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**Laboratory 4**

**Group - 6**

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**OBJECTIVE**

The utmost objective of this laboratory experiment was to create a miniature water level controlling system mainly using the understanding of interrupts and the various other techniques that were learnt throughout the module. This development was done on the PIC16F877A microcontroller and was later implemented physically on a self-manufactured PCB board containing various components.

**INTRODUCTION**

PIC16F877A is a 40-pin PIC Microcontroller, designed using RISC architecture, manufactured by Microchip, and is used in Embedded projects. It has five Ports on it, starting from Port A to Port E. It has three Timers in it, two of which are 8-bit Timers while 1 is of 16 Bit. It supports many communication protocols like Serial Protocol, Parallel Protocol, I2C Protocol. It supports both hardware pin interrupts and timer interrupts. One of the main advantages is that it can be write-erase as many times as possible because it uses Flash memory Technology. PIC16F877A is being used in a number of different devices. It is used in several industrial instruments, home automation, security and safety equipment, and remote sensors. It also has an EEPROM, which enables the permanent storage of some data including transmitter codes, receiver frequencies, and some other data.

This lab is to develop a small water level controlling system of a water tank using the knowledge of interrupts and other programming techniques of PIC16F877A.

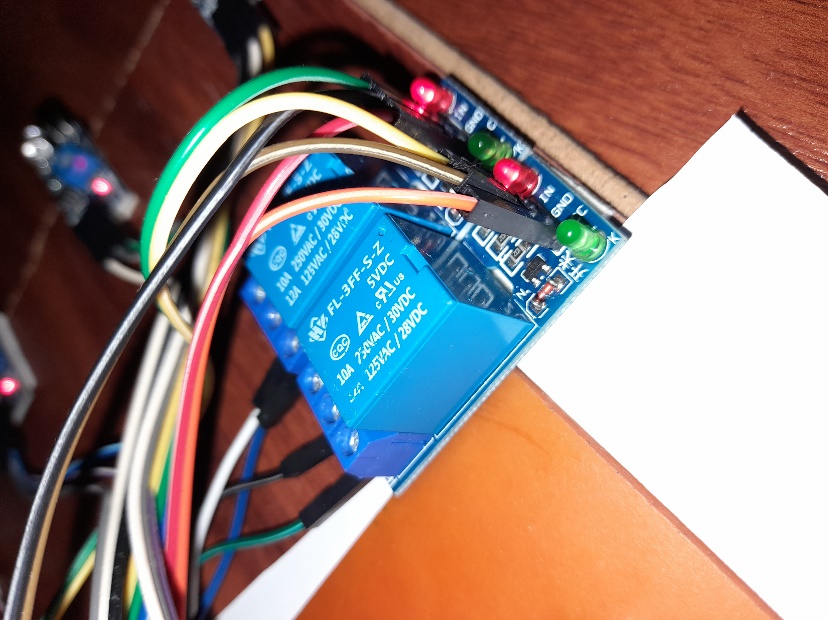
An interrupt is a signal sent by software to the processor informing it of an immediate activity. When an interrupt happens, the controller completes carrying out the current instruction and initiates the execution of an interrupt handler or Interrupt Service Routine (ISR). When an interrupt occurs, ISR instructs the processor or controller what to do. PIC 16F877A has the following 15 interrupt sources which are External, Timer 0, Timer 1, RB Port Change, Parallel Slave Port Read/Write, A/D Converter, USART Receive, USART Transmit, Synchronous Serial Port, CCP1 (Capture, Compare, PWM), CCP2  (Capture, Compare, PWM), TMR2 to PR2 Match, Comparator, EEPROM Write Operation, Bus Collision. There is only one external interrupt which is in PORTB0.

