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Offline Emergency Communication System for Disaster Recovery

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Abstract: *Communication failure is one of the major problems during disasters and emergency situations, especially in black spot areas where mobile network signals are unavailable. Conventional communication systems depend completely on cellular networks, which may fail due to environmental conditions, damaged infrastructure, or remote locations. This paper presents the design and implementation of an Offline Emergency Communication System for Disaster Recovery using LoRa and GSM technologies. The proposed system establishes communication between black spot zones and network available areas using long-range wireless communication.*

The system consists of two embedded modules: a transmitter (master) module and a receiver (slave) module. The transmitter module contains an Arduino Uno controller interfaced with a 4×4 matrix keyboard, LCD display, and LoRa transmitter. The receiver module consists of Arduino Uno, LoRa receiver, and GSM modem. The entered message and mobile number are transmitted through LoRa communication and then forwarded as SMS through GSM networks.

The proposed system provides reliable long-distance communication with low power consumption and low operational cost. The developed prototype demonstrates efficient emergency communication in areas where cellular connectivity is unavailable.

Keywords: LoRa, GSM, Arduino Uno, Emergency Communication, Disaster Recovery, Embedded Systems, Wireless Communication

I. INTRODUCTION

Reliable communication is essential during emergency and disaster situations. In many remote locations and black spot areas, cellular network signals are weak or completely unavailable.

During natural disasters such as floods, earthquakes, landslides, and cyclones, communication infrastructure may become damaged, making it difficult for people to communicate with rescue teams and emergency services.

Conventional communication systems rely heavily on mobile towers and internet connectivity. When these systems fail, people in affected areas cannot send messages or request assistance. Hence, there is a need for an alternative communication system that can operate independently of traditional cellular infrastructure.

The proposed Offline Emergency Communication System is designed to overcome this problem using LoRa technology. LoRa provides long-range wireless communication with very low power consumption. The system uses LoRa modules to establish communication between black spot areas and nearby regions where GSM network coverage is available.

The transmitter unit is placed in the black spot area and allows users to enter a mobile number and predefined emergency message through a matrix keyboard. This information is transmitted wirelessly using LoRa technology. The receiver unit receives the transmitted data and sends the message as SMS using a GSM modem.

The system is highly useful in disaster recovery operations, rural communication, emergency rescue systems, and military applications where conventional communication infrastructure is unavailable.

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II. DESIGN AND METHODOLOGY

The proposed system is designed using an embedded system architecture based on Arduino Uno microcontrollers. The communication process is divided into two modules:

• Master (Transmitter) Module

• Slave (Receiver) Module

The master module contains a 4×4 matrix keyboard, LCD display, Arduino Uno, and LoRa transmitter module. The user enters the mobile number and predefined emergency code using the keyboard. The Arduino controller processes the information and transmits it through the LoRa module.

The slave module consists of another Arduino Uno controller interfaced with a LoRa receiver and GSM modem. The receiver captures the transmitted data and decodes the message. The GSM modem then sends the decoded information to the corresponding mobile number in the form of SMS.

The methodology follows these steps:

1. User enters mobile number and emergency code.
2. Arduino controller stores and processes the information.
3. LoRa transmitter sends data wirelessly.
4. LoRa receiver captures transmitted data.
5. Arduino controller decodes the message.
6. GSM modem sends SMS to destination number.

This modular architecture ensures reliable communication in areas without cellular connectivity.

