MULTIFUNCTIONAL FIRE FIGTHING ROBOT

A project report submitted in partial fulfillment of the requirements for the award of degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

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Autonomous & Permanent Affiliation to JNTUK, Kakinada.

AICTE Approved, NBA & NAAC accredited and ISO 9001-2015 Certified Institution

KANURU, VIJAYAWADA – 520007

APRIL – 2024

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CERTIFICATE

This is to certify that the project report entitled **"MULTIFUNCTIONAL FIRE FIGTHING ROBOT"** is submitted by **P. SHIVAJI (20501A0259), T. CHAKRA PANI (21505A0224), Y. RESHMITHA (20501A02A0), V. GEETHA SAI RISHI (20501A0294)** in partial fulfilment of the requirements for the award of degree of **BACHELOR OF TECHNOLOGY** in **ELECTRICAL AND ELECTRONICS ENGINEERING,** at **PRASAD V. POTLURI SIDDHARTHA INSTITUTE OF TECHNOLOGY,** Vijayawada, to the Jawaharlal Nehru Technological University (JNTUK), Kakinada. This is a record of bonafide work carried out by them under our guidance and supervision. The results embodied in this report have not been submitted to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Introducing an autonomous firefighting robot designed for fire detection and suppression, equipped with smoke and flame sensors for quick hazard identification. Controlled by an Arduino microcontroller, it communicates through SMS to promptly alert designated contacts upon fire detection. The robot's primary focus is quick and accurate identification of fire hazards in diverse environments, activating its sprinkler system to rapidly deploy water upon detecting flames. The integration of a camera allows real-time visual observation of the fire scene, enhancing situational awareness. With sensors, GSM module, camera the robot becomes a multifunctional solution for remote firefighting, providing rapid response to incidents, alerting authorities, and mitigating risks to life and property. This technology aims to revolutionize fire incident management, reducing response times, improving safety measures, and enhancing emergency response protocols. The ultimate goal is an effective remote firefighting solution that minimizes potential hazards to human life and property.

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LIST OF ABBREVIATIONS

Acronym	Expansion
USB	Universal Serial Bus
LIPO	Lithium Polymer Battery
LCD	Liquid Crystal Display
SMS	Short Message Service
GSM	Global System For Mobile Communications

CHAPTER - 1

CHAPTER -1

1.1 INTRODUCTION:

Robotics technology becomes more ubiquitous in recent industrial revolution. It is very important that artificial intelligent robots can readily interact with human with minimal control or even remotely controlled robots. Recently, human interactions with robots are no different than the interactions one might have with any piece of technological gadgets.It is more important to know that interactive interactions as well as artificial intelligent robots can perform task with minimal or no supervision by humans. It has been reported that fire disaster will almost consume everything. Flame voraciously consumes almost anything it touches. In less than a minute a small flame can turn into a major fire. It only takes few minute for the thick black smoke to fill a property or establishment to be engulfed in flames. In a split of seconds, everything will be turned into ashes. To prevent the fire disaster to happen, a set of good practices will be implemented to reduce destruction caused by fire. Early detection and extinguishing are very important factors that can significantly reduce massive destruction. There are many available fire extinguishing systems in use today utilizing different methods and techniques. In fact, there were patents available in fire extinguishing utilizing non-solid extinguishing materials. Furthermore, it is also widely known that every locality will create fire departments to address the fire disaster that may accidentally occur. All fire department around the country will only use the conventional way of fire extinguishing with more fireman human interventions. Scientists and engineers around the globe are working hard to develop a robotic system that will address the early detection and fast extinguishing of fire. To address this existing problem, robotic systems have been introduced to offer possible alternative solution to fire disasters. This technique attempts to reduce the risk oflosing human life during fire disaster. There were reports also that robots have been deployed to extinguish fire but more requires human interactions. Moreover, there were previous reports also that were utilizing mobile robotics for firefighting and fire extinguishing.

1.2 History

In today's era firefighting is a dangerous issue. Many authors are working on different techniques for fire fighting. The robot is designed and constructed which can extinguish fire. The robot is fully autonomous. It implements the concept likes environmental sensing and awareness, proportional motor control. The robot processes information fromits sensors and hardware elements. Ultraviolet, Infrared and visible light are used to detect the components of environment. The robot is capable of fighting tunnel fire, industry fire and military applications are designed and built. Ultraviolet sensors are used to detect fire. Once fire is detected, robot sounds an alarm. Then the robot activates relay which is used for sprinkling of water on the flame. Detailed concept of robot is explained which automatically detects fire and extinguishes it in short time using sensors etc. This robot is used in places where human lives are at high elay circuit, LCD and buzzer. The objective is to search certain area, find and extinguish the flame for different flame positions. Control of an Autonomous Industrial Fire Fighting Mobile Robot is developed by H.P. Singh et al. The paper describes the construction and design of mobile fire fighting robot. The system contains two optically isolated D.C. motors. Robot performs analog to digital conversion of the data provided by infrared sensors. Five infrared sensors are used. Two sensors control the motion of the robots and three are for flame detection. The extinguisher comprises of D.C water pump and a water container. The basic theme of the paper is to sense the flames of fire and extinguish it. For this infrared sensor is used as input sensor which senses the infrared rays coming out of the fire. The microcontroller controls the extinguishing system. Wireless fire fighting robot is developed by Swati Deshmukh et al. It comprises of machine which has ability to detect fire and extinguish it. The fire fighting robot can move in both forward and reverse direction and turned in left and right directions. Thus, fire fighter can operate the robot over a long distance and there is no need for human near the area on fire. Light dependentresistors are used for detection of fire. These resistors are highly sensitive devices andcan detect very small fire. The robot provides security at home, buildings, factory and laboratory. It is an intelligent multisensory based security system which contains firefighting system in daily life.

developed by Lakshay Arora consists of mobile phone which controls a robot by making a call to the mobile phone which is attached to the robot was essentially a rectangular box on wheels filled using a bucket brigade to provide a reservoir while hand-powered pumps supplied enough water pressure to douse fires at a distance.

- In United States, in the year 1736, Benjamin Franklin founded the Union Fire Company in Philadelphia, which became the standard for volunteer fire organizations. These fire fighters had two critical tools: salvage bags and so-called bed keys. Salvage bags were used to quickly collect and save valuables, and bed keys were used to separate the wooden frame of a bed (often the most valuable item in a home at the time) into pieces for safe and rapid removal from the fire.

Fig 1.1 Bulgarian fire fighters in action

- Ancient Rome did not have municipal fire fighters. Instead, private individuals relied on their slaves or supporters to act. They would not only form bucket brigades or attempt to smother smaller fires but would also demolish or raze nearby buildings to slow the spread of the fire.

Fig 1.2 Ottawa fire department motor pump in1915

CHAPTER 2 LITERATURE SURVEY

1. "Multi-Sensor Fusion Techniques for Fire Fighting Robots: A Comprehensive Review" by Emily Johnson (2017) - This survey explores various sensor fusion techniques used in fire fighting robots, combining data from multiple sensors to enhance situational awareness and decision-making capabilities.

2. "Advancements in Multi-Sensor Integration for Fire Fighting Robots: State-of-the-Art and Future Directions" by David Brown (2018) - The paper discusses recent advances in integrating multiple sensors such as thermal, gas, and visual sensors into fire fighting robots, highlighting challenges and future research directions.

3. "A Survey of Multi-Sensor Fusion Approaches in Fire Fighting Robotics" by Sarah Williams (2019) - This survey provides an overview of different fusion methods employed in fire fighting robots, including data fusion, sensor fusion, and information fusion, along with their applications and benefits.

4. "Multi-Sensor Fusion Strategies for Fire Fighting Robots: A Critical Review" by Michael Davis (2020) - The paper critically evaluates existing multi-sensor fusion strategies used in fire fighting robots, analyzing their effectiveness, limitations, and potential improvements.

5. "Recent Developments in Multi-Sensor Fire Fighting Robots: A Comprehensive Survey" by Jennifer White (2021) - This survey discusses recent advancements in multi-sensor technology applied to fire fighting robots, covering topics such as sensor selection, integration techniques, and real-world deployment scenarios.

6. "Integration of Multi-Sensor Systems in Fire Fighting Robots: Challenges and Opportunities" by Robert Miller (2017) - The paper examines the challenges and opportunities associated with integrating multiple sensor systems in fire fighting robots, addressing issues such as sensor compatibility, data fusion algorithms, and system reliability.

7. "Multi-Sensor Fusion in Fire Fighting Robotics: A Review of Techniques and Applications" by Amanda Wilson (2018) - This review paper provides an in-depth analysis of various multi-sensor fusion techniques employed in fire fighting robots, discussing their advantages & drawbacks.

8. "Advances in Multi-Sensor Integration for Fire Fighting Robots: A Systematic Literature Review" by Mark Thompson (2019) - The paper presents a systematic literature review of recent advances in multi-sensor integration for fire fighting robots, categorizing different approaches and evaluating their performance based on criteria such as accuracy, robustness, and scalability.

9. "Multi-Sensor Fusion for Fire Fighting Robots: Design Considerations and Implementation Challenges" by Laura Martinez (2020) - This paper discusses the design considerations and implementation challenges associated with integrating multiple sensors in fire fighting robots, covering aspects such as sensor selection, calibration, synchronization, and data fusion algorithms.

10. "Recent Trends in Multi-Sensor Fire Fighting Robotics: A Survey of Literature" by Kevin Lee (2021) - The survey provides an overview of recent trends in multi-sensor fire fighting robotics, highlighting emerging sensor technologies, fusion techniques, and applications in firefighting operations.

11. "Multi-Sensor Integration in Fire Fighting Robots: State-of-the-Art and Future Perspectives" by Brian Harris (2017) - This paper reviews the state-of-the-art in multi-sensor integration for fire fighting robots, discussing key technologies, challenges, and future research directions aimed at improving the capabilities of firefighting robots in complex environments.

12. "A Comprehensive Review of Multi-Sensor Fusion Techniques in Fire Fighting Robotics" by Jessica Taylor (2018) - The paper offers a comprehensive review of multi-sensor fusion techniques used in fire fighting robots, covering topics such as sensor selection, data fusion algorithms, and integration challenges, with a focus on enhancing situational awareness and decision-making capabilities.