**APPARATUS**

* Breadboard
* PIC16F877A microcontroller
* 2×DC motors of each 5V
* 2×1 Channel Relay module (5V)
* LED bulbs
* 3× IR sensors
* 1.5 V DC batteries
* 2×330 Ω resistors
* 10 kΩ resistor
* 20 MHz oscillator
* Jumper wires
* 2×20 pF capacitors
* PCB raw materials such as Copper board, sandpaper, FeCl3 ,1mm drill bit and Driller

**Procedure**

* To make a PCB , it was first required to clean the copper surface from unwanted precipitates
* Secondly, the schematic that was created on the Proteus software was printed.
* Thirdly, the PCB board was soaked in water so that the print applied paper was fully rubbed off.
* Then, the PCB board was again dipped in FeCl3 solution and was properly shaken.
* Afterwards, the PCB board was removed from the FeCl3 solution and was cleaned using distilled water so that the remaining chemical solution was fully washed off.
* Later, the 1 mm drill bit was used to drill holes on the manufactured PCB board.
* Once the PCB board was made, it was cleaned properly to ensure the chemical precipitates were removed.
* After that, the components such as microcontroller base, capacitors, oscillators, and male & female headers were fixed and soldered using soldering lead.
* Then, the PIC16F877A microcontroller was placed on the attached base.
* Afterwards, the power supply for the PIC microcontroller was provided using the breadboard power supply and later the microcontroller was programmed using the PICKIT 3 programmer.
* Thereafter, the three IR sensors were connected to the input pins of the PIC microcontroller while the two relays were connected to the output pins of the microcontroller.
* Next, a separate power supply was employed to connect the DC motor. Here, the negative end of the DC motor was connected to the relay which was connected to the PIC microcontroller.
* Finally, the entire apparatus was fitted to a wooden board and the instrument was operated.



A picture containing text

Description automatically generated

Figure -1 Channel Relay module (5V)

Figure - 3 IR sensors were attached for the input

Diagram

Description automatically generated

Figure - The instrument assembled

**RESULTS**

The output pins were connected to both LEDs and DC motors. The results were obtained as follows,

Condition 1

For this instance, the sensor 1 had to be activated and according to the developed instrument, the green LED, and the MOTOR 1 was turned ON.

