Design and Development of A PIC Microcontroller Based Embedded System Trainer Panel for Electrical Personnel Training

Engr. Muhammad Mujtaba Asad[1], Dr. Razali Bin Hassan[2] and Engr. Fahad Sherwani[3]

FPTV, Universiti Tun Hussein Onn Malaysia, Parit Raja Batu Pahat, Johor Malaysia.
Mujtabaasad11@gmail.com, razalih@uthm.edu.my, fahad.sherwanis@gmail.com.

Abstract: This paper describes a project where the aim is to design and develop PIC based embedded system trainer. Scientific technical courses are important components in any student's education. Traditionally those courses are usually characterized by the fact that the students execute experiments in special laboratories. This leads to extremely high costs, a reduction in the maximum number of possible participants and also the time constraint in learning. Commonly, experiments were carried out within the laboratory at special fully equipped workstations that comes complete with microprocessor or microcontroller training kits. However, the price range for one trainer is very high and also additional costs such as maintenance of the board should be taken into account. This contributes to the limited number of boards and the ratio of available board to the students. The primary objective is to provide the students with an opportunity to be familiar with software tools like compilers, simulators, and chip programming software. The purpose of designing and development of multifunctional PIC microcontroller based trainer is to design such embedded system trainers which have different functions modules to be used for teaching and learning. This PIC trainer consists of ten on-board embedded modules including main board and programmer, and experimental Lab manuals for all embedded modules.

[Engr. Muhammad Mujtaba Asad, Dr. Razali Bin Hassan, Engr. Fahad Sherwani. **Design And Development Of A PIC Microcontroller Based Embedded System Trainer Panel for Electrical Personnel Training.** *Nat Sci* 2014;12(8):129-133]. (ISSN: 1545-0740). http://www.sciencepub.net/nature. 18. doi:10.7537/marsnsj120814.18

Keywords: Microcontroller, PIC, Training Kit, Technical Education, Electronics, Programming.

1. Introduction

The current curricular in technical universities and institutions are more theoretical rather than technical hands on based, thus producing graduates who are unable to meet the ever-rising demand of industry for skilled engineers. This ultimately leads to more employment cost, as the employers have to spend extra on providing the required training [1,9,10]. This work is undertaken in the light of feedbacks from industry employer, suggesting tighter curricular schedules and coupled with more technical teaching and with sizeable practical element. The emphasis in the light of education policy is to have more hands-on practical rather than academic.

Scientific technical courses are important components in any student's education. Traditionally those courses are usually characterized by the fact that the students execute experiments in special laboratories. This leads to extremely high costs, a reduction in the maximum number of possible participants and also the time constraint in learning.

Commonly, experiments were carried out within the laboratory at special fully equipped workstations that comes complete with microprocessor or microcontroller training kits. However, the price range for one trainer is very high and also additional costs such as maintenance of the board should be taken into account. This contributes to the limited number of boards and the ratio of available board to the students.

In the lab is very high – 1:2 or 1:3. Such weakness may depreciate the effectiveness of the teaching and learning process. In addition, the time taken to complete the whole syllabus will lengthen and probably the objective of the module taught will not be achieved.

Furthermore, most of the technical courses are using modules prepared by vendors with mostly low academic background. Hence, such modules are produced with fixed features and usually have constraints in adapting to the changing needs of a technical institution. To elaborate, many problems are related to the features of the board, the microcontroller employed, peripherals and software used. Usually these boards come with a specific microcontroller with some fixed features that cannot be changed; even when there is a possibility of changing the microcontroller. This sometimes happens because the new one does not match the present peripherals of the board.

The primary objective is to provide the students with an opportunity to be familiar with software tools like compilers, simulators, and chip programming software. The best thing is that the development of the programs, compiling, and then the simulations are all carried out with the freely available software tool Microchip MPLAB on internet [6,11,12,13].

1.1 Problem Statement

The purpose of designing and development of multifunctional PIC microcontroller based trainer is to design such embedded system trainers which have different functions modules to be used for teaching and learning. It will help the students of engineering and technical education to get in depth knowledge and practical hands on experience about programming and implementation of PIC microcontroller in various embedded systems applications. On very affordable price, students may even place this trainer board in their home made labs especially for technical education students trainings ,the panel to be developed should support the good process of learning.