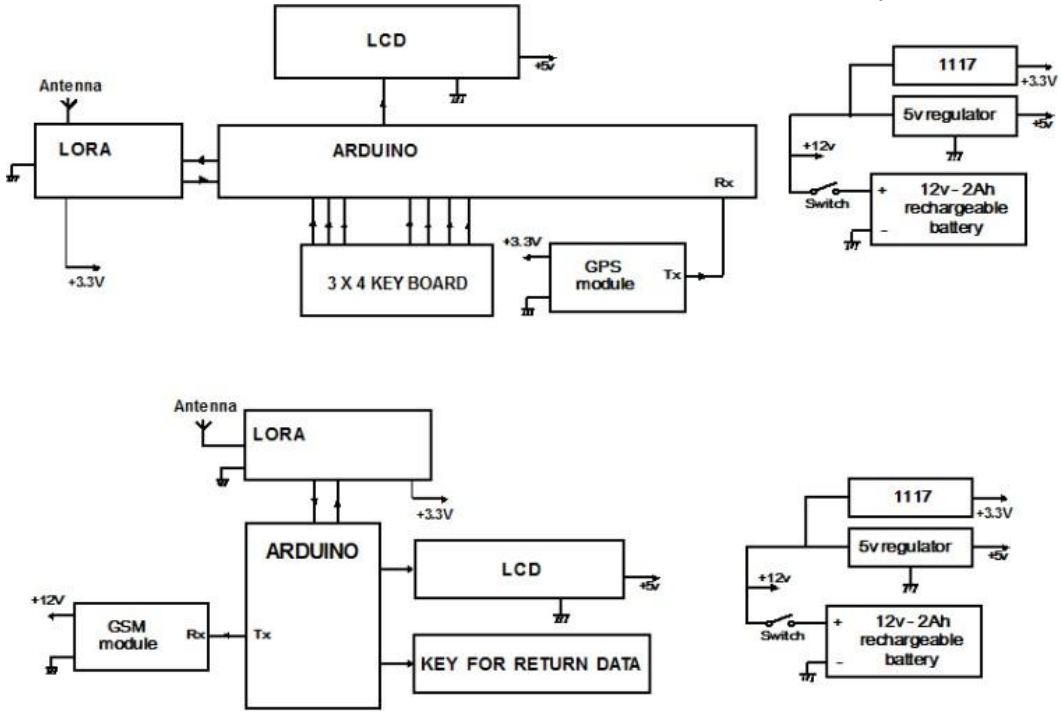

Fig .1. Block diagram

III. SYSTEM CONFIGURATION AND DESIGN

The proposed system consists of electronic and wireless communication modules integrated together for emergency communication.

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A. Master Module

The master module includes:

- Arduino Uno controller
- 4×4 matrix keyboard
- LCD display
- LoRa transmitter module

The keyboard is used to enter the mobile number and message code. The LCD display shows the entered data for confirmation. The Arduino controller processes the information and send s it to the LoRa transmitter.

B. Slave Module

The slave module includes:

- Arduino Uno controller
- LoRa receiver module
- GSM modem
- MAX232 serial communication interface

The LoRa receiver captures the transmitted data and forwards it to the controller. The controller checks the received message and sends it through the GSM modem as SMS.

C. LoRa Communication

LoRa (Long Range) communication technology is used because of its ability to transmit data over long distances with low power consumption. The SX1278 LoRa module operating at 433 MHz is used in the system.

Advantages of LoRa include:

- Long-distance communication
- Low power consumption
- High interference immunity
- Cost-effective wireless communication

D. GSM Communication

The GSM modem acts as an SMS gateway between the receiver module and mobile network. The modem uses AT commands for communication with the microcontroller.

Important AT Commands:

- AT – Check modem status
- AT+CMGF – Set SMS mode
- AT+CMGS – Send SMS
- AT+CMGR – Read message

E. Power Supply Unit

The system uses a regulated power supply consisting of:

- Step-down transformer
- Bridge rectifier
- Filter capacitor
- Voltage regulator IC 7805

The power supply provides stable DC voltage required for the Arduino, LoRa, and GSM modules.

