Women Safety Device V1.0

Technical Documentation

ESP32 + SIM800C + GPS + Environmental Sensors + Motion Alert System

Introduction

Device Purpose

The Women Safety Device V1.0 is a compact wearable/portable emergency response system engineered for critical safety situations. This sophisticated embedded system combines real-time location tracking, environmental monitoring, and intelligent motion detection to provide comprehensive personal security.

The device autonomously detects high-impact motion events and transmits SOS alerts containing precise GPS coordinates via SMS through the SIM800C GSM module. Location data is formatted as a Google Maps link for immediate emergency response. Real-time system status and sensor readings are continuously displayed on an integrated OLED screen.

Core Objectives

- Automatic distress detection via motion analysis
- Real-time GPS coordinate transmission
- Emergency alert to pre-configured contacts
- Environmental data logging capabilities
- Manual panic button activation
- Continuous system status monitoring

System Overview

The Women Safety Device V1.0 implements a distributed sensor architecture with the ESP32 serving as the central processing unit, coordinating data acquisition from multiple peripherals and managing emergency response protocols.

ESP32 Controller

Main processor managing three UART channels, I2C bus, and GPIO interfaces for sensor integration and communication protocols

GPS Positioning

Real-time latitude, longitude, and UTC time acquisition at 115200 baud with NMEA sentence parsing

BMP280 Sensor

Environmental monitoring providing temperature, barometric pressure, and calculated altitude data

MPU6050 IMU

6-axis accelerometer and gyroscope detecting unusual or violent movement patterns for automatic alert triggering

SIM800C Module

GSM communication interface transmitting SMS alerts to emergency contacts with location and sensor data

OLED Display

Real-time visualization of sensor readings, network status, GPS validity, and system operational state

Hardware Components

ESP32 Microcontroller

Dual-core processor with integrated WiFi/Bluetooth, three hardware UART interfaces, I2C/SPI support, and extensive GPIO capabilities. Operates as the central control unit managing all sensor inputs and communication protocols.

SIM800C GSM Module

Quad-band GSM/GPRS module providing SMS communication capabilities. Operates at 9600 baud via UART1, supporting text-mode messaging for emergency alert transmission with network signal monitoring.

GPS Module

High-precision positioning system communicating via UART2 at 115200 baud. Outputs NMEA sentences for real-time coordinate acquisition, UTC time synchronization, and altitude determination.

BMP280 Sensor

Digital pressure and temperature sensor with I2C interface. Provides barometric pressure readings in hPa, ambient temperature in Celsius, and altitude calculation using standard atmospheric model.

MPU6050 IMU

Six-axis inertial measurement unit combining 3-axis accelerometer and 3-axis gyroscope. Monitors device orientation and detects high-impact motion events through continuous acceleration vector analysis.

SSD1306 OLED Display

0.96-inch monochrome display with 128x64 resolution, I2C interface at address 0x3C. Renders real-time sensor data, GPS status, network signal strength, and system operational parameters.

Additional components include a manual SOS button for emergency trigger override and regulated power circuitry providing stable 5V supply to all subsystems.

Hardware Architecture & Connections

Pin Configuration & Interface Mapping

The system implements a multi-bus architecture utilizing UART, I2C, and GPIO interfaces. Three independent UART channels prevent data collision while I2C bus sharing optimizes pin utilization for sensor integration.

Component	Interface	ESP32 Pins	Configuration
SIM800C GSM	UART1	TX: 25, RX: 26	9600 baud
GPS Module	UART2	TX: 17, RX: 16	115200 baud
SSD1306 OLED	I2C	SDA: 21, SCL: 22	Address: 0x3C
BMP280	I2C	SDA: 21, SCL: 22	Shared bus
MPU6050	I2C	SDA: 21, SCL: 22	Shared bus
SOS Button	GPIO	Pin 23	Pull-up input

Communication Architecture

- UART1: GSM module command/response
- UART2: GPS NMEA data stream
- I2C: Multi-sensor bus topology
- GPIO: Digital input with debouncing

Power Distribution

- 5V regulated supply to all modules
- 3.3V logic level compatibility
- Independent module power sequencing
- Current limiting protection circuits

Software Architecture

The firmware implements a sequential polling architecture with non-blocking sensor acquisition and event-driven alert transmission. The main control loop maintains continuous system monitoring while preserving responsive emergency detection capabilities.

