

A MAJOR PROJECT REPORT

ON

“ARDUINO FIRE FIGHTING ROBOT”

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD

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Session (2021-2022)



CERTIFICATE

This is to certify that the project report entitled “SEMI AUTOMATIC UREA FERTILIZER SPREADER”

Was successfully completed by student of sixth semester Diploma in mechanical engineering.

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In partial fulfilment of the requirements for the award of the Diploma in mechanical engineering and submitted to the Department of Mechanical Engineering of Galgotias University, University Polytechnic, work carried out during a period for the academic year 2021-22 as per curriculum.

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ABSTRACT

Detecting fire and extinguishing is a hazardous job for a fire extinguisher, it often risks the life of that person. This project aims in giving a technical solution to the mentioned problem. A robot is a mechanical design that is capable of carrying out a complex series of actions automatically, especially one programmable by a computer. A fire extinguisher robot is a DTMF tone controlled robot that has a small fire extinguisher unit added on to it. This mobile robot is controlled using a mobile phone through DTMF tones for its movement and reaching the fire, the flame sensor detects the fire and gives the further signal to the extinguisher units to trigger the pump and spray the water. The whole system is programmed using an Arduino UNO board (ATmega328P microcontroller) which forms the brain of the system.

Keywords: DTMF technology, DC motors, flame sensor, water pump, Arduino

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INTRODUCTION

Robot is a machine that looks like a human being and performs various complex tasks. There are many types of robots such as fixed base robot, mobile robot, underwater robot, humanoid robot, space robot and medicine robot etc. In this paper a FIRE EXTINGUISHING ROBOT is proposed. This robot is equipped with a single flame sensor used to sense environmental fire and feed the signals to the microcontroller in order to trigger the pump which sprinkles water in order to extinguish the fire. This robot is controlled using a mobile phone through DTMF tones decoded by the DTMF decoder. This robot implements the concepts of environmental fire sensing, proportional motor control. The motor driver is used for the bidirectional control of the motors equipped in the robot. Every instruction for motion control is given to the robot with the help of DTMF technology.

Thus, the robot processes information from its various key hardware elements such as flame sensor, DTMF decoder via Arduino Uno board (microcontroller). The programming of the robot is done using the arduino C which is derived from C and C++ languages. This paper is presented as follows. Proposed methodology in section II which constitutes of block diagram and components and their explanation. Hardware and software details are included in section III. In Section IV, results and conclusions are included.

Fig.1 shows the Block Diagram of Fire Fighting robot. The basic theme of this paper is to sense the environmental fire and extinguish it with the help of a water pump. The Arduino UNO Microcontroller board based on the ATmega328P. The ATmega328P is good platform for robotics application. Thus the real time fire extinguishing can be performed.

The Arduino software runs on different platforms such as mac, windows and Linux. Simple and clear programming is possible in case of Arduino software. The Arduino libraries play a major role in making the programming easier by providing wider range of libraries. There are many built in libraries available in the Arduino software and it allows to add additional libraries that are available in the open source for download. Adding of new boards to Arduino software is possible. Since, Arduino C is derived from C and C++ programming and is much easier when compared other

controller programming.

