Princess Sumaya University for Technology

King Abdullah II Faculty of Engineering

Princess Sumaya University for Technology جامعة الأميرة سميّة للتكنولوجيا

Embedded Systems & Microprocessors

"AUTOMATED CAR FIRE EXTINGUISHER"
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Abstract

In this project a PIC16F877A microcontroller was designed in the aim of creating an automated car that detects fire and stops it. Ultrasonic sensors, flame sensors and many other components were used to create a small robot that can guarantee a safe environment.

We were successfully able to build our project that aims to offer an effective solution in fire detecting and suppressing. The system was put through testings and it was proven that it can do the job it was designed for.

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I. Introduction

In an era defined by technological advancements, the importance of placing this technology in creating a safer environment for humankind has never been more evident. One of the most critical challenges that we are facing in the modern world is the need of advanced firefighting solutions that override traditional methods.

Traditional firefighting techniques face limitations in accessing hazardous spaces which makes it challenging to locate the source of the fire. The resource intensity traditional firefighting requires is also considered a main issue since in some cases the availability of these resources may be limited. Most importantly, traditional firefighting solutions are considered dangerous for humans.

The journey of identifying the problem and computing a solution led to the development of a firefighting robot. Although this machine is small in size, it's powerful enough to detect and extinguish fires. Equipped with sophisticated sensors and intelligent control mechanisms, this robot is designed to autonomously navigate its surroundings, detects fire and implements preventive measures. With that we minimize human exposure to potential dangers. In some scenarios where immediate response is crucial, the capabilities of this robot become invaluable. By developing this technology, we aim to enhance the overall efficiency of firefighting efforts.

Main Idea of the Designed Project

The designed project has two main objectives. Navigating surroundings and alerting in case fire was detected then extinguishing the detected fire.

The following are the main components used for each part:

<u>To navigate surroundings:</u>

- Ultrasonic sensor that is used to detect the distance between the robot and the obstacles around to make sure it doesn't collide with any obstacle.
- Flame sensors to detect fire so that the robot could take action.
- DC motors & servo motors to help the robot move around and sense its surroundings more effectively.

<u>To extinguish fire:</u>

- Buzzer that serves as an alert system on the robot.
- Relay and water pump which work together to extinguish a fire, such that the relay works as a switch that turns on the water pump.

The process starts with the robot's movement, coupled with the activation of flame sensors to check the presence of fire. Upon detecting fire, the flame sensor transmits a signal to the microcontroller via the receiver. This triggers the activation of the buzzer for alerting purposes. Simultaneously, the microcontroller records the angle of the detected fire, prompting the robot to adjust its position. Subsequently, the water pump is aligned with the fire's location, starting the fire extinguishing process.
Conversely, if none of the sensors detect any fire, the receiver transmits a signal to the microcontroller, indicating a safe environment. The robot then proceeds to the next area for assessment.

Flow Diagram

The following is a flow diagram that represents the design of the project:

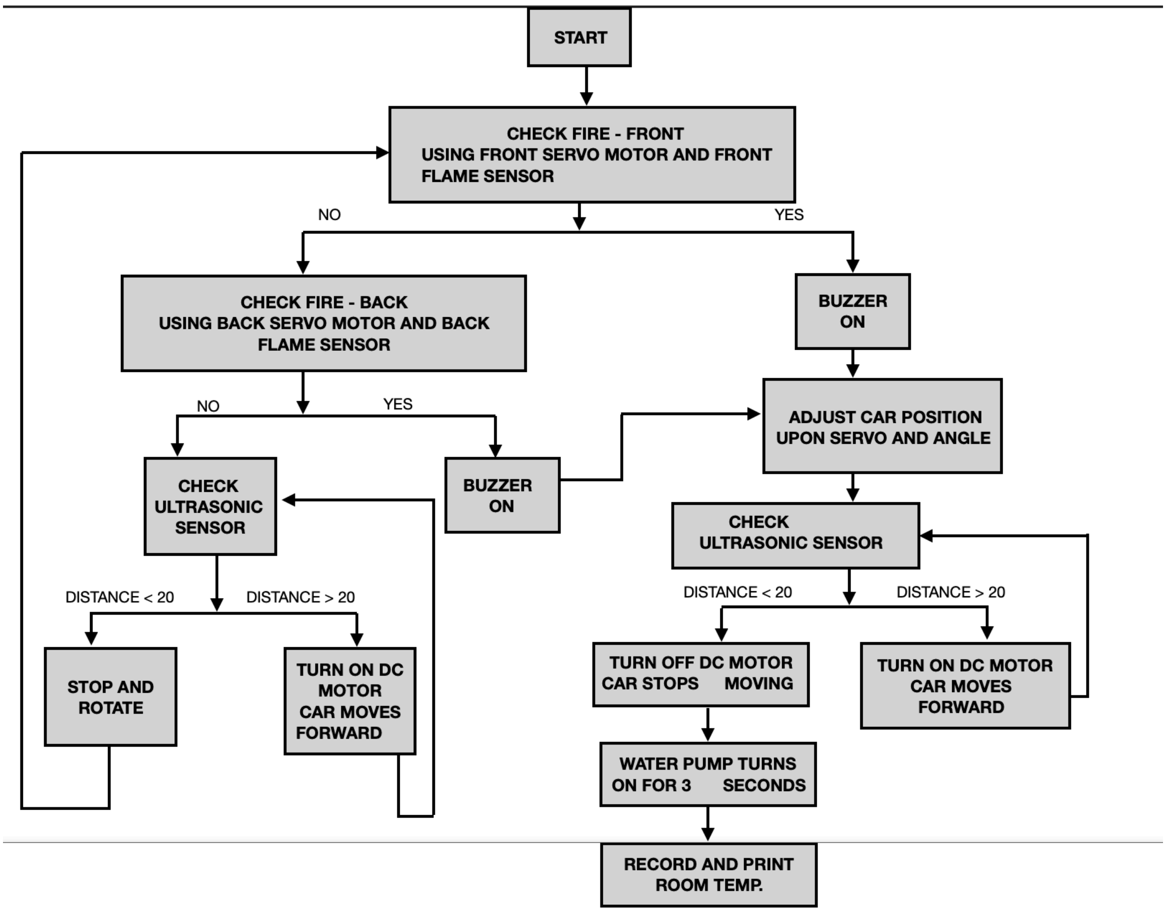


Figure (1): Flow Diagram

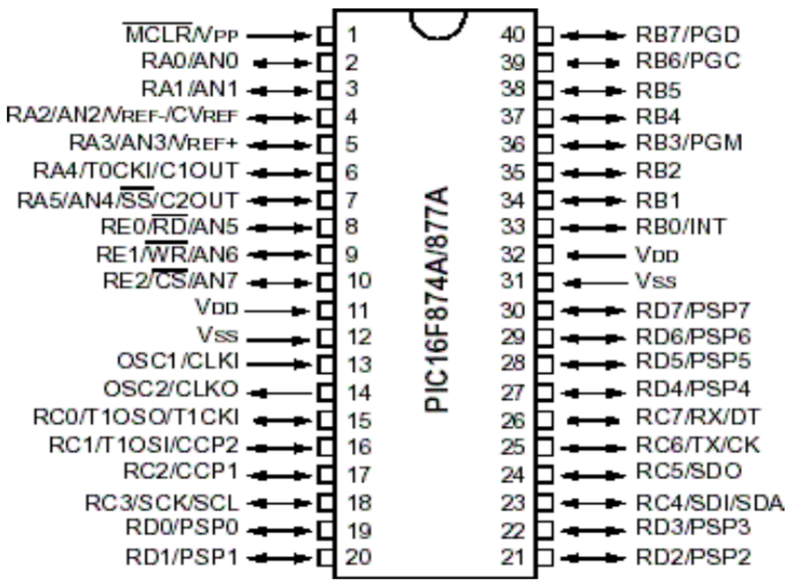
II. Overview of the Used Components

This section will provide a concise overview of the components employed in our project and outline the methods through which we incorporated them.

A. PIN16F877A Microcontroller

The PIC16F877A is a widely used microcontroller that has 40 pins, 35 of which are I/O pins. It comes with many built-in functions, such as timers, ADC, and PWM. It's used in lots of different fields like industrial control systems, home automation and IoT. It features 8K of program memory and 368 bytes of RAM, which makes it unique in the industry. The PIC16F877A stands as a user-friendly, contributing to its widespread popularity.

In Figure 2, you can see what the PIC16F877A looks like and where its output pins are.