1.2 Project Objectives

The objectives of this Project are:

a).To design and develop a PIC based educational trainer that can support the teaching and learning of Microprocessor System or Embedded System Design.

b).To Identify and analyze the importance of trainer boards and concerning hardware hands- on experience in skilled engineering and technical education.

c).To integrates several embedded modules in one training board to facilitate the learning environment for the students of technical education.

d).To provides the students with an opportunity to be familiar with software tools like compilers, simulators, and chip programming software.

e).To asses and improve the syllabus of the Microprocessor System or Embedded System Design.

1.3. Significance

An embedded system design, or in layman term is to have certain glue logic inside to intelligently control devices or peripheral, is the utmost important knowledge not only for electronics/electrical engineering or computer engineering but also for all engineering disciplines. Many control problems that were previously solved using mechanical or electrical switching systems can now be solved more effectively and reliably using electronic devices. The heart of such an electronic monitoring and control system is a microcontroller [15-19].

Therefore this project serves as a fundamental for the students to indulge actively in the development of embedded system. The approach consists of shifting the focus of the course from the microprocessor itself to learning the design methodology in which the microprocessor could be used as a tool to solve practical engineering problems. New idea arose to design a complete reference suited and dedicated to the both theoretical and practical teaching of microcontroller. This PIC Educational Board is specially addressed to teach the fundamental development of stand-alone and embedded systems, which are the best places where a microcontroller fits.

1.4. Project Scope

This work is to develop a multifunctional PIC based electronics/technical educational trainer that can support the teaching of Microprocessor System or Embedded System Design in technical education. This is in parallel with the approach of teaching that requires students to experience with the method of design build and test their own circuit. Normally students are divided into a group of two or three to design one circuit and at the end there will be a presentation and Q&A session to present their solution for both hardware and software to the rest of the class. This method also permits them to exchange the module developed for further test run and research [1].

Furthermore, the module to be developed should support the good process of learning and since its portable so that students can bring it home and continue work at their own place. This eliminates the traditional teaching method where the course is [1] firmly tied to a laboratory since the students have to accomplish experiments at specially equipped and immobile hardware workstations.

It is intended that the module designed should be free from any firmware, meaning that it should be open to any program and configuration without having any firmware that could interfere with user programs. This simplified design module would be adopted to provide a high degree of flexibility of use, which will allow the trainer/lab board to be used in varying applications [4].

2. Literature Review

PIC is a family of modified Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Peripheral Interface Controller" [20,21,22].

PICs are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability. They are also commonly used in educational programming as they often come with the easy to use 'pic locator' software.[8,23,24]

- **Space (RAM)**

PICs have a set of registers that function as general purpose RAM. Special purpose control registers for on-chip hardware resources are also mapped into the data space. The addressability of memory varies depending on device series, and all PIC devices have some banking mechanism to extend addressing to additional memory. Later series of devices feature move instructions which can cover the whole addressable space, independent of the selected bank. In earlier devices, any register move had to be achieved via the accumulator [25].

To implement indirect addressing, a "file select register" (FSR) and "indirect register" (INDF) are used. A register number is written to the FSR, after which reads from or writes to INDF will actually be to or from the register pointed to by FSR. Later devices extended this concept with post- and pre- increment/decrement for greater efficiency in accessing sequentially stored data. This also allows FSR to be treated almost like a stack pointer (SP).[2]

External data memory is not directly addressable except in some high pin count PIC18 devices.

