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Applying Esp32 and Lora Ra-02 Module, Controlling and Monitoring Water Saving System in Agriculture

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ABSTRACT: This research introduces a novel approach employing ESP32 and LoRa RA-02 modules to regulate and monitor water systems in agricultural applications. It provides a comprehensive evaluation of emerging smart agriculture solutions and explores the potential of LoRa technology for various field environmental applications. The study specifically investigates the application of long-range LoRa technology for regulating water systems and monitoring environmental parameters within the context of Vietnamese agriculture. By examining the performance of long-range LoRa-based solutions under Vietnamese environmental conditions, this research aims to optimize water regulation and management practices. Additionally, the paper discusses potential future directions for this technology and highlights the challenges involved in its implementation. The findings of this study demonstrate the potential of this technology to reduce water waste and contribute to sustainable agricultural development and climate change adaptation.

KEYWORDS: Lora, ESP 32, Internet of Things (IoT),…

I. INTRODUCTION

Currently in Vietnam, within the context of agricultural restructuring and climate change, the increasing water demands of various economic sectors have led to the risk of drought and water scarcity in many localities. Therefore, to improve water use efficiency in all sectors, particularly in agriculture, it is necessary to enhance the efficiency of irrigation infrastructure and proactively prevent and combat drought and saltwater intrusion. However, the approach of managing demand to improve water use efficiency remains relatively limited. In Vietnam, IoT technology and wireless sensor networks have been researched and applied in agriculture to improve production efficiency [1]. These research directions often utilize traditional communication technologies such as Zigbee, Wi-Fi, GSM/GPRS, and Bluetooth for remote monitoring of environmental parameters in agriculture [2]. Among these communication technologies, Wi-Fi, Zigbee, and Bluetooth have limited operating ranges of 10 to 100 meters. With such a limited range, these communication standards are only suitable for control and monitoring within a small area. When the monitoring area is large or there are multiple areas, building a sensor network becomes more complex and costly. Moreover, the high energy consumption of the system also leads to a decrease in the battery life of the sensor nodes. To expand the need for connecting a large number of sensors over a wide area and consuming less energy to serve the needs of data collection, monitoring, and control, the Lora communication standard has emerged with many advantages over existing technologies. Therefore, this paper focuses on the application of the ESP32 module and Lora RA-02 to control and monitor the water regulation system in agriculture through the control of pumping stations and gates, and monitoring environmental parameters in agriculture to improve the efficiency of managing, monitoring, and using water resources in agriculture today

II. RESEARCH CONTENT

Introduction to LoRa Technology: LoRa (Long Range Radio) is a long-range wireless communication technology used to transmit data between devices. This technology was researched and developed by Cycleo and later acquired by Semtech in 2012. LoRa is emerging as a promising solution for large-scale IoT deployments with low power consumption, including smart agriculture applications.

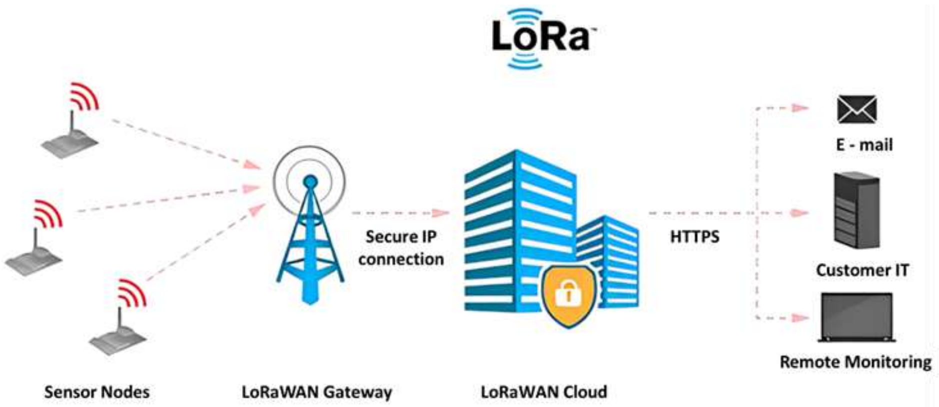
With this technology, data can be transmitted over distances of several kilometers without the need for power amplifiers, thus saving energy consumption during data transmission/reception. LoRa operates on unlicensed Industrial, Scientific, and Medical (ISM) radio bands.