Figure(2): PIC17F877A Pins

The following table illustrates the pins of the microcontroller and how they were used:

Pin Number	Port Name	Use
2	RA0	Temperature Sensor
25	RC6	Ultrasonic Sensor Trigger Pin
24	RC5	Ultrasonic Sensor Echo Pin
23	RC4	Servo Motor (2) Back
18	RC3	Servo Motor (1) Front
17	RC2	CCP1 Motor Enable(Left)
16	RC1	CCP2 Motor Enable (Right)
40	RB7	Flame Sensor - Front
39	RB6	LCD D7
38	RB5	LCD D6
37	RB4	LCD D5
36	RB3	LCD D4
35	RB2	LCD EN
34	RB1	LCD RS
30	RD7	DC Motor
29	RD6	DC Motor
28	RD5	DC Motor
27	RD4	DC Motor
22	RD3	Relay Module

Table(1)

Pin Number	Port Name	Use
21	RD2	Buzzer
20	RD1	Green LED
19	RD0	Flame Sensor - Back

Table(1)

B. Flame Sensor

The flame sensor Model FC-01-H is a device designed to detect the presence of flames. It works by sensing the infrared light emitted by flames. When it detects a flame, the sensor sends a signal, indicating that a fire is present. This type of flame sensor is commonly used in various applications, such as fire detection systems and robotics, to provide a quick response to potential fire hazards.

Figure(3): Flame Sensor

The flame sensor has four pins, we used three of them:

- GND pin that is connected to the breadboard's ground.
- VCC pin that connected to an external 5V DC power supply, which is the H-Bridge.
- Digital utput pin connected to the output pins RB7 and RD0 on the PIC16F877A, such that the flame sensor that's placed in the front is linked to the pin RB7 and the one placed in the back is linked to RD0.

C. Ultrasonic Sensor

The ultrasonic sensor Model HC-SR04 is a distance measuring device. It operates by sending ultrasonic waves and measuring the time it takes for the waves to bounce back after hitting an object. This sensor consists of a transmitter that emits ultrasonic pulses and a receiver that detects the reflected signals.

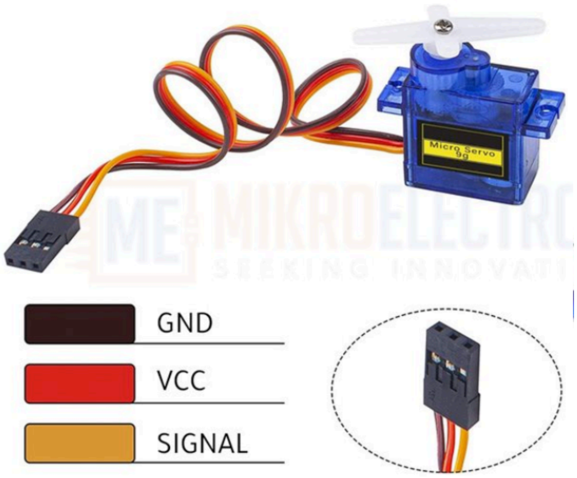
Figure(4): Ultrasonic Sensor

The ultrasonic sensor used in this project was linked to the PIC16F877A as follows:

- Triggering pin was connected to the output pin RC6 of the microcontroller.
- Echo pin was connected to the input pin RC5 of the microcontroller.
- GND pin was connected to the breadboard's GND pin.
- +5V pin is connected to an external 5V DC supplier.

D. Servo Motors

The Mini Servo Motor SG90 that was used for this project is a small yet a powerful device used in electronics projects. It is designed to control the movement of various parts in response to electrical signals. When connected to a microcontroller, the servo motor responds to signals, allowing it to rotate to a specified angle.



Figure(5): Servo Motor

For this project, two servo motors were used. One was placed in the front and the other one in the back.

Servo Motors Linking:

For the power supply, we connected the VCC pin of the servo motors to an external +5V DC supplier which is the same power supply linked to the PIC16F877A, and the GND pin was connected to the breadboard's GND pin. To control the signal flow, the signal pin of the front servo motor was connected to the output pin RC3, and for the servo motor placed in the back, it was linked to the output pin RC4 on the PIC16F877A.

E. DC Motors

The motor converts electrical energy into mechanical energy, driving the rotation of the wheels. The movement of the motor, when appropriately controlled, determines the speed and direction of the robot car.