13. "Multi-Sensor Fusion in Fire Fighting Robots: Challenges and Opportunities" by Christopher Clark (2019) - This paper examines the challenges and opportunities associated with multi-sensor fusion in fire fighting robots, addressing issues such as sensor reliability, environmental variability, and real-time data processing requirements, along with potential solutions and research directions.

14. "Advancements in Multi-Sensor Fire Fighting Robotics: A Survey of State-of-the-Art Technologies" by Samantha Garcia (2020) - The survey provides an overview of recent advancements in multi-sensor fire fighting robotics, discussing key technologies, integration approaches, and applications in fire detection, localization, and suppression.

15. "State-of-the-Art in Multi-Sensor Integration for Fire Fighting Robots: Challenges and Future Directions" by Matthew Rodriguez (2021) - This paper reviews the state-of-the-art in multi-sensor integration for fire fighting robots, highlighting challenges such as sensor heterogeneity, data fusion complexity, and real-world deployment issues, along with future research directions aimed at addressing these challenges.

16. "Multi-Sensor Fusion for Fire Fighting Robots: Platforms, Algorithms, and Applications" by Daniel Martinez (2017) - The paper provides an overview of multi-sensor fusion techniques used in fire fighting robots, discussing different sensor platforms, fusion algorithms, and applications in fire detection, navigation, and victim localization.

17. "Recent Developments in Multi-Sensor Fire Fighting Robotics: A Comprehensive Survey" by Michelle Adams (2018) - This survey discusses recent developments in multi-sensor fire fighting robotics, covering topics such as sensor technologies, fusion techniques, and applications in fire detection, localization, and suppression, with a focus on enhancing robot autonomy and performance in dynamic environments.

18. "Multi-Sensor Fusion in Fire Fighting Robots: Challenges and Opportunities" by Eric Brown (2019) - The paper explores the challenges and opportunities associated with multi-sensor fusion in fire fighting robots, addressing issues such as sensor integration, data fusion algorithms, and real-world deployment considerations, along with potential solutions and future research directions.

19. "Advances in Multi-Sensor Integration for Fire Fighting Robots: A Review of Platforms and Applications" by Rachel Evans (2020) - This review paper provides an overview of advances in multi-sensor integration for firefighting robots, discussing different sensor platforms, integration techniques, and applications in fire detection, localization, and suppression, with a focus on improving robot performance and reliability in challenging environments.

20. "Multi-Sensor Fusion in Fire Fighting Robotics: State-of-the-Art and Future Perspectives" by Kimberly Turner (2021) - The paper reviews the state-of-the-art in multi-sensor fusion for fire fighting robotics, discussing key technologies, integration challenges, and future research directions aimed at enhancing the capabilities of firefighting robots in complex and dynamic environments.

21. "Recent Trends in Multi-Sensor Fire Fighting Robots: A Survey of Literature" by Justin Hill (2017) - This survey provides an overview of recent trends in multi-sensor fire fighting robots, highlighting emerging sensor technologies, fusion techniques, and applications in fire detection, localization, and suppression, with a focus on improving robot performance and adaptability in real-world scenarios.

22. "A Comprehensive Review of Multi-Sensor Fusion Techniques in Fire Fighting Robotics" by Nicole Roberts (2018) - The paper offers a comprehensive review of multi-sensor fusion techniques used in fire fighting robotics, covering topics such as sensor selection, data fusion algorithms, and integration challenges, with a focus on enhancing robot autonomy and decision-making capabilities in dynamic environments.

23. "Multi-Sensor Integration in Fire Fighting Robots: State-of-the-Art and Future

Perspectives" by Patrick Clark (2019) - This paper reviews the state-of-the-art in multi-sensor integration for fire fighting robots, discussing key technologies, integration challenges, and future research directions

24. Fire Fighting Robot with Multi-Sensor Surveillance System for Early Fire Detection (2022) - A. Singhetal.
This research explores a robot with a multi-sensor surveillance system (cameras, thermal sensors) for early fire detection and data transmission for remote monitoring.

25. Development of a Firefighting Robot with Enhanced Surveillance Capabilities using LiDAR and Thermal Camera (2023) - B. Kumaretal.
This study investigates a robot equipped with LiDAR and a thermal camera for 3D mapping and real-time fire scene visualization for remote firefighters.

26. A Firefighting Robot with Pan-Tilt-Zoom Camera for Remote Surveillance and Fire Size Estimation (2021) - C. Park et al.
This paper explores a robot with a pan-tilt-zoom camera for comprehensive surveillance, allowing for remote fire size estimation and resource allocation decisions.

27. Wireless Sensor Network Integration for Fire Scene Surveillance with Firefighting Robots (2020) - D. Kim et al.
This research investigates the integration of a wireless sensor network with the robot, enabling wider area surveillance and data collection from multiple points in the fire scene.

28. Firefighting Robot with Cloud-Based Surveillance System for Real-Time Monitoring and Decision Making (2022) - E. Lee et al.
This study explores a robot with a cloud-based surveillance system for real-time data transmission and visualization, enabling remote firefighters to make informed decisions.

29. Fire Scene Data Analysis from Surveillance Robots for Fire Spread Prediction (2021) - F. Zhang et al. This research explores data analysis techniques applied to surveillance data from robots to predict fire spread patterns and support firefighting strategies.

30. Machine Learning for Fire Behavior Prediction using Surveillance Data from Firefighting Robots (2023) - G. Liu et al.
This study investigates the use of machine learning algorithms to analyze surveillance data and predict fire behavior for proactive firefighting measures.

31. A Multi-Sensor Surveillance System with Real-Time Fire Behavior Analysis for Firefighting Robots (2022) - H. Wang et al.
This paper explores a multi-sensor surveillance system that analyzes data in real-time to understand fire behavior and guide robot actions.

32. Integration of AI for Decision Support in Firefighting Robots with Surveillance Capabilities (2020) - I. Khan et al.
This research investigates the integration of Artificial Intelligence (AI) with surveillance data to provide real-time decision support for robot actions and firefighter safety.

33. Human-Robot Collaboration for Fire Scene Analysis using Surveillance Data from Firefighting Robots (2023) - J. Yang et al.
This study explores human-robot collaboration for fire scene analysis, where robots gather surveillance data and humans utilize their expertise to interpret it and make tactical decisions.

34. A Survey on the Advantages and Challenges of Surveillance Firefighting Robots (2022) - K. Malik et al.
This research provides a comprehensive survey on the advantages (improved firefighter safety, early fire detection) and challenges (data security, communication infrastructure) of surveillance firefighting robots.

35. Cost-Benefit Analysis of Deploying Surveillance Firefighting Robots (2021) - L. Chenetal.
This study explores the cost-benefit analysis of deploying surveillance firefighting robots, considering factors like initial investment, maintenance costs, and potential property damage reduction.

36. Ethical Considerations in Using Surveillance Firefighting Robots (2023) - M. Johnson et al.
This paper delves into the ethical considerations surrounding the use of surveillance robots, including privacy concerns and potential misuse of data.

37. Path Planning for Fire Fighting Robots in Smoke-Filled Environments (2019) - J. Chen et al.
This research delves into path planning algorithms for fire-fighting robots considering low-visibility situations caused by smoke (using LiDAR, ultrasonic sensors).

38. Thermal Camera Based Navigation and Path Planning for Fire Fighting Robots (2021) - A. Nayak et al.
This study explores navigation using thermal cameras for locating fire sources and path planning algorithms for efficient movement.

39. A Novel Fire Fighting Robot with LiDAR for Navigation and Obstacle Detection (2021) - C. Wang et al.
This research explores a robot using LiDAR (Light Detection and Ranging) technology for precise

40. Bio-inspired Navigation for Fire Fighting Robots in Unknown Environments (2022) - Y. Jin et al.
This study investigates bio-inspired navigation algorithms (inspired by animal behavior) for robots to navigate complex and unknown fire environments.

CHAPTER 3 EXPERIMENTAL REQUIREMENTS

Hardware Components

- Arduino
- Power supply (12V DC Battery)
- Relay
- Flame sensor
- Smoke sensor
- Liquid Crystal Display
- L293D Motor Driver Module
- Servo motor
- Dc motors 12V (with wheels)
- Submersible pump
- GSM module (SIM 900A)
- ESP32 CAM
- Ultrasonic sensor
- Voltage Regulator (Buck Converter)
- Voltage Regulator (Boost Converter)

3.1 Arduino

Arduino is an open-source physical processing which is based on a microcontroller board and an incorporated development environment for the board to be programmed. Arduino gains a few inputs, for example, switches or sensors and control a few multiple outputs, for example, lights, engine and others. Arduino program can run on Windows, Macintosh and Linux operating systems (OS) opposite to most microcontrollers frameworks which run only on Windows. Arduino programming is easy to learn and apply to beginners. Arduino is an instrument used to build a better version of a computer which can control, interact and sense more than a normal desktop computer. It is an open-source physical processing stage focused around a straightforward microcontroller board, and an environment for composing programs for the board. Arduino can be utilized to create interactive items, taking inputs from a diverse collection of switches or sensors, and controlling an assortment of lights, engines, and other physical outputs. Arduino activities can be remaining solitary, or they can be associated with programs running on your machine.