When the PORTB pin 2 was given logic high, logic high was given for PORTC pin 2

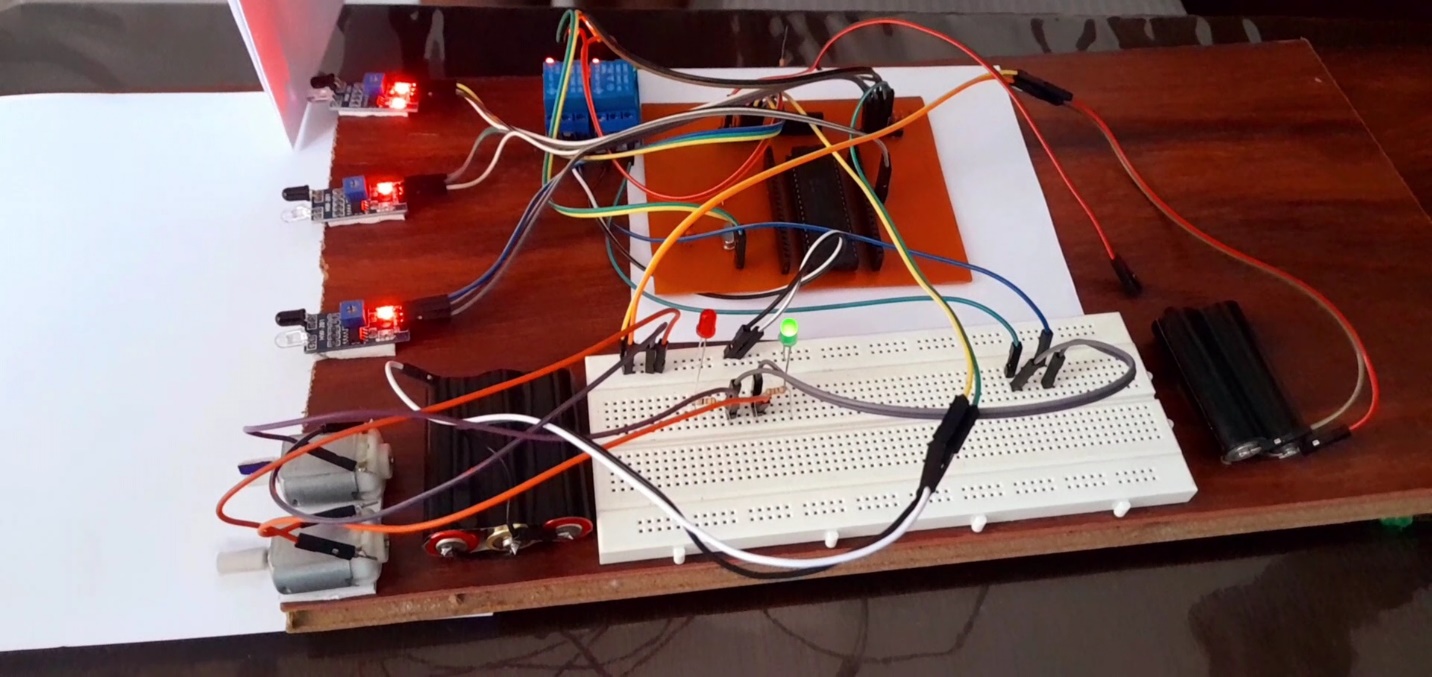


Figure -Execution of condition 1

Condition 2

For this instance, the sensor 1 and sensor 2 had to be activated and according to the developed instrument, the green LED, and the MOTOR 1 was turned ON.

When the PORTB pin 2 and PORTB pin 1 was given logic high, logic high was given for PORTC pin 2

