EC6020

Embedded Systems Design

Beacon Receiver and Beacon Transmitter

Project Proposal

By

Faculty of Engineering

University of Jaffna

Title: Beacon Receiver and Beacon Transmitter

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Executive Summary

This mini project proposes the design and implementation of a wireless beacon transmitter and receiver system using LoRa technology for emergency communication applications. The project is motivated by recent natural disasters in Sri Lanka, such as floods and landslides, where conventional communication systems became unreliable or completely unavailable. In such situations, there is a critical need for a low-power, long-range communication system that can operate independently of existing cellular or internet infrastructure.

The proposed system consists of two main units: a person tag (beacon transmitter) and a base station (beacon receiver). The person tag is carried by the user and periodically transmits a short beacon message containing a unique identification code and optional status information. In an emergency situation, an SOS push button allows the user to immediately transmit an emergency alert. The base station continuously monitors incoming LoRa messages and provides visual (LED) and audio (buzzer) alerts when an SOS signal is detected. Although the system does not provide precise location information with a single base station, it reliably confirms the presence of the user within communication range and records the last contact time. This solution aims to enhance emergency response capability and improve safety during disaster conditions.

Introduction

Natural disasters such as floods and landslides are becoming increasingly frequent in Sri Lanka, often causing extensive damage to infrastructure and severe disruption to communication networks. In these situations, conventional communication methods like mobile calls and text messages may fail due to network congestion, power outages, or damaged infrastructure, leaving affected individuals isolated and unable to send emergency alerts. To address this challenge, this project proposes a LoRa-based wireless beacon system for emergency locating and alerting. The system consists of a portable person tag, carried by the user, and a fixed base station. The person tag transmits periodic beacon messages and can send an emergency SOS signal, while the base station receives these signals and activates audio-visual alerts. This system provides a reliable, low-power solution for emergency communication in disaster-prone areas.

Problem Statement

During natural disasters, traditional communication systems may fail, preventing individuals from sending or receiving emergency alerts. There is a critical need for a long-range, lowpower wireless communication system that operates independently of existing network infrastructure to transmit emergency and status signals, ensuring timely assistance and improved safety.