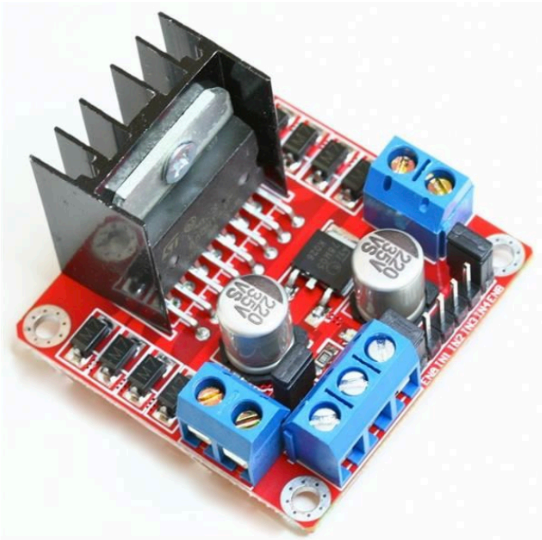
Both DC motors used for this project are powered through the H-Bridge, in which is linked to the microcontroller to pins RD4, RD5, RD6 and RD7 to control the direction of the wheels.

We used the PWM feature of the microcontroller to control the speed of the motors of the car. The pins used were port C1 (CCP2) connected to ENA and port C2 (CCP1) connected to ENB.

Figure(6): DC Motor

F. H-Bridge

The H-bridge is the interface between the PIC16F877A microcontroller and the motors of the automated car. It allows precise and controlled movements, facilitating the effective response of the car to fire incidents.



Figure(7): H-Bridge

The H-Bridge used for this project is connected to two motors through the output pins. As for the PIC16F877A microcontroller, the H-Bridge's input pins are connected to the output pins RD4, RD5, RD6 and RD7 and the motor enablers are linked to the pins RC1 and RC2 of the microcontroller.

G. Relay Module and Water Pump

The relay module is like a switch that is controlled by electricity. It allows a low-power electrical signal, such as from a microcontroller or sensor, to control a higher-power circuit, like the one connected to a water pump. In our project, the relay allows the microcontroller to turn on the water pump without directly handling the higher voltage required for the pump's operation.

Figure(8): Relay Module

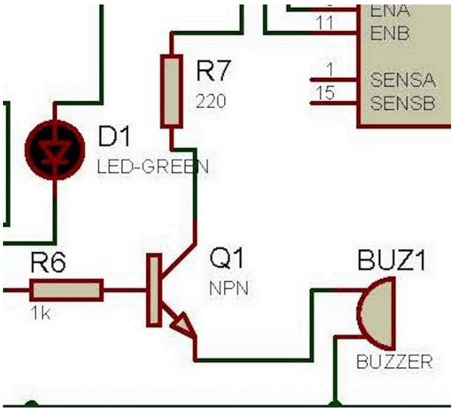
Figure(9): Water Pump

The input pin of the relay module is connected to the output pin RD3, the GND is connected to the breadboard's ground, and the VCC pin is connected to an external +5V DC power supply. The output pins of the relay are connected to the water pump with a +4.5V DC power supply that's only linked to the water pump.

H. Buzzer

The buzzer likely plays a crucial role in alerting users or nearby individuals when the robot detects a fire or encounters a critical situation. It serves as an audible indicator for the need of attention or action.

Figure(10): Buzzer



Figure(11): Buzzer Circuit Diagram

Figure(11) illustrated how we configured our buzzer and linked it to the microcontroller. We used 2222A NPN with the resistors mentioned above.

I. LCD Display

The 16x2 LCD display operated in this project in 4-bit-mode acts as a visual output device. It plays a crucial role in making the project more user-friendly and providing valuable feedback about the system's state and operation.

Figure(12): LCD Display

Control pins on the LCD were connected as follows:

- RS - Register Select: linked to pin RB1 on the microcontroller.
- RW - Read or Write: linked to GND.
- E - Enable: linked to pin RB2 on the microcontroller.

To connect power and ground pins on the LCD, VSS pin was connected to GND, and the VDD pin was connected to an external +5V DC power supply. The VEE pin was connected to a potentiometer to allow manual adjustment of the contrast of character displayed on the LCD.
The data pins D4, D5, D6, D7 of the LCD were connected to the digital output pins RB3, RB4, RB5 and RB6 on the microcontroller.

J. Temperature Sensor

The temperature sensor used for this project was the LM35. It's an analog temperature sensor that provide accurate temperature readings in a straightforward manner.

Figure(13): Temperature Sensor

Since the LM35 is an analog temperature sensor, we needed to connect it to one of the analog input pins of the PIC16F877A which is RA0.
LM35 temperature sensor has zero offset voltage, which means at 0°C the output will be 0V. The maximum voltage it can handle is 1.5V which means it can be able to sense a maximum temperature of 150°C (1.5V / 10mV).
As we already told that LM35 gives analog output, so first we need to read that analog values using PIC Microcontroller and then we will convert them into digital values using ADC (Analog to Digital Conversion).