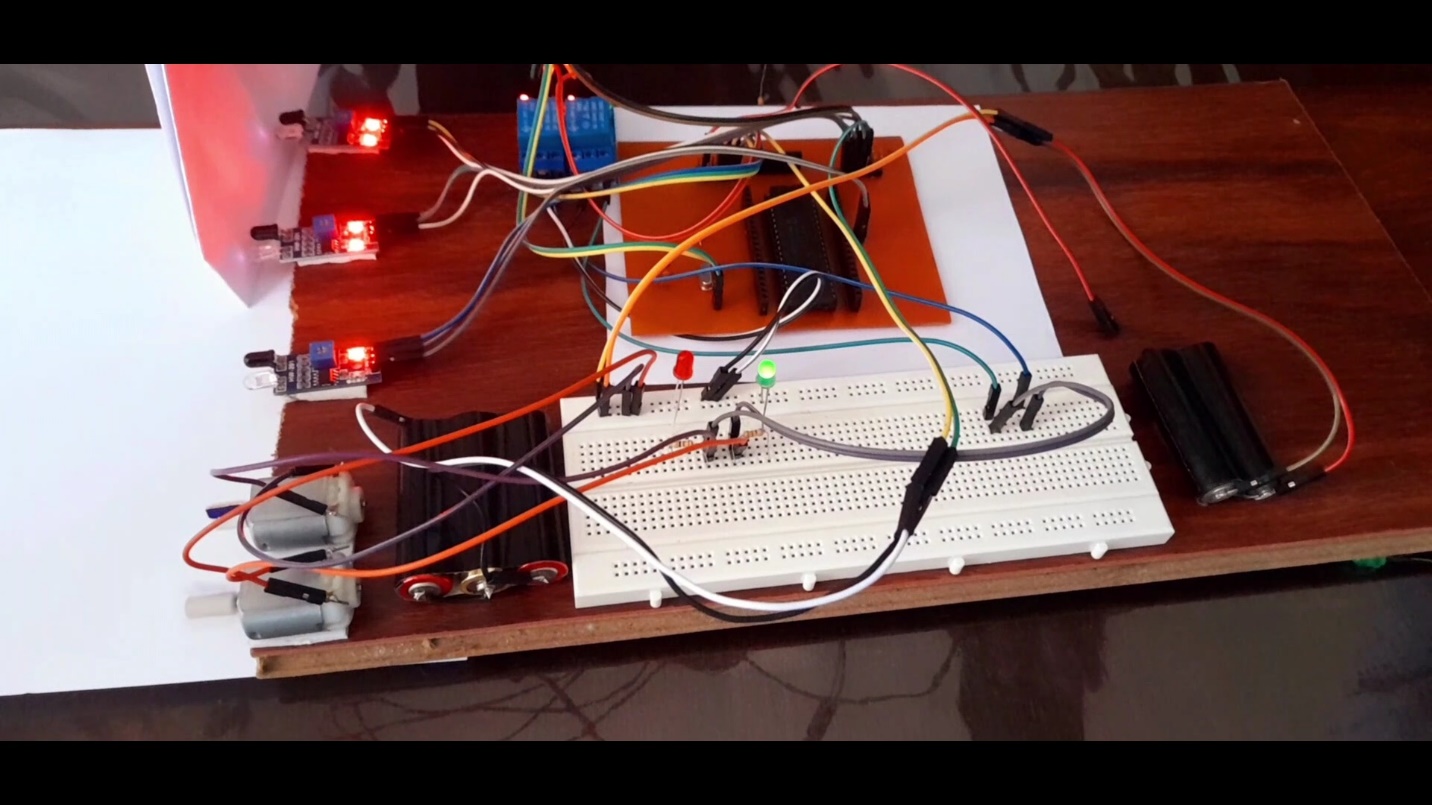


Figure -Execution of condition 2

Condition 3

For this instance, the sensors 1, 2 and 3 had to be activated and according to the developed instrument, the Red LED, and the MOTOR 2 were turned ON only for 500 milliseconds. (This was the interrupt service routine).

When the PORTB pin 2 , PORTB pin 1 and PORTB pin 0 were given logic high, logic high was given for PORTC pin 1 **ONLY for 500 milliseconds.**