Proposed Solution

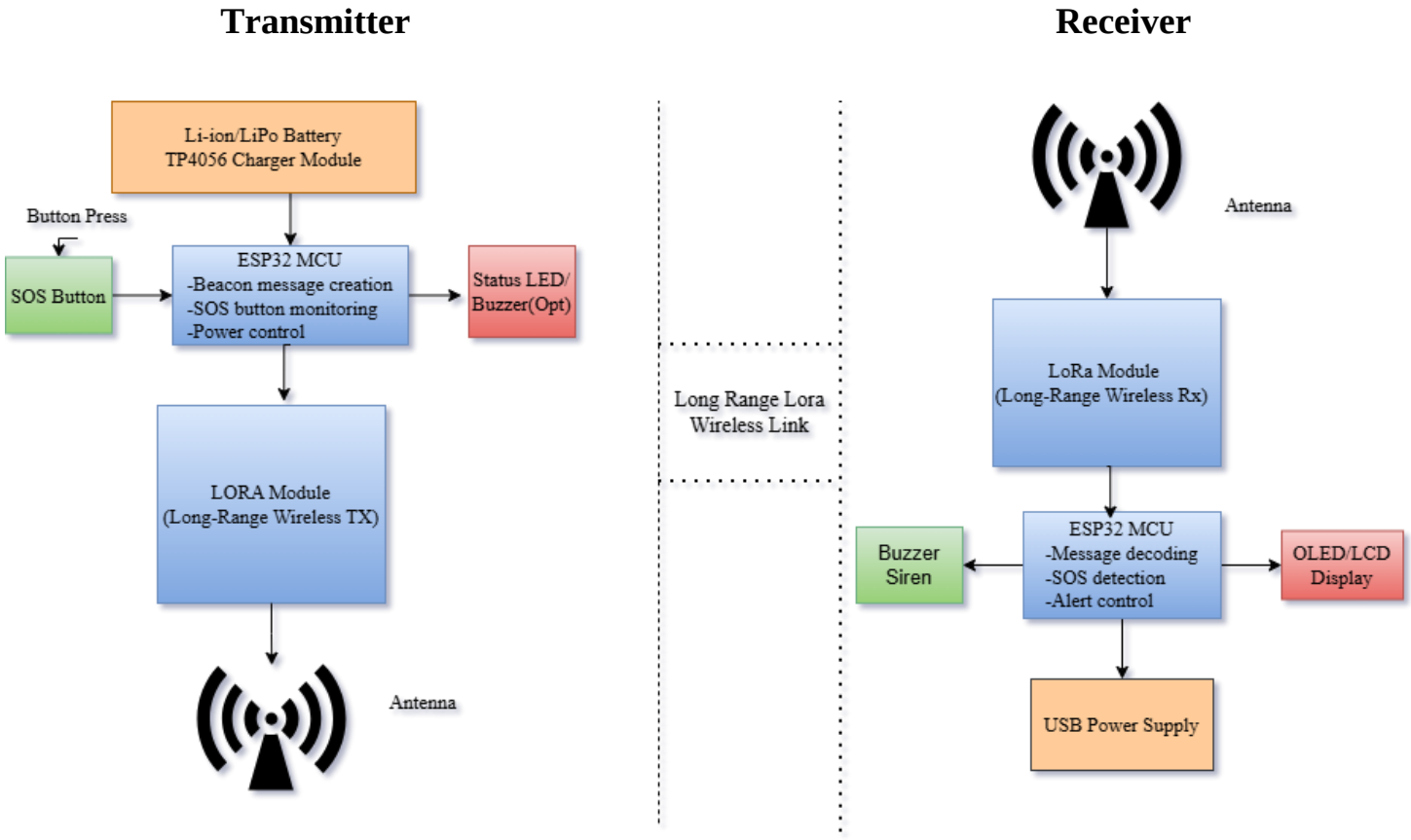
The proposed solution is a LoRa-based wireless beacon transmitter and receiver system, comprising:

1. Beacon Transmitter (Person Tag): A portable device that periodically transmits beacon messages containing a unique ID and optional battery status via a LoRa RA-02 module. An SOS push button allows immediate transmission of an emergency signal during critical situations.
2. Beacon Receiver (Base Station): A fixed unit that continuously listens for incoming LoRa messages. Normal beacons indicate the user's active status, while SOS messages trigger audio and visual alerts through a buzzer and LEDs.

The system provides reliable, long-range communication with minimal power consumption, offering critical last-contact information and a practical solution for emergency communication where conventional networks may fail.

