

LoRa-based wearable women safety alert system

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Abstract- Women's safety remains a critical global concern, with increasing incidents of harassment, assault, and emergencies requiring immediate intervention. Traditional safety devices such as panic buttons and mobile applications have limitations: they rely on cellular connectivity, which may be unavailable in remote areas, and they lack automatic fall detection for situations where the user cannot manually trigger an alert. This project presents a comprehensive LoRa based women safety device that combines manual panic activation, automatic fall detection, and dual communication channels for maximum reliability. The system consists of two units: a portable transmitter unit carried by the user and a stationary receiver unit placed at a trusted location such as home, workplace, or police station. The transmitter unit uses an ESP32 microcontroller with a panic button for manual emergency activation and an MPU6050 sensor for automatic fall detection. When an emergency is detected, the transmitter sends an alert via LoRa wireless communication (operating at 433MHz) over long distances (several kilometers). Simultaneously, a GSM800L module sends an SMS alert directly to authorities or emergency contacts. The receiver unit, comprising another ESP32 with a LoRa module, buzzer, and LCD display, receives the LoRa transmission, displays the alert message on the LCD, and activates an audible buzzer to notify personnel at the receiving location. This dual-path communication ensures that even if one channel fails (GSM network down or LoRa interference), the other channel may still deliver the alert. The system is designed to be wearable, low-power, and effective in both urban and remote areas where cellular coverage may be unreliable.

Key words: Lora-based , GSM module, SOS module, Fall sensor.

I. INTRODUCTION

Women's safety has become an important social concern due to the increasing number of harassment, assault, and emergency incidents occurring in both public and private places. In many situations, immediate communication with family members, security personnel, or emergency services plays a vital role in preventing serious consequences. Although several safety solutions such as mobile applications, whistles, and alarm devices are available, they often depend on internet connectivity, smartphone access, or limited communication range, making them less reliable during emergencies.

To address these limitations, this project proposes a LoRa-Based Women Safety System that provides reliable long-range emergency communication. The system is designed using two units a portable transmitter carried by the user and a receiver unit placed at a secure monitoring location such as a home, office, or security center.

The transmitter unit is developed using the ESP32 microcontroller and includes a panic button for manual

emergency activation along with an MPU6050 accelerometer and gyroscope sensor for automatic fall detection. If the user presses the panic button or a sudden fall is detected, the system immediately activates the emergency alert process.

The alert is transmitted through two communication methods for improved reliability. A LoRa module sends the emergency signal over a long distance without relying on cellular networks, while a GSM800L module sends an SMS notification to predefined emergency contacts whenever network coverage is available.

The receiver unit consists of another ESP32, a LoRa receiver module, an LCD display, and a buzzer. When an alert is received, the LCD displays the emergency message and the buzzer generates an audible warning to notify nearby personnel.

The proposed system provides a dependable, low-power, and cost-effective solution for women's safety. By combining LoRa and GSM technologies, the system ensures continuous emergency communication even in areas with poor network connectivity, making it suitable for both urban and rural environments.

Literature Survey

1. "Safe Connect: A LoRa, GSM, and GPS-Based Women's Emergency Alert System" – Niwangune, B., Pujari, S., Khandage, T., & Hon, S. P. – 2025.

Observations: This paper proposes "Safe Connect," a wearable emergency alert system integrating LoRa for long-range communication with GSM fallback and GPS real-time location tracking. It includes features like video capture for incident recording and emphasizes power management to provide reliable distress alerts in both urban and remote areas.

2. "Implementation of a LoRa Mesh Library" – Mishra, S., Chandak, S., & Maheshwari, P. A. – 2020 International Conference on Computing, Communication and Automation (ICCCA)

Observations: This paper discusses the design and implementation of a LoRa mesh networking library, explaining routing algorithms and node behaviors that enable multi-hop communication and network resilience. It is useful for developing scalable wearable IoT networks requiring efficient routing and communication continuity.