III. Equations and Guidelines

1. Ultrasonic Sensor

When using the HC-SR04 to measure distance, we send a pulse for 10 microseconds to the sensor's trigger pin. The transmitter circuit responds by releasing eight pulses of 40 kHz ultrasonic sound into the atmosphere. As a result, the transmitter circuit transforms the electrical signal into an 8-pulse, 40 kHz burst.
Once an 8-pulse transfer from an ultrasonic transmitter circuit is complete. The echo pin goes high. The echo pin stays active high until the ultrasonic sound wave hits the object under test and does not bounce back to the receiver circuit. The echo pin becomes low as soon as the receiver circuit picks up an ultrasonic signal from an item that has been struck.
Assume that the PIC16F887 timer was used to measure the pulse length. How to convert the pulse duration (t) into distance. By using the well-known distance, time, and speed equation, we may translate the pulse duration (t) into the distance (S).

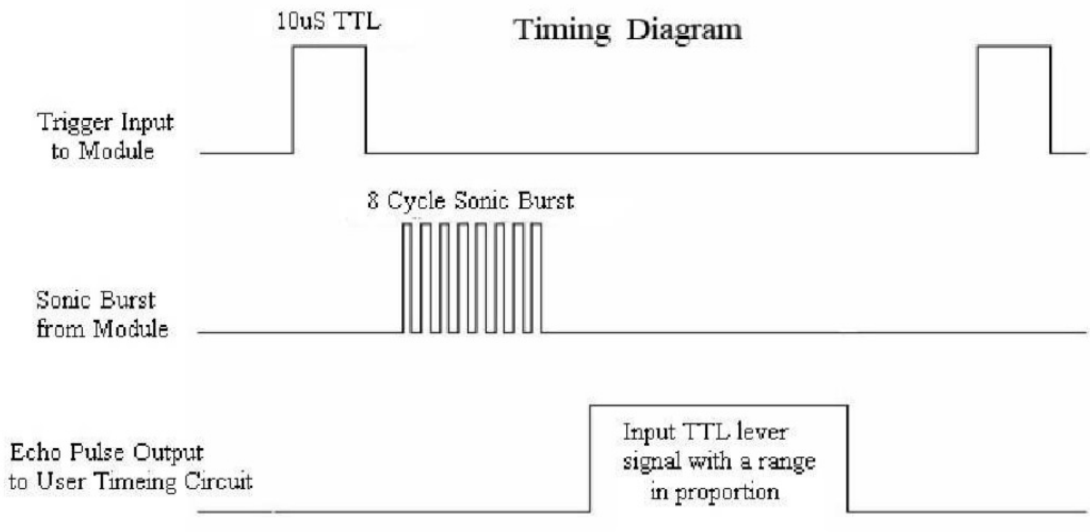
$$\text{Distance } (S) = \text{Speed } (v) * t$$

Here, V represents the airborne ultrasonic wave speed. The speed of sound, which is 340 m/s, is equivalent to the speed of ultrasonic waves in air (meter per second). As a result, the equation above becomes:

$$S = 340 * t \text{ (distance in meters)}$$

The outcome of the equation above is the distance measured in meters. However, multiply 340 by 100 if you want the distance in centimeters. Moreover, divide it by 2 to obtain one path distance.

$$S = (34000 * t) / 2 \text{ (distance in centimeters)}$$



As shown in the image above, we will use the Pic microcontroller to deliver a trigger pulse to the sensor that lasts at least 10 microseconds. The sensor will then produce an 8-cycle sound burst after that. After striking obstacles, this electrical burst returns. The time it takes for an electrical burst to send and receive back will be produced by the echo pin.

