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Development of Microcontroller Trainer Module for Embedded System Application Course in Politeknik Mukah

Full Paper

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Abstract

This paper describes the development of a microcontroller trainer module for the Embedded System Application course at Politeknik Mukah, using PIC18F45K22. To facilitate the learning process, the module was developed by offering hands-on instruction and practical skills in microcontroller programming. The aim of the proposed trainer module is to expose the student in creating the hardware of embedded system and microcontroller programming. The trainer was designed to produce an output based on the program that will be uploaded into PIC18F45K22 microcontroller. The trainer module was able to be used for practical work and mini projects based on course syllabus. From the proposed trainer module, students were able to demonstrate hardware output of the programming and enhance their knowledge for the DEC40053 Embedded System Application course.

Keywords: - PIC18f45k22, microcontroller, programming, trainer, hardware

1. Introduction

Microcontrollers serve an important role in technical education for teaching students the abilities and knowledge necessary to design, construct, and program embedded systems. To achieve this, the development of a microcontroller trainer module can offer students a practical learning opportunity that improves their comprehension of microcontroller programming for embedded systems. The performance, power consumption, and overall cost of the system are all impacted by the microcontroller choice for a given application. Microcontrollers from several families, including the PIC16F877A, ARM-based, PIC24F (24-bit), MOPICs, and PIC18F8722, have been extensively employed in the field of embedded systems because of their superior performance and functionality. However, PIC18F45K22 is regarded as the best option for this study due to its affordability, accessibility, and usability. Due to its simplicity of use and extensive programming choices, the PIC18F45K22 is the suitable choice in developing the trainer module for Embedded System Application course.

The PIC18F45K22 Trainer Module is a useful tool design to provide students with actual experience in microcontroller programming and creating embedded systems. It enables students to gain practical experience in creating embedded systems and microcontroller programming. The learner can experiment with various input and output set-ups, program the microcontroller using C programming languages, and debug and troubleshoot our code using this tool. It's an effective teaching tool that facilitates learning embedded system development and microcontroller programming through hands-on practice, making the ideas much clearer.

An embedded-based industrial temperature monitoring system utilising GSM was developed by Murugan, Periasamy and Muruganand (2012). Although the system was created for industrial use, it may also be useful for teaching and learning in educational settings. The system, for instance, might be used to instruct students on microcontroller programming and sensor and GSM interfaces. As a teaching and learning platform for embedded systems design, educational institutions frequently use the PIC16F877A microcontroller. In a GSM-based industrial temperature monitoring system, Murugan, Periasamy and Muruganand (2012) showed the utilisation of the PIC16F877A microcontroller (see Fig. 1). This project serves as a superb illustration of how the PIC16F877A microcontroller may be applied in practical settings. With the use of these tools, educators can create lab exercises, projects, and activities that are both interesting and useful for developing students' skills in embedded systems design and related areas.

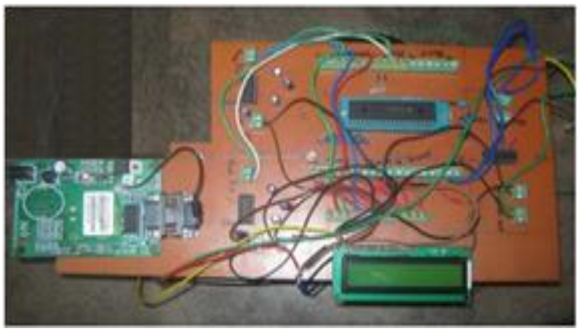

Fig. 1. Hardware set up (Murugan, Periasamy & Muruganand,2012)

The accessibility of low-cost hardware and software tools has LED to an increase in the use of microcontrollers in educational settings in recent years. A low-cost student experiment was created by Kommu, Kanchi and Varadarajula (2013) for the purpose of teaching an ARM-based embedded system laboratory. With the use of an ARM-based microcontroller, the study intended to give students practical experience designing and implementing embedded systems. According to the authors, the students who took part in the lab experiment showed a notable improvement in their comprehension of the ideas around embedded systems and microcontroller programming.