Design Overview

- **System Architecture**



- **Communication Protocols**

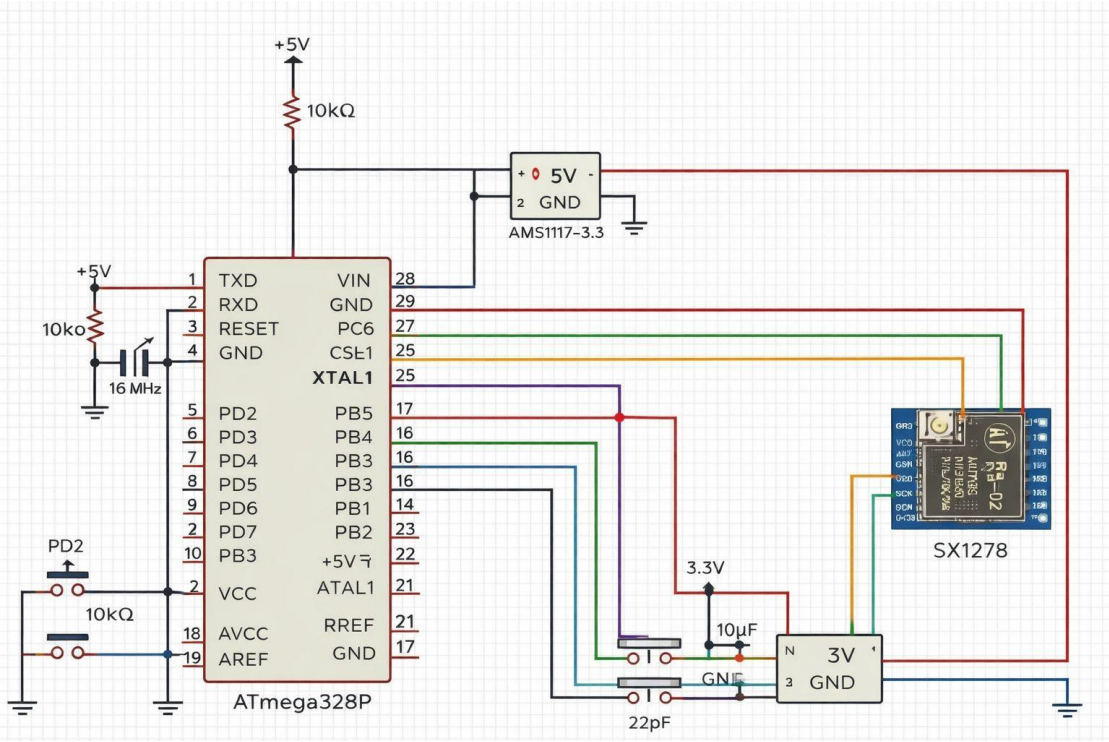
The proposed beacon transmitter and receiver system utilizes multiple communication protocols to ensure reliable and efficient data transfer between system components.

- **SPI:** Used to communicate between the ESP32 and the LoRa module.
- **UART:** Used for serial communication and debugging.
- **I2C (Optional):** Used to connect OLED/LCD displays with minimal wiring.

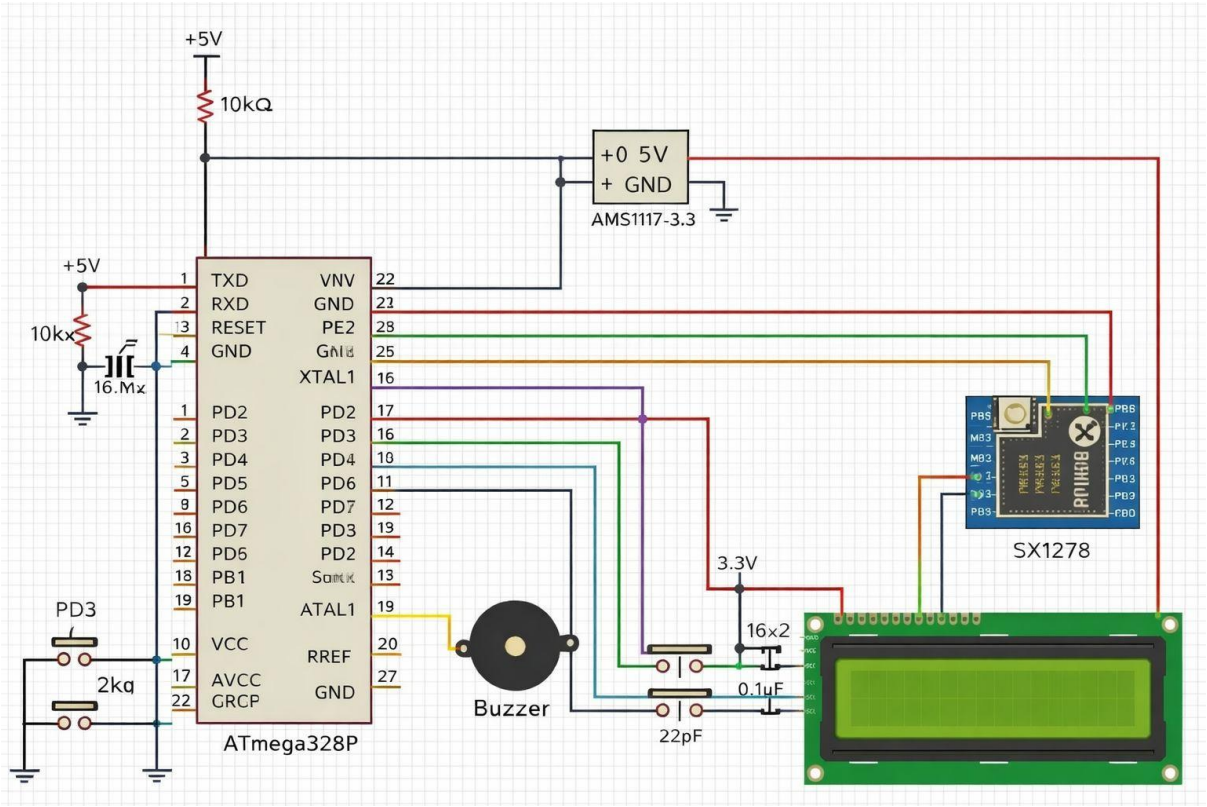
The selected protocols provide a balanced combination of speed, simplicity, and scalability, making the system suitable for emergency communication applications.