Initialization

Sensor and module configuration, I2C device detection, UART setup

GPS Parsing

Continuous NMEA sentence decoding, coordinate extraction, time conversion

Sensor Reading

Environmental data acquisition, motion detection algorithm execution

UI Rendering

OLED display update, signal strength visualization, status indicators

Alert Protocol

SMS composition, GSM transmission, confirmation handling

Core Processing Loop

1. Poll GPS module for new NMEA data
2. Parse coordinates and update location buffer
3. Sample accelerometer data from MPU6050
4. Calculate motion vector magnitude
5. Read environmental sensors (BMP280)
6. Query GSM signal strength (AT+CSQ)
7. Refresh OLED display with current data
8. Check SOS button and motion threshold
9. Trigger emergency SMS if conditions met

Motion Detection Algorithm

The MPU6050 acceleration vectors undergo averaging across 10 consecutive samples to filter transient noise. The averaged magnitude is compared against a calibrated threshold value of 23 units.

When exceeded, the system interprets the motion as a potential fall, impact, or violent movement, automatically invoking the SOS alert routine without manual intervention.

GPS Processing System

NMEA Data Acquisition & Processing

The GPS module transmits NMEA 0183 formatted sentences at 115200 baud through UART2. The TinyGPS++ library performs real-time parsing of $GPGGA, $GPRMC, and related sentence types to extract positioning data.

01

Serial Reception

UART2 buffer continuously receives GPS data stream at 115200 baud rate, captured character-by-character for sentence assembly

02

NMEA Decoding

TinyGPS++ library validates checksums and parses standard NMEA sentence structures to extract raw positioning data

03

Coordinate Extraction

Latitude and longitude values converted from degrees-minutes format to decimal degrees with six-digit precision

04

Time Conversion

UTC timestamp from GPS adjusted to IST (UTC+5:30) for local time representation in alert messages

05

Validity Assessment

GPS fix status monitored continuously, displaying valid/invalid state on OLED based on satellite acquisition

06

Maps Link Generation

Coordinate strings formatted into Google Maps URL structure for immediate location visualization by emergency contacts

Coordinate Storage Format

Latitude and longitude values are maintained as formatted string variables with appropriate decimal precision. The coordinate strings are constructed to ensure compatibility with SMS transmission constraints and Google Maps URL parameters.

The system continuously updates these values as new valid GPS fixes are acquired, ensuring the most recent position is always available for emergency transmission.

GPS Performance

Baud Rate: 115200

Update Rate: 1 Hz typical

Accuracy: ±3 meters CEP

Time to Fix: 30-45 seconds cold start

GSM & SMS Communication System

SIM800C Module Configuration

The SIM800C operates at 9600 baud via UART1, utilizing AT command protocol for configuration and message transmission. The module initializes in text mode (AT+CMGF=1) for simplified SMS composition without PDU encoding requirements.

1 Module Initialization

Power-on sequence, baud rate synchronization, and AT command responsiveness verification

2 Network Registration

Automatic carrier detection and network attachment with signal quality monitoring

3 Text Mode Selection

AT+CMGF=1 command enables text-based SMS composition for simplified message formatting

4 Message Composition

SMS body constructed with device identification, timestamp, coordinates, sensor data, and Maps link

5 Transmission Execution

AT+CMGS command sends completed message to pre-configured emergency contact number

Emergency SMS Content Structure

Message Components

- **Device Name:** Women Safety Device V1.0
- **Timestamp:** IST (UTC+5:30 converted)
- **Latitude:** Decimal degrees format
- **Longitude:** Decimal degrees format
- **Altitude:** Meters above sea level
- **Pressure:** Barometric reading in hPa
- **Temperature:** Ambient temperature in °C
- **Maps Link:** Google Maps URL with coordinates

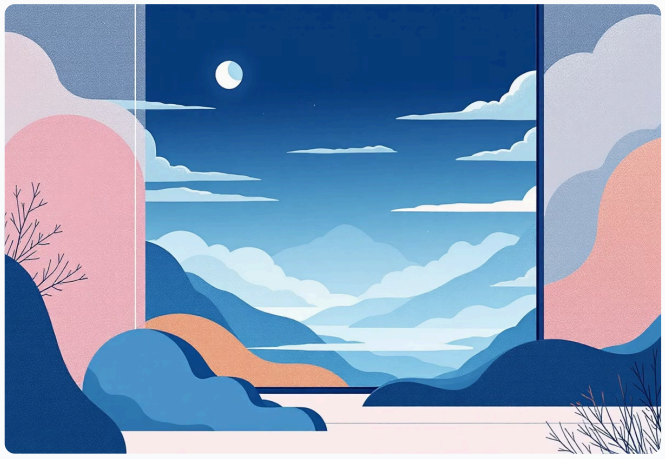
Signal Strength Monitoring

The system queries network signal quality every second using the AT+CSQ command. The response contains RSSI (Received Signal Strength Indicator) values ranging from 0-31, which are mapped to a 0-5 bar visual representation on the OLED display.