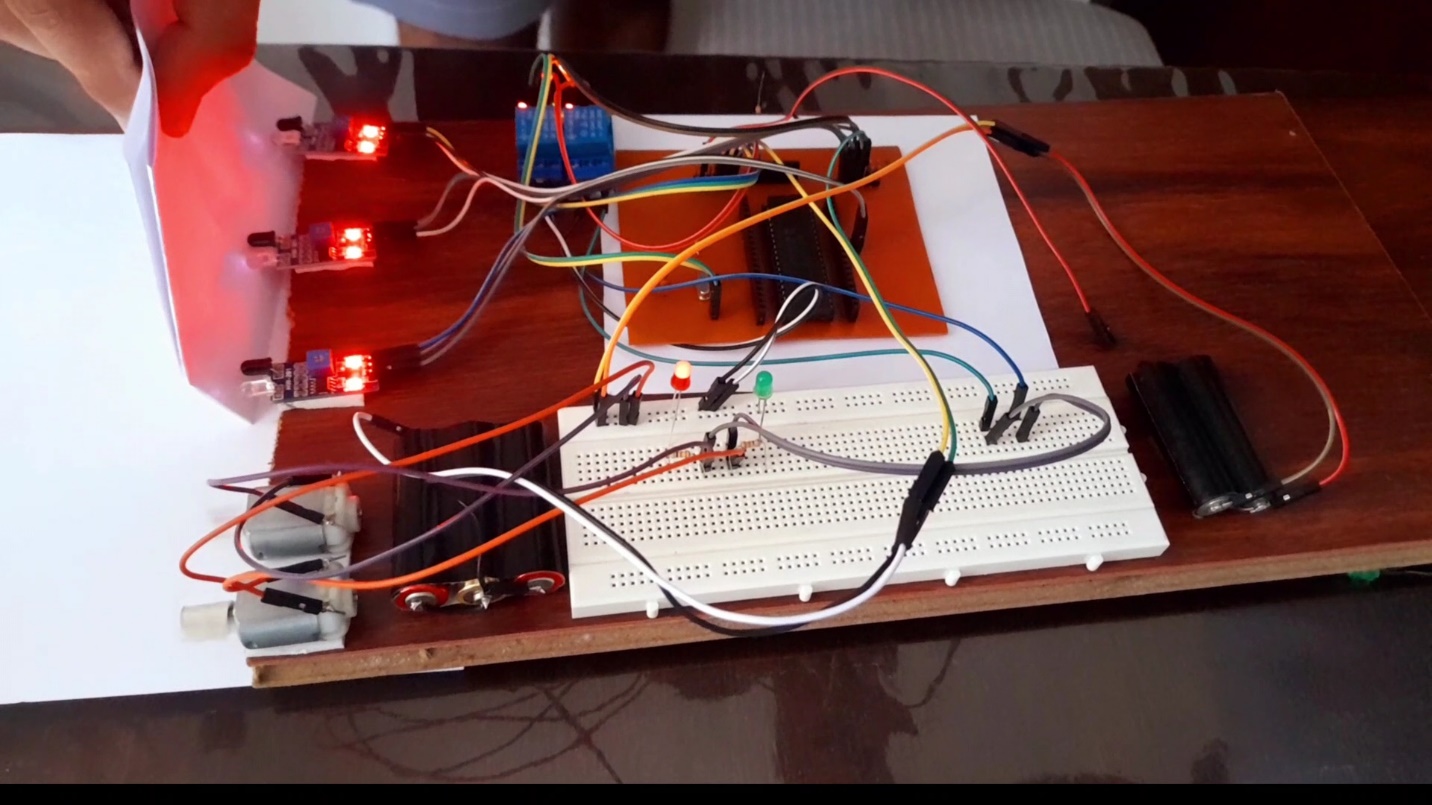
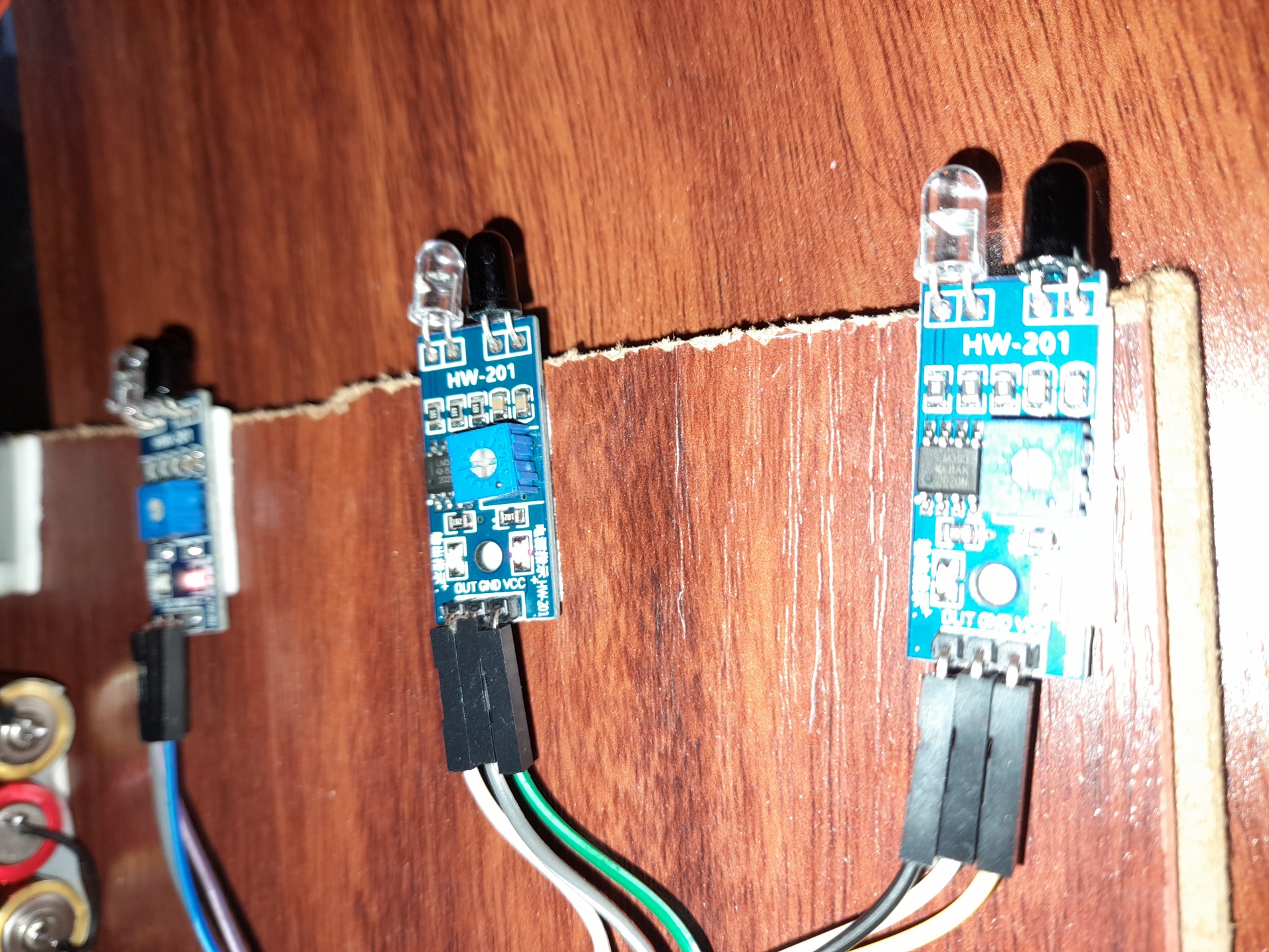


