WATER QUALITY MONITORING SYSTEM USING LORAWAN

ECD334 Mini Project: Report Submitted by

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Towards the partial fulfillment of the requirement for the award of B. Tech. degree in

Electronics and Communication Engineering

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GOVERNMENT COLLEGE OF ENGINEERING KANNUR

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CERTIFICATE

Certified that this is a bonafide report of the project work done by **ASRAY P (Reg. No. KNR20EC024)**, **ATHUL K (Reg. No. KNR20EC029)** , **SAMRUDH KISHSAN P. M. (Reg. No. KNR20EC073)** and **HEMANTH V. K. (Reg. No. LKNR20EC104)** on the topic **WATER QUALITY MONITORING SYSTEM USING LoRaWAN**, towards the partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Electronics and Communication Engineering under APJ Abdul Kalam Technological University during the academic year 2022-2023.

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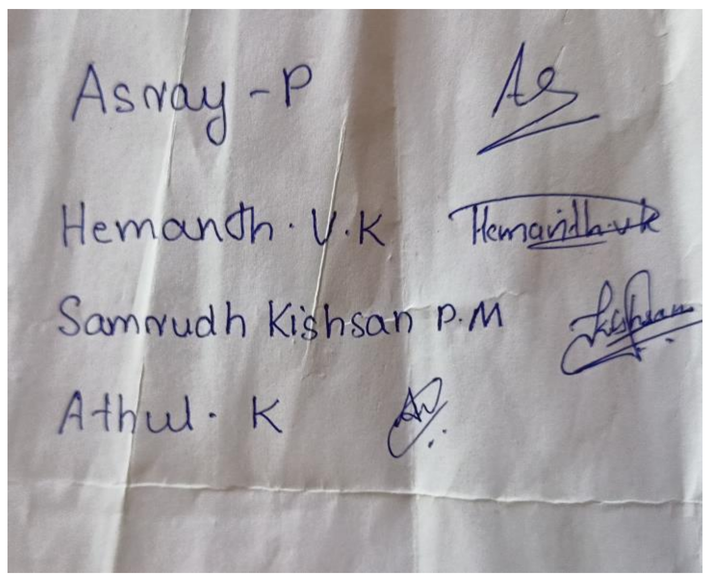
DECLARATION

We, the undersigned, hereby solemnly declare that this project report titled **WATER QUALITY MONITORING SYSTEM USING LoRaWAN**, submitted for the partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Electronics and Communication Engineering from APJ Abdul Kalam Technological University is a bonafide record of our own work carried out under the supervision of **Prof. Laseena C. A.**.

Wherever we have used materials (data, theoretical analysis, and text) from other sources, we have adequately and accurately cited the original sources.

We also declare that this work has not been submitted to any other institution in this University or any other University.



ACKNOWLEDGMENTS

It is with enthusiasm and learning spirit that we bring out this project report. We also feel that it is the right opportunity to acknowledge the support and guidance that came in from various quarters during the course of the completion of our project.

We are extremely grateful to the Principal Dr. P. Jayaprakash, Govt. College of Engineering, Kannur, for providing the necessary facilities. We would like to express our sincere gratitude to Dr. A. Ranjith Ram, Head of Department of Electronics and Communication Engineering and Dr. Sajesh Kumar U, Class Advisor ECE A 2020 batch, for giving us all the support and confidence to work with project. We express our sincere gratitude to our project guide Prof. Laseena C.A. for their great support given for doing this project.

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ABSTRACT

The water quality monitoring system using LoRaWAN consists of sensor nodes that are deployed in a water body to measure various water quality parameters such as temperature, pH level, dissolved oxygen, and turbidity. The sensor is connected to end node device (Arduino UNO with Lora Sheild) transmit the data wirelessly to a gateway device, which forwards the data to a cloud-based server(The Things Network) for storage and analysis. The LoRaWAN technology allows for long-range and low-power transmission of data,making it suitable for monitoring remote and hard-to-reach areas. The system can provide real-time monitoring of water quality, allowing for early detection of potential hazards and prompt actions to be taken. The proposed system can be used in a variety of applications, including drinking water quality monitoring, aquatic ecosystems monitoring, and industrial waste water monitoring.

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CHAPTER 1

INTRODUCTION

Water quality monitoring is essential for maintaining the health of aquatic organisms and to ensure safe drinking water for human consumption. Water quality monitoring using LoRaWAN has a wide range of application as LoRaWAN is a low power long-range data transmission network, so it can be used to monitor water bodies such as rivers located in remote areas to measure the parameters and to check if water is polluted or not. It can be also used in aquaculture farms to analyze the pH, temperature etc. to maintain to maintain optimum health and quality of the fish. This is cost effective and allows long term monitoring of the data in remote areas with low power consumption.

The sensors such as the pH, Temperature, Turbidity, TDS are connected to the end node device which is to be placed in a water source. The sensors collect data such as pH, temperature, turbidity, total dissolved solids which is modulated by the end node and transferred to a gateway. Gateway demodulates the information and delivers it to a cloud server with the use of ethernet/3G/4G. The information collected will be processed and displayed in the cloud. LoRaWAN has a range of 5km up to 15km, long battery life and data rate ranging from 0.3kbps to 50kbps. The system is designed to be low power and cost-effective, allowing for long term monitoring and real collection of data in remote and far to reach areas for effective decision making for the researchers and the authorities concerned.

1.1 Objectives

- To build a low power water quality monitoring system to monitor in remote areas
- To obtain quantitative information on the physical, chemical and biological characteristics of water.
- To provide a real time monitoring of water bodies .

1.2 Motivation

This project is to analyze the quality of water in water sources like rivers which is located in remote areas, for aquaculture farms to setup a condition for proper growth of fishes and other aquatic lives. To check the quality of drinking water is satisfied with standard range.

1.3 Literature Survey

Nikhil Kedia entitled “Water Quality Monitoring for Rural Areas-A Sensor Cloud Based Economical Project.” Published in 2015 1st International Conference on Next Generation Computing Technologies (NGCT-2015) Dehradun, India. This paper highlights the entire water quality monitoring methods, sensors, embedded design, and information dissipation procedure, role of government, network operator and villagers in ensuring proper information dissipation. It also explores the Sensor Cloud domain. While automatically improving the water quality is not feasible at this point, efficient use of technology and economic practices can help improve water quality and awareness among people.[1]

Jayti Bhatt,Jignesh Patoliya entitled “Real Time Water Quality Monitoring System”.This paper describes to ensure the safe supply of drinking water the quality should be monitored in real time for that purpose new approach IOT (Internet of Things) based water quality monitoring has been proposed. In this paper, we present the design of IOT based water quality monitoring system that monitor the quality of water in real time. This system consists some sensors which measure the water quality parameter such as pH, turbidity, conductivity, dissolved oxygen, temperature. The measured values from the sensors are processed by microcontroller and this processed values are transmitted remotely to the core controller that is raspberry pi using Zigbee protocol. Finally, sensors data can view on internet browser application using cloud computing.[2]

