

WATER DEPTH MEASUREMENT USING UAV

Submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering Degree in Electronics and Communication Engineering

by

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

CATEGORY-1 UNIVERSITY BY UGC

**Accredited with Grade "A++" by NAAC | 12B Status by UGC | Approved by AICTE
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Lavanya C (40130125)** and **Negha R (40130155)** who carried out the project entitled "**Water Depth Measurement using UAV**" under our supervision from November 2023 to April 2024.

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DECLARATION

We **Lavanya C (40130125)** and **Negha R (40130155)** hereby declare that the Project Report entitled **Water Depth Measurement using UAV** done by us under the guidance of **Dr. V.Vijaya Baskar, M.E., Ph.D., Professor, Dept. of Electronics and Communication Engineering** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree Electronics and Communication Engineering.

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ABSTRACT

Unmanned aerial vehicles (UAVs) have gained considerable popularity across a broad spectrum of applications due to their adaptability and ease of use. Designed to utilize cutting-edge sensor technology and wireless communication protocols, this methodology involves the integration of waterproof ultrasonic sensors with LoRa communication modules, facilitating data transmission to a ground station for real-time analysis. Through integration with the Blynk IoT cloud platform, the collected data is processed and analyzed, facilitating applications in environmental monitoring and hydrology research. By leveraging Internet of Things (IoT) principles and cloud-based data processing, the system offers a scalable and adaptable solution for environmental monitoring and hydrological research by addressing challenges in water depth measurement, offering a cost-effective and efficient solution for monitoring aquatic environments. The study highlights the potential of innovative technologies in advancing water resource management practices and environmental conservation efforts. By combining UAV capabilities with advanced sensor technology and wireless communication protocols, the system provides researchers and practitioners with valuable insights into water resources management and environmental conservation efforts by monitoring the environment, conducting hydrological surveys, and mapping underwater terrains. This, in turn, provides invaluable insights for scientific research and the management of water resources. The system's versatility and scalability make it a valuable tool for a wide range of industries and fields requiring accurate water depth measurements in various settings enabling its application in environmental monitoring, hydrology, and various other fields.

TABLE OF CONTENT

CHAPTER NO	TITLE	PAGE NO.
	ABSTRACT	v
	LIST OF FIGURES	ix
	LIST OF TABLES	xi
	LIST OF ABBREVIATIONS	xii
1.	INTRODUCTION	1
2.	LITERATURE SURVEY	3
3.	EXISTING SYSTEM	6
	3.1 Technologies Used By The Existing System	7
	3.2 Significance Of Accurate Bathymetric Mapping	7
	3.3 Challenges Integrating GNSS/GPS Into UAV - Based Water Depth Measurement Systems	7
4.	AIM AND SCOPE OF PROPOSED SYSTEM	9
	4.1 Proposed System	9
	4.2 Advantages Of This Proposed System	10
	4.3 Aim And Scope	10
5.	MATERIALS, METHODS AND ALGORITHMS USED	12
	5.1 Block Diagram Of The Proposed System	12
	5.2 Algorithms Used	12
	5.2.1 Algorithm For The Interfacing Of UAV With Arduino Uno, Sensors And Lora Module at Transmitter	13
	5.2.2 Algorithm For The Interfacing Of Esp32 Wi-Fi And Lora Module With Iot Cloud Network at Receiver	14

5.3 Hardware Used	14
5.3.1 Waterproof Ultrasonic Sensor- Ajsr04m	14
5.3.2 Lora Module – Sx1278	17
5.3.3 Arduino Uno	19
5.3.4 Esp32 Module	23
5.3.5 Drone	25
5.4 Software Used	27
5.4.1 Blynk Iot Cloud Storage	27
5.4.2 Arduino IDE	29
5.5 Transmitter Module	33
5.6 Receiver Module	35
6. RESULTS AND DISCUSSION	37
7. CONCLUSION AND FUTURE WORK	40
7.1 Conclusion	40
7.2 Future Work	40
REFERENCES	41
APPENDIX	43
A. Transmitter Source Code	43
B. Receiver Source Code	45
C. IEEE Standards	47
D. Constraint	47
E. Trade-Offs	48

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE NO.
2.1	Schematic diagram of the existing system	4
3.1	Different methods of the Existing system	6
3.2	Flow chart of the existing system	8
5.1	Block diagram of the proposed system	12
5.2	Flow chart of the proposed system	13
5.3	AJ-SR04M and circuit board	15
5.4	Obstacle Detection	16
5.5	AJ-SR04M Modes of Operation	16
5.6	LoRa SX1278 Module	17
5.7	LoRa SX1278 Block diagram	18
5.8	LoRa Communication Protocol	19
5.9	Arduino UNO Power Tree	21
5.10	Arduino UNO Pin out	21
5.11	ESP32 Functional Block Diagram	23
5.12	ESP32 Pin out	25
5.13	Blynk process layout	28
5.14	Blynk Server	28

5.15	Blynk to ESP32	28
5.16	Arduino	29
5.17	Arduino IDE Sketch Window	29
5.18	Arduino IDE Uploading	30
5.19	Serial Monitor	31
5..20	Transmitter Module	33
5.21	Connection of Arduino UNO to LoRa and sensor	33
5.22	Receiver Module	35
5.23	Connection of LoRa SX1278 and EP32	36
6.1	Integration of hardware components with the drone	38
6.2	Sensor transducer measuring water depth from drone	38
6.3	Real-time Water depth analysis	39
6.4	Monitoring water depth in IoT Cloud Network	39

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
5.1	Arduino UNO Pin out	21
5.2	ESP32 Peripherals and I/O	24
5.3	6 Buttons of Menu bar	29
5.4	Pin connections of transmitter Module (1)	34
5.5	Pin connections of transmitter Module (2)	35
5.6	Pin connections of Receiver Module	37
6.1	Results of Water Depth Measurement in different water bodies	37

LIST OF ABBREVIATIONS

UAV	Unmanned Aerial Vehicle
LoRa	Long Range
USV	Unmanned Surface Vehicle
SVR	Support Vector Regression
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GIS	Geographic information systems
DTM	Digital Terrain Model
IoT	Internet of Things
AC	Alternating Current
DC	Direct Current
PWM	Pulse Width Modulation
RF	Radio Frequency
I/O	Input/Output
EEPROM	Electrically Erasable Programmable Read-Only Memory
TTL	Transistor-Transistor Logic
SPI	Serial Peripheral Interface
I2C	Inter-Integrated Circuit
ADC	Analog-To-Digital Converter
DAC	Digital-to-Analog Converter
MAC	Media Access Control Address
LAN	Local Area Network

CHAPTER 1

1. INTRODUCTION

In the vast expanse of aquatic environments, grasping the depth of the water is paramount for various applications which vary from environmental assessment to hydrographic mapping. The farther we explore those fields, the more abundantly obvious it is that precise measurements need to be accomplished, which is why adaptive technology solutions are being explored. Among these, Unmanned Aerial Vehicles (UAVs) have been demonstrated to be extremely helpful in order to gather data and implementing airborne surveillance, particularly whilst determining the depth of water. Afresh, a new era of efficiency and accuracy is being launched in by the amalgamation of UAV technology with water depth monitoring, with quite possibly ground-breaking implications across a wide range of industries.

When it comes to the field of water depth measurement, we as a team are particularly intrigued in mapping out how challenging it is in order to measure water levels precisely. The requirement in obtaining accurate information concerning water levels—a fundamental parameter critically important to environmental monitoring, hydrographic surveying, and disaster management motivates this endeavour. Our attempts aim to concentrate on elucidating the process adopted for using UAVs to collect such vital data, which will enable wise choices and environmentally conscious resource management.

The primary objective is to equip the UAV with an assortment of electronic devices for carrying out the work at hand. The sensor we are using is the key component of our system since it transmits sound waves into the water and uses the reflection of those waves to calculate the distance to the waterbed. A LORA Module communicates all data gathered to the ground's surface unit using its Lora communication protocol. Thus enabling the sensor data to be interpreted in real time and stored on an IoT cloud platform. Here, water depth data is gathered, displayed, and preserved to allow for remote access and analysis, providing constituents with pertinent data.

Simultaneously with advancements in the field of sensing technologies, unmanned aerial vehicles (UAVs) have been getting more and more ubiquitous. These effortless and accurate aerial devices navigate the air. Unmanned Aerial Vehicles (UAVs) have been complimented extensively for their ability to adapt, as they could potentially be used for virtually anything from agricultural surveying to aiding those affected by disasters. Their deployment in situations that had previously been considered insurmountable has been bolstered by their capacity for one to navigate arduous and far-flung terrains. With their encompassing GPS navigational systems coupled with the ability to carry specialized sensors, unmanned aerial vehicles (UAVs) gravitate toward the less commuted direction whilst surveying the waters beyond the surface.

In conclusion, our all-encompassing system functions as a comprehensive approach for measuring water depth using UAVs, with an extensive spectrum of applications in hydrology and environmental monitoring. We intend to get a more comprehensive grasp of the underwater environment by utilizing state-of-the-art technology and UAV capabilities. This is going to widen up the possibilities toward more effective the management of resources and knowledgeable choices in the field pertaining to water management.

CHAPTER 2

2. LITERATURE SURVEY

Ultrasonic sensors for measuring water depth have been the focus of a great deal of research and development in a variety of fields. The potential, constraints, and uses of ultrasonic sensors for precisely measuring water depth have been the subject of numerous studies. An overview of significant discoveries and developments in this topic can be found in the literature survey that follows.

In order to ascertain the depths of shallow water, Specht M, Wiśniewska M, and Stateczny A (2022) evaluated five methods using a comparative analysis of photos obtained by UAVs. The study finds applications in navigational safety, coastal zone management, hydro-engineering structure monitoring, environmental impact assessment, and conservation efforts. It emphasizes the importance of ground control points and addresses water-wave refraction in photogrammetric data processing. This study adds to the development of nautical charts, management procedures, and environmental monitoring by offering insightful information to researchers.

In 2021, Sabuj Das Gupta et al., introduced an easy-to-use method for identifying things without making physical touch and estimating water depth. The authors examined various techniques for determining the depth of water, emphasizing the efficiency of the ultrasonic range finder system, which uses transducers and electronic circuitry to produce ultrasonic signals. This versatile device uses a mechanical component to determine the angle of reflected ultrasonic signals. The study emphasizes how adaptable this method is, providing useful information for engineering and technology applications including irrigation, construction, and water conservation.

Using a case study in Tuscany, Giambastiani Y. et al., (2020) examine the application of aquatic drone surveys for volume assessment of lakes and reservoirs.

Using optical modeling, Alevizos E et al., (2022) evaluated the efficiency of drone-based sensors in measuring the bathymetry of shallow water. Experimented

on several coastal locations, the technique demonstrates a robust connection and low inaccuracy when compared to sonar readings. Water depth extraction and multispectral satellite imagery have been studied in the past. The paper tackles issues including the non-uniqueness problem and the effect of seagrass patches on depth overestimation, highlighting the crucial significance of end-member spectra for precision. The importance of seafloor geometry and homogeneity is emphasized. In conclusion, the work sheds light on the difficulties associated with mapping shallow water bathymetry with drone-based sensors.