Figure -Execution of condition 3

**DISCUSSION**

* During the operation of the instrument, the sensitivity of the IR sensor was very high which caused it to detect even the slightest change of motion. However, this issue can be prevented by changing the resistance. For this purpose, there is a variable resistor on-top of each of the 3 IR sensors that were used.



Variable resistor

Figure - The IR sensor with a variable resistance as a screw

* There had been an error because of short circuit during the printing of the PCB design. This issue was prevented by disconnecting the short circuited region with a knife.

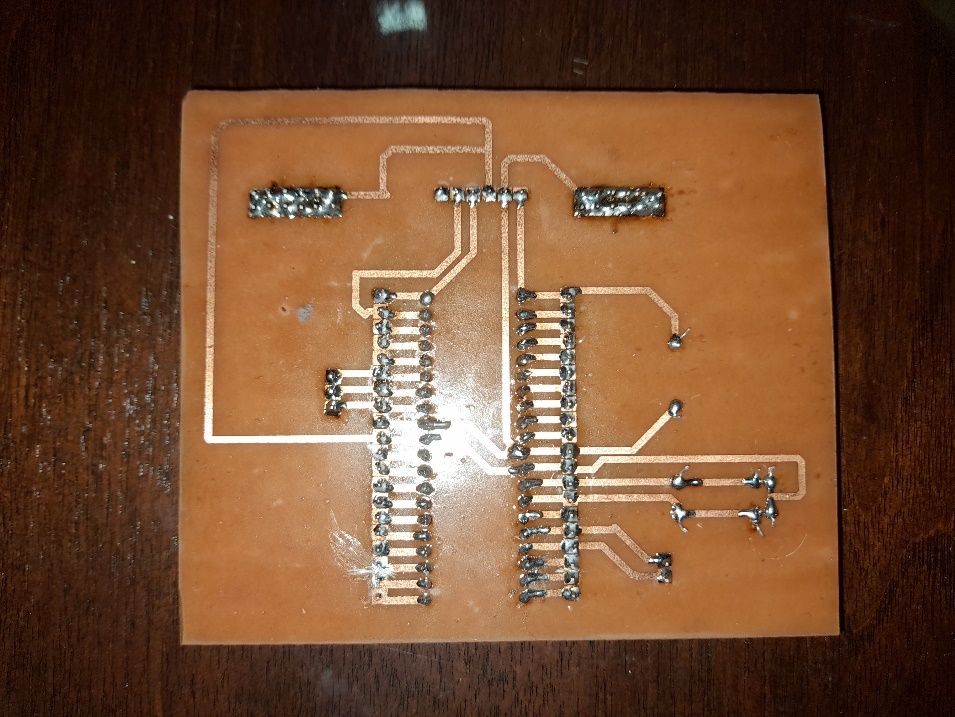


Figure - The manufactured PCB board

* Since the current supply was not enough to bear the load of the two DC motors, it was decided to utilize a two separate power supply in which one of those were connected to the motors while the other one was used for the rest of the PCB and its connected instrument.
* Infrared sensors are not commonly used for the surface water detection as the beam emitted by the sensors needs to be interrupted by a non-transparent edge, which is not the case with water.
* It was not possible to connect the two DC motors directly to the microcontroller. This is because the PIC16F877A microcontroller is only possible to supply merely a 100mA current which is not enough to operate the DC motors. Therefore, it was decided to use two separate 5V relay modules to be connected to the microcontroller output ports and connect the two DC motors to the relay modules.



