

Development of a Computer Aided Learning Tool for PIC Microcontroller

Engr. Mainur Rahman Tarafder (FBCS, MIEB)

B.Sc. Engg in CSE (RUET), M. Engg. in ICT (IICT, BUET)

ORACLE 9I DBA CC, ORACLE 6I DEV. CC. MCSE CC, MCAD CC. CCNA CC, CCNP CC. BGP CC. RHCE CC. A+ CC.

Jr. Prin. Executive (Software Engineer), IT, The Ibn Sina Pharmaceutical Ind. Ltd. Dhaka, Bangladesh

ipilbd@gmail.com

mainur.it@ibnsinapharmacom

Prof. Dr. Md. Liakot Ali

B.Sc. Engg. (EEE, BUET), M.Sc in EESE (UKM, Malaysia), Ph.D. in Micro-Electronics (UPM, Malaysia)

IICT, BUET, Dhaka, Bangladesh

liakot@iict.buet.ac.bd

Abstract— Microcontroller is now a days very important tool widely used in different fields of science and technology. Due to its enormous importance it is being accommodated in the curriculum of different branches of engineering and even it is being introduced to the students of the college and poly-technique college. In this circumstances Computer Aided Learning Tool (CALT) has been essential for teaching and learning of the microcontroller. Learning of PIC microcontroller is very easy due to its less number of instruction set. There are many types of microcontroller in the market. Among all of the microcontrollers PIC is most familiar. This projects presents the development of a CALT for teaching and learning PIC microcontroller. It has user friendly GUI for familiarizing the beginners with the PIC instruction sets with the help of graphical view. It provides them easy understanding and realization about the different instruction sets. Once the beginners are familiar with the PIC instruction then the CALT provides an interface with proteus simulator where they can design the circuits of microcontroller based projects and simulate the design. The simulation results further increases their interest to go to the physical circuits. The CALT helps to interface with a customized educational kits where they can develop the projects and see the action and results in reality. So the CALT brings the dream to the real life which sparks the interest of the students and beginners in microcontroller education which in turn motivates them to be the designer and implementer of real life complex projects.

Keywords— CALT, PIC18F4550, MCU, GUI, RAM, PROTEUS, PORT

I. INTRODUCTION

Low power portable smart system or intelligent system is a demand of this era of Information and Communication Technology (ICT). Intelligent system is basically named as embedded system where information processor acquires, process and control the system. It has been forecasted that future electronic system will be embedded system. Every person on the earth will use at least three embedded systems. It has been shown in a report that 95% of the processor is now being used to develop embedded system. For developing embedded system, microcontroller is widely used as information processor due to its availability and low cost. A microcontroller (sometimes abbreviated μ C, uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems. Among different types of microcontroller the PIC18 is widely used microcontroller. There are many reasons for this, including the existence of massive support in both software and hardware by Microchip Technology. Due to enormous importance of microcontroller education the microcontroller courses are being incorporated at various levels of education such as Schools, Poly techniques, Colleges and University .related Works.

II. LITERATURE REVIEW

A. Introduction

The Project has three part's, first one is development of a graphical user interface for PIC microcontroller, second is some proteus simulation, third is some hardware experiments. Since a GUI is one kind of software hence software development lifecycle have been implemented here. In order to develop a software requirement analysis is mostly necessary. After requirement analysis design phase have to start. After design program code has to be completed. After coding test phase have to be performed. Finally the implementation In order to develop software, a software development model is mostly necessary. In the hardware experiment a programmer is connected with the pc and microcontroller mother board. The mother board is connected with daughter board by additional cable. Microcontroller mother board has microcontroller chip(PIC18F4550) and rs232 port..

B. SDLC for GUI

A software development process, also known as a software development lifecycle, is a structure imposed on the development of a software product. Similar terms include software life cycle and software process. There are several models for such processes, each describing approaches to a variety of tasks or activities that take place during the process. Some people consider a lifecycle model a more general term and a software development process a more specific term. For example, there are many specific software development processes that 'fit' the spiral lifecycle model.