3. "Smart Device for Automated Emergency Alerts Using Sensors" – Hyndavi N. Sai Nikhita, S. Rakesh. – 2020

Observations: This work presents a smart device that automates emergency alerts using sensor-based anomaly detection. It transmits real-time location and distress signals to predefined contacts. However, the approach depends on network availability and does not explore mesh-based or network-independent communication.

4. "Dynamic Dual-Function Safety Wristband: A Simulation-Driven Design for Enhancing Women's Security and Personal Safety" – Kowshik M. R., Aditya Narayan, P. M. Nagarajan, Sundararaman Gopalan. – 2025

Observation: The study proposes a wristband capable of both emergency distress signaling and health monitoring. It uses IoT hardware with dual communication modules to ensure reliability. The system was validated through simulation, showing that a discreet wearable device can effectively enhance women's safety while providing continuous vital-sign monitoring.

5. "A Wearable Fall Detection System Based on LoRa LPWAN Technology" – Elma Zanaj, Devis Disha, Susanna Spinsante, Ennio Gambi. – 2020

Observation: This paper proposes a fall detection system that leverages LoRa LPWAN technology for wearable devices. It highlights LoRa's strengths in long-range, low-power communication, demonstrating its suitability for safety-critical monitoring applications.

6. "LoRa Mesh-Based IoT GPS Tracking System for Mountain Climbers" – Muladi, Hisyam Wijaya, Singgih Dwi Prasetyo, et al. – 2024

Observations: The authors propose a LoRa mesh-enabled GPS tracking system for mountain climbers in areas lacking cellular coverage. The system periodically transmits GPS coordinates, with data forwarded through mesh hops to extend range. While effective for outdoor tracking, it is limited to periodic location updates and does not incorporate health or emergency sensor integration.

Problem Statement

Women continue to face significant safety risks such as harassment and assault. Many current safety options are either difficult to access quickly in emergencies or depend on manual activation, which may delay help. There is a need for a discreet, reliable wearable device that automatically detects emergencies like abnormal health conditions or falls and instantly alerts trusted contacts with precise location information. This will enable faster response and better personal protection for women in critical situations.

Objectives

The Objectives are specified below

- To design a wearable women safety device using ESP32 with panic button and MPU6050 sensor for manual and automatic emergency detection.
- To implement LoRa technology for long-range emergency communication without depending on cellular networks.
- To integrate a GSM800L module for sending SMS alerts to predefined emergency contacts.
- To develop and test a reliable receiver unit with LCD display and buzzer for immediate local emergency notification.

- Relevancy of the SKILL/Academic courses in Project Selection
- Skill Development Program on “Embedded Systems – helped in understanding microcontroller programming and interfacing various modules like ESP32, LoRa, and GSM.
- Academic courses on “Wireless Communication Technologies – explained wireless protocols and long-range communication methods essential for reliable alert transmission.

Overview Of Report

The project titled “LoRa Based Women Safety Device with Dual Alert System” focuses on developing a reliable and efficient emergency safety solution for women using modern wireless communication technologies. The system is designed to provide immediate assistance during dangerous situations through both manual and automatic emergency detection mechanisms.

The proposed model consists of a wearable transmitter unit and a monitoring receiver unit. The transmitter section is developed using an ESP32 microcontroller integrated with a panic button and an MPU6050 sensor for fall detection. Emergency alerts can be triggered manually by the user or automatically through abnormal movement detection. To achieve dependable communication, the system combines LoRa and GSM technologies. LoRa enables long-range wireless transmission without complete dependence on cellular networks, while the GSM module provides SMS notifications to predefined emergency contacts for additional reliability. The receiver section includes an ESP32 controller, LoRa receiver module, LCD display, and buzzer. When an alert signal is received, the LCD displays the emergency information and the buzzer provides an audible warning for immediate attention.

The overall system is designed to be compact, low-power, cost-effective, and suitable for real-time safety applications in both urban and remote environments.

