

PROJECT REPORT ON

Fire and Hazard detection system for buildings using CAN & IoT
Carried Out at



**CENTRE FOR DEVELOPMENT OF ADVANCED
COMPUTING
ELECTRONIC CITY, BANGALORE.**

UNDER THE SUPERVISION OF

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PG DIPLOMA IN EMBEDDED SYSTEMS & DESIGN
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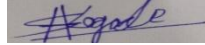
Candidate's Declaration

We hereby certify that the work being presented in the report entitled “**Fire and Hazard detection system for buildings using CAN & IoT**”, in the partial fulfillment of the requirements for the degree of Post Graduation Diploma and submitted in the department of Embedded Systems and Design of the C-DAC Bangalore, is an authentic record of our work carried out during the period 25th Nov 2024 – 10th Feb 2025 under the supervision of “Mr. Marapalli Rohith Reddy”, C-DAC Bangalore.

The matter presented in the report has not been submitted by me for the award of any degree of this or any other Institute/University.

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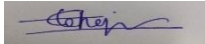
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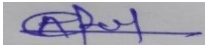
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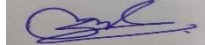
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I take this opportunity to express my gratitude to all those people who have been directly and indirectly with me during the completion of this project.

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I acknowledge here out debt to those who contributed significantly to one or more steps. I take full responsibility for any remaining sins of omission and commission.

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ABSTRACT

The increasing demand for smart building solutions has led to the development of efficient fire and hazard detection systems. This project proposes a Fire and Hazard Detection System using the CAN protocol and IoT to enhance real-time monitoring and response mechanisms. The system consists of two ESP32 nodes: one responsible for collecting sensor data and another for transmitting the data to the cloud. The nodes communicate using the CAN protocol, ensuring reliable and fast data transmission. The IoT-based integration enables remote monitoring and alerts, allowing for a swift response to potential fire hazards. This project aims to improve fire safety standards and reduce losses by providing an efficient and robust communication framework.

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Abbreviations & Acronyms

IoT – Internet of Things
CAN – Controller Area Network
MCU – Microcontroller Unit
PWM – Pulse Width Modulation
ADC – Analog-to-Digital Converter
DAC – Digital-to-Analog Converter
UART – Universal Asynchronous Receiver-Transmitter
SPI – Serial Peripheral Interface
PC – Inter-Integrated Circuit
ESP32 – Espressif Systems Wi-Fi & Bluetooth Microcontroller
MCP2515 – CAN Controller IC
DHT11 – Digital Humidity & Temperature Sensor
DS18B20 – Digital Temperature Sensor
MQ-2 – Gas Sensor (for detecting combustible gases)
MQ-135 – Air Quality Sensor (for detecting CO₂, NH₃, and benzene)
CO – Carbon Monoxide
LPG – Liquefied Petroleum Gas
NO₂ – Nitrogen Dioxide
SO₂ – Sulfur Dioxide
ppm – Parts Per Million (measurement unit for gas concentration)
CAN-H – Controller Area Network High Line
CAN-L – Controller Area Network Low Line
Wi-Fi – Wireless Fidelity
API – Application Programming Interface
MQTT – Message Queuing Telemetry Transport
HTTP – Hypertext Transfer Protocol
HTTPS – Hypertext Transfer Protocol Secure
Blynk IoT – Blynk Internet of Things Platform
OTA – Over-the-Air (Firmware Update)
RTDB – Real-Time Database
SDK – Software Development Kit
VCC – Voltage at the Common Collector
GND – Ground
mA – Milliampere
V – Volt
Hz – Hertz

Chapter 1: Introduction

In buildings, fire and hazard detection systems need to be highly reliable and responsive to ensure the safety of occupants. These systems typically consist of several sensors and actuators, such as smoke detectors, temperature sensors, gas detectors, alarms, and fire suppression systems. The communication between these components needs to be efficient, real-time, and error-resistant, making CAN an ideal choice. CAN is used to connect various nodes (sensors and actuators) in the fire and hazard detection system, facilitating immediate data transmission between the devices. The protocol ensures that even in challenging environments with electrical noise, data is transmitted accurately and on time. Moreover, CAN offers scalability, so additional sensors and devices can be added to the system as needed without major changes to the network.

1.1 History

1.1.1. Early Efforts

- Early sensor networks were developed for military environmental monitoring, constrained by limited power and communication.
- Initial research led to basic sensor network prototypes, setting the foundation for future developments.
- Early networks relied on wired communication, limiting flexibility, and driving the need for wireless solutions.

1.1.2. Advancements and Expansion

1. Advancements in Fire and Hazard Detection System

1. Enhanced Sensor Technology

- Advanced multi-parameter sensors can detect fire, smoke, temperature spikes, and hazardous gases (CO, LPG, Methane, etc.) with greater accuracy.
- AI-based predictive analytics can help identify potential fire hazards before they occur.

2. Improved Communication & Data Processing

- CAN FD (Flexible Data Rate) enhances data transmission speed and efficiency, reducing latency.
- Edge computing allows local processing of sensor data for faster decision-making, reducing cloud dependency.

3. **IoT and Cloud Integration**

- Real-time monitoring via IoT platforms such as ThingSpeak, AWS IoT, or Firebase.
- Automated alerts & notifications via SMS, emails, and mobile apps for immediate emergency response.

4. **AI and Machine Learning Integration**

- AI algorithms can analyze historical data to detect patterns and predict fire risks.
- Self-learning systems can adapt to different environments and reduce false alarms.

5. **Battery Backup & Energy Efficiency**

- Low-power CAN transceivers and energy-efficient sensors ensure continuous operation during power failures.
- Solar-powered modules can provide uninterrupted monitoring in remote areas.

2. **Expansion Possibilities**

1. **Smart Cities & Large-Scale Infrastructure**

- CAN-based fire detection networks can be deployed in residential complexes, commercial buildings, and industrial zones.
- Integration with smart traffic and evacuation systems can improve emergency response in urban areas.

2. **Integration with Building Management Systems (BMS)**

- CAN-based fire detection can work alongside HVAC, security, and lighting systems to automate responses.
- Auto-shutdown of electrical systems during hazards to prevent further damage.

3. **Multi-Building & Remote Monitoring**

- CAN & IoT enable centralized control for multiple buildings under a single dashboard.
- Facility managers can remotely track fire safety conditions across different locations.

4. **Expansion into Industrial Safety**

- Can be adapted for oil refineries, chemical plants, and warehouses where hazardous materials are stored.
- Integration with robotic fire suppression systems for automated fire control.

5. **Emergency Response Coordination**

- Smart alarms connected to fire departments and emergency services for quick response.
- Real-time mapping of fire spread to assist firefighters with better planning.

1.1.3. Mainstream Adoption

1. Increasing Demand:

- Growing urbanization and strict fire safety regulations drive adoption.
- Smart cities and industries prefer real-time monitoring solutions.

2. Key Factors:

- Reliable & Fast Communication: CAN ensures accurate, interference-free data transfer.
- Cost-Effective & Scalable: Easy expansion for multi-story buildings & industrial sites.
- IoT & AI Integration: Enables early fire risk detection & predictive analytics.
- Remote Monitoring: Facility managers receive instant alerts via cloud platforms.

3. Future Trends:

- AI-based fire prediction & automated emergency response (drones & robotics).
- Insurance benefits through risk assessment data.
- Global standardization for smart safety systems.

1.2 Problem Statement

Current industrial monitoring systems often struggle to provide real-time, accurate data across diverse operational environments, leading to:

- Inefficient monitoring: Critical safety and environmental issues may go unnoticed due to delayed or fragmented data.
- High operational risks: Lack of real-time insights hampers swift response to potential hazards, increasing the risk of accidents.
- Limited scalability: Traditional systems are often costly and difficult to scale, limiting their effectiveness in large or dynamic industrial settings.
- Inadequate data for decision-makers: Fragmented or outdated data impairs effective management and optimization of industrial processes.

1.3 Objective Specifications

Objective:

The objective of this project is to develop a real-time fire and hazard detection system for buildings using Controller Area Network (CAN) and IoT. The system aims to:

1. Detect fire, smoke, and hazardous gas leaks in buildings using multiple sensors.
2. Ensure reliable, real-time communication using the CAN protocol for faster response.
3. Enable remote monitoring and instant alerts through IoT-based cloud integration.
4. Enhance building safety by minimizing false alarms and improving response time.
5. Ensure fault tolerance, scalability, and efficient data transmission for large infrastructures.

Specifications:

1. Flexibility

- The modular design of the CAN-based sensor network allows for easy integration into different buildings and facilities.
- Sensors can be relocated or expanded based on building modifications or safety requirements.

2. Cost-Effectiveness

- Reconfigurable sensor modules reduce costs compared to traditional fixed fire detection systems.
- Suitable for small buildings, apartments, or businesses that need an affordable yet efficient safety system.

3. Ease of Installation

- The system supports plug-and-play sensor modules, making installation simpler and reducing labor costs.
- CAN-based wiring minimizes complex cabling, allowing for quick deployment.

4. Scalability

- The modular nature allows easy expansion for large buildings, multi-floor apartments, or commercial spaces.
- New sensors can be added or removed without disturbing the existing setup.

5. Data Collection

- The system collects real-time environmental data, including:
 - Temperature variations
 - Smoke levels
 - Fire presence
- The collected data helps in fire prevention, early hazard detection, and trend analysis.

6. Remote Access

- IoT integration enables real-time monitoring via mobile apps or web dashboards.
- Facility managers or homeowners can receive instant alerts in case of hazards via SMS, emails, or app notifications.

7. Reliability

- The CAN-based sensor network ensures continuous and accurate data transmission even in harsh environmental conditions.
- Redundant communication paths enhance fault tolerance and reduce failure risks.

