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Design and implementation of a microcontroller development kit for STEM education.

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Abstract: In many high schools all over the country, electronics engineering and embedded systems design are being seriously neglected for many reasons, including a lack of equipment and materials for teaching. In this paper, our main aim is to solve this pressing issue. Young people and students in Nigeria are entering a new era of technology in which STEM education and embedded system design are becoming more accessible and affordable. We want to encourage more growth in STEM education to promote technological advancement in the country[1]. This aspect becomes essential in a high school laboratory, where students have to work with different types of embedded systems. For example, in our department of Electronic Technology, three 8-bit and one 16-bit microcontroller families are used in different projects. Each microcontroller type requires its development board with its own set of peripheral devices that requires its code; this is a waste of resources, and so came the idea to use the same set of peripherals on a motherboard and to plug in a daughterboard with a specific microcontroller and its associated circuitry, to prevent waste and aid learning[2].

Introduction: Research and education activities at universities and high schools in Nigeria involving embedded systems design and development are currently on the low side because of the unavailability of materials. People interested in learning how to code embedded systems and schools looking to teach students to code embedded systems can easily use the board and achieve the same results as individual components brought together[3]. We have many components embedded in the board, like the Liquid Crystal Display (LCD), the GSM module, the Bluetooth module, and many other components, which reduces the risk of interfacing the individual components[4].

The advantages of this board over other boards like the Arduino are simple; in the Arduino, you have to interface all the peripherals, and chances are that the wires might not be firmly connected; when you run your code, it might not work, then you begin troubleshooting, which would take a long time. Our development board has its programmer inside the board[5], and it was locally fabricated in our lab, and we are looking to encourage more people to buy locally fabricated boards and not always look to China for their boards.

LITERATURE AND CONCEPTUAL REVIEW

Problem Statement

Significant evidence of a theory-based learning strategy may be found in several institutions nowadays. However, in order to properly understand and furthermore implement the concepts being taught in disciplines like science and technology, industrial sciences, it is necessary to have practical experience. An important foundational element for the implementation of a practical-based learning approach is the use of microcontroller systems and test/simulation kits. This then poses questions to:

- The availability and affordability of microcontroller systems and test kits?
- The frequency of use of these systems in STEM education?
- How can educational institutions integrate practical based learning, such as that described using microcontroller test kits with theoretical concepts?

Microcontrollers are incredibly important in many areas of life nowadays. They are utilized for design in a variety of scientific and industrial domains, they are utilized for design. It offers the perfect fusion of theoretical and applied knowledge. By combining distance learning with the suggested training toolbox for practical work, Ahlam F. Mahmood *et al*. (2022) suggests a blended learning approach as a remedy for the issue with teaching microcontroller courses today. The research focuses on developing models that enable electronic simulation of the proposed IoT projects at any time and from any location using the Proteus design suite, assisting students in conducting them prior to the scheduled laboratory appointment. The models were written in assembly language, which is closely tied to the internal architecture of the microcontroller and gave insights into the properties of its central processing unit, in order to describe the underlying architecture of these systems [8]. The paper subsequently explored the replication of numerous IoT projects, each one devoted to learning its architecture aspects, to better grasp the capabilities of the microcontroller integrated circuit. This is a crucial method for practical learning, which forms the cornerstone of STEM education.

R.S.K. Selvakuma *et* al. (2009) noted that many electrical and electronics engineering students lack a thorough understanding of program structure and hardware creation, which serves to underline the need for a practical approach to learning. The MCS51 microcontroller development project was created in an attempt to promote practical based learning. The MCS51 served as a learning resource for anyone who wanted to learn more about microcontrollers. The MCS51 Educational Development System was used for the students to test their software. The MCS51 Microcontroller Educational Development System gave users hands-on experience. The MCS51 Microcontroller Educational Development System is another hands-on learning program that introduces students to microcontroller concepts in the context of electronic design [9].

The cost of purchasing microcontroller laboratory kits is also a setback to the use of these training kits. [This underlying reason promulgated by Steve Hsiung *et* al. (2010) led them to develop a cost-effective microcontroller trainer for students to keep and improve student learning. [10] The approach resolved challenges in teaching courses linked to digital microprocessors and microcontrollers that are provided through remote learning and campus-based formats by eliminating the typical institutional budget limits for lab equipment acquisition. This is a huge step towards STEM learning digitisation. The use of microcontroller training kits is imperative to learning microcontroller systems and embedded systems technology. Theoretical knowledge is never sufficient enough to cement the concepts of electronics engineering and embedded systems. Simulation kits are ultimately a low cost option to better improve learning.