Vaishnavi V Daigavane, Dr. M A Gaikwad entitled "Water Quality Monitoring System Based on IOT". This paper highlights the entire water quality monitoring methods using sensors such as pH sensor, Turbidity sensor, Temperature sensor, Flow sensor. This project lays an idea of real time monitoring of water quality paramerters using IoT that the manual method of collecting samples and testing. This project makes use of the wifi module and arduino uno which is employed with the four sensors such as pH, temperature, turbidity and flow sensor. The data is collected and value is monitored in real time to check if there is pollution or not. The sensor value can be seen using BLYNK app.[3]

Sokratis Kartakis, Weiren Yu, Reza Akhavan, and Julie A. McCann entitled "Adaptive Edge Analytics for Distributed Networked Control of Water Systems" This paper presents the burst detection and localization scheme that combines lightweight compression and anomaly detection with graph topology analytics for water distribution networks. We show that our approach not only significantly reduces the amount of communications between sensor devices and the back end servers, but also can effectively localize water burst events by using the difference in the arrival times of the vibration variations detected at sensor locations. Our results can save up to 90 percent communications compared with traditional periodical reporting situations.[4]

V. Savel, P. Rakluea, T. Jangjing, B. Kumkhet and C. Mahatthanajatuphat entitled "IoT Based Water Quality Monitoring System Using Solar Powered and LoRaWAN" This paper presents the water quality monitoring of remote water bodies such as lakes, rivers using the LoRaWAN technology. The system work with solar power and is very energy efficient.This project makes use of sensors such as pH sensor, turbidity sensor, temperature sensor and EC sensor (Electrical Conductivity).Other devices such as arduino nano, lithium battery, solar cells,CAT starter kit S767S. The data collected by the sensors are stored and processed in Cayenne cloud. [5]

CHAPTER 2

PROPOSED SYSTEM

This chapter goes through the explanation about the working of the system, different hardware used for the project, software used and the design process that has taken for the completion of the project.

2.1 Block Diagram

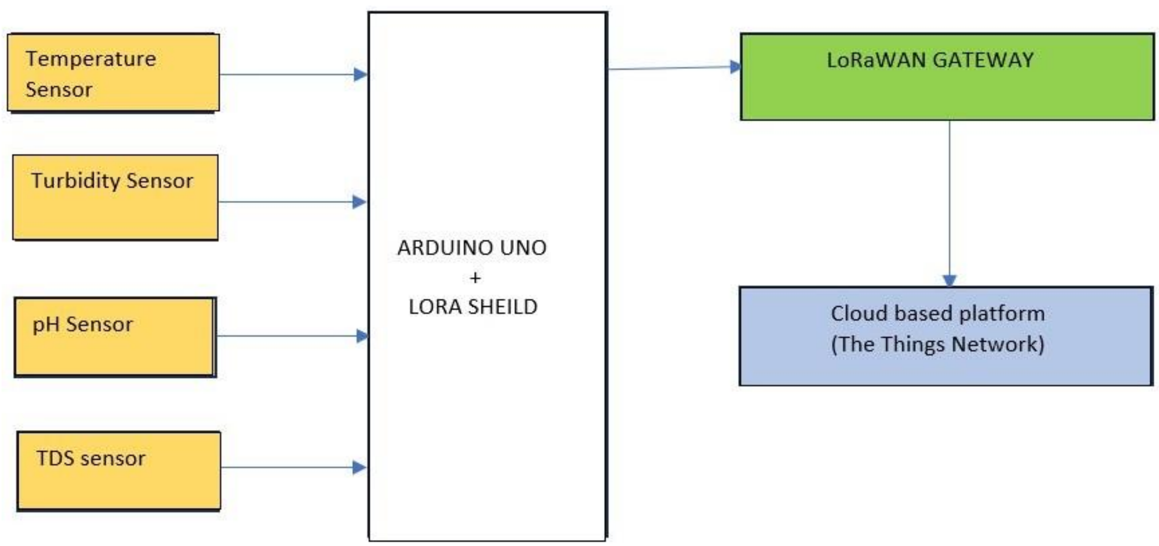


Fig. 2.1. Block Diagram of Water Quality Monitoring System

The sensors such as the pH sensor, Turbidity sensor, TDS sensor and temperature sensor collects data from a given water source which may be river or other sources. The sensors that are connected with the Arduino UNO and the Lora shield gives the measured value, i.e Arduino UNO reads the sensor values using analog or digital interface and converts it into a suitable format for transmission such as voltage level or digital value. The Arduino UNO equipped with LoRaWAN protocol stack and Lora shield formats the sensor data into a LoRaWAN- compactible message. These messages include the information such as sensor identifier, data collected and any additional metadata. The Arduino UNO, acting as a LoRaWAN device, sends the formatted message to the nearest LoRaWAN gateway within the range. The gateway receives the transmission from Arduino and forward it to a LoRaWAN network server with the help of ethernet or cellular connectivity.

2.2 Circuit Diagram

This section we look at the circuit diagram of the Water Quality Monitoring System.

Here the VCC pin of all the sensors is shorted and connected to the +5 pin of the lora

