Phil.), and Aceduino (Alexan Phil.). [ARDU2011]

Though it has some advanced programming features, the board does not include electronic devices for interfacing.

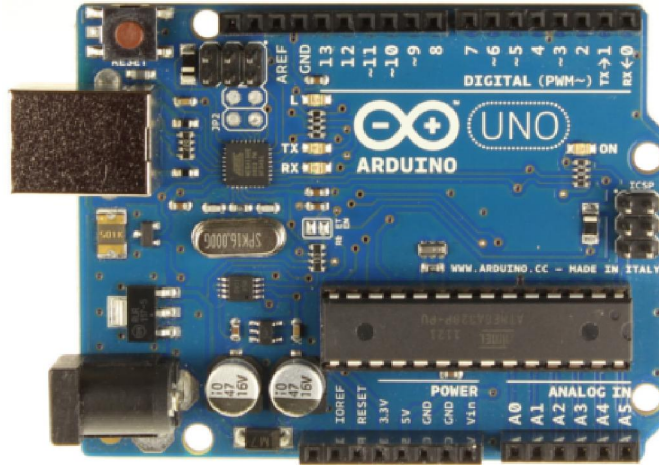


Figure 1.5 Arduino UNO board

Lastly, E-gizmo Mechatronics Central Philippines have a variety of MCU devices as well. Some of these are the ePIC-KIT2 (USB interface) and eICD2 (serial RS232), clones of Microchip's PicKit2 and ICD2 system. Both have in-circuit programming and debugging capability for most PIC MCUs. Another one is the ePICPRO that uses a ZIF (Zero Insertion Force) socket and a parallel port interface. [EGIZ2011]

These three kits do not include a demo board or training kit for interfacing.

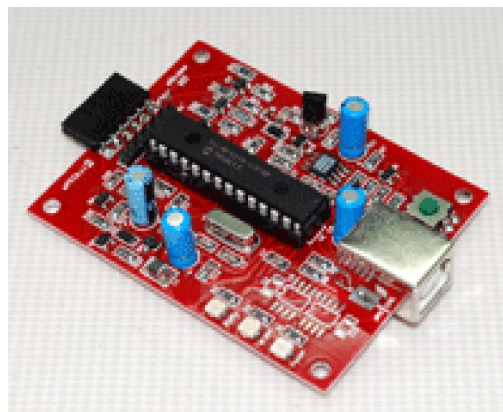


Figure 1.6 ePIC-KIT2

With the problems and limitations faced by the current technologies stated above such as limited devices for interfacing and limited MCU socket, the developers came up with the project that provides an MCU programmer with ZIF socket for multiple pin types, a training kit with more devices, and a software.

This project adopted some properties from the existing devices such as USB interface, connection headers for interfacing, a GUI software environment, and devices such as LEDs, 7-segment and LCDs.

Some components and features were also added to complete the functionality of the project, such as a 40-pin ZIF socket, a virtual emulator, and additional devices such as dot matrix display, motor, and a temperature sensor.

This device also separates the training kit modules from the programming device, unlike the devices stated earlier where all the circuits are confined in one board. This design makes it simple and clear for the beginning users, where they only need to connect what they will use. Likewise, it also provides more control for the advanced users, where they can modify the default connections to devices

1.3 Objectives

1.3.1 General Objective

This project aims to develop a PC - Based Microcontroller Programmer and Training Kit.

1.3.1 Specific Objectives

Specifically, this study aims to:

1. Develop a microcontroller programmer for a variety of PIC Microcontrollers

The developers used a 40-pin ZIF (Zero Insertion Force) socket that can accommodate 8/14/18/28/40 – pin PIC Microcontrollers. The ZIF socket allows easy removal of the MCU chips through a lever on its side that can be moved easily to lock or unlock the inserted chip. It reduces strain to the IC pins compared to traditional sockets where the chip is placed by pushing and removed by pulling.

2. Develop an MCU training kit with a variety of electronic devices

The training kit included separate modules containing LEDs, 7-segment Display, pushbuttons, LCD, Dot Matrix display, motor, and a sensor. These devices are commonly used in electronic projects. The LEDs represent the logic of the MCU pins clearly and are suitable for beginners for they are easy to interface. The 7-segment displays are good numerical indicators, while the LCD is suitable for displaying messages. Pushbuttons are essential in studying MCU input and can be used for event-triggered applications. The Dot Matrix display can be

used to show text in an attractive manner. The motor used is a stepper motor which can be controlled to rotate with accuracy. Stepper motors can be found in devices and mechanisms that require precise movement and positioning. The sensor used is a temperature sensor that can accurately read ambient temperature. This provides a good start in learning analog input and Analog to Digital Conversion (ADC).

3. Develop a beginner- oriented software with Virtual Emulator

The developers designed a GUI application that provides experiments that can be customized by the user. Included in the software is a Virtual Emulator that will display the experiments graphically through a simple animation. The developers used Visual Basic to develop this software.

4. Develop an efficient communication link between the host PC and the device.

The developers implemented USB communication between the host PC and the device. A USB cable is also provided to the user.

1.4 Scope and Limitations

Scope

1. The MCU programming device can program PIC Microcontrollers, such as 8/14/18/28 and 40- pin DIP (Dual In-line Package) types.
2. The device can simplify removing of MCU from the programming device through the included 40-pin ZIF (Zero Insertion Force). It can also protect the MCU from pin bending and ESD (Electrostatic Discharge)

3. The programming device also supports reading from and writing to standard 24Cxx series of EEPROM.
4. The device can control the training kit modules containing basic electronic devices, such as LEDs, Dot Matrix Display, 7 segment Display, LCD, motor, and a temperature sensor. This is done by connecting the modules to the MCU.
5. The project software can simplify programming for the user through a software with predefined MCU experiments.
6. The project software contains a feature called 'Virtual Emulator' which can simulate the experiments graphically on how it would execute in the hardware components in the training kit. This will be advantageous to the user for him to see the output before it is actually burned into the MCU.
7. The project software also allows the user to create his own code for the training kits through the 'Advanced Mode'. In this mode, the user can edit the code of the selected experiment or start from scratch with a blank code editor.
8. The project can be interfaced with the host PC through the use of standard USB Interface. This would increase convenience and compatibility of the device to most desktop PCs and laptops.

Limitations

1. The MCU programmer can only accommodate 8-bit PIC Microcontrollers and 24Cxx EEPROMs. Based on the researches conducted, 8-bit PIC Microcontrollers are more suitable for beginners because of its small instruction set, extensive collection of application notes and its large user base. Meanwhile, the 24Cxx series EEPROMs are very common and widely available.

2. The ZIF socket of the MCU Programmer can only handle PIC MCUs and 24Cxx EEPROMs in DIP (Dual In-Line Package). DIP types are more suitable for experimenting for it can be handled and removed easier than SMD (Surface Mount Device) types.
3. The training kit does not include transceivers, servo motors, motion sensors, and other advanced electronic devices. The modules included are suitable for starters to assist them in learning PIC MCU interfacing easier. In addition, the modules can also be used in advanced experiments.
4. The software only runs on Windows 95/98/NT/2000/ME/XP systems. This is brought about by the limitations of the device drivers used. Windows XP are still widely used today for its stability and speed especially with older systems.
5. The Virtual Emulator can only simulate the predefined experiments in Beginner mode, but not when they are edited in advanced mode with the code editor. It also does not directly communicate with the target MCU and the training kit modules.

2.0 THEORETICAL FRAMEWORK

2.1 Introduction

This chapter discusses the theories and concepts employed in the course of designing and constructing the PC-Based Microcontroller Programmer and Training Kit.

2.2 Microcontroller Units (MCU)

A microcontroller unit (MCU) is a single-chip computer. Micro suggests that the device is small, and controller suggests that it is used in control applications. Another term for microcontroller is embedded controller, since most of the microcontrollers are embedded in the devices they control. [IBRA2008]

A microprocessor differs from a microcontroller in many ways. The main difference is that a microprocessor requires several other components for its operation, such as program memory and data memory, I/O interfaces, and external clock circuit. A microcontroller on the other hand has all the support chips incorporated inside the same chip. In essence, the microprocessor is only one component in the microcontroller chip. [BATE2008]

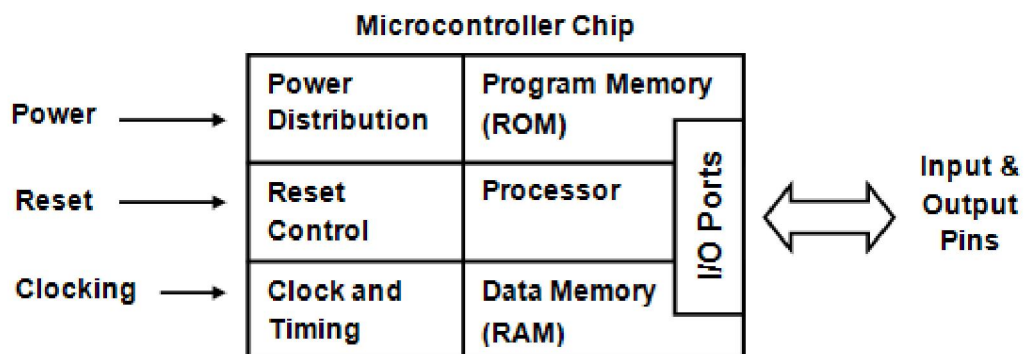


Figure 2.1 Microcontroller Block Diagram

2.3 PIC Microcontrollers

One of the most popular and easy to use microcontroller families available in the market today is the “PIC microcontroller” by Microchip Technology Inc. Originally known as the PIC (for Peripheral Interface Controller), the PIC MCU consists of over 400 variations (or Part Numbers), each designed to be optimal in different applications. These variations consist of a number of memory configurations, different I/O pin arrangements, amount of support hardware required, packaging, and available peripheral functions. [PRED2008]

The PIC microcontroller architecture is based on a modified Harvard RISC (Reduced Instruction Set Computer) instruction set with dual-bus architecture, providing fast and flexible design with an easy migration path. The basic assembler instruction set of PIC microcontrollers consists of only 33 instructions and most of the family members (except the newly developed devices) use the same instruction set. This is why a program developed for one model can run on another model with similar architecture without any changes. [IBRA2008]

Two types of architectures are conventional in microcontrollers. Von Neumann architecture, used by a large percentage of microcontrollers, places all memory space (program and data) on the same bus. Instructions and data have to be fetched in sequential order (known as the Von Neumann Bottleneck), limiting the operation bandwidth. In the Harvard architecture (used by the PIC microcontrollers), code and data are on separate busses and

this allows the code and data to be fetched simultaneously, resulting in an improved performance. [IBRA2008]

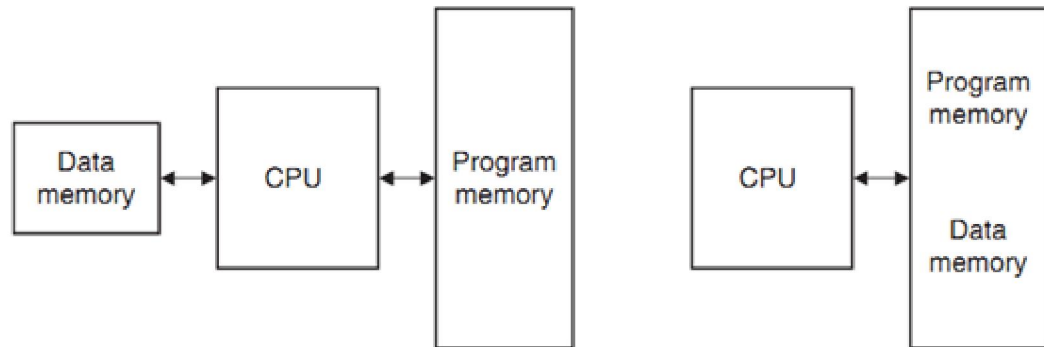


Figure 2.2 Harvard Architecture (left) and Von Neumann Architecture (right)

2.4 Memory

Memory is an important part of a microcontroller system. It stores the data used by the program and the program itself. [IBRA2008]

RAM Data Memory

The data memory (also variable memory) available in an embedded microcontroller consists of a fairly small amount of RAM (random-access memory), which is used for the temporary storage of data. Variable memory is volatile, which means that its values will be lost when power is removed from the microcontroller. Most microcontrollers have some amount of internal RAM, 256 bytes being a common amount, although some have more or less. The PIC16F88 MCU, for example, has 368 bytes of RAM. Memory can usually be extended by adding external memory chips. [IBRA2008]

Flash Program Memory

Program memory (also known as control store and firmware) is used to store the application software. Being nonvolatile, it has ability to retain the information stored in it even when power is removed. This is important because each time power is applied to the MCU, the application code should start working. The program memory space is the maximum size of application that can be loaded into the microcontroller and contains all the code that is executed in an application along with the initial values for the variables used in the application. Program memory is not generally changed during program execution. [PRED2008]

Modern PIC MCUs commonly employs a Flash-type program memory. Flash is a version of EEPROM memory that has become popular in microcontroller applications to store the user program. Flash EEPROM is usually very fast. The program can be erased and then reprogrammed using a suitable programming device. Mid-range PIC MCUs have flash EEPROM ranging from 1 Kb to 8 Kb. The PIC16F88 MCU has 4K bytes of flash memory. [IBRA2008]

Internal EEPROM Data Memory

Internal EEPROM-type data memory is also included in some PIC MCUs. The advantage of an EEPROM memory is that the programmer can store nonvolatile data there and change this data whenever required. For example, in a temperature monitoring application, the maximum and minimum temperature readings can be stored in EEPROM memory. If the power supply

is removed for any reason, the values of the latest readings are available in the EEPROM memory. The PIC16F88 MCU has microcontroller has 256 bytes of EEPROM memory. Compilers specialized in PIC Programming provides instructions for reading and writing to the internal EEPROM of a PIC MCU. [IBRA2008]

External EEPROM Data Memory

In some cases where an internal EEPROM data memory is not enough or not included at all (such as in PIC16F73 and PIC16F747), an external EEPROM data memory can be used. The standard 24Cxx-series chips can be readily interfaced to a PIC MCU circuit. The 24C16 chip has 16K bytes of EEPROM memory. [WREN2010]

2.5 PIC MCU Ports and I/O Registers

Port refers to a group of pins on a microcontroller which can be accessed simultaneously, or on which we can set the desired combination of zeros and ones, or read from them an existing status. The MCU uses them in order to monitor or control other components or devices. Ports represent physical connection of the PIC MCU's processor to the outside world in the form of the pins. [MATI2010]

Every port in the PIC microcontroller has two registers: port data register and port direction control register. Port data register has the same name as the port it controls. For example, PIC16F628A microcontroller has two port data registers PORTA and PORTB. A PIC16F877A microcontroller has 5 port data registers PORTA, PORTB, PORTC, PORTD, and PORTE. An 8-bit data

can be sent to an 8-pin port, or an 8-bit data can be read from the ports. It is also possible to read or write to individual port pins. For example, any bit of a given port can be set or cleared, or data can be read from one or more port pins at the same time. [MATI2010]

Ports in a PIC MCU are bi-directional. Thus, each pin of a port can be used as an input or an output pin. Port direction control register configures the port pins as either inputs or outputs. This register is called the TRIS register and every port has a TRIS register named after its port name. For example, TRISA is the direction control register for PORTA. Similarly, TRISB is the direction control register for PORTB and so on. [IBRA2008]

Setting a bit in the TRIS register makes the corresponding port register pin an input. Clearing a bit in the TRIS register makes the corresponding port pin an output. For example, to make bits 0 and 1 of PORTB (RB0 and RB1) input and the other bits output, we have to load the TRISB register with the bit pattern 00000011. [IBRA2008]

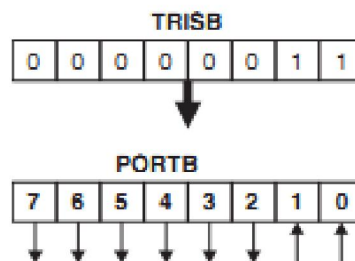


Figure 2.3 TRISB and PORTB direction

The number of ports, port pins and port names varies depending on which PIC MCU type is used. For instance, 8-pin PIC MCU 12F683 has only one port named GPIO, which consists of five bidirectional I/O Pins, while 28-

pin PIC MCU 16F737 has three ports named PORTA, PORTB and PORTC, each with 8 bidirectional I/O pins. PORTA of 28 and 40-pin types can either have 6 or 8 pins depending on the specific PIC MCU's features. [WILM2010]

PIC MCU type	Sample PIC MCUs of each type	No. of Ports	No. of bidirectional I/O Pins in each PORT					
			GPIO	PORTA	PORTB	PORTC	PORTD	PORTE
8-pin	12F683	1	5	–	–	–	–	–
14-pin	16F684	2	–	5	–	6	–	–
18-pin	16F628A	2	–	7	8	–	–	–
28-pin	16F737	3	–	6 \ 8	8	8	–	–
40-pin	16F747	5	–	6 \ 8	8	8	8	3

Table 2.1 PIC MCU Ports and I/O Pins

2.6 In-Circuit Serial Programming™ (ICSP)

The PIC MCUs' In-Circuit Serial Programming (ICSP) capability provides a significant advantage for developers, hobbyists, and manufacturers. Unlike many other MCUs, PIC MCUs feature simple serial programming interfaces that allow them to be programmed using simple circuitry and without being removed from the application circuit. The ICSP connector can also be added to any application circuit, simplifying code modifications. [MICR2010]

ICSP requires the use of these PIC MCU pins:

- + Power supply (VDD)
- Ground (VSS)
- Programming Voltage (VPP)
- Clock (ICSPCLK/PGC)
- Data (ICSPDAT/PGD) [MICR2010]

Following some design guidelines, the clock and data pins can be fully utilized as I/O pins during normal operation and programming pins during ICSP. This mechanism paves the way for the development of efficient PIC MCU development boards, which simplifies the transition of programming to testing for the user's convenience. [MICR2010]

2.7 C Programming Language

Microcontrollers have traditionally been programmed using the assembly language (ASM) of the target device. Although ASM is fast, it has several disadvantages. An assembly program consists of mnemonics, which makes learning and maintaining a program written using the assembly language difficult. Also, microcontrollers manufactured by different firms have different ASM instruction sets, so the user must learn a new language with every new microcontroller he or she uses. [IBRA2008]

Microcontrollers can also be programmed using a high-level language which is much easier to learn than assembly language. High-level languages also facilitate the development of large and complex programs. C language holds several advantages over other high-level languages such as speed, portability, and flexibility. [CRAS2010]

For modern systems, C is the programming language of choice because it is available for a wide range of systems and processors (including the PIC® microcontroller). This ubiquity requires anyone who is planning on developing applications for processing systems to have at least a passing knowledge of the language. C is often referred to as the universal assembly language because it

is designed in such a way that it can access a system's lowest levels efficiently.
[PRED2008]

2.8 Graphical User Interface (GUI)

A graphical user interface (GUI) is a human-computer interface that uses windows, icons and menus and which can be manipulated by a mouse (and often to a limited extent by a keyboard as well). A GUI represents the information and actions available to a user through graphical icons and visual indicators such as secondary notation, as opposed to text-based interfaces, typed command labels or text navigation. The actions are usually performed through direct manipulation of the graphical elements. GUIs stand in sharp contrast to command line interfaces (CLIs), which use only text and are accessed solely by a keyboard. The most familiar example of a CLI to many people is MS-DOS. A major advantage of GUIs is that they make computer operation more intuitive, and thus easier to learn and use, especially for people with few computer skills. The most common combination of such elements in GUIs is the WIMP ("window, icon, menu, and pointing device") paradigm, especially in personal computers. [SAPH2011]

2.9 Emulation

Emulation refers to the ability of a computer program or electronic device to emulate (imitate) another program or device. It is also the process of mimicking the outwardly observable behavior to match an existing target. The internal state of the emulation mechanism does not have to accurately reflect the internal state of the target which it is emulating. This focus on exact

reproduction of external behavior is in contrast to some other forms of computer simulation, in which an abstract model of a system is being simulated. Simulation, on the other hand, involves modeling the underlying state of the target. The end result of a good simulation is that the simulation model will emulate the target which it is simulating. [TOYB2009]

2.10 Universal Serial Bus (USB)

Universal Serial Bus (USB) is a set of connectivity specifications developed by Intel in collaboration with industry leaders. USB allows high-speed, easy connection of peripherals to a PC. When plugged in, everything configures automatically. USB is the most successful interconnect in the history of personal computing and has migrated into consumer electronics (CE) and mobile products. It holds some significant advantages over serial and parallel ports, such as a higher bandwidth, higher bus power, plug n' play support, etc. (shown in Table 2.2) [TOTA2011]

	USB	Serial	Parallel
Industry Standard	Yes	Yes	No
Bandwidth	12 Mbps	115 Kbps	115 KBps EPP/ECP - 3 MBps
Number of Devices	127 devices on a single USB bus	Limited to the number of ports available on the computer.	Limited to the number of ports available on the computer.
Bus Power	Yes, can provide up to 500 mA at 5V	No	No
Cable Length Limit	5 m / 16.4 ft	3 m / 10 ft	1.8 m / 6 ft
Plug'n'Play	Yes	No	No
Hot Swapable	Yes	No	No

Table 2.2 Comparison of USB, Serial and Parallel protocols

2.11 Summary

Several theories served as the foundation for development of the PC-Based Microcontroller Programmer and Training Kit. Each of the concepts are analyzed and applied in designing and constructing the project.

