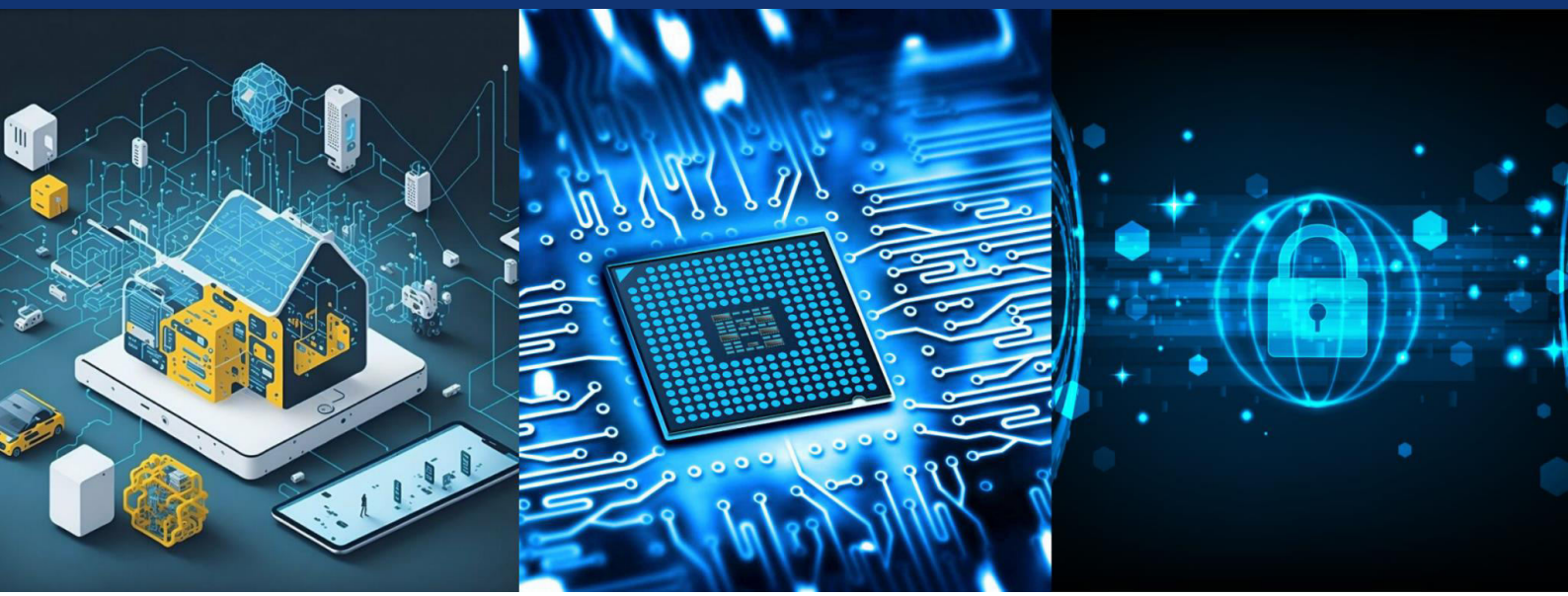
IJIRCCE

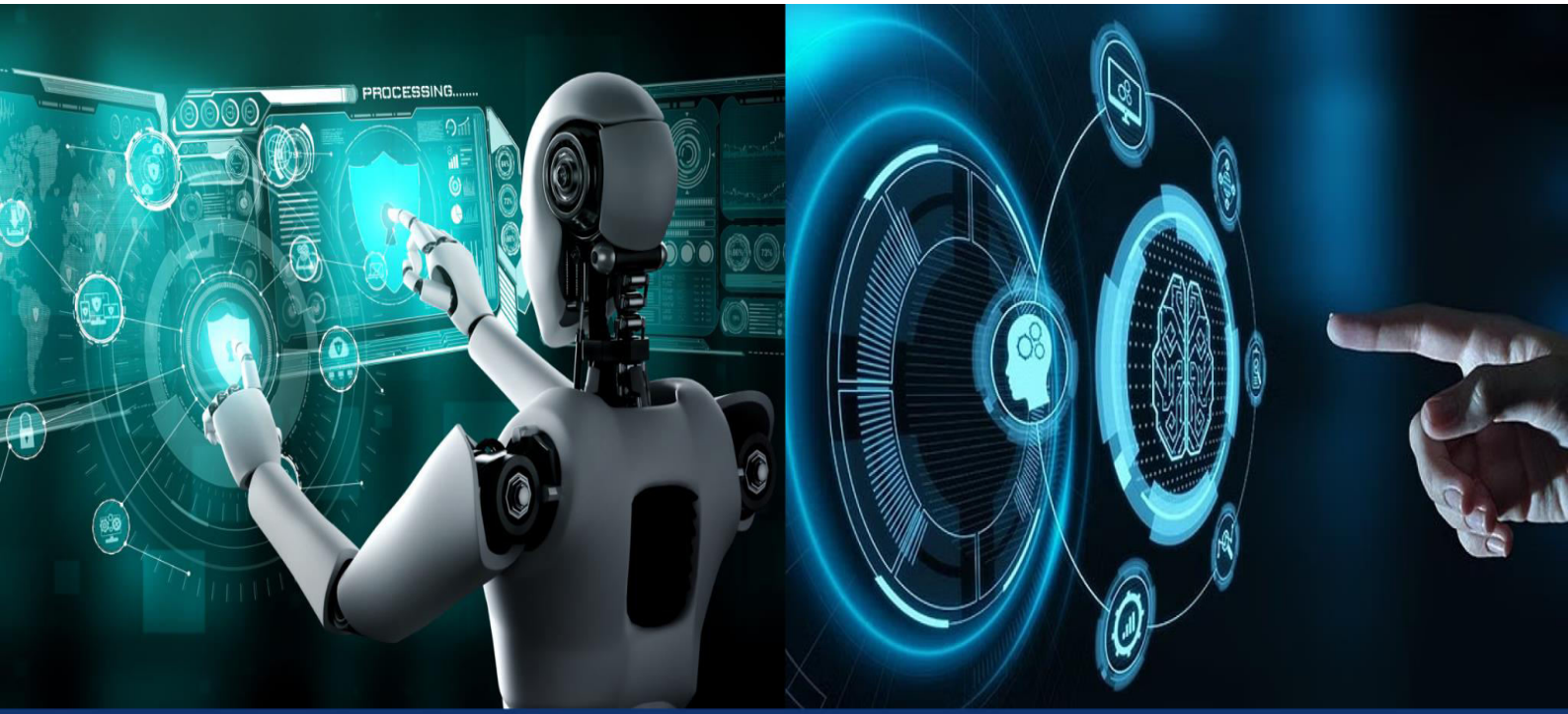
ISSN(O): 2320-9801

ISSN(P): 2320-9798



International Journal of Innovative Research in Computer and Communication Engineering

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 9.927

Volume 14, Issue 6, June 2026

© 2026 IJIRCCE | Volume 14, Issue 6, June 2026 DOI: 10.15680/IJIRCCE.2026.1406037

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 9.927| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Smart Energy Meter for Monitoring Home Appliances Using IoT

Dr. R.S. Kawitkar[1], Dr. N.R. Dhumale[2], Pragati D. Shelke[3], Isha T. Kate[3], Pratik S. Vaidya[3]

Head of Department, Dept. of Electronics & Telecommunication Engineering, Sinhgad College of Engineering, Pune, India[1]

Lecturer, Dept. of Electronics & Telecommunication Engineering, Sinhgad College of Engineering, Pune, India[2]

UG Students, Dept. of Electronics & Telecommunication Engineering, Sinhgad College of Engineering, Pune, India[3]

ABSTRACT: The sharp rise in electricity consumption, along with the increased use of smart home technologies, has resulted in a demand for intelligent energy management systems. Traditional energy meters lack advanced capabilities, providing only information on cumulative energy consumption without any options for real-time monitoring, remote control, and device-based control. Thus, the purpose of this paper is to introduce a Smart Energy Meter for Monitoring Home Appliances based on the Internet of Things (IoT). This energy meter allows performing real-time energy monitoring, using the prepaid option, and remotely controlling devices. The project includes the ESP32 microcontroller, PZEM004T energy measurement module, relay control module, and the Blynk IoT platform. The energy meter monitors electrical parameters such as voltage, current, power, and energy consumption and transmits this data to a cloud platform. There is a need to have a prepaid billing system that helps in keeping track of energy usage and automatically switches off the electricity connections once there is no balance left. Besides, the system uses a network that ensures continuous monitoring and alarm provision irrespective of the availability of the Internet in the locality. It also allows real-time monitoring, automation of load switching, a data logging facility, and remote access via mobile phone. The experimentation carried out showed that the system can be helpful in increasing energy awareness and avoiding unnecessary consumption of energy.