Design and architecture

It is important that students should be able to translate the theories being taught in class into tangible value in the form of physical devices. That is exactly the main focus of this work; it turns ideas or theories into reality without much difficulty. We tried to simplify the board so that a novice could actually make use of it with ease. This is evident in the methodology followed during the design and implementation.

The development board is made up of various units, as shown below: microcontroller unit, DC in, voltage regulators, UsBasp programmer, liquid crystal display, relay module, Bluetooth module, GSM module, buzzer, I/O breakout units, and so on.

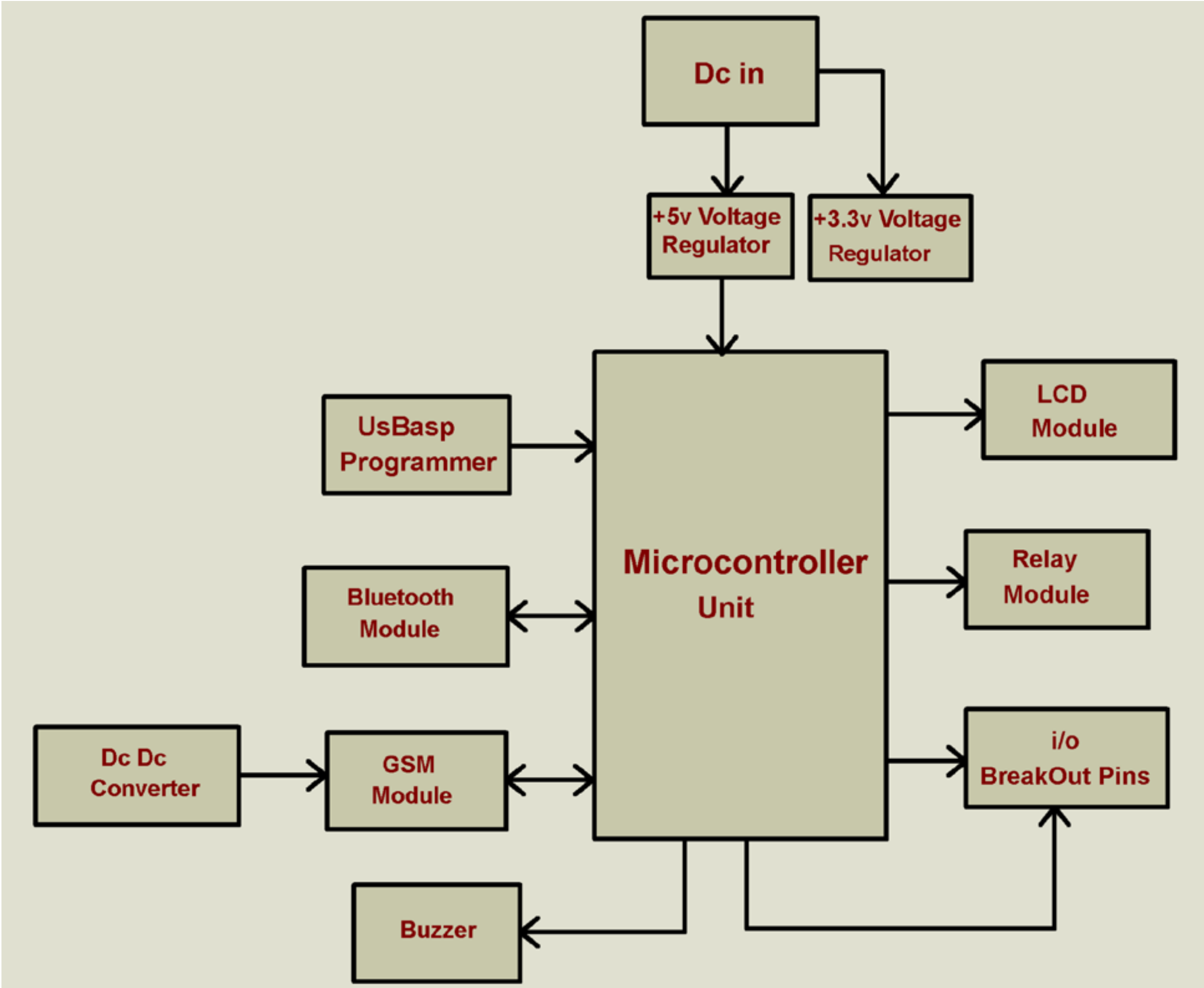

Figure 1: The block Diagram

The microcontroller unit – Atmega32A

Except for the AVR32, which is a 32-bit microcontroller, the AVR family's microcontrollers are all 8-bit, which means that the CPU can only work on 8 bits of data at a time [6]. To work on data greater than 8 bits, you have to break it down into chunks of 8 bits.

The Atmega32 is an 8-bit microcontroller with the following features: flash memory (ROM), RAM, EEPROM, timers, and I/O ports. The chips also allow us to work with different devices since they support protocols like SPI, USART, I2C, USB, CAN, etc. Other features of the Atmega32 include an internal analog-to-digital converter (ADC) and pulse width modulation (PWM).

It is also important to note that the Atmega32 is a 40-pin integrated circuit with 32 I/O pins, of which 8 out of the 32 pins are dedicated to analog to digital conversion.

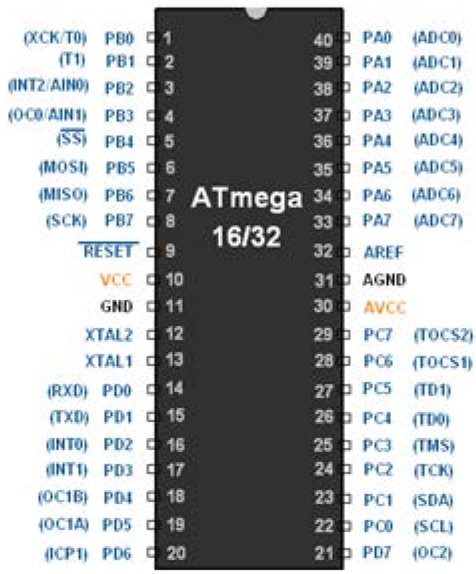