Figure - Functioning relay module

**CONCLUSION**

This laboratory experiment was based on the water level controlling system that was physically made on a PCB board. The task was carried out by the PIC16F877A microcontroller for which the code was done on C language. In summary, it can be said that the experimental project was completed successfully. However, there were some issues and constraints related to the actual components itself which were rectified by substituting with the available instruments.

Moreover, it was an immense experience of understanding the procedure of manufacturing a PCB and learning to do soldering as well. It was also possible to understand on how the relay and sensors work. Additionally, it was also understood on the procedure of designing a PCB layout on the simulation software.

**APPENDIX**



Figure - Components of the developed instrument

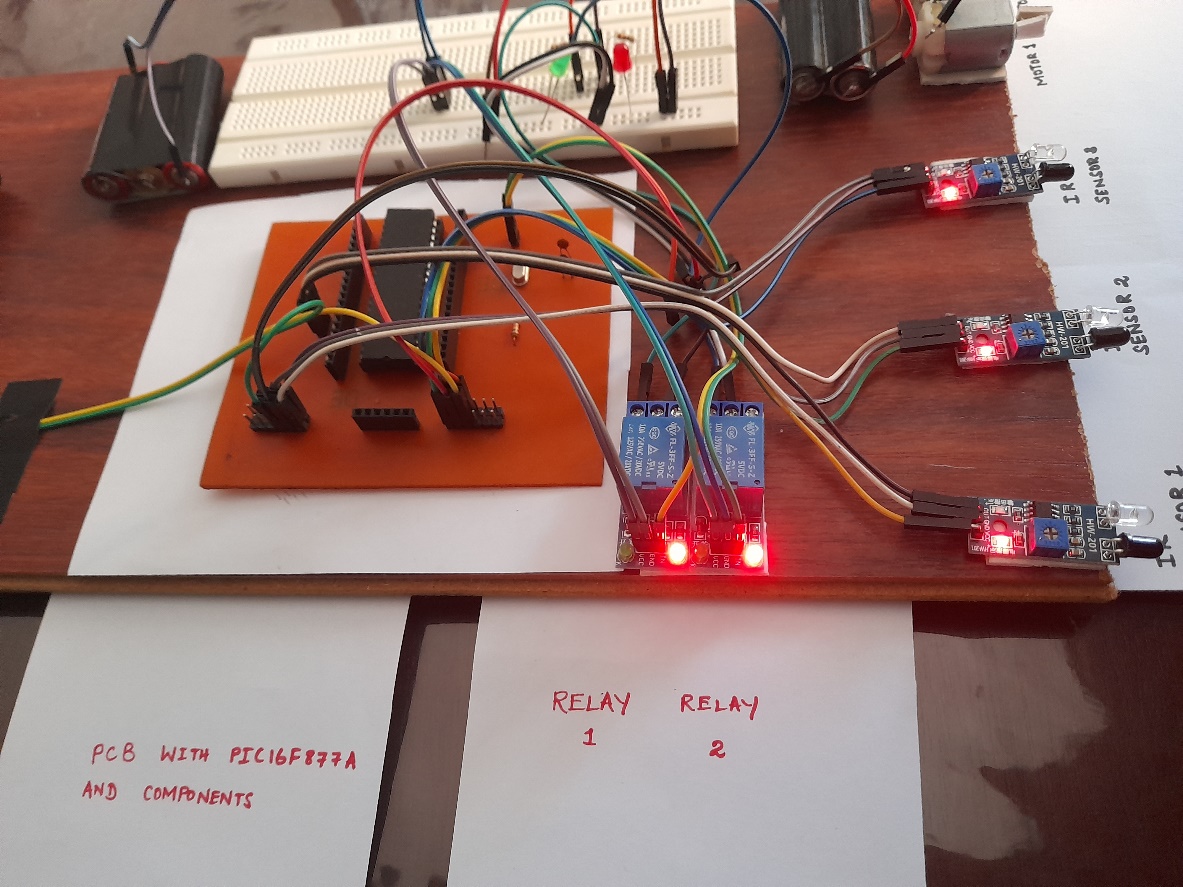


Figure -Testing the instrument



Figure -Finished instrument

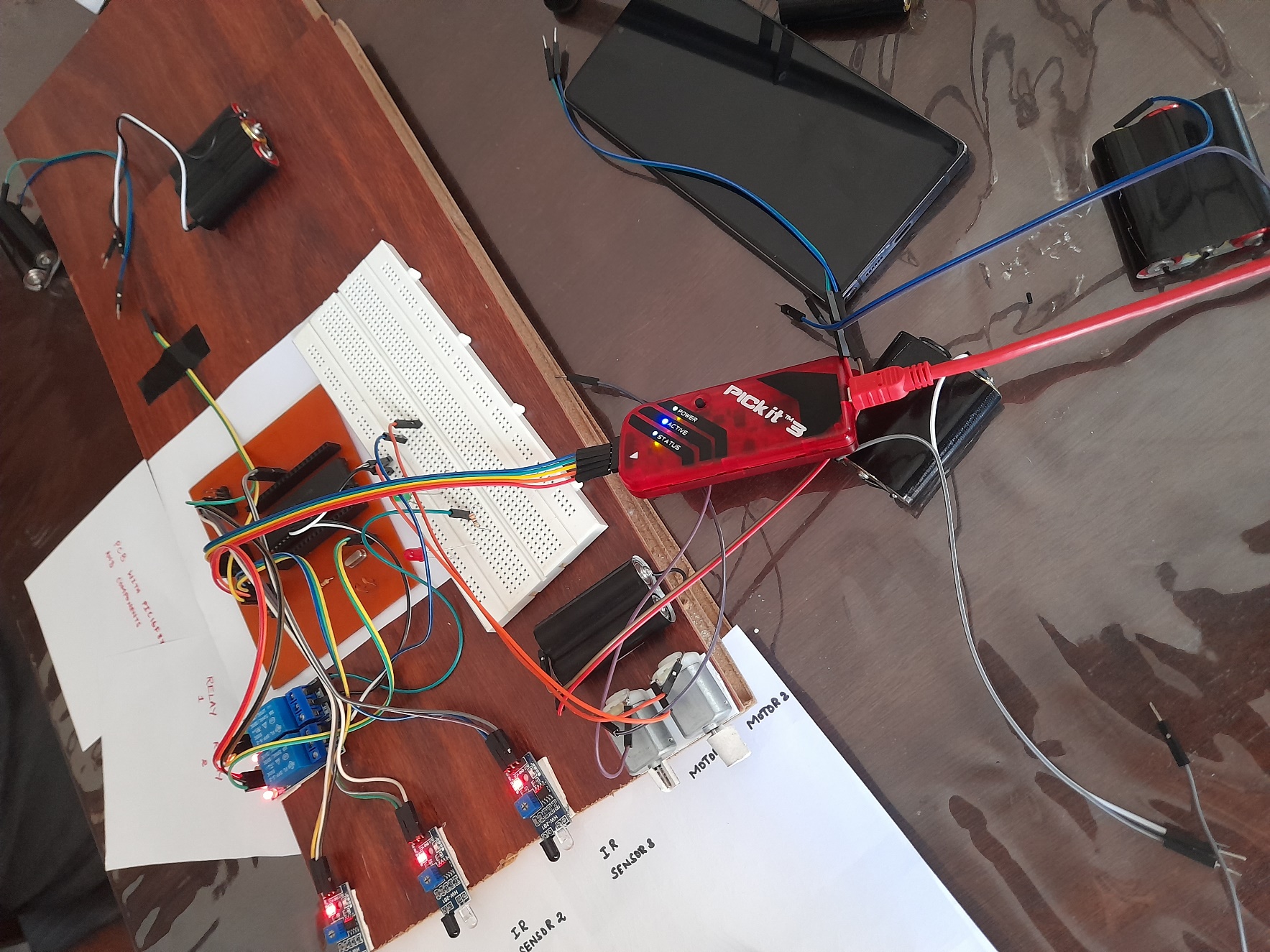


Figure - Programming the PIC16F877A

**REFERENCE**

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