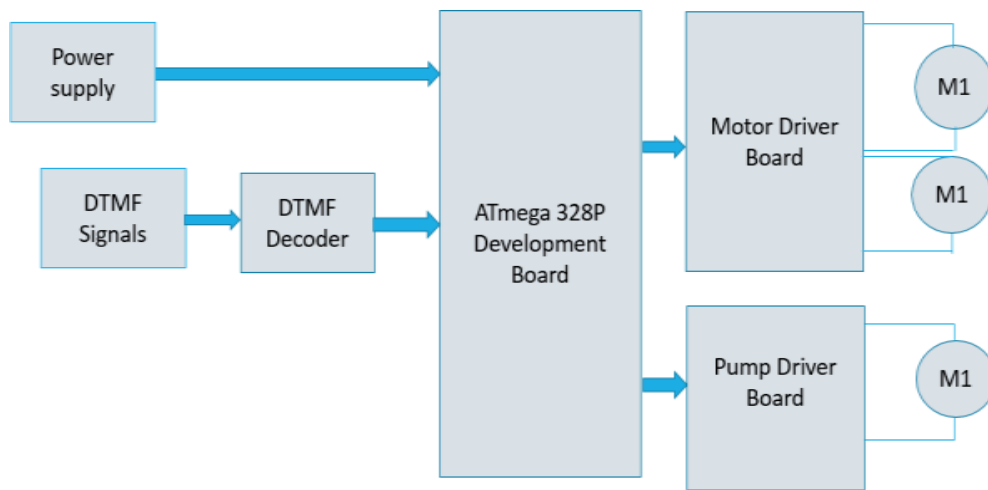


Figure 1

The microcontroller in turn control the extinguishing system. The Operating Voltage of the controller is 5V and the Clock Speed is 16 MHz, and the recommended Input Voltage 7-12V, whereas the limitation of Input Voltage between 6-20V. The Dual-tone multi-frequency signaling (DTMF) is an in-band telecommunication signaling system which use the voice-frequency band over telephone lines between telephone equipment and other communications devices and switching centers. Here, the IC MT8870DE, a touch tone decoder IC is used. The main aim of this project is to develop a DTMF controlled fire extinguishing robot which detects the fire location and extinguish fire by using sprinklers on triggering the pump. The direction of movement of the robot are described by the motor driver board. It is used to give high voltage and high current is given as an output to run the motors which are used in the project for the movement of the robot. In this project a simple DC motor is used for the rotation of the wheel which are responsible for the movement of the robot. DC motors usually convert electrical energy into mechanical energy. To extinguish the fire a pump is used to pump the water on to the flame. A simple motor is used to pump the water. The pumping motor in extinguishing system controls the flow of water coming out of pumping.

The project that is being presented is focused on a firefighting robot. Robots are capable of performing tasks in a more efficient, cost-effective, and accurate manner than humans. It has grown in popularity as technology has advanced, making human work simpler. The firefighting robot is programmed to

scan for and extinguish fires in affected areas. The consequences of fire cannot be prevented, and they can occur in both young, newly formed forests and mature natural forests. Fire has a focused impact on plant growth because it destroys undesirable vegetation, allowing other species to emerge. To occupy Gas sensor, tank which consists of water, wireless remote, wireless android device and Wi-Fi powered camera are all important components in the robot's construction [1]. A wireless robot can conduct successful work, allowing the robot to be operated from a distance [2]. LIDAR is an algorithm developed ultraviolet radiation sensor to reliably find fire using a long wave infrared camera, and created for a mobile intelligent firefighting robot [3]. The act of sprinkling water on a fire is known as firefighting. The robotic vehicle is equipped with water tanks and a pump that is operated by wireless communication [4]. As a result of a fire outbreak (or) fire explosion, we are demanding that we use human resources that are not secure to put out the fire. It is very much possible to replace human work in putting out a fire in a dangerous environment by using higher technology, specifically robotics [5]. This strategy would free firefighters from dangerous tasks, increase their efficiency, and reduce the number of fires. Moreover,

it will discourage human lives from being jeopardized. Forth is, we'll create an Arduino based firefighting robot that will detect the fire and it will begin to pump water on the fire detected area using sprinkler.

1. Material Required:

1. Arduino UNO
2. Fire sensor or Flame sensor (3 Nos)
3. Servo Motor (SG90)
4. L293D motor Driver module
5. Mini DC Submersible Pump
6. Small Breadboard
7. Robot chassis with motors (2) and wheels(2) (any type)
8. A small can
9. Connecting wires

2. PROBLEM FORMULATION

Fire disaster is one of the dangerous problems that can lead to heavy loss both financially and by taking lives. Sometime it becomes difficult for fighters to access the site of a fire because of explosive materials, smoke, and high temperatures. Such situations risk the lives of fire fighters too. In such environments, fire-fighting robots can be useful. This Fire Extinguishing Robot is based on IOT Technology. In Fire Extinguishing Robot, we intend to build a system that could extinguish a small flame by sensing and moving to the location itself. Sometime delay in the arrival of fire fighters leads to numerous consequences. The Fire Extinguishing robot continuously monitors the environment and extinguishes it without delay