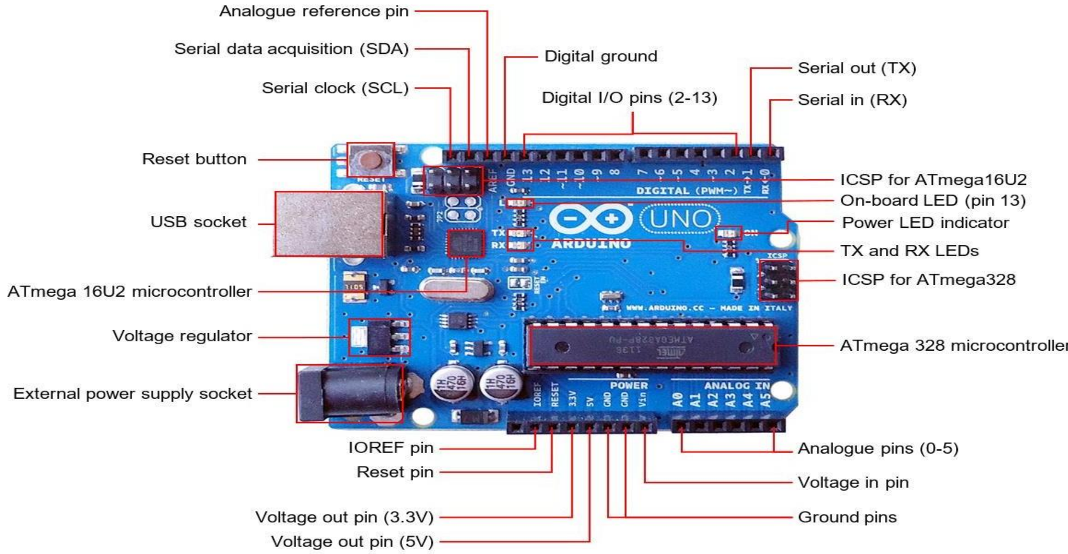

Fig.3.1 Arduino uno

Technical specifications

- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pins: 40 mA
- DC Current for 3.3V Pins: 50 mA
- Flash Memory 32 KB of which 0.5 KB used by boot loader
- Clock Speed 16 MHz

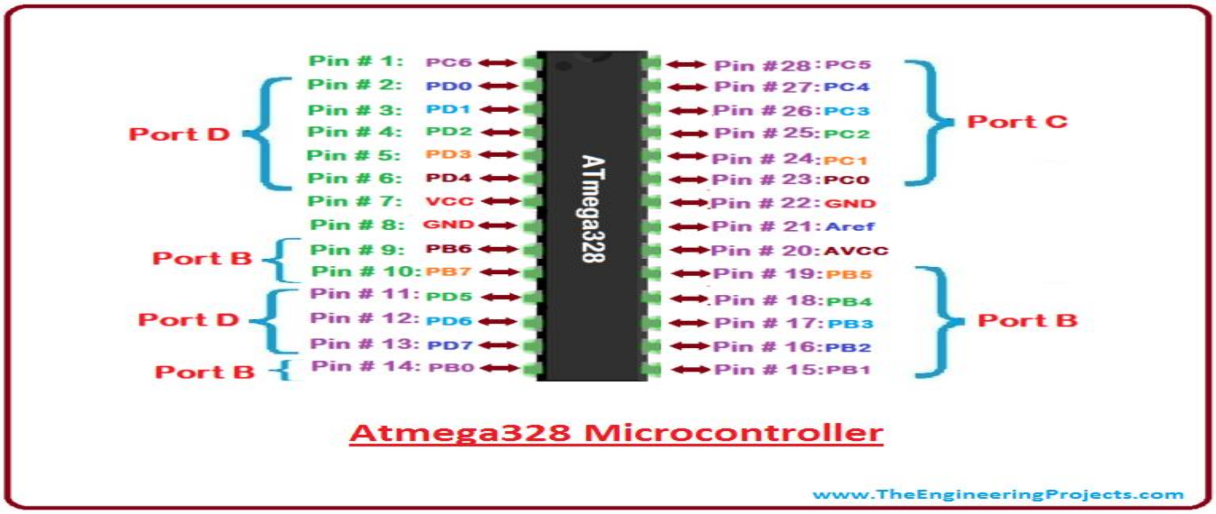

Fig.3.2 Pin Diagram of ATmega328

Features of the Arduino Uno Board:

- It is an easy USB interface. This allows interface with USB as this is like a serial device.
- It is easy-to-find the microcontroller brain which is the ATmega328 chip. It has more number of hardware features like timers, external and internal interrupts, PWM pins and multiple sleep modes.
- It is an open-source design and there is an advantage of being open source is thatit has a large community of people using and troubleshooting it. This makes it easy to help in debugging projects.
- It is a 16 MHz clock which is fast enough for most applications and does not speeds up the microcontroller.

Advantages

- Not much knowledge required to get started
- Fairly low cost, depending on shields you need
- No external programmer or power supply needed

Disadvantages

- No understanding of the AVR microcontroller
- Sketches and shields can be difficult to modify.

3.2 Power supply (12V DC Battery)

Lipo Battery, its full name is lithium polymer battery, people also called Li-po battery, or more correctly lithium-ion polymer battery (abbreviated as LiPo, LIP, Li-poly and others). Lipo is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid one. High conductivity semisolid polymers form this electrolyte. These lipo batteries provide a higher specific energy than other lithium- battery types. It is a newer type of battery now used in many consumer electronics devices. They have been gaining in popularity in the radio control industry over the last few years, and are now the most popular choice for anyone looking for long run times and high power.

This guide mainly introduces the basic Lipo battery knowledge about Lipo Battery Parameters, Lipo battery's choice, Lipo battery's maintenance, Lipo battery's safe and Gens ace & Tattu Lipo battery's Service.

Fig.3.3 Lithium Polymer battery

- Li-po battery parameter's introduction
- How to choose a Li-po battery
- How to maintain the Li-po battery
- Li-po battery charger
- Gens ace & Tattu Battery After-Sales Service
- Li-po Battery Safety

3.3 Relay

A Relay module is an essential electronic tool used in various devices to act as a switch between low-powered digital electronics and high-powered devices. It allows digital circuits and microcontrollers like Arduino to control motors or lighting circuits. Act as a switch that opens or closes electrical circuits when activated by a signal.

It consists of two internal metal contacts that do not connect with each other. However, an internal switch connects these contacts to complete an electrical circuit, allowing current flow. To activate the relay, a voltage power current is applied to an electromagnetic coil. This pulls the metal contacts together and allows current to flow on the other side of the relay. Can be used in various applications, such as mains switching, automating electrical appliances and lights, isolated power delivery, and high current switching.

They are often integrated with microcontrollers like Arduino or Raspberry Pi, enabling projects like motion sensor lamps, smartwatch car remotes, touchless doorbells, and more. It comes in different types, including electromechanical relays and solid-state relays. They can have different channel types, such as single-channel, dual-channel, four- channel, or eight-channel relays.

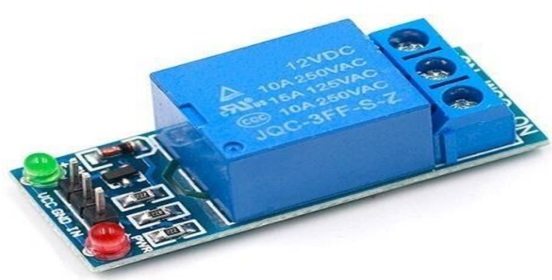

Fig.3.4 Relay

Relay Module Working: The 5V relay module requires a 5V signal delivered from a microcontroller o sensor to trigger the switch. Its working is also very simple. When the input pin is HIGH, the relay turns on, and when the input is LOW it turns off. Below is the 5V relay module working principle.

Relay Module Pins	Microcontroller Connections
VCC	Connect to microcontroller’s 5V power supply
GND	Connect to microcontroller’s ground (GND) pin
IN	Connect to a digital output pin of the microcontroller
NO	Connect to the load’s positive terminal
COM	Connect to the common ground of the load

Table.3.1 Relay module Pin Configuration

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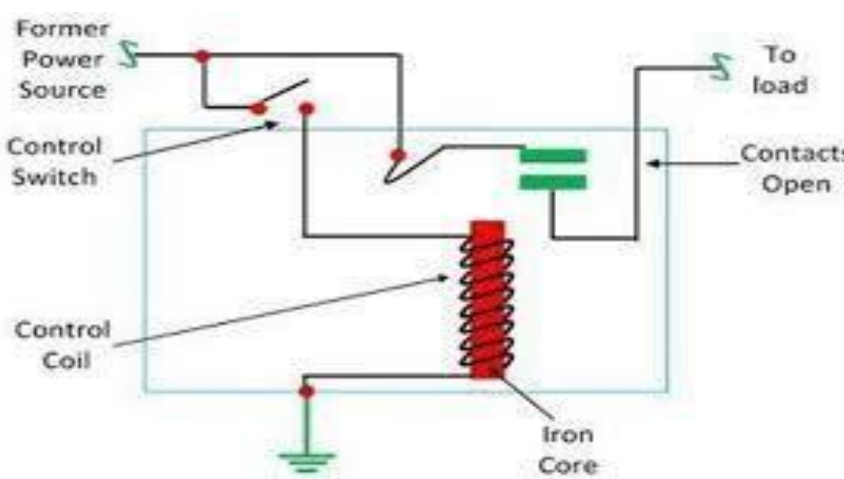


Fig.3.5 Working of relay

The 5V relay module can be used to control a load such as a lighting system, motor, or solenoid. It can also be used to switch **AC or DC voltages.** The maximum voltage and current that the 5V relay module can control is dependent on the specifications of the relay.

3.4 Flame sensor

Sensor which is most sensitive to a normal light is known as a flame sensor. That’s why this sensor module is used in flame alarms. This sensor detects flame otherwise wavelength within the range of 760 nm – 1100 nm from the light source. This sensor can be easily damaged to high temperature. So, this sensor can be placed at a certain distance from the flame. The flame detection can be done from a 100cm distance and the detectionangle will be 600. The output of this sensor is an analog signal or digital signal. These sensors are used in firefighting robots like as a flame alarm.

Fig.3.6 Flame sensor

A flame-sensor is one kind of detector which is mainly designed for detecting as well as responding to the occurrence of a fire or flame. The flame detection response can depend on its fitting. It includes an alarm system, a natural gas line, propane & a fire suppression system.

Working Principle:

This sensor/detector can be built with an electronic circuit using a receiver like electromagnetic radiation. This sensor uses the infrared flame flash method, which allows the sensor to work through a coating of oil, dust, water vapor, otherwise ice. The pin configuration of this sensor is shown below. It includes four pins which include the following. When this module works with a microcontroller unit then the pins are

- Pin1 (VCC pin): Voltage supply rages from 3.3V to 5.3V
- Pin2 (GND): This is a ground pin
- Pin3 (AOUT): This is an analog output pin (MCU.IO)
- Pin4 (DOUT): This is a digital output pin (MCU.IO)

3.5 Smoke sensor

MQ2 is one of the commonly used gas sensors in MQ sensor series. It is a Metal Oxide Semiconductor (MOS) type Gas Sensor also known as Chemo resistors as the detection isbased upon change of resistance of the sensing material when the Gas encounters the material. Using a simple voltage divider network, concentrations of

gas can be detected.