According to Aslam, Ahsan, Hannan, Hamza and Jaffery (2019), a software based PIC24F series microcontroller educational trainer was created to aid students in understanding the fundamentals of microcontroller programming. To program and simulate various microcontroller-based applications, the trainer's hardware and software components can be employed. The trainer's hardware comprises of a microcontroller board, power supply, and different input/output devices, while its software consists of a programming environment, simulation tools, and virtual hardware components (see Fig. 2). The trainer's primary processor is a microcontroller from the PIC24F series, which is also compatible with the MPLAB integrated development environment. The goal of this trainer is to give students a cheap and convenient way to learn about microcontrollers and embedded systems.

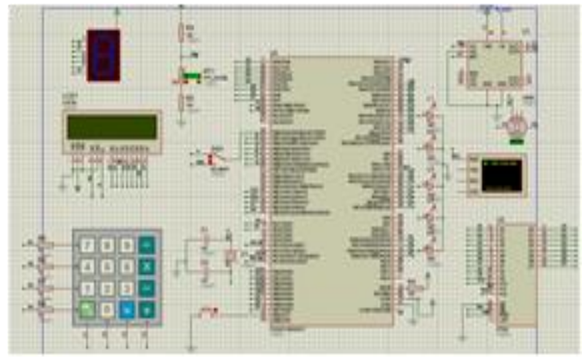

Fig. 2. Schematic for educational trainer (Aslam, Ahsan, Hannan, Hamza & Jaffery, 2019)

The creation of a Multiple Outputs Programmable Integrated Circuits (MOPICs) microcontroller trainer for educational applications has turned into a crucial part of teaching embedded systems, claim Burhan, Azman, Talib, and Aziz (2015). The hardware design was thoroughly analysed in the study, which made use of several peripheral devices like alphanumeric LCD, 7-segment display, relay, and LED. The MOPICs microcontroller trainer was created utilising a technique that included both hardware and software design, with the Proteus design suite software being utilised for the design phase. The dependability, cost-effectiveness, and adaptability of the MOPICs microcontroller trainer were tested and analysed, and the results demonstrated that the produced trainer could meet the requirements for embedded systems teaching. The study also discovered that students' learning experiences and comprehension of microcontroller programming were improved by the trainer's capacity to combine numerous peripheral devices.

Alfonso et al. (2012) claim that the authors created and carried out a lab experiment utilising a PIC18F8722 microcontroller. The goal of the project was to automatically measure an environment's humidity and temperature. To detect the temperature and humidity, the scientists employed a DHT11 sensor and a DS18B20 sensor, respectively. A script was written for the microcontroller to read the sensor values and show them on an LCD screen. The experiment was also managed by the authors using a real-time graphical user interface (GUI) built on a PC. The experiment's findings demonstrated that the system that was created could precisely measure and display temperature and humidity measurements. The system's performance was also assessed by the authors in terms of response time and power usage. Less than one second was discovered to be the system's response time, which was deemed suitable for real-time monitoring applications. The technology was discovered to have a low power consumption, making battery-powered applications possible. The study also highlighted the significance of building an effective system to reduce power consumption and choosing the right sensors and peripherals for a particular application.

In comparison to the PIC24F and ARM-based microcontrollers, the PIC18F45K22 has a smaller footprint and is more affordable, making it a good option for low-budget applications. The PIC18F45K22 is also great for battery-powered applications due to its low power consumption rate. Previous tests have shown that, although having an 8-bit architecture, the PIC18F45K22 nevertheless offers adequate performance for most embedded systems applications. Comparatively, PIC24F and ARM-based microcontrollers have 16-bit and 32-bit architectures, respectively, but they are typically more expensive and difficult to use, which can raise the cost of the whole system and lengthen the time it takes to create. Its affordability, availability, usability, and appropriate performance for the intended application make the PIC18F45K22 microcontroller a good choice for this trainer module.