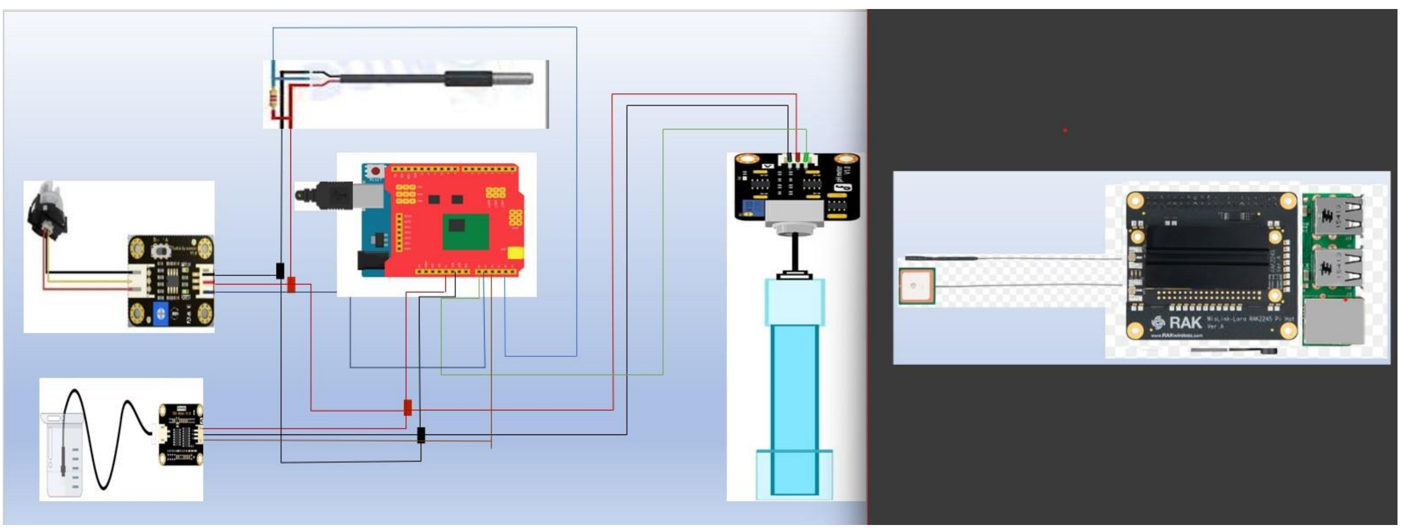


Fig. 2.2. Circuit Diagram of Water Quality Monitoring System

sheild mounted on Arduino UNO. The same procedure is done for the ground pin.In DS18B20 sensor, data line and VCC pins are connected with a 4.7k ohm resistor as pull-up.The data pin of pH sensor is connected to A0 pin, turbidity sensor data pin is connected to A1, TDS pin to A2 and DS18B20 pin to the A3 pin of the Lora sheild. The lora sheild is powered with a +5v power bank.

2.3 LoRa, LoRaWAN Communication Protocol and System Architecture

This section covers LoRa and LoRaWAN properties.

2.3.1 LoRa and LoRaWAN Overview

LoRaWAN is a wireless networking standard established by LoRa Alliance to address several long-range communication issues inn IoT deployments. LoRa uses CSS modulation (Chirp Spread Spectrum) to keep the low-power kind of strategy while extending the communication range. LoRa is a low-power, long-range radio frequency technology that can be used in many fields such as industrial, technical etc. The main aim of this design is to improve the battery life along with decreasing the cost. SimTech implemented CSS modulation at the LoRa modulation layer. The LoRa Alliance established the LoRaWAN communication protocol specification at the protocol layer.

2.3.2 LoRa Basis

The frequency range, distribution factor, spectrum and source code rate of the LoRa Radio can be customized. Different energy values and transmitting ranges can be obtained by combining the parameters such as frequency, encoding rate, spread factor and carrier frequency. These parameters are used to calculate minimum byte rate. The value of the binary digits is given by the following equation

$$R_{bit} = SF.\frac{BW}{2^{SF}}.CR$$

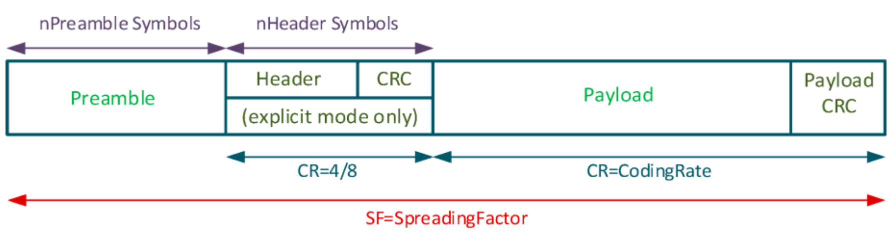
2.3.3 Lora Packet Structure

A LoRa packet structure typically consists of the following components:

- Preamble: A series of alternating 0s and 1s at the beginning of the packet to aid receiver synchronization and signal detection.

- Sync Word: A predefined pattern used to further aid in synchronization and distinguishing LoRa packets from other signals.
- Header: Contains important information about the packet, such as the length of the packet, addressing, and message type.
- Payload: The actual data to be transmitted. This could be sensor readings, commands, or any other information being exchanged between devices.
- CRC (Cyclic Redundancy Check): A checksum or error-checking code that helps the receiver detect and correct errors in the received packet.
- Explicit Header (optional): In some LoRa modes, an explicit header mode is used where additional information is included in the header, such as coding rate and bandwidth settings.
- Implicit Header (optional): Alternatively, implicit header mode uses a fixed packet length and doesn't include extra header information, which can save bandwidth.

The LoRa packet structure may vary depending on the LoRa mode, regional parameters, and application requirements. LoRa technology provides flexibility in configuring various parameters like spreading factor, bandwidth, coding rate, and power level, which enables optimization for different use cases and trade-offs between range, data rate, and power consumption.



2.3.4 LoRaWAN Network Architecture

All the sensors are connected into the LoRaWAN node and the node is placed in a water source, the gateway will be placed in another point and the data is transmitted from the node to the gateway and this data can be assessed from the cloud-based platform. Construction and design of an efficient and effective LoRaWAN based water quality monitoring system achieves objectives as shown in the figure 2.2.1. For the network to function correctly at various phases, it must be precisely planned.

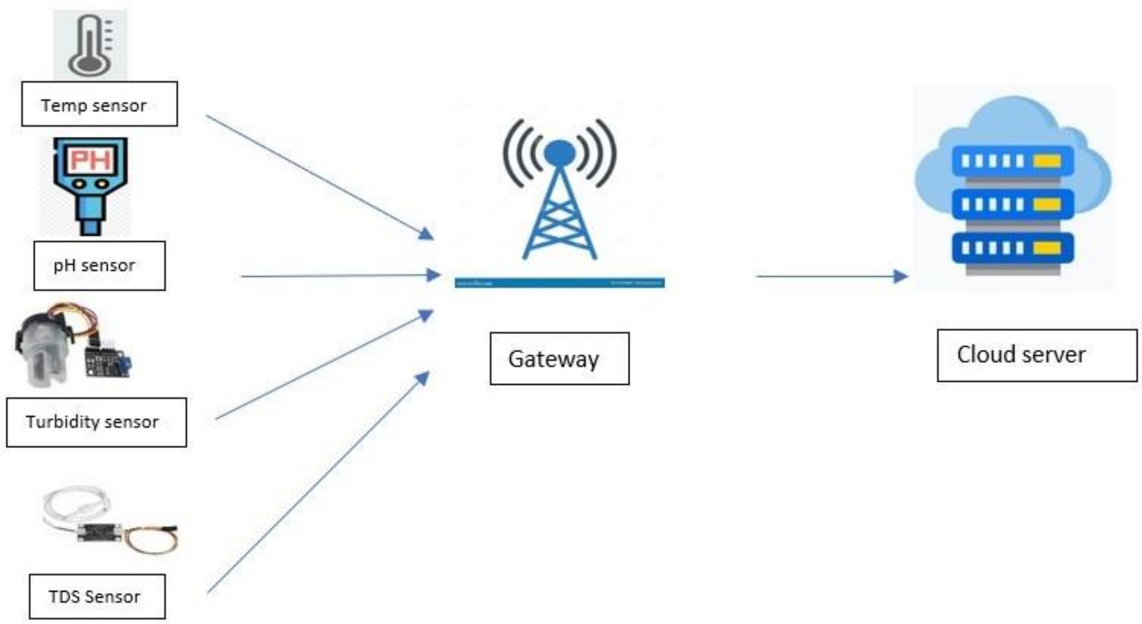


Fig. 2.3. LoRaWAN Network Architecture

2.4 Hardware Requirements

This section deals with the list of hardware that is used to implement this project.