The use of USVs and UAVs for bathymetric monitoring was investigated by Lewicka O. et al., (2022). Their research emphasizes the significance of high shoreline extraction, integration, and radiometric depth measurement with Support Vector Regression (SVR). Different reference techniques are covered. Standardized reference methodologies are also recommended in the study in order to facilitate precise quantitative comparisons. The Gdynia Maritime University and the National Centre for Research and Development in Poland provided money for the study, and the authors had no disclosed conflicts of interest.

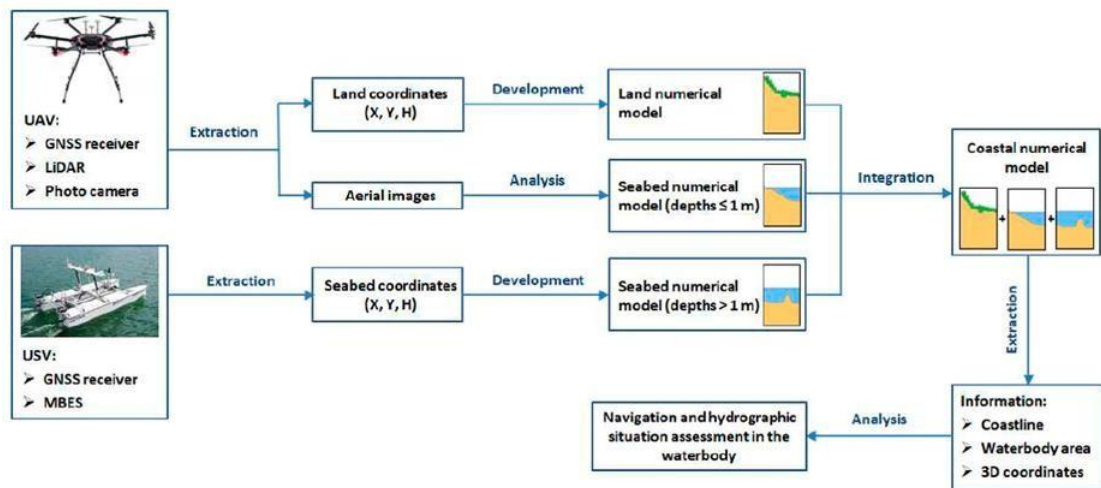


Figure 2.1 Schematic diagram of the existing system

In an overview, the method suggested in this study presents a straightforward to operate and cost-effective way to locate objects and measure the water's depth utilizing an ultrasonic signal system. Ultrasonic signal systems have been widely employed for object detection and water depth measuring, according to a study of related literature. Ultrasonic signal techniques have been the subject of numerous

research, which have shown how successful they are at detecting objects in a variety of contexts and measuring water depth. To sum up, the review of the literature indicates that there is an increasing amount of research being done on the integration, application, and optimization of ultrasonic sensors for measuring water depth. All of the investigations covered here advance our knowledge of the potential applications and difficulties of ultrasonic sensors in many environmental settings. Future studies in this area could lead to even greater advancements in the precision, dependability, and adaptability of ultrasonic water depth measuring devices.

CHAPTER 3

3. EXISTING SYSTEM

GNSS/GPS integration in UAVs is crucial for performing precise georeferencing during flights to measure water depth. With this method, the UAV is equipped with GNSS/GPS receivers that use satellite signals to locate the device. The UAV's position data is then combined with depth measurements or other collected data to create geospatial maps that provide precise location information. Post-processing techniques can yield data that is useful for a variety of applications, including assessment of the environment and hydrographic surveying. Considering GNSS/GPS integration allows UAV-based water's depth measurements to be exceedingly accurate, they can be integrated with GIS for advanced analysis and graphic representation.

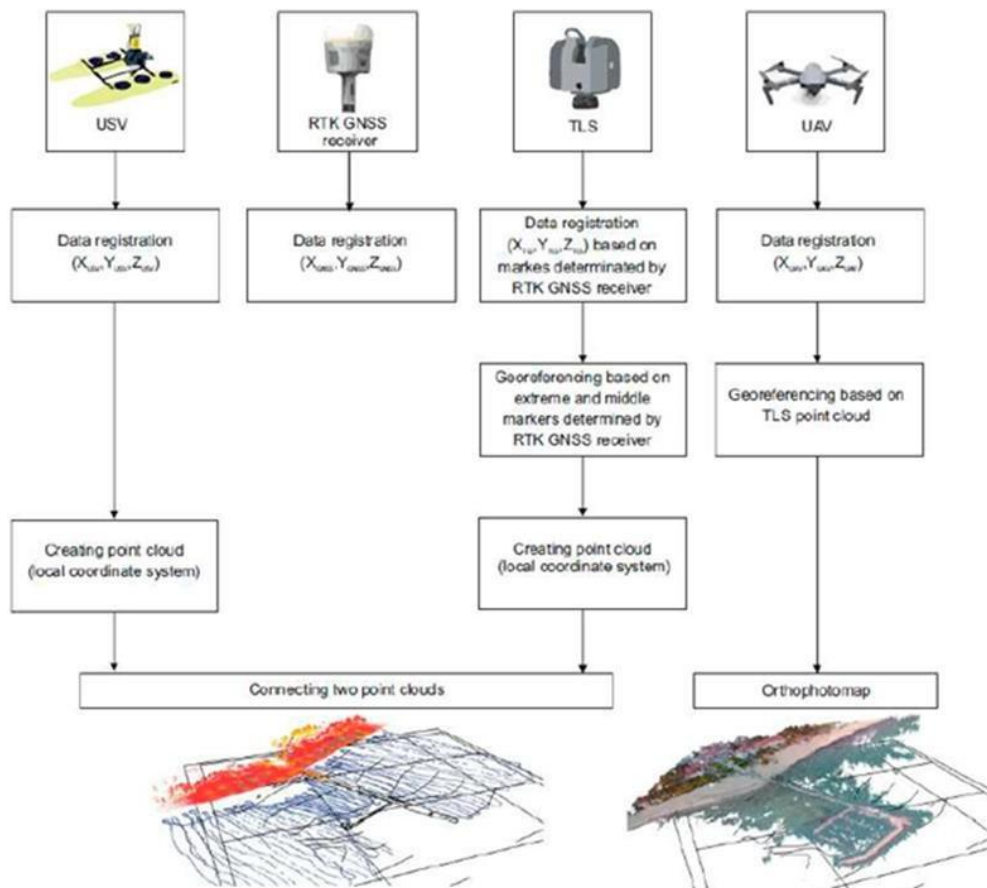


Figure 3.1 Different methods of the Existing system

3.1. TECHNOLOGIES USED BY THE EXISTING SYSTEM

Three types of technologies make up the Integration Data Model of the Bathymetric Monitoring System for Shallow Waterbodies Using UAV and USV Platforms:

- i. Hydro acoustic and optoelectronic data integration component: The aforementioned component creates a high resolution (HR) bathymetric picture of the seafloor by combining data from optoelectronic and hydro acoustic sensors.
- ii. Radiometric depth determination component: The radiometric depth perseverance component uses the Support Vector Regression (SVR) method with optoelectronic data to determine the water's depth.
- iii. Coastline extraction component: These components work together to produce a digital terrain model (DTM) of the shoreline area, which is then utilized for a number of objectives such as sea navigation, for instance, security for the general public, and preservation of the natural environment.

Together, these elements create a digital terrain model (DTM) of the coastal area, which is then used for a variety of purposes, including environmental preservation, public safety, and marine navigation.

3.2. SIGNIFICANCE OF ACCURATE BATHYMETRIC MAPPING

Exactitude bathymetric cartography is crucial in superficial watercourses for several reasons. Inconsistent waterbodies are vital for safeguarding individuals because people often use them for recreational activities including swimming, boating, and fishing. Using precise bathymetric maps, one may identify hazards such as boulders, sandy areas, and various other obstructions that could jeopardize submerged safety for humans.

Secondly, accurate bathymetric mapping is essential to environmental protection. Shallow depths reservoirs are home to a variety of marine species, and changes to the seafloor's alleviation can have a significant impact on these the natural environments of species. Detailed bathymetric maps can help identify areas that are particularly sensitive to abrupt shifts in the undersea alleviation, which may

facilitate targeted on environmental preservation.

The accurate bathymetric cartography is essential for marine navigation. Proper bathymetric geographical charts, particularly are extensively employed for maritime as well as additional economic endeavors in shallower watercourses, can facilitate secure voyages and help avoid mishaps.

3.3. CHALLENGES IN INTEGRATING GNSS/GPS INTO UAV-BASED WATER DEPTH MEASUREMENT SYSTEMS

- High cost of high-precision GNSS/GPS equipment
- Limited satellite visibility in certain environments
- Multipath interference affecting signal accuracy
- Weather conditions impacting signal quality
- Variability in GNSS/GPS receiver quality

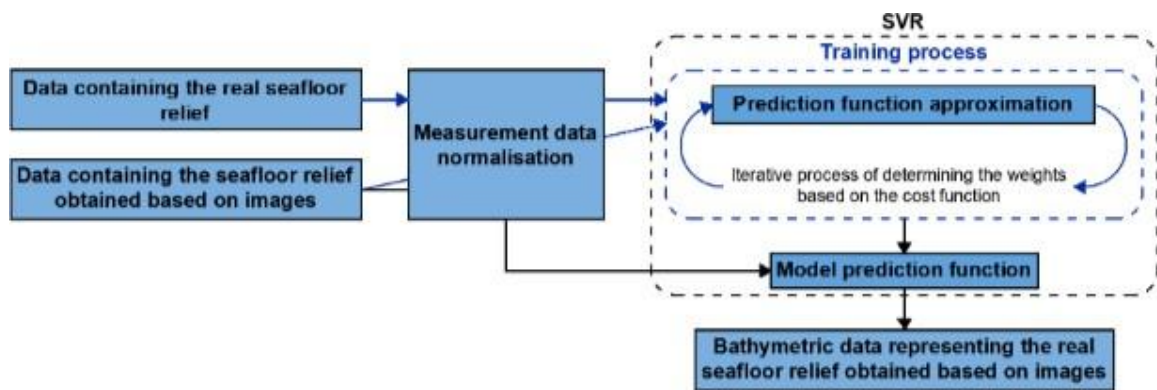


Figure 3.2 Flow chart of the Existing system

CHAPTER 4

4. AIM AND SCOPE OF PROPOSED SYSTEM

4.1. PROPOSED SYSTEM

The proposed approach makes use of unmanned aerial vehicles (UAVs) outfitted with cutting-edge sensor technology and long-range wireless connectivity in an effort to overcome the shortcomings of the current water depth assessment techniques. A Waterproof Ultrasonic Sensor AJSR04M for accurate distance measurements in aquatic conditions and LoRa communication technology for real-time data transmission over long distances are two of the system's key components.

The AJSR04M Waterproof Ultrasonic Sensor is perfect for underwater applications because it is made to endure harsh environments including wetness and exposure to water. The sensor provides precise water depth readings by measuring the distance to the water's surface or bed by generating high-frequency sound waves and examining their reflections. LoRa communication technology also makes it possible for sensor data from the UAV to be wirelessly transmitted to a central server or ground station. Even in isolated or difficult-to-reach places, LoRa's long-range capabilities and low power consumption allow for smooth communication over wide distances. This improves resource management and decision-making by enabling real-time monitoring and analysis of water depth data.