3.0 PC- BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT

3.1 Introduction

This chapter includes the methodology, design, components, and processes involved in the development of PC-Based Microcontroller Programmer and Training Kit.

3.2 System Design Specification

3.2.1 Methodology

The developers employed the prototyping model for this project. After the Planning and Initiation process, the Analysis, Design and Development phases are performed concurrently and on each cycle resulting in a system prototype that will undergo Integration and Testing. The cycle repeats continually until the prototype successfully meets the requirements. The last prototype will then be implemented as the system. [ADI2009]

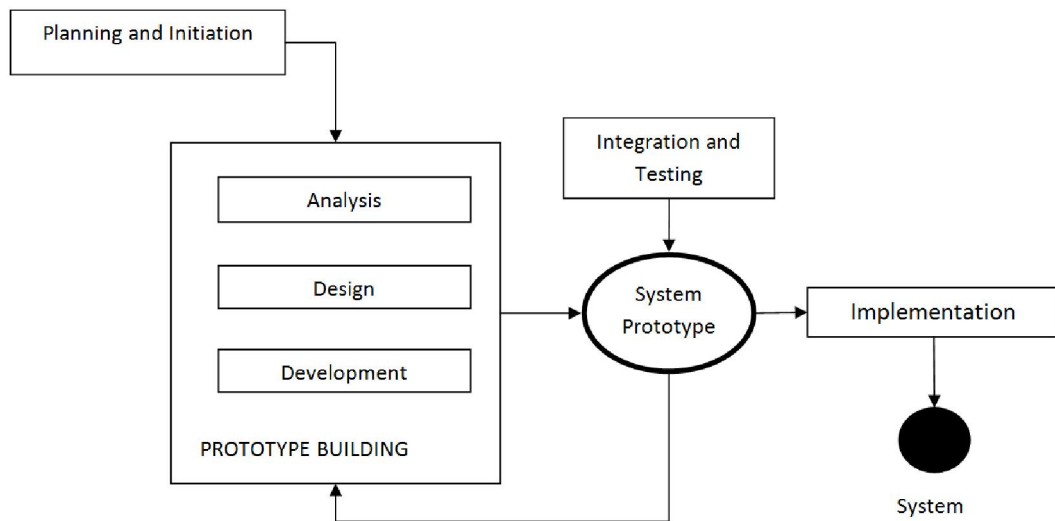


Figure 3.1 Prototyping Model

3.2.2 Project Design

The software consists of a graphical user interface (GUI), a Virtual Emulator, C compiler and burning software. The hardware consists of the USB PIC Programmer, ZIF socket and header pins, and the training kit modules.

The compiled program in .hex code is burned to the PIC MCU using the burning software through the USB PIC Programmer and ZIF + header block. The program in the PIC MCU is then tested in the training kit modules.

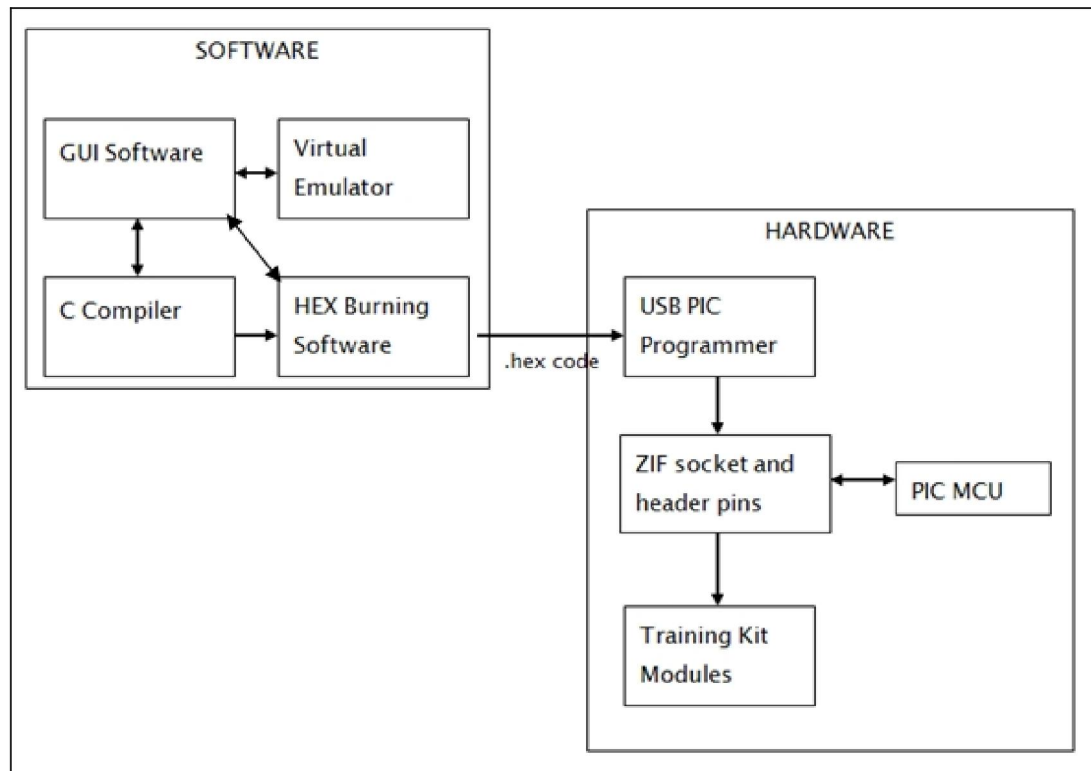


Figure 3.2 Block Diagram

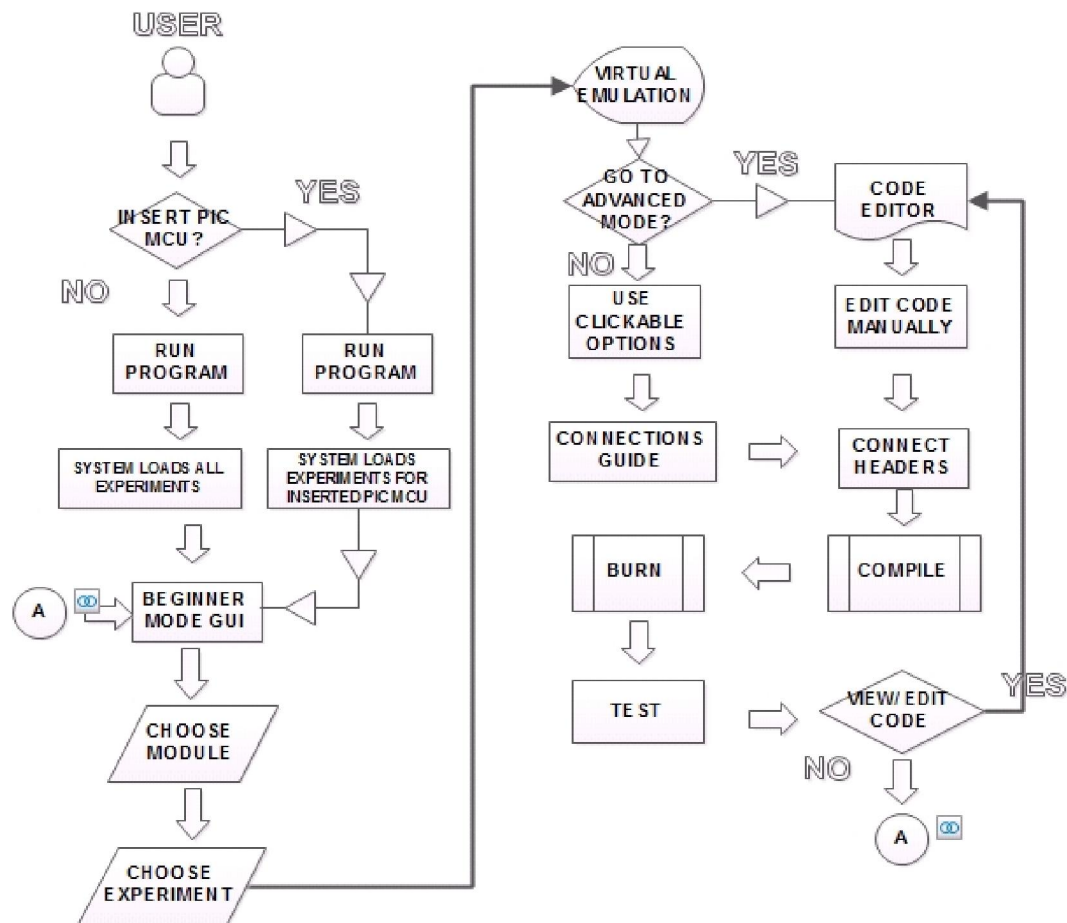


Figure 3.3 Operational Flowchart

The operational flow chart of the “PC- Based Microcontroller Programmer and Training Kit” is briefly explained here.

Before the user runs the software, he can choose to insert a PIC MCU to the device. As a result, only the experiments for the inserted PIC MCU will be activated. Otherwise, if the user does not insert a PIC MCU, the system will load all experiments and the user can later insert the chip upon selection.

Afterwards, the program will start in Beginner Mode where the user would be presented with an enhanced windows environment with objects to interact with. Then, the user can choose which training kit module to interface. Afterwards, the user can

select from a collection of predefined experiments, all of which can be simulated by the Virtual Emulator. The Virtual Emulator would display how the codes is supposed to work in the training kit graphically. At this point, the user can choose to go to advanced mode or stay in beginner mode. In beginner mode, the user can study and test the experiments and customize the output through some options provided by the program. In essence, the user would be actually creating the program without having to code in a text-based environment. Customizations are reflected in the Virtual Emulator. In advanced mode, the user can view or modify the C code manually or choose to start from scratch with a blank code editor. Virtual Emulator is not supported in this mode and the user will be presented with a text- based environment.

After modifications to the program, the user must now prepare the hardware connections necessary to actualize the codes. The user can view the connection guides in beginner mode. Using the header cables, the user must connect the USB PIC Programmer, ZIF+Headers Block, and the training kit module/s to be used.

Afterwards, the user can compile the program. The software is connected to the C Compiler (Hi-Tech PICC Lite). The compiler would check the code and inform the user if there are any errors. It would succeed in compiling if there are no errors. An object .hex file of the program is created at this point.

Then, the user can burn the program. The burning software (WinPic800) communicates with the USB PIC Programmer to transfer the program in .hex code into the PIC Microcontroller. The device is in program mode for this process.

After the device is set to test mode, power is applied to the training module and to the PIC MCU. The program accomplished by the user is expected to be executed,

displayed or realized in the module. Consequently, the user can again modify, compile, burn and test the program.

3.3 Project Hardware Components

The PC-Based MCU Programmer and Training Kit consist of the USB PIC Programmer, the ZIF + Headers block, and the training kit modules.

3.3.1 USB PIC Programmer

The USB PIC Programmer handles programming and testing of the program and serves as the main component of the device.

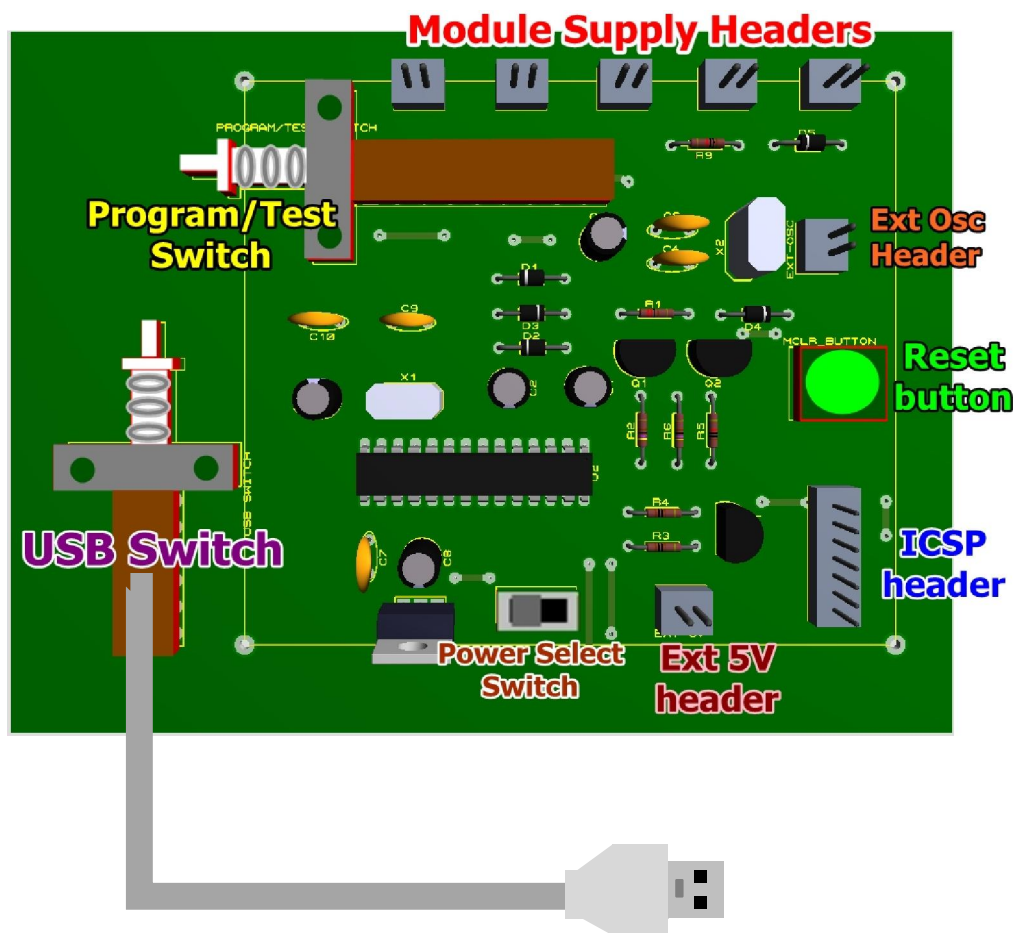


Figure 3.4 USB PIC Programmer

Switches

USB switch - a 4P2T (Four Pole – Double Throw) push-switch that toggles the device ON/OFF while directly connected to the host PC USB port. The four poles handle the VDD, GND, DATA, and CLOCK lines of the USB interface.

Program/ Test switch - a 6P2T (Six Pole – Double Throw) push-switch that determines the operating mode of the device. When in its initial position (not pushed or the spring is released), the device is in Program Mode. In this mode, the PIC MCU pins communicate with the programmer and are able to accept programming signals, such as clock and data. When pushed (the spring is pressed), the device is in “Test Mode”, wherein the PIC MCU pins are configured as I/O to interface with the training kit modules.

Power Select Switch – a SPDT (Single Pole – Double Throw) slide switch that lets the user choose from the internal 5V supply (from the USB port) and from an external 5V supply connected to the Ext 5V Header (if available).

Reset button – a SPST (Single Pole – Single Throw) Momentary NO (Normally Open) pushbutton that resets the executing program in the PIC MCU when triggered. This button can be enabled and disabled through the program.

Headers

ICSP header – ICSP (In Circuit Serial Programming) is a technique used to program a microcontroller with simpler circuitry. The ICSP header, composed of 7 pins, is essential to connect the USB PIC Programmer to the PIC MCU housed in the ZIF + Headers Block. A 7-pin header cable is used.

Module Supply header – this 2-pin header, composed of +5V and GND, is used to connect power rails to the training kit module used.

Ext 5V header - this 2-pin header is used to connect the USB PIC Programmer to an external 5V power supply. Connecting an external 5V power supply would be useful when the current requirement of the modules exceeds the current capability sourced by the host PC, indicated by “USB Power Surge” notifications.

Ext Oscillator header - this 2-pin header is used to provide clocking for certain

type of PIC MCUs that does not include an internal oscillator. Oscillators are important in MCU operations, especially in timing- dependent applications.

USB Port – a type B female USB port would be connected to the host PC using a USB cable

USB PIC Programmer chip – the 18F2550 PIC MCU serves as the brain of the USB PIC Programmer. It holds the firmware that performs processing of the USB signals and programming of the target PIC MCU. The user would not be dealing with this chip, and is expected not to touch it, nor remove it from its socket.

3.3.2 ZIF+Headers Block

The ZIF+Headers block provides the socket for the PIC MCU and all the headers necessary for interfacing the latter with the Training Kit modules.

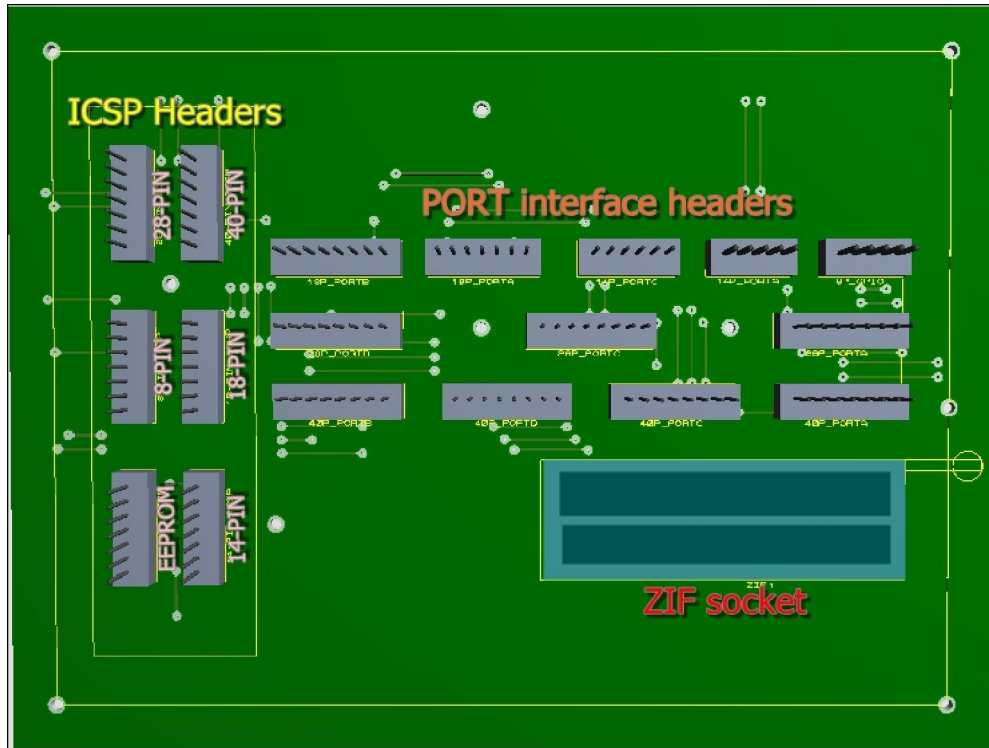


Figure 3.5 ZIF + Headers Block

ZIF Socket – the 40-pin ZIF (Zero Insertion Force) Socket can accommodate 8/14/18/28/40 – pin PIC MCUs and 24Cxx EEPROMs. It allows easy removal of the chips via the lever.

ICSP headers – these are the connection points of the ICSP header in the USB PIC Programmer. The five varieties refer to the PIC MCU types based on pin number. One of the headers is reserved for the 24Cxx EEPROM chips.

Port Interface headers – these headers provides the actual connection between the PIC MCU in the ZIF Socket and the electronic devices in the training kit modules. These headers are categorized according to pin number and the port name of the PIC MCUs.

3.3.3 Training Kit Modules

The modules in the training kit are necessary for the actual testing of the program. All of the modules contain I/O headers with its matching cable. The other side of the cable is to be connected to Port Interface Headers in the ZIF + Headers Block. The header cables are color-coded based on the module, such as red for LEDs module and green for LCD module. This property simplifies connections for the user in conjunction with the software guide. All of the modules also have supply headers which should be connected to the USB PIC Programmer using a color-coded 2-pin connector. This is necessary for the modules to obtain +5V and GND from the USB PIC Programmer.

LED module

The LED Module consists of an 8 LED array corresponding to 8-bit binary output. There are two headers included, one I/O header and one Module Supply header.

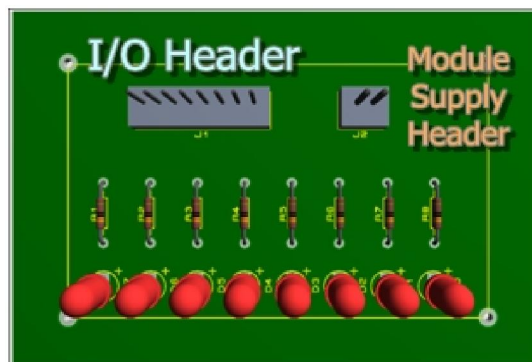


Figure 3.6 LED Module

7 segment module

The 7-segment module is composed of a pair of dual 7-segment displays and 4 SPST (Single Pole Single Throw) Momentary NO (Normally Open) push

buttons. This circuit implements multiplexing of the 4 digits, which requires less microcontroller pins to be used. This module comprises 3 headers: the Module Supply header and two I/O headers.