C. Microcontroller

A microcontroller is an integrated chip that is often part of an embedded system. It includes a CPU, RAM, ROM, I/O ports, and timers like a standard computer, but because they are designed to execute only a single specific task to control a single system, they are much smaller and simplified so that they can include all the functions required on a single chip. Unlike a microprocessor, which is a general-purpose chip used to create a multi-function computer or device and requires multiple chips to handle various tasks, this device is meant to be more self-contained and independent, and functions as a tiny, dedicated computer. The great advantage of microcontrollers, as opposed to using larger microprocessors, is that the parts-count and design costs of the item being controlled can be kept to a minimum. They are typically designed using complementary metal oxide semiconductor (CMOS) technology, an efficient fabrication technique that uses less power and is more immune to power spikes than other techniques. There are also multiple architectures used, but the predominant architecture is Complex Instruction Set Computer (CISC), which allows the chip to contain multiple control instructions that can be executed with a single macro instruction. Some use a Reduced Instruction Set Computer (RISC) architecture, which implements fewer instructions, but delivers greater simplicity and lower power consumption.

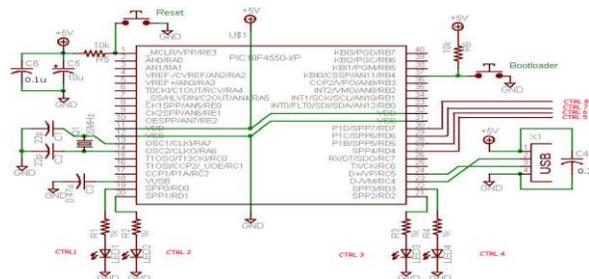


Fig. 1. Microcontroller

D. Graphical User Interface

GUI is a software that works at the point of contact (interface) between a computer and its user, and which employs graphic elements (dialog boxes, icons, menus, scroll bars) instead of text characters to let the user give commands to the computer or to manipulate what is on the screen. GUI elements are usually accessed through a pointing device such as a mouse, pen, or stylus. All programs running under a GUI use a consistent set of graphical elements so that once the user learns a particular interface, he or she can use all programs without learning additional or new commands. Pioneered by Xerox and developed by Apple computers, GUI is now employed by all modern operating systems and application programs.

instructions. The most important part of the GUI is the connectivity between the proteus simulator software and visual basic 6.0. Datasheets of different hardware equipments like decoder, keypad, 7-segment display and dot matrix display have been included to the GUI. Website of different microcontroller producers have also been included to the software so that a novice user can learn other available options in the market. The project has three parts i) Development of GUI ii) Proteus Connectivity with GUI iii) Hardware Experiments.

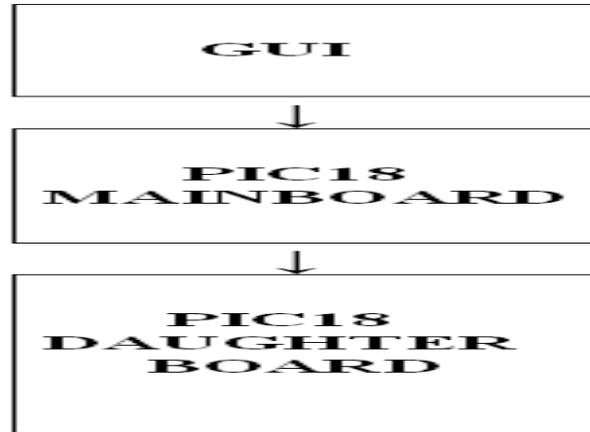


Fig. 5. CALT Block Diagram

Development of GUI follows the Software Development Life Cycle. Software Development Life Cycle has few steps like recognition of need, requirement analysis, design, coding, testing and implementation. In the requirement analysis first of all PIC18F4550 microcontroller architecture, instruction set, interfacing peripheral hardware devices and timer counter, interrupt have to be studied. The GUI has focused on all the features of the PIC18F4550 microcontroller. The GUI Includes three parts 1) Set of Instructions Visualization 2) Digital Representation of the Set of Instructions 3) Connectivity with Proteus simulator software.

