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Development of Programmable Integrated Circuit (PIC) Module with Multiple Outputs for Students Psychomotor Skill Enhancement

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Abstract. Programmable Integrated Circuit (PIC) module for educational purposes is developed based on the existing unsatisfactory PIC simulation which is not able to achieve the objective and learning outcome in enhancing the student's psychomotor aspect through circuit designing, installation and trouble shooting. The existing PIC programming through computer simulation, which students facing difficulty in observing and understanding the wiring assembly between the input module, PIC microcontroller and output modules. The development of PIC module has been designed and improved by increasing the number of output components,cost reduction and it is also user friendly. Furthermore, this PIC module is embedded with I/O module such as normally open push buttons, 12VDC motor, servomotor, LEDs light, LCD display, and seven-segment display. Newly developed PIC module can be programme and re-programme for various tasks. Based on students Lab Practical Assessment record, there is an average of 39% and 22% of improvement on knowledge and psychomotor skill respectively when students used newly developed PIC modules for laboratory practical work.

Introduction

PIC is extensively belong to microcontrollers family that manufactured by Microchip Technology Inc. A microcontroller is a microprocessor which has Input/Output (I/O) circuitry and build-in peripheral, allowing for interface directly with real-world devices such as sensors, switches, lights, buzzer, and motors. PIC simplifies the design of the logic and control systems, allowing complex behaviour to be design into a piece of electronics instruments. Its represent both the hardware (psychomotor skills) and software design (programming skills) and called as E*mbedded System* [1].

The role of PIC-programming in automation engineering education in polytechnic is quite significant. Automation technicians and engineers are normally trained in automation technology study programs where the Electrical Engineering Department, Polytechnic Sultan Salahuddin Abdul Aziz Shah (PSA) offer four main programmes namely Diploma in Electronic Engineering (Control), Diploma in Electronic Engineering, Diploma in Electronic Engineering (Medical) and Advance Diploma in Electronic Engineering (Medical). Engineering students should receive hands-on experience with PIC devices as a component in instrumentation and electronic courses. Understanding of control and PIC principles is anticipated to provide more job opportunities and good performance for engineering graduates [2].

Suitable equipment or trainer modules are unavailable to conduct partially the psychomotor skills aspect during the laboratory session in executing the educational objective for several courses such as *Embedded System Application*, *Embedded Robotic* and *Final Year Project*.

This development of PIC module also will focus more on students studying Programmable Integrated Circuit course that are offered in other programmes especially in Malaysian polytechnics system [3].

Existing Execution of PICs in Laboratory Assessment

PIC-programming and execution is learned best by practising with real devices, machines or in automation system [4, 5]. During the establishment of Sultan Salahuddin Abdul Aziz Shah Polytechnic in 1997, there was no suitable device prepared for teaching and learning. To overcome the absence of practical (psychomotor) assessment, educator only can provide graphical simulation that can be done through computer simulation as shown in Fig. 1. Furthermore, there are no suitable trainer available in market that can execute the output of PIC-programme in one small (embedded) and compact design [6, 7, 8, 9].

Fig. 1 Execution of graphical simulation through computer

The development of this module is based on the problems faced by the educator and also the students at Electrical Engineering Department, Sultan Salahuddin Abdul Aziz Shah Polytechnic. Learning PIC-programming is best by applying with the practical lab work. Unsuitable facilities at Electrical Engineering Department unable to meet the practical requirement outline in the educational syllabus. With regard to this, educators often face problems in complying with the syllabus requirement.

The existing approach used also does not enhance the students' circuit wiring skills. The use of PIC in teaching is considered vital as less of existing equipment can be used by students for gaining the psychomotor skills. Most equipment in the market also hardly meets the syllabus requirement.

The existing technique used barely needs any hand-on circuit wiring and this skill is hardly assess for students competency. Moreover, there are a great need to reform teaching methods and assessment tools, laboratory equipment and experiments, enhancing students' practical skills and practical ability, laying a good foundation for job and improving their social competitiveness and the quality of personnel training [10]. There are two main objectives in development of PIC module:

i) To enhance the students psychomotor skills for PIC related courses.
ii) Multiple types of output mechanisms embedded in the PIC hardware development.