KEYWORDS: IoT, Smart Energy Meter, Home Appliance Monitoring, ESP32, Wi-Fi, Real-Time Data, Current Sensor, Voltage Sensor, Cloud Analytics, Energy Consumption, Power Optimization.

I. INTRODUCTION

The need for electricity generation on one hand and the increasing cost of electricity generation, as well as its impact on the environment, have made it imperative that there should be an effective system for energy management. The traditional energy management system measures the total energy consumption without providing any other features. There is no provision for remote monitoring, analysis of individual appliances, or monitoring.

With the recent technological advancements in the Internet of Things, it is now possible to create intelligent power management systems that can enable the monitoring, control, and analysis of energy usage remotely. IoT systems help in providing consumers with information about energy usage through the use of cloud computing technologies. These systems play an important role in promoting the conservation and sustainable use of electrical energy.

Several researchers have suggested the development of intelligent energy monitoring and management systems using wireless communication technologies like Wi-Fi. Although these systems allow for remote monitoring and control of energy usage, many cannot implement pre-paid billing systems, remote appliance control, or lack good communication support in places where there are no good internet connections. Most of these systems only monitor energy usage, without managing loads and optimizing energy usage.

II. PROBLEM DEFINITION

Conventional energy meters lack real-time monitoring, remote control, and prepaid functionalities. Users have no direct visibility into the energy consumption of individual appliances, resulting in energy wastage and billing inefficiencies.

© 2026 IJIRCCE | Volume 14, Issue 6, June 2026 DOI: 10.15680/IJIRCCE.2026.1406037

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 9.927| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Furthermore, the manual reading and postpaid billing process cause delays and inaccuracies. Hence, there is a need for a smart energy metering system that allows:

- Real-time monitoring of energy consumption.
- Remote appliance control via IoT.
- Data logging for transparency and analytics.

The proposed system addresses these challenges using IoT and technologies integrated with the ESP32 microcontroller.

III. LITERATURE SURVEY

Several studies have been conducted in recent years to improve the performance, accuracy, and intelligence of energy metering systems using IoT technologies. Researchers have proposed a variety of approaches integrating microcontrollers, Wi-Fi, and cloud platforms for energy monitoring and billing automation.

[1], A. Sharma et al. (2022) presented an IoT-based prepaid energy meter using the ESP8266 Wi-Fi module and Arduino Uno. The system measured voltage and current parameters, displayed energy usage on the Blynk IoT platform, and implemented a prepaid mechanism that automatically disconnected the load once the credit balance was exhausted.

[2], where a microcontroller interfaced with a GSM module transmitted power consumption readings via SMS to the electricity board.

[3], D. Banerjee and P. Nair (2023) developed a cloud-integrated energy management system using an ESP32 microcontroller and Firebase cloud database. The system allowed users to visualize consumption data in real time and control loads via a smartphone.

[4]. The system measured voltage, current, and energy consumption using the PZEM004T module and uploaded the readings to ThingSpeak for cloud visualization.

[5], R. Prasad and A. Joshi (2021) designed a hybrid GSM and Wi-Fi-enabled smart energy meter to ensure uninterrupted data transmission. The system sent SMS alerts and updated data on the IoT dashboard simultaneously.

