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Prototype-Based Flood Detection Device Ultrasonic Sensor HC-SR04 And Using Lora SX1278 Case Study Gelam Sidoarjo

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ABSTRACT

Keywords
Lora SX1278
HC-SR04
Flood detection

The prototype device is a flood detection tool based on an ultrasonic sensor HC-SR04 and using a LoRa SX1278 module. The device is designed for use in a flood case study in Gelam, Sidoarjo. The ultrasonic sensor measures the water level around the device, while the LoRa module transmits the water level data to a receiving device. With this device, it is expected that the surrounding community can monitor the water level in the area, thereby predicting the risk of floods and taking necessary preventive measures. The device can also help authorities make the right decisions in dealing with flood situations. However, it should be noted that this is a prototype device and still needs to be tested more widely to determine its accuracy in monitoring water levels and the reliability of the LoRa module in transmitting data.

1. Introduction

Advances in technology and science play an important role in improving the standard of living of the people. One of them is the development of electronic technology which is very closely related to human life [1]. Many convenient and flexible electronic devices have been born to help people meet their needs. The device is made and designed as much as possible so that it can be used properly and efficiently [2].

LoRa (Long Range) is a wireless communication technology that uses spread spectrum modulation, specifically chirp spread spectrum (CSS) modulation [3]. It is designed for long-range communication and is particularly useful for applications in the Internet of Things (IoT) space. LoRa operates in the unlicensed radio spectrum, which allows for low-cost deployment and flexibility in usage. It uses a unique modulation scheme that allows for long-range communication while maintaining low power consumption [4]. This makes it well-suited for IoT applications where devices are often battery-powered and may be located in remote or hard-to-reach areas [5]. LoRa networks can be set up in a variety of topologies, including point-to-point, star, and mesh. The technology supports bi-directional communication, allowing devices to both transmit and receive data. This makes it ideal for applications such as remote monitoring, asset tracking, and smart agriculture, among others [6]. Overall, LoRa technology offers a powerful and flexible solution for IoT communication, particularly in scenarios where long-range and low power consumption are critical factors [7].

LoRa is used for machine-to-machine (M2M) communication. With LoRa, sensors can communicate directly with machines or humans from anywhere at any time [8]. One of the key features of LoRa is its geolocation capability, which enables devices to determine their location using low power consumption. The power consumption required for LoRa is typically around 13mA to 15mA, which allows batteries to last up to 10 to 20 years [9]. In addition, one LoRa unit

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can transmit signals up to 100km. Security is also an important consideration in IoT applications, and LoRa has end-to-end encryption with AES128, which ensures secure communication between devices. LoRa is widely used in various applications such as smart cities, agriculture, healthcare, and industrial automation [10]. Its long-range capability, low power consumption, and secure communication make it a popular choice for IoT applications where reliability and security are critical [11].

Flood detection devices can be very useful in helping communities respond to and prepare for floods [12]. However, traditional flood detection devices can be costly to manufacture, require extensive testing, and may require specialized skills to operate. As a result, not everyone can afford to purchase them or know how to use them effectively [13]. there is a growing need for simple and affordable flood detection devices that can be easily operated by individuals and work effectively. One approach is to develop low-cost, easy-to-use sensors that can be placed in flood-prone areas to monitor water levels and detect potential floods. These sensors can then transmit data to a central server or mobile app to alert people in real time about the potential threat of flooding [14].

Another approach is to utilize existing technologies such as IoT devices or smartphones to create flood detection systems. For example, smartphone apps can be used to crowdsource data from users in flood-prone areas to create real-time flood maps, which can then be used to warn people in the affected areas [15]. Similarly, IoT devices such as water level sensors or weather sensors can be used to monitor flood-prone areas and send alerts when flooding is detected [16].

Therefore, in this study, we designed a prototype flood detection device based on the HC-SR04 ultrasonic sensor and LoRa SX1278, with a Lithium-Ion battery as the power source. The device is designed to automatically detect floods and display water level conditions on an LCD screen, as well as emit a buzzer sound [17]. The ultrasonic sensor is used to determine the water level, while the LoRa SX1278 is used to transmit water level data from the device's transmitter to its receiver [18]. The device also includes three LED lights to indicate water conditions, an Arduino Uno microcontroller as the main controller, and the power supply for the transmitter on the riverbank are provided by a battery. The water level data is displayed in centimeters on the LCD screen. The device is designed for use in Gelam Sidoarjo village [19].