Figure 2 The ATmega Microcontroller pin diagram

Voltage Regulators

As indicated in fig 1.0, two different voltage regulators were used in the design; the LM7805 and the LM1117T.

The LM7805 voltage regulator is a +5V linear regulator. It's a 3-pin IC with an absolute maximum input voltage of 35v with an output voltage and current of +5v and 1.5A, respectively.

The LM1117T is a 3 pin linear regulator with a low dropout of 1.2v at 800mA of load current. It comes in different specifications; 1.8v, 2.5v, 3.3v, and 5v.

UsBasp programmer

This device is a USB in-circuit programmer for Atmel AVR controllers. It has an Atmega8 microcontroller as the main component and a few passive components. The programmer uses a firmware-only USB driver; no special USB controller is needed. [7]

Liquid crystal display

The type of display used in this design is a 16x2 liquid crystal display. This device is used as an output device to display alphanumeric data. As the name suggests, it has 16 columns and 2 rows and can display a total of 32 characters, 16 per row.

Display technical specifications:

- · Operating voltage – 4.7v to 5.3v
- · 16 columns and 2 rows
- · Display size – 72 x 25mm
- · Operating current without backlight – 1mA

- · HD47780 controller
- · It can work in both 4- and 9-bit modes
- · Backlight color—green and blue

Bluetooth module

HC-05 uses serial communication to communicate with electronics chips, the rate of data transfer can vary up to 1mbps and the maximum distance it can cover is 10meters. It communicates with the microcontroller using universal synchronous/asynchronous receiver/transmitter (USART) protocol.