IV. SYSTEM DESIGN

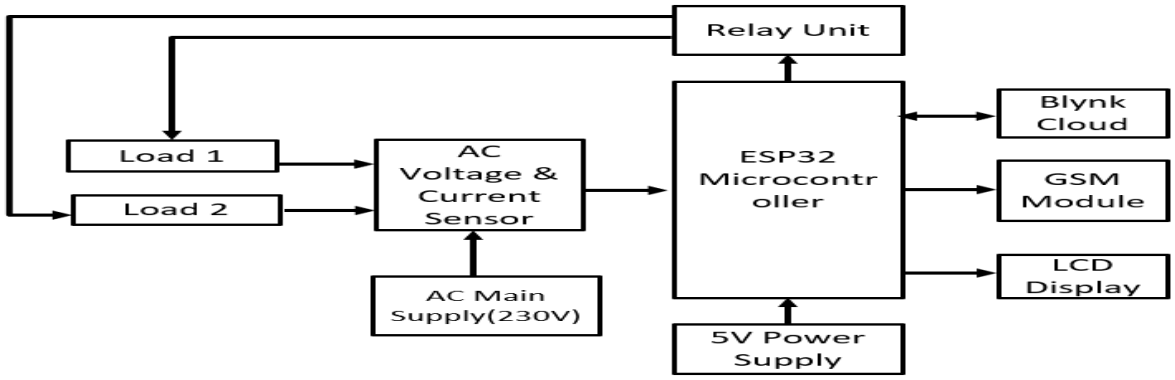


FIGURE.1. BLOCK DIAGRAM

A. System Overview

System Consists Of

- **ESP32 Microcontroller:** Processes data and provides built-in Wi-Fi connectivity.
- **Sensors:** PZEM- 004T.
- **Power Supply:** Steps down AC mains to 5V/3.3V DC to power the hardware.
- **IoT Cloud Backend:** Platform (Blynk) to store and analyze incoming data.
- **User Dashboard:** Mobile app or webpage for real-time graphs and cost tracking.

Working

- **Sensing:** Sensors continuously sample raw analog voltage and current from the appliance.
- **Processing:** ESP32 converts signals to digital and calculates Power (W) and Energy (kWh).
- **Transmission:** Data is sent wirelessly via Wi-Fi to the IoT cloud using MQTT/HTTP protocols.

© 2026 IJIRCCE | Volume 14, Issue 6, June 2026 DOI: 10.15680/IJIRCCE.2026.1406037

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 9.927| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

- **Analytics:** backend logs historical usage and tracks daily/monthly consumption trends.
- **Alerting:** User receives real-time dashboard updates and instant notifications if thresholds are exceeded.

B. System Requirements

Hardware Requirements:

- **Microcontroller:** ESP32 Development Board (with integrated Wi-Fi).
- **Current Sensor:** PZEM-004T.
- **Voltage Sensor:** PZEM-004T.
- **Power Supply:** 5V DC adapter .
- **Interconnects:** Jumper wires, breadboard or custom PCB.
- **Load/Appliance:** Any household appliance (e.g., bulb, fan) for testing.

Software Requirements:

- **Development IDE:** Arduino IDE .
- **Programming Language:** Embedded C / C++.
- **Core Libraries:** EmonLib (for energy monitoring calculations) and WiFi.h.
- **IoT Cloud Platform:** Blynk IoT.
- **Protocols:** MQTT or HTTP REST API for data transfer.
- **User Interface:** Blynk Mobile App (Android/iOS) or web-based dashboard.