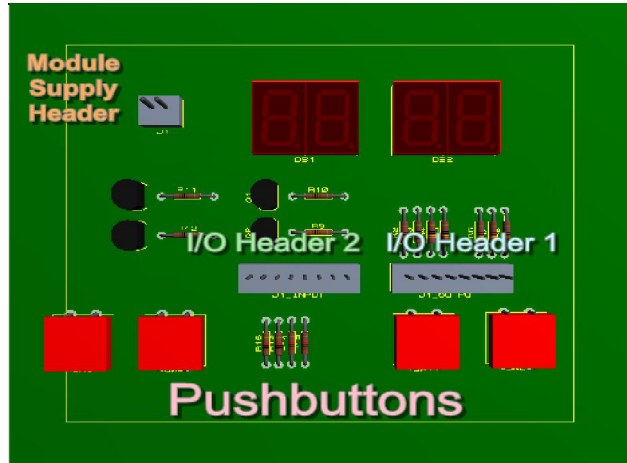


Figure 3.7 7- segment Module

Dot Matrix module

The Dot Matrix module includes an 8x8 dot matrix and a 74LS138 decoder IC that runs the cathodes of the matrix through multiplexing. The IC reduces the required number of MCU pins for interfacing. This module also contains 3 headers: the Module Supply header and two I/O headers.

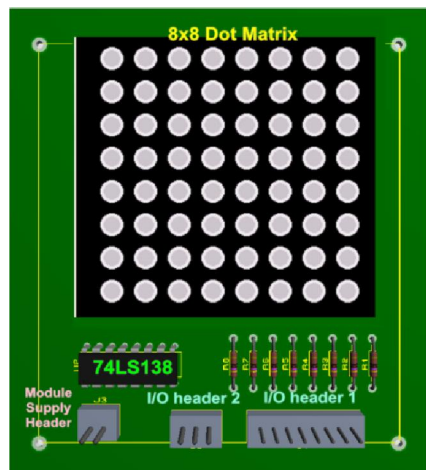


Figure 3.8 Dot Matrix Module

LCD module

The LCD module features a 16x2 characters LCD with backlight. It is used in 4-bit mode to reduce the interface pins. This module contains 2 headers: the Module Supply header and one I/O header.

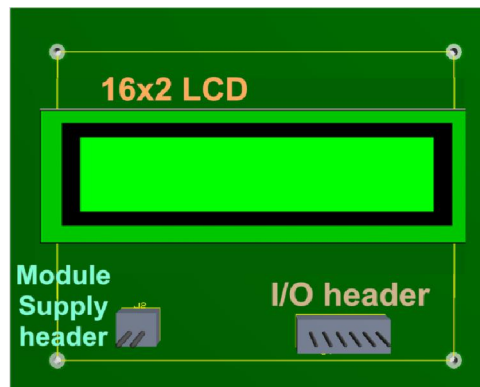


Figure 3.9 LCD Module

Motor Module

The motor module employs a bipolar stepper motor. It can rotate for the exact number of steps based on the user program. A L293D driver chip was used to control the output signals from the MCU port to the motor coils. Another chip, the 74LS04 is used to invert the power signals to the required logic of the L293D chip. This module contains 2 headers: the Module Supply header and one I/O header.

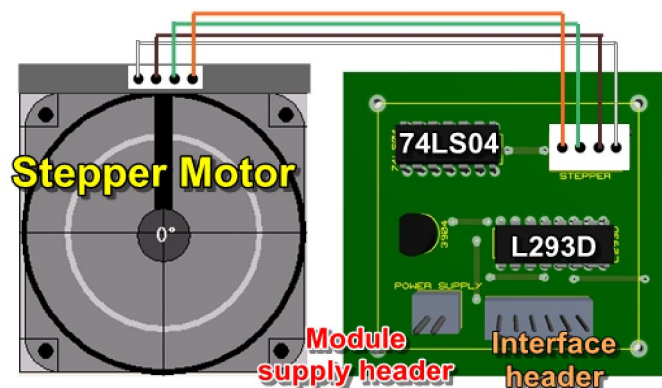


Figure 3.10 Motor Module

Temperature Sensor

The sensor used is a LM-35 precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius temperature. This 3-pin IC in a transistor package is directly connected to the power supply and to the ADC (Analog to Digital Converter) pin of the PIC MCU port.

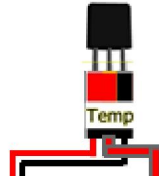


Figure 3.11 LM-35 Sensor

Project Case

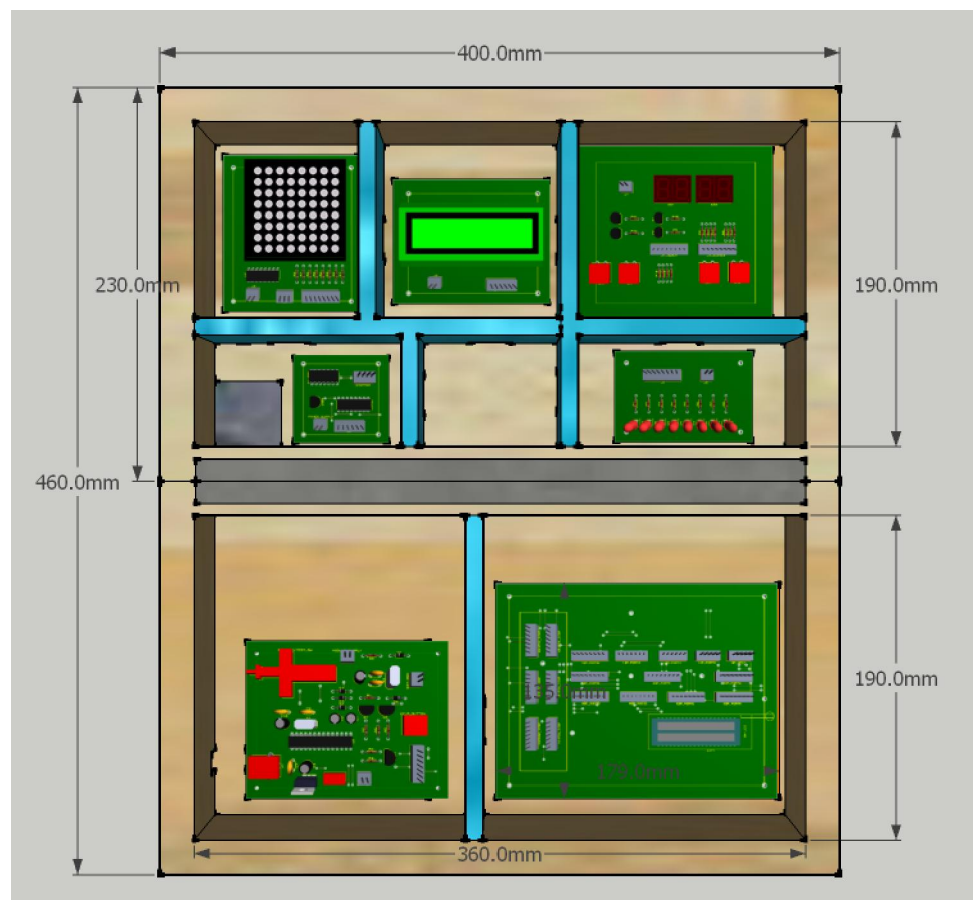


Figure 3.12 Project Case with Dimensions

3.4 Project Software

The project software named “PICSoft” is composed of several divisions.

a. Beginner mode

The Beginner mode contains options to choose the PIC MCU to be used, the training kit module to be controlled, as well as the predefined experiments for the module. It also provides options to customize the experiment. The Virtual Emulator also runs in conjunction with this mode.

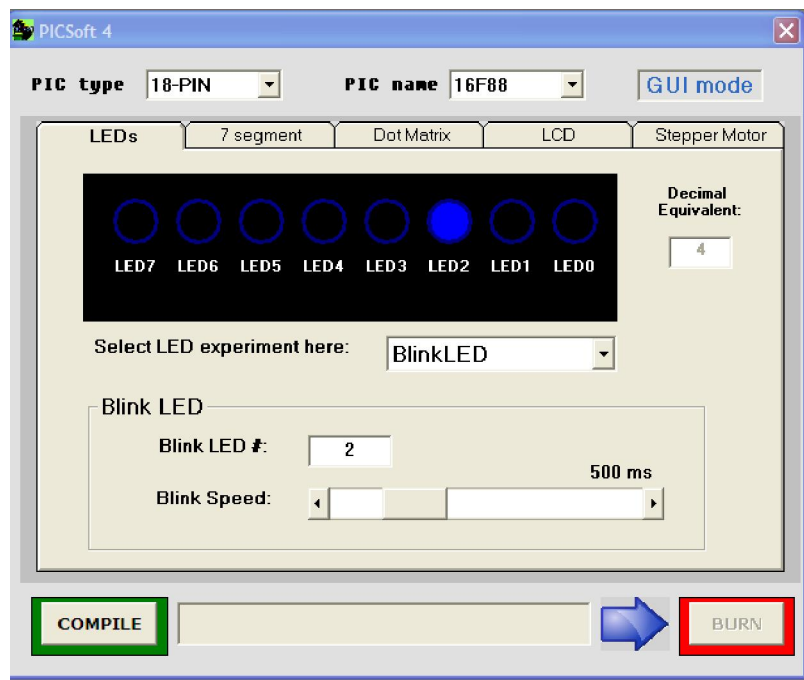


Figure 3.13 Beginner mode GUI

b. Virtual Emulator

The virtual emulator can simulate the code and the way it would execute in the hardware components in the training kit. This is only available in Beginner mode GUI.

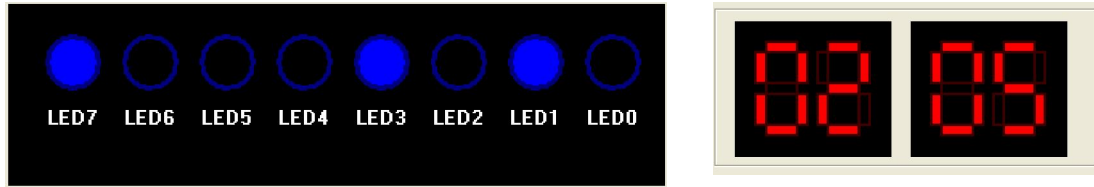


Figure 3.14 Virtual Emulator

c. Advanced Editing Mode / PICpad

In Advanced Editing Mode, the user would be presented with a code editor named 'PICpad'. This mode provides options for opening, saving, printing, compiling and burning C code files (*.C) written in Hi-Tech PICC compiler syntax. It is also possible to load the code running at the Beginner mode GUI directly to PICpad. This option helps the user analyze codes of the experiments.

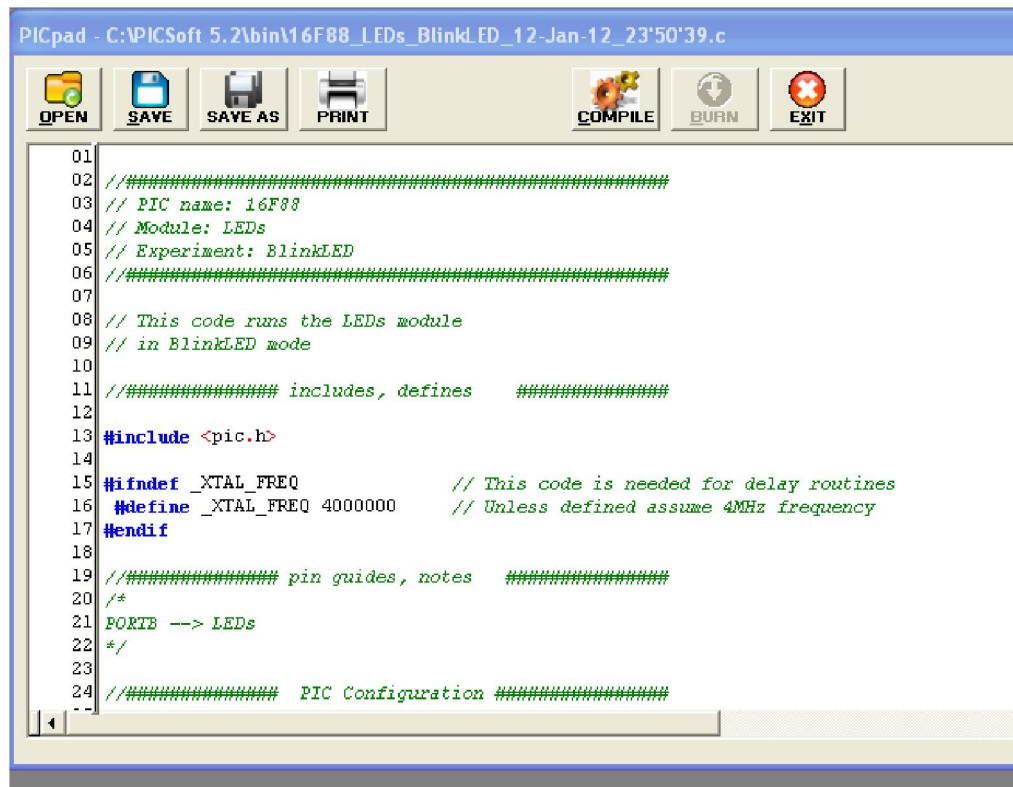


Figure 3.15 Advanced Editing Mode

d. Software guides and information window

The project software includes several guides and information windows. Quick information on the currently selected PIC MCU, as well as some description of the module used and the current experiment selected is displayed. There are also three options available, namely: ‘View Code’ which opens PICpad along with the code of the experiment, ‘Schematic’ which displays the actual schematic representation of the interface, and ‘Connections Guide’ which opens a step-by-step guide on setting up the connections necessary for actualization of the experiment.

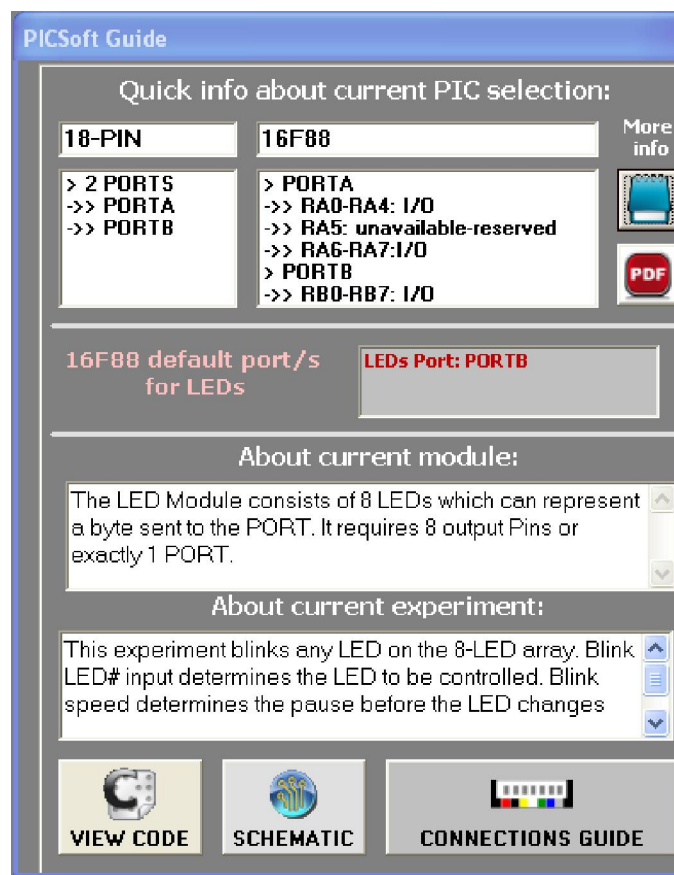


Figure 3.16 Software Guide

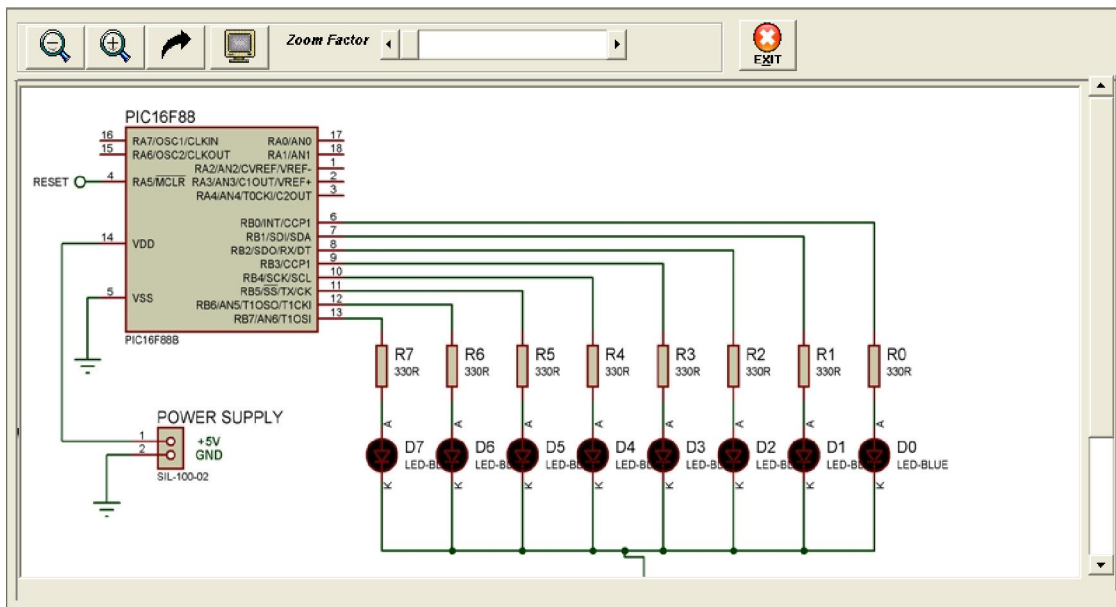


Figure 3.17 Schematic view window

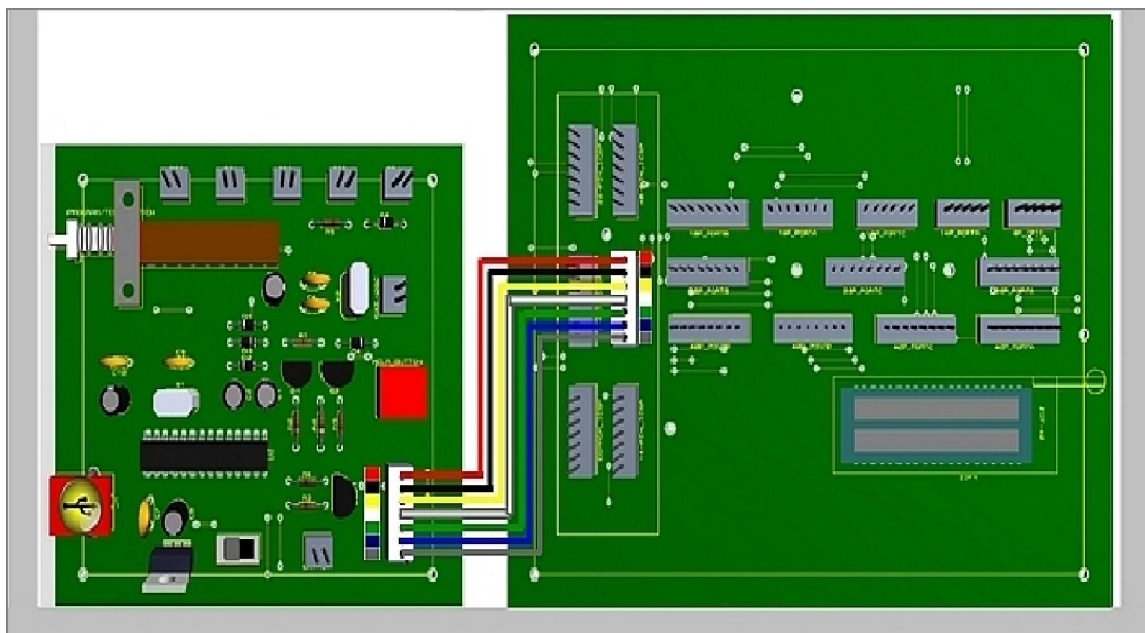


Figure 3.18 Connections guide window

3.5 Hardware Parts Specifications

PIC Microcontroller

The PIC (Peripheral Interface Controller) microcontroller family of microcontrollers is manufactured by Microchip Technology Inc.