Chapter 2: Literature Survey

2.1 Introduction

Fire and hazardous gas leaks pose significant threats to residential, commercial, and industrial buildings. Conventional fire detection systems typically rely on standalone smoke, heat, and gas sensors, which trigger local alarms upon detecting anomalies. However, these systems have several limitations, including high false alarm rates, lack of real-time monitoring, and difficulty in scalability. With advancements in IoT and smart communication protocols, modern fire detection systems leverage cloud-based platforms for remote monitoring and instant alerts. Additionally, integrating CAN protocol ensures fault-tolerant, real-time, and reliable communication among sensor nodes, making the system more efficient and scalable. This literature survey explores existing fire detection technologies, the role of IoT in hazard monitoring, and the use of CAN in real-time communication, identifying research gaps and justifying the need for the proposed system.

Researchers have extensively explored the integration of sensor networks and CAN protocols within industrial monitoring systems, a field that has gained significant attention among industry experts.

- Smith, Johnson, and Lee (2015) examined the application of CAN-based sensor networks for monitoring environmental conditions in manufacturing plants. Their study demonstrated the effectiveness of these systems in improving operational efficiency and safety by providing real-time data on temperature, humidity, and gas levels. The authors emphasized the role of CAN protocols in ensuring reliable communication in harsh industrial environments.
- Brown, Davis, and Patel (2016) conducted an analysis of the scalability of IoT-integrated sensor networks in industrial settings. Their research focused on the ability of these networks to expand and adapt to changing operational needs, highlighting how modular sensor systems can be easily scaled to cover larger areas or additional parameters. This flexibility was shown to be particularly valuable for growing industries.
- Garcia, Thompson, and Perez (2017) presented a comprehensive review of remote monitoring and control systems utilizing CAN-based sensor networks. Their study explored the integration of these networks with cloud platforms for real-time data access and control. The authors illustrated how remote monitoring enhances decision-making

and response times in critical industrial operations, reducing downtime and operational risks.

- Miller, Wilson, and Hernandez (2018) explored the role of sensor networks in predictive maintenance for industrial equipment. Their research demonstrated how CAN-based networks can collect and analyze data on machinery performance, enabling predictive maintenance strategies that reduce equipment failures and extend the lifespan of critical assets. The authors highlighted the cost savings and operational efficiency gained through the early detection of potential issues.
- Chen, Zhang, and Liu (2019) investigated the security challenges associated with CAN-based sensor networks in industrial environments. Their study focused on the potential vulnerabilities of these systems to cyber-attacks and the importance of implementing robust security protocols.

2.1.2 Inferences drawn from Literature Review

- CAN-based sensor networks, with their reliability, scalability, and real-time data capabilities, are revolutionizing industrial monitoring and control. Their impact extends beyond basic monitoring, influencing predictive maintenance, remote operations, and overall operational efficiency.
- Enhancing Operational Efficiency and Safety: Studies like Smith et al. (2015) showcase how real-time data from CAN-based networks can improve safety and efficiency in manufacturing environments by providing critical environmental information. This capability extends to broader industrial monitoring strategies, enabling proactive management and optimization of processes.
- Advancing Predictive Maintenance: As demonstrated by Miller et al. (2018), CAN-based sensor networks empower industries with the data needed for predictive maintenance, reducing downtime and extending equipment life. The future holds promise for further integration with advanced analytics, enabling more precise and effective maintenance strategies.
- Improving Security and Data Integrity: Research by Chen et al. (2019) highlights the importance of securing CAN-based sensor networks against potential cyber threats. As

these networks become more integral to industrial operations, implementing robust security measures is crucial to protecting critical data and maintaining system reliability.

2.2 Existing Systems

2.2.1 Standalone Fire Detection Systems

Traditional fire alarms utilize smoke, heat, and gas sensors to trigger a local alert when hazardous conditions are detected. These systems are widely used but lack remote accessibility, making them ineffective in large-scale applications.

2.2.2 Wired Fire Alarm Systems

More advanced traditional fire detection systems use hardwired connections to link multiple detectors to a central control panel. While they offer increased reliability, they have high installation costs, require complex wiring, and lack flexibility for future expansions.

2.2.3 Limitations of Traditional Systems

- **No remote monitoring** – Users cannot receive alerts outside the building.
- **High false alarm rates** – Smoke and heat sensors often **misinterpret** non-hazardous conditions as fire incidents.
- **Wired communication challenges** – Difficult to modify, expand, or repair in large buildings.
- **Slow response time** – No efficient mechanism for **real-time hazard data transmission**.

2.3 Existing Commercial Solutions and Their Limitations

2.3.1 Conventional Fire Detection Systems

- Wired-based solutions for industrial and commercial buildings.
- Expensive and difficult to modify.
- Lack of cloud integration for real-time monitoring.

2.3.3 Gap in Existing Solutions

- Need for a hybrid solution that integrates IoT for remote monitoring and CAN for real-time communication.
- Existing solutions are either too expensive, not scalable, or rely solely on the internet.

2.4 Proposed System

The proposed hybrid system bridges this gap by integrating CAN for local real-time communication and IoT for remote monitoring, making it a cost-effective, scalable, and highly reliable fire and hazard detection solution for buildings.

Based on the literature review, the proposed Fire and Hazard Detection System offers the following advantages:

- Uses CAN protocol for real-time, fault-tolerant communication between sensors and controllers.
- Uses IoT for remote monitoring and alerts via Blynk IoT cloud platform.
- Minimizes false alarms by integrating multiple temperature, gas, and smoke sensors.
- Ensures scalability by allowing the addition of new sensors via the CAN network.
- Reliable even during internet failures – CAN-based communication continues to function locally.

Chapter 3: Software Requirements

3.1 Embedded C language

Embedded C is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded systems. Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations.

The C programming language is perhaps the most popular programming language for programming embedded systems. We mentioned other popular programming languages).

Most C programmers are spoiled because they program in environments where not only there is a standard library implementation, but there are frequently a number of other libraries available for use. The cold fact is, that in embedded systems, there rarely are many of the libraries that programmers have grown used to, but occasionally an embedded system might not have a complete standard library, if there is a standard library at all. Few embedded systems have capability for dynamic linking, so if standard library functions are to be available at all, they often need to be directly linked into the executable. Oftentimes, because of space concerns, it is not possible to link in an entire library file, and programmers are often forced to "brew their own" standard c library implementations if they want to use them at all. While some libraries are bulky and not well suited for use on microcontrollers, many development systems still include the standard libraries which are the most common for C programmers.

C remains a very popular language for micro-controller developers due to the code efficiency and reduced overhead and development time. C offers low-level control and is considered more readable than assembly. Many free C compilers are available for a wide variety of development platforms. The compilers are part of an IDEs with ICD support, breakpoints, single-stepping and an assembly window. The performance of C compilers has improved considerably in recent years, and they are claimed to be more or less as good as assembly, depending on who you ask. Most tools now offer options for customizing the compiler optimization. Additionally, using C increases portability, since C code can be compiled for different types of processors.

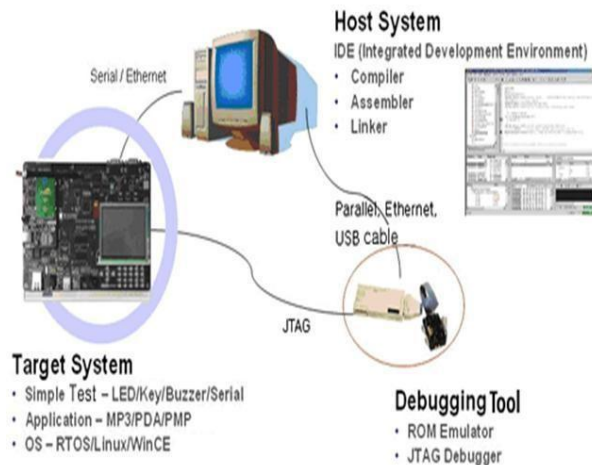


Figure 1: Embedded System Development Environment

3.2 Arduino IDE compiler

Arduino is an open-deliver electronics platform based mostly on smooth-to-use hardware and software utility. Arduino boards can observe inputs - slight on a sensor, a finger on a button, or a Twitter message - and flip it into an output - activating a motor, turning on an LED, publishing a few components online. You could tell your board what to do by sending a hard and fast of commands to the microcontroller at the board. To do so that you use the Arduino programming language (based totally mostly on Wiring), and the Arduino software (IDE), based on Processing.

Over the years Arduino has been the brain of lots of obligations, from regular gadgets to complex medical gadgets. A worldwide community of makers - college students, hobbyists, artists, programmers, and specialists - has collected spherical this open-deliver platform, their contributions have brought as much as a terrific amount of available know-how that can be of terrific assist to novices and experts alike.

Arduino has become born on the Ivrea interaction format Institute as a clean tool for instant prototyping, geared towards university college students without a historic past in electronics and programming. As quickly as it reached a miles wider community, the Arduino board started converting to conform to new dreams and traumatic situations, differentiating its provide from smooth eight-bit boards to merchandise for IoT

Programs, wearable, three-D printing, and embedded environments. All Arduino boards are without a doubt open-deliver, empowering clients to assemble them independently and ultimately adapt them to their unique dreams. The software program, too, is open-supply, and its miles growing thru the contributions of customers globally.

