# Module-Based Edukit for Teaching and Learning 8051 Microcontroller Programming

Liakot Ali,[1] Lutfor Rahman,[2] and Shahin Akhter [3]

[1, 2, 3]Institute of Information and Communication Technology, Bangladesh University of Engineering and Technology
Dhaka-1000, Bangladesh

[1]liakot@iict.buet.ac.bd

*Abstract*- **A microcontroller unit (MCU) is the critical part of an embedded system. The knowledge of MCU is essential for every field of science and technology which in turn directs that a strong curriculum based on MCUs at various levels of education is necessary for universities, colleges, and schools. For learning Atmel MCU programming, various trainer board models are available in the local market. But these currently available trainer board components are assembled on a large single printed circuit board (PCB) which is expensive, consumes high power and inconvenient for portable applications. Moreover, it is not possible to integrate new components in these trainer boards. This paper presents a module-based Edukit to overcome those problems. Miniaturization is the main contribution of Edukit. an ice-cream size box contains the whole Edukit which proves that the Edukit is simple, portable, low cost, consuming less power. Moreover, the Edukit is module based which in turn makes it a low-cost and suitable educational tool for any disciplines of science and engineering.**

***Index Terms*—Educational Kit, Microcontroller, Embedded System, Printed Circuit Board, 8051.**

## I. Introduction

Low power portable embedded system is a demand in this era of information and communication technology. A microcontroller is one of the powerful but low-cost devices to realize an embedded system. At present, a microcontroller unit (MCU) is being widely used in almost all areas of science and engineering disciplines. It is imposed by the Accreditation Board for Engineering and Technology (ABET) that engineering students must demonstrate a knowledge of data acquisition, processing and control in which use of computers, MCUs are essential [1]. Considering the high demand for MCU knowledge, curriculum containing MCUs at various levels of education are being introduced in different universities, colleges and schools [2], [3]. This requires suitable simulation tools and Educational kits (Edukit) for teaching and learning MCU programming as well as for real-time application development [4], [5]. In the market there are many types of MCUs such as Motorola, Intel, Microchip, Zilog, Atmel etc. and their educational MCU boards are available for this purpose. Among all the MCUs, 8051 family has many unique features such as inexpensive, low power consumption, and good cross-platform support. Usually, educational boards are manufactured for general purpose and so components are assembled on a big size single printed circuit board (PCB). Due to the crowdedness of components and big size of the board, this may appear inconvenient and cumbersome for MCU beginners [6].

Hence, the scope of our current study in this paper is to develop 8051 MCU based educational boards having the following features:

- It will simple and portable,
- It will affordable for everybody,
- It will suitable for any disciplines of science and engineering.

## II. Prior Work

There have been remarkable efforts in literature for developing multi-module 8051 MCU experimental board for teaching MCU courses in different disciplines of science and engineering [7]. This experimental board is multi-module based where the 8051 MCU is on the main module and other modules are related to interfacing application such as the 16X2 LCD display, 7-segment display, dc motor speed control, DAC, etc. Texas A&M University-Corpus Christi recently established a Digital Systems Laboratory (DSL) that provides interdisciplinary educational and research capabilities in several sciences and engineering areas [8]. A research in [9] describes teaching aid – platform for courses of embedded systems programming. This platform consists of an MCU unit (evaluation kit), an industrial computer (panel PC), several models of real-world processes and I/O modules and other supporting circuitry for connecting the computer systems to the models. A project-based MCU system laboratory has been designed and developed using BK300 development board with PIC16F887 chip [10]. A modular-approach of multi-microcontroller based educational training system with IDE has been designed for MCU training system that is based on 8-bit MCU Intel® MCS51 and Motorola®MC68HC11 [11]. Considering the importance of MCU in the academic curriculum of BUET, a concept of module-based Educational kit for Edukit programming was proposed in [12].

## III. Conceptual Design Of Edukit

Our current study considered MCU of 8051 architecture due to its low cost, simplicity, availability and many other attractive features [13].

Fig. 1 shows a conceptual design of the Edukit where 1(a) and 1(b) indicates a sample of motherboard and daughterboard respectively. The motherboard was equipped with an AT89S51 processor, power supply and usually used common components such as resistors, capacitors, switches, and connectors. The oval icon in Fig. 1(b) is used to indicate the

978-1-5386-3374-8/17/$31.00 ©2017 IEEE

typical components in the motherboard. There were male connectors around the periphery of the motherboard. The daughterboard was equipped with components for developing specific applications as indicated by the oval icon. The male connector resided in the periphery. It is to be mentioned that the motherboard and the daughterboard can be easily connected through the connector wires. MCU port pins were not kept fixed for any components to ease the adoption of a new daughterboard with the motherboard.