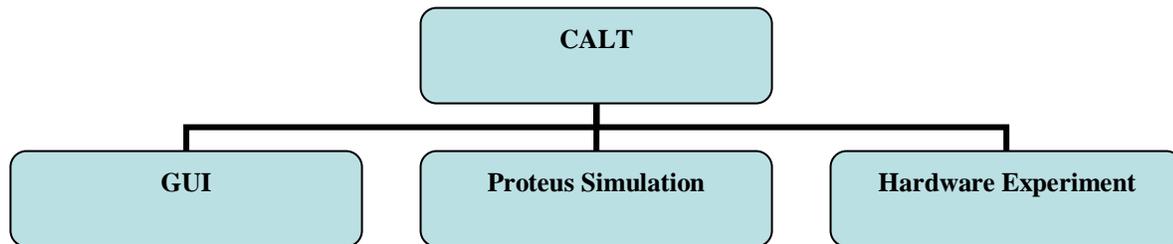


Fig. 6. Flow Chart of CALT

GUI focused on the digital representation of set of instructions. The proposed GUI have been simulated the process or flow of executing the instructions. The ANDLW, XORLW, RRNCF, RLNCF, RRCF, RLCF, BTG, ADDLW, DECF, COMF, INCF, MOVLW, BSF, BCF, DECFSSZ, MOVFF, MOVF, NEGf, SUBLW etc. instructions have been simulated both event driven and digital representation. Instructions are represented graphically in digital format. The GUI is developed for PIC18F4550 microcontroller features. But it can be used for other PIC18 microcontrollers also. The motto is to represent the different features of the PIC18F4550 microcontroller to a novice user. Some sample codes are also included so that a user can visualize the process and also practice it by him self.

In order to implement the proposed system MPLAB IDE v8.56 have been used compiling and creating the .HEX file and connectivity to the programmer. Proteus simulation software have been used for the simulation. The PIC18_EduKit have been used for the hardware implementation. The complete CALT is consists of mainly three parts. First of all GUI development which consists of various features of PIC18F4550 microcontroller. The PIC is chosen because of its less number of set of

instructions and ease to use. The GUI hosts all the feature of PIC18F4550 microcontroller set of instructions. It also hosts the event driven simulation of the set of instructions and digital representation of the set of instructions. It also consists of connectivity with proteus simulation software which simulates various simulation such as dc motor speed control, keypad interfacing, LED shifting and rotating etc. Another feature of CALT is hardware implementation of some simulated experiments. Keypad interfacing with microcontroller is a great job of the CALT. In order to implement keypad scanning algorithm was used.

```

unsigned char keypad_read(void)
{
    //start the scanning process
    KP_R1 = 0; // scan keypress on 1st row: 1, 2, 3, A
    KP_R2 = 1;
    KP_R3 = 1;
    KP_R4 = 1;
    _delay_us(30);
    if (KP_C1 == 0) return '1'; // Key '1' is pressed
    if (KP_C2 == 0) return '2'; // Key '2' is pressed
    if (KP_C3 == 0) return '3'; // Key '3' is pressed
    if (KP_C4 == 0) return 'A'; // Key 'A' is pressed,

    KP_R1 = 1; // scan keypress on 2nd row: 4, 5, 6, B
    KP_R2 = 0;
    KP_R3 = 1;
    KP_R4 = 1;
    _delay_us(30);
    if (KP_C1 == 0) return '4'; // Key '4' is pressed
    if (KP_C2 == 0) return '5'; // Key '5' is pressed
    if (KP_C3 == 0) return '6'; // Key '6' is pressed
    if (KP_C4 == 0) return 'B'; // Key 'B' is pressed,

    KP_R1 = 1; // scan keypress on 3rd row: 7, 8, 9, C
    KP_R2 = 1;
    KP_R3 = 0;
    KP_R4 = 1;
    _delay_us(30);
    if (KP_C1 == 0) return '7'; // Key '7' is pressed
    if (KP_C2 == 0) return '8'; // Key '8' is pressed
    if (KP_C3 == 0) return '9'; // Key '9' is pressed
    if (KP_C4 == 0) return 'C'; // Key 'C' is pressed,

    KP_R1 = 1; // scan keypress on 4th row: *, 0, #, D
    KP_R2 = 1;
    KP_R3 = 1;
    KP_R4 = 0;
    _delay_us(30);
    if (KP_C1 == 0) return '*'; // Key '*' is pressed,
    if (KP_C2 == 0) return '0'; // Key '0' is pressed,
    if (KP_C3 == 0) return '#'; // Key '#' is pressed,
    if (KP_C4 == 0) return 'D'; // Key 'D' is pressed,

    return 0xFF; // if no key press, the register is 0xFF
}
    
```