2. Methodology

To ensure that the microcontroller trainer module for the Embedded System Application course at Politeknik Mukah is efficient in enhancing the learning experience for students, a thorough methodology is needed. The PIC18F45K22 microcontroller was chosen as the course's chosen device because it was both readily available and reasonably priced, as well as suitable for the course's goals. With a variety of I/O pins to allow users to communicate with other devices, the programmable training kit's architecture was made to give students a thorough learning environment for microcontroller programming.

2.1 Designing the Schematic Circuit

Proteus software was used to build the schematic circuit for the microcontroller training module. The PIC18F45K22 microcontroller's I/O pins, a 20MHz crystal oscillator, and a 5V voltage regulator circuit were among the crucial parts that needed to be chosen during the design process shown in Fig. 3. These parts were added to the circuit design using Proteus's component.

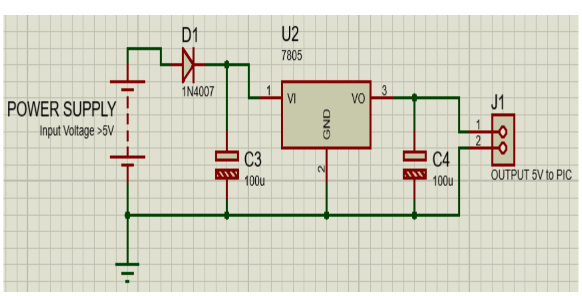

Fig. 3. Schematic of 5V voltage regulator circuit

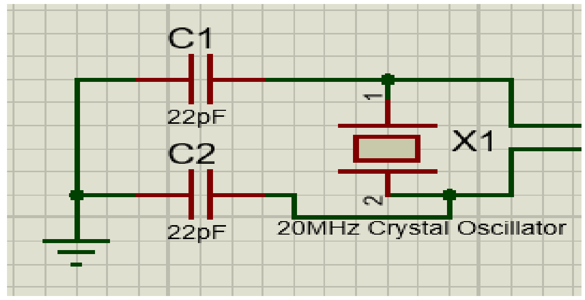

Fig. 4. Schematic of 20MHz crystal oscillator

The microprocessor and other components on the board require a consistent voltage supply, hence the main input of the circuit must be larger, then it will be step down which the 5V voltage regulator circuit was created to deliver. To give the microcontroller an accurate clock signal, a 20MHz crystal oscillator was added to the device as shown in Fig. 4.

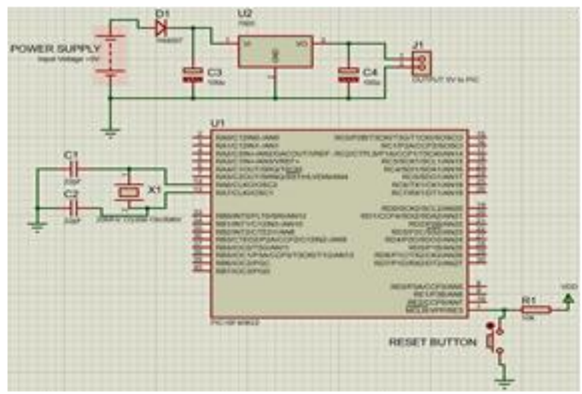

Fig. 5. Schematic of PIC18F45K22 trainer module

2.2 Producing the Module Prototype PCB

Making a printed circuit board (PCB) design from the schematic circuit diagram is the first stage in generating the hardware prototype. In the PCB design process, the electronic components are positioned on the board and the electrical connections are routed. The electronic components chosen in the schematic circuit diagram can be purchased and placed on the board once the PCB design is complete. This entails positioning each component on the PCB in its proper location and soldering it in place. To avoid harming the components or the circuit, it's crucial to check that the component polarity and orientation are right throughout construction. The components are 22pF ceramic capacitor, 100uF electrolytic capacitor, LM7805 voltage regulator, terminal block, input/output pin header, resistor, LED and push button.