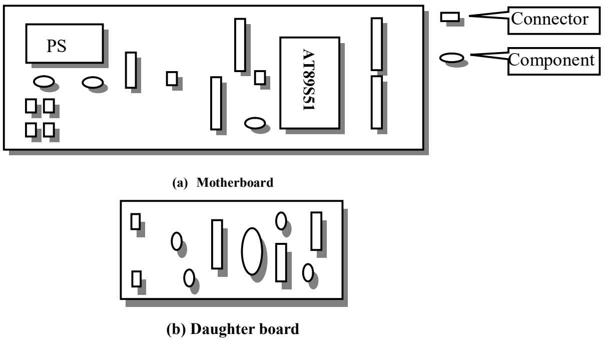



Fig. 1 Conceptual motherboard and daughter board of the proposed Edukit.

## IV. Implementation

The Orcad software was used for preparing the schematic design and layout of motherboard and daughter board of Edukit and the simulation was carried out in the Proteus software. Finally, the prototype of the Edukit from Orcad was implemented in Printed Circuit Board (PCB). Fig. 2 shows the motherboard of the Edukit.

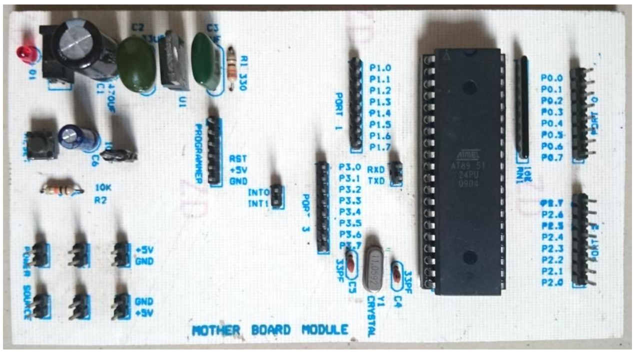



Fig. 2 Mother Board Module.

It is to be observed in Fig. 2 that there is a port connector, programmer connector, power connector, and reset button on the motherboard. Port connectors are used to establish a connection between motherboard and daughter board module for various application purpose. The program connector in the MCU is to connect with MCU programmer and the power connector is to supply power to the daughter board module. A reset button is kept for restarting the MCU program.

Other components such as the LED module, 7 segment modules, 8×8 dot matrix module, 16×2 LCD module, ADC module, a serial communication module, a motor driver module, keypad, and RTC respectively are shown in Fig. 3 to Fig. 11.

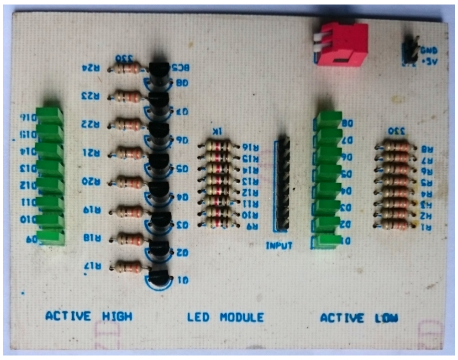



Fig. 3 LED Module.

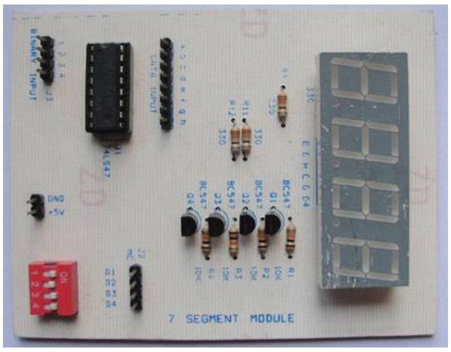



Fig. 4 7 Segment Module.

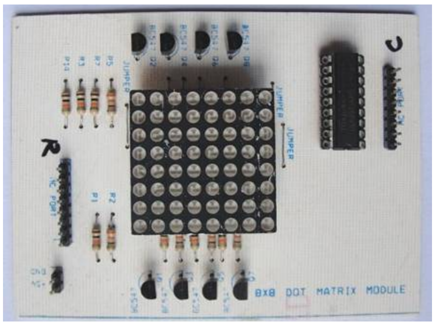



Fig. 5 8×8 Dot Matrix Module.