V. FLOW CHART

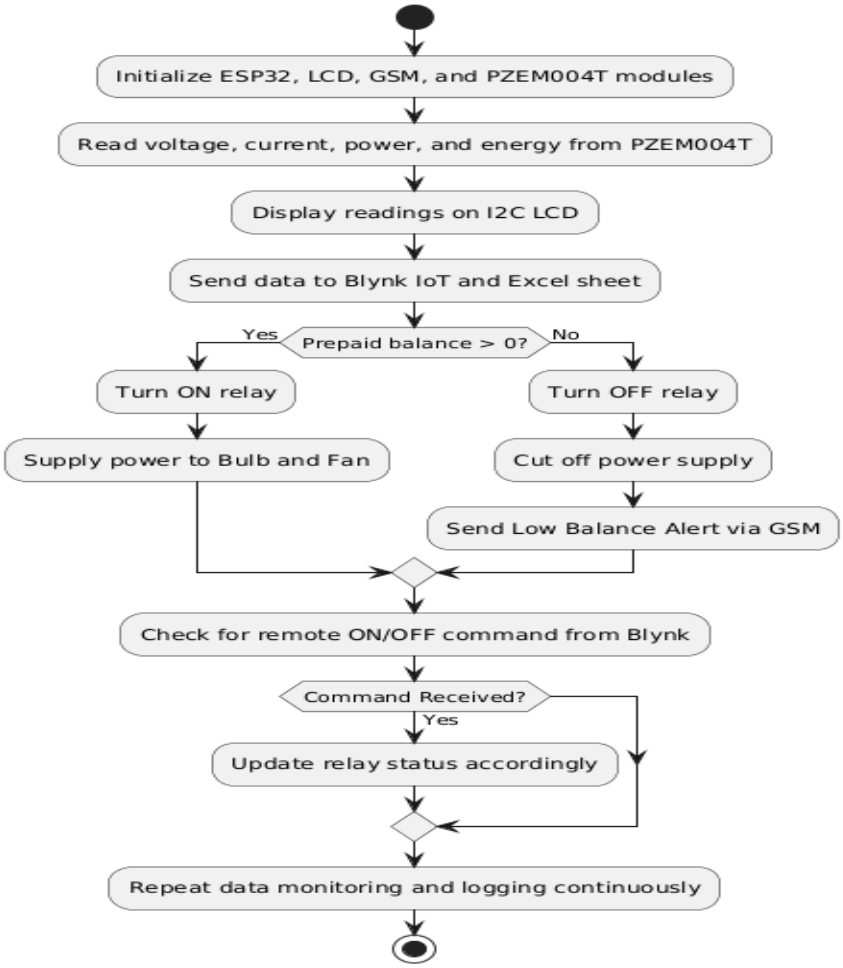


FIGURE.2. FLOW CHART

© 2026 IJIRCCE | Volume 14, Issue 6, June 2026 DOI: 10.15680/IJIRCCE.2026.1406037

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 9.927| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

VI. FINAL RESULT

The final implementation of the IoT-based Smart Energy Meter successfully achieved automated, real-time power tracking and granularity in home appliance monitoring. The hardware unit seamlessly captured voltage and current fluctuations, allowing the ESP32 to accurately calculate power consumption parameters with minimal error. This processed data was continuously updated on the cloud dashboard, providing users with instant visibility into their energy consumption trends, accurate electricity cost estimations, and automated threshold alerts. Ultimately, the system proved highly effective in identifying energy-hogging appliances and reducing overall household electricity waste through informed, data-driven consumer choices.

FIGURE.3. FABRICATED PROTOTYPE OF THE PROPOSED SMART ENERGY METER

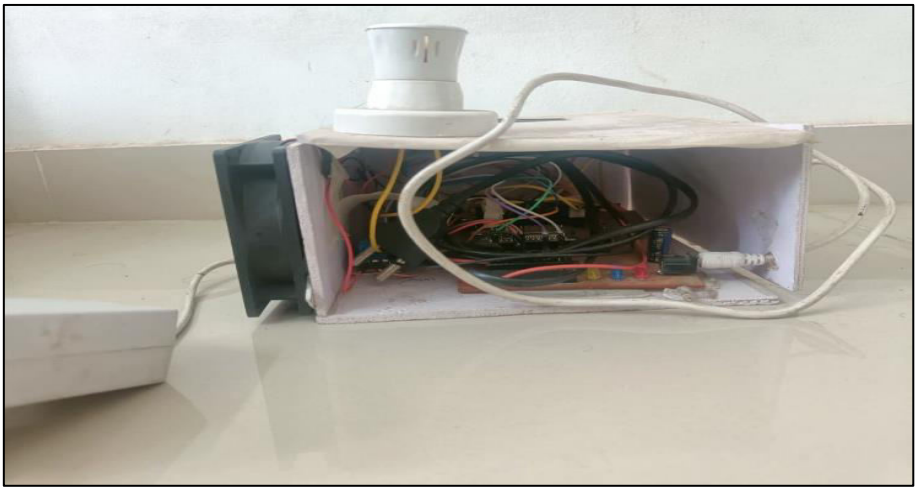


FIGURE.4. INTERNAL HARDWARE INTEGRATION OF THE PROPOSED SYSTEM

© 2026 IJIRCCE | Volume 14, Issue 6, June 2026 DOI: 10.15680/IJIRCCE.2026.1406037