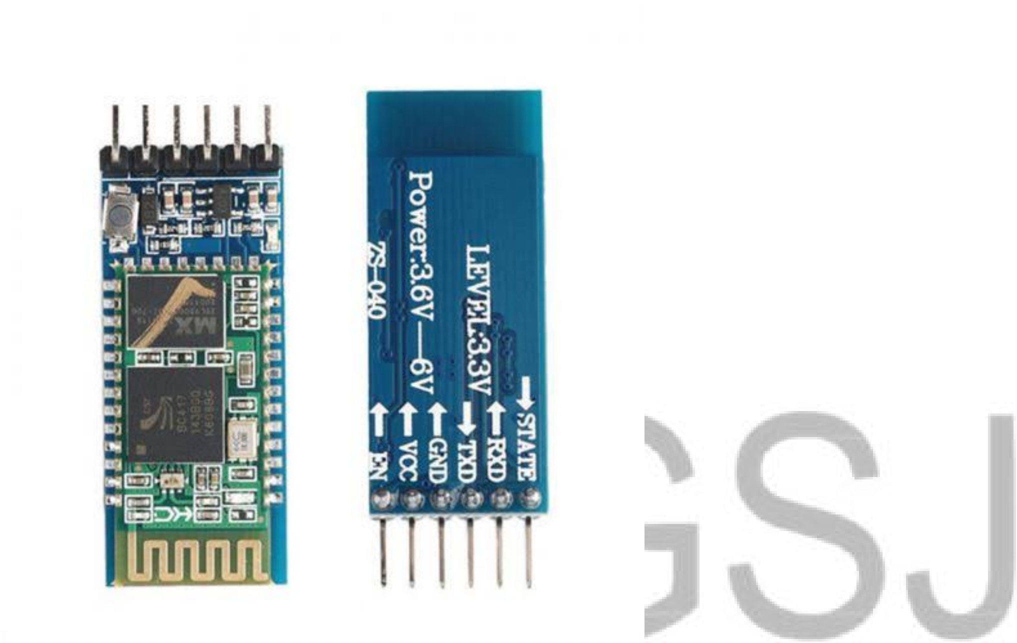

Figure 3 The bluetooth module

GSM module

The GSM module used in the design is sim800l. The module has both GSM and GPRS capabilities, which can be integrated into numerous IoT projects.You can use the module to accomplish a lot of things e.g. SMS text messages, make or receive phone calls, connect to the internet using the GPRS capability of the module.

It is worthy to note that the module operates within the voltage ranges of 3.4 to 4.4, and during transmission, its capability of consuming up 2A, this is why we used a 3A DC DC converter to power the module separately.

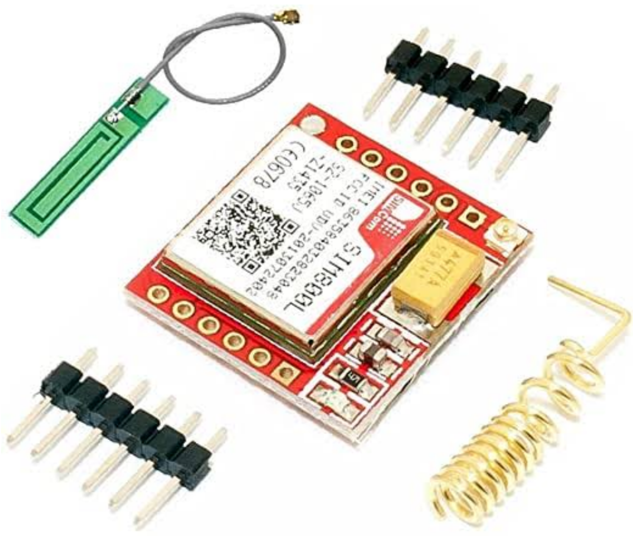

Figure 4 The GSM module

PCB schematics and design

The schematics diagram and printed circuit diagram was designed in Kicad simulation software. The figure below is the schematics diagram showing the complete parts of the device.

