Princess Sumaya University for Technology
King Abdullah II Faculty of Engineering
Electrical Engineering Department

King Abdullah II School of Engineering
كليـــــة الملك عبد الله الثاني للهندســـة

EMBEDDED SYSTEMS
FINAL PROJECT
AUTONOMOUS FIREFIGHTING ROBOT

Authors:

Kareem Kawaar	20200230	P&E Engineering
Omar Asa'd	20200462	NIS Engineering
Obeeda Doulat	20200358	NIS Engineering

Supervisor:

Dr. Anastassia Gharib

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Abstract

The objective of this project is to build an autonomous vehicle that could detect and put out fires using a PIC16F877A microprocessor. We created a small robot with the intention of guaranteeing safety by utilizing IR sensor, flame sensors, and other parts. We were successfully able to build our project that aims to offer an effective solution in fire detecting and suppression. Thorough testing confirmed that the system could perform as intended.

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1 INTRODUCTION

In this project, we developed a firefighting robot that can detect and approach fires for quick extinguishment. The robot uses a system of three flame sensors positioned at the front to accurately locate fires and an IR sensor for obstacle avoidance. Its motors are controlled by an H-bridge connected to a 12V battery, ensuring smooth movement. The robot has another H-bridge to manage the water pump, which is powered by a separate 5V battery, and a servo motor to control the direction flow of the water, it also features a compact water tank and a pump, all controlled by a PIC16F877A microcontroller.

1.1 MAIN IDEA OF THE DESIGNED PROJECT

The project's design entails two primary goals: navigating its surroundings and promptly alerting upon detecting a fire, followed by extinguishing the identified flames.

The following are the main components used for each part:
To navigate surroundings:
• IR 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.
To extinguish fire:
• water pump which is connected to a H-bridge, such that the H-bridge works as a switch that turns on the water pump.

First, flame sensors are activated to search for any signs of fire. When fire is detected, the flame sensor sends a signal to the microcontroller through the receiver. The microcontroller registers the fire's direction, guiding the robot to reposition itself accordingly. Next, the water pump aligns with the fire's location, initiating the extinguishing process. Conversely, if no fire is detected by any of the sensors, the receiver sends a signal to the microcontroller, signifying a safe environment.