II. METHODOLOGY OF PROPOSED WORK

2.1 System Block Diagram

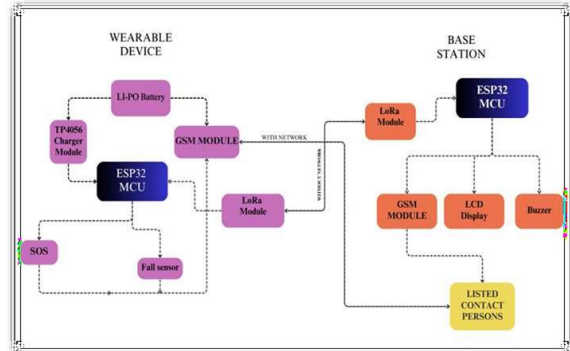


Fig 2.1 System block diagram

The block diagram indicates a wearable device and a base station for emergency alerts. The wearable unit, powered by a Li-Po battery and ESP32, uses a fall sensor and SOS button to detect emergencies. It sends alerts via GSM (with network) or LoRa (without network). The base station receives the alert, displays it on an LCD, activates a buzzer, and notifies listed contacts.

2.2 Flow Chart With Working Mechanism

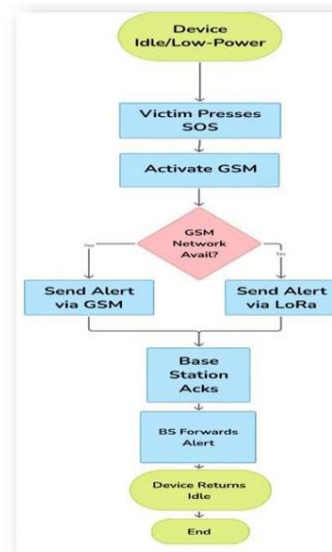


Fig 2.2

Fig 2.2 The flow diagram represents the system starts in idle mode. When the victim presses the SOS button, the device activates GSM and checks for network availability. If GSM is available, the alert is sent via GSM; otherwise, it is sent via LoRa. The base station acknowledges and forwards the alert, after which the device returns to idle state.

2.3 Working Procedure

The methodology of the system is based on developing a reliable emergency alert mechanism using both manual and automatic detection techniques. The complete system is divided into two units: a transmitter unit and a receiver unit. The transmitter unit is developed using an ESP32 microcontroller integrated with a panic button, MPU6050 sensor, LoRa module, and GSM800L module. The panic button is used for manual emergency activation, while the MPU6050 sensor continuously monitors motion and detects sudden falls or abnormal movements automatically. The LoRa module is used for long-range wireless communication, and the GSM module provides SMS-based emergency notification to predefined contacts. The receiver unit consists of another ESP32 controller connected with a LoRa receiver module, LCD display, and buzzer. The receiver continuously listens for incoming emergency signals and provides both visual and audible alerts whenever an emergency message is received. The system is implemented using Arduino IDE and Embedded C programming. Power management techniques such as sleep mode operation and selective activation of communication modules are used to improve battery efficiency and ensure reliable long-term operation.

1. The wearable transmitter unit continuously monitors the panic button and MPU6050 sensor data.
2. During normal conditions, the system remains inactive while continuously checking for SOS activation or fall detection.
3. When the user presses the panic button or when abnormal fall movement is detected, the ESP32 identifies the emergency condition.
4. The LoRa module immediately transmits an emergency alert message to the receiver unit over long-range wireless communication.
5. Simultaneously, the GSM800L module sends SMS notifications to predefined emergency contacts or authorities.

6. The receiver unit continuously listens for incoming LoRa signals using the SX1278 receiver module.
7. After receiving the emergency message, the LCD displays the alert information and the buzzer generates an audible alarm for immediate attention.

Components Requirements

Hardware components:

- LoRa module(Ra-02)
- SIM800L GSM Module
- ESP32 Microcontroller
- MPU6050 Sensor
- I2C LCD Display (16x2)
- LM2596 DC-DC Buck Converters
- Buzzer
- LoRa external antenna

1. LoRa Module (Ra-02)

LoRa is a long-range wireless communication module used to transmit data over several kilometers. It is very useful in remote areas where GSM network is not available. It consumes low power, making it suitable for battery-operated devices. In this system, it acts as a backup communication method. It ensures alerts are still sent even without mobile network coverage.