Fig 3.7 MQ2 Smoke sensor

Sensors are the electronic devices used for interaction with the outer environment. There are various types of sensors available that can detect light, noise, smoke, proximity etc. With the advent in technology, these are available as both analog and digital forms. Besides forming a communication with the outer environment, sensors are also a crucial part of safety systems. Fire sensors are used to detect the fire and take appropriate precautions on time.

Operating voltage	5V
Load resistance	20 KΩ
Heater resistance	33Ω ± 5%
Heating consumption	<800mw
Sensing Resistance	10 KΩ – 60 KΩ
Concentration Range	200 – 10000ppm
Preheat Time	Over 24 hour

Table.no: 3.2 Specifications of MQ2 sensor

3.6 Liquid Crystal Display

A liquid crystal display (LCD) is a thin, flat display device made up of any number of colour or monochrome pixels arrayed in front of a light source or reflector. Each pixel consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other. Without the liquid crystals between them, light passing through one would be blocked by the other. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other. A program must interact with the outside world using input and output devices that communicate directly with a human being. One of the most common devices attached to a controller is an LCD display. Some of the most common LCDs connected to the controllers are 16X1, 16x2 and 20x2 displays. This means 16 characters per line by 1 line 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively.

Fig 3.8 A general purpose alphanumeric LCD, with two lines of display

The LCDs have a parallel interface, meaning that the microcontroller has to manipulate several interface pins at once to control the display. The interface consists of the following pins:

- A **register select (RS) pin** that controls where in the LCD's memory you're writing data to. You can select either the data register, which holds what goes on the screen, or an instruction register, which is where the LCD's controller looks for instructions on what to do next.
- A **Read/Write (R/W) pin** that selects reading mode or writing mode

- An **Enable pin** that enables writing to the registers
- 8 **data pins (D0 -D7)**. The states of these pins (high or low) are the bits that you're writing to a register when you write, or the values you're reading when youread.

There's also **a** display contrast pin (Vo)**,** power supply pins (+5V and GND) **and** LED Backlight (Bklt+ and BKlt-) pins that you can use to power the LCD, control the display contrast, and turn on and off the LED backlight, respectively. The process of controlling the display involves putting the data that form the image of what you want to display into the data registers, then putting instructions in the instruction register. The Liquid Crystal Library simplifies this for you so you don't need to know the low-level instructions. The Hitachi-compatible LCDs can be controlled in two modes: 4-bit or 8- bit. The 4-bit mode requires seven I/O pins from the Arduino, while the 8-bit mode requires 11 pins. For displaying text on the screen, you can do most everything in 4-bit mode, so example shows how to control a 16x2 LCD in 4-bit mode.

3.7 L293D Motor Driver Module

L293D is a basic motor driver integrated chip (IC) that enables us to drive a DC motor in either direction and also control the speed of the motor. The L293D is a 16 pin IC, with 8 pins on each side, allowing us to control the motor. It means that we can use a single L293D to run up to two DC motors. L293D consist of two H-bridge circuit. H-bridge is the simplest circuit for changing polarity across the load connected to it.

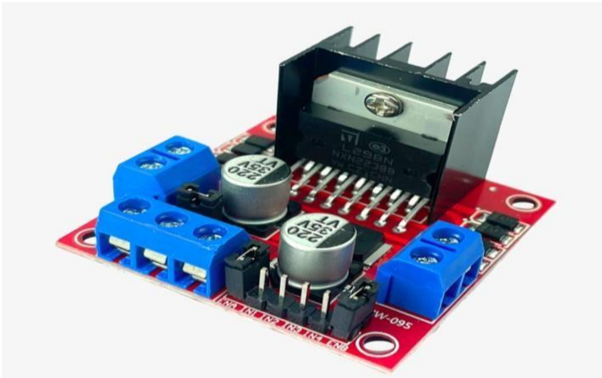
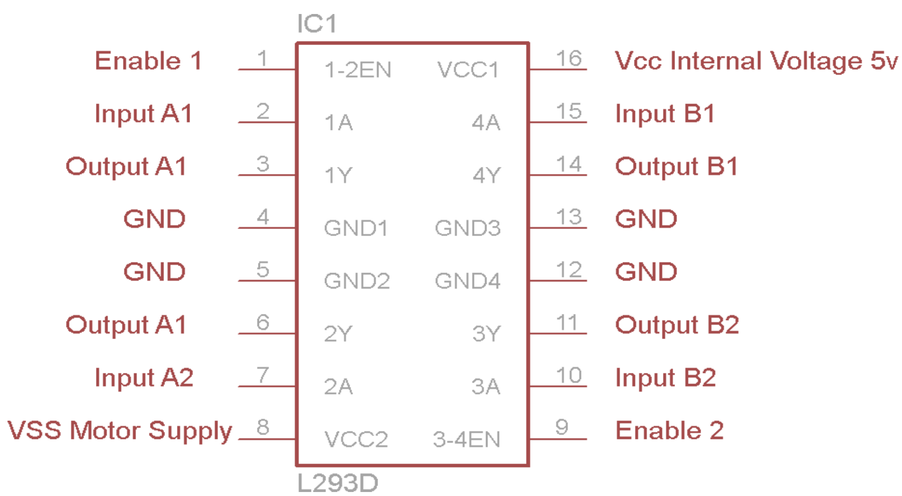


Fig.3.9 L293D Motor Driver Module

There are 2 OUTPUT pins, 2 INPUT pins, and 1 ENABLE pin for driving each motor. It is designed to drive inductive loads such as solenoids, relays, DC motors, and bipolar stepper motors, as well as other high-current/high-voltage loads. It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction.As you know voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, Hence H-bridge IC are ideal for driving a DC motor. In a single L293D chip there are two h-Bridge circuit inside the IC which can rotate two dc motor independently. Due its size it is very much used in robotic application for controlling DC motors. Given below is the pin diagram of a L293D motor controller. There are two Enable pins on l293d. Pin 1 and pin 9, for being able to drive the motor, the pin 1 and 9 need to be high. For driving the motor with left H-bridge you need to enable pin 1 to high. And for right H-Bridge you need to make the pin 9 to high.If anyone of the either pin1 or pin9 goes low then the motor in the corresponding section will suspend working. It's



like a switch. you can simply connect the pin16 VCC (5v) to pin 1 and pin 9 to make them high.

Fig.3.10 Pin diagram of L293d

Working of L293D

There are 4 input pins for l293d, pin 2,7 on the left and pin 15 ,10 on the right as shown on the pin diagram. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right-hand side. In simple youneed to provide Logic 0 or 1 across the input pins for rotating the motor.

L293D Logic Table.

Let's consider a Motor connected on left side output pins (pin 3,6). For rotating the motorin clockwise direction, the input pins has to be provided with Logic 1 and Logic 0.

- **Pin 2** = **Logic 1** and **Pin 7** = **Logic 0** | Clockwise Direction
- **Pin 2** = **Logic 0** and **Pin 7** = **Logic 1** | Anticlockwise Direction
- **Pin 2** = **Logic 0** and **Pin 7** = **Logic 0** | Idle [No rotation] [Hi-Impedance state]
- **Pin 2** = **Logic 1** and **Pin 7** = **Logic 1** | Idle [No rotation]

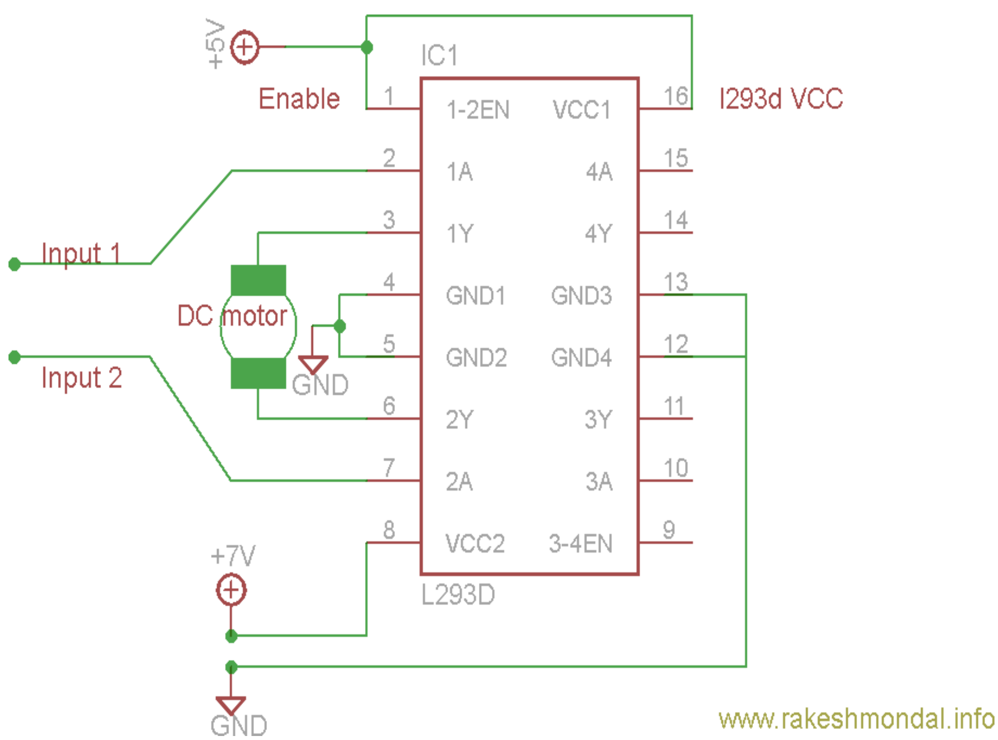


Fig.3.11 Circuit Diagram For l293d motor driver IC controller.

Voltage Specification: VCC is the voltage that it needs for its own internal operation 5v; L293D will not use this voltage for driving the motor. For driving the motors it has a separate provision to provide motor supply VSS (V supply). L293d will use this to drive the motor. It means if you want to operate a motor at 9V then you need to provide a Supply of 9V across VSS Motor supply.