The advantages of the Arduino IDE utility are

1. Much less steeply-priced
2. The clean smooth programming surroundings
3. Extensible software program application utility and hardware

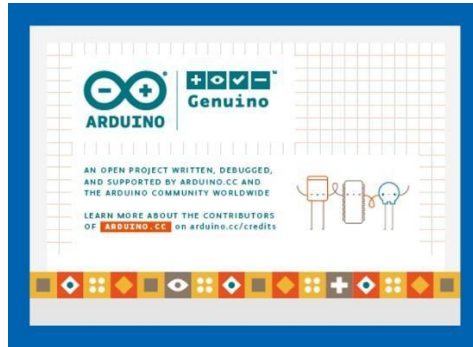


Figure 2: Arduino IDE

The Arduino venture gives the Arduino blanketed development surroundings (IDE), it really is a go-platform software program software developed in the programming language Java. It is developed to introduce programming application with software improvement.

The Arduino venture gives the Arduino blanketed development surroundings (IDE), it really is a go-platform software program software developed in the programming language Java. It is developed to introduce programming application with software improvement. It includes a code editor with features in conjunction with syntax highlighting, brace matching, and automatic indentation, and offers a simple one-click mechanism to collect and load packages to an Arduino board. A software program written with the IDE for Arduino is known as a "cool lively film".

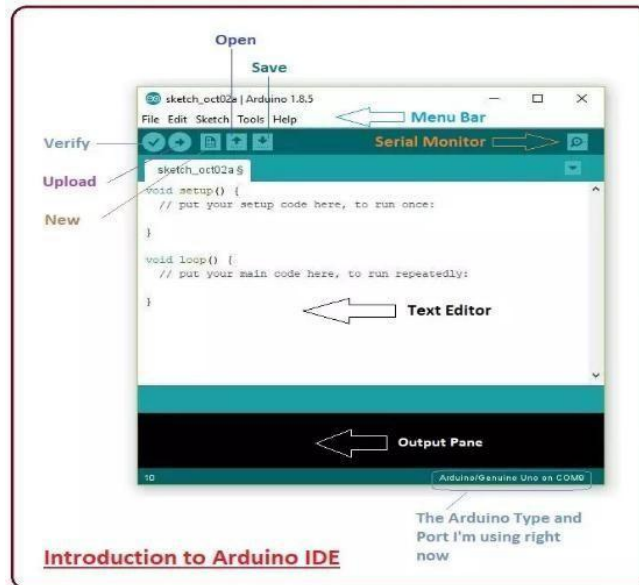


Figure 3: Using Arduino IDE app

Arduino IDE permits the languages C and C++ the use of special hints to set up code. The Arduino IDE materials a software program software library called Wiring from the Wiring task, which offers many, not unusual enter and output techniques. a massive Arduino C/C++ cool animated film embodies abilities that might be compiled and related with a utility stub vital() into an executable cyclic government software:

The Arduino Software (IDE) - carries a text editor for writing code, a message location, a text console, a toolbar with buttons for all functions, and a group of menus. It joins to the Arduino and Genuino hardware to add packages and talk with them.

3.2.1 Serial Monitor

Indicates serial facts being despatched from the Arduino UNO or Genuino board (USB or serial board). To ship data to the board, enter textual content and click on at the "supply" button 36 2336 or press enter. Choose out the baud price from the drop-down that fits to Serial. 12 Begin in your comic strip. Be conscious that on domestic home windows, Mac or Linux, the Arduino UNO or Genuino board will reset whilst you join with the serial display.

We should also interface to the board from Processing, Flash, MaxMSP, and so on (see the 12- interfacing net page for information). Possibilities: A few picks can be set inside the options dialog (determined under the Arduino menu on the 36 Mac, or document on home windows and Linux). The relaxation can get in the options file, 12 whose region is confirmed in the choice conversation.

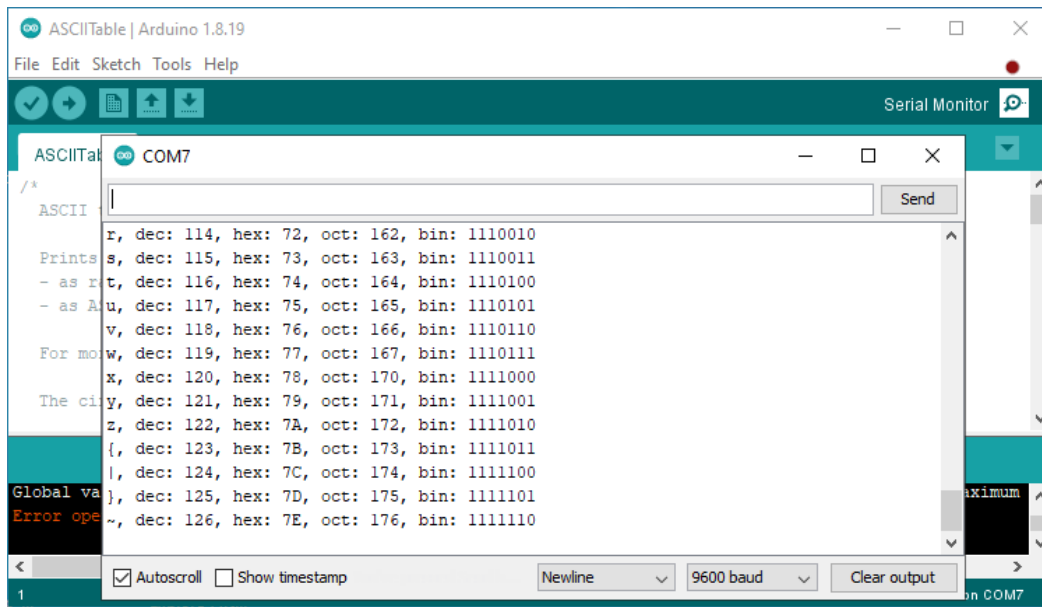


Figure 4: Serial Monitor

Arduino software (IDE) consists of the built-in to befit for the forums in the following listing, all primarily based on the AVR mcu. The Boards manager included inner the fashionable set up allows to feature assist for the growing variety of new boards based totally on special cores like Arduino UNO, Arduino 0, Edison, Galileo and so on.

3.2.2 Steps to dump

- Connect your Arduino device to your computer using a USB cable.
- Open the Arduino Integrated Development Environment (IDE) on your computer.
- Open the code you have written in the Arduino IDE editor.
 - Choose the correct board type and port under the "Tools" menu. The board type should match the type of Arduino board you have, such as Uno, Mega, or Nano. The port should correspond to the serial port to which the Arduino is connected.
 - Verify your code by clicking the "Verify" button (the checkmark icon) in the top left corner of the IDE window. This will compile your code and check for errors.
 - If there are no errors, click the "Upload" button (the right-facing arrow icon) to upload the compiled code to the Arduino.

- Wait for the upload to complete and the status message "Done uploading" to appear in the bottom status bar of the IDE.
- The code is now on your Arduino and running. You can interact with it by sending commands via the serial monitor in the Arduino IDE, or by using other means, such as physical inputs or outputs on the board.

3.2.3 Working Procedure

The working procedure of Arduino can be broken down into the following steps:

1. Connecting the hardware: Connect the Arduino board to your computer using a USB cable. Make sure that you have all the required components for your project, such as sensors, actuators, and other components.
2. Writing the code: Open the Arduino Integrated Development Environment (IDE) on your computer and write the code for your project. The code should define the functionality of the project and control the behaviour of the components connected to the Arduino.
3. Uploading the code: Verify the code for syntax errors and upload it to the Arduino board by clicking the "Upload" button in the Arduino IDE.
4. Running the code: Once the code is uploaded, the Arduino board will start executing it. Depending on the code, the board may interact with the components connected to it a perform various tasks, such as reading input data from sensors, controlling actuators, and displaying information on an output device.
5. Monitoring the performance: You can monitor the performance of the Arduino by using the serial monitor in the Arduino IDE. The serial monitor allows you to view the output generated by the code and send commands to the Arduino board.

3.3 Blynk Software

Blynk is a powerful and easy-to-use Internet of Things (IoT) platform that allows developers to create smart applications with real-time monitoring, remote control, and automation capabilities. It provides a cloud-based infrastructure that enables communication between IoT devices and mobile/web applications, making it ideal for projects that require sensor data visualization and remote alerts.

Originally launched in 2015, Blynk has gained popularity among hobbyists, developers, and industrial users for its versatility and ease of integration with microcontrollers like ESP32, Arduino, Raspberry Pi, and STM32. The no-code/low-code environment allows users to build and deploy IoT applications without deep programming knowledge.

3.3.1 Features of Blynk

1. Cloud-Based IoT Platform
2. Cross-Platform Compatibility
3. Drag-and-Drop Interface
4. Real-Time Data Monitoring
5. IoT Device Control & Automation
6. Multi-Device Connectivity
7. Instant Notifications & Alerts

Chapter 4: Hardware Requirements

4.1 ESP32-WROOM-32

4.1.1 Description

ESP32-WROOM-32 is a powerful Wi-Fi + Bluetooth + Bluetooth LE MCU module, with two complementary PCB antennas in different directions. This module has the same layout of pins as ESP32-WROOM-32E except some pins are not led out, facilitating quick and easy migration between these two modules. With two unique antennas design on one single module, ESP32-WROOM-DA can be used to develop IoT applications that need stable connectivity over a broad spectrum, or to deploy Wi-Fi in challenging and hazardous environments, or to overcome communication problems in Wi-Fi-dead spots. This module is an ideal choice for indoor and outdoor devices for smart home, industrial control, consumer electronics, etc.