Designed of the System

The PICs provide analogue and digital series of input and output that can be used to control the PIC module. Fig. 2 shows the block diagram of PIC module. It consists of PIC Module, Input Module, Output Module and Power Supply unit

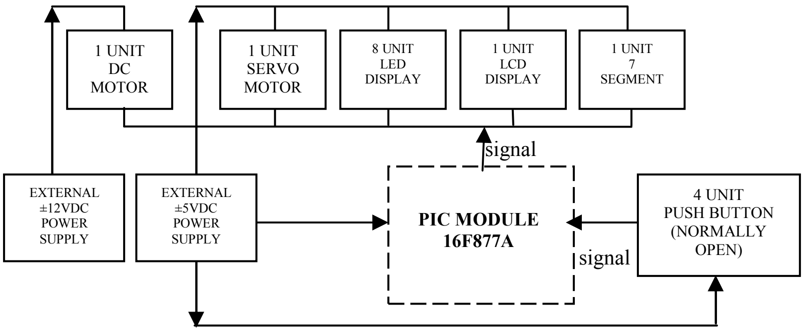

Fig. 2 Block diagram for complete PIC module

Building the PICs Module

Fig. 3 shows the power supply distribution for PICs module. The wiring starts from the 240 VAC power supply to the PIC interface board by using 5VDC and 12VDC for DC motor.

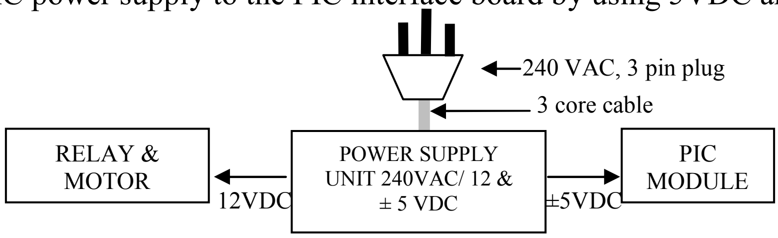

Fig. 3 240VAC supply power connection

The fabrications of this PIC module are set to three segments: the casing that is made of aluminium steel with 35^0 slanting panel, PIC module and Power Supply unit. The aluminium steel as the front panel is divided into three sections: PIC Programming Section, Input Section and Output Section as in Fig. 4.

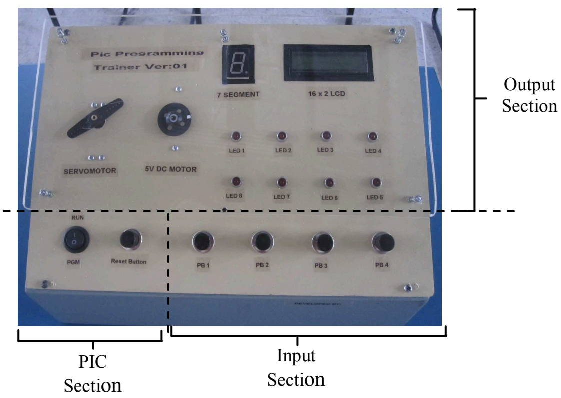

Fig. 4 Front panel view of PIC module

The PIC Programming Section is basically consists of the RUN/PROG switch and Reset Button. RUN is used to execute the program and when switched to PROGRAM is for write or download the HEX code generated by compiler program from computer to PIC microchip via USB cable.

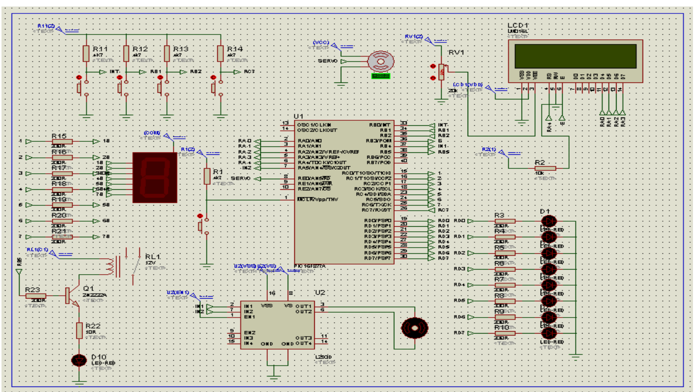

Fig. 5 Circuit design for PIC module

Input Section consists of four normally open push buttons and output section comprises of eight units of LED display, one unit of servomotor, one unit of 12VDC motor, one unit of seven segment display and one unit of 16 x 2 LCD display. The circuit diagram for the developed PIC module is shown in Fig. 5. The microprocessor used in this circuit is 40-pin PIC16F877A.

Implementation and Measurement Stages

In order to measure the enhancement of psychomotor skills, eight classes from the Electrical Engineering Department were asked to conduct the existing PIC laboratory (observing the graphical illustration of computer simulation on computer screen once finish programming) for their *Embedded System Application* (EC501) lab course.