Fig. 7. Psodocode of the Keypad Scanning Algorithm

In the above diagram keypad scanning algorithm have been shown. 4x4 Keypad has been connected with a microcontroller and the key is scanned. When a key is pressed the correspond digit is display on the 8x8 dot matrix display.

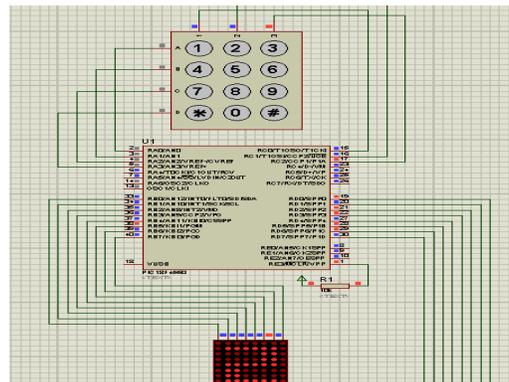


Fig. 8. Proteus Simulation of 4x3 Keypad interfacing

In the above proteus simulation 4x3 keypad is connected with PIC18F4550 microcontroller and a 8x8 dot matrix display is connected with the PIC18F4550 microcontroller. At a time one row is active and all the column is scanned. When a key is pressed the corresponding row and column is short and the PORT of row and column is active and according digit display algorithm the digit is display on the 8x8 dot matrix display.

IV. IMPLEMENTATION AND RESULTS

A. GUI

Graphical User Interface has been developed by applying the software development life cycle. The GUI is developed for the PIC microcontroller preferred for PIC18F4550. Since development of GUI follows the SDLC hence microcontroller architecture, set of instructions, timers, counters and interrupts of PIC18F4550 have been reviewed for development the GUI.

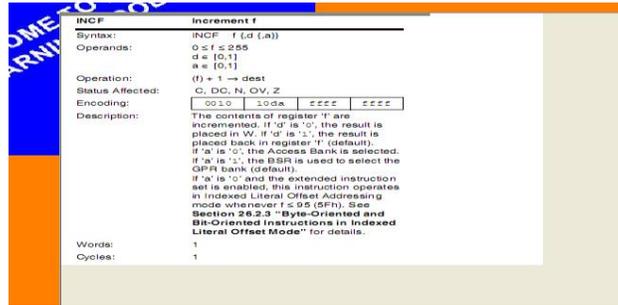


Fig. 9. GUI instruction set

The Fig. 9. INCF instruction has been explained where the instruction increments the register value. The register R has the value 04H after execution the instruction INCF R, the register value becomes 05H.

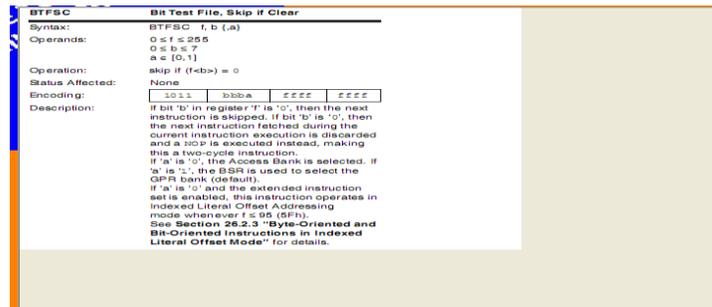


Fig. 10. BTFSC GUI instruction set

In the Fig. 10. the BTFSC instruction has been explained. BTFSC is conditional statement. The BTFSC tests a flag and escapes to the next instruction if the result is zero. Another part of the GUI is digital representation of instruction sets.