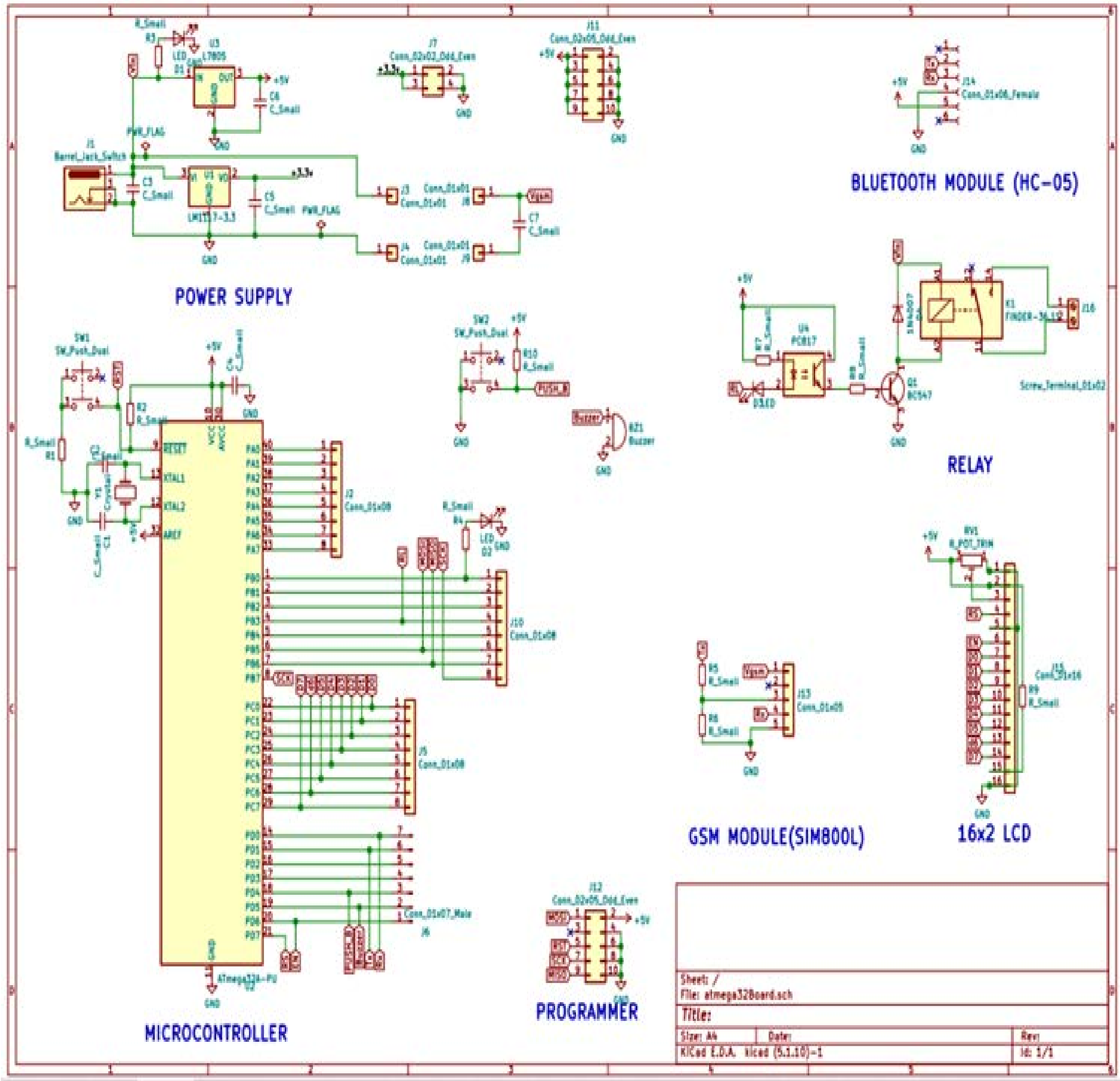

Figure 5 The Schematic Diagram of the circuit

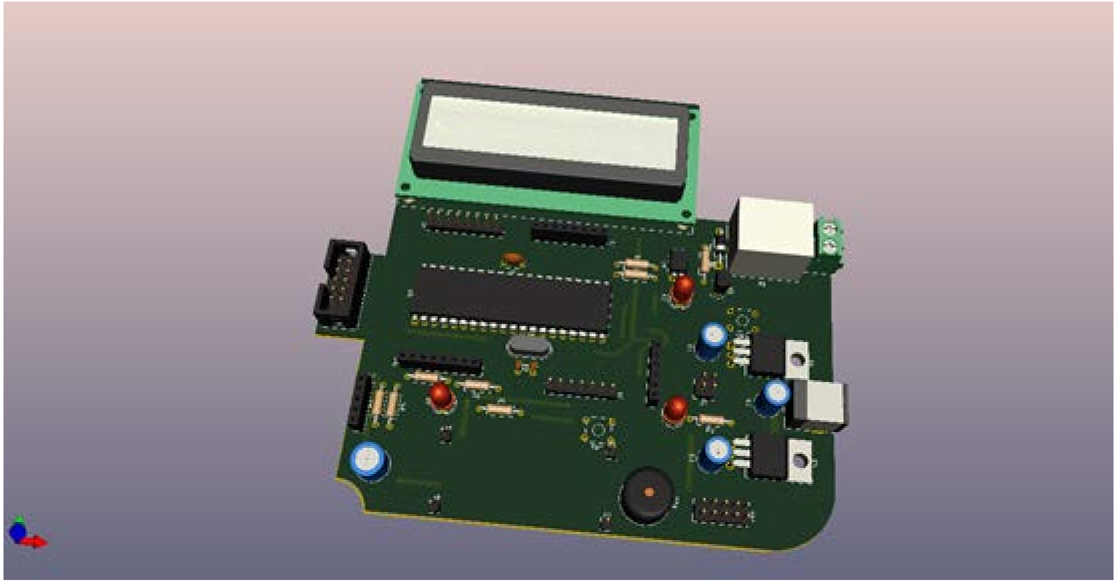

Figure 6 The 3D diagram of the complete board in Kicad CAD software

Results and Discussion

We were able to develop and use an Atmega32 based 8-bit development board targeted at kids within the age range of 11–18 years.

Figure 7 shows the complete board.

The aim of the work was to build a development board that incorporates all the functionality a learner of STEM would need, which we accomplished. We hope to keep improving on the design.

Conclusion

We evaluated the ease of use and flexibility of the board as stated by the teachers and students, and we came to the conclusion that the technology resolves the problem we intended it to. Our findings can be expanded upon in a number of ways by future research. Future studies may look at the addition of sensors like the ultrasonic sensor and MQ135 sensor to increase the board's utility. The goal of our study was to provide teachers and students in the STEM field with teaching assistance. It is important to look at the numerous accessories that may be added to this board, as well as its use and integration in subjects other than STEM, such as art and design. This board finds use, particularly in educational institutions and technological hubs. It illustrates a homegrown product's potential and dispels the misconceptions about construction held by young people in our community.

Acknowledgment

We want to express our profound gratitude to God Almighty for providing the inspiration for this concept and the willpower to put it into action. We also want to thank all of the Nigerian students for their interest in and support of this fantastic project.

Reference