3. LITERATURE SURVEY

Tawfiqur Rakib, M. A. Rashid Sarkar proposed a fire fighting robot model which consists of a base platform made up of 'Kerosene wood', LM35 sensor for temperature detection, flame sensors to detect the fire and a water container of 1 litre capacity which is made up of a strong cardboard that makes it water resistant. The robot has two wheels for its movement. [1] Saravanan P.,Soni Ishawarya proposed a model which uses Atmega2560 micro-controller and in which the robot is divided into three basic units according to their functions which are as locomotive unit, fire detecting unit and extinguishing unit.Each unit performs their task in order to achieve the desired output of extinguishing fire.The locomotive unit is used for the movement of the robot and to avoid the obstacles with the help of four IR and four ultrasonic sensors.The fire detecting unit is used to detect fire using LDR and temperature sensor. The extinguishing unit is used to extinguish the fire using water container and BLDC Motor. The robot also have a Bluetooth module that is connected with the smartphones in order to navigate it in the proper direction. [2] S.Jakthi Priyanka, R. Sangeetha proposed an android controlled firefighting robot which uses Arduino UNO R3. The robot consists of gas sensor for fire detection, gear motor and motor drive for the movement of robot, a Bluetooth module to connect the robot with the android device and to control the robot with the smartphone as well. Water pump and sprinkler is also used in this. To instruct the Arduino UNO an open source software which is Arduino IDE is required to code and to implement that code in Arduino UNO. [3] Nagesh MS, Deepika T V , Stafford Michahial, Dr M Shivakumar proposed a fire extinguishing robot which employs DTMF (Dual Tone Multi Frequency Tones) technology for the navigation of the robot and uses a flame sensor for fire detection that is capable of sensing flame of the wavelength range 760 to 1100 nm and sensitivity varies from 10cm to 1.5feet. [4] Sushrut Khajuria, Rakesh Johar, Varenym Sharma, Abhideep Bhatti proposed an arduino based fire fighter robot which consists of RF based remote operation to operate the robot and water pump.The robot is controlled by the user within a range of 7 metres.It also consists of a wireless camera which helps user to move the robot in the required direction.[5] Khaled Sailan, Prof. Dr.-Ing. Klaus-Dieter Kuhnert, Simon Hardt proposed an obstacle avoidance robot named as Amphibious Autonomous Vehicle. In this robot, a fuzzy controller is used to avoid static obstacle in real time.It aims to guide the robot or vehicle along its path avoiding all the obstacle that comes along the path.[6] J Jalani¹ , D Misan¹ , A S Sadun¹ and L C Hong¹ proposed a automatic fire fighting robot with notification.This robot consists of three flame sensors for fire detection in left,right and centre direction.It also consists of three ultrasonic sensors for obstacle detection and avoidance.When the robot detects fire it also sends a warning notification to the user using bluetooth module.

4. METHODOLOGY

The theme of this paper is to automatically sense the environmental fire and extinguish it without human intervention. The methodology is divided into three parts. The first part is on the design structure, followed by hardware description and the finally on the programming design. All these three parts were assembled together and experiments were then performed to build a system that can extinguish the fire that was carried out.

5. Hardware Implementation

The hardware part is one of the crucial parts in the development of firefighting robot. It includes Arduino UNO, IR flame sensors, servo motors, submersible water pump, motor driver, mini breadboard, BO motors, and rubber wheels. Fig 3 shows the block diagram of firefighting robot which consists of three IR flame sensors as the input of the system. Arduino UNO is used as a micro-controller that connects other components. L293D Motor driver is used to drive motors and is capable of running two DC motors (Left DC motor and Right DC motor) at the same time.

6. Design Structure

In this section, the prototype of robotic system is presented, in which it consists of IR flame sensors, servo motors, submersible water pump, motor driver, mini breadboard, BO motors, rubber wheels, processor, and communication module for exchanging data between the fire-fighting robot and Arduino software. Fig 2 shows the basic prototype of our firefighting robot. The robot carries four main functions: First, it initializes itself i.e. its sensors gets initializes as the power is supplied. Second, robot sense the surrounding environment (for instance for the level of temperature) and identify the fireplace. Third, robot sends the navigating information and starts to navigate itself towards the fireplace. Fourth, finally the robot starts to extinguish the fire with the help of servo motors and submersible water pump

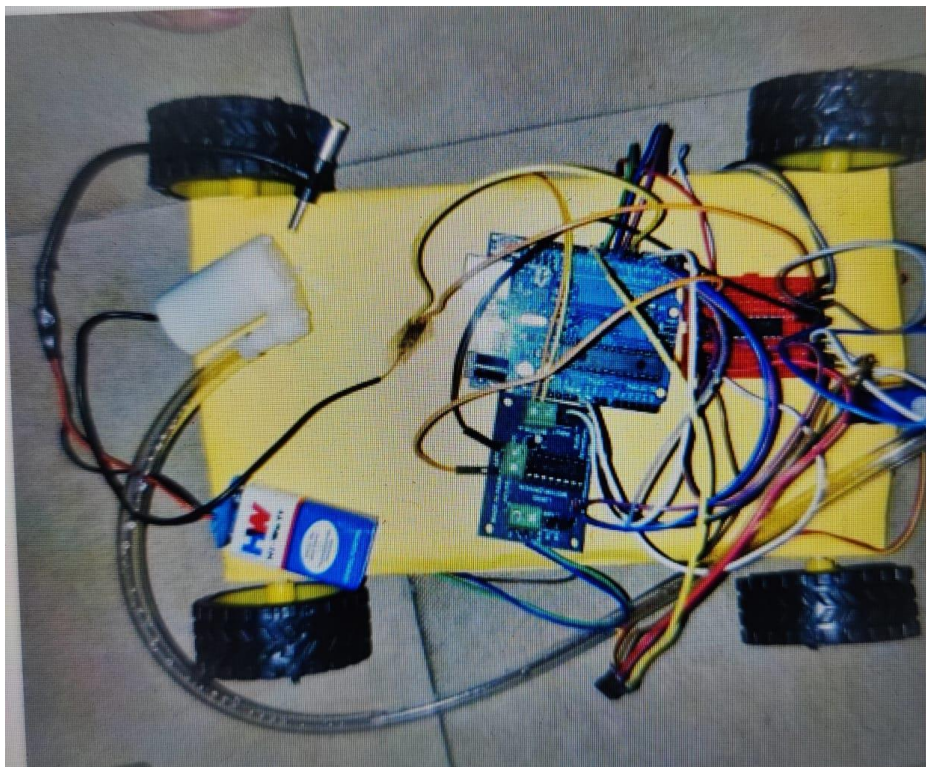


Figure 1.1. Fire Fighting Robot

7. Working Concept of Fire Fighting Robot:

The main brain of this project is the Arduino, but in-order to sense fire we use the **Fire sensor module** (flame sensor) that is shown below.