- **Circuit Design**

Transmitter



Receiver



Design Technologies

Hardware Design

The system is implemented using low-cost and widely available hardware components suitable for rapid prototyping

- **ESP32 Development Board:** Main controller for both transmitter and receiver units.
- **LoRa Module (RA-02 / SX1278):** Long-range, low-power wireless communication.
- **LoRa Antenna:** Improves signal strength and communication distance.
- **Push Button (SOS Switch):** Emergency trigger input.
- **LEDs:** Visual status and alert indication.
- **Buzzer / Siren:** Audio alert during emergency situations.
- **Li-ion / LiPo Battery (3.7 V):** Portable power source for the person tag.
- **TP4056 Charging Module:** Safe battery charging and protection.
- **OLED / LCD Display (Optional):** Displays user ID and emergency status at the base station.

Software Technology

- **Programming Language**

  Embedded C / C++ is used for firmware development due to its efficiency and compatibility with embedded systems.
- **Development Environment**

  Arduino IDE is used for coding, compiling, and uploading programs to the ESP32.
- **LoRa Communication Libraries**

  Standard LoRa libraries are used to simplify packet transmission, reception, and configuration of radio parameters such as frequency and spreading factor.

Uniqueness of the Proposed System

The proposed LoRa-based beacon transmitter and receiver system offers several innovative features compared to existing communication solutions.

Innovation and Novelty

- Operates independently of cellular networks and the internet, making it highly suitable for disaster scenarios.
- Uses low-power LoRa communication, enabling long operating times on battery power.
- Simple and cost-effective design that can be easily deployed and scaled.
- Provides immediate audio and visual alerts upon receiving emergency signals.
- Suitable for indoor and outdoor emergency monitoring.

Comparison with Existing Solutions

- The proposed beacon system operates independently of cellular and internet networks, unlike mobile phone communication.
- It provides reliable operation during natural disasters, whereas mobile networks often fail due to power and network outages.
- The system consumes low power, making it suitable for battery-operated emergency devices.
- LoRa offers long-range communication, even in challenging environments, compared to limited range in conventional systems.
- The proposed system performs well indoors, where GPS-based solutions often fail.
- The overall system is low-cost and simple to deploy, compared to GPS and network-based emergency systems.

Budget and timeline

- **Budget**

Required Components	Quantity	Cost Estimation
Atmega328p-PU Microcontroller	2	Rs.1700.00
IPEX to SMA Cable WIFI 3G 4G GSM Female Wire 30cm	2	Rs.460.00
Lora Ra-02 SX1278 Module	2	Rs.3000.00
LED	Approx 10 pcs	Rs.50.00
5V mini Buzzer	1	Rs.40.00
RF 433MHz Antenna	2	Rs.560.00
1602 16x2Yellow Backlight LCD Display	1	Rs.470.00
Total Cost		Rs.6280.00

- **Timeline**

Task	Week														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Literature review and requirement analysis															
Component selection and system planning															
Project Proposal Submission															
Simulation setup and testing															
Final simulation and design validation															
Hardware Development															
Software Development															
System testing and debugging															
Performance evaluation and optimization															
Final prototype completion and demonstration															