Fig 3.1 LoRa Module (Ra-02)

2. SIM800L GSM Module

This miniature GSM modem provides the project with cellular connectivity to send SMS alerts or transmit data over GPRS networks. It is a quad-band device that operates globally on standard cellular frequencies and requires a stable power supply between 3.7V and 4.2V. The module includes an external antenna to maintain a strong signal even when the electronics are housed inside a protective metal or plastic enclosure.



Fig 3.2 SIM800L GSM Module

3. ESP32 Microcontroller

ESP32 is the main processing unit of the system. It controls all modules like GSM, LoRa, sensors, and display. It reads inputs from the SOS button and MPU6050 sensor. Based on conditions, it decides how to send alerts. It is powerful, energy-efficient, and supports multiple interfaces.



Fig 3.3 ESP32 Microcontroller

4. MPU-6050 3-Axis Accelerometer and Gyro Sensor

The MPU-6050 3-Axis Accelerometer and Gyro Sensor module use MPU-6050 which is a little piece of motion processing tech. The MPU6050 devices combine a 3-axis gyroscope and a 3-axis accelerometer on the same silicon together with an onboard Digital Motion Processor (DMP) capable of processing complex 9-axis Motion Fusion algorithms.

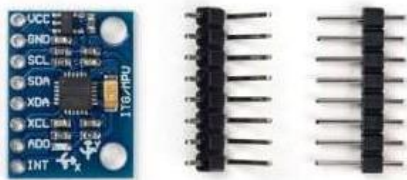


Fig 3.4 MPU-6050 3-Axis Accelerometer and Gyro Sensor

4. I2C LCD Display

The alphanumeric display provides real-time visual feedback to the user by showing 16 characters across two distinct lines. By utilizing an I2C communication backpack, the screen only requires two data wires to communicate with the Arduino instead of the traditional six pins. The module includes a built-in potentiometer on the back for manual adjustment of the screen contrast to ensure readability in different lighting conditions.



Fig 3.4 I2C LCD Display

5. LM2596 DC-DC Buck Converters

These step-down switching regulators efficiently convert the 12V input voltage into the specific lower voltages required by the different system modules. They operate at a high frequency of 150kHz to minimize heat generation and allow for the use of small internal filtering components. One converter is typically tuned to 5V for the logic circuits while a second is set to 4.2V to meet the strict power requirements of the GSM module.

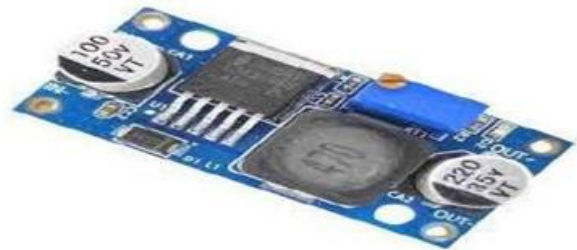


Fig 3.5 LM2596 DC-DC Buck Converters

6. Buzzer

High Current Active Alarm Buzzer Driver Module is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Operating voltage 3.3V-5V PCB Dimension: 3.1cm*1.3cm.



Fig 3.6 Buzzer

7. LoRa external antenna

This is a LoRa external antenna with SMA connector used for wireless communication. It is connected to the LoRa module to transmit and receive signals. It helps increase communication range over long distances. It works without internet or mobile network. This antenna is useful in IoT and safety projects.

In our project, it is used to send emergency alert data.



Fig 3.7 LoRa external antenna

Software Requirements:

- Arduino IDE
- Embedded C Programming

1. Arduino IDE

The Arduino Integrated Development Environment (IDE) is the primary open-source software used to write, compile, and upload code to the ATmega328P microcontroller. It provides a user-friendly interface that includes a text editor for writing code, a message

area for debugging, and a serial monitor for real-time data inspection. The software is compatible with various operating systems and supports a vast array of libraries that simplify the process of interfacing with complex hardware like GSM modules and LCDs.



