Application of wireless communication technology in safety monitoring system of Guandi Hydropower Station

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Abstract. In the early stage, the monitoring system for No. 4 Adit in Guandi power station is mainly based on manual measurement. Considering the measuring period and safety problems, it needs to be transformed into automatic measurement. At present, there are two mature technologies, one is using fiber grating measurement scheme, and the other adopts wireless communication technology scheme. According to the actual situation of the field, the author finally adopts the wireless communication technology scheme. On the basis of the actual effect of automation system, NANRI GPRS DTU 4100 wireless communication technology is stable and reliable. This technology provides a guarantee for the safe operation of Guandi Hydropower Station.

1. Introduction
Located in the border zone between Xichang City and Yanyuan County, Liangshan Yi Autonomous Prefecture, Sichuan Province, the Guandi hydropower station project hub area is about 30km away from Xichang City. The main task of this hydropower station is to generate power, whose normal water storage level of the reservoir is 1330.00m, total storage capacity is 760 million steres, return water of the reservoir length is 58km and installed capacity is 2400MW.

The river section of the official site of the Yalong River bends to the right bank and its left bank is bounded by the river bay with an arc length of about 4.75km and a chord length of about 1.88km. Surrounded by the river bay, the left bank of the dam site forms a thin watershed with steep east-west terrain. The next permian period and the carbonate rock of middle-upper carbonic period distribute in the north-south trend in the river bend. After the construction of the Guandi Dam, the carbonate rock formation forms a limestone (karst) fracture seepage through the reservoir and the downstream of the river bend (dam). To find out the problems of the karst leakage in the river bay, this paper designed No. 4 flat hole and supporting hole and arranged the monitoring equipment in the flat tunnel, such as seepage gauge, measuring weir and thermometer. The manual measurement was used in the early stage. However, the manual measurement has the following limitations: (1) the measuring period is long (about once a month), so that the measured data cannot reflect the change of Karst leakage in time and the anomaly cannot be found in time; (2) No. 4 flat hole includes the main hole and the supporting hole. The depth of the main hole is about 800 meters while the depth of the supporting hole is about 1000 meters. Since there is no oxygen in the hole and there is a collapse and falling stone at the top of the cave, the safety risk of manual measurement is high. Considering the shortcomings above, this paper decided to transform the artificial monitoring of groundwater in No. 4 flat hole into automatic monitoring, which was integrated into the automatic monitoring and management system of
Guandi Power Station.

2. Proposal of problem and comparison and selection of scheme
Located at about 5 kilometers upstream of Guandi Dam, No. 4 flat hole is geographically remote and its environment is extremely worse. It is difficult to access security monitoring automation in the conventional way. The main difficulties mainly include: (1) the distance between optical cable and cable laying is long and the excavation task of trenches is large; (2) The power cords are installed from power station plant to No. 4 flat hole. The voltage drop is serious and the voltage is not enough to maintain the normal operation of the acquisition module; (3) Geological disasters such as rock rollers and debris flow occur in the road to No. 4 flat hole. The roads are often interrupted. The laying of the optical cable and the cable is extremely easy to be broken and its later maintenance workload is large. After considering the actual situation above, it is necessary to realize automatic monitoring to make the No. 4 flat hole monitoring equipment run stably for a long time. There are two feasible schemes, which are shown as follows:

2.1. The first kind: fiber grating technology
The principle of fiber brag grating (FBG) is that the condition of fiber wave guide is changed due to the variation of refractive index period in fiber core, which leads to the corresponding mode coupling of light wave at a certain wavelength and makes the transmission spectrum and reflection spectrum sense odd fiber grating to the wavelength [1]. The monitoring system includes three main parts, the fiber grating sensor, transmission fiber and fiber grating tuner. The main advantages and disadvantages of the project are shown as follows:

Advantages:
(1) The measured signal is not affected by the fluctuation of light source, bending loss of optical fiber, connection loss and aging of detector. Therefore, it has good long-term stability and anti-interference ability.
(2) The sensitivity and resolution are high.
(3) The sensing signal can be transmitted from a long distance, which is convenient to realize real-time and on-line measurement.

Disadvantages:
(1) The existing monitoring equipment needs to be completely replaced by fiber grating monitoring equipment; it cost is high.
(2) The price of the optical fiber demultiplexer is high.
(3) The construction scope is large, the slope construction is difficult and the safety risk is large.
(4) The optical fiber is easy to be broken by the slope rolling stone. The site recovery is difficult and the daily maintenance is inconvenient.

2.2. The second kind: wireless communication GPRS DTU technology
The wireless communication technology transmits the monitoring data collected by the field module to the rear server through GPRS, wireless bridge and other communication methods [2]. The wireless communication technology replaces the traditional optical cable and 485 communication line. The main advantages and disadvantages of the project are shown as follows:

Advantages:
(1) The price is cheap.
(2) Its construction is convenient and daily maintenance is simple.

Disadvantages:
(1) The GPRS mobile phone signal is needed on the spot. The mobile phone card needs to be recharged on the regular basis.
(2) The requirement of power supply is high, because the wireless communication is powered by solar panels. There are requirements for the number of sunshine hours.
(3) The requirements of on-site grounding lightning protection are required. Through exploration, it
is found that there is a piece of relatively flat land outside the hole of the No. 4 flat hole and there is no cover nearby. Therefore, the solar panels can be installed. The GPRS signal outside the hole is good and stable and the lightning can be protected by installing grounding flat iron on the spot. Considering the economic investment, construction operation and later maintenance workload, the wireless communication technology scheme was selected finally.