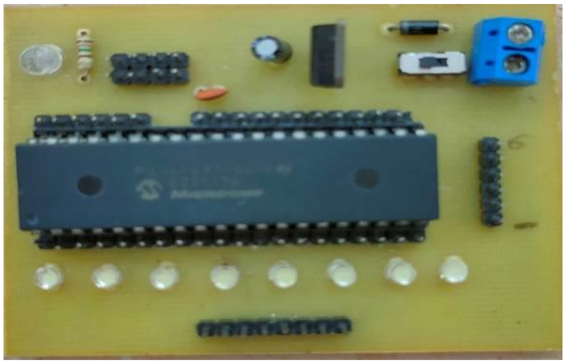

Fig. 6. PIC18F45K22 trainer module prototype

The circuit was tested to make sure it operates as expected after the PCB assembly was finished as shown in Fig. 6. To do this, the circuit must be powered up and the PIC18F45K22 microcontroller must be programmed with a test programme using a microcontroller programmer. To ensure that the circuit works, it should be tested with a range of input signals and output loads. Any problems or bugs found during testing should be investigated, fixed, and the PCB design or component assembly modified.

Once the prototype design was tested and operating accordingly, the PCB design was sent to the manufacturer to be fabricated. Fig. 7 shows the fully fabricated trainer module based on the PCB prototype.

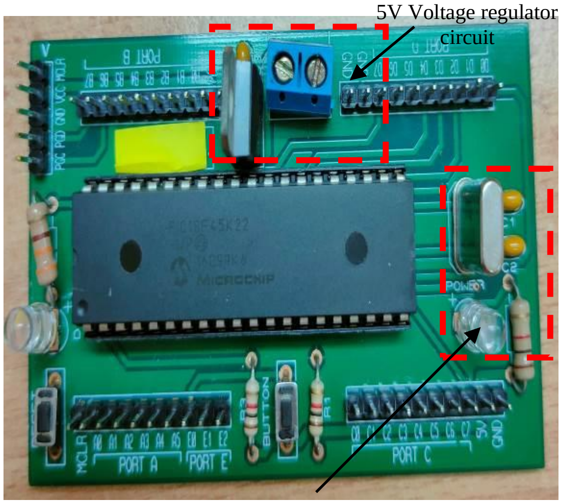

Fig. 7. PIC18F45K22 trainer module

Fig. 7 shows the magnified view of the 20MHz Crystal Oscillator circuit part on the PCB board of the trainer module. It is a must have component to provide accurate clock signal for the microcontroller when there is delay time used in the programming, specifically when TIMER programming implemented. The 5V voltage regulator circuit will provide stable and constant 5V voltage for the trainer module to enable the input output pin operating accordingly as programmed.

3. Result and Discussion

When the trainer module is connected to the power supply, a blue LED indicator will light on. This can be observed on Fig. 8. LED ON shows that the trainer module is receiving constant and stable 5V voltage.

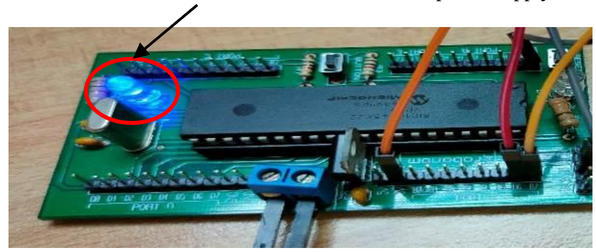

Fig. 8. Trainer module ON condition

Then the trainer module is connected to PIC programmer. Fig. 9 shows the jumper cable connection between the trainer module and the PIC programmer.

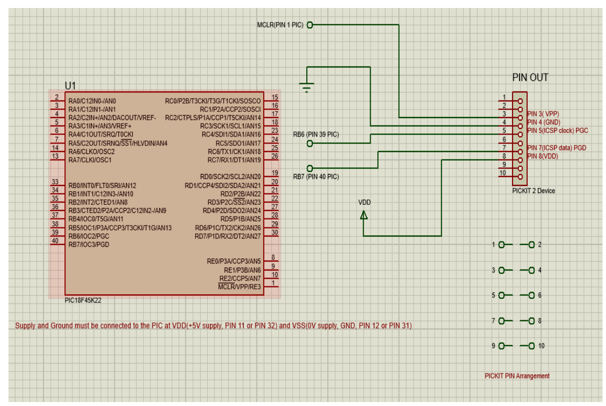

Fig. 9. Schematic guide to connect microcontroller with PIC programmer.