There are many benefits to integrating these parts into a UAV-based system, such as improved accessibility, affordability, and efficiency. When compared to traditional approaches, UAVs can cover larger regions faster, giving access to isolated locations and thorough monitoring of aquatic bodies. Furthermore, the data collecting process is streamlined by the use of wireless connection and modern sensor technology, which eliminates the need for specialist equipment and manual labour. Power Management make sure there is enough battery life left in the UAV to last the whole operation. Safety Procedures put emergency protocols and fail-safes in place to deal with unforeseen circumstances like low battery or communication failure.

With all factors analysed, the proposed methodology provides a thorough approach to measuring water depth, resolving the issues with current techniques and delivering precise, up-to-date data for a range of uses, such as environmental monitoring, hydrographic surveying, and disaster relief.

4.2. ADVANTAGES OF THIS PROPOSED SYSTEM

- Enhances decision-making capabilities with timely and precise data on water depth.
- Facilitates remote monitoring and management of aquatic environments.
- Improves resource allocation by optimizing data collection processes.
- Enhances the understanding of aquatic ecosystems and supports conservation efforts.
- Promotes sustainable practices by minimizing environmental impact through efficient data collection methods.
- Increases operational efficiency by streamlining data transmission and analysis processes.
- Offers scalability and adaptability to accommodate varying project requirements and environmental conditions.

4.3. AIM AND SCOPE

The purpose of this document is to look into and assess the viability and efficiency of putting in place a water depth measurement system based on unmanned aerial vehicles. This system achieves accurate and real-time data collecting in aquatic environments by integrating cutting-edge sensor technologies, unmanned aerial vehicles (UAVs), and Internet of Things connectivity. The main goal is to evaluate the system's ability to detect water depth properly, track changes in the environment, and assist in the making of decisions in areas like hydrography, environmental assessment, and disaster management.

This study covers the water depth measurement system's design, development, and implementation using a UAV. A thorough examination of the system's constituent parts, such as sensors, UAVs, communication modules, and internet of things (IoT) platforms, is included. The synchronization of these elements to produce a unified and effective data collection system will be examined in the study. It will also assess the system's performance in different aquatic conditions, taking scalability, precision, and reliability into account.

The study will also evaluate the usefulness and possible advantages of the UAV-based water depth measurement system in a variety of fields, such as infrastructure development, environmental management, and the evaluation of water resources. It will also look at the challenges and limitations involved in establishing such a system in place and make suggestions for future developments and lines of inquiry. This report's overall goal is to give participants a comprehensive awareness of how UAVs are used to assess water depth and how that affects environmental management and monitoring.

CHAPTER 5

5. MATERIALS, METHODS AND ALGORITHMS USED

5.1. BLOCK DIAGRAM OF THE PROPOSED SYSTEM

The block diagram for our proposed system illustrates the flow of data from the ultrasonic sensor mounted on the UAV to the Blynk IoT cloud platform. The ultrasonic sensor detects the water depth, and the Arduino UNO processes the sensor data. The processed data is then transmitted wirelessly using a LoRa transmitter module. The UAV receives the transmitted data and relays it to the ground station. The ground station consists of a LoRa receiver module connected to an ESP32 microcontroller. The ESP32 microcontroller communicates with the Blynk IoT cloud platform, where the water depth measurements are stored and can be accessed remotely for monitoring and analysis.

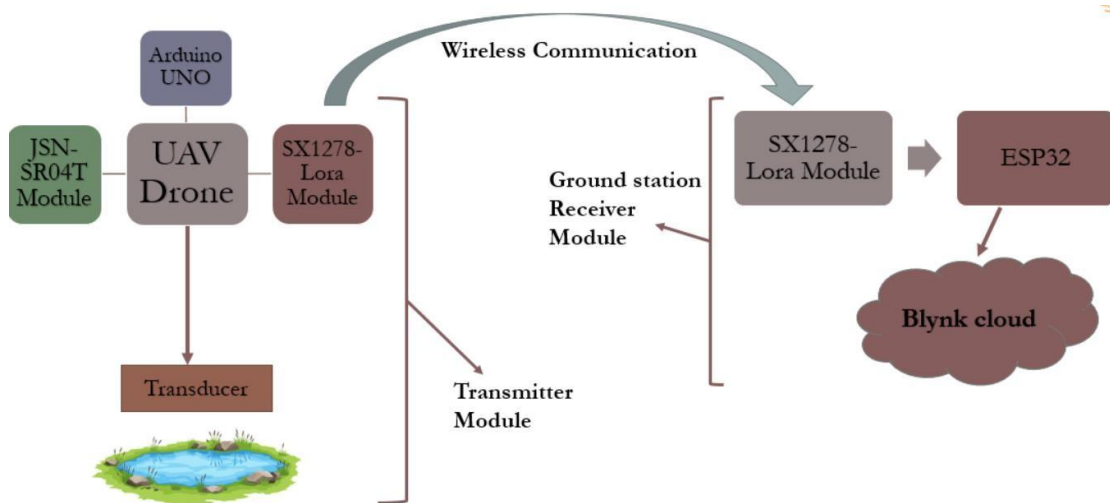


Figure 5.1 Block Diagram of the Proposed System

5.2. ALGORITHMS USED

The algorithm and flow chart of the proposed system is given below. This algorithm outlines the steps involved in the proposed system for measuring water depth using UAVs. It includes initializing the components, activating the ultrasonic sensor, transmitting and receiving data using LORA modules, processing data with ESP32, and storing data in the Blynk IoT cloud platform.

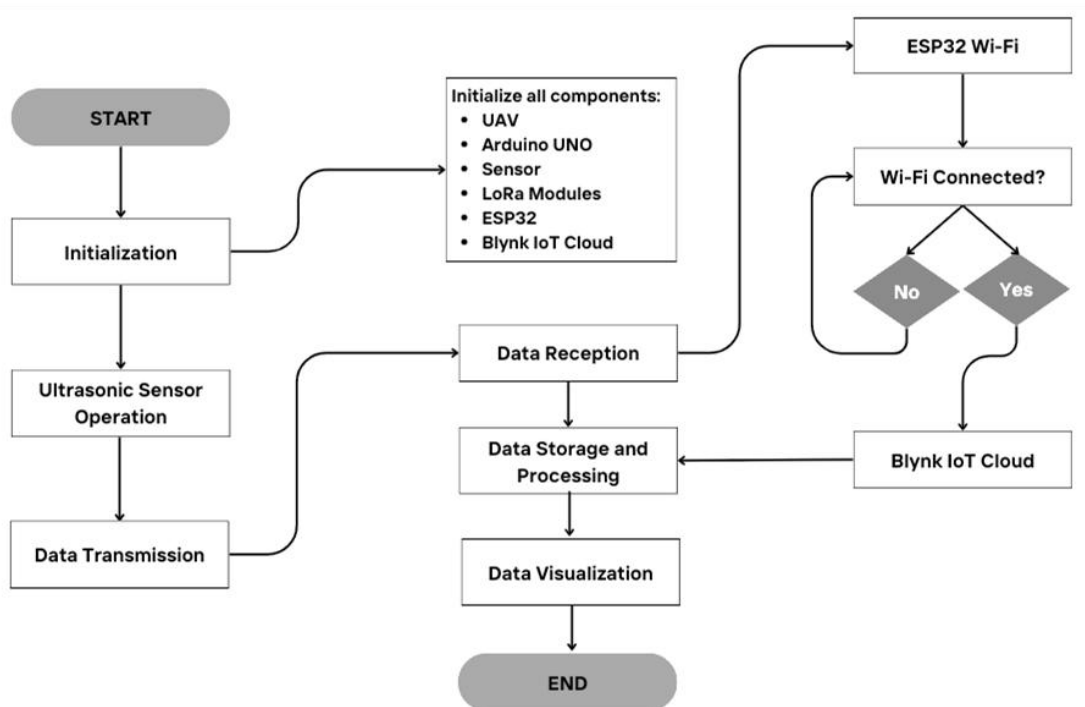


Figure 5.2 Flow chart of Proposed System

5.2.1. Algorithm for the interfacing of UAV with Arduino UNO, Sensors and LoRa Module on the Transmitter Side

Step 1: Start

Step 2: Initialize the components:

- Connect the waterproof ultrasonic sensor AJ SR04M to the Arduino UNO
- Connect the LORA SX1278 Module to the Arduino UNO for data

transmission

Step 3: Activate the ultrasonic sensor AJ SR04M to send out sound waves underwater

Step 4: Receive the reflected sound waves data from the waterbed and calculate the distance underwater

Step 5: Send the distance data to the ground station through the LORA SX1278 Module connected to the Arduino UNO

Step 6: End

5.2.2. Algorithm for the interfacing of ESP32 Wi-Fi and LoRa Module with IoT Cloud Network on the Receiver Side

Step 1: Start

Step 2: Initialize the components:

- Connect another LORA module with the ESP32 for data reception
- Establish connection with the Blynk IoT cloud platform for data storage and real-time processing

Step 3: Receive the sensor data using the LORA module connected with the ESP32

Step 4: Process the received data using the ESP32

Step 5: Store the processed data in the Blynk IoT cloud platform for further real-time processing

Step 6: Blynk acts as the main center for gathering, presenting, and storing data on water depths

Step 7: End

5.3. HARDWARE USED

5.3.1. Waterproof Ultrasonic Sensor- AJSR04M

The AJSR04M Waterproof Ultrasonic Sensor, renowned for its multifunctionality in obstacle detection and water level monitoring, operates on ultrasonic wave emission principles. Its waterproof construction ensures robust performance in adverse conditions, making it ideal for outdoor applications such as water tank management and marine operations. Structurally comprising an operating board and a transducer, the sensor calculates distances by analyzing the time taken for emitted audio pulses to return after interacting with water surfaces. This functionality facilitates precise distance measurements, rendering the sensor indispensable for accurate water level assessments and obstacle detection tasks in technical domains.



Figure 5.3 AJ- SR04M and Circuit board

Specifications

- Operating voltage: DC 5V
- Quiescent current: 5mA
- Total current draw: 30mA
- Frequency: 40khz
- Range: 25cm to 450cm
- Resolution: about 0.5cm
- Beam Angle: less than 50 degrees
- Working temperature: -10 ~ 70 Celsius
- Storage temperature: -20 ~ 80 Celsius

Basic Working Principle

- Switch TRIG Pin on to 5V for a minimum of 10 microseconds.
- A total of eight 40 kHz ultrasonic wave bursts are released by the ultrasonic sensor module.
- When these waves of energy come into contact with an object, they reverberate backward onto the sensing device after traveling through the air.
- The ECHO pin generates a high-level signal when it detects the reflected signal.
- We may calculate the distance to the item by timing how long it takes for the

signal's reflection to be received immediately following transmitting (Time to Receive Reflected Signal).

- Distance may be determined by applying a formula as follows: $\text{Distance} = (\text{Time to Receive Reflected Signal} * \text{Sound Speed (340 m/s)}) / 2$.
- The ultrasonic wave's all-encompassing travel time is calculated by dividing by two.



