

# LoRa Network Based Integrated Sluice Gates Group Automation Control System

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**Abstract.** A kind of gate automation group control system is designed based on LoRa networking, which is composed of intelligent gate control subsystems installed on all levels of channels, LoRa network and a cluster control system running in the monitoring centre. The system uses the water level and flow rate method, Doppler ultrasonic flowmeter, and laser water level gauge to realize the automatic metering function of the gate; the ultra-low power gate cluster control system based on LoRa network realizes the intelligent control and wireless remote communication of the gate terminal; Provides three different types of gate automatic control modes to meet the water supply needs of different types of irrigation areas; through the design of dual-circuit redundant power supply system design for solar power supply and mains power supply, the power supply problem of the gate field work is solved; remote dynamic water transfer control application software package realize the remote control, automatic control and system linkage of the gate.

**Keywords.** LoRa network, smart gate control, solar power supply, water level and flow rate method

## 1. Introduction

In water conservancy projects, the gate is one of the important components of water conservancy buildings. It can close the orifices of the building according to the needs, or open the orifices in whole or part to adjust the upstream and downstream water level and flow, to obtain the aim of flood control, Irrigation, water supply, power generation, navigation, wooden crossing, rafting and other benefits. The existing gate opening size control is manually controlled, that is, the hydrological information such as precipitation and reservoir water level collected by the sensor is first used, and then the staff integrates the various hydrological information collected by the sensor, and adjusts the gate opening according to experience. Manually adjusting the opening of the gate is not accurate enough, and it is difficult to achieve real-time control. It also requires manual monitoring of various hydrological information day and night, which is labor intensive. In order to solve this problem, this paper proposes an integrated gate

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automation group control system based on LoRa networking, which realizes the remote control, automatic control, and system linkage of the gate in monitoring center remotely by controlling the upstream and downstream water level of the gate, gate load, gate opening and closing state, gate opening size, and the image information automatic collection and transmission [1]. At the same time, it can intuitively understand the operating conditions of the gate and the surrounding environment through real-time images, realize the efficient and accurate dispatch of the gate, and improve the utilization rate and benefits of water resources [2].

## 2. System Architecture

The integrated gate automation group control system based on LoRa network can accurately control gate dispatching by combining flow measurement, water level monitoring, remote monitoring, and gate control into a unified whole [3-6]. At the same time, the system can build new gates or modify existing gates according to actual needs. According to user requirements and system characteristics, single control and group control can be realized. It can also be remotely controlled in different places, which has good scalability and robustness. A complete integrated gate automation group control system based on LoRa network is shown in the figure 1:

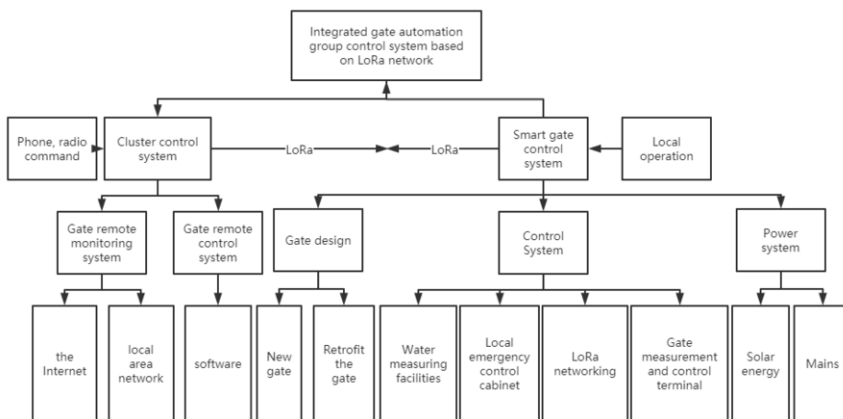


Figure 1. Composition of integrated gate automation group control system based on LoRa network.

## 3. Intelligent Sluice Gate Control System

### 3.1. Gate design

According to the actual situation of the current water conservancy project, this paper provides two design schemes of new gate and retrofit the gate.