From the PIC programmer there are ten i/o pins but only five pins will be used. Pin 3 is connected to MCLR pin of the PIC, then pin 4 is connected to the ground of the trainer module. After that pin 5 is connected to the programming clock pin (PGC) that is at pin RB6 of the PIC, then pin 7 is connected to programming data (PGD) that is at pin RB7 of the PIC. Lastly pin 8 from the PIC programmer is connected to the VCC from the trainer module. Hence the result of the connection is shown in Fig. 10.

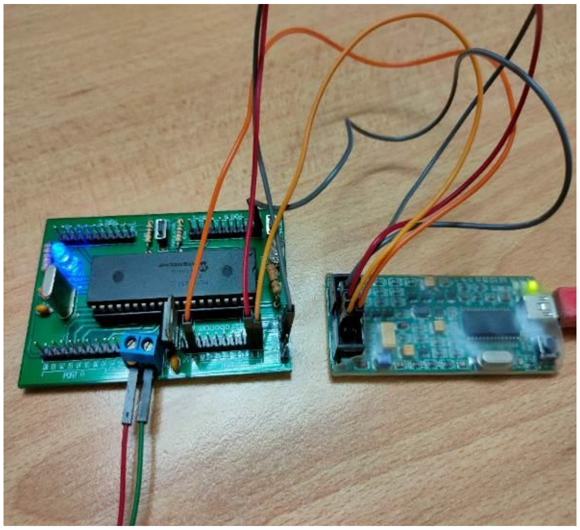

Fig. 10. Trainer module connection with the PIC programmer

When the connection is secure, PICKIT2 software will be open as the interface between the program and the hardware. Then the result of the connection will establish the communication between two devices and the software will detect the microcontroller and the result is as shown in Fig. 11. The results show that the PIC programmer detected that the trainer module is using PIC18F45K22 as the microcontroller.

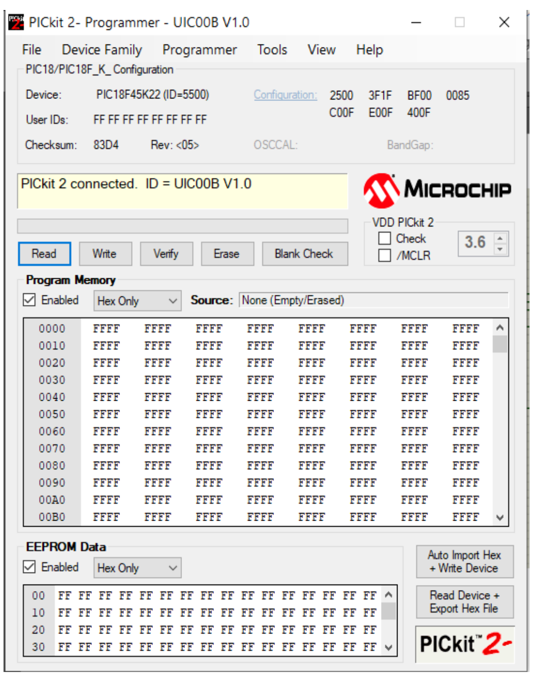

Fig. 11. Detecting the trainer module microcontroller

Once the trainer module and the PICKIT 2 interface were able to communicate, a testing program was uploaded to implement the hardware output. To enable the trainer module to operate in real time accordingly, there are four main configurations that need to be adjusted. The configuration is displayed in Table 1. Without the configuration bit setting, the program will be successful when built and compiled but only be able to simulate in the software.

Table 1. Configuration bit setting

Category	Option	Configuration Bit Setting
Oscillator Selection bits	HSHP	HS oscillator (high power > 16 MHz)
4X PLL Enable	OFF	Oscillator used directly
Power-up Timer Enable bit	OFF	Power up timer disabled
PORTB A/D Enable bit	OFF	PORTB<5:0> pins are configured as digital I/O on Reset

Once the configuration bit was configured, the trainer module will now be able to implement the output on the hardware.