Figure 5.4 Obstacle Detection

Modes of Operation

- i. Traditional Trigger and Echo Mode
- ii. Automatic Serial Port Mode
- iii. Controlled Serial port mode
- iv. PWM Output
- v. Low Power Auto Mode
- vi. 1.5 meter Switch

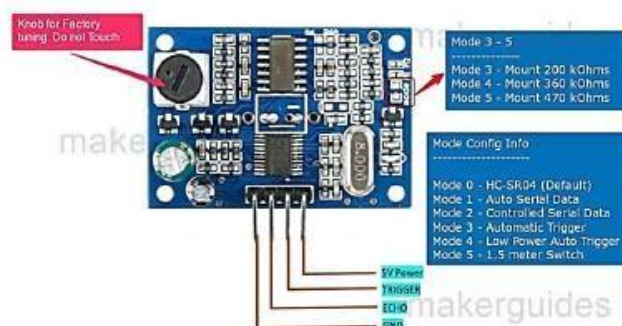


Figure 5.5 AJ-SR04M Modes of Operation

Application

- Investigation and artificial intelligence
- Longitudinal separation
- Avoiding obstacles and using computerized maneuvering
- Regulation of transportation
- The industrial surveillance and safety
- Investigation and artificial intelligence

5.3.2. LORA Module – SX1278

The SX1278 LoRa module by Semtech enables long-range wireless communication with low power usage, operating between 137MHz to 525MHz. Its high sensitivity allows communication over hundreds of meters in urban and kilometers in rural areas, making it reliable in various conditions. Supported by open-source libraries, it seamlessly integrates with platforms like Arduino and Raspberry Pi, facilitating rapid deployment in IoT projects for scalable and dependable networks.



Figure 5.6 LoRa SX1278 Module

Features and Specifications

- Maximum link budget: 168dB LoRa™ Modem
- Constant RF output: +20dBm - 100mW vs. V supply
- High efficiency PA: +14dBm
- Programmable bit rate: Up to 300kbps

- High sensitivity: Down to -148dBm
- Maximum link budget: 168dB LoRa™ Modem
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- Programmable bit rate: Up to 300kbps
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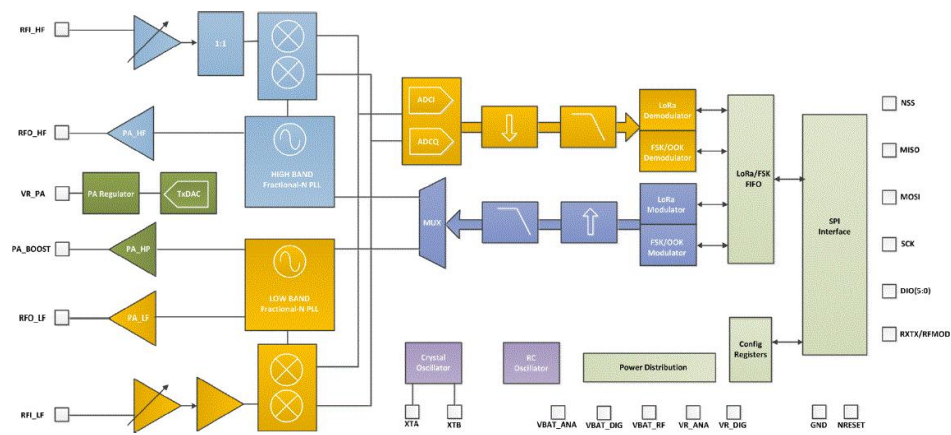


Figure 5.7 LoRa SX1278 Internal Block Diagram

Applications

- Autonomous Utility Scanning
- The computerization for Homes in addition to Buildings
- Networks for wireless communication Surveillance and Alerts
- Supervision and Controlling in Industry
- Extended-range Watering Systems

LORA Communication Protocol

Semtech's LoRa communication protocol is transforming IoT connectivity, operating in unlicensed frequency bands like 433MHz, 868MHz, or 915MHz for long-range data transmission with minimal power consumption. Its high sensitivity and interference tolerance ensure reliable communication over vast distances,

making it ideal for diverse IoT applications. LoRa's scalability, adjustable data rates, and long-range capabilities enable cost-effective and resilient IoT networks, empowering industries from agriculture to industrial automation with innovative solutions.

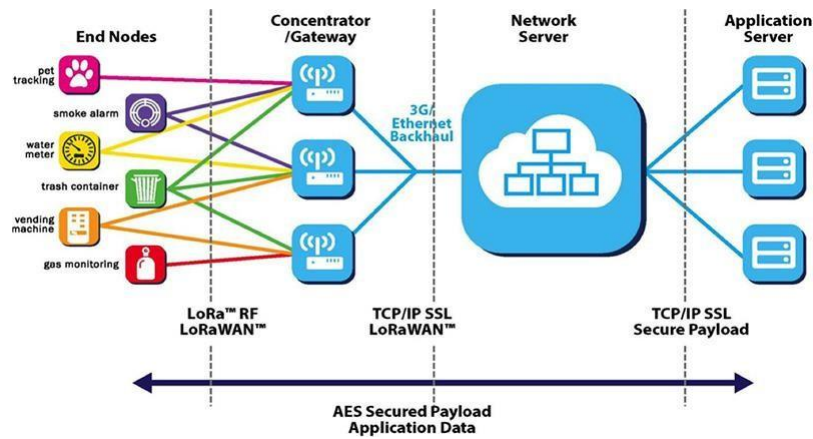


Figure 5.8 LORA Communication Protocol

5.3.3. Arduino UNO

The Arduino Uno is a versatile microcontroller board with an accessible interface and an intuitive IDE, facilitating code development and deployment. Its C/C++ programming language allows seamless integration with various sensors and actuators through digital and analog ports. With a clock speed of 16 MHz and support for voltages ranging from 7 to 12V, it offers ample processing power and flexibility. Equipped with 2 KB of SRAM, 1 KB of EEPROM, and 32 KB of flash memory, it can handle a wide range of tasks, from basic data processing to complex LED control. Its user-friendly design makes it suitable for professionals, beginners, and enthusiasts alike, enabling easy realization of electrical projects.

Features and Specifications

- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Inout Voltage (limit): 6-20V

- Digital I/O Pins: 14 (of which 6 provide PWM output)
- PWM Digital I/O Pins: 6
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)
- Clock Speed: 16 MHz
- LED_BUILTIN: 13
- Length & Width: 68.6 mm & 58.4 mm
- Weight: 25 g

Powering the Arduino Uno on

The Arduino Uno board can be powered via USB or an external source, automatically switching between the two. External power options include batteries or AC-to-DC adapters, connected via a 2.1mm center-positive connector. Battery leads can also be connected to the board's GND and Vin pin headers. For optimal performance, the recommended voltage range is 7 to 12 volts, avoiding potential damage to the voltage regulator.

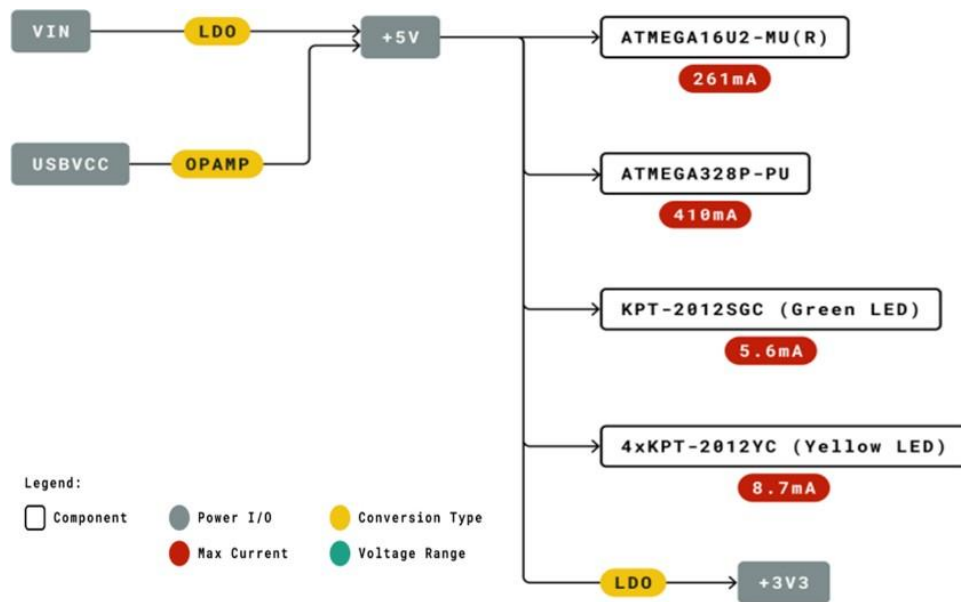


Figure 5.9 Arduino UNO Power Tree

Arduino Uno Pin Out

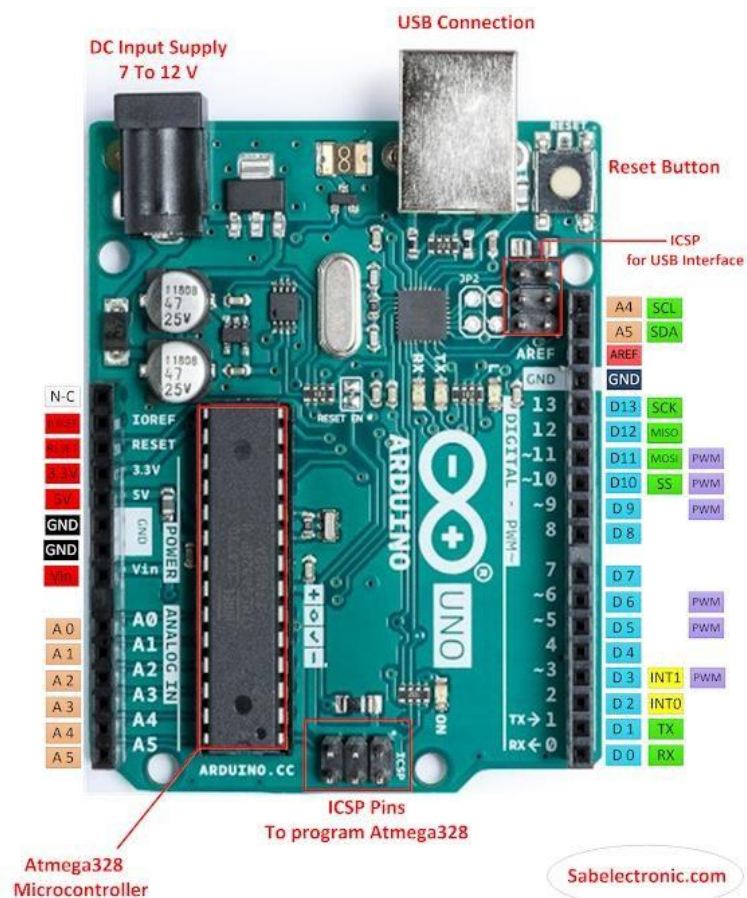


Figure 5.10 Arduino UNO Pinout

Pin Type	Pin Name	Function
<i>Power</i>	Vin, 3.3V, 5V, GND	Vin: voltage that the Arduino receives when powered externally. 5V: A regulating power source that powers the board's microprocessor 3.3V: The voltage generated on-board is 3.3V supply. 50mA is the max current draw. GND: ground pins.
<i>Reset</i>	Reset	Resets the microcontroller.
<i>Analog Pins</i>	A0-A5	supply an analog input with values between 0-5V
<i>I/O Pins</i>	Input/output Pins	Input Output Pins
<i>Serial</i>	0(Rx), 1(Tx)	TTL serial data sending and receiving data.
<i>External Interrupts</i>	2, 3	To set off an interruption
<i>PWM</i>	3, 5, 6, 9, 11	8-bit PWM output is enabled.
<i>SPI</i>	10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK)	Utilized for SPI communications.
<i>Inbuilt LED</i>	13	To activate the built-in LED.
<i>TWI</i>	A4 (SDA), A5 (SCA)	Utilized for communication inside TWI.
<i>AREF</i>	Analogue REFerence	To supply the input voltage's reference.