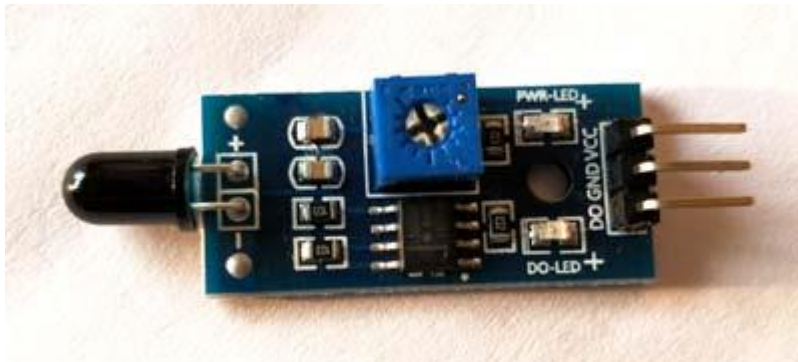
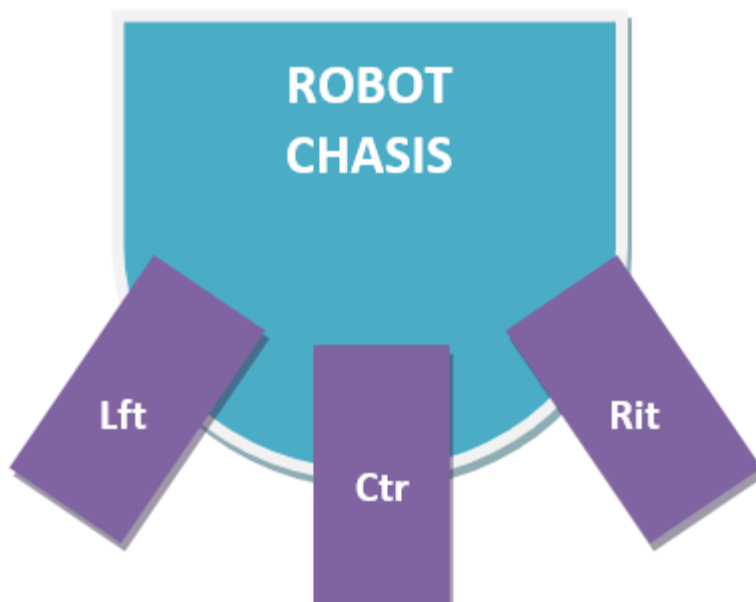


Figure 2. Fire Sensor Module

As you can see these sensors have an **IR Receiver (Photodiode)** which is used to detect the fire. How is this possible? When fire burns it emits a small amount of Infra-red light, this light will be received by the IR receiver on the sensor module. Then we use an Op-Amp to check for change in voltage across the IR Receiver, so that if a fire is detected the output pin (DO) will give 0V(LOW) and if there is no fire the output pin will be 5V(HIGH).

So, we place three such sensors in three directions of the robot to sense on which direction the fire is burning.



We detect the direction of the fire we can use the motors to move near the fire by driving our motors through the **L293D module**. When near a fire we have to put it out using water. Using a small container we can carry water, a 5V pump is also placed in the container and the whole container is placed on top of a **servo motor** so that we can control the direction in which the water has to be sprayed. Let's proceed with the connections now

1.1 HARDWARE USED:

1. ATmega328P microcontroller (Arduino UNO):

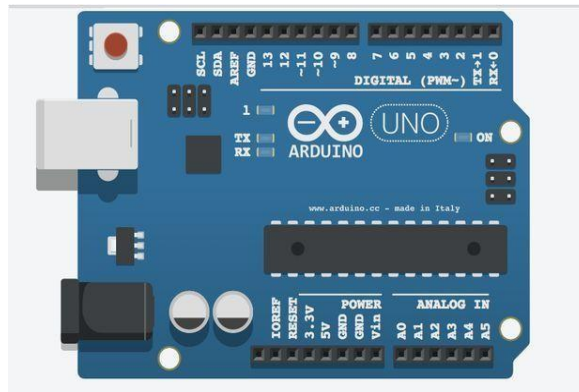


Fig 3: Arduino Uno microcontroller based development board

A Microcontroller is a compact device with a processor, storage and configurable input/output devices on a single integrated circuit. We'll be using the Arduino UNO board, which combines a microcontroller with all of the extras needed to quickly create and debug projects. The ATmega3288based UNO is a microcontroller board

1. 14 Digital input/output pins,
2. 6 Analog inputs,
3. 16MHz Quartz crystal
4. USB connector,
5. Power jack,
6. ICSP header, and
7. Reset button.