Therefore, LoRa can be widely applied in data collection applications such as sensor networks where slave sensors can send measurement values to a central unit several kilometers away. Additionally, LoRa's transmit power is strictly regulated in each country with a maximum transmit power of 25mW (14 dBm), configurable bandwidth of 125, 250, or 500 kHz, and duty cycle of 0.1%, 1.0%, and 10%, allowing for low power consumption. Therefore, it can operate on battery power for extended periods depending on the duty cycle [3].

Operating Principle of LoRa: LoRa employs a modulation technique known as Chirp Spread Spectrum (CSS). This technique involves chopping data into high-frequency pulses to create a signal with a frequency band higher than the original data (a process called chipping). Subsequently, this high-frequency signal undergoes further encoding using chirp signals. Chirp signals are sinusoidal waves with time-varying frequencies; there are two types: up-chirps (increasing frequency over time) and down-chirps (decreasing frequency over time). The encoding scheme uses up-chirps for bit 1 and down-chirps for bit 0 before transmission via the antenna.

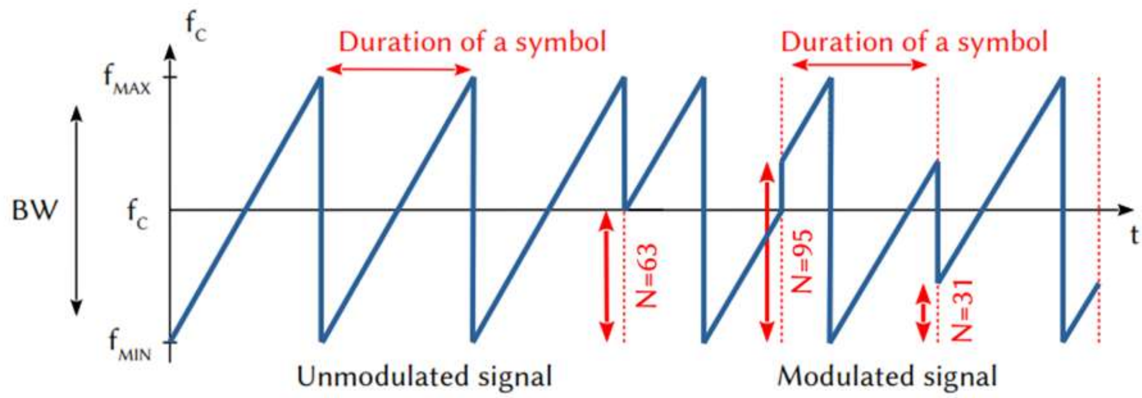
According to Semtech, this principle reduces the complexity and required precision of the receiver circuitry for data decoding and demodulation. Furthermore, LoRa can achieve long-range transmission without the need for high transmit power, as LoRa signals can be received over long distances even when the signal strength is lower than the ambient noise.

By utilizing chirp signals, LoRa signals with different chirp rates can coexist in the same area without interfering with each other. This enables multiple LoRa devices to exchange data on multiple channels simultaneously (each channel corresponds to a specific chirp rate).



BASIC LORA CONFIGURATION

CSS modulation: Chirp Spread Spectrum (CSS) is the foundation of the correction method used in LoRa wireless communication technology, using chirp frequencies with a linear variation of frequency over time to encode information. This technique allows for easy removal of frequency offset between the transmitter and receiver in the demodulator. The frequency offset between the transmitter and receiver can be up to 20% of the bandwidth without affecting decoding performance. Additionally, modules can switch to using FSK or GFSK modulation as needed. Parameters for customizing LoRa modulation include bandwidth (BW), spreading factor (SF), and code rate (CR)..