[1] L.C. Ling, “The MC68HC11 Development Board with Integrated Development Environment (IDE)”, Thesis University Malaysia Pahang 2008

[2] K.C. Seong ``The MC68HC11 Development Board”, Thesis University Malaysia Pahang 2007

[3] R.S.K Selvakumar, N.M.K Nik Yusoff, and H. Abdul Aziz, “MCS51 Educational Development System with IDE Approach,” in Proc International Conference on Software Engineering and Computer Systems 2009 (ICSECS09), Kuantan, Pahang, 2009, pp. 434-437

[4] M.Z.B.M.Sapien, “MINI 11-Microcontroller Laboratory Hardware Platform with IDE Approach," Thesis, University Malaysia Pahang, 2009

[5] T. Stoltz, M. Paulik & N. Al-Holou, “A Microcontroller Laboratory Hardware Platform for the Academic Environment: The UDMEVB,” in Proc Frontiers in Education 35th Annual Conf, FIE’05, Indianapolis, IN, 2005, pp. S2G-1–S2G-6

[6]The microcontroller and embedded system using assembly and c by Muhammad Ali Mazidi, Sarmad Naimi and Sepehr Naimi 2009

[7]AC-PG-USBasp AVR programmer user guide, version 2.0, January 18, 2012

Cady (2010, July 23), M68HC11 Microcontroller Board and Prototyping [online], Available: http://www.coe.montana.edu/ee/cady/ee361/hc 11lnks.htm#student_evb

[8] Ahlam F. Mahmood, Kasim A. Ahmed, Hamed A. Mahmood, Design and Implementation of a Microcontroller Training Kit for Blend Learning, Computer Applications in Engineering Education, April 2022, 10.1002/cae.22517

[9] R.S.K. Selvakumar, N.M.K Nik Yusoff, H. Abdul Aziz, Educational Development System with IDE Approach, International Conference on Software Engineering and Computer Science, September 21-23, 2009, 26300 Gambang Kuantan, Malaysia

[10] Dr. Steve Hsiung, Dr. John Ritz, Mr. Richard Jones, and Mr. Jim Eiland, Design and Evaluation of a Microcontroller Training System for Hands-on Distance and Campus-Based Classes, Peer-Refereed Article Applied Papers, October 2010 through December 2010