2.4.1 Raspberry Pi 3

The Raspberry Pi 3 is a compact single-board computer that packs a punch with its impressive features. It boasts a 1.2GHz quad-core ARM Cortex-A53 processor and 1GB RAM, delivering powerful performance for a range of tasks. With built-in Wi-Fi and Bluetooth connectivity, it effortlessly connects to networks and peripherals. The device offers a variety of ports, including USB, HDMI, and Ethernet, enabling easy integration with external devices. The Raspberry Pi 3 is favored for its affordability, versatility, and compatibility with various operating systems.

The Raspberry pi can be utilized as a LoRaWAN gateway by adding a LoRaWAN gateway hat, connecting an appropriate antenna, configuring software, registering the gateway with a LoRaWAN network provider, and testing the setup. With its compatibility and connectivity options, the raspberry pi, along with the LoRaWAN gateway software, allows for long-range, low-power communication between IoT devices.

Fig. 2.4. Raspberry Pi 3

2.4.2 Arduino UNO

The Arduino Uno is a popular microcontroller board known for its simplicity and versatility. It features an ATmega328P microcontroller, digital and analog input/output pins, and a USB connection for programming and power supply. With a wide range of compatible sensors and modules, the Arduino Uno is ideal for prototyping and DIY electronics projects. Its user-friendly interface and extensive community support make it an accessible choice for beginners and experienced enthusiasts alike.

Fig. 2.5. Arduino UNO

2.4.3 Dragino Lora Shield RFM95W

The Dragino LoRa Shield RFM95W is an Arduino-compatible shield that enables long-range wireless communication using LoRa technology. It operates at the 915MHz frequency band and is equipped with the RFM95W module. The shield provides an easy way to integrate LoRa capabilities into Arduino Uno projects, allowing for low-power, long-range communication over distances of several kilometers. It is compatible with various sensors and can be used for IoT applications, remote monitoring, and other projects requiring reliable wireless communication.

2.4.3.1 Wireless Specification of RFM95W

- 168dB maximum link budget.

- Programmable bit rate upto 300Kbps.
- Low RX current of 10.3mA ,200nA register retention.
- 127dB dynamic RSSI ranging.
- Preamble detection.
- Built-in bit synchronizer for clock recovery.

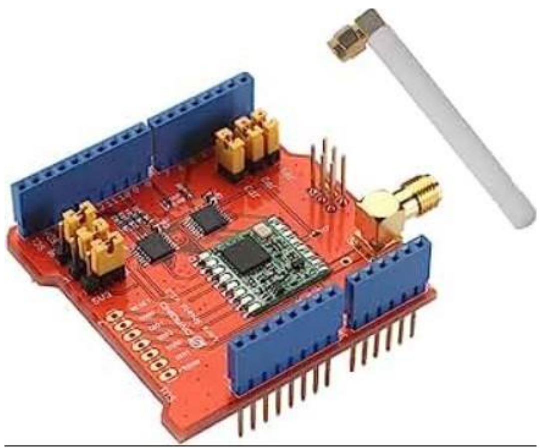


Fig. 2.6. Dragino Lora Shield RFM95W

2.4.4 RAK2245

The RAK2245 is a LoRaWAN gateway module that enables long-range and low-power communication for Internet of Things (IoT) applications. It is based on Semtech's SX1301 chip and supports the LoRaWAN protocol, allowing for secure and reliable data transmission over large distances. The RAK2245 features a compact form factor, making it easy to integrate into various IoT devices and gateways. It operates in the 868MHz or 915MHz frequency band, providing excellent coverage and penetration capabilities.

2.4.4.1 Key features of RAK2245

- LoRa Module: RAK2245(1 x Semtech SX1301 transceiver concentrator and 2 X Semtech SX125X highly integrated RF front end I/Q tranaceivers)

- GPS Module: Ublox MAX-7Q
- Heat sink: Metal material
- Frequency: EU433, CN470, EU886, US915, AS923, AU915, KR920, IN865, S920
- TX Power: 27dB max
- Range: Urban- 2 to 4 km, Suburb- 5 to 10 km, Open Area- 15 km

Fig. 2.7. RAK2245

2.4.5 Sensors

2.4.5.1 Temperature Sensor

The DS18B20 temperature sensor is a popular digital sensor compatible with Arduino. It uses the one-wire protocol, allowing multiple sensors to be connected using a single digital pin. With its compact size and low power consumption, the DS18B20 provides accurate temperature readings with a resolution of up to 12 bits. It has a wide temperature range and high measurement accuracy, making it suitable for various applications such as weather monitoring, home automation, and industrial control.

2.4.5.2 Turbidity Sensor

The turbidity sensor is a device used to measure the cloudiness or turbidity of a liquid. It employs an optical method to determine the suspended particle concentra-

Fig. 2.8. DS18B20 temperature sensor

tion in water or other liquids. By measuring the amount of light scattered or absorbed by particles, it provides an indication of water quality. The sensor is compatible with the Arduino Uno and can be easily integrated into projects for applications such as water monitoring, environmental analysis, and industrial processes. It enables real-time monitoring of turbidity levels, facilitating effective control and analysis of water quality parameters.

Fig. 2.9. Turbidity Sensor

2.4.5.3 pH Sensor

The pH sensor is a device designed to measure the acidity or alkalinity of a solution. It utilizes a pH-sensitive electrode to detect hydrogen ion activity in the liquid being tested. The sensor interfaces with the Arduino Uno and provides accurate pH readings for various applications, including hydroponics, aquaponics, water quality monitoring, and chemical analysis. By integrating the pH sensor with Arduino, users can obtain real-time pH measurements and implement pH control systems for precise monitoring and adjustment of pH levels in their projects.

Fig. 2.10. pH Sensor

2.4.5.4 TDS Sensor

The TDS (Total Dissolved Solids) sensor is a device that measures the concentration of dissolved solids in water. It works by analyzing the electrical conductivity of the water, which is directly related to the presence of dissolved ions. The sensor provides a digital output that can be easily read and processed by the Arduino Uno. It is commonly used in applications such as water quality monitoring, hydroponics, and aquaculture to assess the purity and salinity of water .

2.5 Software Environment

This section deals with all the software that we use to implement this project.

Fig. 2.11. TDS Sensor

2.5.1 Arduino IDE

The Arduino IDE (Integrated Development Environment) is a software platform that simplifies the process of programming and developing applications for Arduino boards. It provides an intuitive and user-friendly interface where users can write, compile, and upload code to their Arduino microcontrollers. With a simplified programming language based on C/C++, the Arduino IDE is accessible to beginners while still offering flexibility for advanced users. It comes with a vast library of functions and examples that can be easily utilized, allowing users to quickly prototype and implement projects. The IDE supports various Arduino boards and shields, ensuring compatibility across a wide range of hardware. Additionally, it includes a serial monitor for debugging purposes, allowing users to view and analyze the communication between their Arduino and computer. The built-in editor offers features such as syntax highlighting and auto-completion to enhance the coding experience. The Arduino IDE also provides tools for managing libraries and board settings, simplifying the installation and configuration of additional functionality.