1.2 FLOWCHART DIAGRAM

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

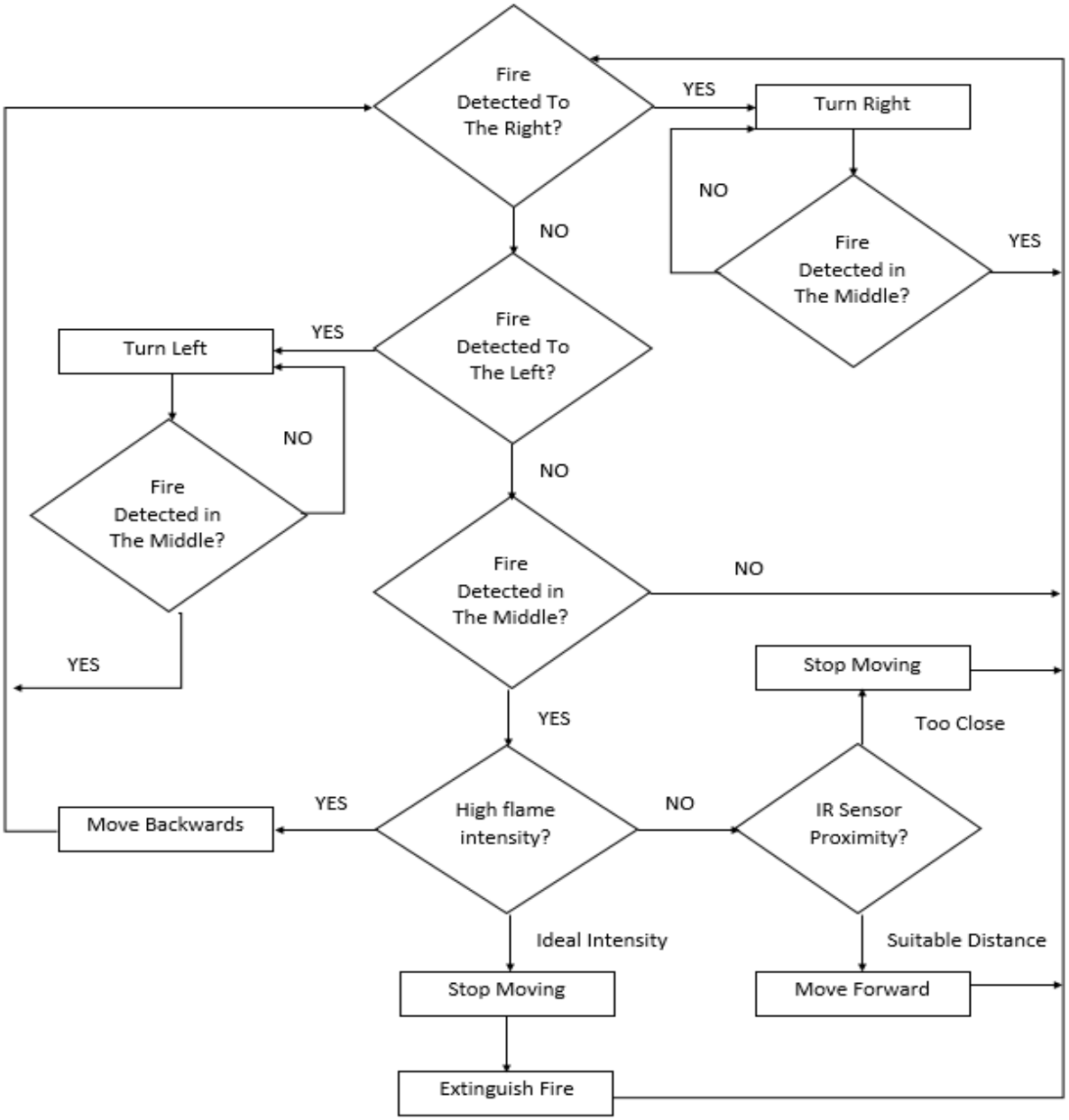

Figure (1): Software Design

II. Overview of the Used Components

This section will give a brief summary of the components we used in our project and describe the procedures we used to integrate them.

1.3 A. PIN16F877A Microcontroller

The PIC16F877A microcontroller is a popular choice with 40 pins, 35 pins are for input/output. It comes packed with useful features like timers, ADC, and PWM, making it handy for a wide range of uses, from controlling machines in factories to automating household tasks and even powering IoT devices. Its memory specs 8K of program memory and 368 bytes of RAM are pretty impressive for its class. What really sets it apart, though, is how easy it is to use, which explains why it's so widely loved and used.