Fig 4.1 Arduino IDE

2. Embedded C Programming

The system logic is developed using Embedded C, which is an extension of the C programming language specifically designed for microcontrollers and limited-resource devices. This language allows for direct hardware addressing and efficient memory management, which is essential for handling real-time tasks like pulse counting from the coin acceptor. The code follows a specific structure consisting of a setup function for initialization and a loop function that continuously executes the main operational logic.

IV. DESIGN AND IMPLEMENTATION

4.1 Overview of the System Design

The system is designed as a smart emergency safety device consisting of two major sections: a wearable transmitter unit and a receiver monitoring unit. The transmitter section is carried by the user and is responsible for detecting emergency situations, while the receiver section receives the alert signal and generates visual and audible notifications. The overall design focuses on reliable emergency detection, long-range wireless communication, low power consumption, and dual alert transmission. The system combines manual SOS activation and automatic fall detection using embedded sensors and communication modules. LoRa communication technology is used as the primary wireless communication method for long-range alert transmission, while GSM technology is

used for sending SMS notifications to predefined emergency contacts. The system integrates ESP32 microcontrollers, MPU6050 sensor, SX1278 LoRa modules, GSM800L module, LCD display, buzzer, rechargeable battery, and power regulation circuits for efficient operation.

4.2 Transmitter Unit Hardware Design

The transmitter unit is designed as a compact wearable device using an ESP32 DevKit board as the main controller. A panic button is connected to a GPIO pin for manual emergency activation. The MPU6050 accelerometer and gyroscope sensor is interfaced using the I2C communication protocol to detect sudden falls and abnormal movements automatically. The SX1278 LoRa module is connected through SPI communication for long-range wireless alert transmission. A GSM800L module is connected through UART communication for sending SMS alerts to predefined emergency contacts. The transmitter unit is powered using a rechargeable Li-ion battery with TP4056 charging circuit and voltage regulator for stable operation.

4.3 Transmitter Unit Firmware

The ESP32 continuously monitors the panic button and MPU6050 sensor data. When an emergency condition is detected, the system performs the following operations:

- LoRa module transmits emergency alert packets immediately.
- GSM800L module sends SMS alerts to stored emergency contacts.
- Status LED indicates successful alert transmission.
- System enters a temporary cooldown period to avoid repeated alerts. The fall detection algorithm works using three conditions:
- Sudden impact detection through acceleration values.
- Inactivity detection after impact.
- Orientation change from normal body position.

When all conditions are satisfied, the system automatically triggers a fall alert.

4.4 Receiver Unit Hardware Design

The receiver unit is designed as a stationary monitoring system using another ESP32 DevKit board. The SX1278 LoRa module receives emergency

messages transmitted from the wearable unit. 16×2 LCD display with I2C interface is used to display emergency information, while a 5V active buzzer provides audible alert notification. The receiver section operates continuously using a regulated 5V power supply.

4.5 Receiver Unit Firmware

The receiver ESP32 continuously checks for incoming LoRa packets. When an emergency message is received:

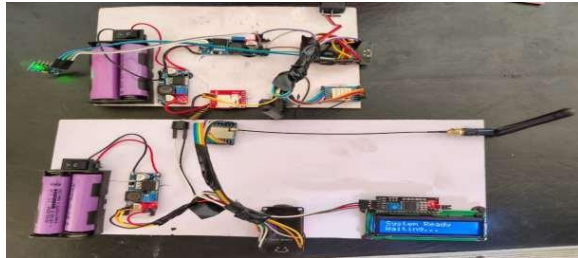
- The message is processed and displayed on the LCD.
- The buzzer generates an audible emergency alert.
- The alert remains active until the system is manually reset.
- LoRa Communication Configuration
- Both transmitter and receiver units use identical LoRa settings for reliable communication.
- Frequency: 433 MHz
- Spreading Factor: 12
- Bandwidth: 125 kHz
- Coding Rate: 4/5
- Output Power: 20 dBm