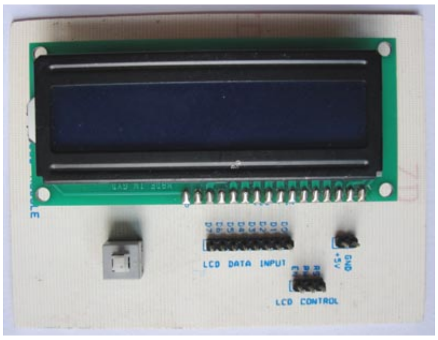



Fig. 6 16×2 LCD Module.

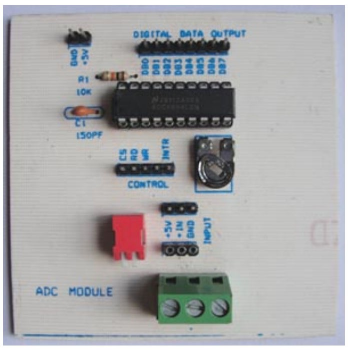



Fig. 7 ADC Module.

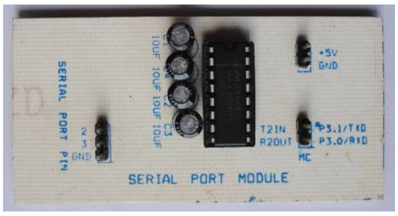



Fig. 8 Serial Port Module.

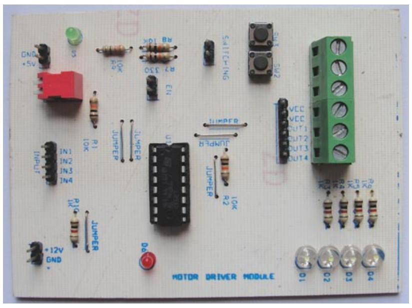



Fig. 9 Motor Driver Module.

Fig. 10 Keypad


Fig. 11 RTC module.

In LED module in Fig. 3 has one input connector, one power connector, one two-digit switch, resistors, transistors and two row LEDs. The basic component of the 7-segment module was a four-digit common anode 7-segment display. The module has digit selection connector, digit selection switch, data input connector, a binary input connector, power connector, 74LS47 and other peripheral components.

In 8×8 dot matrix module in Fig. 5, there were two 8 pin connectors to connect with the motherboard, power connector, ULN2803A IC, resistors, transistors. The ULN2803A contained a high-voltage, high-current Darlington transistor array. The 16 pins female connector LCD module in Fig. 6 contained a 3-pin connector for LCD control, power connector, an sw1 switch for LCD back light and VR1 variable resistor for adjusting display contrast in the LCD module.

In the ADC module of Fig. 7, there were input connectors for analog input voltage, control connector for controlling ADC operation, digital data output connector for digital signal output and power connector. The serial communication module in Fig. 8 consists of an MC connector, power connector, and serial port pin to connect with RS232 DB9 pin. The motor module in Fig. 9 was developed to operate DC motor and stepper motor. Here, L293D acted as a motor driver and D1-D4 LED were for displaying the correspondent output value status in the motor module.

The RTC module in Fig. 11 was developed to provide the time (hour, minute, second) and the date (year, month, day) continuously, regardless of whether the power is on or off. DS1307 was used as RTC in this module.

The whole kit including the motherboard, daughterboard, cables, adapter, and programmer can be packed in an ice cream box as shown in Fig. 12.

Fig. 12 Edukit in an Ice-cream Box.

## V. Test Results

The Keil µVision compiler and Hex code were used to compile the necessary codes and burned inside the MCU. Finally, the daughter board was tested for different applications.

### *A. LED module*

Fig. 13 displays the microcontroller port status through LED. Here, MCU P0 port of motherboard was connected to the input connector of LED module through connector wire.

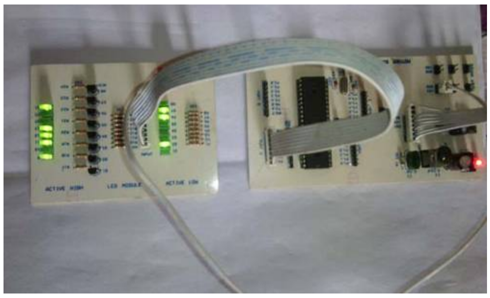


Fig. 13 LED Module Testing Result Output.

### *B. 7 segment module*

A sample numeric value in the 7-segment display is shown in Fig. 14 by connecting the MCU port P2 of motherboard to the input port of 7-segment module.


Fig. 14 7 Segment Module Testing Result Output.

*C. Dot matrix module*

Fig. 15 shows the symbol ‘A’ in the Dot Matrix module by connecting the P1 and P3 ports of the motherboard MCU to the input port of Dot Matrix module.