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

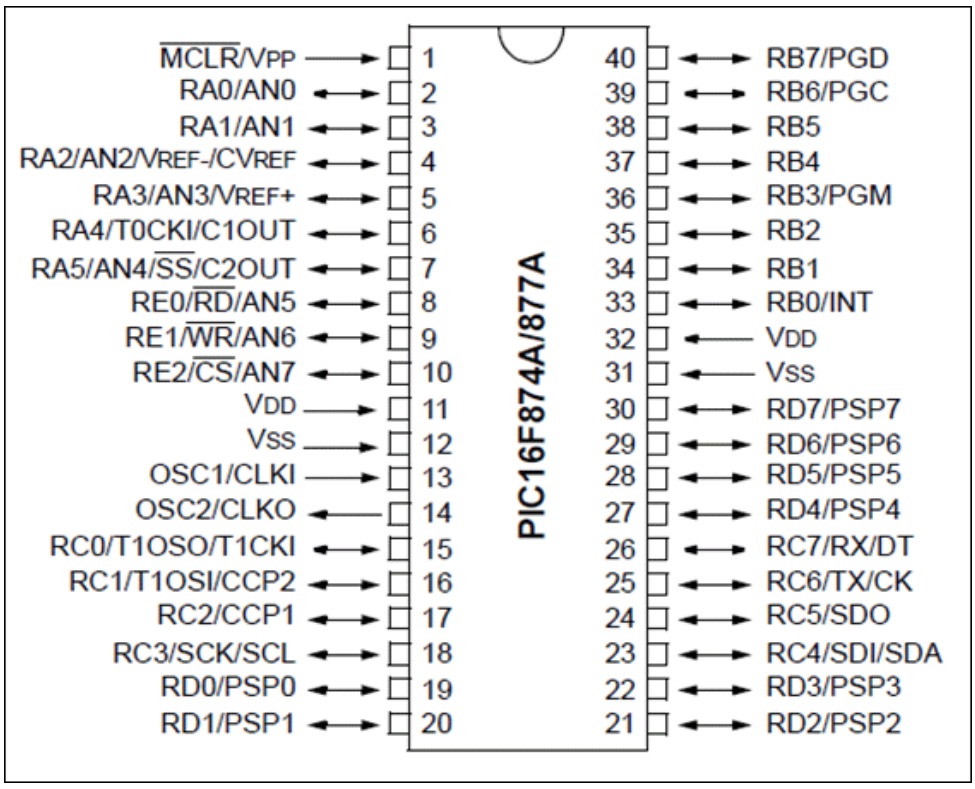

Figure (2): PIC17F877A pins

B. Flame Sensor

The FC-01-H flame sensor is specifically designed to spot flames by detecting their emitted infrared light. Upon sensing a flame, it promptly transmits a signal, signaling the presence of a fire. Widely employed across multiple domains like fire detection systems and robotics, it ensures swift reactions to potential fire risks.

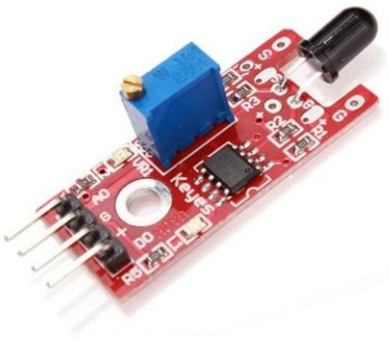

Figure (3): Flame Sensor

We used three flame sensors each with four pins, we used three of the four pins for the right and the left sensors:

- The GND pin connects to the breadboard's ground.
- The VCC pin links to an external 5V DC power source, specifically the H-Bridge.
- The Digital Output pin interfaces with the PIC16F877A through output pins RD4 and RD5 and RD7.
- The Analog Output pin interfaces with the PIC16F877A on pin AN0

C.IR sensor

To detect obstacles in the path and provide feedback to the control system, enabling it to navigate around the obstacles. IR sensors emit infrared light and measure the reflection or absence of this light to determine the presence of an obstacle. When an obstacle is detected, the control system can adjust the movement of the robot or vehicle to avoid collisions.

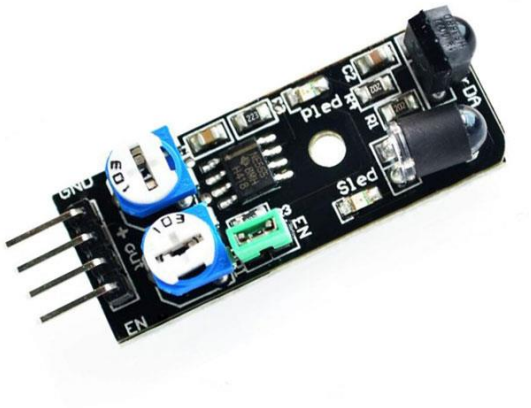

Figure (4): IR Sensor

The IR sensor has four pins:

- The GND pin connects to the breadboard's ground.
- The VCC pin links to an external 5V DC power source, provided by the H-bridge.
- The enable pin connects to the VCC.
- The signal pin connects to RB6.