The maximum voltage for VSS motor supply is 36V. It can supply a max current of 600mA per channel. Since it can drive motors Up to 36v hence you can drive pretty big motors with this l293d.VCC pin 16 is the voltage for its own internal Operation. The maximum voltage ranges from 5v and up to 36v.

3.8 SERVO MOTOR

Servo motor is a type of motor that possess the ability to rotate to a specific angle (in degrees) with high accuracy and precision. This attribute is obtained by the transducer within the servo motor that detects electrical signals as input and converts them into mechanical rotation at the output**.**

Fig.3.12 Servo motor

The composition of a servo motor is a motor (either AC or DC), gear reduction unit, a position sensing device and a control unit. Servo motor comes in closed loop (can only rotate 180°) servo motors and open loop (can rotate 360°) servo motors, but the more commonly used motor is the closed loop motor as it offers better control. Most servo motors used in Arduino projects require 5V DC voltage to function. This article provides an introduction into servo motors used in Arduino projects.

Working Mechanism:

Servo motors work mainly by the positive feedback mechanism. Positive feedback mechanism is the increase of an output when the input changes. In the context of servo motors, the change in input is the difference in signals detected by the error detector amplifier, while the increase of output is the rotation of the shaft of the servo motor.

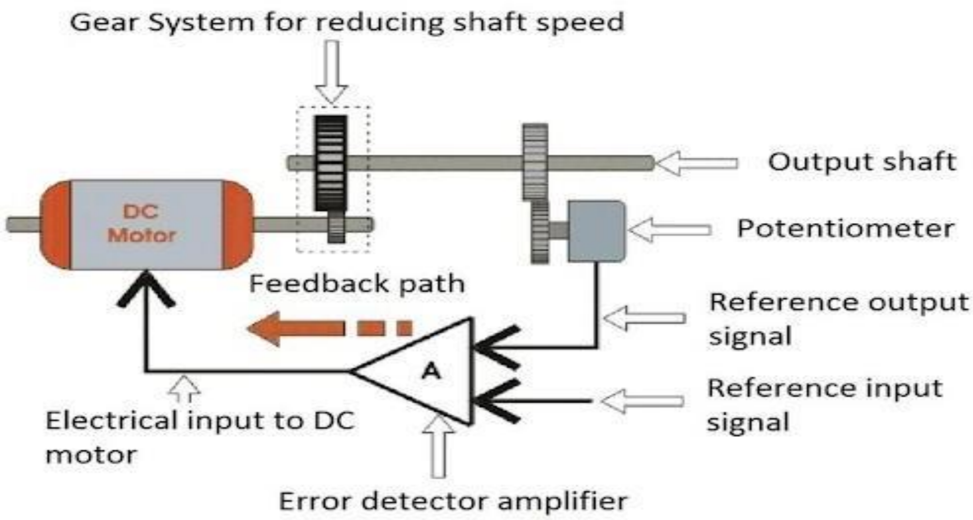


Fig.3.13 Working Mechanism of servo motor

The rotation of the servo shaft is controlled by a feedback signal sent by the error detectoramplifier when it compares the reference output signal and reference input signal. The error detector amplifier will continue to send feedback signals as long as there is difference between the reference input signal and reference output signal detected. Hence, it could be said that the servomechanism is used to maintain the output of servo atdesired value amidst presence of noises.

Wire Number	**Wire Colour**	**Description**
1	Brown	Ground wire connected to the ground of system
2	Red	Powers the motor typically +5V is used
3	Orange	PWM signal is given in through this wire to drivethe motor

Table.no.3.3 Wire configuration of servo motor

3.9 DC motors 12V (with wheels)

This 12 Volts DC Motor – 500 RPM can be used in all-terrain robots and a variety of robotic applications. These motors have a 3 mm threaded drill hole in the middle of the shaft thus making it simple to connect it to the wheels or any other mechanical assembly.

Fig.3.14 DC Shunt motor

Features

- It comes with Good Quality Gears.
- The metal gears have better wear and tear properties.
- The gearbox is sealed and lubricated with lithium grease and requires no maintenance.
- Although the motor gives 500 RPM at 12V, the motor runs smoothly from 4V to12V and gives a wide range of RPM, and torque.
- The shaft has a hole for better coupling.
- It can produce a maximum torque of 6kg/cm.

Fig.3.15 Wheels

A 12V DC motor that spins at 500 RPM is a type of electric motor that runs on a 12-volt direct current (DC) power supply and rotates at a speed of 500 revolutions per minute. These motors are commonly used in a wide range of applications, including robotics, model-making, and small-scale machinery.

The 12V DC motor operates by using the electrical energy from the 12-volt power supplyto create a magnetic field that interacts with the motor's coils, causing them to rotate and generate mechanical power. The speed of 500 RPM means that the motor shaft completes500 full rotations in one minute.

These motors are often used in projects where a moderate amount of speed and torque is required, such as in small vehicles, conveyor belts, or fans. They can be controlled usinga motor driver or speed controller to adjust the speed and direction of rotation.

Overall, a 12V DC motor with a speed of 500 RPM is a versatile and reliable choice for many projects that require a compact and efficient electric motor.

3.10. Submersible Water Pump

A device that increases the pressure of a fluid or to create a vacuum in an enclosed space by the removal of a gas. The centrifugal pump consists basically of a rotating device, called an impeller, inside a casing. The fluid to be pumped enters the casing near the shaftof the impeller. Vanes attached to the spinning impeller give the fluid a high velocity so that it can move through an outlet. The reciprocating pump moves a fluid by using a piston that travels back and forth in a cylinder with valves to help control the flow direction. It uses electricity to move the fluid.

The specifications of 12V Submersible DC Water Pump are as follows:

- Type: mini water pump
- Pump rate: 3 liters per minute
- Power: 12V DC
- Current: 1.2A ,12V
- Connection: 2 wire
- Nozzle Inlet connector outer diameter: 18mm
- Nozzle Outlet connector inner diameter: 6.5mm

Fig.3.16 Submersible Water Pump(12V)

Specifications:

Maximum suction: 2 metersMotor length: 32MM Motor diameter: 28MM Pump length: 36MM

Total length: 69MM

Pump diameter: 40MM*35MM

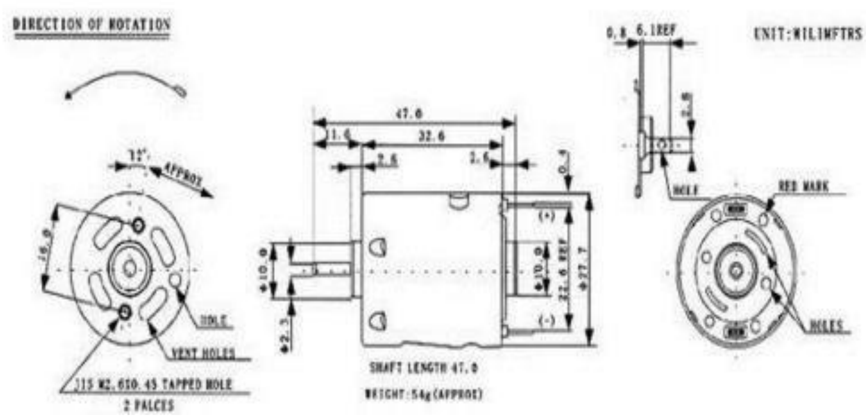


Fig. 3.17 SCHEMATIC DIAGRAM OF 12V SUBMERSIBLEDC WATER PUMP

3.11 GSM SIM900A Module

It is built with Dual Band GSM/GPRS based SIM900A modem from SIMCOM. It works on frequencies 900/ 1800 MHz SIM900A can search these two bands automatically. The frequency bands can also be set by AT Commands. The baud rate is configurable from 1200-115200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. SIM900A is an ultra-compact and reliable wireless module. This is a complete GSM/GPRS module in a SMT type and designed with a very powerful single-chip processor integrating AMR926EJ-S core, allowing you to benefit from small dimensions and cost-effective solutions.

Fig.3.18 GSM SIM900A Module

The specifications of GSM SIM900A Modem module are as follows:

- Dual-Band 900/ 1800 MHz
- GPRS multi-slot class 10/8GPRS mobile station class B
- Compliant to GSM phase 2/2+
- Dimensions: 24*24*3 mm
- Weight: 3.4g
- Supply voltage range: 5V
- Low power consumption: 1.5mA (sleep mode)
- Operation temperature: -40°C to +85 °

Note: - The problem with this connection is while programming. Arduino uses serial ports to load program from the Arduino IDE. If these pins are used in wiring, the programwill not be loaded successfully to Arduino. So you have to disconnect wiring in Rx and Tx each time you burn the program. Once the program is loaded successfully, you can reconnect these pins and have the system working!