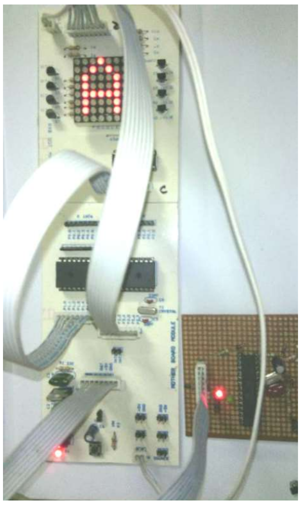


Fig. 15 Dot Matrix Display Module Testing Result Output.

*D. LCD module and Keypad*

The keypad port was connected to the P0 port and the LCD data input port was connected to the P2 port of the motherboard. Fig. 16 displays the keypad assigned values to the LCD module.

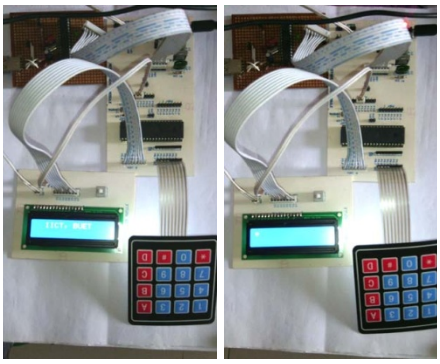


Fig. 16 Keypad Interfacing Testing Result Output.

*E. LCD module and ADC module*

The ADC module for digital data output was connected to the P1 port and the LCD data input port was connected to the P2 port of the motherboard. We provided analog voltage to the +VIN of the ADC module. Fig. 17 displays a sample decimal value on the LCD display.

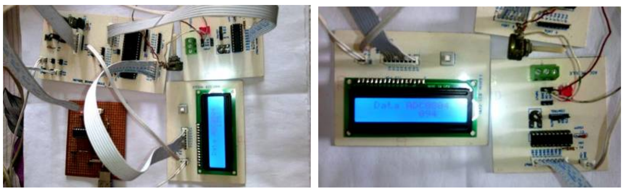
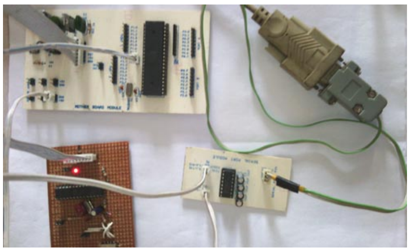


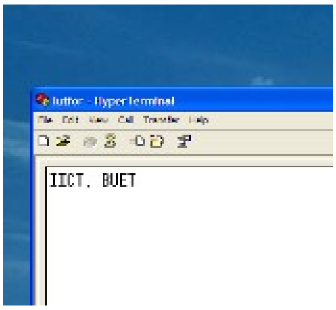
Fig. 17 ADC Module Testing Result Output.

*F. Serial communication module*

The MC connector in serial port module was connected to the P3.1 and P3.0 of the motherboard. Fig. 18(a) shows the connection within the PC, motherboard and serial communication module, while Fig. 18(b) displays a sample output in the hyper terminal.



(a)

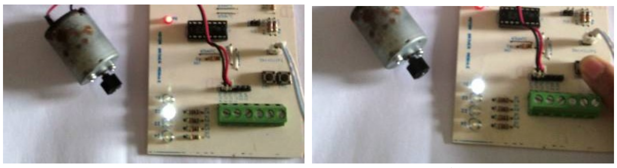



(b)

Fig. 18 Serial Port Module Testing Result Output.

*G. Motor driver module for DC motor*

P2.0 and P2.1 pins of the motherboard were connected to the input terminal of motor driver terminal and P1.7 pin of the motherboard was connected to the switching terminal of motor driver terminal. Different LED status is shown in Fig. 19 indicates that a change in the direction of motor rotations (i.e., clockwise in Fig. 19(a) and anti-clockwise in Fig. 19(b)).



(a) (b)

Fig. 19 Motor driver module testing result output using DC motor.

*H. Motor driver module for stepper motor*

P1 port of motherboard was to the input terminal of motor driver terminal and stepper motor was connected to the output terminal of motor driver module. The 4-step sequence of the stepper motor rotation is displayed in Fig. 20 through LED status.

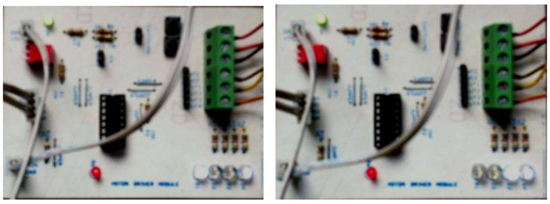


Fig. 20 Motor Driver Module Testing using Stepper motor.