3.1 Basic Input Output Circuit with Switch

To test the functionality of the trainer module input output, a basic input output program was designed using basic delay function. The schematic is as Fig. 12 below.

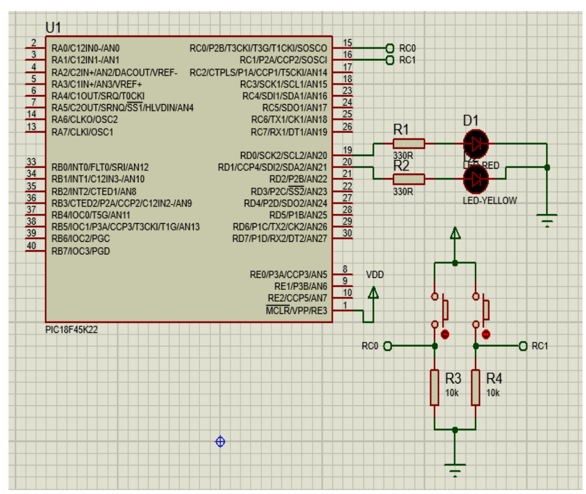

Fig. 12. Two LED and two switches

In this experiment, two switches are connected to RC0 and RC1 which is the input pin then two LED is connected to RD0 and RD1 pin which is the output pin. Once the program was successfully written in the trainer module, the output produced is as shown on Table 2.

Table 2. Output result

Input	Output
Both Switches off	LED 1 and LED 2 off
Only Switch 1 pressed	LED 1 blinking with 500ms LED 2 off
Only Switch 2 pressed	LED 2 blinking with 500ms delay LED 1 off
Both switches pressed	LED 1 on LED 2 blinking with 500ms delay

The hardware output operates accordingly with the programmed done. The hardware connection with the trainer module is shown in Fig. 13. The connection was done on a breadboard. The breadboard to connect the external input output hardware is to enable students to design the circuit and connection themselves and help them understand more on the topic tested.

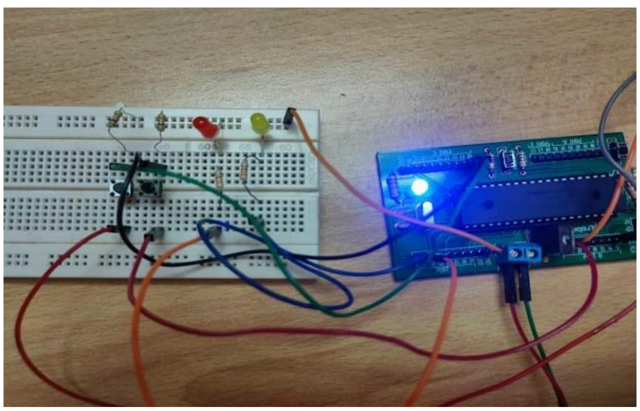

Fig. 13. Basic input output hardware connection

3.2 Interrupt Function

The other experiment tested is the interrupt function, the interrupt function utilized the output pin at RB0 for INT0 and RB1 for INT1. The schematic is as shown on Fig. 14. For this experiment is to demonstrate the dual interrupt function. The "while" program is both LED will turn on once the trainer module is turn on, then when INT0 is pressed LED1 will blink with 500ms delay, LED 2 will turn off, then when INT0 is pressed, LED 2 will blink with 500ms delay, LED1 will turn off. The result was summarized in Table 3.

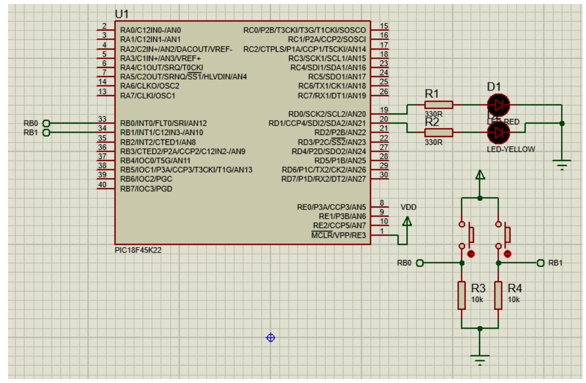

Fig. 14. Interrupt function

Table 3. Result on dual interrupt

Input	Output
When no interrupt occurs	Both LED turn on when trainer module is turn on.
INT0 Pressed	LED 1 blinking with 500ms LED 2 off
INT1 Pressed	LED 2 blinking with 500ms delay LED 1 off
Both interrupts pressed	No changes because only one interrupt can occur at one time