D. Servo Motor

The Mini Servo Motor SG90 used in this project may be small, but it is powerful. Its main job is to control the water tube's movements in response to electrical signals. When connected to a microcontroller, it smoothly rotates to specific angles, following the commands it receives.

Figure (5): Servo Motor

For this project, one servo motor was used. placed in the front.
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 is connected to the breadboard's GND pin. To control the signal flow, **//**the output pin of the servo motor is connected to the output pin RC2.

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. The four DC motors used for this project are powered through the H-Bridge, in which is linked to the microcontroller to pins RC4, RC5, RC6 and RC7 to control the direction of the wheels.

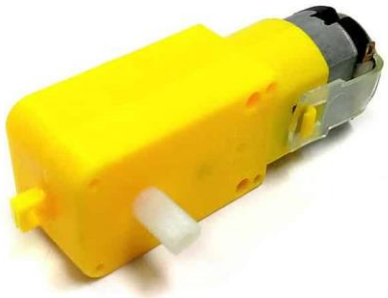

Figure (6): DC Motor

F. H-Bridge

The H-bridge serves as the interface between the PIC16F877A microcontroller and the motors of the automated car. Its role is crucial in enabling precise and controlled movements, thereby enhancing the car's ability to respond effectively to fire incidents.

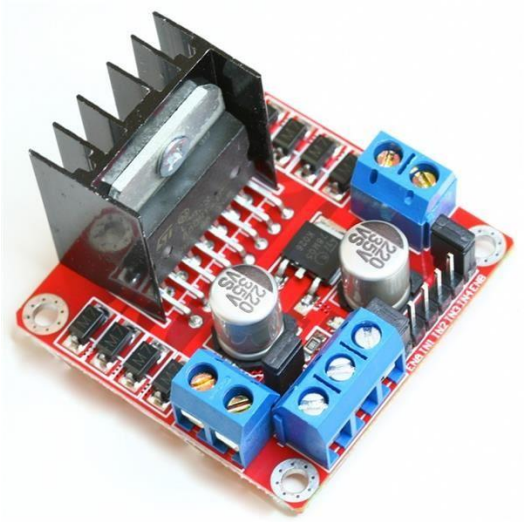

Figure (7): H-Bridge

The first H-Bridge used for this project is connected to four motors through the output pins. As for the PIC16F877A microcontroller, the H-Bridge's input pins are connected to the output pins RC4, RC5, RC6 and RC7. The second H-Bridge is connected to the pump, out1 is connected to the GND of the pump, out2 is connected to the +5V of the pump, IN1 is connected to RD1 and IN2 is connected to the GND.

G. Water Pump

The H-Bridge allows the microcontroller to turn on the water pump to turn off the fire. The pump is connected to the second H-Bridge as mentioned above.