2. The Proposed Method

In the design of this tool, there are three parts, The first part of the system design process involves wiring design, which outlines the components that will be used in the system and the connections between them [20]. The second part involves creating a flowchart, which illustrates the system's workflow and how the various components interact with each other. The third part is designing a block diagram, which shows the input, processing, and output components of the system and how they relate to each other. Together, these three parts provide a comprehensive understanding of the system's design and operation [21].

2.1. Wiring Design

The overall system block diagram of the Flood Detector Prototype based on the Ultrasonic HC-SR04 Sensor and LoRa SX1278 consists of several components:

- Ultrasonic Sensor HC-SR04: This component is used to detect the water level in the river.
- Arduino Uno: This is the main controller of the system that receives the data from the ultrasonic sensor and sends it to the LoRa module.
- LoRa SX1278: This module is used for long-range communication between the transmitter and receiver. It receives the data from the Arduino Uno and sends it wirelessly to the LoRa SX1278 on the receiver side.
- Battery: This component provides the power supply for the system.

- LCD: This component displays the water level in centimeters received from the Arduino Uno.
- Buzzer: This component produces a sound alarm when the water level reaches a critical level.
- LED: There are three LED components, green, yellow, and red. Each LED represents a different level of water height.

By combining these components, the Flood Detector Prototype can automatically detect the water level in the river and send the data wirelessly to the receiver module. The data can be displayed on the LCD screen and the alarm can be sounded if the water level reaches a critical level.

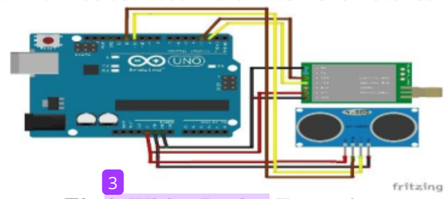

Fig 1. Wiring Design Transmitter

Table 1. Arduino UNO Port Usage

NO	Arduino UNO port	Usage
1	2	TXD Lora SX1278
2	3	RXD Lora SX1278
3	11	Echo Ultrasonic
4	12	Trig Ultrasonic
5	5V	VCC Ultrasonic/Lora SX1278
6	GND	GND Ultrasonic, Lora SX1278, M0, M1

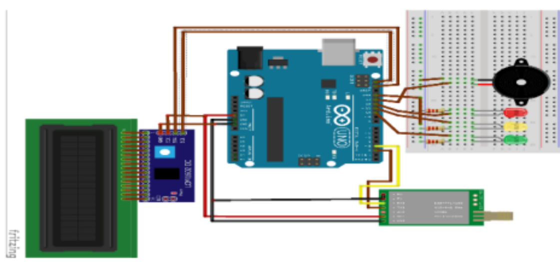

Fig 2. Wiring Design Receiver

Table 2. Arduino UNO Port Usage

NO	Arduino UNO port	Usage
1	10	LED Green (+)
2	11	LED Yellow (+)
3	12	LED Red (+)
4	13	Buzzer (+)
5	SDA	SDA LCD
6	SCL	SCL LCD
7	5V	VCC LCD/Ultrasonic
8	GND	GND Ultrasonic, LCD, Buzzer, LED Red, LED Yellow, LED Green

Table 1 and 2 likely shows the specific pin connections between the Arduino UNO and the various components in the system, including the ultrasonic sensor, Lora SX1278, LCD, and LED. The table likely shows which Arduino UNO pins are connected to the input/output pins of each component, as well as the type of connection. The correct pin connections must be made so the system can function properly.

2.2. System Flowchart

Flowchart for the transmitter circuit of the flood detection device. The flowchart begins by initializing the LoRa module and checking its connection status. Then, the Ultrasonic sensor is initialized and checked for connection as well. The transmitter circuit waits for a trigger signal from the Ultrasonic sensor, which prompts it to measure the water level using the sensor. The water level data is then sent to the LoRa module for transmission to the receiver circuit. The transmitter circuit checks for successful transmission and then repeats the process from the beginning. Overall, the flowchart outlines the steps needed to establish and maintain a stable LoRa connection between the transmitter and receiver circuits, and to continuously monitor and transmit water level data using the Ultrasonic sensor and LoRa module.