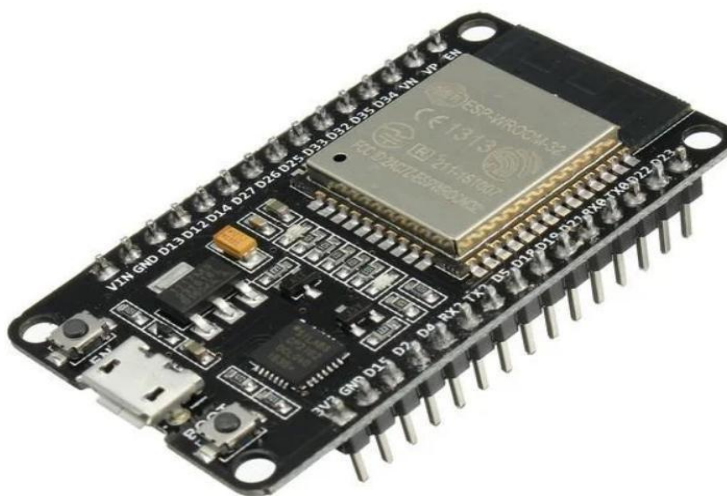


Figure 5: ESP32

4.1.2 Features

1. CPU and On-Chip Memory

- ESP32-D0WD-V3 embedded, Xtensa® dual-core 32-bit LX6 microprocessor, up to 240 MHz
- 448 KB ROM for booting and core functions
- 520 KB SRAM for data and instructions
- 16 KB SRAM in RTC

2. Wi-Fi

- 802.11b/g/n
- Bit rate: 802.11n up to 150 Mbps
- A-MPDU and A-MSDU aggregation
- 0.4 μ s guard interval support
- Center frequency range of operating channel: 2412 ~ 2484 MHz

3. Bluetooth

- Bluetooth V4.2 BR/EDR and Bluetooth LE specification
- Class-1, class-2 and class-3 transmitter
- AFH
- CVSD and SBC

4. Peripherals

- SD card, UART, SPI, SDIO, I2C, LED PWM, Motor PWM, I2S, IR, pulse counter, GPIO, capacitive touch sensor, ADC, DAC, TWAI® (compatible with ISO 11898-1, i.e. CAN Specification 2.0)

5. Integrated Components on Module

- 40 MHz crystal oscillator
- 8 MB SPI flash

6. Antenna Options

- On-board dual PCB antennas

7. Operating Conditions

- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating ambient temperature: $-40 \sim 85^{\circ}\text{C}$

4.1.3 Applications

- Home Automation
- Smart Building
- Industrial Automation
- Smart Agriculture
- Audio Applications
- Health Care Applications
- Wi-Fi-enabled Toys
- Wearable Electronics
- Retail & Catering Application

4.1.4 Block Diagram

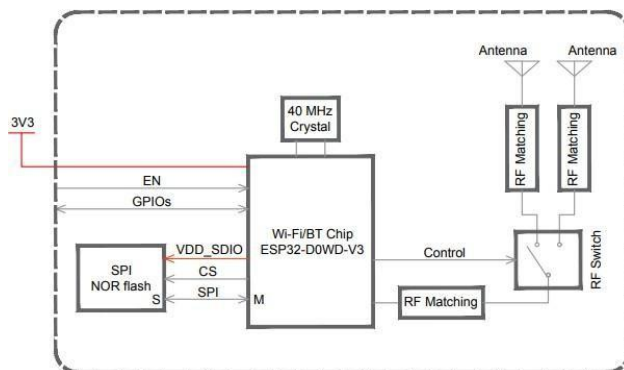


Figure 6: ESP32-WROOM-32 Block diagram

4.1.5 Pin Layout

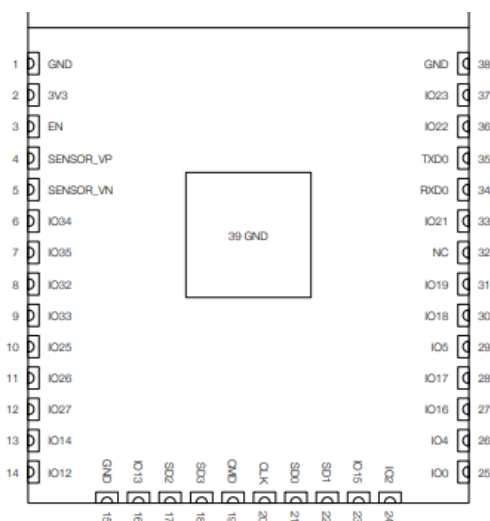


Figure 7: Pin Layout (Top view)

4.1.6 Programming

- **Arduino IDE:** The ESP32 is compatible with the **Arduino IDE** through the ESP32 core, making it easy to program with familiar tools.
- **MicroPython:** Support for programming the ESP32 with **MicroPython**, a Python- based interpreter.
- **ESP-IDF (Espressif IoT Development Framework):** The official framework for ESP32 development using C or C++.

4.1.7 Peripheral Schematics

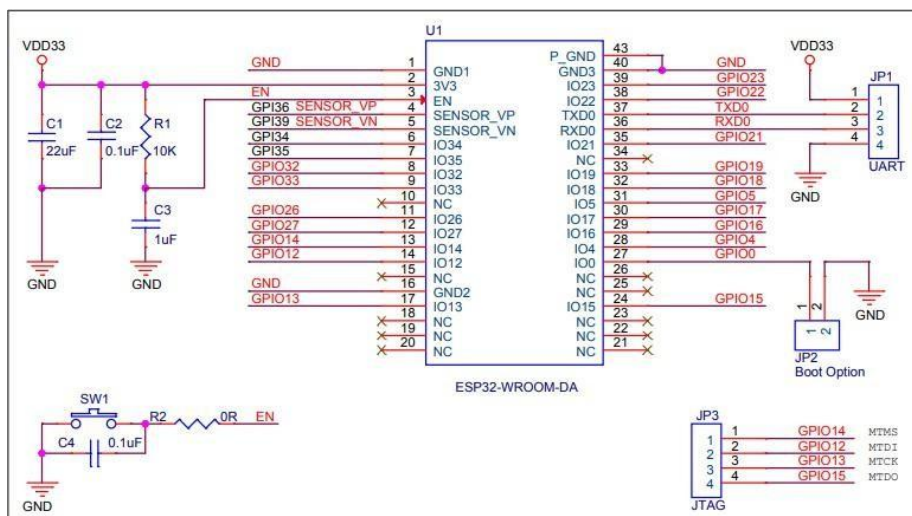


Figure 8: Peripheral schematic of ESP32

4.2 DHT11 Temperature and Humidity sensor

4.2.1 Introduction

The DHT11 is a widely used temperature and humidity sensor that provides accurate environmental measurements in real-time. It is popular in IoT applications, home automation, weather stations, and industrial monitoring due to its low cost, ease of use, and digital output. It consists of a thermistor for temperature sensing and a capacitive humidity sensor for measuring moisture in the air. The sensor outputs calibrated digital signals, making it easy to interface with microcontrollers like ESP32, Arduino, and STM32.

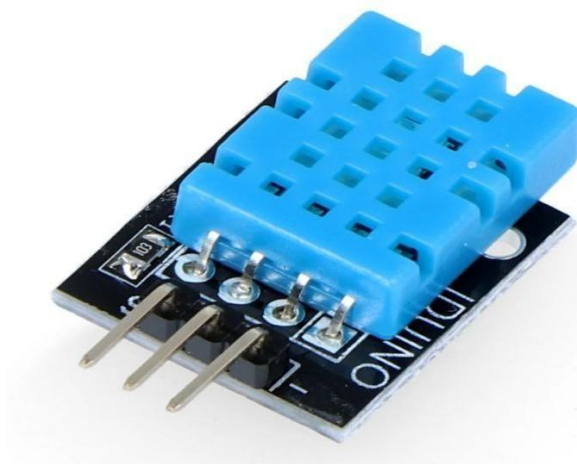


Figure 9: DHT11 sensor

4.2.2. Features of DHT11

- Temperature Range: 0°C to 50°C ($\pm 2^\circ\text{C}$ accuracy)
- Humidity Range: 20% to 90% RH ($\pm 5\%$ accuracy)
- Operating Voltage: 3.3V to 5V
- Digital Output: Uses single-wire communication
- Low Power Consumption: Ideal for battery-powered IoT devices
- Sampling Rate: 1 reading per second (1 Hz)

4.2.3. DHT11 Pinout and Connections

The DHT11 sensor has three pins:

Pin	Function	Connection
VCC	Power Supply	3.3V or 5V
DATA	Digital Output	Connected to microcontroller GPIO
GND	Ground	0V

Optional: A **10k Ω pull-up resistor** is recommended between **VCC** and **DATA** for stable communication.

4.2.4. Working Principle

The DHT11 measures:

- Temperature using an NTC thermistor, which changes resistance based on heat.
- Humidity using a capacitive sensor, where a dielectric material's capacitance changes with moisture.

The sensor sends **digital data** in a **40-bit format** (5 bytes):

1. 8-bit Humidity Integer
2. 8-bit Humidity Decimal
3. 8-bit Temperature Integer
4. 8-bit Temperature Decimal
5. Checksum (for data integrity)

Microcontrollers decode this signal and display the readings.

4.2.5 Interfacing DHT11 with ESP32

Wiring:

DHT11 Pin	ESP32 Pin
VCC	3.3V
DATA	GPIO4 (or any GPIO)
GND	GND

4.2.6 Applications of DHT11

- Fire and Hazard Detection (temperature monitoring)
- Weather Stations
- Smart Agriculture
- HVAC (Heating, Ventilation, and Air Conditioning)
- IoT-Based Smart Homes

4.2.7 Advantages

- Low-cost and widely available
- Easy to interface with microcontrollers
- Digital output (no ADC required)
- Low power consumption

4.3 Flame Sensor

4.3.1 Introduction

Flame sensors are crucial components in fire detection and safety systems. They are designed to rapidly and accurately detect the presence of a flame or fire, enabling quick responses to prevent potential hazards. Flame sensors are specialized detectors that respond to the unique electromagnetic radiation patterns emitted by flames. Unlike heat or smoke detectors that sense the byproducts of fire, flame sensors directly detect the flame itself, making them faster and more accurate in certain applications.