2.5.2 The Things Network

The Things Network (TTN) is a global, open, and decentralized LoRaWAN (Long Range Wide Area Network) infrastructure that enables secure and scalable communication for Internet of Things (IoT) devices. It provides a community-driven platform for building and deploying LoRaWAN networks, allowing individuals and organizations to connect their devices and exchange data wirelessly. TTN offers various features such as device registration, data handling, and secure communication through end-to-end encryption. It also provides integration with popular IoT platforms and services, enabling seamless data management and application development. With its global coverage and collaborative ecosystem, The Things Network empowers users to create innovative IoT solutions and leverage the power of LoRaWAN technology.

2.6 Design Process

After selecting the required components, the major challenge is to check the sensors i.e., calibrating each sensors and connecting the sensors to the hardware without any fail.

2.6.1 Define System Objectives and Requirements

Determine the purpose of the water quality monitoring system, such as environmental monitoring or water resource management. Identify the specific parameters to be monitored, including temperature, turbidity, TDS (Total Dissolved Solids), and pH. Define the required measurement range, accuracy, and resolution for each parameter. Consider the sampling frequency and data transmission interval based on the monitoring goals.

2.6.2 Sensor Selection

Research and select suitable sensors for each parameter. Ensure they are compatible with LoRaWAN communication. Choose sensors that provide accurate measurements within the desired range and have good sensitivity. Consider factors such as sensor reliability, power consumption, and environmental durability.

2.6.3 LoRaWAN Network Infrastructure

Plan the LoRaWAN network infrastructure by assessing the coverage area and number of sensor nodes required. Determine the location and number of LoRaWAN gateways needed to cover the monitoring area. Consider factors like signal strength, interference, and potential obstacles that may affect network performance.

2.6.4 Sensor Node Design

Select a microcontroller or development board capable of interfacing with the selected sensors and LoRaWAN module. Design the circuitry to connect the sensors to the microcontroller or development board. Include appropriate signal conditioning circuits to ensure accurate readings from the sensors. Consider power requirements and choose a suitable power source such as power bank.

2.6.5 Sensor Integration and Calibration

Connect the selected sensors to the microcontroller or development board as per their specifications. Implement calibration procedures for each sensor to ensure accurate and reliable measurements. Calibrate the sensors periodically to compensate for drift or aging effects.

2.6.5.1 Calibration of sensors

The sensors such as pH sensor, Turbidity sensor and TDS sensor shows deviation from original value when taking reading, so these sensors need to be calibrated precisely.

2.6.5.2 pH Sensor

pH Sensor is used to detect pH of a solution. Calibration of the pH sensor requires a buffer solution whose pH is known.

Fig. 2.12. pH Standard solution powder

Here we use a pH standard solution powder which give a specific pH value to a known temperature. The different values of pH for different temperatures are given with the powder. The powder is mixed with 250 mL of distilled water and the pH electrode after interfacing with the microcontroller is dipped into the solution and the reading is calculated. As the pH value is known the knob of the pH sensor interfacing circuit is adjusted to set correct value if there is any error.

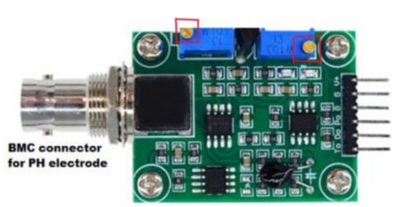


Fig. 2.13. pH Electrode interface circuit

The pH sensor will gave a reading between 0 to 1024 so to calibrate the sensor, these values is needed to be mapped to equivalent voltage from voltage it is converted to equivalent pH. A sample code for the same is given

```
sketch_jun20a §
// Define the analog pin to which the pH sensor is connected
const int pHSensorPin = A0;

// Constants for calibration
const float pH7Voltage = 2.5;   // Voltage reading at pH 7 (adjust if necessary)
const float pH7Value = 7.0;     // pH value at calibration point (adjust if necessary)
const float slope = -59.16;     // pH electrode slope (adjust if necessary)

void setup() {
  // Initialize serial communication
  Serial.begin(9600);
}

void loop() {
  // Read the voltage from the pH sensor
  int sensorValue = analogRead(pHSensorPin);

  // Convert the voltage to pH value
  float voltage = sensorValue * (5.0 / 1023.0);  // Convert the 10-bit ADC value to voltage (0-5V)
  float pHValue = pH7Value + ((pH7Voltage - voltage) / slope);  // Convert voltage to pH using Nernst equation

  // Print the pH value
  Serial.print("pH value: ");
  Serial.println(pHValue, 2);  // Print pH value with 2 decimal places

  delay(1000);  // Delay for stability, adjust as needed
}
```

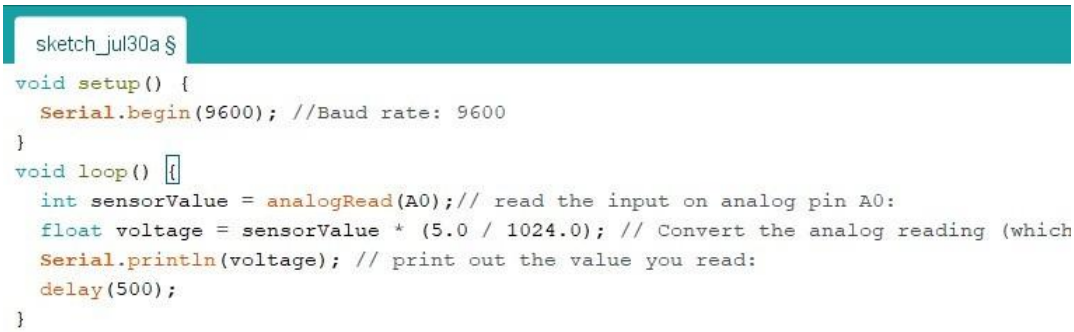
Fig. 2.14. pH interfacing code

2.6.5.3 Temperature Sensor

To calibrate a DS18B20 temperature sensor, start by connecting it to Arduino. Next, obtain a known reference temperature source, such as a high-accuracy thermometer. With both the DS18B20 sensor and the reference source in place, read temperature data from both sources simultaneously. Calculate the difference between the readings obtained from the sensor and the reference temperature source. This difference represents the calibration offset. Adjust the sensor’s readings by applying the calibration offset, either by adding or subtracting it as needed. It’s important to test and verify the accuracy of the calibrated sensor by comparing its readings against known temperatures. Once you have confirmed the calibration, you can incorporate the calibrated sensor into your project for accurate temperature measurements. Following these steps will help ensure the DS18B20 temperature sensor provides reliable and accurate temperature data.