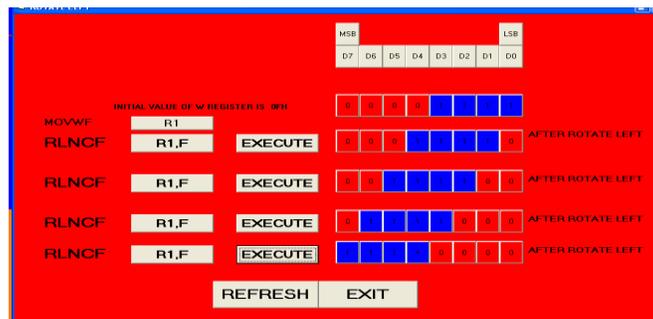


Fig. 11. GUI instruction set

In the Fig. 11. the Rotate Left No Carry Flag has been displayed with example. Here Register R1 is initialized by a value and RLNCF instruction has been executed. Initially the register is initialized by a value 00001111 and the RLNCF R1, F has been executed and the register value becomes 00011110.



Fig. 12. GUI Proteus Connectivity

B. Different Microcontroller Manufacturers

There are different microcontroller manufacturers in the market and each of them has many families of microcontrollers.



Fig. 13. Different Microcontroller Manufacturers

In the Fig. 13. a list of popular microcontroller manufacturers are given. PIC16XXX/18XXX microcontroller is produced by Microchip and its website is <http://www.microchip.com> and 8051 microcontroller is produced by Intel and its website is <http://www.intel.com/design/mcs51>. AVR microcontroller is produced by Atmel and its website is <http://www.atmel.com>. 8051 microcontroller is produced by Philips and its website is <http://www.semiconductors.philips.com>. Z8, Z80 microcontroller is produced by Zilog and the website is <http://www.zilog.com>. Another 8051 microcontroller is produced by Dallas Semi/Maxim and, its website is <http://www.maxim-ic.com>.

C. Different Features of Graphical User Interface

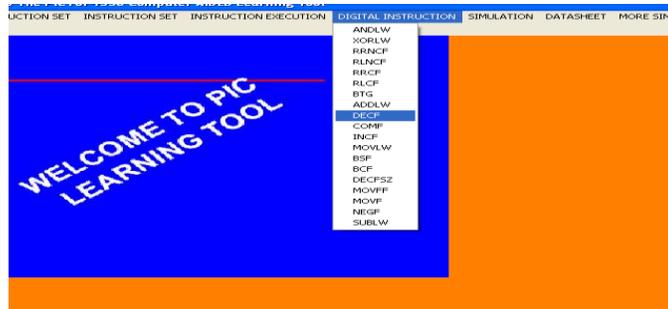


Fig. 14. Digital Simulation of Instruction Execution

In the Fig. 14. the digital simulation of various instructions has been shown. There are various options of GUI such as simulations, datasheets, instruction sets, books on microcontroller, website of different microcontroller producers etc. The user can get instruction sets and its explanation by navigating the instruction sets, can view various simulations by navigating simulations, can view different datasheets by navigating the datasheets option and can view various microcontroller producers by navigating websites. As the GUI holds all the feature of PIC18F4550 microcontroller hence the user can get lecture slide on it and can read various books on microcontroller.

D. Hardware Experiment

The project has three hardware experiments.