Table 5.1: Arduino UNO pin out

Applications

- Kiosk in the Parking Garage
- Transport Signal Countdown timer Chronometer

- Railroad Critical Lighting with Embedded System
- Health care Device Protection and security settings Framework
- Automation Systems for Homes and Businesses
- Creation of an Automated processes Framework
- Digital Intelligent robots and the electronics sector
- Developing fundamental circuit schematics.

5.3.4. ESP32-WiFi Module

The ESP32 processor, renowned for its dual-core processing capability and integrated Bluetooth and Wi-Fi connectivity, serves as a key component in the project. With two powerful Xtensa LX6 CPUs running at up to 240 MHz, it provides robust processing power. Its built-in Wi-Fi module supports protocols such as 802.11 b/g/n and 802.11ac, enabling high-speed data transfer and seamless connectivity to IoT networks.

In the project, the ESP32 acts as the receiver, responsible for wirelessly receiving water depth data transmitted by the LoRa module. Upon reception, it processes the data for accuracy and integrity before forwarding it to the Blynk IoT cloud platform for further analysis and storage, thus facilitating real-time monitoring and remote access.

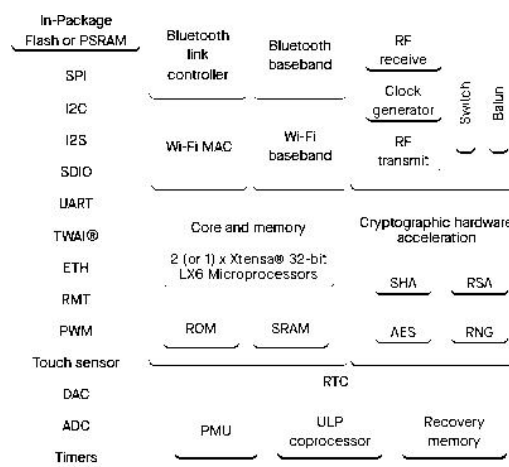


Figure 5.11 ESP32 Functional Block Diagram

Features and Specifications

- Single or Dual-Core 32-bit LX6 Microprocessor with clock frequency up to 240 MHz.
- 520 KB of SRAM, 448 KB of ROM and 16 KB of RTC SRAM.
- Supports 802.11 b/g/n Wi-Fi connectivity with speeds up to 150 Mbps.
- Support for both Classic Bluetooth v4.2 and BLE specifications.
- 34 Programmable GPIOs.
- Up to 18 channels of 12-bit SAR ADC and 2 channels of 8-bit DAC
- Serial Connectivity include 4 x SPI, 2 x I2C, 2 x I2S, 3 x UART.
- Ethernet MAC for physical LAN Communication (requires external PHY).
- 1 Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI.
- Motor PWM and up to 16-channels of LED PWM.
- Secure Boot and Flash Encryption.
- Cryptographic Hardware Acceleration for AES, Hash (SHA-2), RSA, ECC and RNG.

ESP32 Peripherals and I/O

Peripheral Pins	Functions
15 ADC channels	15 channels of 12-bit SAR ADC with selectable ranges of 0-1V, 0-1.4V, 0-2V, or 0-4V
2 UART interfaces	2 UART interfaces with flow control and IrDA support
25 PWM outputs	25 PWM pins to control things like motor speed or LED brightness
2 DAC channels	Two 8-bit DACs to generate true analog voltages
SPI, I2C and I2S interface	Three SPI and one I2C interfaces for connecting various sensors and peripherals, as well as two I2S interfaces for adding sound to your project

9 Touch Pads	9 GPIOs with capacitive touch sensing
--------------	---------------------------------------

Table 5.2: ESP32 Peripherals and I/O

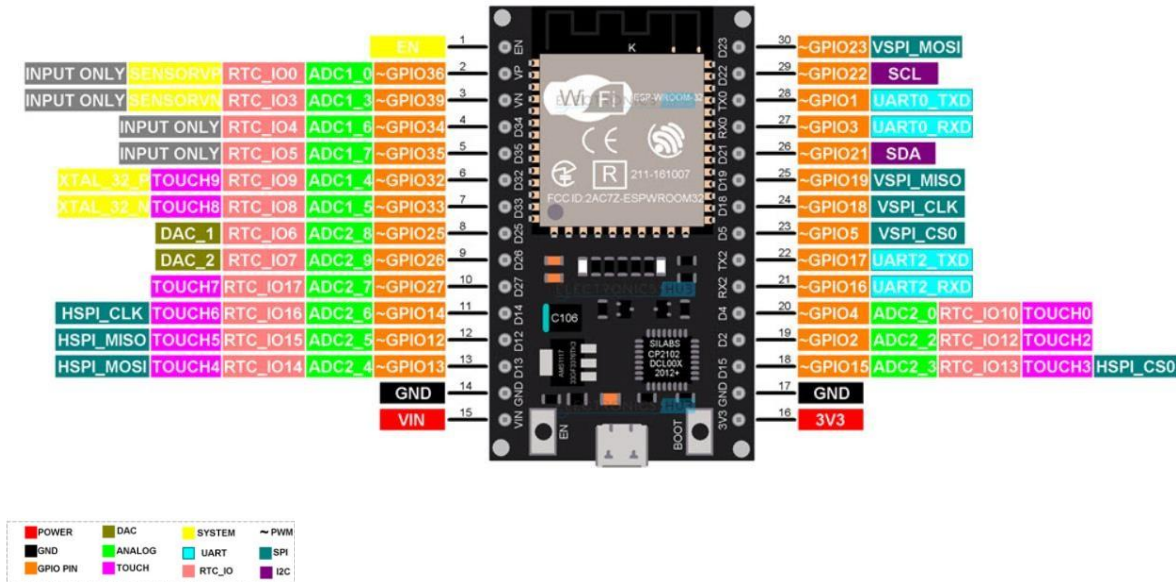


Figure 5.12 ESP32 Pinout

5.3.5 Drone

Pixhawk 2.4 is a popular autopilot system designed for various unmanned aerial vehicles (UAVs) including quadcopter drones. It's an open-source autopilot system that provides advanced features for autonomous flight, including stabilization, waypoint navigation, and mission planning capabilities.

The Pixhawk 2.4 autopilot system enhances our project's efficiency with precise flight control and autonomous navigation capabilities. Its redundancy features ensure reliable operation during data collection flights, while its compatibility and expandability enable seamless integration with our UAV platform. Additionally, the open-source software allows customization to meet specific project requirements, optimizing performance for water depth measurement tasks

Specifications

- **Processor**
 - 32-bit ARM Cortex M4 core with FPU
 - 168 Mhz/256 KB RAM/2 MB Flash
 - 32-bit failsafe co-processor
- **Sensors**
 - MPU6000 as main accel and gyro
 - ST Micro 16-bit gyroscope
 - ST Micro 14-bit accelerometer/compass (magnetometer)
 - MEAS barometer
- **Power**
 - Ideal diode controller with automatic failover
 - Servo rail high-power (7 V) and high-current ready
 - All peripheral outputs over-current protected, all inputs ESD protected
- **Interfaces**
 - 5x UART serial ports, 1 high-power capable, 2 with HW flow control
 - Spectrum DSM/DSM2/DSM-X Satellite input
 - Futaba S.BUS input (output not yet implemented)
 - PPM sum signal
 - RSSI (PWM or voltage) input
 - I2C, SPI, 2x CAN, USB
 - 3.3V and 6.6V ADC inputs
- **Dimensions**
 - Weight 38 g (1.3 oz)
 - Width 50 mm (2.0")
 - Height 15.5 mm (.6")
 - Length 81.5 mm (3.2")

5.4 SOFTWARE USED

5.4.1. *Blynk IoT Cloud Storage*

Blynk is an IoT infrastructure service facilitating lightweight code development and management of networked components. It offers firmware archives, an intuitive app builder, and secure cloud encryption. Acting as a central hub, Blynk enables data gathering, presentation, and storage for water depth measurements from UAV-based systems. The ESP32 microcontroller, at the receiver side, processes sensor data from the LoRa module and sends it to Blynk for real-time monitoring and control. With Blynk's user-friendly interface, users can access data visualization, generate reports, set alerts, and conduct analysis via the mobile app or web dashboard.

The Blynk platform consists of:

- Deployment of devices
- Interpretation of sensor data
- Utilizing mobile and web applications for surveillance
- Upgrades to firmware over the internet
- Analytical tools of data
- Notifications for user and access management
- Automated system

The platform consists of the following three main parts:

- i. The Blynk App: With the help of the numerous available widgets, you may use it to develop stunning interfaces for your projects.
- ii. Server Blynk: All of the engagement between the equipment and the handset are handled by it. You can host your personal Blynk server locally or utilize the Blynk Cloud. It can run on a Raspberry Pi, is free and open-sourced and can effortlessly manage thousands of devices.
- iii. Blynk Libraries: It allows all of the widely used hardware platforms to

communicate with the hosting platform and processes all incoming and outgoing commands.



Figure 5.13 Blynk process layout

The process that occurs when someone presses the Button in the Blynk application is that the data will move to Blynk Cloud, where data magically finds its way to the hardware that has been installed. It works in the opposite direction and everything happens in a blink of an eye are shown in Figure 4.16.

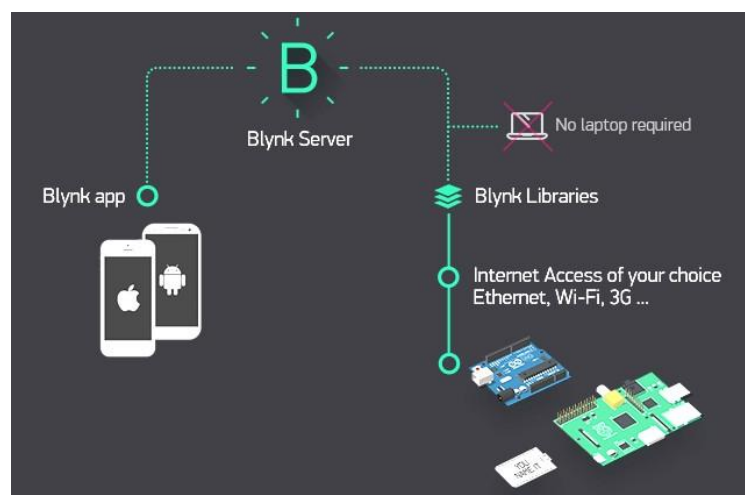


Figure 5.14 Blynk Server

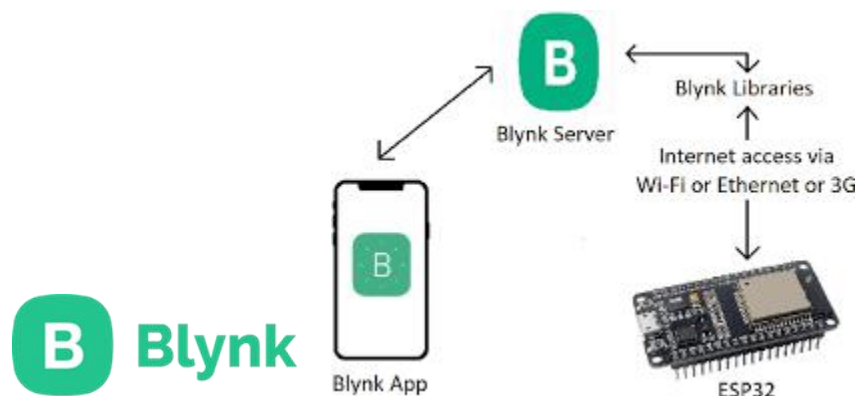


Figure 5.15 Blynk to ESP32

5.4.2. Arduino IDE



Figure 5.16: Arduino IDE

The standard software tool for programming Arduino microcontroller boards is the Arduino Integrated Development Environment (IDE). It functions as the main interface via which users compose, assemble, and upload code to their Arduino boards. Whether you're an experienced developer, trainee, or enthusiast in electronics, the Arduino IDE offers a feature-rich user experience that makes it easy to create embedded projects.