- **Code space**

The code space is generally implemented as ROM, EPROM or flash ROM. In general, external code memory is not directly addressable due to the lack of an external memory interface. The exceptions are PIC17 and select high pin count PIC18 devices. [8]

- **Word size**

All PICs handled (and address) data in 8-bit chunks. However, the unit of addressability of the code space is not generally the same as the data space. For example, PICs in the baseline (PIC12) and mid-range (PIC16) families have program memory addressable in the same word size as the instruction width, i.e. 12 or 14 bits respectively. In contrast, in the PIC18 series, the program memory is addressed in 8-bit increments (bytes), which differ from the instruction width of 16 bits. In order to be clear, the program memory capacity is usually stated in number of (single word) instructions, rather than in bytes.[8]

- **Stacks**

PICs have a hardware which is used to save return addresses. The hardware stack is not software accessible on earlier devices, but this changed with the 18 series devices. Hardware support for a general purpose parameter stack was lacking in early series, but this greatly improved in the 18 series, making the 18 series architecture friendlier to high level language compilers. [2]

- **Instruction Set**

A PIC's instructions vary from about 35 instructions for the low-end PICs to over 80 instructions for the high-end PICs. The instruction set includes instructions to perform a variety of operations on registers directly, the accumulator and a literal constant or the accumulator and a register, as well as for conditional execution, and program branching.

Some operations, such as bit setting and testing, can be performed on any numbered register, but bi-operand arithmetic operations always involve W (the accumulator), writing the result back to either W or the other operand register. To load a constant, it is necessary to load it into W before it can be moved into another register. On the older cores, all register moves needed to pass through W, but this changed on the "high end" cores. [26]

PIC cores have skip instructions which are used for conditional execution and branching. The skip instructions are 'skip if bit set' and 'skip if bit not set'. Because cores before PIC18 had only unconditional branch instructions, conditional jumps are implemented by a conditional skip (with the opposite condition) followed by an unconditional branch. Skips are also of utility for conditional execution of any immediate single following instruction.

The 18 series implemented shadow registers which save several important registers during an interrupt, providing hardware support for automatically saving processor state when servicing interrupts.

In general, PIC instructions fall into 5 classes:

1. Operation on working register (WREG) with 8-bit immediate ("literal") operand. E.g. movlw (move literal to WREG), andlw (AND literal with WREG). One instruction peculiar to the PIC isretlw, load immediate into WREG and return, which is used with computed branches to produce lookup tables.
2. Operation with WREG and indexed register. The result can be written to either the Working register (e.g. addwf *reg*, w). or the selected register (e.g. addwf *reg*, f).
3. Bit operations. These take a register number and a bit number, and perform one of 4 actions: set or clear a bit, and test and skip on set/clear. The latter are used to perform conditional branches. The usual ALU status flags are available in a numbered register so operations such as "branch on carry clear" are possible.
4. Control transfers. Other than the skip instructions previously mentioned, there are only two: go to and call.
5. A few miscellaneous zero-operand instructions, such as return from subroutine, and sleep to enter low-power mode.

- **Performance**

The architectural decisions are directed at the maximization of speed-to-cost ratio. The PIC architecture was among the first scalar CPU designs, and is still among the simplest and cheapest. The Harvard architecture—in which instructions and data come from separate sources—simplify timing and microcircuit design greatly, and this benefits clock speed, price, and power consumption.

The PIC instruction set is suited to implementation of fast lookup tables in the program space. Such lookups take one instruction and two instruction cycles. Many functions can be modeled in this way.

Optimization is facilitated by the relatively large program space of the PIC (e.g. 4096 × 14-bit words on the 16F690) and by the design of the instruction set, which allows for embedded constants. For example, a branch instruction's target may be indexed by W, and execute a "RETLW" which does as it is named - return with literal in W.

Interrupt latency is constant at three instruction cycles. External interrupts have to be synchronized with the four clock instruction cycle, otherwise there can be a one instruction cycle jitter. Internal interrupts are already synchronized. The constant interrupt latency allows PICs to achieve interrupt driven low jitter timing sequences. An example of this is a video sync pulse generator. This is no longer true in the newest PIC models, because they have a synchronous interrupt latency of three or four cycles. [6]

3. Methodology

Before preceding any progress of this project, the data, which is related to this scope, had been collected from time to time. All the data has been analyzed in order to produce the useful information forepart writing later on. Consequently, with all the information available has been arranged accordingly. The final step before finalizing the report is to combine the experimental results to enhanced readability of the report. The description of working in order to design and develop a PIC microcontroller based multifunctional embedded systems trainer board for technical education.

4. Results and Findings

Design and develop of PIC microcontroller based multifunctional embedded systems trainer board for technical education, comprising of various embedded system modules which are controlled using single running board consisting a PIC microcontroller.