2.6.5.4 Turbidity Sensor

The turbidity sensor is calibrated using distilled water. The turbidity sensor is placed in the distilled water and readings is taken. The readings are shown in analog values which is mapped to corresponding voltage. For distilled water the voltage reading should be 4.2 or 4.21. Adjust the knob in the A to D converter to make the values to 4.2 or 4.21.



```
sketch_jul30a §
void setup() {
  Serial.begin(9600); //Baud rate: 9600
}
void loop() {
  int sensorValue = analogRead(A0);// read the input on analog pin A0:
  float voltage = sensorValue * (5.0 / 1024.0); // Convert the analog reading (which
  Serial.println(voltage); // print out the value you read:
  delay(500);
}
```

Fig. 2.15. Turbidity Sensor interfacing code

2.6.5.5 TDS Sensor

The TDS sensor is calibrated using the distilled water. The TDS sensor should give value of 0.5 ppm for distilled water. Adjust the sensor reading to the exact value that should be obtained.

2.6.6 LoRaWAN Communication

Configure the LoRaWAN module to establish communication with the LoRaWAN gateway. Set up the necessary LoRaWAN parameters such as network keys, data rates, and transmission intervals. Implement encryption and authentication mechanisms to ensure secure data transmission.

2.6.7 Data Transmission and Storage

Develop firmware or software for the microcontroller to read sensor data and format it for transmission. Set up data packets with appropriate headers and payload structure for LoRaWAN transmission. Establish a data storage system, in the cloud, to receive and store the transmitted data securely.

2.6.8 Data Analysis and Visualization

Develop algorithms or use existing libraries to analyze the received sensor data. Create a user-friendly interface or dashboard to visualize real-time and historical water quality parameters.

2.6.9 Testing, Deployment, and Maintenance

Test the system in real-world conditions to ensure the accuracy and reliability of the sensor measurements. Deploy the sensor nodes in the target locations, considering factors like accessibility and protection. Monitor the system continuously and address any issues or anomalies promptly.

2.6.10 Safe Drinking Water Range

The safe range of drinking water by considering the parameters such as Temperature, Turbidity, pH and TDS is given in the below table. This range is recommended because, High turbidity in water indicates the presence of bacteria and other micro-organisms.High TDS levels can potentially cause digestive discomfort, such as stomach upset, nausea, or diarrhea in some individuals.High temperature can cause burns in internal organs.Optimum range for pH is also recommended for maintaining pH balance in the body.

Parameter	Safe Range
pH	6.5 to 8.5
Temperature	Typically ambient room temperature
Turbidity	Below 5 NTU
Total Dissolved Solids (TDS)	Below 500 mg/L

Table 2.1. Safe Ranges for Drinking Water Parameters

2.6.11 Source Code

```
  uint32_t pHVal=analogRead(pHPin);
  uint32_t turbVal=analogRead(turbPin);
  sensors.requestTemperatures();
  float waterTemperature = sensors.getTempCByIndex(0);
  float pHValue = map(pHVal, 0, 1023, 0, 14);
  float turbValue= map(turbVal,0, 1024,0,7);

Serial.println("pH sensor Value: "+ String(pHValue));
Serial.println("turbidity sensor Value: "+ String(turbValue));
Serial.print(F("Temperature (C): "));
Serial.println(waterTemperature);

byte payload[6];
uint16_t pHValueInt = static_cast<uint16_t>(pHValue * 100);
uint16_t waterTemperatureInt = static_cast<uint16_t>(waterTemperature * 100);
uint16_t turbValueInt = static_cast<uint16_t>(turbValue * 100);

payload[0] = highByte(pHValueInt);
payload[1] = lowByte(pHValueInt);

payload[2] = highByte(waterTemperatureInt);
payload[3] = lowByte(waterTemperatureInt);

payload[4] = highByte(turbValueInt);

payload[5] = lowByte(turbValueInt);
```

Fig. 2.16. Source Code

This code snippet reads analog data from a pH sensor, a TDS sensor and a turbidity sensor, requests and reads temperature data from a DS18B20 temperature sensor, maps and converts these sensor values to corresponding physical measurements (pH, temperature, turbidity,ppm), and prepares the data for transmission by encoding them as integers within a byte array.

CHAPTER 3

RESULTS AND DISCUSSION

This chapter includes the obtained results of the project and obtained findings of the design process.The figure of the proposed system is given below.

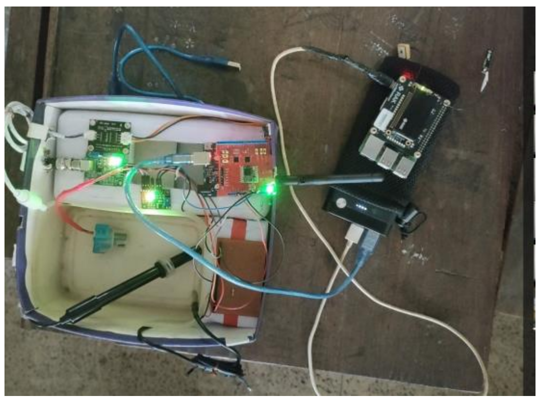


Fig. 3.1. Proposed System

3.1 Results

The result of the given system is shown in this section.

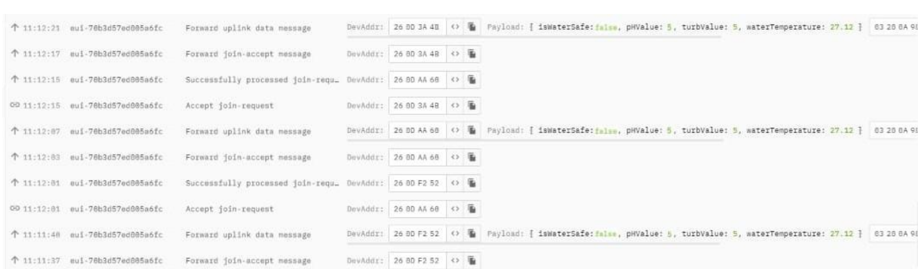


Fig. 3.2. Acidic Sample

Water Quality Monitoring System using LoRaWAN is implemented and verified the expected result. The system has successfully measured the parameters such