Figure 10: Flame sensor

4.3.2. Features of Flame sensor

- Detection Range: 760 nm – 1100 nm (IR sensor)
- Detection Angle: 60° – 120°
- Operating Voltage: 3.3V – 5V
- Output Types:
 1. Analog Output (A0) – Gives proportional voltage based on flame intensity
 2. Digital Output (D0) – HIGH (No flame), LOW (Flame detected)
- Adjustable Sensitivity: Potentiometer for threshold setting
- Fast Response Time: <100 ms

4.3.3. Flame Sensor Pinout & Connection

A typical IR Flame Sensor Module has four pins:

Pin	Function	Connection
VCC	Power Supply	3.3V or 5V
GND	Ground	0V
D0	Digital Output	Microcontroller GPIO
A0	Analog Output	ADC Pin (optional)

4.3.4. Working Principle

The Flame Sensor Module consists of:

1. **IR Photodiode** – Detects IR radiation from flames
2. **Comparator (LM393)** – Converts analog signal to digital output
3. **Potentiometer** – Adjusts sensitivity threshold

When a flame is detected, the IR radiation increases the sensor's output voltage, triggering a LOW signal (D0 = 0). The microcontroller then processes this signal and triggers alerts or fire suppression actions.

4.3.5 Interfacing Flame Sensor with ESP32

Wiring:

Flame Sensor Pin	ESP32 Pin
VCC	3.3V
D0	GPIO5(or any GPIO)
GND	GND

4.3.6 Applications of Flame Sensor

- **Fire s Smoke Detection Systems** (Buildings, Factories, Warehouses)
- **Automotive Fire Detection** (Vehicle engine compartments)
- **Industrial Safety Systems** (Factories, Oil C Gas Plants)
- **Robotics s Automation** (Fire-fighting robots)

4.3.7 Advantages

- Fast Response Time (<100 ms)
- Works in Dark Environments
- Low Power Consumption
- Easy to Interface with Microcontrollers

4.4 Gas sensor(MQ-2)

4.4.1 Introduction

The MQ-2 is a widely used gas sensor capable of detecting combustible gases and smoke in the environment. It is commonly used in fire detection systems, gas leak monitoring, air quality control, and industrial safety applications. In our Fire and Hazard Detection System using CAN Protocol and IoT, the MQ-2 sensor can detect dangerous gases like LPG, methane, propane, hydrogen, and smoke, triggering alerts when hazardous levels are reached



Figure 11: MQ-2 Gas sensor

4.4.2. Features of Gas sensor (MQ-2)

- Detects multiple gases: LPG, methane, propane, hydrogen, carbon monoxide, alcohol, and smoke
- High sensitivity to flammable gases
- Fast response time
- Analog and digital output
- Low power consumption
- Long lifespan (~10 years)

4.4.3. MQ-2 Gas sensor Pinout and Connections

The MQ-2 module typically has four pins:

Pin	Function	Connection
VCC	Power Supply	5V
GND	Ground	0V
A0	Analog Output	ADC Pin of microcontroller
D0	Digital Output	GPIO Pin (threshold-based output)

For higher accuracy, use analog output (A0) with an ADC-enabled microcontroller like ESP32 or STM32.

4.4.4. Working Principle

The MQ-2 sensor consists of a heating element (SnO_2 – Tin Dioxide) and an electrochemical sensing layer.

- When gases are present, the sensor's resistance decreases, causing a change in output voltage.
- The higher the gas concentration, the lower the resistance, and vice versa.
- The sensor outputs an analog voltage proportional to the gas concentration

4.4.5 Interfacing MQ-2 Gas Sensor with ESP32

Wiring: 1 Wiring Diagram

MQ-2 Pin	ESP32 Pin
VCC	5V
GND	GND
A0	GPIO36 (ADC)
D0	GPIO5 (or any GPIO)

4.4.6 Applications of MQ-2 Gas Sensor

- Home Safety (LPG leakage detection)
- Industrial Gas Leak Monitoring (Factories, Refineries)

- Automotive Fire Prevention (CNG, LPG Vehicles)
- Air Quality Monitoring (Smart Cities, IoT Systems)

4.4.7 Advantages

- Affordable & Easy to Use
- Detects Multiple Gases
- Fast Response Time
- Both Digital & Analog Output

4.5 MCP2515 CAN Controller

4.5.1 Introduction

Microchip Technology's MCP2515 is a stand-alone Controller Area Network (CAN) controller that implements the CAN specification, Version 2.0B. It is capable of transmitting and receiving both standard and extended data and remote frames. The MCP2515 has two acceptance masks and six acceptance filters that are used to filter out unwanted messages, thereby reducing the host MCU's overhead. The MCP2515 interfaces with microcontrollers (MCUs) via an industry standard Serial Peripheral Interface (SPI).



Figure 12: MCP2515 CAN Controller

4.5.2. Features of MCP2515 CAN Controller

- Supports CAN V2.0B (up to 1 Mbps data rate)
- SPI Interface (10 MHz) for easy microcontroller connection
- Configurable message filtering and masking
- Automatic retransmission C error handling
- Supports up to 112 nodes on the CAN network
- Low-power mode for energy efficiency

4.5.3. MCP2515 CAN Controller Pinout and Connections

MCP2515 Pin	Description	ESP32 Connection
VCC	Power (5V or 3.3V)	3.3V (or 5V if using level shifter)
GND	Ground	GND
CS	SPI Chip Select	GPIO 5
SO	SPI MISO	GPIO 19
SI	SPI MOSI	GPIO 23
SCK	SPI Clock	GPIO 18
INT	Interrupt (active low)	GPIO 2

4.5.4. Working Principle

The MCP2515 processes CAN messages using three main components:

11. Acceptance Filters & Masks

- Filters incoming messages to reduce processing overhead.
- Only relevant messages are passed to the microcontroller.

22. Message Buffers

- Stores messages temporarily before transmission/reception.
- Two receive buffers (RXB0, RXB1) & three transmit buffers (TXB0, TXB1, TXB2).

3.3. CAN Bus Arbitration

- When multiple nodes try to transmit, MCP2515 uses priority-based arbitration (lower ID wins).

This ensures efficient, real-time data exchange between fire, smoke, and gas sensors in your system.

4.5.5 Applications of MCP2515 CAN Controller

- The MCP2515 is widely used in various applications, including:
- Automotive electronics
- Industrial automation
- Embedded systems
- CAN-based networks

4.5.6 Advantages

- Reliable and Fault-Tolerant Communication
- Works in Noisy Industrial Environments
- Multiple Nodes Supported (Up to 112 devices)
- Real-Time Data Transfer

4.6 Zero PCB

Zero PCB (Zero Printed Circuit Board)

A Zero PCB (also known as a General Purpose PCB or Perfboard) is a type of circuit board that does not have predefined copper traces like standard PCBs. Instead, it consists of a grid of holes with copper pads, allowing flexible circuit prototyping by manually connecting components with soldered wires or jumper wires.

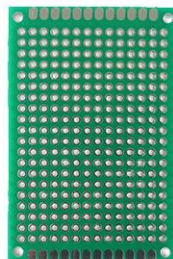


Figure 13. Zero PCB

4.7 Jumper Wires

Jumper wires are electrical wires used to make temporary connections between components on a breadboard or other circuit prototyping setups. They are essential for connecting microcontrollers (ESP32), sensors (DHT11, MQ2, Flame Sensor), and communication modules (MCP2515 CAN Controller) in your Fire and Hazard Detection System.

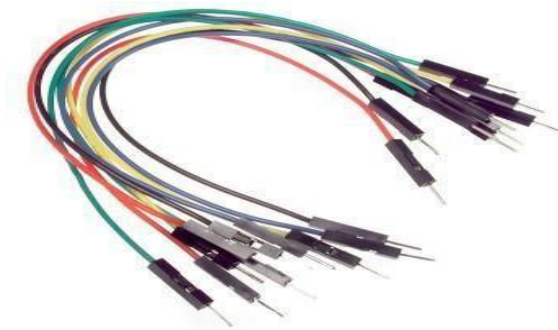


Figure 14: Jumper Wires

Chapter 5: Communication Protocols

5.1 CAN protocol

The CAN bus was developed by BOSCH as a multi-master, message broadcast system that specifies a maximum signaling rate of 1 megabit per second (mbps). Unlike a traditional network such as USB or Ethernet, CAN does not send large blocks of data point-to-point from node A to node B under the supervision of a central bus master. In a CAN network, many short messages like temperature or RPM are broadcast to the entire network, which provides for data consistency in every node of the system.

CAN is an International Standardization Organization (ISO) defined serial communications bus originally developed for the automotive industry to replace the complex wiring harness with a two-wire bus. The specification calls for high immunity to electrical interference and the ability to self-diagnose and repair data errors. These features have led to CAN's popularity in a variety of industries including building automation, medical, and manufacturing.