Figure (8): Water Pump

1.4 HARDWARE DESIGN:

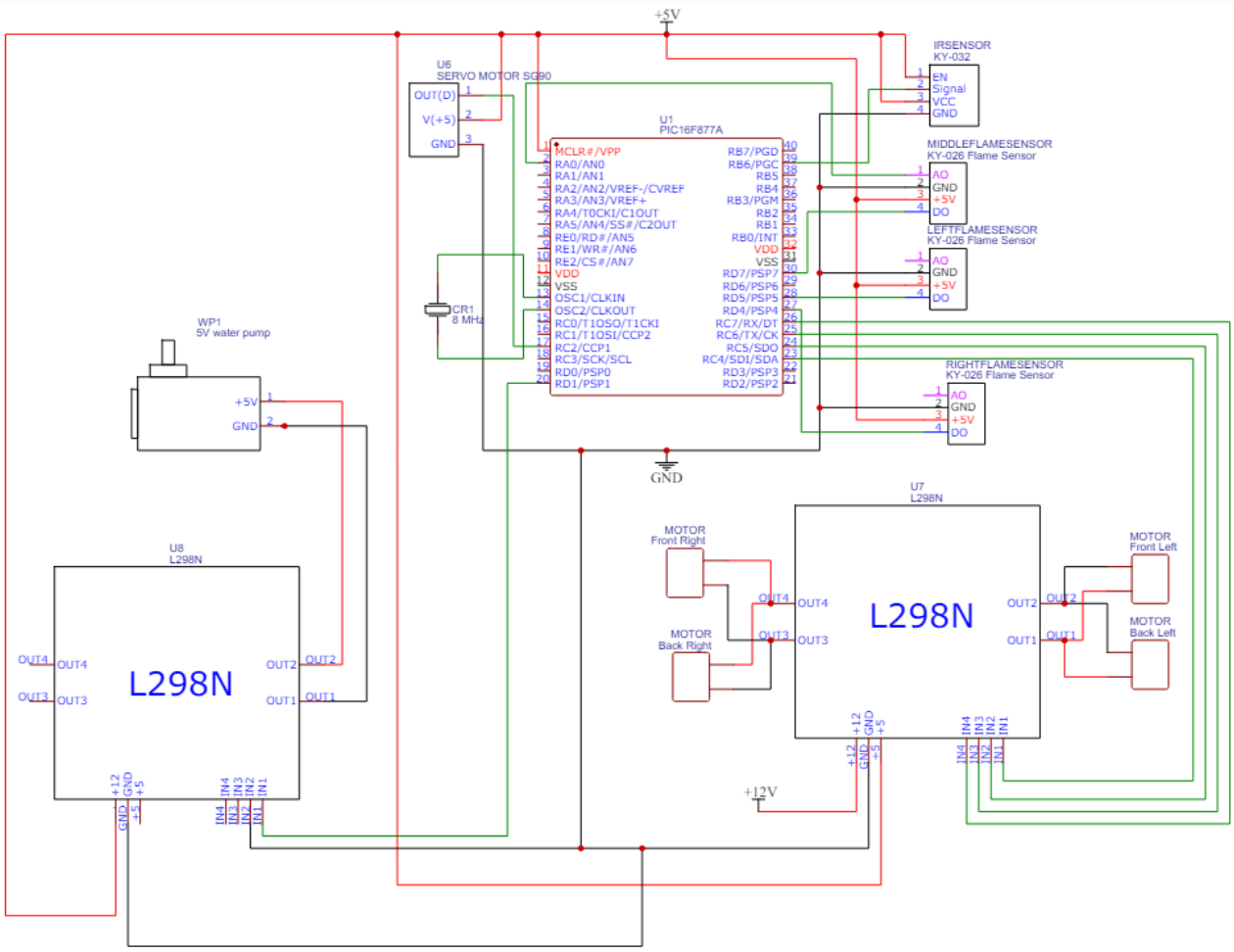

Figure (9): Circuit Schematic

1.5 CONCLUSION AND PROBLEM IDENTIFICATION

Overall, embedded systems have proven to be very effective and convenient. Our project successfully met its goal by detecting fire and extinguishing them with a water pump. The robot autonomously detects and extinguishes small fires, enhancing safety in controlled

environments. This integrated approach ensures that our robot can swiftly respond to fire incidents, providing a reliable and autonomous solution for firefighting tasks. The project highlights the broader significance of embedded systems in improving safety and operational efficiency.

Initially, we weren't able to operate a relay so we replaced it with a H-bridge in order to make the water pump do its job.
Secondly, we faced the power supply problem, we used normal aa batteries and they weren't enough to move the dc motor. So, we replaced them with lithium ion batteries 3.7V 2.2A.
Finally, we faced difficulties when we tried to code the ultrasonic sensor, so we replaced it with IR sensor so we were able to code it correctly.