Key components and features of the Arduino IDE:

i. Editor:

The Arduino IDE's code editor streamlines programming with syntax highlighting, auto-indentation, and auto-completion, supporting C and C++ languages. Its user-friendly interface includes menus for file management, editing, and sketch creation, with a bottom section displaying compilation progress and errors. Sketches, saved as .ino files, are developed within the IDE's text editor for Arduino-based applications.

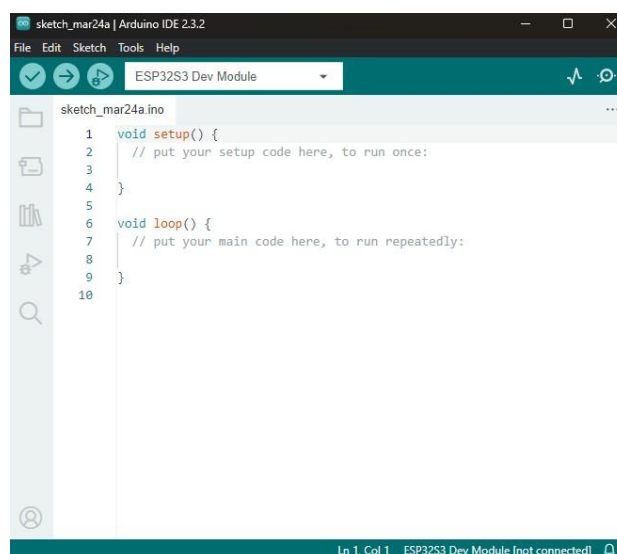


Figure 5.17: Arduino IDE Sketch window

	<i>Verify</i> Checks your code for errors compiling it.
	<i>Upload</i> Compiles your code and uploads it to the configured board.
	<i>New</i> Creates a new sketch.
	<i>Open</i> Presents a menu of all the sketches in your sketchbook. Clicking one will open it within the current window overwriting its content.
	<i>Save</i> Saves your sketch.
	<i>Serial Monitor</i> Opens the serial monitor.

Table 5.3: 6 Buttons of Menu bar

ii. Uploader:

To upload code to the Arduino board using the IDE, ensure the correct board type and port are selected from the Tools menu. Then, click the upload button or choose Upload from the Sketch menu. For older chips without auto-reset, manually reset the board before uploading. During upload, the RX and TX LEDs will blink, and upon completion, the IDE will display a notification or error message.

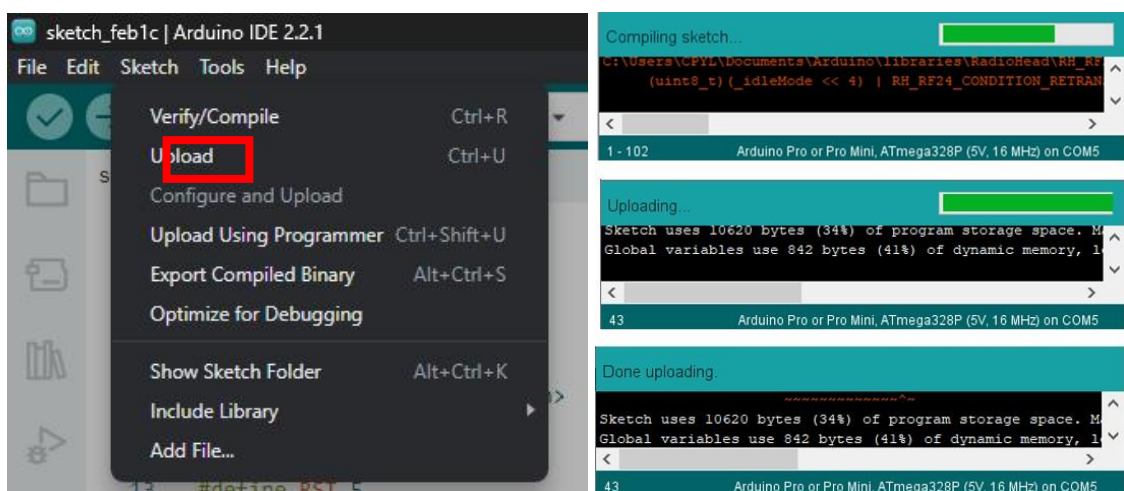


Figure 5.18: Arduino IDE Uploading

iii. Serial Monitor:

The Arduino IDE includes a serial monitor utility that enables bidirectional communication between the Arduino board and the computer via the serial port. This facilitates real-time data display, keyboard-based programming, and troubleshooting. Positioned beneath the editor section by default, users can configure the layout for optimal use of space.

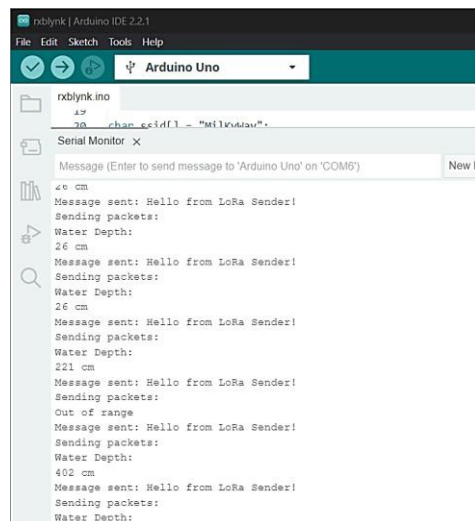


Figure 5.19: Serial Monitor

iv. Libraries:

Arduino libraries simplify development by integrating complex features like sensors and communication protocols. The IDE's tools streamline library management, while abstracting technical details allows focus on application logic. Custom libraries support project-specific functionalities, and extensive documentation fosters innovation.

Installing Required Libraries:

To install these libraries:

- Install it using the Arduino Library manager ("Sketch" -> "Include Library" -> "Manage Libraries..."), or
- Download a zip file from GitHub using the "Download ZIP" button and install it using the IDE ("Sketch" -> "Include Library" -> "Add .ZIP Library...")

a) NewPing:

NewPing library optimizes Arduino ultrasonic sensor performance, addressing issues like inconsistent results and slow response times. With features such as continuous operation and broad sensor compatibility, it enables accurate and responsive distance detection for various applications, from robotics to proximity monitoring.

b) LoRa:

The LoRa library enables Arduino developers to harness long-range transmission and low power consumption for applications like smart agriculture. With an intuitive API, it simplifies configuration of LoRa transceivers such as the SX127x series, offering flexibility in device connections and extended battery life for remote deployments.

c) WiFi:

The <WiFi.h> library simplifies Wi-Fi connectivity for Arduino projects, enabling internet and local network connections without the need for extensive networking knowledge. It streamlines Wi-Fi setup by handling network credential specification and supports encryption schemes like WPA2 for secure data transmission, freeing developers to focus on application logic.

d) WiFiClient:

<WiFiClient.h> is indispensable for Arduino projects needing Wi-Fi connectivity, facilitating bidirectional communication with remote servers. Its simple functions streamline connection setup and data transmission, while built-in support for encrypted protocols ensures secure communication with minimal resource usage.

e) BlynkSimpleEsp32:

<BlynkSimpleEsp32.h> is essential for ESP32 projects connecting to the Blynk IoT platform, simplifying communication setup and enabling bidirectional internet control. With support for various Blynk widgets and advanced features like push notifications, it ensures smooth integration across diverse project requirements via Ethernet and Wi-Fi connectivity.

5.5. TRANSMITTER MODULE

The transmitter module serves as a pivotal component in our water depth measurement system designed for UAVs. At its core lies a waterproof ultrasonic sensor, the AJ SR04M, which emits sound waves into the water. These waves penetrate underwater, bounce off the waterbed, and return to the sensor, providing crucial distance measurements. The collected data is then transmitted to the ground station using a LoRa SX1278 Module, seamlessly integrated with an Arduino UNO microcontroller.

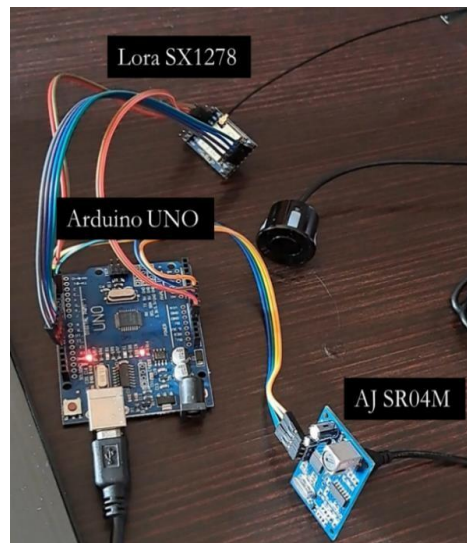


Figure 5.20: Transmitter Module

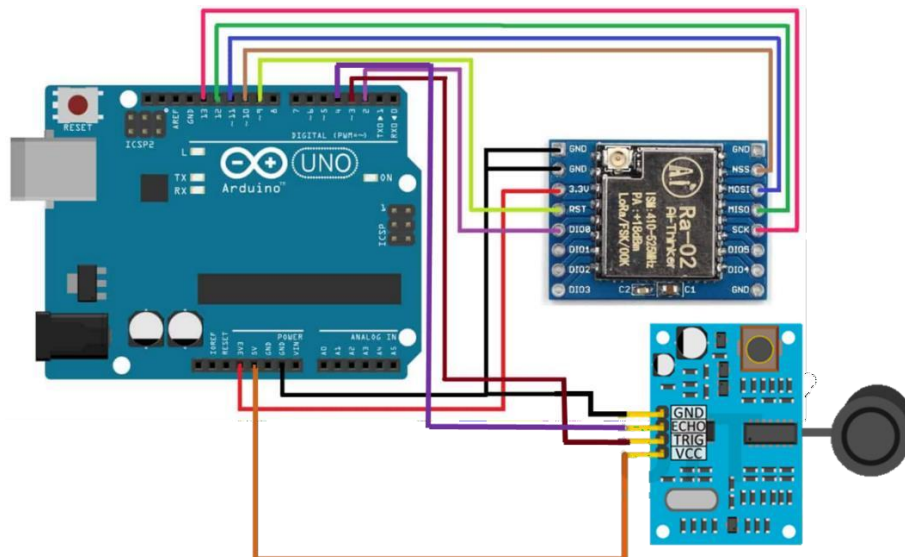


Figure 5.21: Connection of Arduino UNO to LoRa and Sensor

This combination enables efficient communication of water depth information over long distances, facilitating real-time monitoring and analysis. By leveraging these technologies, our system offers a reliable and versatile solution for measuring water depths in various environmental settings.