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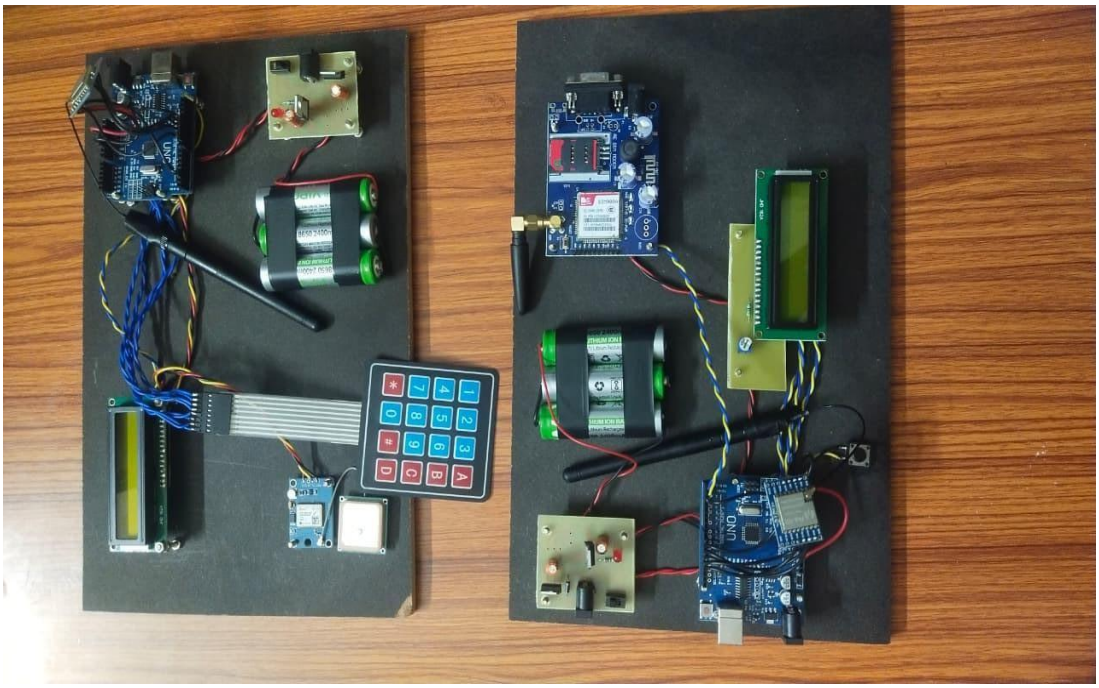

IV. WORKING PRINCIPLE

The transmitter module is placed in the black spot area where cellular signals are unavailable. The user enters the destination mobile number and predefined emergency message through the matrix keyboard.

The Arduino Uno controller converts the information into digital data and sends it through the LoRa transmitter. Since LoRa technology supports long-range communication, the transmitted data reaches the receiver module placed in a network available area.

The LoRa receiver receives the transmitted data and forwards it to the Arduino controller. The controller processes the received information and sends AT commands to the GSM modem.

The GSM modem transmits the emergency message as SMS to the corresponding mobile number.

This process enables communication from areas without network coverage.

V. RESULTS

The proposed prototype was successfully designed and tested under different operating conditions. The LoRa modules established stable wireless communication between the transmitter and receiver units.

The system successfully transmitted mobile numbers and emergency messages from the master module to the slave module. The GSM modem accurately sent SMS messages to the destination mobile numbers.

The developed system demonstrated the following performance:

- Reliable communication in black spot areas
- Long-range wireless transmission
- Low power consumption
- Accurate SMS delivery
- Fast response time

The LCD display provided proper user interaction and confirmation during message transmission. The system performed efficiently in indoor and outdoor conditions.