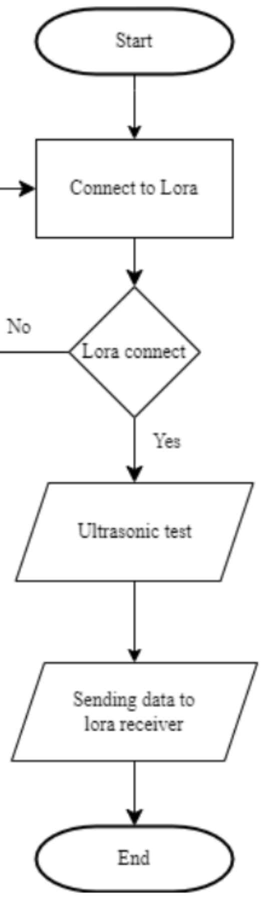

Fig 3. Flowchart Program (1)

The 2nd flowchart is a flowchart for the receiver circuit of the flood detection device.

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Start --> Initialize LoRa module --> Check LoRa connection --> Wait for incoming data --> Receive data from LoRa module --> Check for successful reception --> Display data on LCD --> Check water level --> If water level > 10m, display "10m" on LCD, turn on Green LED, turn off Yellow and Red LEDs --> If water level > 5m and ≤ 10m, display ">5m - ≤10m" on LCD, turn on Yellow LED, turn off Green and Red LEDs --> If water level ≤ 5m, display "≤5m" on LCD, turn on Red LED, turn on Buzzer, turn off Green and Yellow LEDs --> Repeat. The flowchart begins by initializing the LoRa module and checking its connection status. The receiver circuit then waits for incoming data from the transmitter circuit. Once data is received, the receiver checks for successful reception and displays the water level data on the LCD. Depending on the water level, the appropriate LED(s) are turned on or off, and the corresponding message is displayed on the LCD. If the water level is below 5m, the Buzzer is turned on in addition to the Red LED. The receiver circuit then repeats the process from the beginning. Overall, the flowchart outlines the steps needed to receive and process data from the transmitter circuit, and to display the water level data on the LCD while indicating the level of flooding with the LEDs and Buzzer.

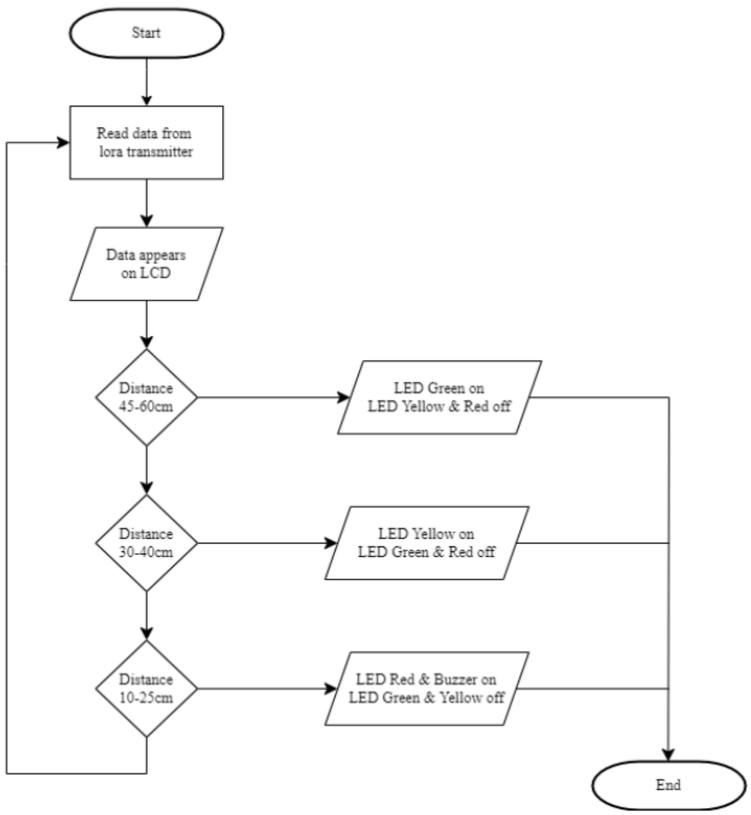

Fig 4. Flowchart Program (2)

2.3. Block Diagram System

To facilitate the design and manufacture of the tool, a block diagram of the system as a whole is made. The following is a block diagram of the control system for type Based Flood Detection Device Ultrasonic Sensor HC-SR04 And Using Lora SX1278 Case Study Gelam Sidoarjo