V. RESULTS AND DISCUSSION

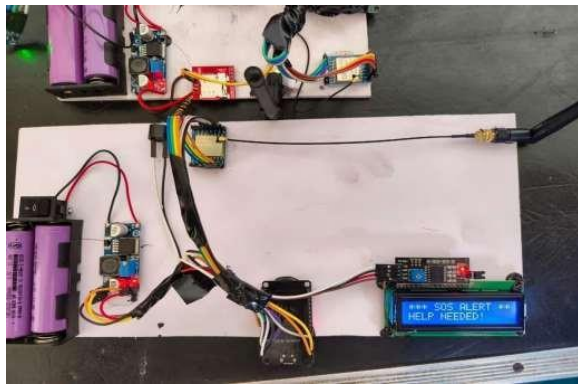
The developed emergency safety system was successfully designed and tested for both manual and automatic emergency alert generation. The transmitter and receiver units operated effectively using LoRa and GSM communication technologies. The panic button generated immediate emergency alerts, while the MPU6050 sensor successfully detected sudden fall conditions based on acceleration and orientation changes.

The LoRa module provided reliable long-range wireless communication, achieving good performance in open areas, while the GSM800L module successfully transmitted SMS notifications to predefined emergency contacts whenever network coverage was available. The receiver unit effectively received emergency alerts, displayed messages on the LCD screen, and activated the buzzer for immediate local notification.

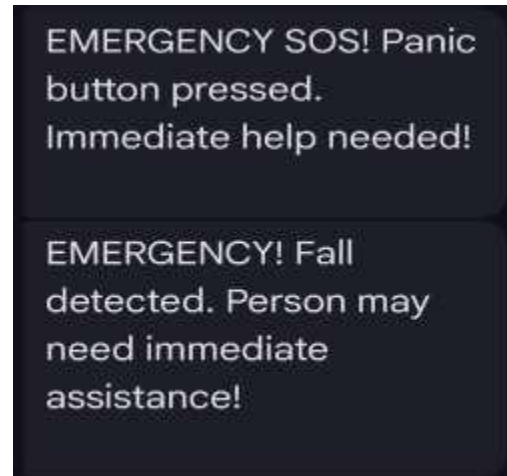
The implemented power management techniques helped in reducing power consumption and improving battery backup during standby operation. Overall, the system demonstrated reliable performance, low power operation, automatic fall detection, and dual communication support, making it a practical and cost-effective solution for real-time emergency safety applications.



5.1 Receiver Unit in Standby Mode



5.2 Transmission of Emergency Alert through LoRa Communication



5.3 GSM-based Emergency SMS Alert to Registered Contacts

VI. CONCLUSION AND FUTURE SCOPE

The developed emergency safety system successfully provides a reliable and efficient solution for real-time emergency alerting using dual communication technologies. By integrating manual panic button activation, automatic fall detection using the MPU6050 sensor, LoRa-based long-range communication, and GSM SMS alert transmission, the system improves personal safety and ensures quick emergency response during critical situations. The implementation of ESP32 controllers, LoRa modules, GSM800L module, LCD display, and buzzer enabled effective transmission and monitoring of emergency alerts. The dual communication mechanism improves system reliability by ensuring that alerts can still be delivered even if one communication channel becomes unavailable. The compact wearable design, low power consumption, and automatic detection capability make the system suitable for practical day-to-day usage. Although the system achieved reliable performance, certain improvements can further enhance its functionality. Future enhancements may include integration of GPS for real-time location tracking, cloud connectivity for internet-based alert monitoring, multiple receiver units for wider coverage, and machine learning techniques for improving fall detection accuracy. Additional features such as vibration feedback, OLED status display, solar-powered receiver units, and encrypted

communication can also improve system efficiency, usability, and security.

Overall, the system demonstrates an effective, low-cost, and practical solution for emergency safety applications and can be further extended for advanced real-time monitoring and protection systems.