5.1.1 The Bit Fields of Standard CAN

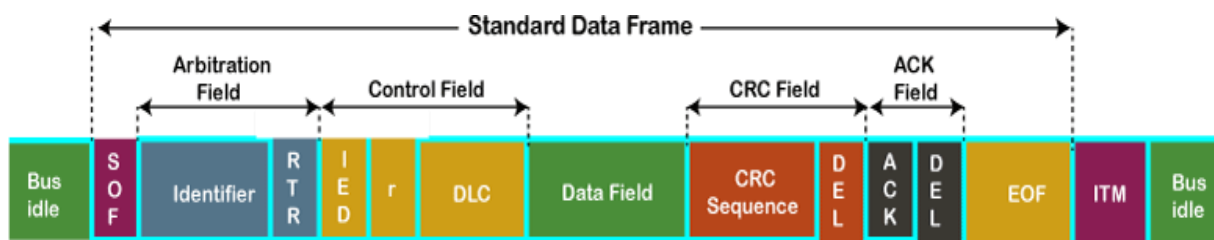


Figure 15: CAN Frame

- **SOF:** SOF stands for the start of frame, which indicates that the new frame is entered in a network. It is of 1 bit.
- **Identifier:** A standard data format defined under the CAN 2.0 A specification uses an 11-bit message identifier for arbitration. Basically, this message identifier sets the priority of the data frame.
- **RTR:** RTR stands for Remote Transmission Request, which defines the frame type, whether it is a data frame or a remote frame. It is of 1-bit.
- **Control field:** It has user-defined functions.
 - **IDE:** An IDE bit in a control field stands for identifier extension. A dominant IDE bit defines the 11-bit standard identifier, whereas recessive IDE bit defines the 29-bit extended identifier.
 - **DLC:** DLC stands for Data Length Code, which defines the data length in a data field. It is of 4 bits.

- **Data field:** The data field can contain upto 8 bytes.
- **CRC field:** The data frame also contains a cyclic redundancy check field of 15 bit, which is used to detect the corruption if it occurs during the transmission time. The sender will compute the CRC before sending the data frame, and the receiver also computes the CRC and then compares the computed CRC with the CRC received from the sender. If the CRC does not match, then the receiver will generate the error.
- **ACK field:** This is the receiver's acknowledgment. In other protocols, a separate packet for an acknowledgment is sent after receiving all the packets, but in case of CAN protocol, no separate packet is sent for an acknowledgment.
- **EOF:** EOF stands for end of frame. It contains 7 consecutive recessive bits known End of frame.

CAN is ideally suited in applications requiring a large number of short messages with high reliability in rugged operating environments. Because CAN is message based and not address based, it is especially well suited when data is needed by more than one location and system-wide data consistency is mandatory.

Fault confinement is also a major benefit of CAN. Faulty nodes are automatically dropped from the bus, which prevents any single node from bringing a network down, and ensures that bandwidth is always available for critical message transmission. This error containment also allows nodes to be added to a bus while the system is in operation, otherwise known as hot-plugging.

The many features of the TI CAN transceivers make them ideally suited for the many rugged applications to which the CAN protocol is being adapted. Among the applications finding solutions with CAN are automobiles, trucks, motorcycles, snowmobiles, trains, buses, airplanes, agriculture, construction, mining, and marine vehicles.

5.2 MQTT (Message Queuing Telemetry Transport)

MQTT is a lightweight, publish-subscribe network protocol ideal for connecting resource-constrained devices over unreliable networks. It's widely used in IoT applications due to its simplicity and efficiency.

Key Features and Concepts:

- **Publish-Subscribe:** Devices ("clients") publish messages on specific "topics," and other clients can subscribe to those topics to receive the messages. This decouples the sender and receiver, making the system more flexible.
- **Broker:** A central server ("broker") manages the topics and distributes messages to the appropriate subscribers. Clients don't communicate directly; they interact with

the broker.

- **Topics:** Hierarchical strings that categorize messages (e.g., sensors/temperature, sensors/humidity). Subscribers can use wildcards to subscribe to multiple topics (e.g., sensors/# for all sensor data).
- **Retained Messages:** The broker can store the last message published on a topic, so new subscribers immediately receive the latest data.
- **Will Messages:** A client can define a "will message" that the broker publishes if the client unexpectedly disconnects. This can be used to notify other clients of a device failure.

Why MQTT is Suitable for our Project:

- **Lightweight:** MQTT's small message size and low overhead are ideal for resource-constrained devices like ESP32s.
- **Efficient:** The publish-subscribe model minimizes network traffic and reduces the processing load on devices.
- **Reliable (with QoS):** MQTT's QoS levels allow you to choose the appropriate level of message delivery reliability for our application.
- **Scalable:** MQTT can handle a large number of connected devices, making it suitable for future expansion of your system.

5.3 SPI Protocol:

The Serial Peripheral Interface (SPI) is a synchronous serial communication protocol widely used for short-distance, high-speed communication between microcontrollers and peripherals. Here's a breakdown of its key features and how it differs from CAN and MQTT:

SPI Protocol Fundamentals:

- **Synchronous Serial:** SPI uses a clock signal (SCK) to synchronize data transmission between devices. This allows for higher data rates compared to asynchronous serial communication.
- **Master-Slave:** SPI communication involves a single master device that initiates and controls the communication, and one or more slave devices that respond to the master's requests.
- **Full-Duplex:** SPI can support full-duplex communication, meaning that data can be

transmitted in both directions simultaneously.

Four Wires (Typically): SPI typically uses four wires:

MOSI (Master Out Slave In): Data line from the master to the slave.

MISO (Master In Slave Out): Data line from the slave to the master.

SCK (Serial Clock): Clock signal generated by the master to synchronize data transfer.

CS/SS (Chip Select/Slave Select): Signal used by the master to select the specific slave device it wants to communicate with.

How SPI Works:

Slave Select: The master pulls the CS/SS line of the desired slave low to activate it.

Clocking: The master generates the clock signal (SCK).

Data Transfer: Data is transmitted bit by bit on the MOSI and MISO lines, synchronized with the clock signal.

Communication End: The master pulls the CS/SS line high to deactivate the slave.

Advantages of SPI:

High Speed: SPI can achieve very high data rates, making it suitable for applications requiring fast data transfer.

Full-Duplex Communication: SPI supports simultaneous data transmission in both directions.

Simple Implementation (Hardware): SPI is relatively easy to implement in hardware.

Chapter 6: Architecture

6.1 Block Diagram

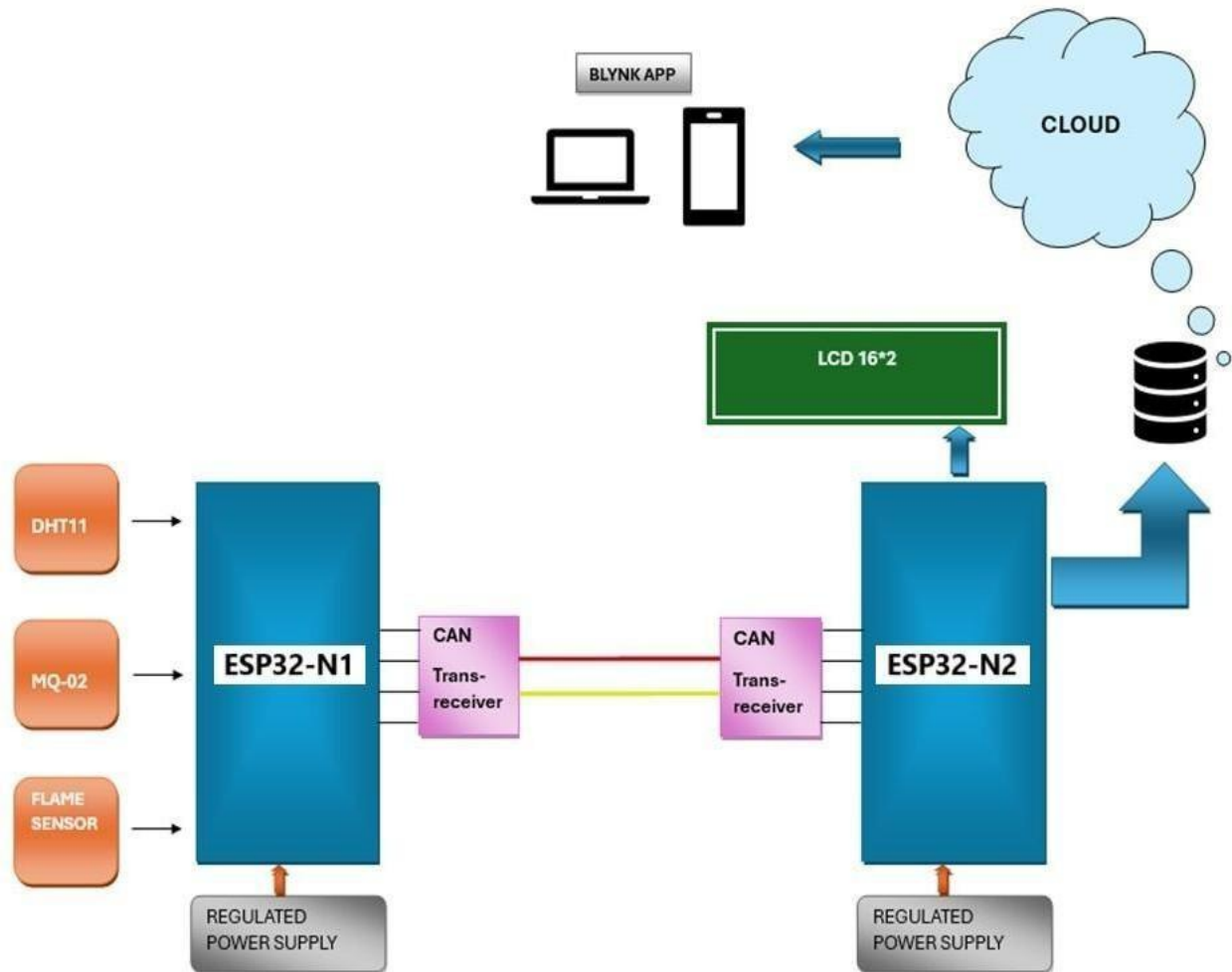


Figure 16: Block Diagram

1. Sensors (DHT11, MQ-02, Flame Sensor)

- DHT11: Measures temperature and humidity in the environment.
- MQ-02: Detects harmful gases such as smoke, LPG, and CO.
- Flame Sensor: Detects the presence of a flame or fire.