Figure 3.19 PIC Microcontroller (PIC16F628A)

The PIC microcontroller architecture is based on a modified Harvard RISC (Reduced Instruction Set Computer) instruction set with dual-bus architecture. The basic assembler instruction set of PIC microcontrollers consists of only 33 instructions and most of the family members use the same instruction set. This is why a program developed for one model can run on another model with similar architecture without any changes. [IBRA2008]

PIC microcontrollers also feature power-on reset, watchdog timer, sleep mode, high source and sink current, on-chip timer and ICSP. PICs operate as most microcontrollers with the standard logic voltage of +5V. Though some can operate at least +2.7 V and at most +6V. [IBRA2008]

The PIC MCUs to be used in this project compose of one 8-pin (12F683), one 14-pin (16F676), three 18-pin (16F88, 16F648A, 16F819), one 28-pin (16F737), and one 40-pin (16F747).

Header Cables

Most of the hardware components are connected using “header cables”. These cables are available in 5, 6, 7, and 8 pins.

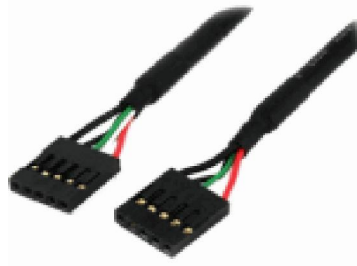


Figure 3.20 5 pin header cable

EEPROM (Electrically Erasable Programmable Read-only Memory)

A small chip that holds bits of data code that can be rewritten and erased by an electrical charge, one byte at a time. EEPROM does not require a power source to maintain its data. In this project, the 24Cxx family of EEPROMs will be used. [KAYN2010]



Figure 3.21 24C08 EEPROM

LEDs (Light Emitting Diode)

A LED is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. [ZHIH2012]

In this project, an 8 LED array will be used corresponding to binary output.



Figure 3.22 LEDs

7 segment Display

A 7-segment display basically consists of 7 LEDs connected such that numbers from 0 to 9 and some letters can be displayed. They are also frequently used as numerical indicators, such as in digital clocks, timers and scoreboards [IBRA2008]

In this project, 2 dual 7-segment displays will be integrated to form a 4-digit number or a pair of 2-digit numbers



Figure 3.23 Dual 7-segment display

Dot Matrix LED Display

Dot Matrix LEDs are group of LEDs that forms characters through the pattern created by lighting each LED on or off. They are commonly used in digital message displays and modern scoreboards. [TUUP2012]

The dot Matrix LED to be used for the project is an 8x8 d5mm High Brightness Row anode- Column Cathode type.

Stepper Motor

A stepper motor is a brushless, electric motor that can divide a full rotation into a large number of steps. The motor's position can be controlled precisely without any feedback mechanism, as long as the motor is carefully sized to the application. Stepper motors consist of a permanent magnet rotating shaft, called the rotor, and electromagnets on the stationary portion that surrounds the motor, called the stator. [SCRI2012]

The project includes a bipolar stepper motor with 1.8° / step resolution.

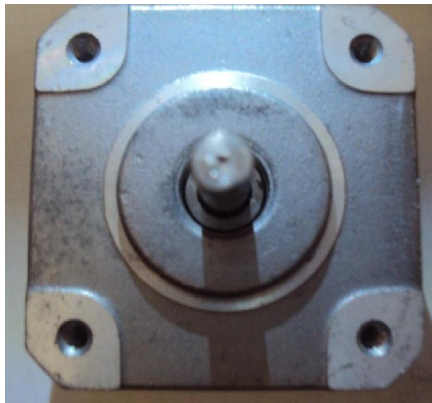


Figure 3.27 Stepper Motor

3.6 Software Resources

Hi-Tech PICC Lite Compiler

This is a freeware ANSI C Compiler, designed primarily for the use of students and hobbyists for educational and small projects. It features unlimited MCU memory usage and eliminates the need for many non-standard C qualifiers and compiler options. It can also be invoked from the command line providing GUI optimization. It also runs on all platforms: Windows (XP, Vista and 7), Linux and Mac OS X [MICR2011]

WinPic800

This free software serves as the burner that transfers the compiled HEX codes from the host PC through the MCU Programming device into the microcontroller. It allows you to program all types of serial PICs using Windows 95/98/NT/2000/ME/XP. It supports many PIC Microcontroller families and 24Cxx EEPROMs. It can also be called through a command line providing GUI optimization [WINP2010]

Visual Basic programming language

This is the IDE (Integrated Development Environment) that the developers use to develop the GUI software.

Visual Basic (VB) is a programming language and environment developed by Microsoft based on the BASIC language. Visual Basic was one of the first products to provide a graphical programming environment and a paint metaphor for developing user interfaces. Instead of worrying about syntax details, the Visual Basic

programmer can add a substantial amount of code simply by dragging and dropping controls, such as buttons and dialog boxes, and then defining their appearance and behavior. [QUIN2011]

The developers chose VB to build the Graphical User Interface because coding in VB is simpler, and it is easy to build an interface that connects to other programs such as the Hi-Tech PICC Lite Compiler and WinPic800 described above.

Proteus PCB Design Package

Proteus PCB design combines the ISIS schematic capture and ARES PCB layout programs to provide a powerful, integrated and easy to use suite of tools for professional PCB Design. It includes an integrated shape based autorouter and a basic SPICE simulation capability as standard. [LABC2011]

The developers use Proteus ISIS and ARES to schematic designs and board layouts for the project hardware.

3.7 Project Development

3.7.1 Hardware

The following procedures are undertaken for the development of the project hardware.

1. Design each of the circuit by making a schematic diagram
2. After the design, the board/ parts placement layout is also prepared.

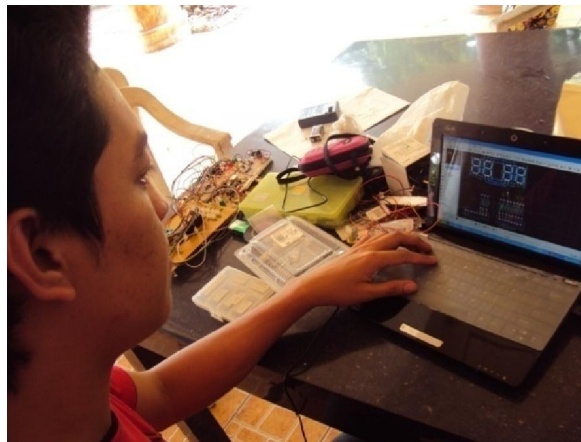


Figure 3.28 Designing the board layout

3. Cut the presensitized PCB according to the size of the layout.



Figure 3.29 Cutting the Presensitized PCB

4. Prepare the printed layout by making it transparent. It can be done by applying and rubbing the paper with baby oil. Otherwise, the layout can be printed in transparency paper.



Figure 3.30 Applying oil to printed layout for transparency

5. The transparent layout is pressed flat to the presensitized PCB using a sheet of glass and exposed to direct sunlight for 60 seconds.



Figure 3.31 Exposing the PCB to sunlight

6. Immerse the exposed board completely in the PCB developer solution until the design is clear.



Figure 3.32 Immersion of board layout to PCB developer

7. Rinse the board with running water to halt the chemical reaction.
8. After drying the board, it is etched by immersing completely in the Ferric Chloride solution. The container is agitated until the unwanted copper etches away, leaving the copper layout of the circuit.



Figure 3.33 The container is agitated until unwanted copper is removed

9. Rinse the board with plenty of water to stop the chemical reaction.
10. Drill the designated holes on the PCB using the proper drill bits for each component holes and screws. Use masking tape to improve drill contact to the copper.



Figure 3.34 Drilling of the holes in the board

11. Test the electronic components, as well as the layout itself using a multimeter.

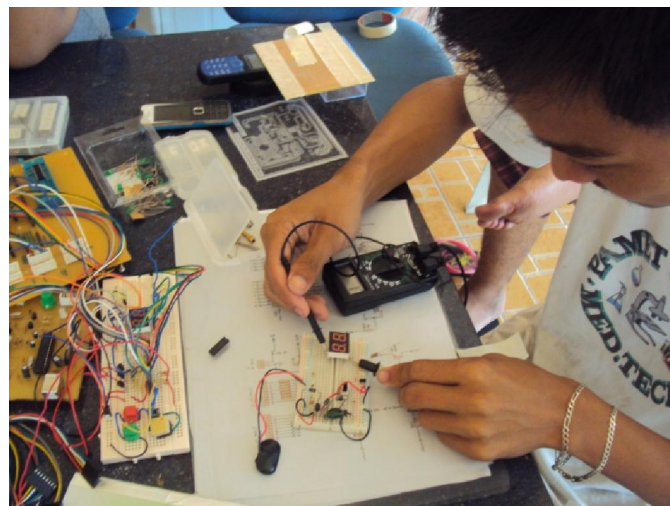


Figure 3.35 Testing of electronic components

12. Solder the components to the board.



Figure 3.36 Soldering of components to the board

13. After all the circuit modules are done, each one is attached to the case using a drill, a screwdriver, and some screws.

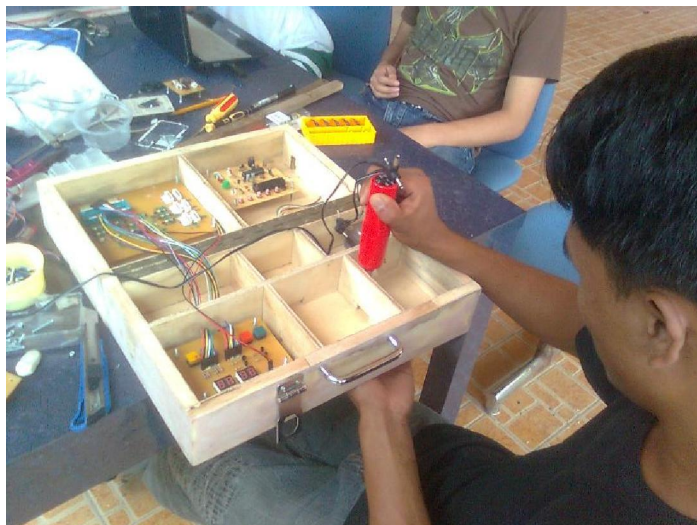


Figure 3.37 Drilling of the case to fix the circuit board

3.7.2 Software

The project software named 'PICSoft' is developed using Visual Basic 6 (VB6) IDE.



Figure 3.38 Programming the project software in VB6 IDE

The built-in objects in the VB6 toolbox along with other additional components are incorporated to the software. The project software contains several forms and code modules. Modular programming is employed to improve code efficiency and maintainability.

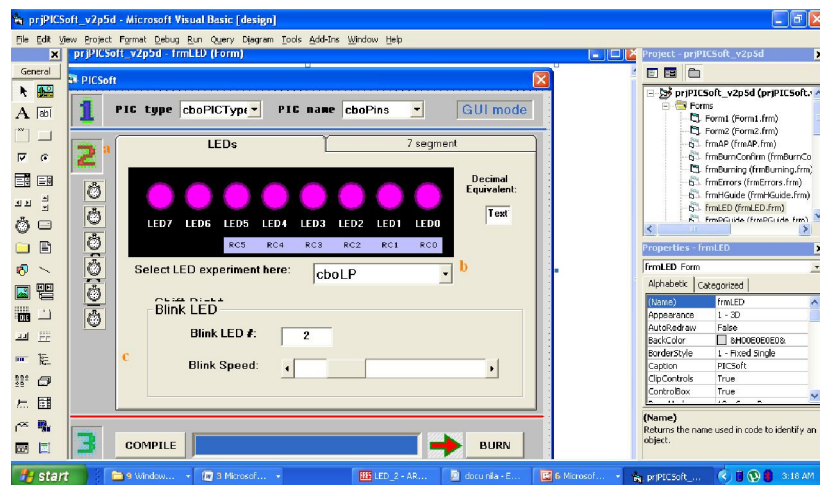


Figure 3.39 PICSoft project inside the VB6 environment

3.8 Summary

The PC-Based Microcontroller Programmer and Training Kit is developed by following a methodology, project design, and certain procedures. Several resources are also utilized in making the project. The project consists of certain components that interact with each other to form the working system.

4.0 PERFORMANCE ANALYSIS

4.1 Introduction

This chapter contains the methods done to evaluate and enhance the PC-Based Microcontroller Programmer and Training Kit. The developers conducted some experiments and testing to analyze and improve the performance of the project.

In evaluation of the project, a questionnaire was presented to student evaluators to rate several aspects of the project, which are Functionality, Reliability, Aesthetics, Durability, Economy and Safety.

4.2 Experimental

The project was tested continuously to measure its efficiency and reliability. The initial testing consists of using each of the training kit modules for 30 times with different experiments and PIC MCU used.

The formula used to compute the percent-error, as well as the results are shown below:

$$\text{Percent error} = \frac{(\text{total no. of trials} - \text{successful trials})}{\text{Total no. of trials}} \times 100$$

Module	Total no. of trials	No. of successful trials	Percent error
LEDs	30	29	3.33%
7-segment	30	29	3.33%
Dot Matrix	30	29	3.33%
LCD	30	28	6.67%
Motor	30	29	3.33%
Temperature Sensor	30	27	10%
TOTAL	180	171	5 %

Table 4.1 Percent error of each training kit module

The project achieved an overall percent- error of 5%, or 95% efficiency. This means that the project works but still has to be improved to increase its reliability and performance.

The project has also undergone several modifications in hardware and software for its continuous development.

Software

Upon completion of each increment or version of the software, it is tested repeatedly to find bugs and test functionality. The emulator, compiler, burner and user interface were tested by executing the program with varying conditions and input. Other external factors are also considered in testing, such as memory consumption, file size, and execution speed.

The error fixes and code improvements were accomplished in each increment of the software.

USB PIC Programmer

Program/Test Switch

The first programming device developed lacks enough power supply to use more than one training kit module. It has also no control of the positive (+5V) supply for the modules resulting to conflicts in programming and testing.

As a result, the developers added power supply headers to the revision of the USB PIC Programmer. The 4P2T (four poles, double throw) switch was also replaced with a 6P2T (six poles, double throw) switch to improve the programming and testing of the device.

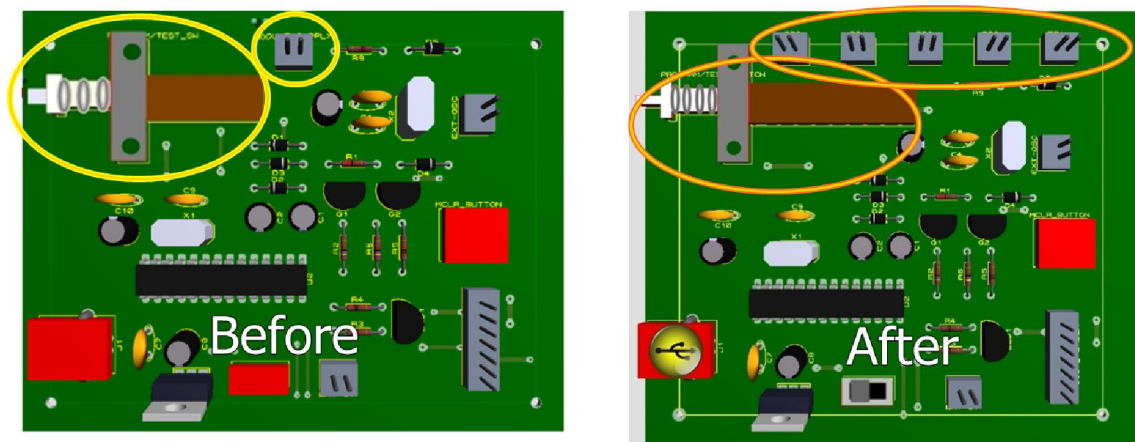


Figure 4.2 Modifications in USB PIC Programmer

USB Switch

A USB switch is also added to the previous USB PIC Programmer so that the USB cable does not need to be connected and disconnected when using the device. This switch toggles the USB lines while the USB cable is fixed into the host PC.

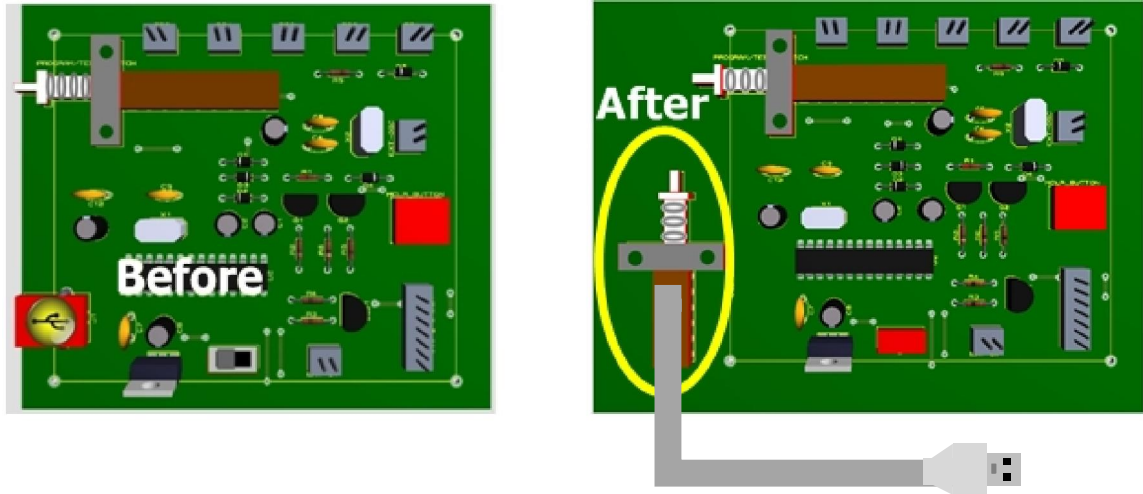


Figure 4.3 Addition of USB Switch to USB PIC Programmer

ZIF + Headers circuit

At first, the ZIF + Headers circuit were causing malfunction of the entire device because of some shorted lines in the board. This was due to the detailed circuit designed in a small area, wherein some thin lines of unwanted copper were left in the board after etching.

The developers checked the continuity of each circuit point using a multimeter and then used a cutter to remove the unwanted copper carefully.



Figure 4.4 Testing continuity of lines in ZIF + Headers Block

Stepper Motor controller circuit

The initial circuit for the Stepper Motor only consists of four interface pins connected to the PIC MCU. Upon testing and experimentation, the developers discovered that two extra pins needed to properly control the rotation of the motor. These two pins are the 'Enable' pins which are pulled-up to the +5V line at first. The developers discovered that these pins should not be supplied with logic 1 at all times, and the PIC MCU must disable the motor by supplying a logic 0.

The two pins are then added to the port interface header upon modification of the circuit, replacing the 4-pin header with a 6-pin header.

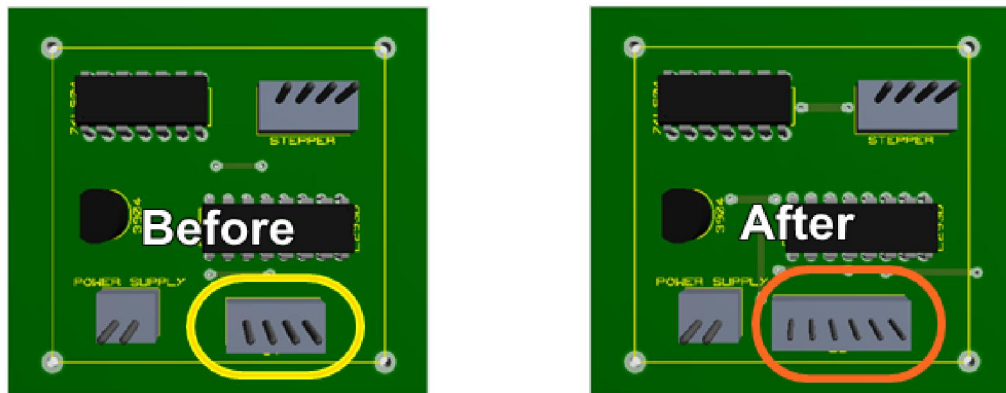


Figure 4.5 Modifications in Stepper Motor Circuit

4.3 Results and Analysis

The project was evaluated by 50 respondents consisting of BSCoE students from STI College Rosario and Cavite State University - Rosario. The evaluation consists of six different criteria. The following table presents the results of the evaluation.

Criteria	Mean	Rating
Functionality	4.37	Very Good
Reliability	4.25	Very Good
Aesthetics	4.29	Very Good
Durability	4.37	Very Good
Economy	4.37	Very Good
Safety	4.35	Very Good

Table 4.2 Overall Rating of the Prototype for each Criteria

The project rated 4.37 in Functionality, which means that it performed its tasks above average and it is also easy to operate and user- friendly.

In terms of Reliability, the project was rated Very Good with a mean rating of 4.25. This means that the system is reliable in terms of errors, speed of execution and information provided.

With regards to Aesthetics, the project was rated 4.29 which proves that it is reasonably attractive. This was probably due to its smooth finish and simple color, as well as the attractiveness of the circuit design and the GUI software.

It also appears that the project is durable with a rating of 4.37, which shows that the case of the project is durable and the circuit boards are fixed steadily in it. The materials used are also of high quality.