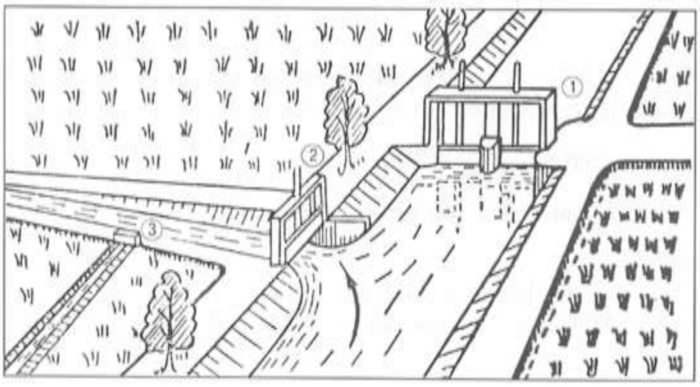


FREQUENCY VARIATION OVER TIME EMITTED BY LORA TRANSMITTER [5]

LoRa Technology and Smart Agriculture LoRa smart agriculture is a specific application of IoT in agricultural production, operation, management, and services. By integrating LoRa technology into traditional farming, IoT is transforming the future of global agriculture. The connected agriculture formed by LoRa and LoRaWAN will automatically adjust and intervene in the production process, thereby improving the quality of agricultural products and enhancing the efficiency and competitiveness of agricultural production. As LoRa wireless technology continues to develop, there will be more applications of LoRa and LoRaWAN in agricultural production. Currently, remote monitoring systems and wireless sensor monitoring supported by LoRa have been gradually improved and applied to smart agriculture, mainly including environmental monitoring, detection of flora and fauna information, greenhouse information monitoring, water-saving irrigation, etc. Figure 3.1 below shows some applications of LoRa technology in smart agriculture [7].

SOME APPLICATIONS OF LORA IN SMART AGRICULTURE [7]

Characteristics of water regulation model in agriculture: Water regulation system includes: connection works, canal system and canal works, irrigation area. They have some of the following characteristics:



1-Water regulating gate; 2-Water distribution gate; 3-Water distribution gate at the lower-level canal

WATER REGULATION AND DISTRIBUTION GATE

Characteristics of water regulation systems: present a wide-ranging analysis, including a variety of tools and equipment. Therefore, the management and maintenance of the system to ensure safety, increase water efficiency and extend the life of the process must be carried out regularly and continuously.

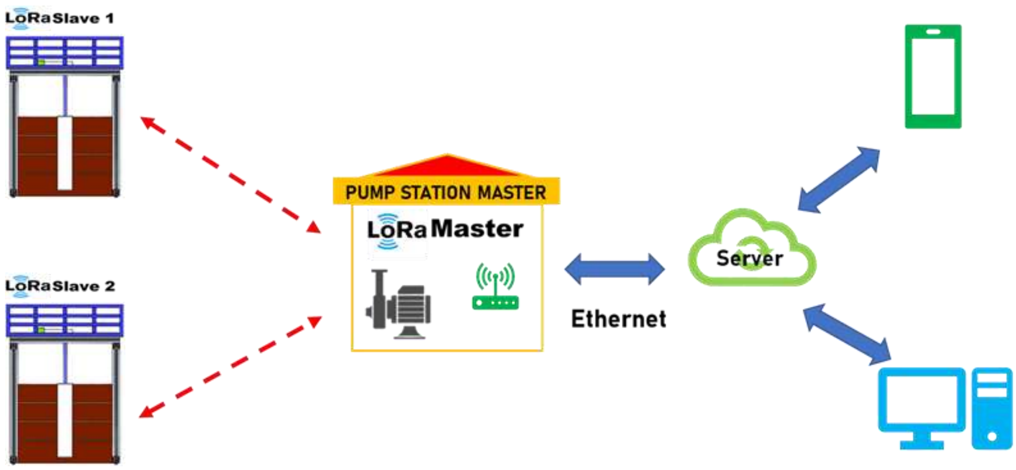
Management and maintenance work is important in promoting the design capacity of the project, ensuring safety and optimizing water resources. The goals include checking the accuracy of the process, design and work, detecting errors quickly and providing a scientific basis for modern systematization. At the same time, the goal of management and maintenance is to extend the life of the process, prioritize water resources and ensure the water needs of the area.

However, the actual state of the current regulatory system is that the system is not yet synchronous, the observation equipment and construction are not complete, the management quality is not high and the technical level of the staff is still low..

IRRIGATION REGULATION WORKS

To ensure water demand as well as improve efficiency and optimize water resources, solutions are needed such as: Supplementing facilities, automating and modernizing control equipment is important to improve the efficiency of exploitation and use of irrigation works. In the current period, the issue of automating and modernizing the operation of construction equipment is being raised and gradually developed in the direction of industrialization and modernization of the country's economic sectors.