Attach it to a computer via USB cable or power it with an AC to DC adapter to get started. The ATmega3288 has 32kb of memory, 2kb of SRAM, and 1kb of EPROM. The Arduino Software can be used to programmed the UNO(IDE). The boot loader on the ATmega3288 on the UNO comes preprogrammed, allowing you to upload new code. It uses the original STK 500 protocol to communicate

Ultrasonic Sensor:

The Transducer's sonic waves would be absorbed by an object and returned to the transducer. The time it takes for the ultrasonic sensor to transition from emitting to receiving sound waves is proportional to the distance between the object and the sensor as shown in Figure 3.



Figure 4. Ultrasonic Sensor

Hard surfaces are the strongest reflectors of sonic waves, and may be solids, granules, liquids, or powder. The distance can be calculated precisely and without touch using an ultrasonic sensor. It could be anywhere from 2cm to 3m long.

Flame Sensors:

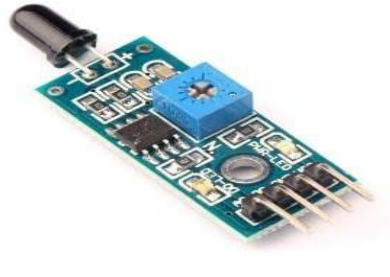


Fig 5: Flame Sensor

A flame sensor is the most sensitive to normal light of any sensor. This sensor senses flame if the light source emits a wave length between 760nm and 1100nm. The detection angle would be 60o and can be achieved from a distance of 100cm. This sensor's output is either an analog or digital signal. The infrared flame flash method is used by this sensor as shown in Figure 4.

Fig 4.2 shows the flame sensor. This sensor is able to detect a flame by sensing light wavelength between 760 –1100 nanometers. The test distance depends on the flame size and sensitivity settings. The detection angle is 60 degrees, so the flame does not have to be right in front of the sensor.

There are two sensor outputs

- i. Digital – sending either zero for nothing detected or one for a positive detection
- ii. Analog – sending values in a range representing the flame probability/size/distance; must be connected to a PWM capable input

It has four pins,

1. Voltage Supply (Vcc),
2. Ground pin (GND),
3. Analog output (Aout), and
4. Digital output (Do)

Servo Motors:

Fig 7 shows the Servo Motors. Servo Motors are electronic devices that are mainly used for providing specific velocity and acceleration