The project also rated Very Good with a rating of 4.37 in terms of economy. The developers used cheaper materials to maintain its low cost compared to existing products. The device also has a market demand due to its importance and timeliness.

In terms of safety, it also rated Very Good with 4.35. The project does not pose any potential hazard in toxicity or electrical shock. The developers also made sure that there are no sharp edges in the case.

The weighted mean was computed to determine the performance and acceptability of the project. The result can also be a basis for its improvement.

$$\text{Grand Mean} = \frac{4.37 + 4.25 + 4.29 + 4.37 + 4.37 + 4.35}{6}$$

$$\text{Overall Mean Rating} = 4.33 \text{ (Very Good)}$$

Based on all of the criteria, it appears that the student evaluators recognized the good qualities of the project, as well as its potential for improvement. It is indicated by the overall mean of 4.33, which means a Very Good rating.

The developers also gathered feedback from the faculty members of the schools through an essay-type form. The responses generally show that they are interested with the project, especially regarding its functionality in programming the MCU and how it is interfaced to the training kit modules. According to them, the project can also be competitive in the market, for it is advantageous to beginners in MCUs, and an effective tool in testing MCU programs. The respondents also expressed that the project can be beneficial to the institution with its usefulness. The faculty respondents also gave suggestions that are essential in improving the project.

Among the faculty respondents where Engr. Lirio Ambulo from Polytechnic University of the Philippines (PUP)- Maragondon, Engr. Raiza Borreo from Cavite State University (CvSU) – Rosario, and Engr. Eugenio Peñalosa IV from STI College Rosario.

4.4 Summary

The PC-Based Microcontroller Programmer and Training Kit was proven to serve its purpose efficiently. The device succeeded in programming a microcontroller and provided detailed guides that the user can follow in using the project. Although rated above average, the device can be further developed to improve its performance.

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Throughout the inception, development, completion, and evaluation of the project, the developers came up with the following conclusions:

1. The project, which is a PC- Based Microcontroller and Training Kit, provides a complete solution of hardware and software for the users. It can help BSECE and BSCoE learn MCU programming and device interfacing.
2. The device is completed with a programmer for a variety of PIC Microcontrollers and a training kit with several electronic devices for interfacing.
3. The project software is highly functional for it has several features that make it efficient and user-friendly, not only for beginners but for advanced users alike.
4. The project performed efficiently in the conducted testing and was rated very good by the evaluators.
5. Prior to its completion, the project helped some engineering students in the development of their projects and thesis proposals. It served its purpose of programming their MCUs and providing experimentation and learning.

5.2 Recommendation

For further enhancement of the project, the developers highly recommend the following:

1. Include a reliable external power supply, particularly one that obtains 220 VAC from a wall outlet and provides a stable +5 VDC.
2. Incorporate Assembly Language in the project, where the user can also study and/or edit the generated codes in ASM.
3. Provide a way of easily replacing the LEDs and 7-segments, such as adding pin connectors between the device and the circuit board.
4. Improve the Dot Matrix module by adding additional 8x8 displays, particularly forming a 8x16 or 8x32 matrix display.
5. Add support for other types of MCUs, such as the newer PIC24 and PIC32 MCUs from Microchip, as well as MCUs from other manufacturers, namely Zilog and Atmel.
6. Add support for Windows Vista / 7, as well as MAC and Linux operating systems.
7. Include more training kit module devices, such as servo motors, transceivers, and a variety of sensors.
8. Improve the Virtual Emulator by implementing a code- based emulation, which responds to changes in the codes while being edited.

APPENDIX A

Gantt Chart of Activities

	NOV 2011		DEC 2010			JAN 2011			FEB 2011			MAR 2011		JUN 2011				JUL 2011				AUG 2011				SEPT 2011				OCT 2011				NOV 2011				DEC 2011			JAN 2012				FEB 2012				MAR 2012		
WEEK #	3	4	1	2	3	2	3	4	1	2	3	4	1	2	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	2	3	4	1	2	3	4	1	2	3				
Brainstorming	■		■			■			■			■		■				■				■				■				■				■			■				■										
Data Gathering	■		■			■			■			■		■				■				■				■				■				■			■				■										
Conducting interviews and surveys	■		■			■			■			■		■				■				■				■				■				■			■				■										
Analysis	■		■			■			■			■		■				■				■				■				■				■			■				■										
	■		■			■			■			■		■				■				■				■				■				■			■				■										
	■		■			■			■			■		■				■				■				■				■				■			■				■										
Design	■		■			■			■			■		■				■				■				■				■				■			■				■										
	■		■			■			■			■		■				■				■				■				■				■			■				■										
Development	■		■			■			■			■		■				■				■				■				■				■			■				■										
	■		■			■			■			■		■				■				■				■				■				■			■				■										
	■		■			■			■			■		■				■				■				■				■				■			■				■										
Overall Testing	■		■			■			■			■		■				■				■				■				■				■			■				■										
Evaluation	■		■			■			■			■		■				■				■				■				■			■				■														
Improving the prototype	■		■			■			■			■		■				■				■				■				■			■				■														
Finalizing project	■		■			■			■			■		■				■				■				■				■			■				■														

APPENDIX B

Journal

November 19, 2010	Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Brainstorming Result: Various ideas on possible thesis proposals
November 26, 2010	Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Preparation of thesis proposal titles and areas of research Result: Three thesis proposal titles
December 3, 2010	Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Preparing the documentation of three thesis proposal titles Result: Three thesis proposal titles documentation- Chapters 1 to 3
December 8, 2010	Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Description of Activities: Presented the three thesis proposal titles in Mock Defense Result: The thesis title regarding MCU Programmer and Training Kit is approved

Paolo Roberto O. Lozada, MEng
Thesis Adviser

January 7, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Internet research regarding microcontroller units
Result: Information about MCUs such as PIC and Zilog MCU

January 14, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Internet research about existing MCU Programming Devices and Development Kits
Result: Information about several MCU programming devices and kits, such as those produced by Microchip, Zilog, E-gizmo and Alexan

January 21, 2011

Agustin Ace Dones
Lenmor Dimanalata
Location: San Sebastian College- Recoletos de Cavite
Description of Activities: Inquiry and observation regarding the MCU devices used in San Sebastian College – Recoletos de Cavite
Result: Information regarding the PicKit1 and Pic Demo Board 2

January 28, 2011

Romeo Paderna
Jon Jon Legaspi
Location: STI College Rosario Library
Description of Activities: Internet research about software used in MCU Programming
Result: Information regarding the various MCU Programming software, such as compilers and IDEs (Integrated Development Environment)

Paolo Roberto O. Lozada, MEng
Thesis Adviser

February 4, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Internet Research about electronic devices Result: Information about LEDs, 7 segment displays, Dot matrix displays, and LCDs</p>
February 11, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Preparation of thesis documentation – Chapters 1 to 3 Result: Organized documentation</p>
February 15, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Interview with BSCoE student Result: Transcript and interpretations from interview</p>
February 18, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Completed the thesis documentation for submission Result: Submitted documentation</p>
March 1, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Description of Activities: Conducted survey with STI Rosario 3rd and 4th year BSCoE students Results: Survey tally, graphs, and interpretation</p>

Paolo Roberto O. Lozada, MEng
Thesis Adviser

March 3, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Description of Activities: Thesis proposal defense Results: Thesis approved with major revision</p>
March 7, 2011	<p>Agustin Ace Dones Romeo Paderna III Lenmor Dimanalata Location: Cavite State University – Rosario campus Description of Activities: Conducted survey with 3rd and 4th year BSCoE students Results: Survey tally, graphs, and interpretation</p>
March 9, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Revision of thesis documentation Results: Revised chapters 1 and 2 of thesis documentation</p>
March 11, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Location: Polytechnic University of the Philippines - Maragondon campus Description of Activities: Conducted survey with 3rd and 4th year BSECE students Results: Survey tally, graphs, and interpretation</p>
March 15, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Final revisions for submission of documentation Results: Revision of chapter 3 and appendices</p>

Paolo Roberto O. Lozada, MEng
Thesis Adviser

June 17, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario library Description of Activities: Making schematic layouts and board placement layouts for the USB PIC Programmer Result: Finished layout for USB PIC Programmer</p>
June 22, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Revision of thesis documentation Results: Revised chapters 1 and 2 of thesis documentation</p>
June 24, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: Dones Residence Description of Activities: PCB Transfer of USB PIC Programmer layout using Presensitized PCB and Photodeveloper chemical, and PCB etching using Ferric Chloride; Drilling of PCB and soldering of components Result: Finished preliminary prototype for USB PIC Programmer</p>
June 29, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario library Description of Activities: Making schematic layouts and board placement layouts for the ZIF + Headers circuit Result: Finished layout for ZIF + Headers circuit</p>

Paolo Roberto O. Lozada, MEng
Thesis Adviser

July 1, 2011
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: Dones Residence
Description of Activities: PCB Transfer of ZIF + Headers layout using Presensitized PCB and Photodeveloper chemical, and PCB etching using Ferric Chloride; Drilling of PCB and soldering of components
Result: Finished preliminary prototype for ZIF + Headers circuit

July 5, 2011
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario library
Description of Activities: Making schematic layouts and board placement layouts for the LED Module
Result: Finished layout for LED Module

July 8, 2011
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: Dones Residence
Description of Activities: PCB Transfer of LED Modules layout using Presensitized PCB and Photodeveloper chemical, and PCB etching using Ferric Chloride; Drilling of PCB and soldering of components
Result: Finished preliminary prototype for LED Module circuit

July 13, 2011
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Started Chapter 3 of thesis documentation
Results: Initial documentation for Chapter 3

Paolo Roberto O. Lozada, MEng
Thesis Adviser

July 15, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario library Description of Activities: Initial coding of PICSoft -GUI Software of the project Result: Finished initial codings and backbone of the program</p>
July 20, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Revised documentation and prepared Status Report Results: Revised documentation and Status Report</p>
July 27, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario library Description of Activities: Making schematic layouts and board placement layouts for the 7-segment module Result: Finished layout for 7-segment module</p>
July 29, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: Dones Residence Description of Activities: PCB Transfer 7-segment module layout using Presensitized PCB and Photodeveloper chemical, and PCB etching using Ferric Chloride; Drilling of PCB and soldering of components Result: Finished preliminary prototype for 7 segment module</p>

Paolo Roberto O. Lozada, MEng
Thesis Adviser

August 5, 2011	Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: Dones Residence Description of Activities: Performing initial testing of the device Result: Observations, notes and recordings on the initial testing
August 12, 2011	Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Revision of Documentation and preparation of Appendices Result: Revised documentation with Appendices
August 19, 2011	Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Coding of Advanced Editing Mode /PICPad Result: Working code editor for PICSoft
August 26, 2011	Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Coding for the software and hardware guide for PICSoft Result: Finished working codes for the software and hardware guides for PICSoft

Paolo Roberto O. Lozada, MEng
Thesis Adviser

September 2, 2011
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Preparation for Thesis 1 Mock Defense
Result: Revised documentation and powerpoint presentation

September 7, 2011
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario
Description of Activities: Thesis 1 Mock Defense
Result: Obtained ideas to improve the project and some requirements for the next defense

September 9, 2011
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Coding for the Visual Simulator for Dot Matrix and LCD
Result: Finished working codes for the Visual Simulator of Dot Matrix and LCD

September 14, 2011
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario library
Description of Activities: Making schematic layouts and board placement layouts for the Dot Matrix Module and LCD Module
Result: Finished layout for Dot Matrix module

Paolo Roberto O. Lozada, MEng
Thesis Adviser

September 16, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: Dones Residence
Description of Activities: PCB Transfer of Dot Matrix and LCD modules layout using Presensitized PCB and Photodeveloper chemical, and PCB etching using Ferric Chloride; Drilling of PCB and soldering of components
Result: Finished prototype for Dot Matrix and LCD module

September 21, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Coding for the Visual Simulator for Stepper Motor
Result: Finished working codes for the Visual Simulator of Stepper Motor

September 23, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario library
Description of Activities: Making schematic layouts and board placement layouts for the Motor module
Result: Finished layout for Motor module

September 28, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: Dones Residence
Description of Activities: PCB Transfer of Motor module layout using Presensitized PCB and Photodeveloper chemical, and PCB etching using Ferric Chloride; Drilling of PCB and soldering of components
Result: Finished prototype for Motor module

Paolo Roberto O. Lozada, MEng
Thesis Adviser

September 30, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Coding for the C code generator of Dot Matrix, LCD and Motor modules
Result: Finished working codes for the C code generator of Dot Matrix, LCD and Motor modules

October 5, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: Dones Residence
Description of Activities: Performing testing of the device
Result: Observations, notes and recordings on the testing

October 7, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Updated the Documentation, particularly the Chapter 3 based on the finished prototypes, as well as the Journal and Status Report
Result: Updated documentation

November 11, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario library
Description of Activities: Planning the interface of Temperature Sensor to the device, as well as the experiments involving two devices
Result: Finished plan and application notes for Temperature Sensor and interface with two Devices

Paolo Roberto O. Lozada, MEng
Thesis Adviser

November 16, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Coding for the Visual Simulator for Temperature Sensor and dual device interface
Result: Finished working codes for Temperature Sensor and dual device interface

November 18, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Formed experiments for the device involving three devices Coding for the Visual Simulator for experiments involving three devices
Result: Finished experiments and Visual Emulator for three-device interface

November 25, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: Dones Residence
Description of Activities: Designed the wooden case for the project, measurement of dimensions and planning the placement of the project to the case
Result: Finished design and plan for the project case

December 2, 2011

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: Dones Residence
Description of Activities: Smoothed the case using Sandpaper, fixed the circuit boards to the case
Result: Smoother outer shell of case and device fixed into case

Paolo Roberto O. Lozada, MEng
Thesis Adviser

December 7, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Started writing the experiments for the workbook for the project Result: Finished initial parts of the workbook for the six training kit modules</p>
December 12, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Description of Activities: Conducted evaluation of the device to STI College Rosario BSCoE and BSIT students Result: Results and tally from the evaluation</p>
December 14, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Started writing Chapter 4 of thesis documentation including results of the initial evaluation Result: Chapter 4 of thesis documentation</p>
December 30, 2011	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: : Dones Residence Description of Activities: Performed testing of the project Result: Notes, results and analysis obtained from testing</p>
January 3, 2012	<p>Agustin Ace Dones Romeo Paderna III Jon Jon Legaspi Lenmor Dimanalata Location: STI College Rosario Library Description of Activities: Revision of documentation and preparation for Mock Defense Result: Revised documentation</p>

Paolo Roberto O. Lozada, MEng
Thesis Adviser

January 5, 2012
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario
Description of Activities: Thesis 2 Mock Defense
Result: Obtained ideas to improve the project and some requirements for the next defense

January 11, 2012
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario
Description of Activities: Created initial installer for project software
Result: Initial installation setup for project software

January 13, 2012
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Revision of documentation for submission
Result: Revised documentation for submission

January 20, 2012
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Finalize software and installation setup
Result: Finalized software and installation

January 27, 2012
Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario Library
Description of Activities: Revision of documentation for the final defense
Result: Revised documentation for final defense

Paolo Roberto O. Lozada, MEng
Thesis Adviser

February 2, 2012

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: Dones Residence
Description of Activities: Performed overall testing of project
Result: Results and notes from testing

February 4, 2012

Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
Location: STI College Rosario
Description of Activities: Thesis 2 Final Defense
Result: Passed with minor revisions; notes about corrections to be made on final documentation and device

Paolo Roberto O. Lozada, MEng
Thesis Adviser

APPENDIX C

STATUS REPORT

DATE : December 15, 2010
FOR : Paolo Roberto O. Lozada, MEng
FROM : Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata

RE : PC-BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT
STATUS REPORT

SOFTWARE:

Date: December 10, 2010

Finished Activity: Gathered some idea about programming languages that can be used in hardware interfacing

Description: Research on information regarding programming languages and their capability in hardware interfacing

HARDWARE:

Date: December 9, 2010

Finished Activity: Obtained facts regarding the characteristics and capabilities of microcontroller units

Description: Research on information regarding MCUs

DOCUMENTATION:

Date: December 3, 2010

Finished Activity: Submission of initial thesis proposal title and 'Area of Research'

Description: Preparation of thesis proposal title and 'Area of Research'

Date: December 6, 2010

Next Activity: Initial documentation of thesis proposal for Mock Defense

Description: Organized Chapters 1 to 3 of initial thesis proposal

Paolo Roberto O. Lozada, MEng
Thesis Adviser

STATUS REPORT

DATE : January 26, 2011
FOR : Paolo Roberto O. Lozada, MEng
FROM : Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata

RE : PC-BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT
STATUS REPORT

SOFTWARE:

Date: January 20, 2011

Finished Activity: Learned about the capability of C language in MCU programming

Description: Research on the properties of the C language and its functionality in hardware interfacing

HARDWARE:

Date: January 7, 2011

Finished Activity: Acquired some details about various MCUs, their properties and features

Description: Research about various microcontroller units

Date: January 14, 2011

Next Activity: Gained some knowledge about the existing MCU programming devices and development kits

Description: Research on the existing MCU programming devices and development kits

Date: January 21, 2011

Next Activity: Identified some existing MCU programming devices and development kits being used by San Sebastian College – Recoletos de Cavite

Description: Inquired about the existing MCU programming devices and development kits used by San Sebastian College – Recoletos de Cavite

DOCUMENTATION:

Date: January 25, 2011

Finished Activity: Formulation of initial problem statements and objectives

Description: Analysis of gathered data relevant to the thesis proposal

Paolo Roberto O. Lozada, MEng
Thesis Adviser

STATUS REPORT

DATE : February 21, 2011
FOR : Paolo Roberto O. Lozada, MEng
FROM : Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
RE : PC-BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT
STATUS REPORT

SOFTWARE:

Date: February 16, 2011

Finished Activity: Acquired some sample source codes and projects interfacing electronic devices with MCUs using C

Description: Research on references and articles about MCU interfacing using C

HARDWARE:

Date: February 2, 2011

Finished Activity: Intention to employ the PIC Microcontroller family for the project

Description: Research, analysis, and comparison regarding various families of MCUs

Date: February 4, 2011

Next Activity: Gathered information on LEDs, 7 segment displays, Dot Matrix displays and LCD

Description: Research on basic electronic devices that can be interfaced with MCUs

Date: February 7, 2011

Next Activity: Gathered information on Parallel LPT, Serial RS-232 and USB interfaces

Description: Research on the communication interfaces used in MCU programming devices

DOCUMENTATION:

Date: February 11, 2011

Finished Activity: Chapters 1 to 3 of thesis documentation

Description: Preparation of thesis documentation for submission

Date: February 15, 2011

Next Activity: Transcript of interview and interpretation

Description: Conducted interview to a BSCoE student

Date: February 18, 2011

Next Activity: Inclusion of the appendices and completing the documentation for submission

Description: Editing of documentation and organizing the appendices

Paolo Roberto O. Lozada, MEng
Thesis Adviser

STATUS REPORT

DATE : March 15, 2011
FOR : Paolo Roberto O. Lozada, MEng
FROM : Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata

RE : PC-BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT
STATUS REPORT

SOFTWARE:

Date: March 2, 2011

Finished Activity: Plan to use Visual Basic IDE programming language to create the GUI (Graphical User Interface) software

Description: Research on programming languages that can be used to create a GUI software with objects

Date: March 8, 2011

Next Activity: Have an initial idea how to implement Virtual Emulation involving the PIC MCU and the electronic devices to interface with

Description: Research on emulators and their implementation in MCU programming

HARDWARE:

Date: March 10, 2011

Finished Activity: Obtained information regarding MCU interfacing with temperature sensors and motors

Description: Research on information regarding MCU interfacing with temperature sensor and motor

DOCUMENTATION:

Date: March 11, 2011

Finished Activity: Survey results, tallies and interpretation

Description: Conducted surveys on BSECE and BSCoE students from different schools

Date: March 14, 2011

Next Activity: Revised documentation for submission

Description: Revision of documentation through the criticisms and suggestions obtained from the thesis defense

Paolo Roberto O. Lozada, MEng
Thesis Adviser

STATUS REPORT

DATE : July 20, 2011
FOR : Paolo Roberto O. Lozada, MEng
FROM : Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata

RE : PC-BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT
STATUS REPORT

SOFTWARE:

Date: July 15, 2011

Finished Activity: Finished initial codings and backbone of the project software named "PICSoft"

Description: Initial coding of PICSoft - GUI Software of the project

HARDWARE:

Date: June 17, 2011

Finished Activity: Finished layout for USB PIC Programmer

Description: Making schematic layouts and board placement layouts for the USB PIC Programmer

Date: June 24, 2011

Next Activity: Finished preliminary prototype for USB PIC Programmer

Description: PCB Transfer, etching, drilling, soldering of the components for the USB PIC Programmer device