This continuous monitoring ensures emergency messages are transmitted only when sufficient network coverage is available, preventing failed alert attempts.

Sensor System Integration

BMP280 Environmental Sensor



The Bosch BMP280 digital sensor provides high-precision environmental measurements through I2C communication. The sensor operates continuously, updating readings at regular intervals for display and SMS transmission.

Measured Parameters

- **Temperature:** Ambient air temperature with ±1°C accuracy across operating range
- **Pressure:** Barometric pressure measurement with ±1 hPa absolute accuracy
- **Altitude:** Calculated using international standard atmosphere model with 1013.25 hPa reference pressure

Environmental data appears in real-time on the OLED display and is included in every emergency SMS transmission, providing responders with contextual information about the alert location's environmental conditions.

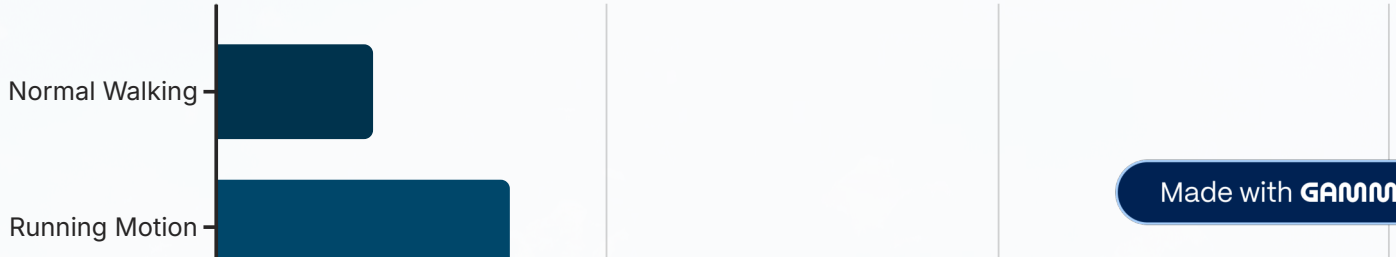
MPU6050 Motion Detection

The InvenSense MPU6050 six-axis inertial measurement unit monitors device acceleration across three orthogonal axes. The firmware implements a sophisticated motion analysis algorithm for automatic distress detection.

Detection Algorithm

1. Continuous sampling of X, Y, Z acceleration vectors
2. Collection of 10 consecutive samples per analysis cycle
3. Arithmetic averaging to reduce noise and false positives
4. Magnitude comparison against calibrated threshold value
5. Auto-SOS trigger when averaged magnitude exceeds 23 units

This threshold represents empirically determined values corresponding to falls, impacts, or violent movements, enabling automatic emergency response without manual button activation.



System Performance & Capabilities

11520..	1	23	10
GPS Baud Rate	**Update Rate (Hz)**	**Motion Threshold**	**Sample Averaging**
High-speed UART communication for rapid NMEA sentence parsing and coordinate updates	Real-time sensor polling and display refresh frequency for continuous system monitoring	Calibrated acceleration magnitude trigger value for automatic emergency detection	Consecutive acceleration samples averaged for noise reduction and false positive prevention

Technical Specifications Summary

Core Capabilities

- Automatic distress detection via motion analysis
- Manual emergency activation through SOS button
- Real-time GPS coordinate acquisition and tracking
- SMS alert transmission with Google Maps integration
- Environmental data logging (temperature, pressure, altitude)
- Continuous network signal quality monitoring
- Live system status visualization on OLED display
- IST time synchronization from GPS UTC timestamp

Future Enhancement Opportunities

- Voice call integration for audio emergency communication
- GPRS data connectivity for web-based tracking
- Geofencing and location-based trigger zones
- Multi-recipient emergency contact distribution
- Battery monitoring and low-power sleep modes
- Encrypted communication protocols for privacy
- Machine learning motion pattern classification
- Cloud-based alert logging and history tracking

The Women Safety Device V1.0 represents a comprehensive embedded systems solution integrating multiple sensor modalities, wireless communication, and intelligent alert algorithms. The modular architecture facilitates iterative enhancement while maintaining reliability in critical safety applications. This documentation provides complete technical reference for hardware replication, firmware modification, and system integration in emergency response scenarios.