Proposed system model: From the current status of the irrigation system model, the research team decided to choose LoRa communication technology for testing the water regulation model, improving the efficiency of monitoring and control in agriculture to serve high-tech agriculture, applying in monitoring management to improve the use of water resources. The system model includes 1 Master for monitoring and control and 2 Slaves for Sluice 1 and Sluice 2. The Master is located in a pumping station 1 km away from the 2 test Sluices.



BLOCK DIAGRAM OF CONTROL AND MONITORING OF WATER REGULATION SYSTEM IN AGRICULTURE

Block diagram of the agricultural water regulation system built by the research team. Environmental data including temperature, air humidity, water level height are collected through the slave sensor and transmitted to the central processing device Lora master, controlled and monitored via the web server. Users can monitor environmental parameters through the application

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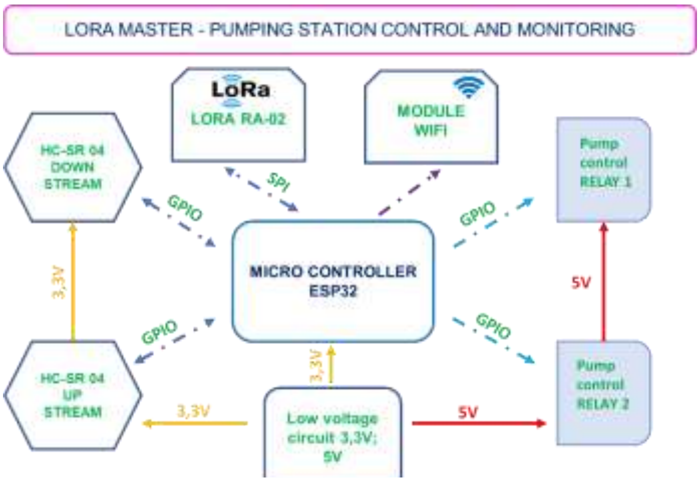
installed on the phone and command the on/off of devices, actuators such as pumps, opening and closing of sewers, etc. Communication between the slave and the central processing device uses Lora communication technology.

III. RESEARCH,RESULTS

Block diagram of the Lora Master central controller: is presented below. This is a Lora Master that acts as the main controller of the system and is composed of 01 ESP 32 microcontroller, 01 Lora RA-02 module with 433 MHz frequency band, 02 relays to control the water pump through the control cabinet.



LORA MASTER BLOCK DIAGRAM

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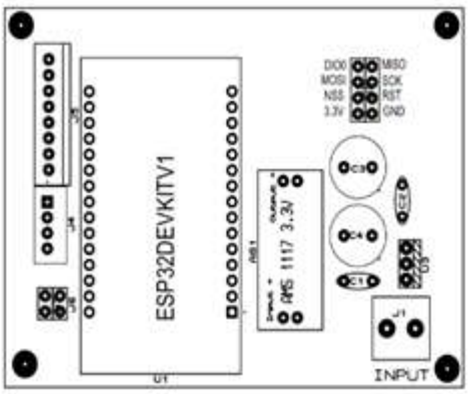

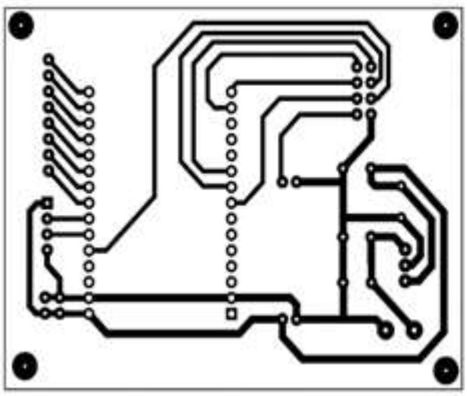

PCB MASTER CIRCUIT

The Lora RA-02 module performs data transmission/reception from the sensor Slaves. The wireless data transmission module is used to connect the central controller to the cloud server via Wi-Fi connection. The central controller will manage the Sewer Slaves No. 1 and No. 2, which are installed at locations 1km away from the Lora Master. The data collected from the Slaves will be transmitted to the Lora Master. The Lora Master central controller analyzes the data and can send control signals to open and close the sewer to each Slave and update the status and environmental parameters from the Slave. In addition, the water