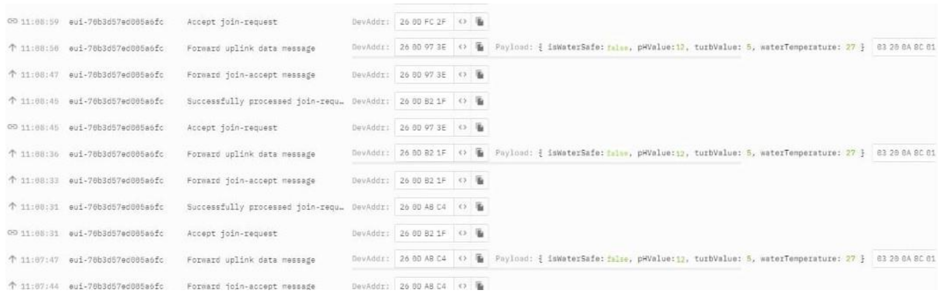


Fig. 3.3. Basic Sample

Fig. 3.4. Mud Water

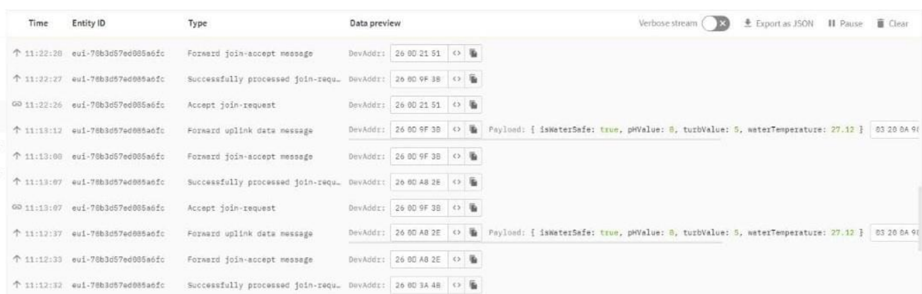


Fig. 3.5. Filter Water

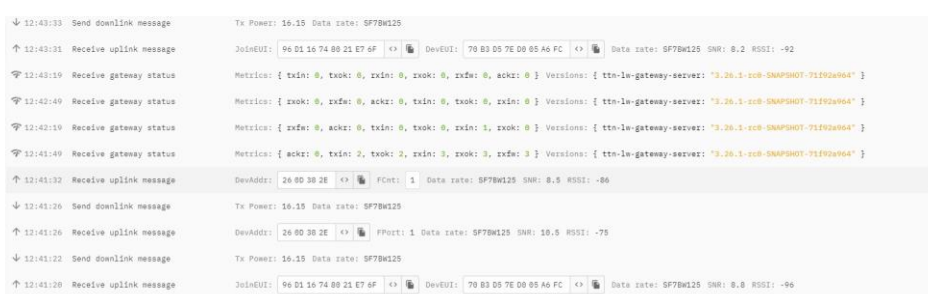


Fig. 3.6. Values of Tx power, SNR, RSSI and data rate

as temperature, turbidity, pH and TDS value of a given water samples.

3.1.1 Discussions

Here through this project, we are performing water quality monitoring system that includes measuring various parameters such as pH, turbidity, total dissolved solids and temperature of the water source. The values are stored in the cloud for analysis. Here different samples of water is taken for measuring its parameters. We have also applied a conditional statement in the program incorporating with the standard parameters of the water. If the water sample satisfies the condition then it is concluded that the water is safe for drinking, if not then it is concluded that not safe for drinking. We have take two samples of water, one from the water filter in Govt. College of Engineering Kannur and other a mud water. From this it is shown that the filtered water meet the parameters of safe drinking water and for the mud water the turbidity value is shown high, which indicates the presence of micro organism and dirt particles and the water is not safe for drinking.We have also tested samples such as acidic and basic and the system is working properly by showing the required result. The signal strength parameters such as SNR,RSSI and TX power is also noted and studied how they change with changing conditions such as confronting an obstacle, it is noted that the parameters reduces slightly when they are interfering with obstacles.

CHAPTER 4

CONCLUSION AND FUTURE SCOPE

4.1 Conclusion

The Water Quality Monitoring System using LoRaWAN provides a real time monitoring of various parameters in the water bodies.The system can collect data from remote areas and transfer it wirelessly, which allows the identification of potential hazards, thus reduces the human effort and time.The experiment is setup using the different sensors connected to the end node and the parameters of different water samples is analyzed. The experiment is tested using the filtered water where the measured parameters met the required parameters for the safe drinking water. The same experiment is tested using mud water as a sample to check its parameters. It is shown that the turbidity, pH value of the sample of mud water changed and were not up to the mark for consumption and it is also tested for acidic and basic solution. From these setup it is concluded that the system is working properly without any error and value of the transmitted power, SNR and RSSI is also noted to study about the signal strength and interference of the signals. From which it is observed that the signal strength slightly reduces when it is interfered with the obstacles and thus a slight delay is produced. The experiment as a whole is implemented without any major faults.

4.2 Future Scope

Further modification in the main program can be implemented to read the various parameters of the water and to detect which water parameter is giving faulty value which can be implemented in water treatment plants. This system can be used in Aquaculture by using the required sensors for reading and collecting relevant data. Machine learning models such as regression model can be incorporated for predicting specific water quality parameters or classification for identifying water quality anomalies or pollution events.

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APPENDIX

DATASHEETS

WisLink-LoRa Concentrator Module

Raspberry Pi HAT Edition

RAK2245 Pi HAT

Package Content

RAK2245 Pi HAT (1x) LoRa Antenna (1x) GPS Active Antenna (1x)

Product Description

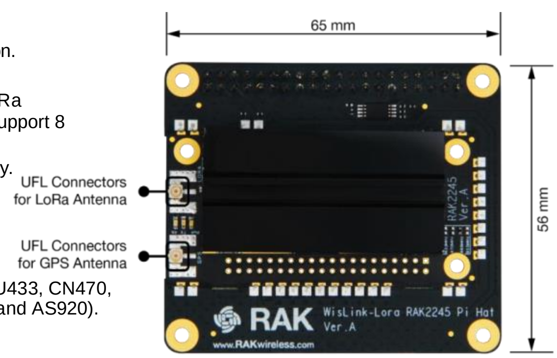
RAK2245 Pi HAT is a module with Raspberry PI form factor. It can be plugged into Raspberry PI such as Raspberry Pi 3 Model B+ as a complete RF front end of LoRa gateway.It supports eight channels and is available for LoRaWAN global frequency bands. The board is the smallest LoRaWAN gateway concentrator which integrates the Ublox MAX-7Q GPS Module and heat sink.

The board can provide low data rate LoRa radio links in ultra-fast speed. It is powered by a Semtech SX1301 transceiver concentrator that is capable of managing packets from many remotely dispersed end-points. Two Semtech SX125X are integrated for RF front end I/Q transceivers.

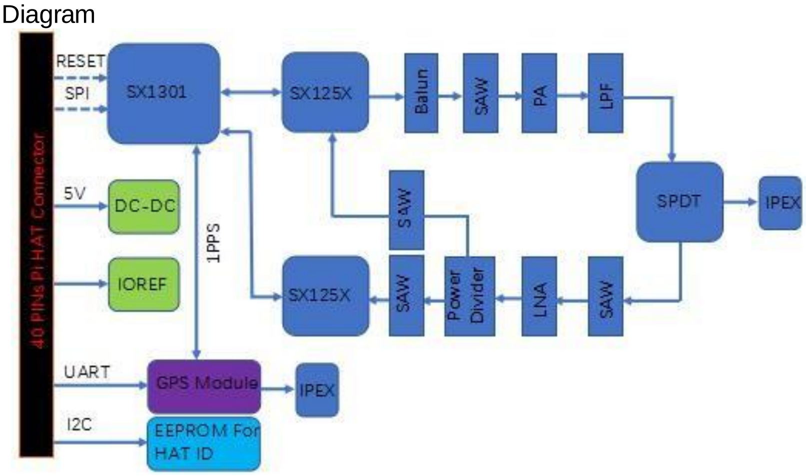
The RAK2245 Pi HAT is a complete and cost efficient LoRa gateway solution that can help you develop a full LoRa system. This is an economical way to create different solutions like smart grid, intelligent farm and other IoT applications. It is also ideal for manufacturing small series that can expand into more applications.