Date: June 29, 2011

Next Activity: Finished layout for ZIF + Headers circuit

Description: Making schematic layouts and board placement layouts for the ZIF + Headers circuit

Date: July 1, 2011

Next Activity: Finished prototype for ZIF + Headers circuit

Description: PCB Transfer, etching, drilling, soldering of the components for the ZIF + Headers circuit

Date: July 5, 2011

Next Activity: Finished layout for LED module circuit

Description: Making schematic layouts and board placement layouts for the LED module

Date: July 8, 2011

Next Activity: Finished prototype for LED module

Description: PCB Transfer, etching, drilling, soldering of the components for the LED Module

DOCUMENTATION:

Date: June 22, 2011

Finished Activity Revised chapters 1 and 2 of thesis documentation

Description: Revision of thesis documentation

Date: July 13, 2011

Next Activity: Initial documentation for Chapter 3

Description: Prepared Chapter 3 of thesis documentation

Date: July 20, 2011

Next Activity: Revised documentation and Status Report

Description: Revised documentation and prepared Status Report

Paolo Roberto O. Lozada, MEng
Thesis Adviser

STATUS REPORT

DATE : August 24, 2011
FOR : Paolo Roberto O. Lozada, MEng
FROM : Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata

RE : PC-BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT
STATUS REPORT

SOFTWARE:

Date: August 19, 2011

Finished Activity: Finished initial codes for the Advanced Editing Mode/ PICpad

Description: Initial coding of PICPad – code editor of the project software

HARDWARE:

Date: July 27, 2011

Next Activity: Finished layout for 7-segment module circuit

Description: Making schematic layouts and board placement layouts for the 7-Segment module

Date: July 29, 2011

Next Activity: Finished prototype for 7-segment module

Description: PCB Transfer, etching, drilling, soldering of the components for the 7-Segment Module

DOCUMENTATION:

Date: August 12, 2011

Finished Activity: Revised documentation and Appendices

Description: Revised documentation and prepared Appendices

Paolo Roberto O. Lozada, MEng
Thesis Adviser

STATUS REPORT

DATE : September 21, 2011
FOR : Paolo Roberto O. Lozada, MEng
FROM : Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata

RE : PC-BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT
STATUS REPORT

SOFTWARE:

Date: August 26, 2011

Finished Activity: Finished initial codes for the software and hardware guide for PICSoft

Description: Coding of the software and hardware guide for PICSoft

Date: September 9, 2011

Next Activity: Finished working Visual Simulator of Dot Matrix and LCD

Description: Coding and creating graphical objects for the Visual Simulator

Date: September 21, 2011

Next Activity: Finished working Visual Simulator of Stepper Motor

Description: Coding and creating graphical objects for the Visual Simulator

HARDWARE:

Date: September 14, 2011

Finished Activity: Finished layout for Dot Matrix and LCD module circuit

Description: Making schematic layouts and board placement layouts for the Dot Matrix and LCD module

Date: September 16, 2011

Next Activity: Finished prototype for Dot Matrix and LCD module circuit

Description: PCB Transfer, etching, drilling, soldering of the components for the Dot Matrix and LCD module

DOCUMENTATION:

Date: September 2, 2011

Finished Activity: Preparation for Thesis 1 Mock Defense

Description: Revised documentation and created a powerpoint presentation

Paolo Roberto O. Lozada, MEng
Thesis Adviser

STATUS REPORT

DATE : October 19, 2011
FOR : Paolo Roberto O. Lozada, MEng
FROM : Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata

RE : PC-BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT
STATUS REPORT

SOFTWARE:

Date: September 30, 2011

Finished Activity: Finished working C code generator for Dot Matrix, LCD, and Motor modules

Description: Scripting the code generator for Dot Matrix, LCD, and Motor modules based on PIC-C compiler

HARDWARE:

Date: September 23, 2011

Finished Activity: Finished layout for Motor module circuit

Description: Making schematic layouts and board placement layouts for the Motor module

Date: September 28, 2011

Next Activity: Finished prototype for Motor module circuit

Description: PCB Transfer, etching, drilling, soldering of the components for the Motor module

DOCUMENTATION:

Date: October 7, 2011

Finished Activity: Preparation for Thesis 1 Defense

Description: Updated documentation, particularly Chapter 3, as well as the Journal and Status Report

Paolo Roberto O. Lozada, MEng
Thesis Adviser

STATUS REPORT

DATE : December 14, 2011
FOR : Paolo Roberto O. Lozada, MEng
FROM : Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
RE : PC-BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT
STATUS REPORT

SOFTWARE:

Date: November 16, 2011

Finished Activity: Finished Visual Simulator for Temperature Sensor and dual- device interface

Description: Coding and creating graphical objects for the Visual Simulator

Date: November 18, 2011

Finished Activity: Finished Visual Simulator for triple-device interface

Description: Coding and creating graphical objects for the Visual Simulator

HARDWARE:

Date: November 25, 2011

Finished Activity: Finished design for project case

Description: Obtaining measurements of the circuit boards and drawing the design of the case

Date: December 2, 2011

Next Activity: Finished fixing the circuit boards to the wooden case

Description: Rubbing the wooden case with sandpaper, drilling holes for screws, and fixing the circuit boards to the case

DOCUMENTATION:

Date: December 7, 2011

Finished Activity: Workbook experiments for the six training kit modules

Description: writing the experiments for the workbook for the project

Date: December 12, 2011

Next Activity: Results from evaluation of the device.

Description: Conducted evaluation of the device to STI College Rosario BSCoE and BSIT students.

Date: December 14, 2011

Next Activity: Chapter 4 of thesis documentation.

Description: Writing Chapter 4 including the results of project evaluation.

Paolo Roberto O. Lozada, MEng
Thesis Adviser

STATUS REPORT

DATE : January 13, 2012
FOR : Paolo Roberto O. Lozada, MEng
FROM : Agustin Ace Dones
Romeo Paderna III
Jon Jon Legaspi
Lenmor Dimanalata
RE : PC-BASED MICROCONTROLLER PROGRAMMER AND TRAINING KIT
STATUS REPORT

SOFTWARE:

Date: January 11, 2012

Finished Activity: Created initial installer for project software

Description: Used setup builder software to create installation setup of project software

HARDWARE:

Date: December 30, 2011

Finished Activity: Performed testing of the project

Description: Performed testing on each training kit module

DOCUMENTATION:

Date: January 3, 2012

Finished Activity: Revision of documentation and preparation for Mock Defense

Description: Revised documentation and prepared for defense

Date: January 13, 2012

Next Activity: Revision of documentation for submission

Description: Revised documentation for submission

Paolo Roberto O. Lozada, MEng
Thesis Adviser

APPENDIX D

Interviews and Survey

A. Interviews

Respondent #1

- Name: Floizel Anne Cruz
- Course: BSCoE (Computer Engineering)
- Year: 5th year 2nd sem
- College/ University: STI College Rosario
- Date of interview: February 14, 2011
- Interview Summary:

Based on the interview with 5th year CoE student Floizel Anne Cruz, the proponents discovered that the respondent's institution didn't have a subject dedicated to the study of MCUs. Though they gained a little knowledge about the basic theories, they were unable to make use of the complex MCU programmer available at that time. They have to "self-study" the topic and refer to external resources and references. Currently, they are using PIC Microcontroller in their thesis proposal device and had to pay programming of the PIC, a price higher than 500 PHP. They had a little hardware interfacing with their programming subjects involving LEDs and LPT (parallel port), an experiment in PC- dependent applications; but such still aren't enough for them to make projects in embedded systems. The respondent also stated the significance of the study of microcontrollers in their endeavors and in the industry, as well as the advantage of its early familiarization and learning for BSCoE students.

Respondent # 2

- Name: Lawrence Jornales
- Course: BSECE (Electronics and Communications Engineering)
- Year: 4th year 2nd sem
- College/ University: San Sebastian College- Recoletos Cavite
- Date of interview: February 15, 2011
- Interview Summary:

Based on the interview with 4th year ECE student Lawrence Jornales, the researchers found out that the respondent's course curriculum didn't include a subject devoted to microcontrollers. Though it is part of the subject Microprocessors and scarcely of other subjects like Logic Design, it was realized that it is not enough knowledge gathered to perform advanced MCU projects. They have a MCU programmer in their school (PicKit 1 and PIC Demo Board 2), but he had not experienced or been taught using it. Aside from not having seminars regarding Microcontrollers, the respondent also didn't have any introduction to hardware interfacing in their programming subjects. The respondent also exclaimed the importance of knowledge regarding MCUs and MCU programming.

B. Surveys

i. Survey Questionnaire

A SURVEY QUESTIONNAIRE ON THE STUDENT'S KNOWLEDGE ON ELECTRONICS, MICROCONTROLLERS, and PROGRAMMING	
Course and Year/Section: _____	School: _____
Name: (optional) _____	
There is no right or wrong answer. Please answer the questions honestly and accurately.	
<hr/> <hr/>	
I. RESPONDENT'S ACQUISITION TO MICROCONTROLLER KNOWLEDGE and MATERIALS	
Please check the box of the answer that corresponds closer to what you think is true or right.	
1. Do you have any subject/s about microcontrollers?	<input type="checkbox"/> yes <input type="checkbox"/> no
2. Do you know what a microcontroller is and can you differentiate it from other types of ICs?	<input type="checkbox"/> yes <input type="checkbox"/> no
3. Does your school have a microcontroller programming device or training kit?	<input type="checkbox"/> yes <input type="checkbox"/> no
4. Have you used an LCD, motor, sensor or EEPROM in a project?	<input type="checkbox"/> yes <input type="checkbox"/> no
5. Do you have any programming subjects?	<input type="checkbox"/> yes <input type="checkbox"/> no
6. Does your programming subject include hardware interfacing and embedded systems (microcontrollers and ICs)?	<input type="checkbox"/> yes <input type="checkbox"/> no

II. RESPONDENT'S OPINION/ EXPERIENCE ON RELEVANT KNOWLEDGE

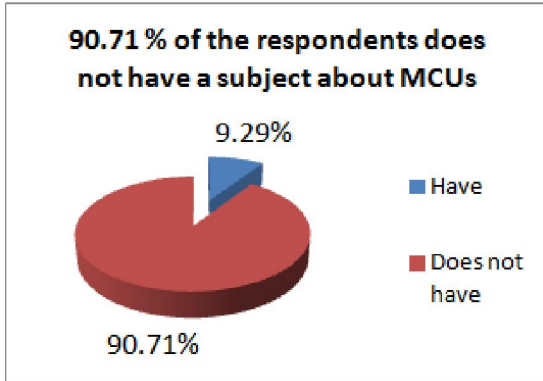
Encircle the appropriate response according to the guide below on your agreement or disagreement.

Legend: 5 - strongly agree
 4 - agree
 3 - uncertain
 2 - disagree
 1 - strongly disagree

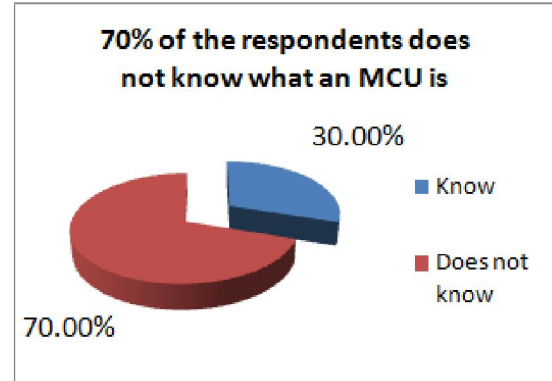
1. Electronics is hard.	5	4	3	2	1
2. I have difficulties in making electronic projects.	5	4	3	2	1
3. Microcontrollers are useful devices but are complicated and difficult to use	5	4	3	2	1
4. It is hard to use a microcontroller in an electronic project	5	4	3	2	1
5. If there will be a device available for me to learn about Microcontrollers, I would prefer it to be simple, easy to use, and cheap, rather than complex and expensive	5	4	3	2	1
6. Advanced programming concepts, such as defines, Headers, subroutines, functions, logic and binary operations, are difficult.	5	4	3	2	1
7. I would prefer Visual Basic than Assembly Language, C and Java.	5	4	3	2	1
8. C is easier than Assembly Language, but Visual Basic is still easier than C	5	4	3	2	1
9. In a programming environment, I would prefer an enhanced windows environment, including buttons, toolboxes and forms,(i.e. Visual Basic) rather than a purely-text environment (i.e. notepad, MS-DOS)	5	4	3	2	1

ii. Survey Results

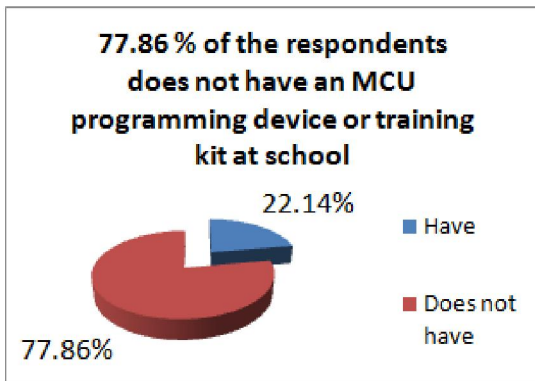
Part I



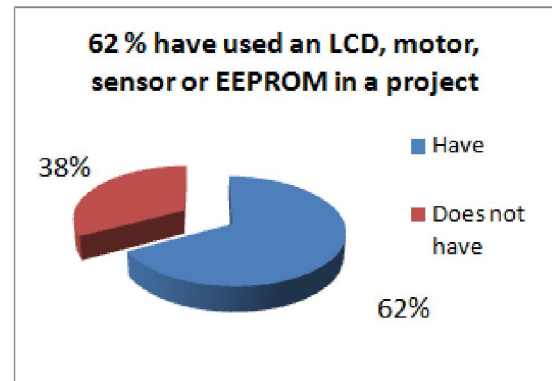
Question # 2



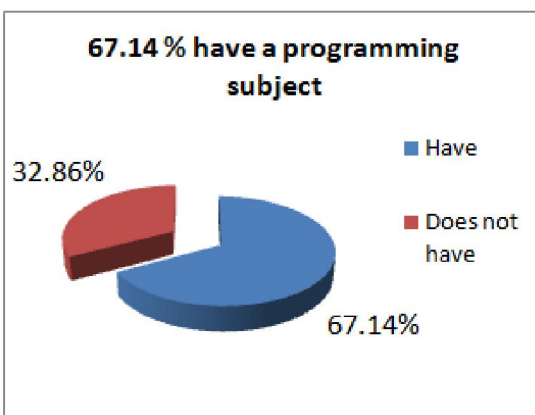
Question # 2



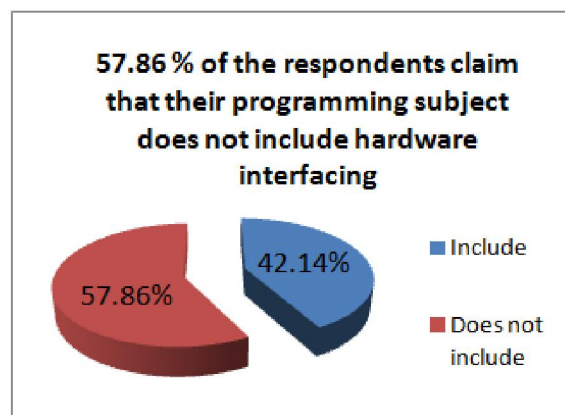
Question # 3



Question # 4



Question # 5



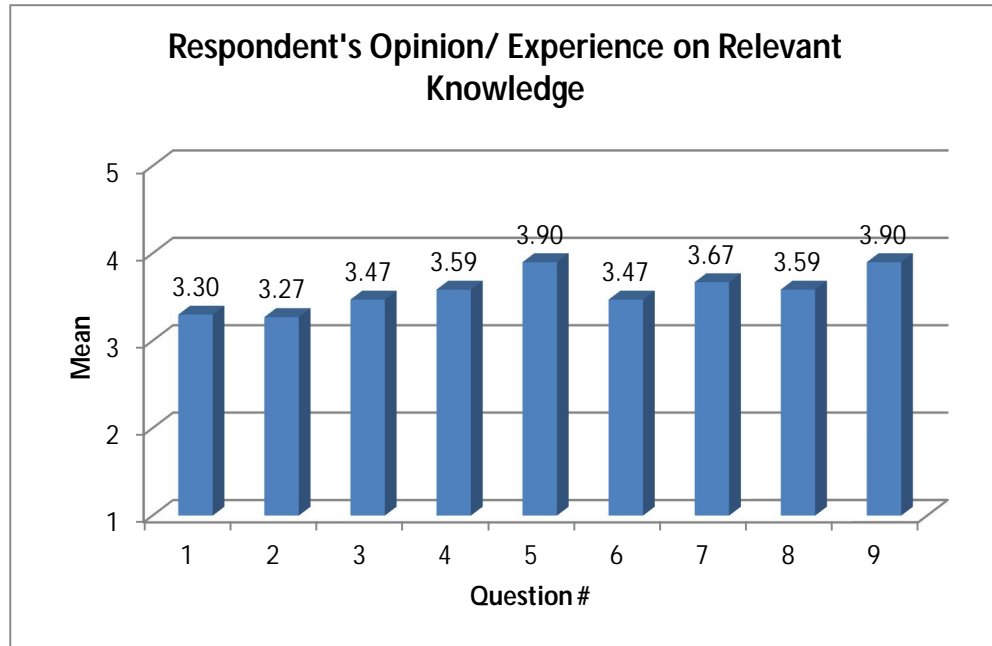
Question # 6

Majority of the respondents do not have a subject about MCUs (90.71 %), most do not know what an MCU is (70%), and most do not have an MCU programming device or training kit at school (77.86%). More respondents have experienced interfacing with either LCD, motor, sensor, or EEPROM in a project (62%). Although more respondents have a programming subject (67.14%), most do not have hardware interfacing and embedded systems in their programming subjects (57.86%).

Based on this data, the developers realized that the students are lacking familiarity and sufficient knowledge regarding microcontrollers. The developers also recognized the students' need for adequate information involving hardware interfacing and embedded systems through programming. The developers then assumed the necessity of a microcontroller programming device and training kit, as well as an enhanced and simplified GUI(Graphical User Interface) software.

Survey Results

Part II



In the second part of the questionnaire, the question was answered through ranking – 5 (strongly agree) to 1 (strongly disagree). Most of the respondents are generally uncertain about the questions presented, such as regarding difficulty of electronics (3.3), difficulty in electronic projects (3.27), usefulness of microcontrollers (3.47), and difficulty in using MCUs (3.59). Respondents also seem to be indecisive regarding difficulty of advanced programming concepts (3.47), preference of Visual Basic (3.67), and comparison between Visual Basic, C and Assembly Language (3.59). Two questions garnered a higher mean such as about the respondents' preference of a simple, easy to use, and cheap MCU device (3.9), and preference of an enhanced windows environment (3.9).

$$\text{Grand Mean} = \frac{3.30 + 3.27 + 3.47 + 3.59 + 3.90 + 3.47 + 3.67 + 3.59 + 3.9}{9}$$

$$\text{Overall Mean Rating} = 3.57$$

The obtained mean ranged from 3.3 to 3.9, and gained an overall mean of 3.57.

Respondents of the survey are composed of 15 students from STI College Rosario 3rd Year and 4th Year BSCoE students, 55 from CvSU-R 3rd Year and 4th Year BSCoE students, and 70 from PUP Maragondon 3rd and 4th year BSECE students, for a total of 140 respondents.

C. Evaluation

STI COLLEGE ROSARIO
Rosario, Cavite

Evaluation Sheet
PC-Based Microcontroller Programmer and Training Kit

NAME (optional): _____ DATE: _____
 COURSE: _____
 SCHOOL: _____

DIRECTION: Encircle your evaluation rating of the project. Use the criteria below.

Numerical Rating	Equivalent
1	Poor
2	Fair
3	Good
4	Very Good
5	Excellent

INDICATORS	NUMERICAL RATING				
A. <u>FUNCTIONALITY</u>					
1. Project achieve its purpose	1	2	3	4	5
2. Overall project is easy to operate	1	2	3	4	5
3. Software is user-friendly	1	2	3	4	5
B. <u>RELIABILITY</u>					
1. System is free of errors	1	2	3	4	5
2. Software does not lag	1	2	3	4	5
3. System provide accurate info	1	2	3	4	5

C. <u>AESTHETICS</u>					
1. Color appeal and attractiveness	1	2	3	4	5
2. Appearance of circuit design	1	2	3	4	5
3. Appearance of software design	1	2	3	4	5
D. <u>DURABILITY</u>					
1. Durability of case and components	1	2	3	4	5
2. Circuits fixed steadily in the case	1	2	3	4	5
3. Quality of materials	1	2	3	4	5
E. <u>ECONOMY</u>					
1. Economy in materials used	1	2	3	4	5
2. Presence of market demand	1	2	3	4	5
3. Competitiveness to price	1	2	3	4	5
F. <u>SAFETY</u>					
1. Absence of toxic/hazardous materials	1	2	3	4	5
2. Absence of sharp edges	1	2	3	4	5
3. Absence of electrical shock hazard	1	2	3	4	5

D. Faculty Evaluation

STI COLLEGE ROSARIO
Rosario, Cavite

Faculty Evaluation Sheet
PC-Based Microcontroller Programmer and Training Kit

NAME: _____ AGE: _____
INSTITUTION: _____
POSITION: _____
DEGREE: _____

DIRECTION: Please evaluate the project by writing down COMMENTS and
SUGGESTIONS regarding each of the given aspects in the spaces
provided.