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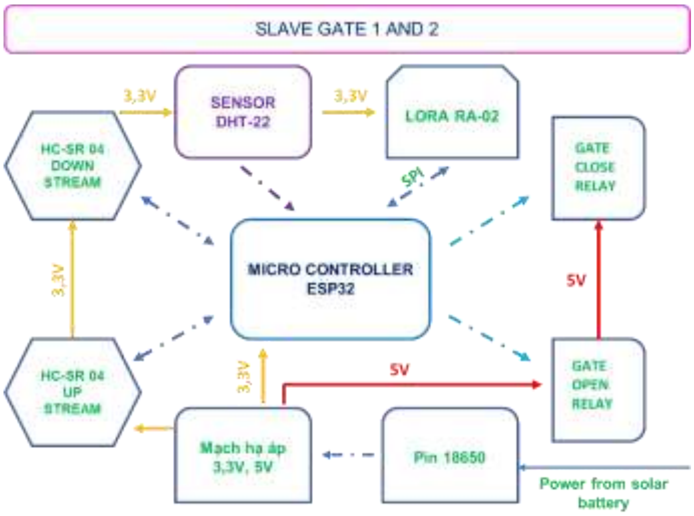
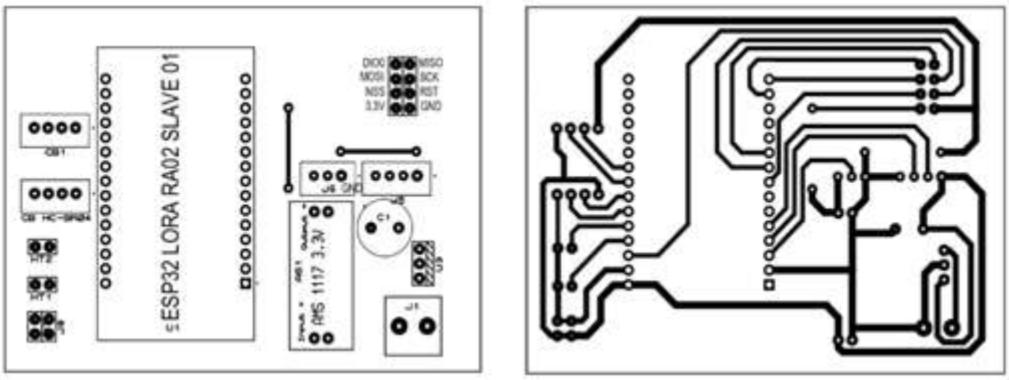
pump controller also receives control signals directly from the Lora Master through 02 relays.



LORA SLAVE BLOCK DIAGRAM

Block diagram of Slave Sewer No. 1 and 2 consists of an ESP 32 microcontroller, a DHT 22 sensor, an HC-SR04 ultrasonic sensor, 02 relays to control the opening and closing of the sewer through the control cabinet and 01 Lora RA-02 module with a frequency range of 433 MHz. In this study, the chip used is the low-power ESP 32 microcontroller. The sensors installed at a Slave include a temperature and humidity sensor and an ultrasonic water level sensor. The sewer status and environmental parameters will be transmitted by the sensor to the central controller via a 433 MHz radio connection. With an antenna with a gain of 5 dBi, the data transmission distance between the sensor Slave and the central controller is about 1km.



SLAVE GATE PCB CIRCUIT

Slave sewer circuit design. In this figure, the sensor is connected via cable, the entire circuit is placed in a protective box to avoid negative environmental impacts. The relay output is connected to the gate opening and closing control cabinet. The power supply for the Slave operation is a 4.2V Li-ion battery, through the voltage regulator circuit to provide stable 5V and 3.3V power to the microcontroller and peripheral devices.