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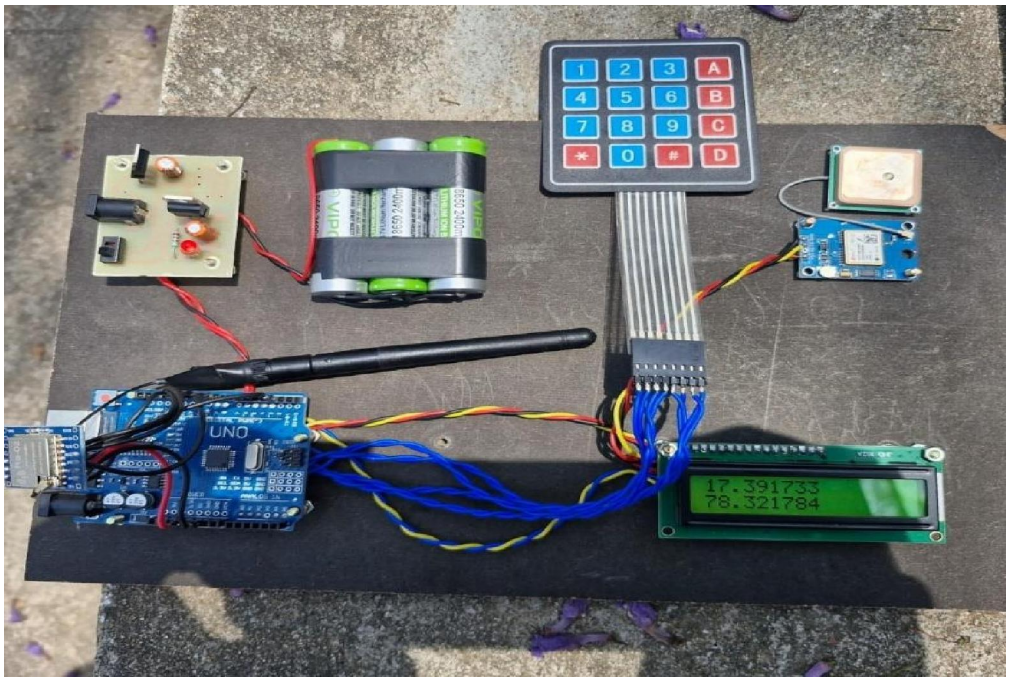
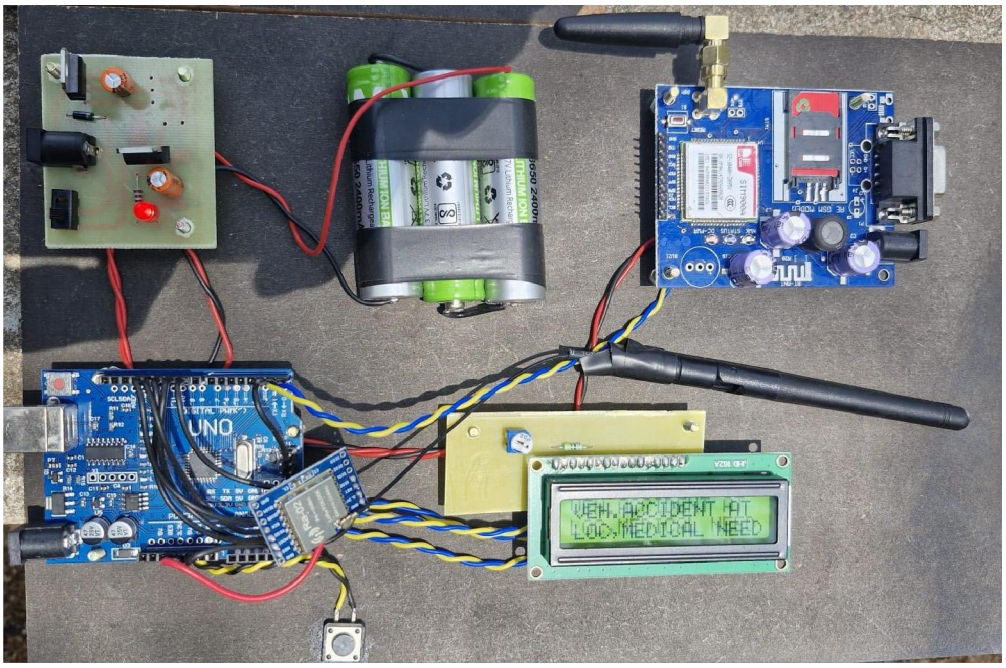
The prototype confirms that the proposed system can be effectively used in emergency communication applications during disasters and network failures.





VI. APPLICATIONS

The proposed Offline Emergency Communication System can be used in the following areas:

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- Disaster recovery operations
- Rural communication systems
- Military communication
- Forest and mining areas
- Emergency rescue operations
- Industrial safety systems
- Remote healthcare communication
- Black spot communication zones

VII. FUTURE SCOPE

Future improvements can be implemented to enhance system performance and functionality.

- GPS integration for location tracking
- IoT-based remote monitoring
- Mobile application support
- Solar-powered operation
- Voice message transmission
- Cloud-based emergency alert system
- AI-based emergency detection
- Multi-node LoRa communication network

The system can also be upgraded with advanced microcontrollers and secure communication protocols for real-time deployment.

VIII. CONCLUSION

The Offline Emergency Communication System for Disaster Recovery was successfully designed and implemented using LoRa and GSM technologies. The system effectively enables communication from black spot areas where conventional mobile networks are unavailable.

The integration of Arduino Uno, LoRa modules, GSM modem, matrix keyboard, and LCD display provides a reliable and low-cost communication solution. The developed prototype demonstrated stable long-range communication and successful SMS transmission.

The proposed system can play an important role during emergency situations, disaster recovery operations, and rural communication systems. With further enhancements, the system can be deployed in real-world applications for reliable emergency communication.

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