This trainer board would be very helpful for the undergraduates and diploma students to test and implement their basic knowledge of microcontroller/microprocessor on various embedded systems circuit designs. The board is likely to support the good cause of teaching and learning in technical education, allowing the teachers to give an insight of the real world applications of the microcontroller/ microprocessor. Especially this training board will help students to improve their hands-on experimental skills in electrical and electronics engineering courses. Proposed Trainer panel shown in Figure 1.

5. Conclusion

In conclusion, the purpose of designing and development of multifunctional PIC microcontroller based trainer is to design such embedded system trainers which have different functions modules to be used for teaching and learning on one board. It will help the students of engineering and technical education to get in depth knowledge and practical hands on experience about programming and implementation of PIC microcontroller in various embedded systems applications.

On very affordable price, students may even place this trainer board in their home made labs especially for technical education students trainings ,the trainer to be developed would support the good process of learning. This PIC trainer consists of ten on-board embedded modules including main board and programmer, and experimental Lab manuals for all embedded modules.

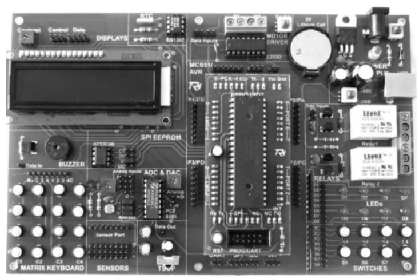

Figure 1: PIC Microcontroller Based Embedded System Trainer Panel

Corresponding Author:
Engr. Muhammad Mujtaba Asad .
FPTV, Universiti Tun Hussein Onn Malaysia
E-mail: mujtabaasad11@gmail.com

References

1. Vahid and T. Givargis, Embedded System Design: A Unified Hardware/Software Introduction, John Wiley & Sons, 2002.
2. PIC Microcontroller Based Training Module: Design and Implementation" Journal: Ra Ximhai, Author(s): Jaime Fonseca-Beltrán | Gerardo Cazarez-Ayala | José de Jesús Montes de Oca-Flores | Huémac Israel Del Ángel Bahena | Carlos Alberto Aguilar-Avelar.
3. AM Ahmad, G Sulong, A Rehman, MH Alkawaz, T Saba (2014) Data Hiding Based on Improved Exploiting Modification Direction Method and Huffman Coding, Journal of Intelligent Systems, vol. 23 (4), pp. 451-459, doi. 10.1515/jisys-2014-0007.
4. T Saba, A Rehman, A Al-Dhelaan, M Al-Rodhaan (2014) Evaluation of current documents image denoising techniques: a comparative study , Applied Artificial Intelligence, vol.28 (9), pp. 879-887, doi. 10.1080/08839514.2014.954344.
5. M Harouni, MSM Rahim, M Al-Rodhaan, T Saba, A Rehman, A Al-Dhelaan (2014) Online Persian/Arabic script classification without contextual information, The Imaging Science