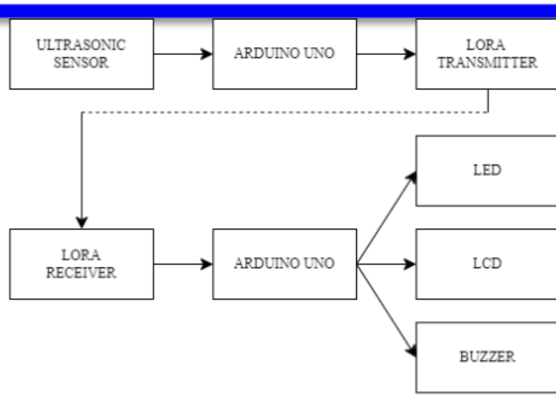

Fig 5. Block Diagram System

3. Result and Discussion

The results and discussion section consists of various tests conducted on the device. The purpose of these tests is to verify that the device is by the intended design. The test results are used to gather data for analysis. In this device, an ultrasonic sensor is used to detect the water level. The sensor readings are displayed on a 16x2 LCD screen, which can be found on the data receiver or the LoRa receiver. The data displayed on the LCD includes the water level and its corresponding condition. The receiver is equipped with four types of indicators: a buzzer, a green LED, a yellow LED, and a red LED. On the transmitting device, there is only a buzzer indicator.

The testing process provides valuable data that will be analyzed to evaluate the performance of the device. By analyzing the data, any issues or findings during testing can be identified and addressed accordingly. The results and discussion section allows for a thorough examination of the device's accuracy and reliability in detecting water levels. It serves to ensure that users receive accurate and timely information, enabling them to take necessary actions during flood situations. Through careful testing, analysis, and discussion, it is expected that the flood detection device meets the desired design specifications and effectively detects water levels.

Fig 6. Result Of Tool Realization

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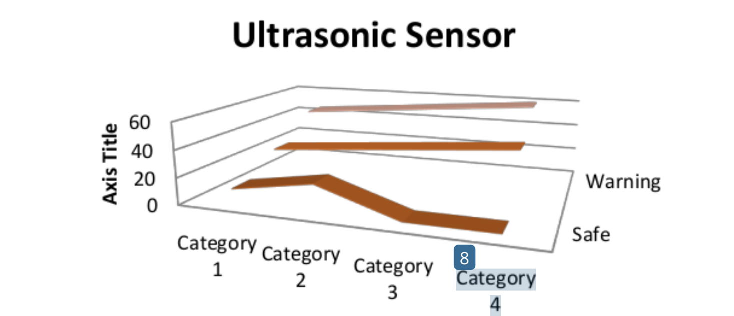
3.1. Ultrasonic Sensor Testing

Ultrasonic sensor testing was conducted up to a height of 60 cm. There are three conditions at the time of testing, namely safe, alert, and warning. The test results of the communication between tools are shown in Table 1.

Table 3. Ultrasonic Sensor Testing

Testing to-	Ultrasonic Sensor		Receiver Indicator
	Water Level	Condition	
1stTest	10cm	Safe	Led green on
2ndTest	20cm	Safe	Led green on
3rdTest	25cm	Alert	Led yellow and buzzer on
4thTest	30cm	Alert	Led yellow and buzzer on
5thTest	35cm	Alert	Led yellow and buzzer on
6thTest	40cm	Alert	Led yellow and buzzer on
7thTest	45cm	Warning	Led red and buzzer on
8thTest	50cm	Warning	Led red and buzzer on
9thTest	55cm	Warning	Led red and buzzer on
10thTest	60cm	Warning	Led red and buzzer on



	Category 1	Category 2	Category 3	Category 4
Safe	10	20		
Alert	25	30	35	40
Warning	45	50	55	60

Fig 7. Graph Testing Ultrasonic Sensor

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Fig 8. Displays a safe condition because the water level is < 25 cm

Fig 9. Displays an alert condition because the water level is 25cm

Fig 10. Displays a warning condition because the water level is > 45cm

4. Conclusion

Based on the test results the sending device and the receiving device work well according to the expected system design. The receiver and sender cannot can communicate at a distance of 200 m and beyond. Observation in real time on the experiment obtained the send time between 1-2 seconds.

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