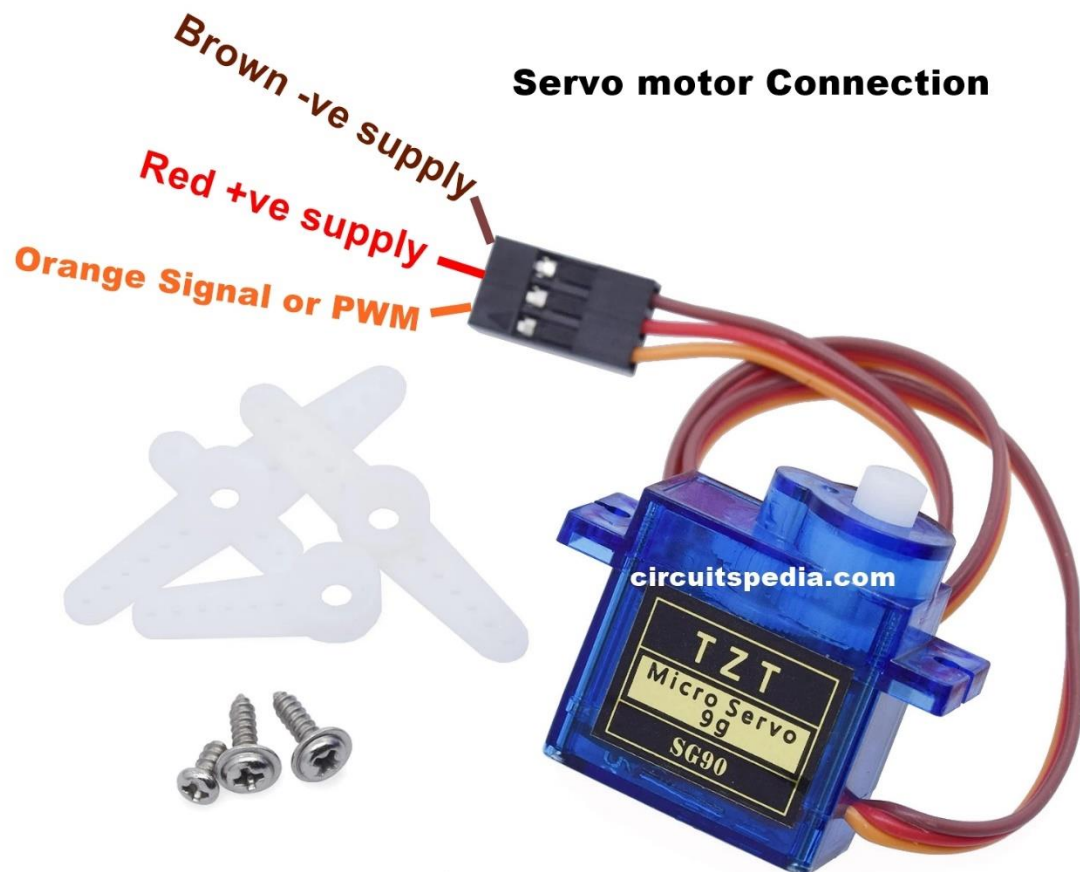


Figure 6. Servo Motor

Submersible Water Pump:

Fig 7. Shows the Submersible Water Pump. Submersible Water Pump is ideal for making automatic watering system using Arduino. The water pump is an important part of the robot as it will pump water to extinguish the fire.



Figure 7. Submersible Water Pump

2. Motor Drivers:

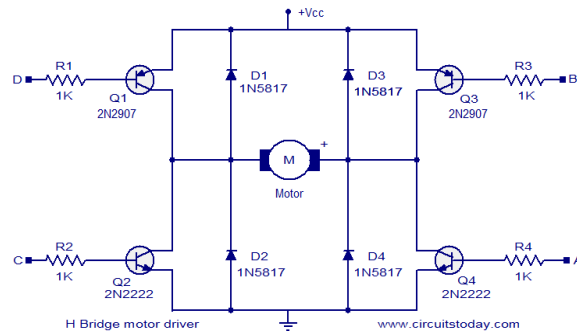


Fig 8: H Bridge circuit

Motor drivers are used to describe the direction of movement of the robot. It is used to give high voltage and high current as an output to run the motors which are used in the project for the movement of the robot. Fig 5 is the circuit of the H Bridge which is used for the motor driving in the IC L293D and also provides the bidirectional motor control.

3. Temperature Sensor (LM35):

The temperature sensors in the LM35 series are accuracy integrated circuits temperature sensors with a linearly proportional output voltage to Celsius scale value. The Temperature can be measured more precisely than with a thermistor as shown in Figure 5.

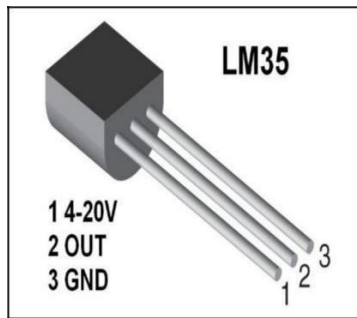


Figure 9. Temperature Sensor (LM35)

The sensor circuitry is fully sealed and is not exposed to the elements. due to oxidation The LM35 produces a higher output voltage than thermocouples, so it might not be necessary to amplify the output voltage. It calibrates in Celsius with a 0.5°C precision guarantee and a measurable range of 55°Cto+150°C.

Relay

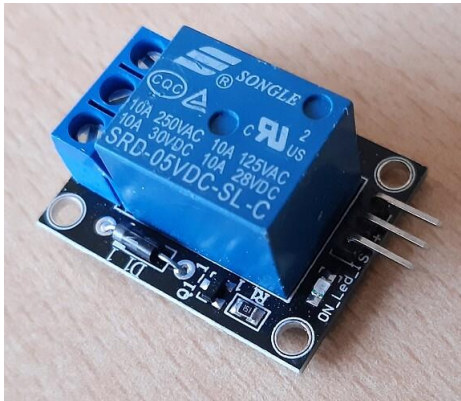


Figure 10. Relay

A relay is a switch that is powered by electricity as shown in Figure 7. A magnetic field is generated by coil of the relay is which the current flows through, which attracts a lever and changes the switch contacts. There are two switch places on their lay, both of which are double throw switches. There is no electrical connection between the two circuits within the relay. Only magnetic and mechanical connections exist. Relays are incredibly basic instruments. Figure 8 shows the Node MCU.