### *I. LCD module and RTC module*

RTC SCL and SDA pin were connected to P1.0 and P1.1 pins of the motherboard, respectively. LCD data input port was connected to the P2 port of the motherboard. LCD RS and EN pin was connected to the P3.5 and P3.4 pins of the motherboard, respectively. The following figure in Fig. 21 shows time and date in the LCD display.

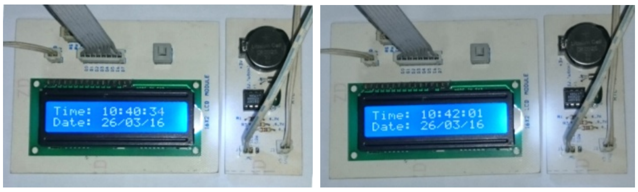



Fig. 21 RTC module testing result.

A list of available features in the traditional Edukit and module-based Edukit is presented below in Table 1. It is evident from Table 1 that the module-based Edukit is simple, inexpensive and suitable for further integration of external modules.

TABLE I
COMPARISON BETWEEN THE TRADITIONAL AND MODULE-BASED EDUKIT

| **Traditional Edukit** | **Module-Based Edukit** |
|---|---|
| Expensive. | Low cost. |
| Single size big PCB. | Not in a single size big PCB. |
| Use is complex. | Use is simple. |
| Not possible to adopt new component. | It is easy to adopt new daughter board. |
| MCU port pin is fixed for specific application. | MCU port pin is free for any application. |
| Program must be written according to the Edukit layout. | It is easy to connect between motherboard and daughter board according to program code. |

## VI. CONCLUSIONS

Based on the comparative performances listed in Table 1, it is expected that the developed Edukit will be complementary for the new MCU curriculum and will satisfy the needs of the students and instructors in the most effective way. This will module based Edukit could be a cost-effective and portable solution for delivering the MCU curriculum. Considering its modular architecture, the daughter board of the Edukit can be of use for various fields of science and technology as well.

## ACKNOWLEDGMENT

The authors are grateful to IICT, BUET for allowing us to conduct research using its Advanced Embedded System Laboratory and all kinds of facilities here.

## REFERENCES

[1] 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.

[2] Anon., http://www.abet.org/. Accessed on October 2005.

[3] E. Montanez, "Micro-controller in Education: Embedded control-Everywhere and Everyday", in *Proc. of American Society for Engineering Education Annual Conference & Exposition*, USA, 2005.

[4] T. K. Hamariata and R.W. McClendon, "A New Approach for Teaching and Learning Micro-controller Courses", *Int. Journal of Engineering Education,* vol. 13, pp. 269-274, 1997.

[5] Anon., http://www.futurlec.com/. Accessed on October 2005.

[6] Sickle, "Programming Micro-controller in C", Hightext, 1994.

[7] Kumbhar D. S., Bhujbal, R. V., "Development and use of multi-module 8051 micro-controller board for teaching and learning micro-controller programming", in *Proc. of National Conference on Emerging Trends in Electronics & Computer Science*, 2010.

[8] R. Bachnak, "Teaching microcontrollers with hands-on hardware experiments", *Journal of Computing Sciences in Colleges*, vol. 20, pp. 207-213, Apr. 2005.

[9] Dolinay J., Dostálek P., Vašek V., Vrba P., "Teaching platform for lessons of embedded systems programming", in *Proc. 13th WSEAS International Conference on Automatic Control, Modelling & Simulation*, Lanzarote, Canary Islands, 2011, pp.158-161.

[10] L. A. Ajao, O. M. Olaniyi, J. G. Kolo, A. O. Ajao, "Project-based microcontroller system laboratory using BK300 development board with PIC16F887 chip", *International Journal of Embedded systems and Applications (IJESA)*, vol. 5, pp. 15-18, Sept. 2015.

[11] R. S. K. Selvakumar, K. H. Ghazali, N. M. K. Nik Yusoff, "Designing a modular-approach of multi-microcontroller based educational training system with IDE", *National Conference on Postgraduate Research,* Malaysia, 2009.

[12] M. L. Ali, S. M. L. Kabir, M. J. B. Alam, and M. A. Kashem, "Module-based Edukit for Teaching and Learning Micro-Controller Programming", in *Proc. of Methods, Materials and Tools for Programming Education*, Finland, pp. 67-70, 2006.

[13] AT89S51 Datasheet from Atmel Corporation, www.atmel.com