Product Features

- Compatible with Raspberry Pi 3 Model B+ edition.
- Integrated the heat sink.
- SX1301 base band processor emulates 49 x LoRa demodulators 10 parallel demodulation paths, support 8 uplinks channel, 1 downlink channel.
- 2 x SX125x Tx/Rx front-ends high/ low frequency.
- Supports 5V power supply.
- TX power up to 27dBm, RX sensitivity down to -139dBm@SF12, BW 125KHz.
- Supports latest LoRaWAN 1.0.2 protocol.
- Supports global license-free frequency band (EU433, CN470, EU868, US915, AS923, AU915, KR920, IN865 and AS920).
- Supports SPI, UART, GPIOs interface.
- Integrated the Ublox MAX-7Q GPS Module.



Block Diagram



WisLink-LoRa Concentrator Module

Raspberry Pi HAT Edition

RAK2245 Pi HAT

RAK | RAKwireless Technology Co., Ltd.

Key Features

LoRa Module	• RAK2245(1 x Semtech SX1301 transceiver concentrator and 2 x Semtech SX125X highly integrated RF front end I/Q transceivers)
GPS Module	• Ublox MAX-7Q
Form Factor	• Raspberry Pi HAT Edition
Heat Sink	• Metal Material
Frequency	• EU433, CN470, EU868, US915 • AS923, AU915, KR920, IN865, AS920
LoRaWAN Version	• LoRaWAN Version: V1.0.2 • Semtech SX1301 Driver Version: V5.0.1 • Packet Forwarder Version: V4.0.1
Range	• Urban: 2~4km • Suburb: 5~10km • Open Area: 15km
Node Numbers	• 500 nodes/km2
TX Power	• 27dBm (Max), typical 25 dBm
RX Sensitivity	• -139dBm(Min)@SF12, BW 125KHz
Power Supply	• DC 5V
LEDs	• 1* Green LED for PWR status • 1* Green LED for TX status • 1* Green LED for RX status
Interfaces	• SPI, UART, GPIOs
Antenna Interface	• 1* U.FL connectors for LoRa • 1* U.FL connectors for GPS
Power Consumption	• TX (Typical): 336mA • RX(Typical): 360mA
Physical Dimension	• Dimension (L x W x H): 56.00 x 65.00 x 22.00 mm (±2mm) • Weight: Approximately 1.15oz
Temperature Range	• Operation Temperature: -40° C ~ +85° C • Storage Temperature:- 40° C ~ +85° C

Order Information

Part Number	Package	Description
RAK2243-0X-R01	1x board, 1x LoRa Antenna and 1x GPS Active Antenna retail package	Supports 433/470/868/915/923/920/865 MHz
RAK2243-0X-C10	10-piece board and Antennas carton package	Supports 433/470/868/915/923/920/865 MHz

RAK IoT Made Easy

About RAKwireless:

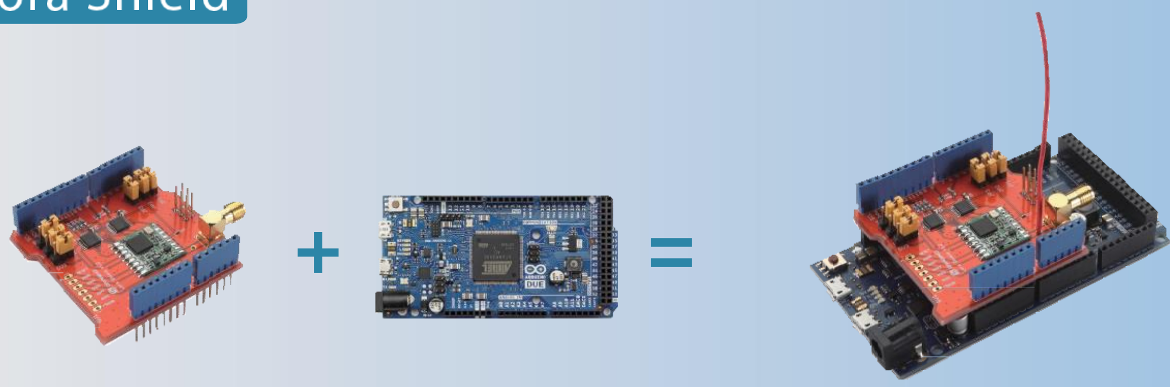
RAKwireless is the pioneer in providing innovative and diverse cellular and LoRa connectivity solutions for IoT edge devices. It's easy and modular designs can be used in different IoT applications and accelerate time-to-market. For more information, visit RAKwireless website at www.rakwireless.com.

Fig. .1. RAK2245

DRAGINO

Long Range Wireless Transceiver for Arduino

Lora Shield



OVERVIEW:

Lora Shield is a long range transceiver on a Arduino shield form factor and based on Open source library.The Lora Shield allows the user to send data and reach extremely long ranges at low data-rates.It provides ultra-long range spread spectrum communication and high interference immunity whilst minimising current consumption.

The Lora Shield based on semtech sx1276/sx1278 targets professional wireless sensor network applications such as irrigation systems, smart metering, smart cities, smartphone detection, building automation, and so on.

Using patented LoRaTM modulation technique the Lora Shield can achieve a sensitivity of over -148dBm using a low cost crystal and bill of materials. The high sensitivity combined with the integrated +20 dBm power amplifier yields industry leading link budget making it optimal for any application requiring range or robustness. LoRaTM also provides significant advantages in both blocking and selectivity over conventional modulation techniques, solving the traditional design compromise between range, interference immunity and energy consumption.

Features:

- Compatible with 3.3v or 5v I/O Arduino Board.
- Frequency Band: one of 433/868/915 MHZ (Pre-configure in factory)
- Low power consumption
- Optional External Antenna via SMA jack
- Compatible with Arduino Leonardo, Uno, Mega, DUE

Specification:

- 168 dB maximum link budget
- +20 dBm - 100 mW constant RF output vs
- +14 dBm high efficiency PA
- Programmable bit rate up to 300 kbps
- High sensitivity: down to -148 dBm
- Bullet-proof front end: IIP3 = -12.5 dBm
- Excellent blocking immunity
- Low RX current of 10.3 mA, 200 nA register retention
- FSK, GFSK, MSK, GMSK, LoRaTM and OOK modulation
- Built-in bit synchronizer for clock recovery
- Preamble detection
- 127 dB Dynamic Range RSSI
- Packet engine up to 256 bytes with CRC
- Automatic RF Sense and CAD
- Built-in temperature sensor
- Low battery indicator

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Fig. .2. DRAGINO RFM95W