They are,

1. Armature,
2. Electromagnet Spring, and
3. Set of Electrical Contacts

Node MCU:

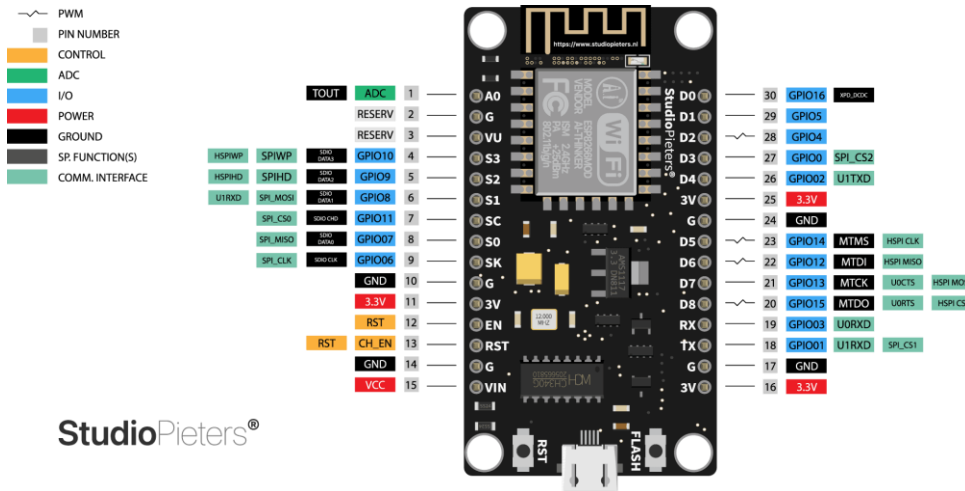


Figure 11. Mode MCU

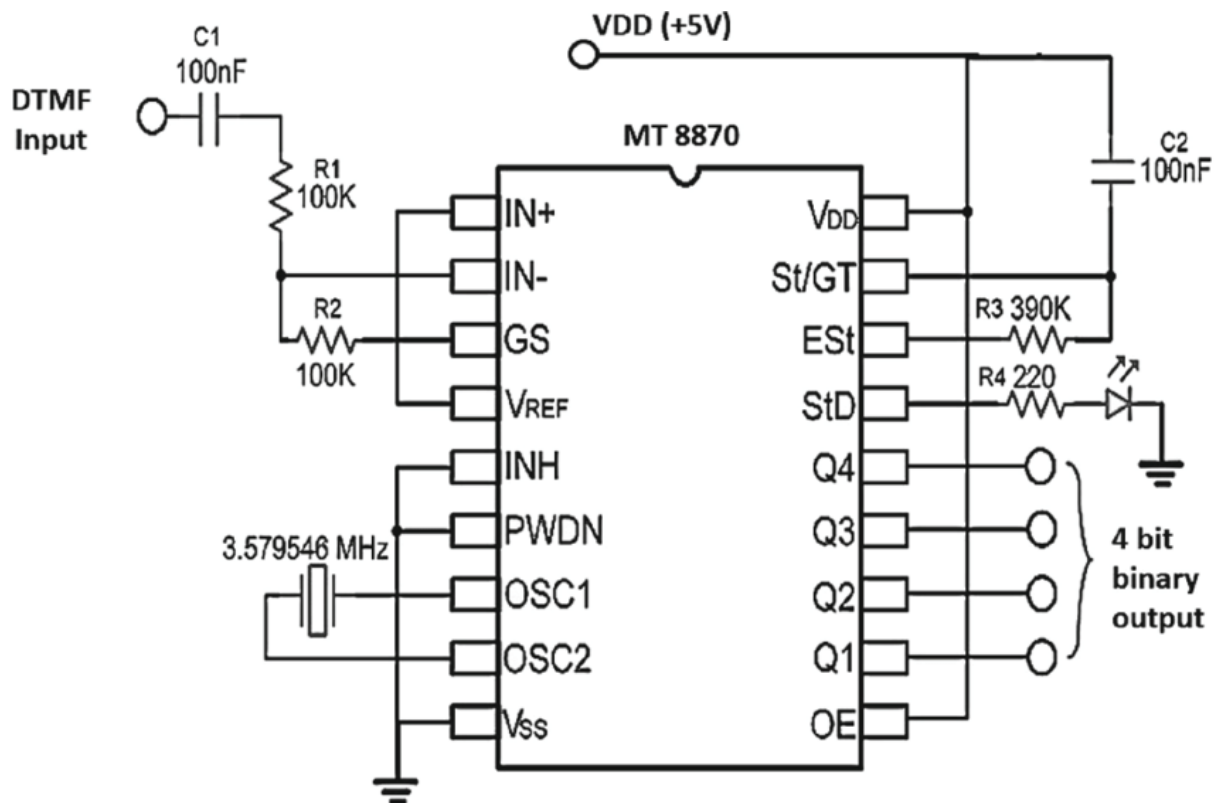
Node MCU is an open source IoT platform with a low cost. It came with firmware for the ESP8266 Wi-Fi SoC from express if systems at first. The ESP-12 module serves as the basis for its hardware. Microcontroller Unit (MCU) is an Open-source prototyping board designs are available for Node MCU, which is an open-source firmware. LUA is the scripting language used by the firmware. The most popular prototyping hardware is a circuit board. Table 1 shows D0 (GPIO16) can only be used for GPIO read/write.