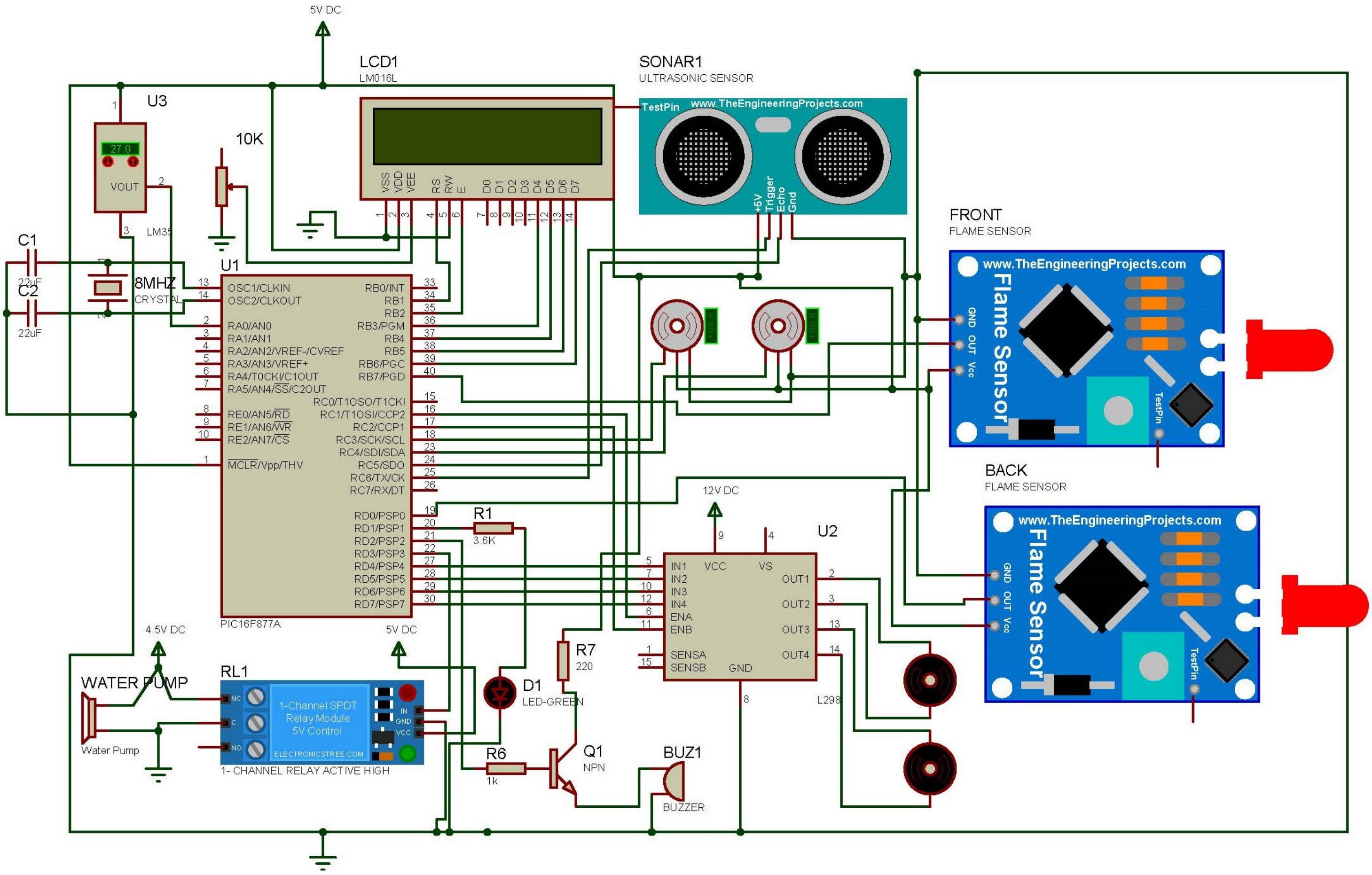
We must measure the output pulse's timing in order to calculate distance. Using the equation above, we can easily determine the distance after measuring the pulse time.

2. Timers Table

	Criteria	Result
TMR0	Used for checking every 10ms if alert=1	Buzzer on for 0.5 s
TMR1	Read timer value using TMR1L and TMR1H	Calculate distance of the ultrasonic sensor
TMR2	Enable TMR2 with 1:16 pre-scaler and use CCP1CON and CCP2CON	Uses PWM to control the speed of the DC motors

Table(2)

IV. Electrical Design



V. Conclusion and Problem Identification

After designing the project, these are the main points that we concluded:

1. We couldn't turn on the both servos and read from the front and back flame sensors at the same time.
2. Using analog ADCON0 for multiple channels does not work with our microcontroller.
3. We couldn't syncronis both motors to move at the same time.
4. Using multiple LCD print caused an overflow in the program RAM.
5. There isn't enough PWM port on the PIC16F877A which led to looking for alternative ways to function PWM needed devices.
6. Short range flame sensor detection does not allow the firefighter to reach far away fires.

References

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- https://mikroelectron.com/
- Textbook and Slides
- Class Demos