#### 3.1.1. New Gate

The mechanical structure of the gate mainly includes the motor, the reducer, the gate, the door frame seal, and the opening and closing shaft. Considering that most of the

gate layout points in the actual water conservancy project application are in the field, it is difficult to supply power. In order to reduce the load of the power supply system, a light-weight high-strength aluminum alloy composite honeycomb panel was designed, which can reduce the weight of the gate plate to the maximum under the premise of ensuring the sealing strength. The energy consumption of the product is optimized and perfected from many aspects such as mechanical structure design and controller function development, so that the power consumption in the standby state of the gate is less than 60mA, and the power consumption in the running state is less than 1500mA. In order to ensure the sealing performance of the gate, the gate is compatible with two solutions, dynamic water stop and static water stop. The hoist adopts a worm gear structure with reverse self-locking performance. In order to ensure the safety of the gate during operation, multiple detection functions such as current monitoring, double limit detection, and gate opening size detection are built in the gate.

### *3.1.2. Retrofit the Gate*

In the face of the already constructed gate, the original gate body is retained. The motor and gear connectors are added according to the original gate transmission structure, and the power transmission unit is upgraded. And according to the size of the gate, the corresponding DC gear motor (1:4/1:6/1:8/1:16/1:32) can be selected. After the transformation, a gate weighing up to 10 tons can be lifted by solar power supply to meet the actual needs of field operation of water conservancy projects.

The retrofit of the gate provides motor speed control and current detection mechanism, make it have intelligent speed control and automatic card arrangement function, access to load detection, integrated design of coded gate and limit switch to coordinate gate opening size detection and gate protection [7].

## *3.2. Control System*

The main functions of the control system are: sensor data acquisition and measurement calculation, remote wireless communication function, multi-mode gate control, on-site operation, and information display, etc.

### *3.2.1. Data Collection System*

In the actual operation of water conservancy projects, it is necessary to accurately measure the gate flow to achieve the goal of efficient water saving and scientific water distribution. Therefore, it is necessary to configure an accurate water measurement system. In this paper, the water level and flow velocity method are adopted, and the Doppler ultrasonic flowmeter (TCLL-700 type) and laser water level meter (TCJG-100 type) are used for accurate measurement.

According to the actual needs of the implementation of this system, the TCLL-700 Doppler ultrasonic flowmeter is specially designed and developed for flow measurement in open channels, rivers, and partial pipes. Through advanced digital processing technology, it measures the water velocity and water level depth [8]. The existing channels do not need to be modified, installation and maintenance are convenient, and only need not be covered by sediments such as silt; for irregular channels or culverts, flow measurement is performed by setting 24 coordinate values to simulate the cross-sectional area appearance. Adopting the dual measurement method

of flow rate and water level, both the water level and flow relationship curve method can be used to measure the water volume, and the flow area method can also be used to measure the water volume. The measuring range is 0.021~5m/s, which can measure extremely low flow velocity in both directions. In use, it can display time, water temperature, water level, flow rate, instantaneous flow, daily cumulative flow, and total cumulative flow to meet the needs of flow monitoring in smart gate control.

The TCJG-100 laser water level/sluice level meter for water level measurement based on the principle of laser distance measurement is a new type of non-contact measuring instrument specially developed. The laser water level/sluice level meter is directly fixed above the top of the gate without a protective tube. The unique EIA-485 interface is converted into a universal standard 485MODBUS digital output interface after being displayed and processed by the instrument, which has high measurement accuracy and long-term stability. During measurement, the instrument emits a red laser beam to the surface of the object to be measured. After the instrument measures the value, it is output through the EIA-485 interface. Address 1-255 can be set, which is convenient for multi-sensor networking; the instrument comes with GPRS communication function, timing collect and send monitoring information to meet the needs of water level monitoring in smart gate control.

### 3.2.2. Wireless Communication Module

In the actual production and application of water conservancy projects, the gate installation points are discretely distributed, and the cost of setting up a dedicated wired network is relatively high. The LoRa network based on Low-Power Wide-Area Network (LPWAN) is one of the most promising low-power wide-area networks, which can achieve long-distance and ultra-long-distance wireless data transmission to the greatest extent. Realize lower power consumption and long-distance communication to a great extent, save the cost of repeaters, can establish affordable connections in wide-area energy-constrained equipment, and implement LoRa technology networking in a large-scale basin gate cluster control have significant dual value of theory and engineering application [9-11]. In smart gate control applications, low-power LoRa nodes with various sensors can be configured to interact with the surrounding environment of the gate, and transmit information with the smart gate measurement and control terminal (such as TCYC-600) to achieve the purpose of management and control.