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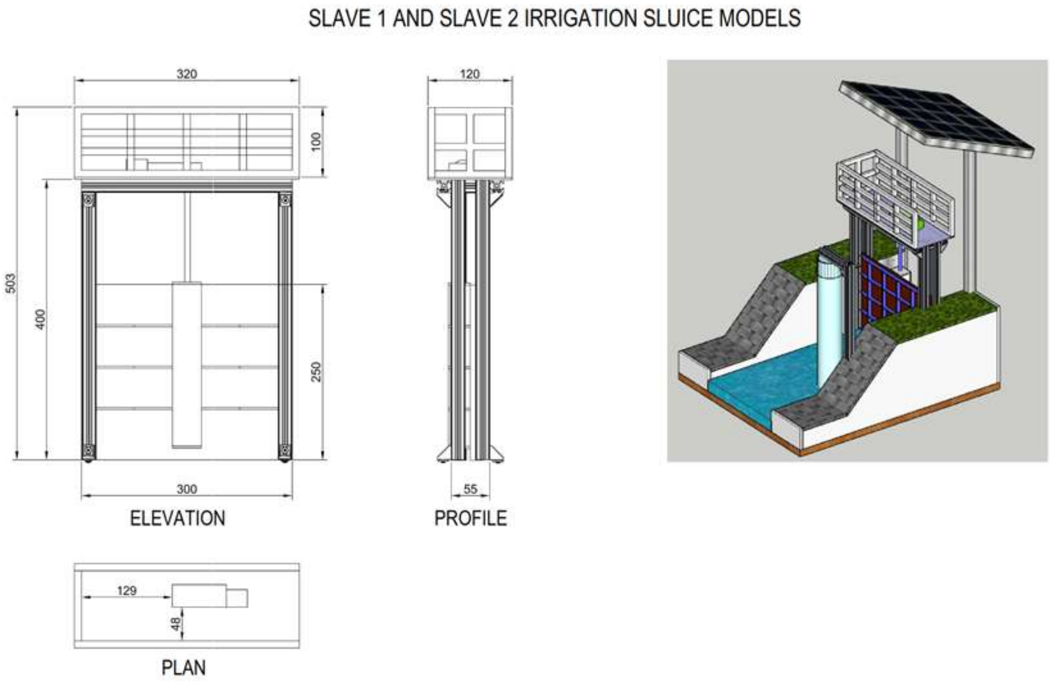
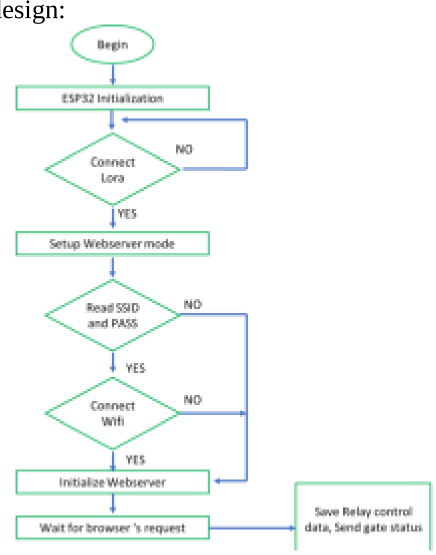
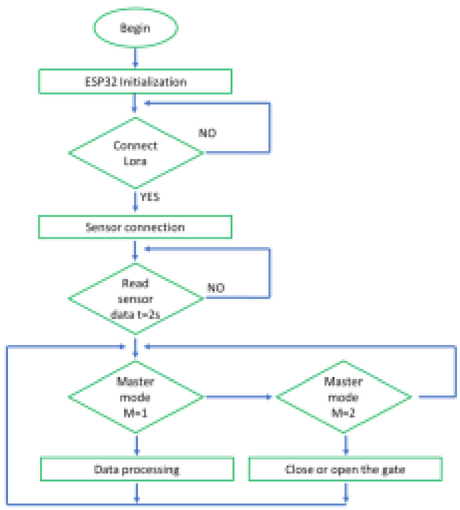


SLAVE 1 AND 2 MODEL HARDWARE

Software design:





a) Master's Process Flow Chart b) Slave execution flowchart

FLOWCHART OF IMPLEMENTATION PROCESS

The current control and monitoring model of water regulation systems in Vietnam only has the function of supporting the operator, because these systems depend on the decisions of the direct management system. The software in Figures a and b built in this paper has allowed the operator to remotely control and monitor... The water distribution plan and the operating parameters of pumps or sluice gates will be calculated directly from the data displayed on the website sent by sensors via Lora. The manager will decide to perform the necessary button presses and the web server will command the control devices to perform.

Monitoring and control on Web server: Environmental parameter data and water column height from Slave will be sent to the server by the ESP 32 central controller for storage and processing. In this study, the designed system uses Web server platform for control and monitoring.