When both interrupt is pressed, no changes occur on the circuit due to only one interrupt can happen at one time. The previous interrupt will still occur until the other interrupt is executed. The hardware implementation interrupt circuit on the trainer module is shown in Fig. 15.

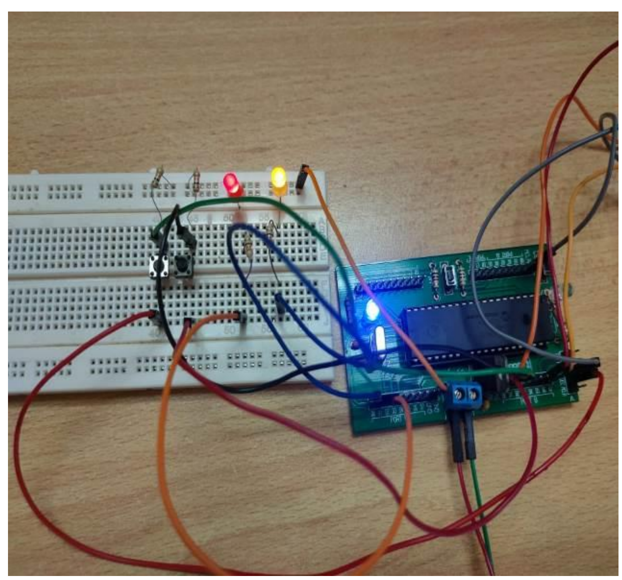

Fig. 15. Interrupt function hardware setup

4. Conclusion

The goal of this trainer module is to enable students to have hands on experience in executing their program into hardware. With a user-friendly design and easy to conduct module, students will be able to relate what they learn in theory and implement it in their practical work. Overall, Polytechnic Mukah students looking to obtain hands-on experience with microcontroller programming will find the PIC18F45K22 trainer module to be a useful educational tool. In the end, it will equip students for success in the field of electronics and embedded systems by allowing them to explore and develop a wide range of projects and applications.

Acknowledgement

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References

Alfonso, A. A., Pérez, S. R., Hernández, O. G., Mendoza, B. R., Valido, M. R., & Hernández, E. G. (2012, June). Utilizing a PIC18F8722 microcontroller to automate a laboratory experiment. In *2012 Technologies Applied to Electronics Teaching (TAEE)* (pp. 243-248). IEEE. doi: 10.1109/TAEE.2012.6235443.

Aslam, S., Ahsan, M., Hannan, S., Hamza, M., & Jaffery, M. (2019, February). Development of a software based PIC24F series microcontroller educational trainer. In *2019 International Conference on Engineering and Emerging Technologies (ICEET)* (pp. 1-5). IEEE. doi: 10.1109/CEET1.2019.8711853.

Burhan, I., Azman, A. A., Talib, S., & Aziz, A. A. A. (2015, December). Multiple Outputs Programmable Integrated Circuits (MOPICs) Microcontroller Trainer for Educational Applications. In *2015 3rd International Conference on Artificial Intelligence, Modelling and Simulation (AIMS)* (pp. 219-223). IEEE. doi: 10.1109/AIMS.2015.43.

Kommu, A., Kanchi, R. R., & Varadarajula, R. P. G. (2013, August). Design and development of a low-cost student experiments for teaching ARM based embedded system laboratory. In *Proceedings of 2013 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)* (pp. 515-520). IEEE. doi: 10.1109/TALE.2013.6654491.

Murugan, T., Periasamy, A., & Muruganand, S. (2012). Embedded based industrial temperature monitoring systems using GSM. *International Journal of Computer Applications*, *58*(19).