FUNCTIONALITY and RELIABILITY

Comments: _____

Suggestions: _____

USABILITY and COMPETITIVENESS

Comments: _____

Suggestions: _____

DESIGN, DURABILITY, and SAFETY

Comments: _____

Suggestions: _____

APPLICABILITY and BENEFIT to the INSTITUTION

Comments: _____

Suggestions: _____

Certified true and correct:

Name and Signature of Evaluator

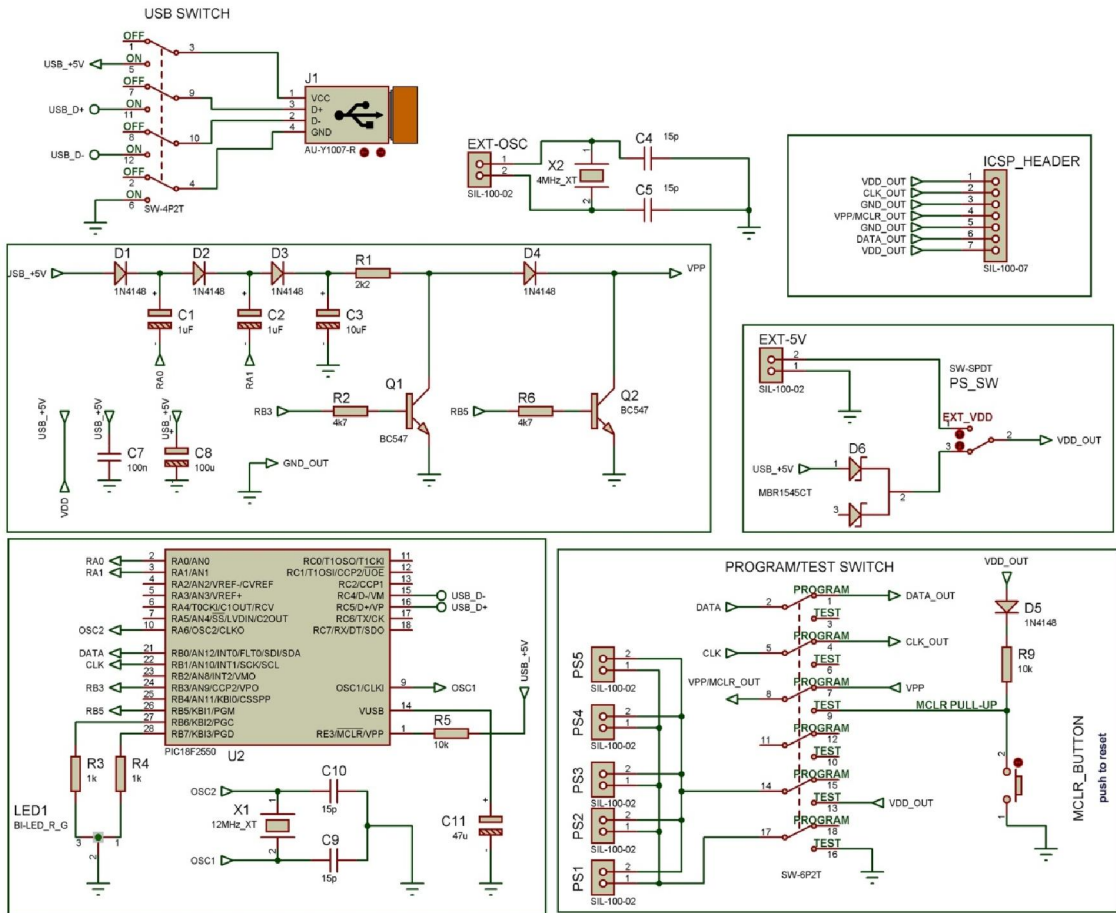
Date: _____

Thank you very much for the help extended. God Bless You.

APPENDIX E

Schematic Diagrams and Components List

A. USB PIC Programmer

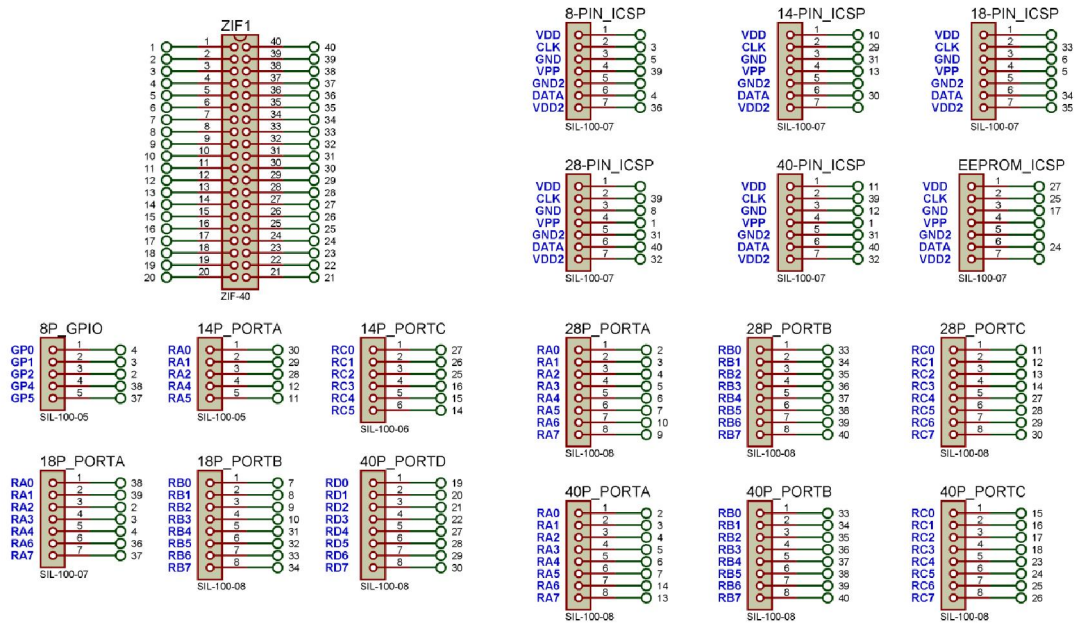


USB PIC Programmer Schematic

QTY	REFERENCES	VALUE	DESCRIPTION	REPLACEMENT
Resistors				
1	R1	2k2	¼ W	N/A
2	R2, R6	4k7	¼ W	N/A
2	R3, R4	1k	¼ W	N/A
2	R5, R9	10k	¼ W	N/A
Capacitors				
2	C1, C2	1uF	Electrolytic	N/A
1	C3	10uF	Electrolytic	N/A
4	C4, C5, C9, C10	15pF	Nonpolar cap	N/A
1	C7	100nF	Nonpolar cap	N/A
1	C8	100uF	Electrolytic	N/A
1	C11	47uF	Electrolytic	N/A
Integrated Circuits				
1	U2	PIC18F2550	28-pin DIP, 32kB code, 2048B data	PIC18F2455
Transistors				
2	Q1, Q2	BC547	NPN General Purpose	BC546, BC548-50, 2N3904, 2N2222
Diodes				
5	D1-D5	1N4148	High-speed	1N914, 1N4448
1	D6	MBR1545CT	Schottky	MBR1535CT, BAT85, BAT54, 1N5820-22
1	LED1	Dual-LED	Red-Green	N/A
Miscellaneous				
3	EXT-5V EXT-OSC MODULE_SUPPLY	2- pin header	Standard 0.1 inch pitch	N/A
1	ICSP_HEADER	7- pin header	Standard 0.1 inch pitch	N/A
1	J1	USB Receptacle	Type B Female Right Angle	N/A
1	MCLR_BUTTON	NO Momentary SPST Push-Button	4-Pin, 5mm pitch	N/A
1	PROGRAM/TEST_SW	6P2T Push Switch	18-Pin , 4mm pitch	N/A
1	USB SWITCH	4P2T Push Switch	12 Pin, 4mm pitch	N/A
1	PS_SW	SPDT Slide Switch	3-Pin, 3m pitch	N/A
1	X1	12 MHz Crystal	2-Pin, 0.2 in pitch	N/A
	X2	4 MHz Crystal		N/A

USB PIC Programmer Component List

B. ZIF + Headers Block

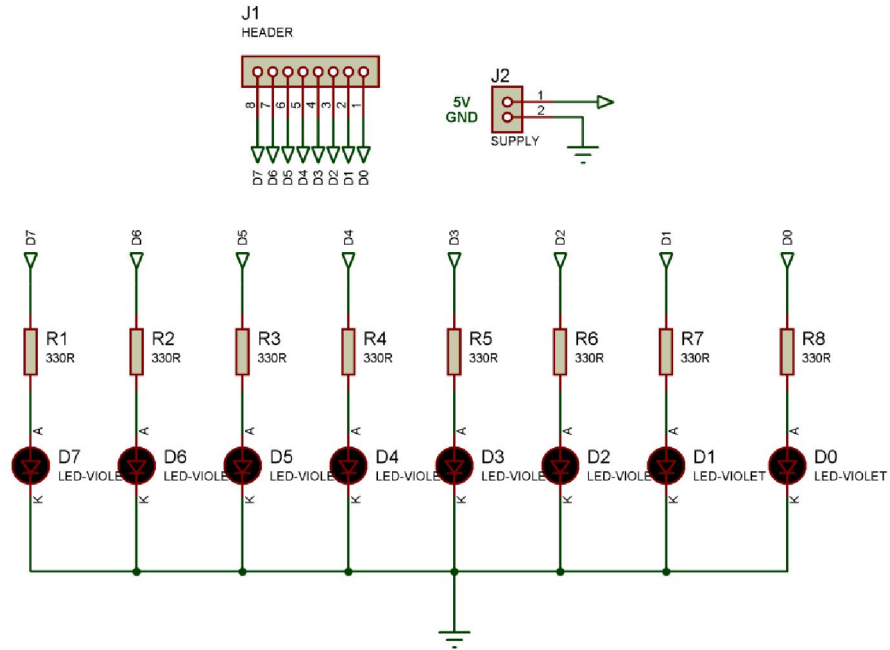


ZIF + Headers Block Schematic

QTY	REFERENCES	VALUE	DESCRIPTION	REPLACEMENT
1	ZIF1	40- pin ZIF socket	Standard 0.1 inch pitch	N/A
2	8P_GPIO, 14P_PORTA	5- pin header	Standard 0.1 inch pitch	N/A
1	14P_PORTC	6- pin header	Standard 0.1 inch pitch	N/A
7	8-PIN_ICSP, 14-PIN_ICSP, 18-PIN_ICSP, 18P_PORTA, 28-PIN_ICSP, 40-PIN_ICSP, EEPROM_ICSP	7- pin header	Standard 0.1 inch pitch	N/A
8	18P_PORTB, 28P_PORTA, 28P_PORTB, 28P_PORTC, 40P_PORTA, 40P_PORTB, 40P_PORTC, 40P_PORTD	8- pin header	Standard 0.1 inch pitch	N/A

ZIF + Headers Block Component List

C. LED Module

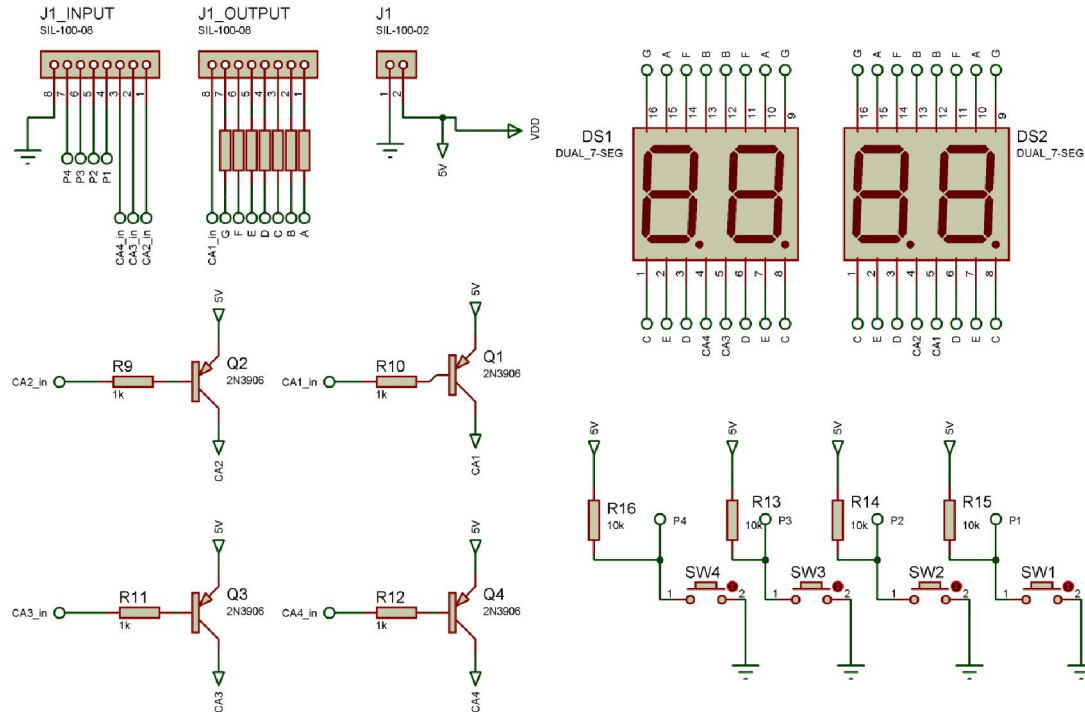


LED Module Schematic

QTY	REFERENCES	VALUE	DESCRIPTION	REPLACEMENT
Resistors				
1	R1-R8	330	¼ W	N/A
Diodes				
8	D0-D7	LED	Super Bright Violet – 5 mm	N/A
Miscellaneous				
1	J1	8- pin header	Standard 0.1 inch pitch	N/A
1	J2	2- pin header	Standard 0.1 inch pitch	N/A

LED Module Component List

D. 7-Segment Module

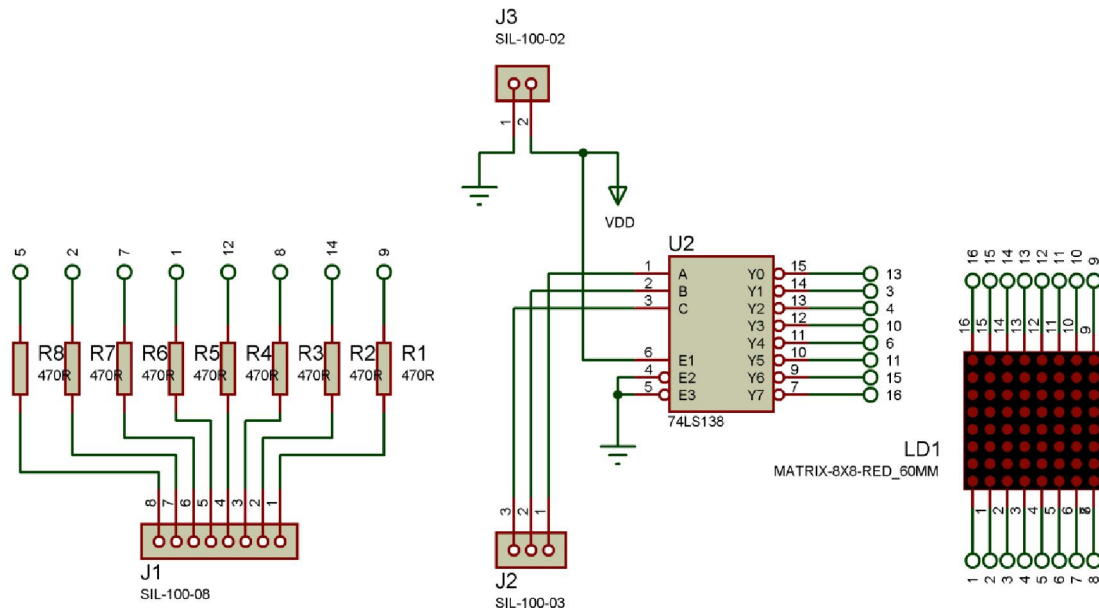


7-Segment Module Schematic

QTY	REFERENCES	VALUE	DESCRIPTION	REPLACEMENT
Resistors				
7	R2-R8	330	¼ W	N/A
4	R9-R12	1k	¼ W	N/A
3	R13-R16	10k	¼ W	N/A
Transistors				
4	Q1-Q4	2N3906	PNP General Purpose	2N3905, BC556-7
Miscellaneous				
2	DS1, DS2	LTD482P-03 Dual 7 Segment	16-Pin Common Anode Red 10 mm	LTD482PC, LA4022
1	J1	2- pin header	Standard 0.1 inch pitch	N/A
2	J1_INPUT, J1_OUTPUT	8- pin header	Standard 0.1 inch pitch	N/A
4	SW1-SW4	NO Momentary SPST Push-Button	4-Pin, 5mm pitch	N/A

7-Segment Module Component List

E. Dot Matrix Module

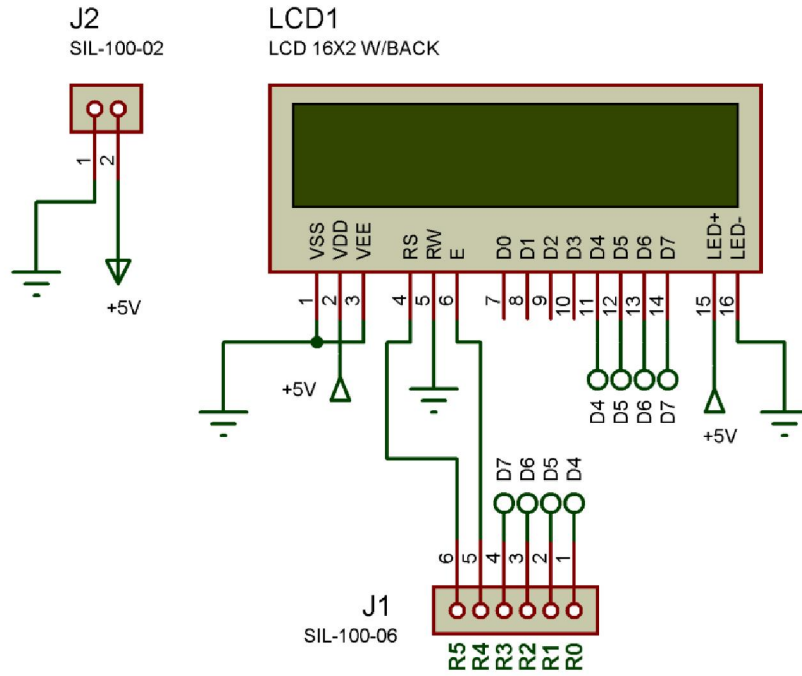


Dot Matrix Module Schematic

QTY	REFERENCES	VALUE	DESCRIPTION	REPLACEMENT
Resistors				
8	R1-R8	470	¼ W	N/A
Integrated Circuits				
1	U2	74LS138	Decoder/ Demultiplexer, 16-pin DIP	N/A
Miscellaneous				
1	LD1	8x8 Dot Matrix	d5mm high brightness red	N/A
1	J1	8- pin header	Standard 0.1 inch pitch	N/A
1	J2	3- pin header	Standard 0.1 inch pitch	N/A
1	J3	2- pin header	Standard 0.1 inch pitch	N/A

Dot Matrix Module Component List

F. LCD Module

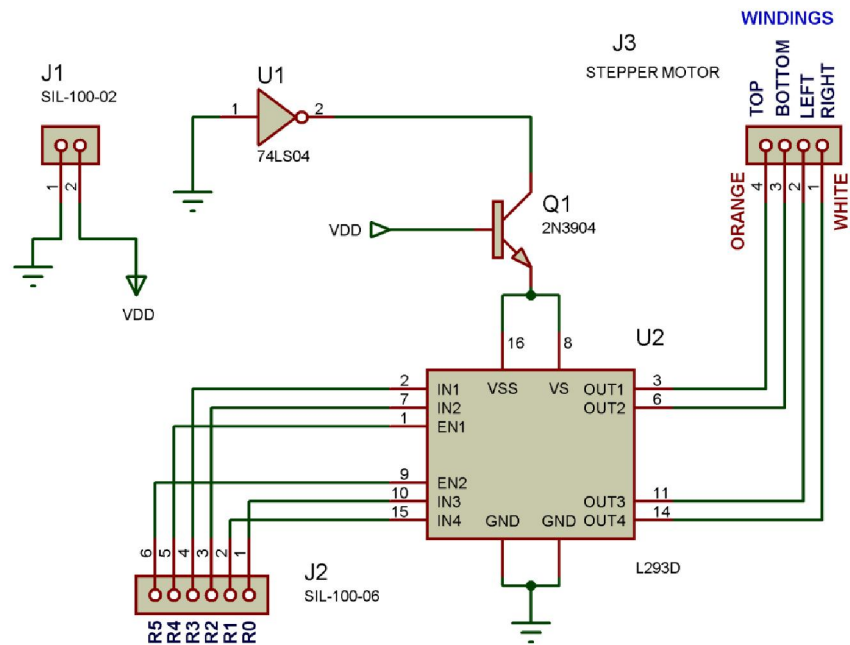


LCD Module Schematic

QTY	REFERENCES	VALUE	DESCRIPTION	REPLACEMENT
1	LCD1	16x2 LCD	HD44780 Standard 16x2 Characters w/ Green Backlight	N/A
1	J1	6- pin header	Standard 0.1 inch pitch	N/A
1	J2	2- pin header	Standard 0.1 inch pitch	N/A