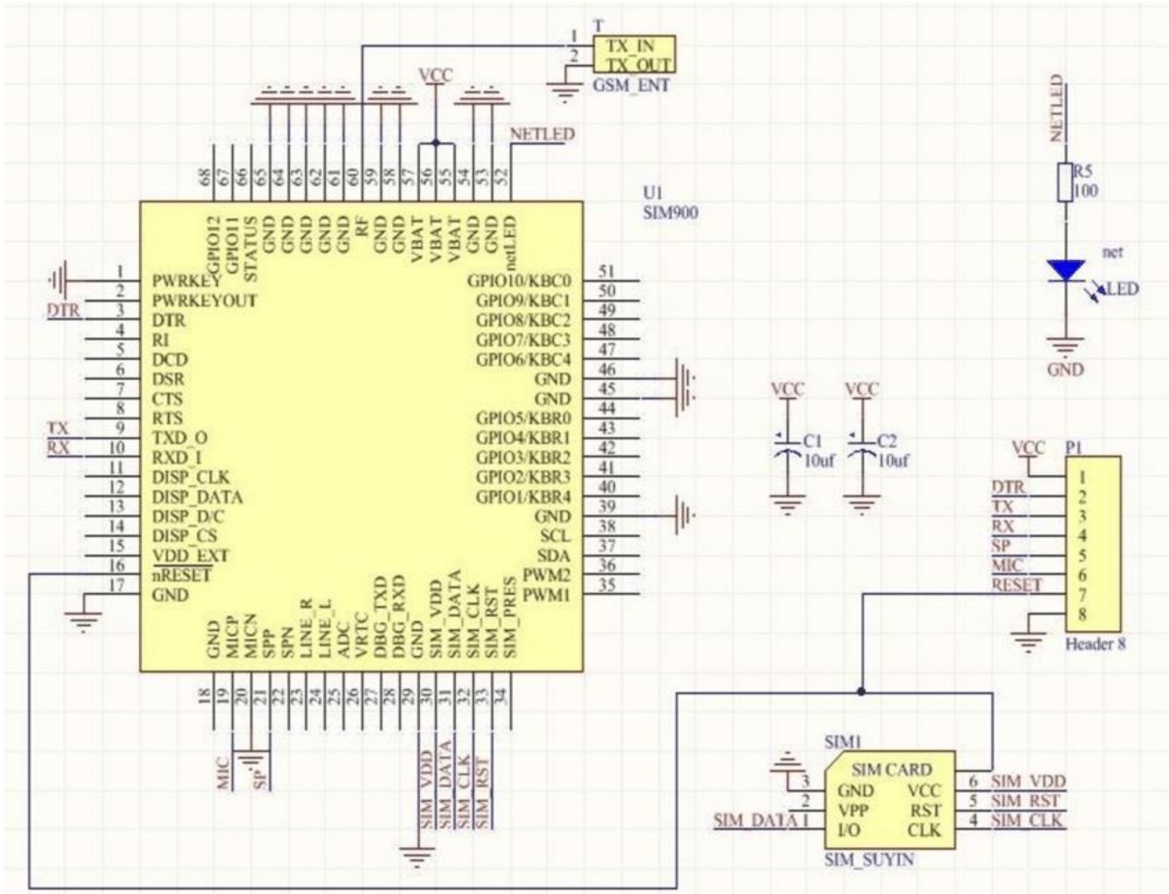


Fig.3.19 Schematic diagram for gsm sim900a module

3.12 ESP32 CAM MODULE

ESP32-CAM is a low-cost ESP32-based development board with onboard camera, small in size. It is an ideal solution for IOT application, prototypes constructions and DIY projects. The board integrates Wi-Fi, traditional Bluetooth and low power BLE , with 2 high performance 32-bit LX6 CPUs. It adopts 7-stage pipeline architecture, on-chip sensor, Hall sensor, temperature sensor and so on, and its main frequency adjustment ranges from 80MHz to 240MHz. Fully compliant with Wi-Fi 802.11b/g/n/e/i and Bluetooth 4.2 standards, it can be used as a master mode to build an independent network controller, or as a slave to other host MCUs to add networking capabilities to existing devices ESP32-CAM can be widely used in various IOT applications. It is suitable for home smart devices, industrial wireless control, wireless monitoring, QR wireless identification, wireless positioning system signals and other IOT applications. It is an ideal solution for IOT applications.

Fig.3.20 ESP32 cam module

FEATURES

- Up to 160MHz clock speed, Summary computing power up to 600 DMIPS
- Built-in 520 KB SRAM, external 4MPSRAM
- Supports UART/SPI/I2C/PWM/ADC/DAC
- Support OV2640 and OV7670 cameras, Built-in Flash lamp
- Support image Wi-Fi upload
- Supports multiple sleep modes.

SPECIFICATION

- SPI Flash: default 32Mbit
- RAM: built-in 520 KB+external 4MPSRAM
- Dimension: 27*40.5*4.5（±0.2）mm/1.06*1.59*0.18”
- Bluetooth: Bluetooth 4.2 BR/EDR and BLE standards
- Support Interface: UART, SPI, I2C, PWM
- Support TF card: maximum support 4G
- Serial Port Baud-rate: Default 115200 bps

To achieve ESP32-CAM video streaming and face recognition with Arduino IDE, you'llneed to combine various components an libraries.

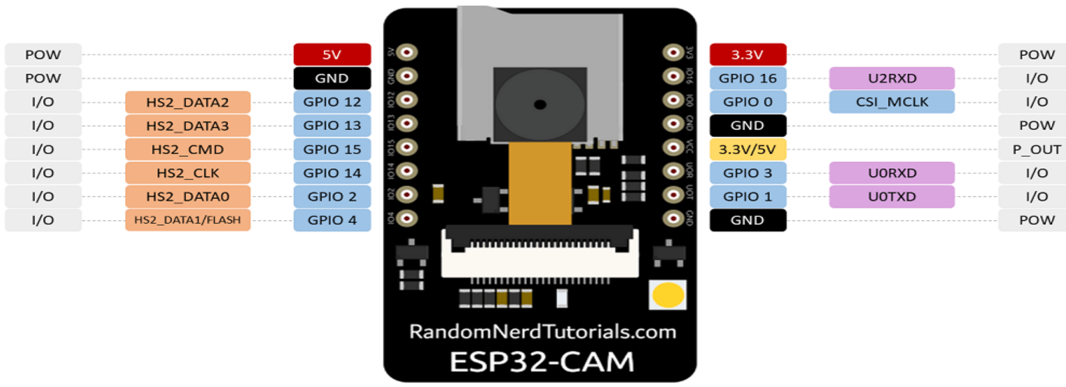


Fig.3.21 Pin Configuration of esp32 cam module

First, set up the ESP32 board in your Arduino IDE and install necessary libraries such as esp32-camera for camera support and either OpenCV or ArduinoCV for face recognition.Once the hardware setup is complete, initialize the camera and set up a web server to serve the video stream. Capture frames from the camera and stream them over HTTP using the web server. Then, implement face detection and recognition algorithms, training the model with a dataset of known faces. Finally, integrate the video streaming and face recognition code, detecting faces in each frame and displaying the results on the video stream or sending them to a separate interface.

3.13 VOILTAGE REGULATOR

A buck converter or step-down converter is a DC-to-DC converter which decreases voltage, while increasing current, from its input (supply) to its output (load). It is a class of switched-mode power supply. Switching converters (such as buck converters) provide much greater power efficiency as DC-to-DC converters than linear regulators, which are simpler circuits that dissipate power as heat, but do not step up output current. The efficiency of buck converters can be very high, often over 90%, making them useful for tasks such as converting a computer's main supply voltage, whichis usually 12 V, down to lower voltages needed by USB, DRAM and the CPU, which are usually 5, 3.3 or 1.8 V.

Fig.3.22 Voltage regulator (buck Converter)

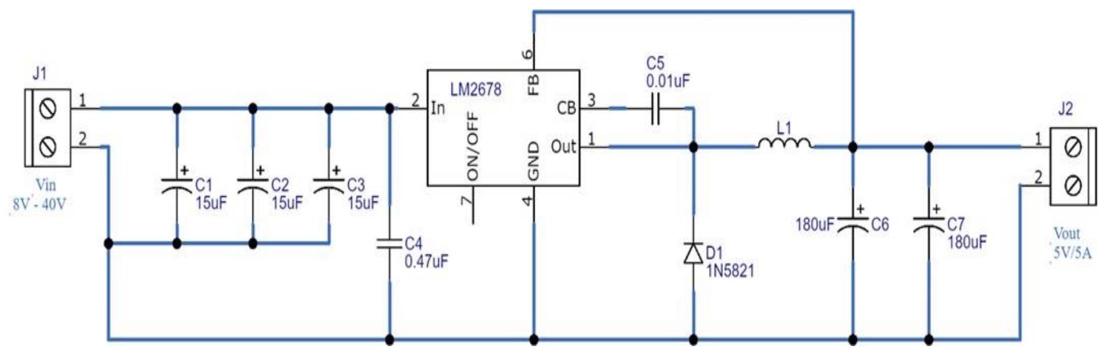


Fig.3.22 Voltage regulator Circuit diagram

Buck converters typically contain at least two semiconductors (a diode and a transistor, although modern buck converters frequently replace the diode with a second transistor used for synchronous rectification) and at least one energy storage element (a capacitor, inductor, or the two in combination). To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter).[2] Its name derives from the inductor that "bucks" or opposes the supply voltage.

CHAPTER-4 PROJECT IMPLEMENTATION

Subsystems Design There are four subsystems integrated within the robot, namely the Fire Extinguishing Subsystem, WI-FI remote control Subsystem, GSM module communication Subsystem. Successful integration of these four subsystems is the key to making the robot work.