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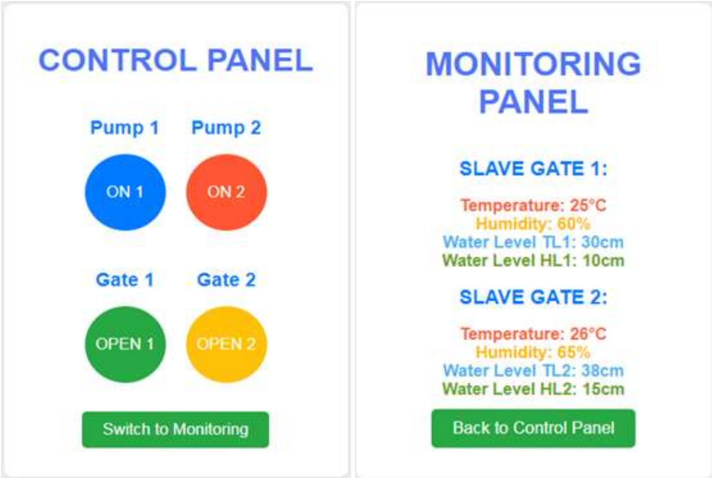
The data transmission process from the sensor slaves to the cloud server is performed by HTTP protocol with 128-bit AES encryption [8]



WEB SERVER CONTROL AND MONITORING INTERFACE

To access the interface, you need to log in to the IP address in the form of 192.168.1.x provided by ESP on the Serial screen of Arduino IDE. On the web server, there are 2 interfaces
- Control panel to control the pump at the pumping station and the sluice gates at the salve
- Monitoring panel to monitor environmental information, the height of the water level of each slave, these parameters are updated every 2 seconds.

Test results: The central controller is located on the 4th floor of building C6 and the football field area of Hai Phong University. Test the device switching control through the software installed on the Web server control panel. The actuator button control function also works stably. When controlling the device, the user must update the check of the water level height and the sewer status to avoid forgetting to turn off the device or losing connection.

Effect of spreading factor on transmission time:

	Bandwidth BW (kHz)	**Spreading Factor (SF)**	**Transmission time 14 bytes**
1	250	7	21,24
2	250	8	40,35
3	250	9	68,15
4	250	10	130,34
5	250	11	352,45
6	250	12	Unstable

Impact of bandwidth on transmission speed:

	Bandwidth BW (kHz)	**Spreading Factor (SF)**	**Transmission time 14 bytes**
1	62,5	7	75,85
2	125	7	38,21
3	250	7	21,24
4	500	7	11,41

The tables show the influence of bandwidth and spreading factor on message transmission time in the LORA system with the antenna used for the central controller being a wire antenna with a gain of 5 dBi. Through the measurement results in Table 1, we can see that the transmission time is inversely proportional to the bandwidth. The larger the bandwidth, the shorter the transmission time. Conversely, when the spreading factor increases, the message transmission time increases.

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a) Distance 1,1Km b) Distance 428m c) Distance 200m

TEST DISTANCE

The results show that a good transmission distance (1.1km) is achieved in figure a when the parameter configuration is SF = 12, BW = 250kHz. When the spreading factor is reduced to SF = 7, the transmission distance is reduced to 1km. When encountering a test environment with large obstacles, it is found that the data is no longer stable.

IV. CONCLUSIONS

This article presents a control and monitoring solution using Lora technology to serve the water regulation system in agriculture. With the solution, the manager and operator of this system can monitor environmental parameters and water height at the sluice regularly and continuously. This system allows the operator to make decisions to pump water, close or open the sluice remotely through the feature of controlling the sluice opening and closing using LoRa waves without the need for internet or GSM, 3G, 4G waves... With this feature, the operator is proactive in regulating water to optimize time and save production costs. However, the implementation of this model still has some difficulties: including the unpopular LoRA network infrastructure, lack of specialized human resources, high investment costs, legal issues when using radio frequencies and lack of support policies from the Government. In addition, there are issues such as network security and maintenance... To be able to deploy this model, in addition to strengthening telecommunications infrastructure, building a smart agricultural network, popularizing energy-saving LoRa devices, reducing deployment costs, developing applications and data platforms, training and supporting the community... The group of authors will continue to research, improve and optimize the system, so that it can be applied to the smart agricultural model in Vietnam.

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