These sensors continuously monitor environmental parameters and send data to ESP32(Node 1).

2. ESP32-(Node 1)

- This module acts as the sensor node and processes data collected from the sensors.
- The sensor data is transmitted via a CAN Transceiver to another ESP32 module (Node 2).

3. CAN Communication

- CAN Transceiver modules enable reliable and robust data exchange between ESP32-N1 and ESP32-N2 over the Controller Area Network (CAN) protocol.
- CAN is used for real-time, fault-tolerant communication, ensuring accurate data transfer between nodes.

4. ESP32-(Node 2)

- This module acts as the data aggregator and processes the received sensor data from Node 1.
- It displays real-time data on an LCD (16×2) and uploads processed data to the cloud for storage and further analysis.

5. LCD (16×2)

- Displays critical information such as temperature, gas levels, and fire detection in real-time for local monitoring.

6. Cloud Integration

- ESP32(Node 2) uses its built-in Wi-Fi capabilities to transmit data to the cloud.
- Cloud storage ensures that the data can be remotely accessed through IoT platforms like the Blynk app.

7. Blynk App (IoT Interface)

- Users can monitor real-time data and receive alerts on their smartphones or computers via the Blynk app.
- This enables remote monitoring of the building's safety parameters.

8. Regulated Power Supply

- Both ESP32 modules (Node 1 and Node 2) and the sensors are powered by a regulated power supply, ensuring stable operation.

Working Summary

1. Data Collection: Sensors collect environmental data like temperature, gas levels, and flame detection.
2. Data Processing: ESP32(Node 1) processes the sensor data and sends it to ESP32(Node 2) via CAN communication.
3. Data Display and Storage: ESP32(Node 2) displays the data locally on an LCD and uploads it to the cloud.
4. Remote Access: Users monitor the data remotely using the Blynk app and receive real-time alerts.

Chapter 7: System Design

6.1 Circuit Diagram

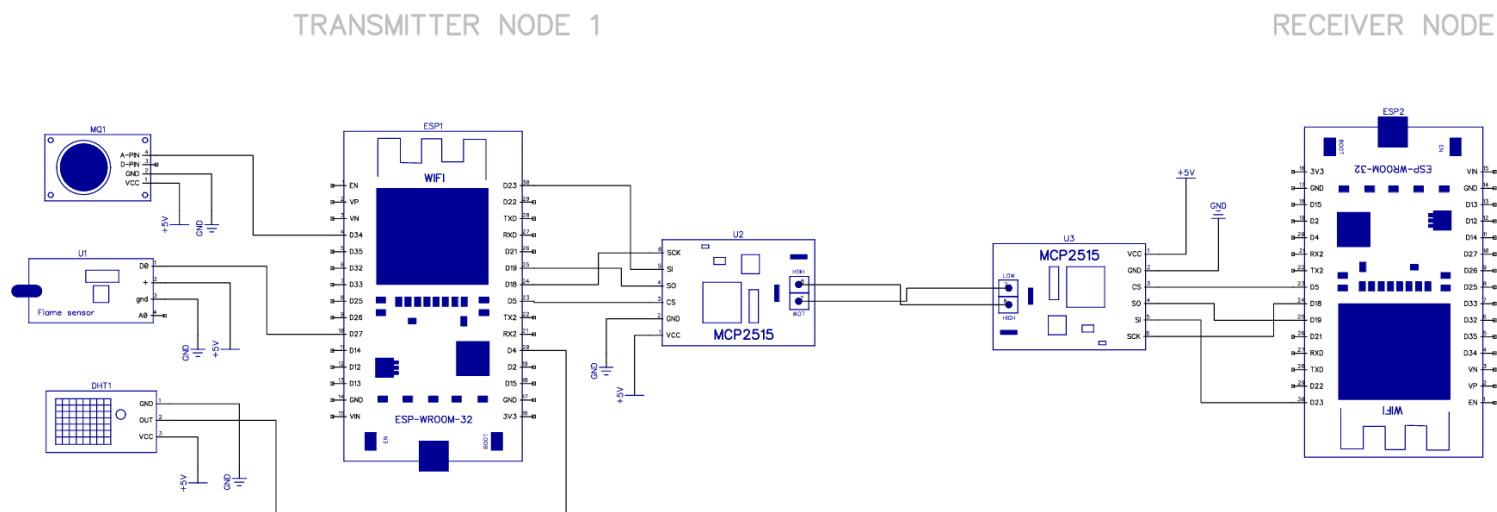


Figure 17: Circuit Diagram

6.2 Flow of the system

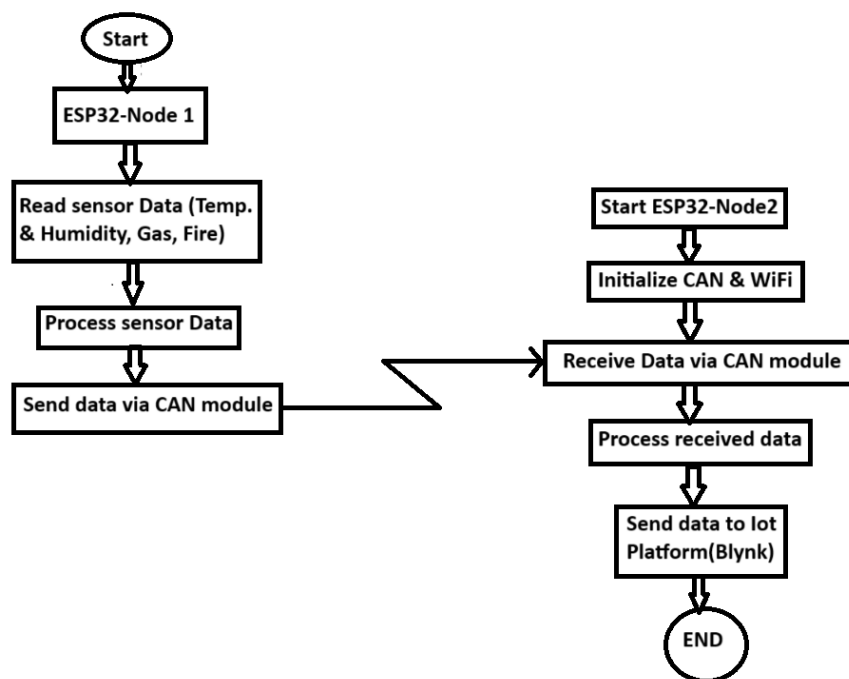


Figure 18. Flowchart

The system uses two ESP32s:

- **ESP32-Node 1:** This node is dedicated to reading and processing data from the sensors (temperature, humidity, gas, and fire).
- **ESP32-Node 2:** This node acts as a central hub. It receives the processed sensor data from ESP32-Node 1 via CAN, and then transmits this data to an IoT platform (Blynk).

ESP32-Node 1 Side:

1. **Start:** The program on ESP32-Node 1 begins execution.
2. **Read Sensor Data (Temp. & Humidity, Gas, Fire):** The ESP32 reads the raw data from all connected sensors. This might involve analog-to-digital conversion for analog sensors (like some gas sensors) and reading digital values from digital sensors.
3. **Process Sensor Data:** The raw sensor data is processed. This step might include:
 - a. **Calibration:** Adjusting readings to account for sensor inaccuracies or environmental factors.
 - b. **Filtering:** Removing noise or smoothing out fluctuations in the readings.
 - c. **Units Conversion:** Converting raw values into meaningful units (e.g., temperature in Celsius, gas concentration in ppm).
 - d. **Thresholding:** Checking if sensor readings exceed predefined thresholds (e.g., high temperature, dangerous gas level).
4. **Send Data via CAN Module:** The processed sensor data is packaged into a CAN message and transmitted over the CAN bus to ESP32-Node 2.

ESP32-Node 2 Side:

1. **Start ESP32-Node 2:** The program on ESP32-Node 2 begins execution.
2. **Initialize CAN & WiFi:** The ESP32 initializes both the CAN communication module (to communicate with ESP32-Node 1) and the WiFi module (to connect to the internet).
3. **Receive Data via CAN Module:** ESP32-Node 2 listens for and receives CAN messages transmitted by ESP32-Node 1.
4. **Process Received Data:** The received data might undergo further processing if needed. This could include:
 - a. **Formatting:** Preparing the data for transmission to the Blynk platform.
 - b. **Combining Data:** If data from multiple sensors is received, it might be combined or averaged.
5. **Send Data to IoT Platform (Blynk):** ESP32-Node 2 connects to the internet via WiFi and transmits the processed sensor data to the Blynk platform. Blynk likely provides a cloud service and a mobile app to visualize and interact with this data.
6. **END:** The program on ESP32-Node 2 finishes its main loop. It's likely that this process repeats continuously, allowing for real-time monitoring of the sensors.

Chapter 8: Implementation

1. System Design and Planning

- **Objective Definition:** Define the goals, such as real-time fire and hazard detection, reliable communication, and cloud integration.
- **Component Selection:** Identify the required hardware components, such as ESP32 modules, sensors (DHT11, MQ-02, Flame Sensor), CAN transceivers, and LCD displays.
- **Architecture Design:** Design a block diagram showing data flow between nodes, sensors, cloud, and monitoring devices.