LoRa SX 1278	Arduino UNO
NSS	10
MOSI	11
MISO	12
SCK	13
GND	GND
VCC	3.3V
RST	9
Dio0	2

Table 5.4: Pin connections of transmitter Module (1)

Arduino UNO	JSN SR04T
5V	5V
4	Trig
3	Echo

Table 5.5: Pin connections of Transmitter (2)

5.6. RECEIVER MODULE

The receiver module is in charge of receiving data from the UAV and this Real-time monitoring gives the ground station the ability to monitor at all times. This includes analyzing and showcasing the data gathered from the UAV, including the water depth readings. The sensor data is wirelessly received by an ESP32 microcontroller at the receiver side, which is linked to another LORA module. After processing, the data is stored in the Blynk IoT cloud platform by the ESP32. Blynk functions as the primary center for compiling, displaying, and archiving water depth information, enabling remote access and examination.

The Blynk IoT platform and the ESP32 microcontroller are used in our system to process and analyze water depth data that the UAV collects in real time. This all-encompassing method improves the efficacy and precision of measuring water depth, which makes it appropriate for a variety of uses in hydrology, environmental monitoring, and related disciplines.

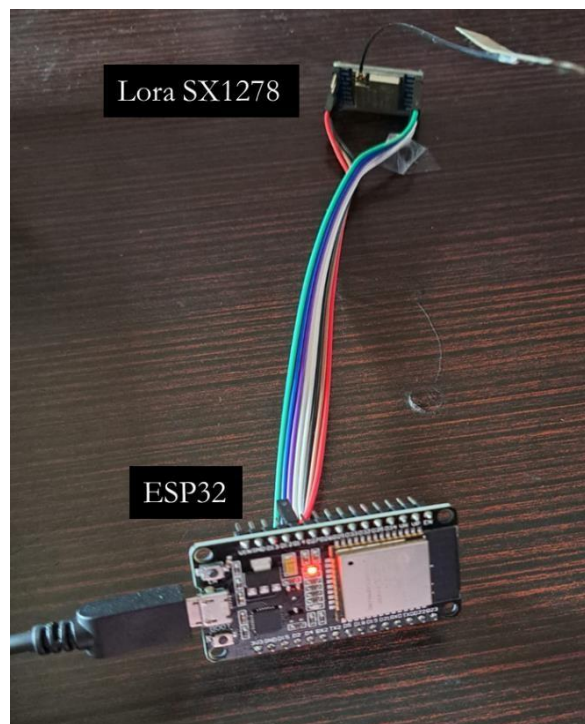


Figure 5.22: Receiver Module

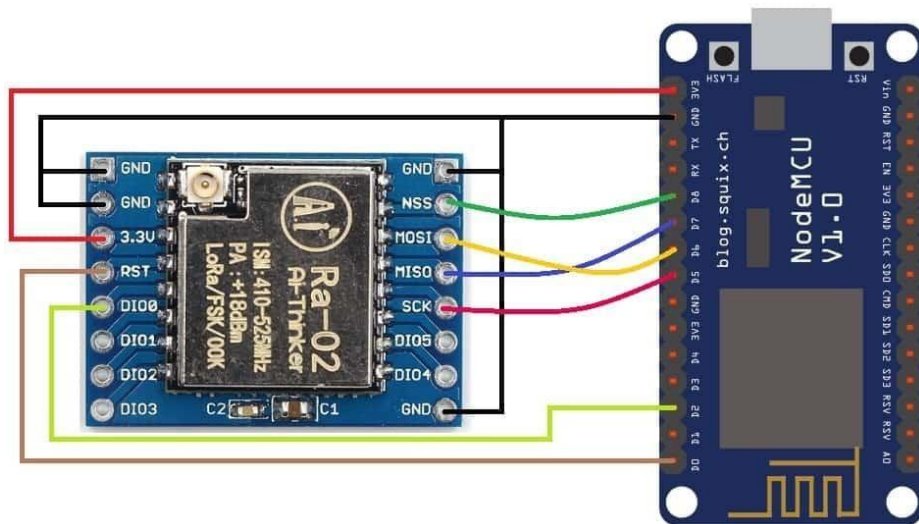


Figure 5.23: Connection of Lora SX1278 and ESP32

LoRa SX 1278	ESP32 Wi-Fi
NSS	IO 4
MOSI	IO 3
MISO	IO 19
SCK	IO 18
GND	GND
VCC	3.3V
RST	IO 5
Dio0	IO 2

Table 5.6: Pin connections of Receiver Module

CHAPTER 6

6. RESULTS AND DISCUSSIONS

The project successfully implemented a system for monitoring and storing water depth measurements in an IoT cloud network. By integrating a waterproof ultrasonic sensor, LoRa communication technology, and the ESP32 microcontroller, accurate and real-time data transmission was achieved. Our integrated system provides a smooth solution for water depth measuring using unmanned aerial vehicles (UAVs) and produces insightful data for multiple applications. Our solution gives the capability to manage and preserve water resources by collecting, processing, and storing data remotely. This allows users to take preventative steps and make well-informed decisions. The results gathered from measuring across different water bodies is tabulated.

WATER LEVEL IN WATER BODIES		WATER DEPTH MEASURED IN SENSOR		ACCURACY (In %)
Depth (In)	Depth (cm)	Depth (In)	Depth (cm)	
14	35.56	11.8	30	84.285%
20	50.8	18.5	47	92.5%

Table 6.1: Results of Water Depth Measurement in different water bodies



Figure 6.1: Integration of hardware components with the drone



Figure 6.2: Sensor transducer measuring water depth from drone

Figure 6.2 depicts the sensor transducer mounted on the drone, measuring water depth. This transducer, equipped with the AJ SR04M ultrasonic sensor, emits sound waves that penetrate the water surface, bounce off the waterbed, and return data to determine the depth. This data is crucial for various applications such as environmental monitoring and hydrology.

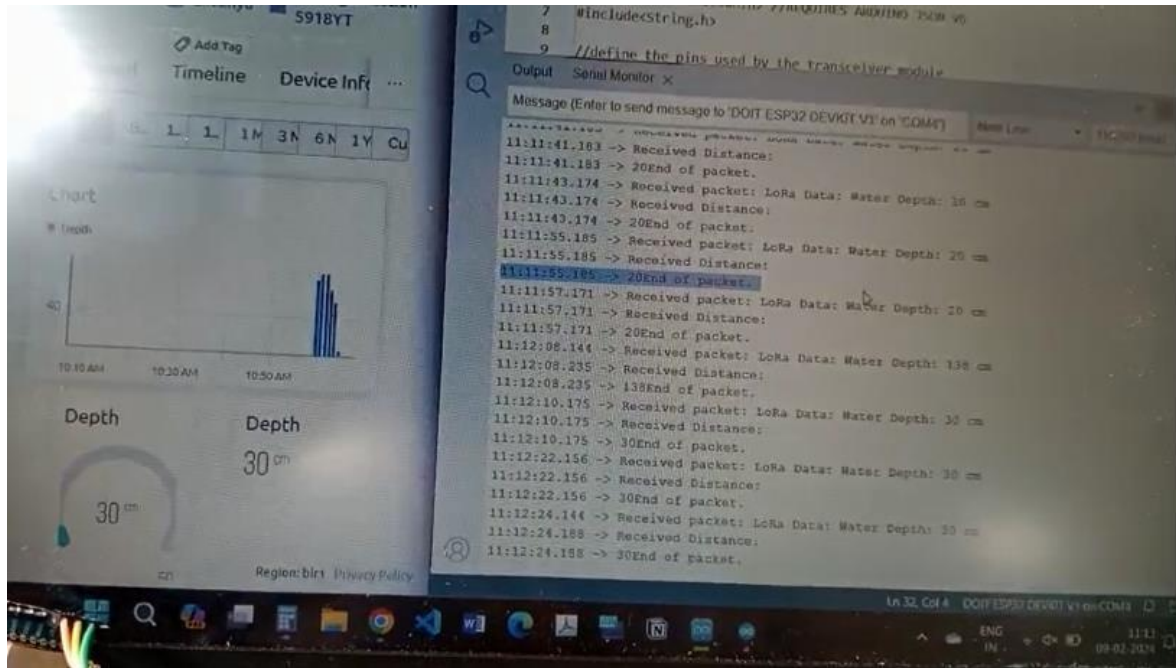


Figure 6.3: Real-time Water depth analysis

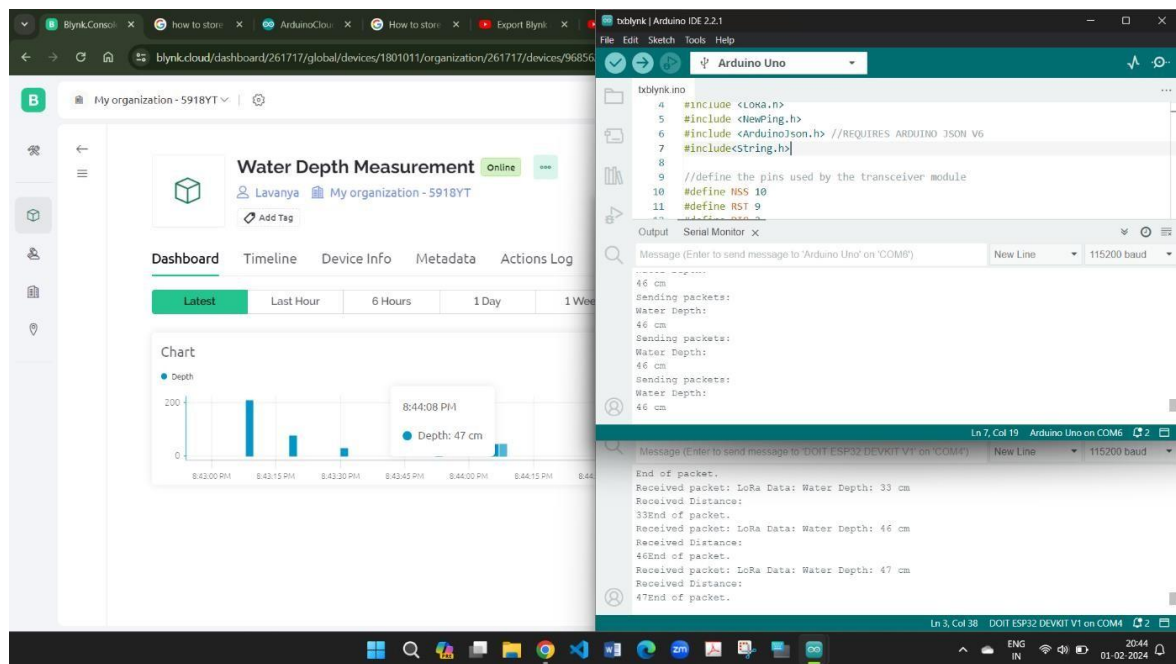


Figure 6.4: Monitoring water depth in IoT Cloud Network

Figure 6.3 and Figure 6.4 showcases remote water depth monitoring and analysis capabilities facilitated by the Blynk IoT cloud platform, empowering users to analyze water depth data remotely.