To measure psychomotor skills, the students were assessed based on connection of power supply (240 VAC from bench supply to PIC module with safety precaution), USB connection (from PIC module USB port to computer USB port), writing programming code, compilation (debugging) and execution skills (run the program and observed the hardware output i.e: LED light On/Off, Servomotor/DC motor rotate clockwise/counter-clockwise, seven-segment display number and etc.). After the students carried out the practical task, they were required to submit a report to their educator. Again, they were asked to carry out the same practical task, but this time the newly design PIC module was used. Once they completed the practical task, the students were also required to submit a report. Based on Table 1, a total number of 228 students were involved in the assessment. By following a similar routine, the students were continuously assessed throughout the Jun 2013 session (from Jun 2013 till Dec 2013).

Table 1: Total Number of Students

Course Name	Programme Name	Class	No of Students
Embedded System Application (EC501)	Diploma in Electrical Engineering (Control)	DJK 5A	27
		DJK 5B	25
		DJK 5C	28
	Diploma in Electrical Engineering (Communication)	DEP 5A	31
		DEP 5B	30
		DEP 5C	28
	Diploma in Electrical Engineering (Medical)	DEU 5A	32
		DEU 5B	27
TOTAL			228

Table 2 and Table 3 compare the students' results based on identical practical tasks assigned using the existing PIC method as well as the PIC module. On the average, the students score 53% when using the existing PIC method as compared to 92% when using the PIC module. This indicates that there is a significant improvement of 39% in their marks when using the PIC module. Table 3 also shows that the score on their psychomotor skills (assessment on ability of student's to connect power supply (240 VAC)), USB connection (from PIC module USB port to computer USB port), writing programming code, compilation and execution skills (observe the output from the hardware i.e: LED On/Off, Servomotor/DC motor rotate, seven segment display number and etc.) also increases at an average of 22%. Since items for programming, discussion and conclusion (refer Table 2 and Table 3) are not relevant for assessing their psychomotor skills, the findings will not be discussed in this paper.

Table 2: Students Achievement Using Existing Graphical Technique

LAB PRACTICAL ASSESMENT ITEM FOR EC501: EMBEDDED SYSTEM APPLICATION						
CLASS	USING OLD VERSION OF PIC SIMULATION (SOFTWARE ONLY)					
	Attandance (5 %)	Wiring Skill (25 %)	Programming (20 %)	Discussion (30 %)	Conclusion (20 %)	Total (100 %)
DJK 5A	5%	0%	19%	13%	16%	53%
DJK 5B	5%	0%	19%	12%	17%	53%
DJK 5C	5%	0%	19%	13%	16%	53%
DEP 5A	5%	0%	19%	14%	16%	54%
DEP 5B	5%	0%	19%	13%	17%	54%
DEP 5C	5%	0%	18%	12%	16%	51%
DEU 5A	5%	0%	19%	12%	16%	52%
DEU 5B	5%	0%	19%	14%	16%	54%

Table 3: Students Achievement Using PIC Module

LAB PRACTICAL ASSESMENT ITEM FOR EC501: EMBEDDED SYSTEM APPLICATION							
CLASS	USING PIC MODULE (SOFTWARE AND HARDWARE)						% IMPROVEMENT
	Attandance (5 %)	Wiring Skill (25 %)	Programming (20 %)	Discussion (30 %)	Conclusion (20 %)	Total (100 %)	
DJK 5A	5%	22%	19%	28%	17%	91%	38%
DJK 5B	5%	23%	19%	28%	18%	93%	40%
DJK 5C	5%	22%	19%	27%	18%	91%	38%
DEP 5A	5%	23%	19%	28%	17%	92%	38%
DEP 5B	5%	22%	19%	27%	18%	91%	37%
DEP 5C	5%	22%	19%	27%	19%	92%	41%
DEU 5A	5%	23%	19%	28%	18%	93%	41%
DEU 5B	5%	22%	19%	28%	18%	92%	38%

In order to assess the psychomotor skill, it is based on standard rubric for Laboratory Assessment.

Conclusion

Through this newly developed PIC module trainer, it helps the students to achieve the objective and learning outcome in enhancing the psychomotor skill aspect through circuit designing, installation and trouble shooting. The development of PIC module has been designed and improved by increasing the number of output components, cost reduction, compact, and also it is user friendly whereby all the input and output components are build-in in one devices. Furthermore, this is supported by the Lab Practical Assessment record which shows that students have improved by an average of 39% and 22% on knowledge and psychomotor skills respectively.

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