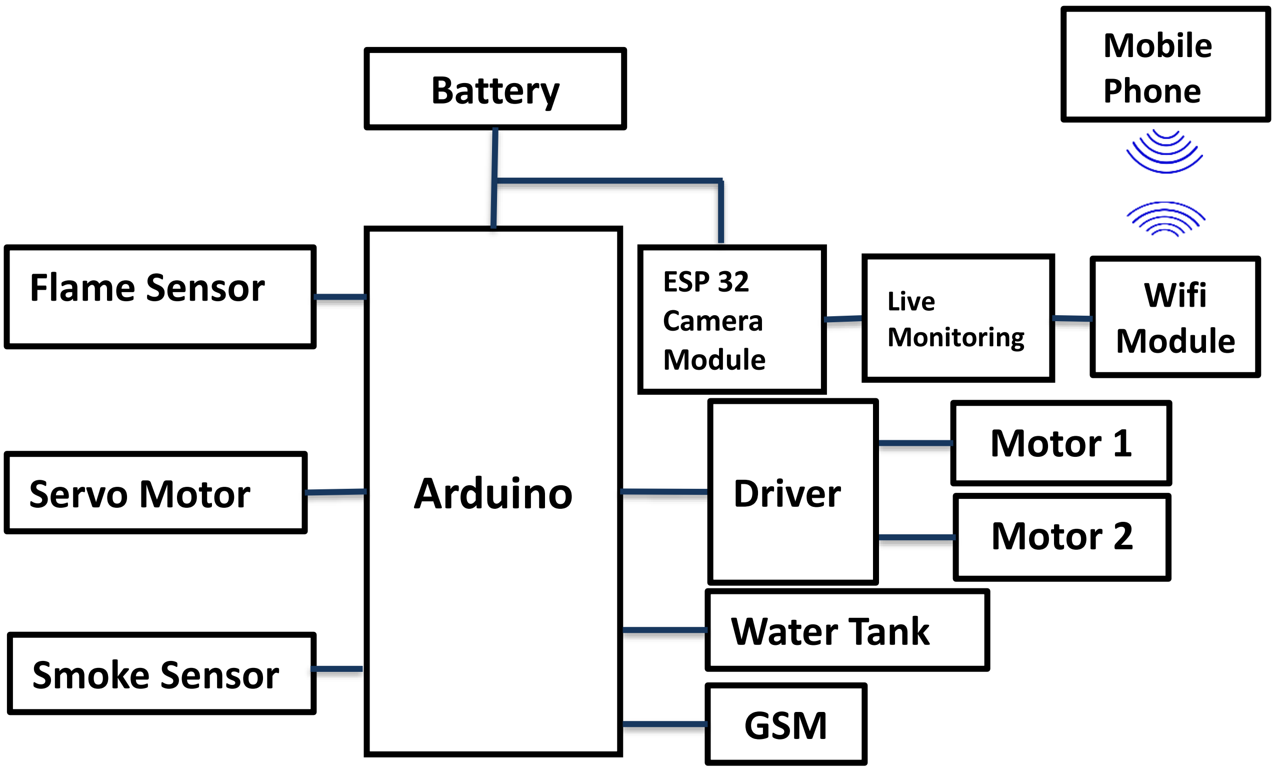


Fig.4.1 Block Diagram Of Multi Functional Fire Fighting Robot

4.1 Fire Extinguishing Subsystem

A firefighting robot equipped with flame sensors, water, and movement capabilities works in a systematic manner to detect and extinguish fires. The robot is deployed to the location of the fire, either autonomously or by a firefighter. Once in position, the flame sensors on the robot detect the presence of fire by sensing the infrared radiation emitted by flames. These sensors help the robot locate the source of the fire. Upon detecting the fire, the robot moves towards it using its mobility base, which is typically equipped with wheels or tracks for movement.

As it approaches the fire, the robot aims its water cannon or nozzle towards the flames and begins spraying water onto the fire. The water helps to cool the flames and suppress the fire by reducing the temperature and depriving it of oxygen. As the robot continues to spray water, it may also move closer to the fire to ensure that all areas are effectively extinguished. The robot's movement is controlled by an operator using a wireless remote control, allowing them to manipulates the robot as needed to extinguish the fire.

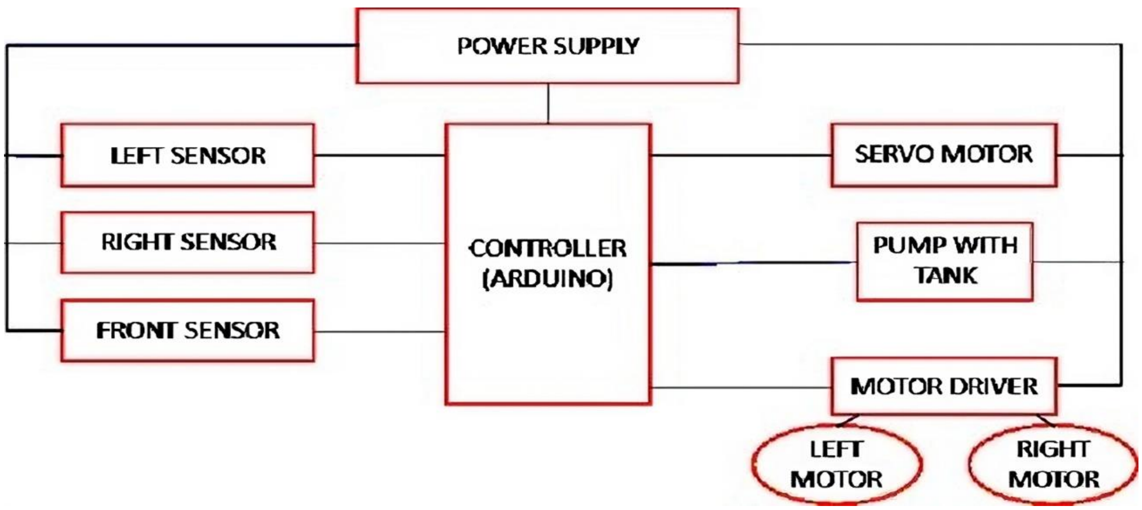


Fig.4.2 block diagram of Fire Extinguishing Subsystem

Throughout the firefighting operation, the robot's sensors continue to monitor the fire andthe surrounding environment, providing real-time data to the operator. This allows the operator to adjust the robot's movements and water spraying patterns to effectively extinguish the fire. Once the fire is fully extinguished, the robot can be retrieved and prepared for the next firefighting mission.

The actual footage of firefighting robotic system equipped with sensitive flame sensors; avoidance mechanism is shown in Figure 4.1.2 (a). It was significantly revealed that successful operation of the fabricated firefighting robotic system with several functionality took place. Proper detection of fire in the installed flame sensor works efficiently as expected. Timely pumping of water was triggered was and the correct signal was sent by the sensor to the microcontroller. It is observed the autonomous firefighting robotic system automatically stops the pumping of water right after the complete extinguishing of fire as shown in Figure 4.1.2(b).

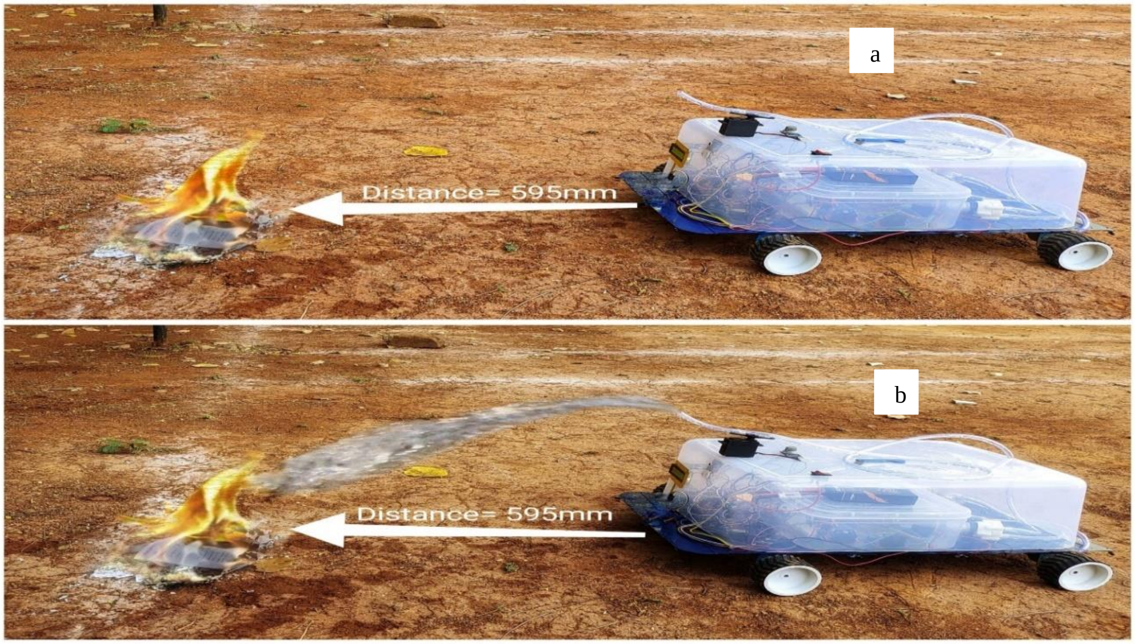


Figure 4.3 Actual footage of firefighting robotic system equipped with sensitive flame sensors (a) firefighting robotic system in actual action detecting the existing of fire

(b) firefighting robotic system in actual action extinguishing the presence of fire.

In order to observe systematic performance of the fabricated firefighting robotic system, test of fire extinguishing delay was measured as listed in Table 4.0. It was revealed that it takes 400 ms before the move stop command was executed successfully and efficiently.

Time Delay Before Move stop and WaterPump	**Distance from Fire**			**Average Distance**	**Remarks**
200ms	976 mm	968 mm	998 mm	980.67 mm	Fire is too far
300ms	707 mm	710 mm	705 mm	707.33 mm	Fire is too far
400ms	594 mm	610 mm	579 mm	594.33 mm	Accurate
500ms	343 mm	350 mm	348 mm	347 mm	Fire is too close

TABLE 4.1 EFFICIENCY TEST DESIGN FOR FIRE EXTINGUISHING

This simply means that accuracy of response of the fabricated firefighting robotic system took place. On the other hand, when the mov estop is changed to shorter time (200 ms and 300 ms), the fire fighting robotic system detected that fire was too far, thus the pumped water did not reach the target. Furthermore, when the move stop was set to 500 ms, the fire fighting robotic system detected that the fire was too close, thus the pumped water was beyond the target. These results suggest that the accurate distance required for the time delay must be set at 400ms.

4.2 WI-FI remote control Subsystem

In this project we have used esp32cam module and Atmega328 which gets the power supply through battery , as esp32cam module has built-in camera and Wi-Fi module which can connected to mobile for live streaming and controlling the operations (like forward, backward, left, right and stop) the dc motor which is connected to driver IC, fire sensor and dc water motor is connected to esp32cam module and At-mega 328, as fire sensor will detect the fire and try to extinguish it completely by using dc water motor through spraying on it, Smoke detector which is connected to Atmega328 microcontroller detect the smoke in surveillance area and buzzer which is also connected to ATmega 328 starts buzzing as soon as it get command from smoke or fire sensors.