3. GPRS DTU wireless communication technology

3.1. Principle

The wireless communication technology is one kind of communication mode which uses the characteristics of electromagnetic wave signal propagation in free space [3]. GPRS DTU is a kind of Internet wireless data terminal, which applies public network to operate network GPRS network (also known as G network) and provides wireless long-distance data transmission function for users [4]. The high performance industrial 8-16-32 bit communication processor and industrial wireless module were employed, whose software supporting platform is embedded Real-time operating system [5]. At the same time, the RS232 and RS485 interface can be connected directly to the serial port device to realize the transparent transmission of data. The wireless communication technology of Guandi No. 4 flat hole uses NARI ACS04100 GPRS DTU module, which is an industrial low-power GPRS wireless transmission device. By this product, the transparent transmission channel can be established between the remote telemetry terminal and the data center to realize the data exchange. The applications of the product are shown in following figure.

3.2. Technical parameters of DTU4100

The technical parameters of ACS04100 GPRS DTU were shown as follows:

(1) Power supply: power supply voltage: 5V~32V, idle power consumption: 2mA@12V, the average Power consumption of GPRS communication: 100mA@12V. The device still maintains a signal connection with the GSM base station in its free time and it can receive short messages or GPRS data.

(2) Radio frequency: EGSM900/1800Mhz, which conforms to ETSI GSMPhase2 standard SMS service function. It supports the TEXT and PDU. The point-to-point (MT/MO), cell broadcast GPRS Class 2 ~ 10 coding scheme and CS1~CS4 accord with SMG31bit technical specifications.

(3) Interface: antenna interface 50 ohmic characteristic impedance/SMA negative head; SIM card rate: 300~115200bps; RS485 serial port: phoenix terminal (2 cores) with 300~115200bps baud rate; RS232 configuration port: Phoenix terminal (3 core) with 300~115200bps baud rate. The appearance of DTU4100 is shown in following figure.
4. Application of DTU4100 in Guandi power station

4.1. Site installation and commissioning

The field acquisition and control unit is set at the intersection position of the main hole and the branch hole in the No. 4 flat hole and it is about 800 meters away from the entrance of the main hole. The instrument cable of each part of the sensor is centralized into the acquisition and control unit. The cable is protected by galvanized steel pipe. The solar panel and the storage battery are used for power supply in the field. NARI GPRS DTU4100 wireless communication technology is adopted as the communication mode. A total of two NARI DAU2000 data acquisition boxes, one NDA1404 module and two NDA1104 modules were installed in the No. 4 flat hole, and forty one monitoring instruments were connected. Among them, there were nine vibrating string instruments (eight seepage gauges and one Weir) and thirty-two differential resistance instruments (thirty-two four-core thermometer). The network structure of No. 4 flat hole automation system is shown in the following figure.

The installation position of No. 4 flat hole acquisition module is about 800 meters from the entrance of the hole. At the early period of installation, a set of solar panels (150W) and a battery (100AH) were used to supply power. After installation, it is found that the voltage drop is large that the module cannot work properly. The main reason for the voltage drop is ① the power supply line is too long and the voltage loss on the cable line is serious; ② the resistance of the cable is too large. To solve the voltage drop problem, two sets of solar panels (150W) and two storage batteries (100AH) were used for power supply after the on-site calculation and test. The cross section area of the cable is 4 square millimeters and the power supply is stable after taking measures.

4.2. Establishment and debugging of DSIMS4.0 in Automation system

The project server, database software Microsoft SQL Server 2008, data acquisition software DSIMS4.0 of the project automation system use the original equipment and the software. The data acquisition module information and measurement point were added to the original database.
DMOnline_GD and then the system joint was adjusted.

The creation of system measuring point information includes: (1) the creation of system module information table; (2) the establishment of measuring point, attribute and calculation formula, etc. The debugging of the data acquisition module includes: (1) querying and setting the module address; (2) setting the module clock, channel set, next measurement time and period; (3) comparing the selected data of the module with the historical manual data.

5. Field application effect

The wireless communication system of Guandi No.4 flat hole was installed and commissioned on 1st, November, 2016. It has been operated normally for 540 days. This system obtained more than 22,000 monitoring data, whose normal operation rate was 100%. The process lines of measured points T1-4 and P4-2 in No. 4 flat hole are shown as follows. NARI GPRS DTU 4100 wireless communication technology provides the timely and reliable monitoring data for the official power station and guarantees the safe and stable operation of the official power station.

6. Conclusions

(1) By the field operation effect, it is feasible and correct that the monitoring automation of Guandi No. 4 flat hole adopts NARI GPRS DTU 4100 Wireless Communication Technology.

(2) NARI data acquisition software DSIMS4.0 can accept the monitoring data transmitted by wired communication mode and wireless communication mode. Its system runs stably and reliably.

(3) The areas that have difficulties in using external power supply, can apply the solar panels and batteries to supply power.

(4) NARI GPRS DTU 4100 Wireless Communication Technology in Guandi No. 4 flat hole is applied successfully, which provides a reference for the long distance and bad environment area to realize the monitoring automation.

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