2. Hardware Setup

- **Microcontroller Node Setup:**
 - Configure ESP32(Node 1) to collect sensor data and transmit it over the CAN protocol.
 - Configure ESP32(Node 2) to receive CAN data and send it to the cloud using Wi-Fi.
- **Sensor Integration:**
 - Connect DHT11 for temperature and humidity monitoring.
 - Connect MQ-02 for gas leakage detection.
 - Connect Flame Sensor for fire detection.
- **CAN Network:**
 - Use CAN transceivers to establish communication between ESP32 nodes.
- **Power Supply:**
 - Use regulated power supplies to ensure reliable operation of all components.

3. Software Development

- **Firmware Development:**
 - Write code to interface sensors with ESP32(Node 1) using GPIO or ADC pins.
 - Implement CAN communication protocol between ESP32(Node 1) and ESP32(Node 2).
 - Develop a data transmission algorithm to send processed sensor data from ESP32(Node 2) to the cloud.
- **IoT Platform Configuration:**
 - Use platforms like Blynk for real-time monitoring and data visualization.

- Set up cloud servers to store and analyze sensor data.

4. Testing & Debugging

- Hardware Testing:
 - Ensure proper connections and functionality of sensors, CAN transceivers, and power supply.
 - Verify the integrity of CAN communication between nodes.
- Software Testing:
 - Test sensor data acquisition and processing on ESP32(Node 1).
 - Validate CAN message encoding and decoding.
 - Check cloud data upload and remote monitoring through the mobile app.

5. Deployment

- Installation:
 - Deploy the nodes in a real-world building environment.
 - Position sensors strategically to maximize coverage for fire and hazard detection.
- Calibration:
 - Calibrate sensors (DHT11, MQ-02, Flame Sensor) to ensure accurate readings in the given environment.
- Integration with Cloud:
 - Establish reliable Wi-Fi connectivity for ESP32(Node 2) to communicate with the cloud server.

6. Monitoring and Maintenance

- Real-Time Monitoring:

Continuously monitor environmental conditions using the IoT platform. Generate alerts in case of fire or hazardous gas detection.
- Regular Updates: Update firmware to improve system performance and add new features.
- Diagnostics: Periodically check the CAN communication and sensor functionality for any potential issues.

Chapter 9: Results and Outputs

1. Real-Time Hazard Monitoring:

- Continuous monitoring of environmental parameters such as temperature, gas concentration, flame detection, and humidity.
- Immediate detection of anomalies or hazards like high gas levels, increased temperature, or presence of flames.

2. Reliable Data Communication:

- Use of the CAN protocol ensures robust and real-time communication between sensor nodes (ESP32-N1 and ESP32-N2).
- Efficient data transmission between multiple nodes without data loss or corruption.

3. IoT Integration for Remote Monitoring:

- Sensor data is transmitted to the cloud through ESP32 for remote access.
- Real-time monitoring via mobile or web applications (e.g., Blynk app).

4. Alerts and Notifications:

- Instant alerts (via mobile app or email) in case of hazard detection, such as gas leaks, fires, or temperature spikes.
- Visual alerts displayed on the LCD 16x2 module for local monitoring.

5. Data Logging and Visualization:

- Data collected by sensors is stored on the cloud, allowing historical analysis.
- Graphical visualization of sensor readings on the Blynk app or other IoT dashboards.

6. Enhanced Safety Measures:

- Early detection and notification enable proactive actions to prevent accidents.
- Facilitates better safety compliance in buildings and industrial environments.

7. System Scalability and Modularity:

- Ability to add or remove sensor modules without affecting system performance.
- Supports the integration of additional sensors for expanded functionality.

8. Ease of Deployment:

- Straightforward installation and configuration using standardized components like DHT11, MQ-2, and flame sensors.

9. Demonstration Output:

- Working prototype showcasing hazard detection and reporting.
- Functional remote monitoring through IoT, including real-time alerts and cloud-based data display.

10. Performance Metrics:

- High accuracy in detecting hazardous conditions like gas leaks and flames.
- Reliable operation under various environmental conditions.
- Low power consumption for prolonged deployment

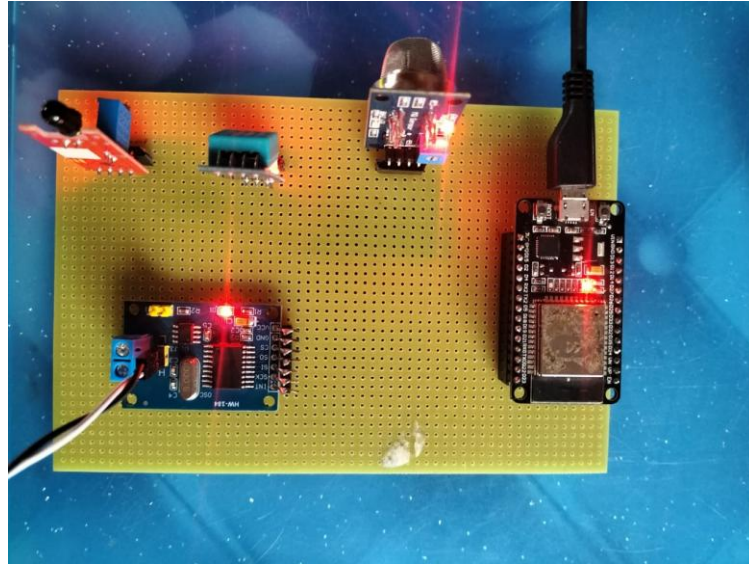


Figure 19. Transmitting Node

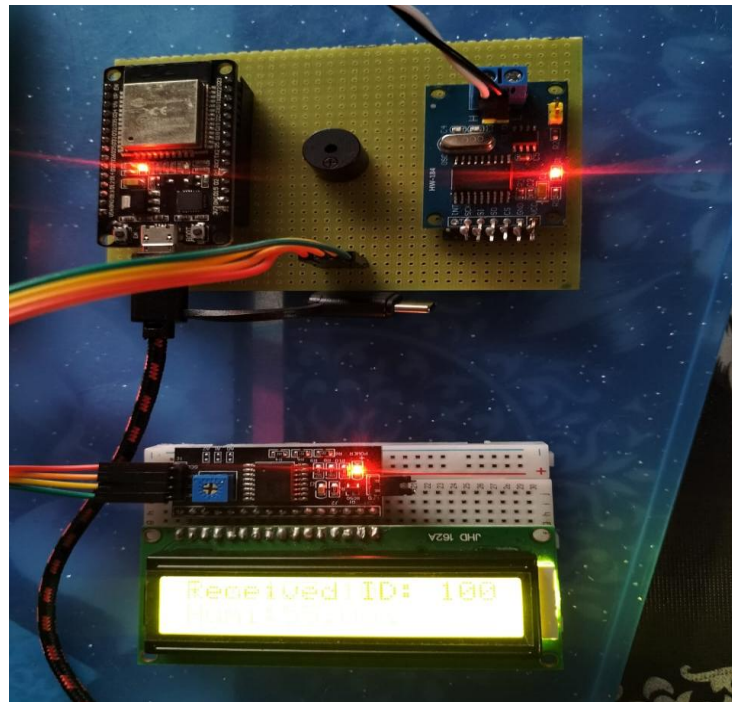
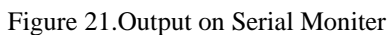


Figure 20. Receiving Node



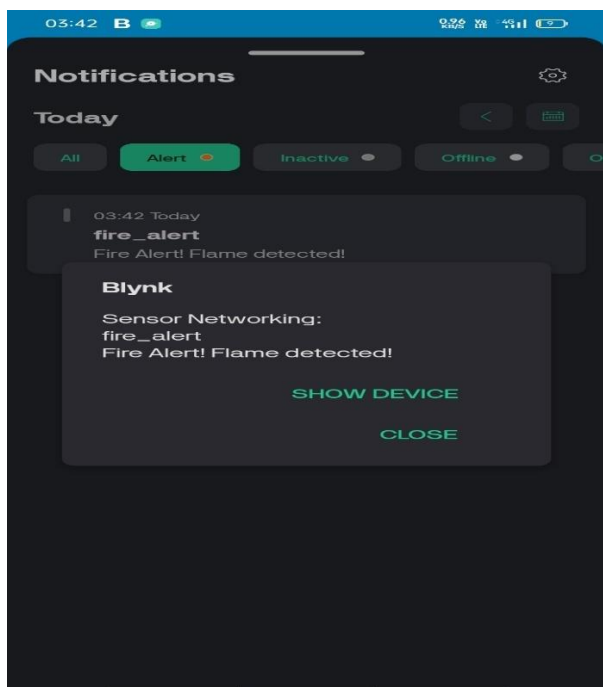


Figure 23.Notification on Mobile

Chapter 10: Conclusion

The Fire and Hazard Detection System for Buildings using CAN and IoT successfully integrates advanced technologies to provide a reliable, scalable, and efficient safety solution. The system achieves the following key objectives:

1. **Real-Time Monitoring:** By integrating sensors such as DHT11, MQ-02, and Flame Sensor, the system ensures continuous monitoring of environmental parameters, including temperature, humidity, gas levels, and fire detection.
2. **Robust Communication:** The use of the CAN protocol enables efficient and fault-tolerant communication between nodes, ensuring reliable data transfer in real-time, even in harsh conditions.
3. **IoT Integration:** Cloud connectivity via the ESP32 module allows remote monitoring and control through platforms like the Blynk App, enhancing accessibility and enabling proactive safety management.
4. **Scalability and Flexibility:** The modular design makes the system easily expandable for larger infrastructures or more complex monitoring requirements without compromising performance.
5. **Cost-Effectiveness:** The system provides a cost-efficient solution by combining locally processed data with IoT capabilities, reducing the need for extensive hardware and installation costs.
6. **Enhanced Safety:** This system ensures early detection of fire and hazardous conditions, minimizing the risk of property damage and safeguarding lives by providing timely alerts and remote access.

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