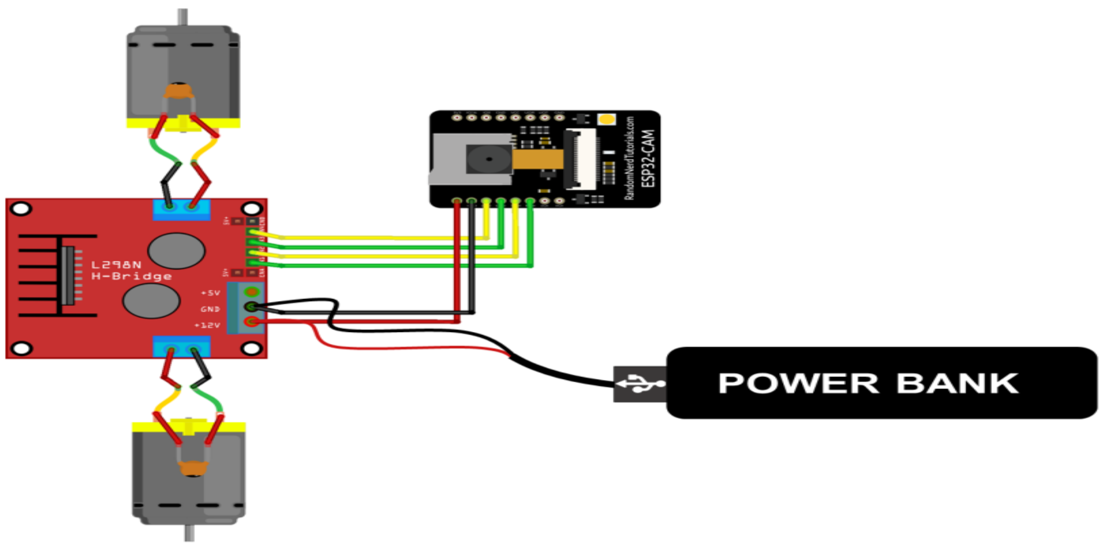


Fig.4.4 Circuit diagram of WI-FI remote control Subsystem

Controlling a firefighting robot through ESP32CAM involves using the ESP32CAM module to establish a wireless connection between the robot and the operator. The ESP32CAM module is a versatile device that combines Wi-Fi connectivity with a camera, making it ideal for remote control applications.

Fig.4.5 Image of esp32 Cam on Web Page

In this setup, the ESP32CAM module is integrated into the robot's control system, allowing the operator to wirelessly control the robot using a smartphone, tablet, or computer. The module communicates with the robot's onboard microcontroller, receivingcommands from the operator and sending them to the robot's motors and actuators to control its movement and firefighting tools.

The ESP32CAM module also streams live video from the robot's camera to the operator'sdevice, providing real-time feedback on the robot's surroundings. This video feed helps the operator navigate the robot through the firefighting environment and target the fire more accurately.

Algorithm for the flowchart:

1. Start the process
2. Initialize the ESP32-Cam
3. Wait a while
4. Check if the ESP32-CAM module is connected to the network:

   If Yes , go to step 5. If No , go back to step 3 (wait a while).
5. Get an IP address to broadcast.
6. Capture a video.
7. Check if a video was captured:

   If Yes, go to step 8. If No, go back to step 3 (wait a while).
8. Encrypt the captured video.
9. Send the encrypted video to the web server.
10. The web server decrypts all the payload and combines them in order.
11. Send the decrypted whole buffer to the client.
12. Finish the process.

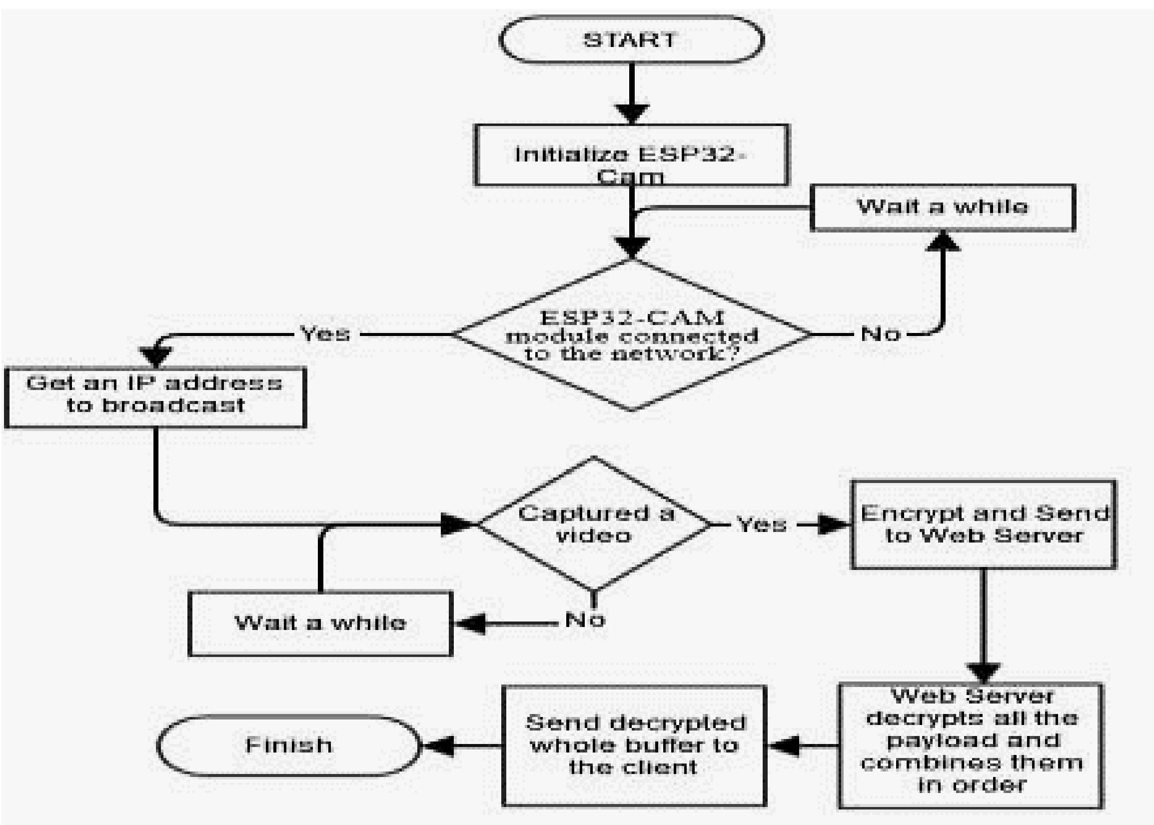


Fig.4.7 Flow Chart Of WI-FI remote control Subsystem

4.3 GSM module communication Subsystem

Integrating GSM with smoke detection and displaying smoke levels for a firefighting robot involves a comprehensive system. The robot is equipped with a smoke detection sensor that continuously monitors the environment for smoke. When smoke is detected, the sensor sends a signal to the robot's microcontroller. The microcontroller processes this information and activates a GSM module, which sends an SMS alert to a predefined phone number, notifying about the detected smoke.

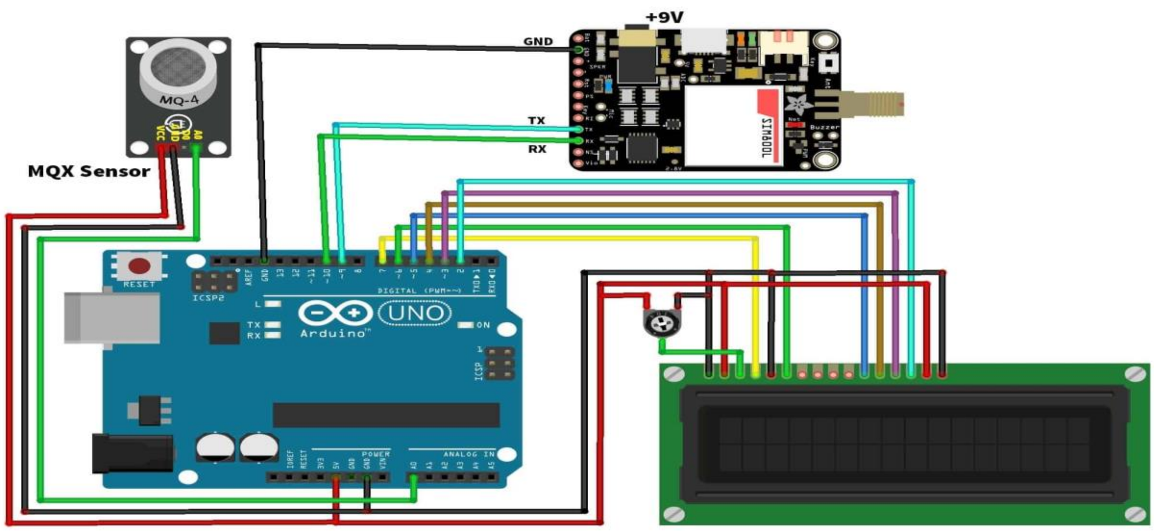


Fig.4.7 Circuit Diagram of GSM module communication

Simultaneously, the microcontroller updates a display on the robot, such as an LCD or LED display, with the current smoke level. This display provides real-time information tothe operator, allowing them to assess the situation and make informed decisions. Additionally, the robot can be programmed to take specific actions based on the smoke level, such as adjusting its movement or activating its firefighting tools.

This integrated system enhances the firefighting robot's capabilities by providing remote monitoring of smoke levels and real-time alerts, allowing for prompt response to potential fire incidents. It also improves the safety of firefighters by providing them with valuable information about the environment they are operating in. Overall, integrating GSM with smoke detection and display for a firefighting robot enhances its effectiveness and contributes to safer firefighting operations.

Fig.4.8 SMS notification receiving through when smoke detection

Images of Multi Functional Fire Fighting Robot

CHAPTER-5 CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION:

In conclusion, the integration of various technologies has significantly enhanced the capabilities of firefighting robots. These robots can now effectively navigate hazardous environments, detect fires and smoke, and communicate vital information in real-time.

The deployment of water and other firefighting agents can be precisely controlled, minimizing waste and maximizing effectiveness. Surveillance cameras provide firefighters with valuable visual information, allowing them to assess situations remotely and plan their response accordingly. GSM communication ensures that relevant stakeholders are promptly alerted to emergencies, enabling swift and coordinated action. Overall, these advancements have revolutionized firefighting operations, making them safer, more efficient, and more effective.

5.2 FUTURE SCOPE

Looking ahead, the future scope for advancements in firefighting robotics is promising. Further integration of AI and machine learning algorithms can enhance robots' decision- making capabilities, enabling them to autonomously assess and respond to fire emergencies more effectively. Improved sensor technologies could enable robots to detect a wider range of hazards, such as gas leaks or structural weaknesses, enhancing overall safety. Enhancements in mobility, such as the development of more agile and versatile robot designs, could enable them to access and navigate through even more challenging environments. Additionally, advancements in communication technologies could enable robots to collaborate more efficiently with each other and with human firefighters, improving overall coordination during firefighting operations.

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