LCD Module Component List

G. Motor Module



Motor Module Schematic

QTY	REFERENCES	VALUE	DESCRIPTION	REPLACEMENT
1	U1	74LS04	Hex Inverter 14-Pin DIP	N/A
1	U2	L293D	H-Bridge Motor Driver IC 16-Pin DIP	SN754410
1	Q1	2N3904	NPN General Purpose	BC546-50, 2N3903, 2N2222
1	J1	2- pin header	Standard 0.1 inch pitch	N/A
1	J2	6- pin header	Standard 0.1 inch pitch	N/A
1	J3	4- pin header	Standard 0.1 inch pitch	N/A

Motor Module Component List

APPENDIX F

Bill of Materials

Materials	Quantity	Unit Price	Total Price
USB PIC Programmer			
Resistors	7	P 0.25	P 1.75
Electrolytic Capacitors	5	1	5.00
Nonpolar Capacitors	5	0.5	2.50
IC (18F2550)	1	187	187.00
Transistors	2	3	6.00
Diodes	10	2	20.00
Schottky	1	55	55.00
LED	1	3	3.00
2- Pin Header	3	2	6.00
28-pin IC socket	1	4.5	4.50
7- Pin Header	1	7	7.00
USB Receptacle	1	16.5	16.50
USB Cable	1	100	100.00
Pushbuton	1	14.5	14.50
6P2T Push Switch	1	20	20.00
4P2T Push Switch	1	20	20.00
Slide Switch	1	5	5.00
4 MHz Crystal	1	20	20.00
Presensitized PCB	1	60	60.00
Screws	4	2	8.00
TOTAL			P 561.75
ZIF + Headers Block			
40-pin ZIF socket	1	120	120.00
SIL-40 pin-Headers	2	16	32.00
Presensitized PCB	1	120	120.00
Screws	4	2	8.00
TOTAL			P 280.00
LED Module			
Resistors	8	0.25	2.00
Super Bright LEDs	7	8	56.00
8-Pin Header	1	8	8.00
2-Pin Header	1	2	2.00
Presensitized PCB	1	30	30.00
Screws	4	2	8.00
TOTAL			P 106.00

Materials	Quantity	Unit Price	Total Price
LCD Module			
LCD 16x2 w/Back	1	P 350	P 350.00
6-Pin Header	1	6	6.00
2-Pin Header	1	2	2.00
Presensitized PCB	1	60	60.00
Screws	4	2	8.00
TOTAL			P 426.00
Temperature Sensor			
LM-35	1	P 50	P 50.00
PIC MCUs			
PIC12F683	1	51.12	51.12
PIC16F684	1	57.18	57.18
PIC16F676	1	56.32	56.32
PIC16F88	1	112.63	112.63
PIC16F648A	1	85.34	85.34
PIC16F737	1	150.32	150.32
PIC16F747	1	172.85	172.85
Shipping Fee			740.03
TOTAL			P 1,425.79
Header Connectors			
2-pin	6	8.00	48.00
3-pin	1	12.00	12.00
4-pin	1	16.00	16.00
6-pin	2	24.00	48.00
7-pin	1	29.00	29.00
8-pin	4	34.00	136.00
TOTAL			P 289.00

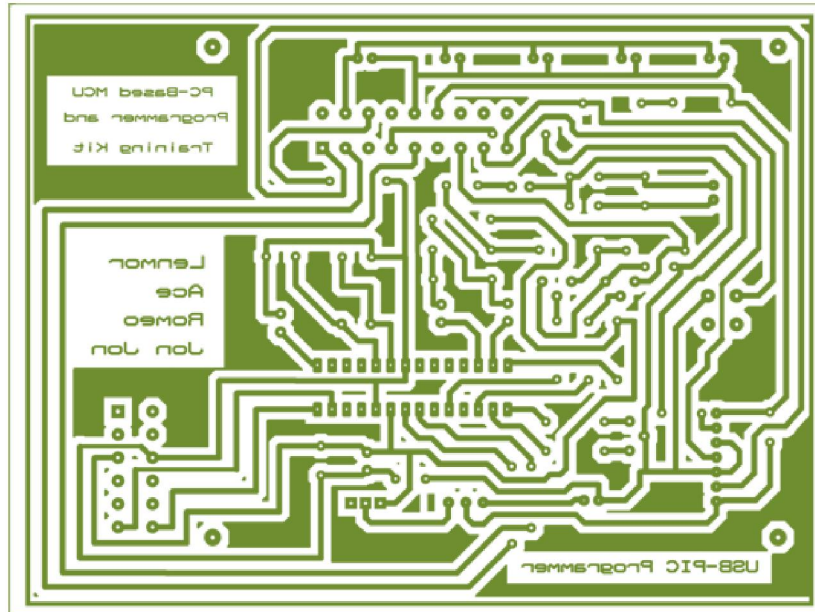
Miscellaneous			
Ferric Chloride	3	25	75.00
Connecting Wires	2	5	10.00
Soldering Lead	1	60	60.00
Wooden Case w/ Paint	1	1000	1000.00
Damaged/ Replaced Components			100.00
Document Printing			1,000.00
Travel Expenses			500.00
TOTAL			2,745.00

Total Device Expenses	Price
USB PIC Programmer	P 561.75
ZIF+Headers Block	280.00
LED Module	106.00
7-Sgment Module	229.50
Dot Matrix Module	241.50
Motor Module	336.00
LCD Module	426.00
Temperatuer Sensor	50.00
PIC MCUs	1,425.79
Header Connectors	289.00
TOTAL	P 3,945.54

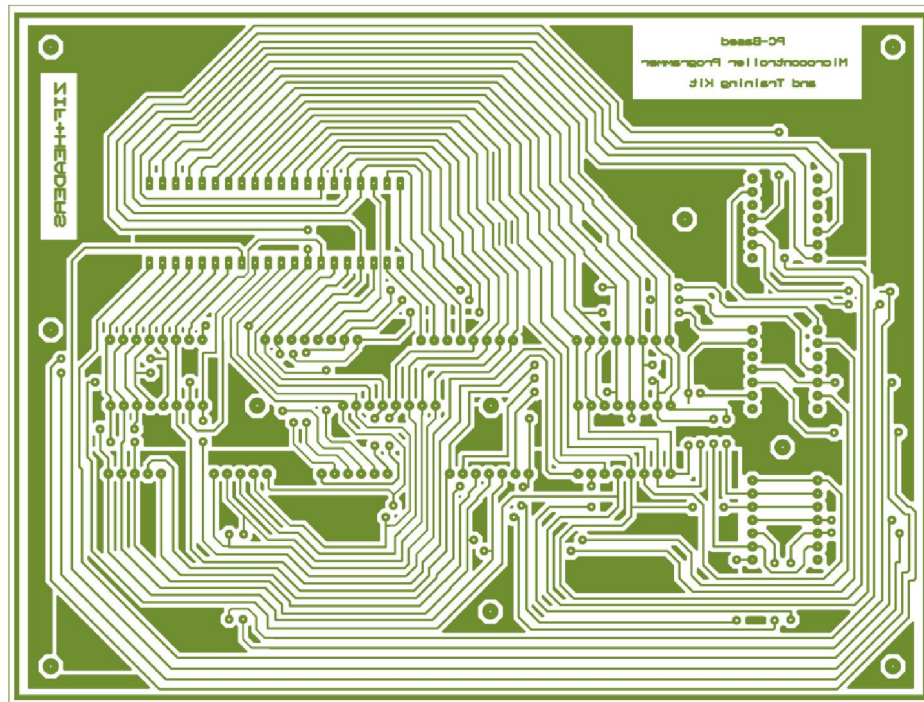
Total Device Expenses P 3,945.54
Total Miscellaneous Expenses 2,745.00
TOTAL EXPENSES P 6,690.54

APPENDIX G

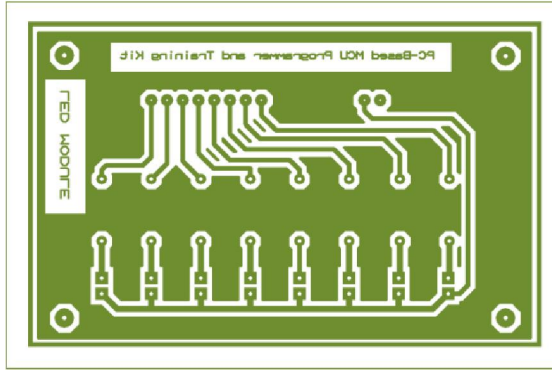
Board Layouts



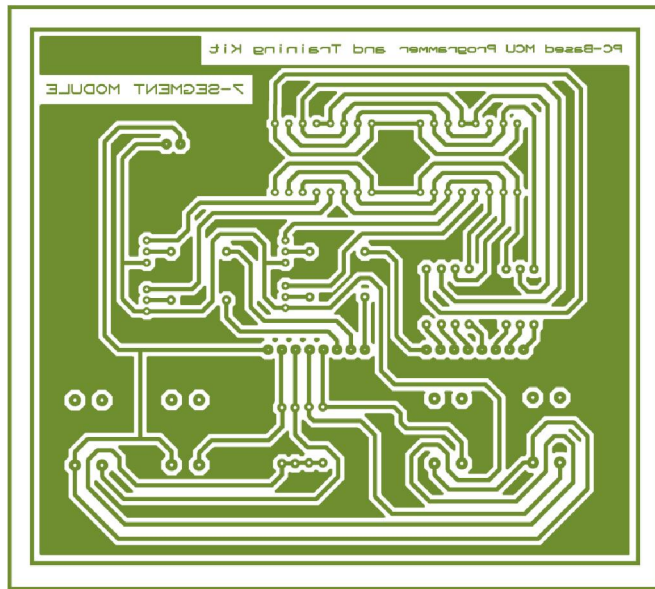
USB PIC Programmer Board Layout



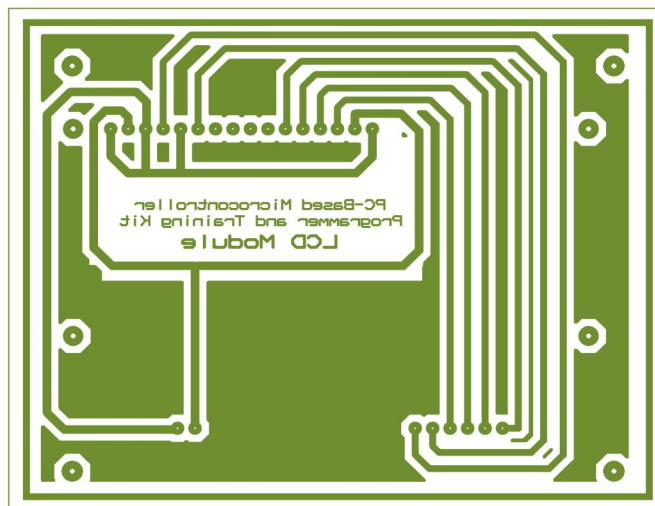
ZIF + Headers Board Layout



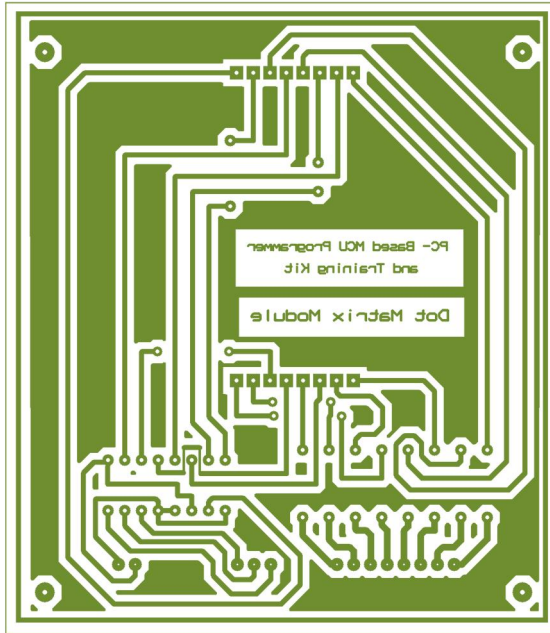
LED Module Board Layout



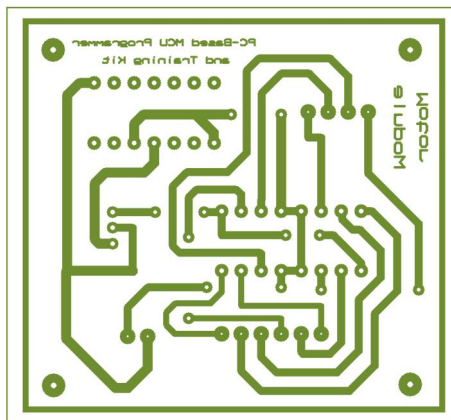
7 segment Module Board Layout



LCD Module Board Layout



Dot Matrix Module Board Layout



Motor Module Board Layout

APPENDIX H

Program Listing

A. Visual Basic 6

- Main Form loading

```
...

Me.Height = 7680
Me.Width = 9200

frmPGuide.Show           'PGuide is side to side with the main form

'MDIPICSoft.mnuBHC.Visible = False

tmrCompile.Enabled = False

cmdBurn.Enabled = False

cboLP.AddItem "BlinkLED"
cboLP.AddItem "BinaryOutput"
cboLP.AddItem "ShiftLeft"
cboLP.AddItem "ShiftRight"
cboLP.AddItem "DecimalIncrement"
cboLP.AddItem "DecimalDecrement"

cboLP.ListIndex = 0      'set Blink LED as default

cboDS.AddItem "DisplayNum"
cboDS.AddItem "CountUp"
cboDS.AddItem "CountDown"
cboDS.AddItem "Counter"
cboDS.AddItem "Scoreboard"

cboDS.ListIndex = 0     'set DisplayNum as default

cboDM.AddItem "SimpleDisplay"
cboDM.AddItem "VerticalScroll"
cboDM.AddItem "HorizontalScroll"

Call myCharset           'setup DotMatrix Character Set

cboLCD.AddItem "StaticDisplay"
cboLCD.AddItem "Count"
cboLCD.AddItem "TextScroll"

cboLCD.ListIndex = 0

cboMotor.AddItem "Rotate_by_exact_degrees"
cboMotor.AddItem "GoTo_exact_degrees"
cboMotor.AddItem "Complete_cycle"

cboMotor.ListIndex = 0

cboPICType.AddItem "8-PIN"
cboPICType.AddItem "14-PIN"
cboPICType.AddItem "18-PIN"
cboPICType.AddItem "28-PIN"
cboPICType.AddItem "40-PIN"

...
```

- Compilation of C code

```

Public Sub compileCode(frmCalling As Form)

Dim fSys3 As New FileSystemObject

compileBat = "compilePICC.bat"

Open compileBat For Output As #2

    errFile = App.Path & "\bin\" & codeFileDir & "\" & errFileName

    Print #2, "cd /d " & Chr(34) & App.Path & "\bin" & Chr(34)
    Print #2, "md " & codeFileDir
    Print #2, "cd " & codeFileDir
    Print #2, "md " & codeFileDir

Call cromCheck

If fSys3.FolderExists(pFdir & _
    "\HI-TECH Software\PICC\9.83\") = True Then

    '==if Hi-Tech PICC is installed in default Program Files directory ==

    Print #2, "cd /d %programfiles%"
    Print #2, "cd " & Chr(34) & "HI-TECH Software\PICC\9.83\bin" & Chr(34)
    '=====

Else

    '====if Hitech PICC folder used is the one inside the App folder ====

    Print #2, "cd /d " & Chr(34) & App.Path & "\HI-TECH
Software\PICC\9.81\bin" & Chr(34)
    '=====

End If

Print #2, "PICC.exe --pass1 " & "--chip="; PICName & _
" -q -P --runtime=default --opt=default" & _
" -D__DEBUG=1 -g" & _
" -O" & Chr(34) & App.Path & "\bin\" & _
codeFileDir & "\" & codeFileDir & Chr(34) & _
" " & Chr(34) & App.Path & "\" & codeFileName & Chr(34) & _
" -E" & Chr(34) & errFile & Chr(34) & " "

Print #2, "PICC.exe " & "--chip="; PICName & _
" -owa.cof -mwa.map --summary=default " & _
" --output=default " & _
" --runtime=default --opt=default " & _
" -D__DEBUG=1 -g " & _
" -O" & Chr(34) & App.Path & _
"\bin\" & codeFileDir & "\" & _
codeFileDir & Chr(34) & " " & Chr(34) & App.Path & _
"\bin\" & p_codeFileDir & "\" & p_codeFileName & Chr(34) & " --ASMLIST" &
-
" -E+" & Chr(34) & errFile & Chr(34) & " "

Print #2, "cd /d " & Chr(34) & App.Path & "\bin"
Print #2, "cd " & codeFileDir
Print #2, "rd " & codeFileDir
Print #2, "cd.."

    Print #2, "move " & plainFileName & " " & codeFileDir & "\"

Print #2, "exit"

```

```

        cFile = App.Path & "\bin\" & codeFileDir & "\" & plainFileName
    Close #2

    sourceHandler = Shell("cmd /k " & compileBat, vbHide)

    frmCalling.tmrCompile.Enabled = True

End Sub

```

- Burning of .hex code

```

Public Sub burnCode()

    frmBurning.tmrBurning.Enabled = False

    KillProcess ("WinPic800.exe")

    frmBurning.Show

    Call Make_Window_TopMost(frmBurning, True)

    hWinPic = Shell(App.Path & "\WinPic\WinPic800.exe -p -s -d" & _
        "PIC" & PICName & " " & Chr(34) & _
        App.Path & "\bin\" & codeFileDir & "\" & codeFileHex & Chr(34),
        vbNormalFocus)

    AppActivate hWinPic

    frmBurning.tmrBurning.Enabled = True

End Sub

```

- Code generation

```

Public Sub genLED(strPICName As String, intFNum As Integer, _
    strMode As String, strDev As String, blnSharing As Boolean, _
    charPORT As String, intDevOption As Integer)

    ...

    Select Case intDevOption

    Case 0                'blink LEDs

        LEDno = frmLED.txtLEDNo.Text

        Print #(intFNum), "    R" & charPORT & LEDno & " = 1" & Chr(59) & "
        // LED on"

        Print #(intFNum), "    __delay_ms(" & frmLED.tmrBlink.Interval & ");
        //pause"

        Print #(intFNum), "    R" & charPORT & LEDno & " = 0" & Chr(59) & "
        // LED off"

        Print #(intFNum), "    __delay_ms(" & frmLED.tmrBlink.Interval & ");
        //pause"
    End Select

```

B. Hi-Tech PICC

- LED module code

```
//#####
// PIC name: 16F88
// Module: LEDs
// Experiment: BlinkLED
//#####

// This code runs the LEDs module
// in BlinkLED mode

//##### includes, defines #####

#include <pic.h>

#ifndef _XTAL_FREQ           // This code is needed for delay routines
#define _XTAL_FREQ 4000000 // Unless defined assume 4MHz frequency
#endif

//##### pin guides, notes #####
/*
PORTB --> LEDs
*/

//##### PIC Configuration #####

__CONFIG(FOSC_INTOSCIO & WDTE_OFF & PWRTE_ON & MCLRE_ON & \
  BOREN_OFF & LVP_OFF & CP_OFF & CPD_OFF & DEBUG_OFF & \
  WRT_OFF );
__CONFIG(FCMEN_OFF & IESO_OFF );

//##### Global Variables and Arrays #####

//##### main #####

main()
{
//      ##### register settings #####

ANSEL = 0;           // Turn off ADC
OSCCON = 0b01100000; // Set intRC to 4 MHz
TRISB = 0;           // Make PORTB Output

//      ##### initializations #####

PORTB = 0;           // Turn off all PORTB pins at start

//      ##### program loop #####

while(1 == 1)        // Loop Forever
{
    RB2 = 1;          // LED on
    __delay_ms(500); //pause
    RB2 = 0;          // LED off
    __delay_ms(500); //pause
} // elihw
} // End

//##### end #####
```

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