- i) LED
- ii) 8x8 Dot Matrix Display
- iii) 4x4 Keypad interfacing

i) LED

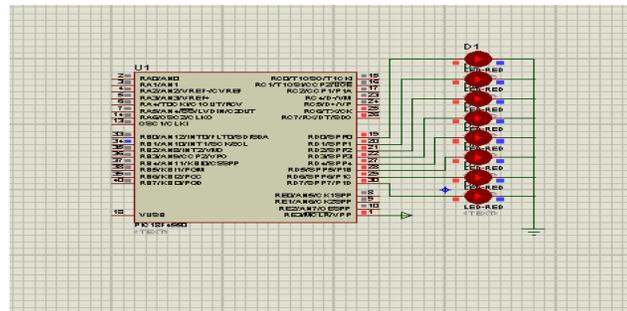


Fig. 15. All LED are rotating

In the Fig. 15. the proteus simulation has been shown for a rotating LED experiment. In the above simulation the 8 LEDs are connected to the PIC18F4550 microcontroller's PORTD.



Fig. 16. Three LED on in hardware experiment

In the Fig. 16. three LEDs are on and it is rotating. The experiment is implemented on PIC18_EduKit module. The program code has been written by PIC C compiler and the hex file is downloaded to the PIC18_EduKit main board by the programmer.

ii) 8x8 Dot Matrix Character Display



Fig. 17. 8x8 Dot Matrix Display 'O'

In the Fig. 17. the programmer, main board and the daughterboard displaying the character “O” are shown. The 8x8 dot matrix display is configured in that way so that it shows the character ‘O’. The program is written in PIC C compiler and the hex file is downloaded to the main board and the character ‘O’ has been displayed to the 8x8 dot matrix display. The PIC18F4550 microcontroller port B and port D are connected to the row and column to the 8x8 dot matrix. Some predefined static configurations have been done for each and every character.

iii) 4x3 Keypad Interfacing

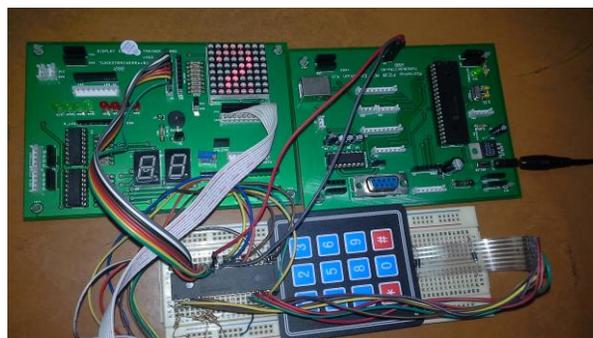


Fig. 18. 8x8 Dot Matrix Display for '2' by Keypad Interfacing

In the Fig. 18. the 4x3 keypad and the 8x8 dot matrix display have been connected with the microcontroller. The 4x3 keypad columns 0,1,2 have been connected with the PORT C0,C1,C2 and the records 0,1,2,3 have been connected with the PORT R0,R1,R2,R3. The 8x8 dot matrix display is connected with the PORT B0-7 and D0-7.

V. CONCLUSION

Computer Aided Learning Tool for learning PIC Microcontroller is a demand of this era of Information and Communication Technology (ICT). The objective of this project was to develop a user friendly CALT for teaching and learning PIC Microcontroller. In this project a CALT has been developed which facilitates to be familiarized with the basics of PIC Microcontroller such as the Instruction set in a visualized manner, to simulate a design using proteus simulator and then to implement the design on a real hardware. These three facilities from a single GUI is one of the novelties of this CALT. A PIC beginners can easily learn PIC Microcontroller if he uses the GUI in a systematic way. There are some other features such as downloading of important lectures on PIC Microcontroller, viewing important websites on Microcontroller, books, news, datasheets etc.

ACKNOWLEDGMENT

First of all I would like to acknowledge and extended my heartfelt gratitude to my supervisor, Dr. Md. Liakot Ali, Professor and Director, IICT, BUET whose encouragement, guidance and support from the initial to the final level enabled me to make this project successful. This project would not have got the success without his ever helping personalities. I would like to convey my thanks to Professor Dr. Md. Saiful Islam , IICT, BUET and Mohammad Imam Hasan Bin Asad , Lecturer ,IICT, BUET. Their inspiration and support gave me the courage to do this work. I also express my gratitude to BUET for allowing me to conduct this research project using its all kinds of facilities. Lastly but by no means the least (probably the most) have my thanks gone to my dearest wife, without whose inspiration with a cup of tea or coffee in my tiresome moments and selfless sacrifice of her privileged time for my office work in my house this could have become a reality. This guide is dedicated to my loving wife.