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 9.927| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

FIGURE.5. LCD DISPLAY OUTPUT SHOWING MEASURED PARAMETERS

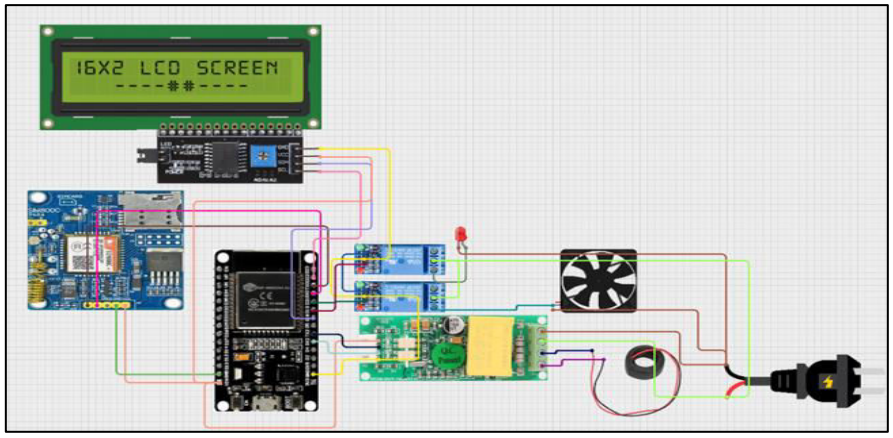


FIGURE.6. HARDWARE INTEGRATION AND CIRCUIT DIAGRAM

VII. CONCLUSION AND FUTURE SCOPE

Conclusion

The IoT-based Smart Energy Meter successfully demonstrates a cost-effective and reliable solution for granular, real-time energy monitoring of household appliances. By integrating non-invasive sensors with the ESP32 microcontroller, the system provides users with precise data visualization and actionable insights into their consumption patterns. This bridges the gap between consumers and utility transparency, proving that localized IoT tracking can effectively alter energy habits, optimize appliance usage, and contribute to both economic savings and reduced carbon footprints.

Future Scope

The system can be expanded by integrating **Machine Learning (ML)** algorithms for **Non-Intrusive Load Monitoring (NILM)**, allowing a single meter to identify and break down individual appliance signatures from total household power data without separate sensors. Future iterations could incorporate bi-directional smart relays for **automated demand response** (automatically shutting off heavy loads during peak tariff hours), and blockchain technology to ensure highly secure, decentralized peer-to-peer energy trading within local microgrids.

REFERENCES

[1] A. Sharma, and K. Gupta, "IoT-Based Vehicle Tracking and Safety System," *IEEE Trans- actions on Internet of Things*, vol. 9, no. 4, pp. 560–567, 2023.

[2] B. Patel, and R. Mehta, "Design of GSM–GPS Based Smart Vehicle Security System," *International Journal of Engineering Research and Technology (IJERT)*, vol. 11, no. 2, pp. 240–245, 2022.

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 9.927| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

[3] C. Mehta, and D. Joshi, "Alcohol Detection and Vehicle Engine Locking System Using MQ3 Sensor," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 9, no. 7, pp. 875–880, 2021.

[4] D. Banerjee, and R. Nair, "IoT Enabled Intelligent Vehicle Monitoring System," *IEEE Access*, vol. 8, pp. 11590–11600, 2023.

[5] S. Ahmed, and N. Khan, "Smart Accident Detection Using Accelerometer and GSM Technology," *International Journal of Innovative Research in Science, Engineering and Technology*, vol. 8, no. 3, pp. 1021–1026, 2019.

[6] M. K. Singh, and P. Chauhan, "Implementation of GPS and GSM Based Vehicle Tracking System," *IEEE International Conference on Computing, Communication and Automation (ICCCA)*, pp. 225–230, 2020.

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

INNO SPACE SJIF Scientific Journal Impact Factor

doi crossref

निस्केयर NISCAIR

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

9940 572 462 6381 907 438 ijircce@gmail.com

www.ijircce.com

Scan to save the contact details