### 3.2.3. Gate Control Cabinet (Local Emergency Console)

The equipment supports local operation. The gate control cabinet (local emergency console) combines a 10-inch color touch screen with a metal button operation panel, which is convenient for users to use the smart gate control monitoring system to realize the local operation and understand the running status of the gate. The intelligent gate control monitoring system is based on the dual CPU design of the ARM processor, and is a system developed by independently completing the embedded hardware [12].

In order to meet the application requirements of ultra-low power consumption of outdoor gates, multi-layer functional designs such as solar charging control, motor rotation control, sensor power control, video power supply control and self-operation power control are adopted. Support video access and wireless video transmission, realize the linkage capture of video and gate status, video call-to-test functions, and support video character superimposition function.

In order to meet the water demand of the gates in the irrigation area, three automatic gate adjustment modes including opening size setting mode, water level setting mode and flow setting mode are provided [13-14]. Support 2G/3G/4G, SMS, LoRa, RS485, Baidoo satellite and other wireless communication methods.

#### *3.2.4. Intelligent Gate Measurement and Control Terminal*

This article uses TCYC-600 smart gate measurement and control terminal, built-in 4G full NetCom module, supports all operators and wireless communication cards of all frequency bands, solves the signal coverage problem, can send and receive text messages and network data at the same time; can simultaneously communicate with 4 servers for data communication; with low power consumption standby function. The storage function is powerful, and it can store up to 5 years of historical data. The device supports video capture with high resolution, rich color and clear display. Provides a variety of ways to automatically adjust the opening height of the gate, such as gate opening, gate flow, water level behind the gate, etc., to achieve precise gate control, and a variety of protection mechanisms, in case of abnormalities such as abnormal power supply, abnormal communication, water flow, sand and stone impurities, can respond quickly, and start the protection mechanism to ensure the normal equipment. It is suitable for complex conditions during the operation of the gate.

#### *3.3. Power System Design*

Considering that the gates are installed on various levels of canal systems, they may face the inability to obtain power from the grid to supply the gate control system to work. This paper designs a utility and photovoltaic complementary power supply system. The overall design adopts a dual redundant power supply system of solar power supply and city power supply to ensure the safety and reliability of the equipment on-site power supply. The photovoltaic power generation system is composed of photovoltaic panels, 12V120AH gelled lead-acid batteries, and controllers. The AC power supply system adopts the AC/DC+DC/DC system with a voltage of 220 volts. The DC remote power supply system uses a high-power UPS centralized power supply system with a voltage of 24 volts.

### **4. Design of Cluster Control System**

#### *4.1. Gate Remote Monitoring System*

The gate monitoring software adopts coordinated control technology and builds a system based on B/S architecture, which can be accessed by users through the Internet or local area network. The background control software enables users to remotely monitor the gate, and intuitively understand the operating conditions and surrounding environment of the gate through real-time images. Its functions include status viewing, equipment control, parameter setting, record query, statistical analysis, etc.

#### 4.2. Gate Remote Control System

The core functions of the gate control software include fault alarm, gate status, opening control and other functions; after the mobile phone successfully connects the gate through Bluetooth, the operator can operate the gate up, gate down, pause and other operations, and the gate water level, flow, opening size and other information can be observed during operation. In addition, the opening size can be controlled, and the opening size can be set by dragging the finger.

### 5. Conclusion

This paper designs an integrated gate automation group control system based on LoRa network, which can be used for gate control of hydropower plants, reservoirs, rivers, and water supply channels. The system consists of cluster control system, LoRa network, and smart gate control system. According to users' requirements and system characteristics, it can be controlled locally or in a group, or remotely controlled. The system adopts high-reliability hardware equipment and industrial control special configuration software platform, which has the advantages of high reliability and simple operation.

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