Journal, vol. 62(8), pp. 437-448, doi. 10.1179/1743131X14Y.0000000083.
6. Practical Aspects of Embedded System Design using Microcontrollers" By Jivan Parab, Santosh A. Shinde, Vinod G Shelake, Rajanish K. Kamat, Gourish M. Naik.
7. Asad, Engr Muhammad Mujtaba, Razali Bin Hassan, and Engr Fahad Sherwani. "Instructional Models For Enhancing The Performance Of Students And Workforce During Educational Training". Academ Arena 2014;6(3):27-31]. (ISSN 1553-992X).
8. MSM Rahim, SAM Isa, A Rehman, T Saba (2013) Evaluation of Adaptive Subdivision Method on Mobile Device 3D Research 4 (2), pp. 1-10.
9. A Nodehi, G Sulong, M Al-Rodhaan, A Al-Dhelaan, A Rehman, T Saba (2014) Intelligent fuzzy approach for fast fractal image compression, EURASIP Journal on Advances in Signal Processing, doi. 10.1186/1687-6180-2014-112.
10. JWJ Lung, MSH Salam, A Rehman, MSM Rahim, T Saba (2014) Fuzzy phoneme classification using multi-speaker vocal tract length normalization, IETE Technical Review, vol. 31 (2), pp. 128-136, doi. 10.1080/02564602.2014.892669.
11. Saba, T. and Altameem, A. (2013) Analysis of vision based systems to detect real time goal events in soccer videos, Applied Artificial Intelligence, vol. 27(7), pp. 656-667, doi. 10.1080/08839514.2013.787779.
12. A. Rehman and T. Saba (2012). Off-line cursive script recognition: current advances, comparisons and remaining problems, Artificial Intelligence Review, Vol. 37(4), pp.261-268. doi. 10.1007/s10462-011-9229-7.
13. Haron, H. Rehman, A. Adi, DIS, Lim, S.P. and Saba, T.(2012). Parameterization method on B-Spline curve. mathematical problems in engineering, vol. 2012, doi:10.1155/2012/640472.
14. T Saba, A Rehman, M Elarbi-Boudihir (2014). Methods And Strategies On Off-Line Cursive Touched Characters Segmentation: A Directional Review, Artificial Intelligence Review vol. 42 (4), pp. 1047-1066. doi 10.1007/s10462-011-9271-5.
15. A. Rehman and T. Saba (2011). Document skew estimation and correction: analysis of techniques, common problems and possible solutions Applied Artificial Intelligence, Vol. 25(9), pp. 769-787. doi. 10.1080/08839514.2011.607009.
16. T. Saba, A. Rehman and G. Sulong (2011) Improved statistical features for cursive character recognition" International Journal of Innovative Computing, Information and Control (IJICIC) vol. 7(9), pp. 5211-5224.
17. Z. F. Muhsin; A. Rehman; A. Altameem; T. Saba; M. Uddin (2014). Improved quadtree image segmentation approach to region information. the imaging science journal, vol. 62(1), pp. 56-62, doi. http://dx.doi.org/10.1179/1743131X13Y.0000000063.
18. Neamah, K. Mohamad, D. Saba, T. Rehman, A. (2014). Discriminative features mining for offline handwritten signature verification, 3D Research vol. 5(3), doi. 10.1007/s13319-013-0002-3 .
19. Saba T, Al-Zahrani S, Rehman A. (2012) Expert system for offline clinical guidelines and treatment Life Sci Journal, vol.9(4), pp. 2639-2658.
20. Mundher, M. Muhamad, D. Rehman, A. Saba, T. Kausar, F. (2014) Digital watermarking for images security using discrete slantlet transform, Applied Mathematics and Information Sciences Vol 8(6), PP: 2823-2830, doi.10.12785/amis/080618.
21. Norouzi, A. Rahim, MSM, Altameem, A. Saba, T. Rada, A.E. Rehman, A. and Uddin, M. (2014) Medical image segmentation methods, algorithms, and applications IETE Technical Review, Vol.31(3), doi. 10.1080/02564602.2014.906861.
22. H. Haron, A. Rehman, L.A. Wulandhari, T. Saba (2011). Improved vertex chain code based mapping algorithm for curve length estimation, Journal of Computer Science, Vol. 7(5), pp. 736-743, doi. 10.3844/jcssp.2011.736.743.
23. A Rehman, D. Mohammad, G Sulong, T Saba (2009). Simple and effective techniques for core-region detection and slant correction in offline script recognition Proceedings of IEEE International Conference on Signal and Image Processing Applications (ICSIPA'09), pp. 15-20.
24. A. Selamat, C. Phetchanchai, T. Saba, A. Rehman (2010). Index financial time series based on zigzag-perceptually important points, Journal of Computer Science, vol. 6(12), 1389-1395, doi. 10.3844/jcssp.2010.1389.1395.
25. A Rehman, F Kurniawan, T Saba (2011) An automatic approach for line detection and removal without smash-up characters, The Imaging Science Journal, vol. 59(3), pp. 177-182, doi. 10.1179/136821910X12863758415649.
26. T. Saba, A. Rehman, G. Sulong (2011) Cursive script segmentation with neural confidence, International Journal of Innovative Computing and Information Control (IJICIC), vol. 7(7), pp. 1-10.

8/3/2014