CHAPTER 7

7. CONCLUSION AND FUTURE WORK

7.1.CONCLUSION

In conclusion, the developed system offers a comprehensive solution for environmental monitoring and hydrology applications through the integration of UAVs and IoT cloud technologies. By effectively utilizing ESP32 microcontrollers, LoRa communication modules, and waterproof ultrasonic sensors, precise water depth data can be transmitted to the Blynk IoT cloud platform in real-time. This enables remote monitoring and storage of water depth measurements, facilitating easy access and analysis from any internet-connected device. Overall, the system presents practical and efficient solutions for environmental monitoring and hydrology, with the potential to enhance data gathering and analysis processes in related disciplines. Further development and refinement could broaden its applications and improve efficiency in water depth monitoring and management practices.

7.2.FUTURE WORK

In future work, expanding the sensor capabilities to include depth extension beyond the current range could be explored. This extension may involve integrating additional sensors or enhancing the existing sensor technology to accurately measure greater depths of water. By increasing the depth range, the system could cater to a wider range of applications, especially in areas with deeper water bodies or varying water levels. Moreover, implementing machine learning algorithms could enable predictive modeling and anomaly detection based on the collected data. Additionally, research and development efforts could focus on optimizing sensor performance in challenging underwater environments, such as murky or turbulent waters, to ensure reliable and accurate data collection under diverse conditions.

REFERENCES

- [1] Balestrieri E, Daponte P, De Vito L, Lamonaca F. Sensors and Measurements for Unmanned Systems: An Overview. *Sensors*. 2021; 21(4):1518. <https://doi.org/10.3390/s21041518>
- [2] Catsamas S, Shi B, Wang M, Xiao J, Kolotelo P, McCarthy D. A Low-Cost Radar-Based IoT Sensor for Noncontact Measurements of Water Surface Velocity and Depth. *Sensors*. 2023; 23(14):6314. <https://doi.org/10.3390/s23146314>.
- [3] Du, Y., Luo, C., Chen, F., Zhang, Q., Zhou, Y., Jang, K.-S., Zhang, Y., Song, C., Zhang, Y., Zhang, Y. and Lu, Y. (2022), Water depth and transparency drive the quantity and quality of organic matter in sediments of Alpine Lakes on the Tibetan Plateau. *Limnol Oceanogr*, 67: 1959-1975. <https://doi.org/10.1002/lno.12180>
- [4] Elkhachy I. Flash Flood Water Depth Estimation Using SAR Images, Digital Elevation Models, and Machine Learning Algorithms. *Remote Sensing*. 2022; 14(3):440.
- [5] Hao A, Kobayashi S, Huang H, Mi Q, Iseri Y. 2020. Effects of substrate and water depth of a eutrophic pond on the physiological status of a submerged plant, *Vallisneria spiralis*. *PeerJ* 8:e10273.
- [6] Kim H, Jeon C, Kim K, Seo J. Uncertainty Assessment of Wave Elevation Field Measurement Using a Depth Camera. *Journal of Marine Science and Engineering*. 2023; 11(3):657.
- [7] Langhammer, J.; Bernsteinová, J.; Miřijovský, J. Building a High-Precision 2D Hydrodynamic Flood Model Using UAV Photogrammetry and Sensor Network Monitoring. *Water* 2022, 9, 861.
- [8] Lewicka O, Specht M, Stateczny A, Specht C, Dardanelli G, Brčić D, Szostak B, Halicki A, Stateczny M, Widźgowski S. Integration Data Model of the Bathymetric Monitoring System for Shallow Waterbodies Using UAV and USV Platforms. *Remote Sensing*. 2022; 14(16):4075. <https://doi.org/10.3390/rs14164075>

- [9] Loubna Hamami, Bouchaib Nassereddine, Application of wireless sensor networks in the field of irrigation: A review, *Computers and Electronics in Agriculture*, Volume 179, 2020, 105782, ISSN 0168-1699, <https://doi.org/10.1016/j.compag.2020.105782>.
- [10] Manmeet Singh, Suhaib Ahmed, IoT based smart water management systems: A systematic review, *Materials Today: Proceedings*, Volume 46, Part 11, 2021, Pages 5211-5218, ISSN 2214-7853, <https://doi.org/10.1016/j.matpr.2020.08.588>.
- [11] Rumki Khatun, Swapan Talukdar, Swades Pal, Sonali Kundu, Measuring dam induced alteration in water richness and eco-hydrological deficit in flood plain wetland, *Journal of Environmental Management*, Vol. 285, 2021, 112157, ISSN 0301-4797.
- [12] Shi B, Catsamas S, Kolotelo P, Wang M, Lintern A, Jovanovic D, Bach PM, Deletic A, McCarthy DT. A Low-Cost Water Depth and Electrical Conductivity Sensor for Detecting Inputs into Urban Stormwater Networks. *Sensors*. 2021; 21(9):3056. <https://doi.org/10.3390/s21093056>
- [13] Sun K, Cui W, Chen C. Review of Underwater Sensing Technologies and Applications. *Sensors*. 2021; 21(23):7849. <https://doi.org/10.3390/s21237849>
- [14] Tauro, F.; Porfiri, M.; Grimaldi, S. Surface flow measurements from drones. *J. Hydrol.* 2021, 540, 240–245.
- [15] Youfei Hu, Haiyan Yang, Haolan Zhou, Qianwen Lv, A Review of Numerical Modelling of Morphodynamics in Braided Rivers: Mechanisms, Insights and Challenges, *Water*, 10.3390/w15030595, 15, 3, (595), (2023).

APPENDIX

A. TRANSMITTER SOURCE CODE

```
//Including arduino default SPI library
#include <SPI.h>
//Including LoRa library
#include <LoRa.h>
#include <NewPing.h>
#include <ArduinoJson.h> //REQUIRES ARDUINO JSON V6
#include<String.h>

//define the pins used by the transceiver module
#define NSS 9
#define RST 1
#define DI0 7
#define TRIGGER_PIN 4 // Define the trigger pin (D1)
#define ECHO_PIN 3    // Define the echo pin (D2)

NewPing sonar(TRIGGER_PIN, ECHO_PIN); // Create an instance of the NewPing
library

void setup() {
    //initialize Serial Monitor
    Serial.begin(9600);

    //attachInterrupt(BUTTON, ISR, FALLING);
    Serial.println("LoRa Sender");

    while (!LoRa.begin(433E6))
        {Serial.println(".");
        delay(500);
        }

    Serial.println("LoRa Initializing Successful!");
}

void loop() {
    //Serial.print("Sending packet: ");

    int distance = sonar.ping_cm(); // Send a ping and get the distance in
centimeters
    Serial.print ("Sending packets: ");

    LoRa.beginPack ();
    //LoRa.print(message);
```

```

    if (distance = 0) {
        LoRa.print("Out of range"); // Print a message if the sensor is out of
range
    } else if {
        LoRa.print("Water Depth: ");
        LoRa.print(distance);
        LoRa.print(" cm"); // Print the water depth in centimeters
    }

    if (distance = 0) {
        Serial.println("Out of range"); // Print a message if the sensor is out
of range
    } else {
        Serial.print ("Water Depth: ");
        Serial.print(distance);
        Serial.print(" cm"); // Print the water depth in centimeters
    }

    LoRa.endPack ();

    delay(500);
}

```

B. RECEIVER SOURCE CODE

```
#define BLYNK_TEMPLATE_ID "TMPL6frG0IgfB"
#define BLYNK_TEMPLATE_NAME "Water depth"
#define BLYNK_AUTH_TOKEN "a5oU25ghjogNMfghgqTEDDY3Y"
#define BLYNK_PRINT Serial

#include <SPI.h>
#include <LoRa.h>
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>

#define NSS 4
#define RST 5
#define DIO 2

char ssid[] = "mil**Wifi";
char pass[] = "WIFI1**201";

BlynkTimer timer;

String LoRaData;

BLYNK_WRITE(V0)
{
  int value = parm.asInt();
  Blynk.virtualWrite(V0, value);
}

// new void sensor data
void sendSensor() {
  int packetSize = LoRa.parsePacket();

  if (packetSize)
  { Serial.print("Received packet:
    ");

    while (LoRa.available ())
    { LoRaData = LoRa.
      String();
      Serial.println("LoRa Data: " + LoRaData);

      // Extract the numeric value from the LoRaData string
      int indexOfCm = LoRaData.indexOf(" cm");
      int receivedDistance = 0;

      if (indexOfCm == -1) {
```

```

    int endIdx = indexOfCm;
    String distanceStr = LoRaData.substring(startIdx, endIdx);

    receivedDistance = distance.toInt();
    Serial.println("Received Distance: " );

} else {
    Serial.println("Error: 'cm' not found in LoRaData");
}

// Generate a unique timestamp for each update
long currentMillis = millis();

Blynk.virtualWrite(V0, receivedDistance);
delay(1000); // Adjust the delay as needed
}

Serial.println("End of packet.");
}
}

void setup()
{
    Serial.begin(9600);
    Serial.println("LoRa Receiver");

    while (!LoRa.begin(433E6))
    {
        Serial.println(".");
        delay(500);
    }

    Serial.println("LoRa Initializing Successful!");

    Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
    timer.setInter (1000L, sendSensor);
}

void loop()
{
    Blynk.run();
    ;
    timer.run();
}

```

C. IEEE STANDARDS

- 1) **IEEE 802.15.4g**: This standard also known as Smart Utility Networks (SUN), is relevant to LoRa technology, providing specifications for low-power, low-data-rate wireless networks, particularly in smart grid applications. However, LoRa itself is not standardized by IEEE; it is developed by the LoRa Alliance.
- 2) **IEEE 802.11**: This standard specifies the protocols for wireless local area networks (WLANs), commonly known as Wi-Fi. It may be applicable if Wi-Fi communication is utilized in any part of the project.
- 3) **IEEE 802.16**: Also known as WiMAX, this standard specifies the air interface for broadband wireless metropolitan area networks (MANs). If long-range wireless communication is implemented using WiMAX, this standard would apply.
- 4) **IEEE 802.1X**: This standard specifies port-based network access control, which may be relevant for ensuring secure access to the network components in the project.
- 5) **IEEE 802.11i**: This standard specifies security mechanisms for Wi-Fi networks, including encryption and authentication protocols. It could be relevant for ensuring the security of wireless communications in the project.
- 6) **IEEE 802.15.1**: Also known as Bluetooth, this standard specifies protocols for short-range wireless communication. It may be relevant if Bluetooth technology is used in any aspect of the project.

D. CONSTRAINT

One constraint for the project is the limited range of the LoRa communication protocol, which may impose restrictions on the distance over which water depth measurements can be transmitted from the UAV to the ground station. Additionally, environmental factors such as interference and obstacles could affect the reliability and accuracy of the data transmitted via LoRa.

E. TRADE-OFFS

- 1) **Communication Range vs. Power Consumption:** Increasing the communication range using LoRa may require higher power levels, impacting battery life. Balancing the desired range with power consumption is crucial.
- 2) **Sensor Accuracy vs. Cost:** Higher accuracy ultrasonic sensors may come at a higher cost. Choosing a sensor with the desired level of accuracy while considering the project budget is essential.
- 3) **Data Transmission Rate vs. Latency:** Higher data transmission rates may lead to increased latency. Optimal transmission rate selection depends on the application requirements for real-time data processing.
- 4) **System Complexity vs. Development Time:** Implementing additional features, such as integration with Blynk IoT platform, may increase system complexity and development time. Balancing complexity with project timelines is necessary.
- 5) **Hardware Compatibility vs. Integration Effort:** Selecting compatible hardware components simplifies integration but may limit choices. Assessing compatibility requirements against integration efforts is crucial for efficient project development.