REFERENCES

- [1] [1] <http://www.abet.org/>. Accessed on October 2014.
- [2] Engineering Accreditation Commission, Accreditation Board of Engineering and Technology, Inc., Criteria for Accrediting Programs in Engineering in the United States, pp,11-12, 1996- 1997.
- [3] E. Montanez, "Micro-controller in Education Embedded control- Everywhere and Everyday", Proc. of American Society for Engineering Education Annual Conference & Exposition, 2005.
- [4] T. K. Hamariata and R. W. McClendon, "A New Approach for Teaching and Learning Micro-controller Courses", Int. Journal of Engg. Ed. Vol. 13 (4), pp. 269-274, 1997.
- [5] M. Ali Akcayol, Aydin Cetin, and Cetin Elmas, "An Educational Tool for Fuzzy Logic-Controlled BDCM", IEEE Transactions on Education, Vol. 45, No. 1, February 2002.
- [6] D. Euan, W. M. Howard, B. Albert and T. Hamish, "A Tool for Supporting the Teaching of Parallel Database Systems", IEEE Transactions on Education, Vol. 48, No. 2, May 2005.

BIOGRAPHY

Engr. Mainur Rahman has passed S.S.C. exam from Sarishabari R.D.M. Pilot high School with Star Marks with Letter in 5 subjects have been scored 82.1% marks and have passed H.S.C. exam. From Notre Dame College, Dhaka, Bangladesh with Star Marks with Letter in 3 subjects and have been scored 77.7% marks. He have completed his B.Sc. Engg. in CSE from Rajshahi University of Engineering and Technology, Rajshahi, Bangladesh and stood 1st class 18th position in the merit list and have been scored 3.34 out of 4.0 have been scored 70.80% marks. He has completed his M. Engg. in ICT from IICT, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh in the specialization of PIC18F4550 Microcontroller. He has completed National ICT internship program under Ministry of Science , Information and Communication Technology in a famous Software Development Company named Alpha Soft Systems Ltd. BSRS Bhaban , Kawranbazar, Dhaka, Bangladesh. He has performed Oracle 9i DBA training from IBCS-PRIMAX Software Bangladesh. He has also performed CCNA training course from CISCOVALLEY, Dhaka. He has performed Oracle Developer 9i from Base Limited, Dhaka. He has also performed MCSE training course from New Horizon, Dhaka. He has also completed various course like Wi-Max, ISP Setup, Hardware and Networking and Software Development. Now he is working as a Jr. Prin. Executive, IT. The Ibn Sina Pharmaceutical Ind. Ltd. Dhaka. Bangladesh. He is a Fellow of Bangladesh Computer Society and Member of Institute of Engineers Bangladesh.

Dr. Md. Liakot Ali is currently Professor and Director of Institute of Information & Communication Technology (IICT) at Bangladesh University of Engineering & Technology (BUET), Dhaka, Bangladesh. Mr. Ali received his B.Sc. degree in Electrical and Electronic Engineering from Bangladesh University of Engineering and Technology (BUET) in 1993, M.Sc. in Electrical, Electronic and Systems Engineering from Universiti Kebangsaan Malaysia (UKM) in 1998 and Ph.D in Electronic Engineering from Universiti Putra Malaysia (UPM) in 2001. He served as a R & D Engineer in few reputed national companies of Malaysia and also as Lecturer in Universiti Putra Malaysia. He has published journal and conference papers. His research interests include advanced electronic system design, IC design & testing and ICT application in health sector. He is fellow of Bangladesh Computer Society (BCS) and member of Institute of Engineers Bangladesh (IEB).