Table 1. [*] D0 (GPIO16) can only be used for GPIO read/write.

I/O Index	ESP8266PIN
0[*]	GPIO16
1	GPIO5
2	GPIO4
3	GPIO0
4	GPIO2
5	GPIO14
6	GPIO12
7	GPIO13
8	GPIO15
9	GPIO3
10	GPIO1
11	GPIO9
12	GPIO10

1.DTMF Signal and Decoder.

Dual-tone multi-frequency signaling (DTMF) is an in- band telecommunication signaling system using the voice- frequency band over telephone lines between telephone equipment and other communications devices and switching centers. DTMF was first developed in the Bell System in the United States, and became known under the trademark Touch-Tone for use in push-button telephones supplied to telephone customers, starting in 1963 we are using the IC MT8870DE which is a touch tone decoder IC.



Button	Low DTMF frequency (Hz)	High DTMF frequency (Hz)	Binary coded output			
			Q1	Q2	Q3	Q4
1	697	1209	0	0	0	1
2	697	1336	0	0	1	0
3	697	1477	0	0	1	1
4	770	1209	0	1	0	0
5	770	1336	0	1	0	1
6	770	1477	0	1	1	0
7	852	1209	0	1	1	1
8	852	1336	1	0	0	0
9	852	1477	1	0	0	1
0	941	1336	1	0	1	0
*	941	1209	1	0	1	1
#	941	1477	1	1	0	0

Table No. 2: DTMF low and high frequency tones and decoded output

Table.1 shows the DTMF low and high frequency tones and decoded output. The DTMF (Dual Tone Multi Frequency) decoder circuit identifies the dial tone from the telephone line and decodes the key pressed on the remote telephone. Here for the detection of DTMF signaling, we are using the IC MT8870DE which is a touch tone decoder IC. The decoded bits can be interfaced to a computer or microcontroller for further application.

2. DC Motors:

In this project we use simple DC motor for the rotation of the wheel which are responsible for the movement of the robot. Usually DC motors convert electrical energy into mechanical energy.

3. Pump:

Pump is a mechanical device which is used to pump water on to the fire to extinguish it. It uses a simple motor to pump water.

Programming

For programming, the Arduino software provides an integrated development environment (Arduino IDE) and core libraries. The Arduino IDE program is a software program written in Java language and based on the Processing. The Arduino IDE is basically a framework built on top of C and C++ and compiled using avr-gcc and AVR Libc. The open source Arduino IDE makes it easy to write code and upload it to the Arduino Uno for execution. It is available for all major desktop platforms i.e., Windows, Mac OS X, and Linux. Fig 10 shows the Arduino IDE program.

Working

The Arduino UNO development board is used to control this firefighting robotic system, which is made up of HC-SR04 sensors. A gas sensor (MQ2) for sensing hazardous smoke, a temperature sensor (LM35) for more precise temperature measurement, and a fire flame sensor (IR) for detecting and sensing the approaching fire are all mounted on a servo-motor for obstacle detection and free path navigation. In addition, for extinguishing the flames, it also makes use of a water tank and a spray gun mechanism. With the aid of a 12V pump, water is pumped from the main water tank to the water nozzle.

RESULT DISCUSSION

Fire Fighting Robot has developed to reduce human life lost and to develop such a device that automatically sense fire and extinguish it without human intervention. In this the fireplace is detected using the IR Flame sensors and are connected to Arduino UNO, which control the movement of Motor drive that helps the robot to reach the fireplace and extinguishes it with the pumping mechanisms. In the industry if any fire accident occurs, there is a need of person to monitor continuously and rectify it. In this process if any time delay takes place irreparable loss occurs in industry. The firefighting robot continuously monitors the surrounding and helps in extinguishing the fire. Fig 11 shows the overall prototype of Fire Fighting Robot



Figure 12. Fire Fighting Robot

Conclusion

The paper not only demonstrates the effective implementation of a firefighting robot, but also adds new features that make it more realistic to recognize the severity of the fire and the form of gases present, which is critical to preventing further fire spread.

SOFTWARE USED:

Arduino IDE

For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on a programming language named Processing, which also supports the languages C and C++. The open source Arduino IDE makes it easy to write code and upload it to the board.

RESULTS AND CONCLUSIONS

The Fire Fighting Robot employs DTMF technology to control the directions of the robot. We design the fire detection system using flame sensor that is capable of sensing the flame of wavelength range 760 to 1100 nm, and the sensing range depends on the sensitivity and varies from 10cm to 1.5feet. The robot can operate in the environment which is out of human reach in very short time, the delay employed is very minimal. The robot accurately and efficiently finds the fire and within minimum time after the fire is detected it is extinguished.



Figure 13. Flame Sensor

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