Research and Design on the DMA Monitoring System Based on Low-power Consumption

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Abstract: Starting from the requirements of lower leakage rate of water supply pipeline network and using DMA (District Metered Area) method, a low-power consumption of flow monitoring system is designed in this paper. Real-time monitoring on the flow points in each DMA (independent measurement area) can help find the abnormal of water supply network, analyse the leakage situation of the area, locate the leakage point, and reduce the leakage rate of supply network and the difference rate between production and sale, connecting with other information systems of supply network to achieve fast trouble-shooting.

1. Introduction
With the development of society and economy, urban industrial water and residential water consumption are increasing. However, the leakage of urban water supply network in China lags far behind the developed countries in the world. The leakage of water supply network will cause the waste of water resources, and easily lead to road collapse and other accidents as well, which is an important factor affecting the safety of water supply and public security. The State Council issued Prevention and Control Action Plan of Water Pollution (hereinafter referred to as the ‘Water Ten Articles’) proposed that the leakage rate of national public water supply network should be controlled under 10% by 2020.

The Outline of the 13th Five Year Plan for National Economic and Social Development (hereinafter referred to as the ‘Outline’) has made it clear that 100 trial cities should be selected, in order to improve the DMA management level of the water supply network, to guide all localities to take the DMA management of water supply network as principle, and coordinate the water quantity measurement and pressure control, water quality safety and facilities management, and build the pipeline leakage control system. Moreover, improve the level of information and fine management of pipeline network, reduce the leakage rate of pipe network, and improve safety to guarantee the water supply. But during the construction of DMA, it is difficult to get AC power supply for some pipe networks with flow meter, so battery power has to be used. In order to prolong the battery life and reduce the maintenance cost, this paper proposes a low-power DMA monitoring system using wireless network and flow meter monitoring terminal with low power consumption.

2. DMA
DMA technology emerged in Britain in 1980s and its principle is to divide the whole urban water supply network into several water supply areas to monitor the flow, pressure, water quality and
leakage points, and quantify the spatial distribution of water leakage. At present, it has become an internationally recognized method of pipe network leakage control.

DMA\(^{[1,2,3,4]}\), also known as area management, is to divide the existing water supply network into several relatively independent sub regions according to certain principles, achieving the separate measurement of water consumption in each area. As shown in Figure 1, according to the natural boundary, the region is divided into three areas: M1, M2 and M3. Each area is relatively independent water supply area, M1 is the first level area, M2 is the second level area, and then M3 is the third level. In order to monitor the inflow and outflow of each area, flow meters are installed on the inlet and outlet pipes of each area. Regional management is helpful to find and locate the problems of pipe burst or leakage in time, in order to repair quickly, reduce leakage and improve the management level and economic benefits of water supply.

![DMA Partition Map](image)

Figure 1. DMA Partition Map

The best time for DMA analysis and monitoring is at night. During this period, the total flow into DMA is the minimum value in a whole day, therefore, the ratio of leakage in total flow will reach the maximum value which is easier to determine. Through observing and analyzing the historical data of the flow meter in this area, if the water consumption reflected by these data has been increasing, it indicates that there may be pipe burst or hidden leakage in the DMA. Therefore, engineers and technicians are required to detect, locate and maintain the water supply network in this area in time.

3. Low-power Consumption DMA Monitoring System Design

The water supply flow measurement and monitoring system\(^{[5]}\), is a wireless data monitoring and management information system to improve the water supply quality and service quality of the whole city, dispatch water resources scientifically, grasp the water utilization information of users timely, reduce the difference rate between production and sale, and achieve the economic and social benefits.

3.1. System Architecture Design

The low-power consumption water supply flow measurement and monitoring system is composed of data center, NB-IoT (Narrow Band Internet of Things) wireless network and electromagnetic flow meter. The system architecture is shown in Figure 2.
Figure 2. System Architecture Graph of the Low-power Consumption Water Supply Flow Measurement and Monitoring system

Data center is consisted of data processing and display system. After receiving the data from the flow monitoring terminal, the data center saves the data into the database, then perform data statistics and analysis, and create data report.

NB-IoT wireless communication network connects data center and flow monitoring terminal, supporting the cellular data connection of low-power devices in WAN (Wide-area Network). It has the characteristics of wide coverage, multiple connections, fast speed, low cost, low-power consumption and excellent architecture.

Electromagnetic flow meter, including NB-IoT wireless communication module, can collect the data of the flow meter and communicate with the data center wirelessly.

3.2. Data Center Function Design

The data center mainly completes the collection, statistics and analysis of flow measurement data, comprised of communication server, data server, data analysis server, operator station, administrator station, DMA monitoring management system software, etc.

(1) Support a variety of communication protocols, can be connected with different manufacturers and different types of flow meters.

(2) System management: operator management, user management, password modification, etc.

(3) Basic information management, attribute management of pipe network, regional information management, user information management, flow meter information management, etc.

(4) Flow meter monitoring management: monitoring the instantaneous flow, positive cumulative flow, and negative cumulative flow of the inlet and outlet flow meters in each area.

(5) Flow meter supporting remote maintenance.

(6) Remote setting for upper and lower limit alarm and over limit alarm.

(7) Inspection and repair management: flow meter inspection management, report for repair management.

(8) Data query management: user information query, flow meter information query, water utilization query, alarm information query, operation log query, historical data query, etc.

(9) Generate various statistical reports of water consumption, generate reports by hour, day, week, ten day, month, quarter, year and other time periods, and generate water consumption detail report by year, month and day.

(10) Generate various water use analysis curves: generate water utilization curve graphics by hour, day, week, ten day, month, quarter, year and other time periods of regional, water users and water
meters.

(11) Intelligent analysis function of flow data: through the statistical analysis of pipe network flow and user data, from the comparison of time dimension (data of year, month, day), spatial dimension, user behavior and other external factors, carry out the pipeline loss analysis, meter allocation analysis and trend analysis, and locate the doubtful points of the difference of production and sale step by step.

(12) Linkage control can share abnormal flow data to GIS system, inspection system and other information systems, related to pipe network for comprehensive analysis and scheduling to fulfill rapid processing of fault.

3.3. Low-power Consumption Electromagnetic Flow Meter

Electromagnetic flow meter is an instrument made according to Faraday's law of electromagnetic induction, composed of electromagnetic flow sensor, electromagnetic flow converter and NB-IoT wireless communication module. The components are shown in Figure 3.

Figure 3. The Component Graph of Low-power Consumption Electromagnetic Flow Meter

In order to solve the problem of no AC power supply, the flow meter is designed with low-power consumption, so do the flow sensor, flow converter and wireless communication network. The power supply uses 3.6V lithium battery and the flow sensor adopts the magnetic circuit structure of non-uniform magnetic field technology, so the magnetic field is stable and reliable. As the induced electromotive force signal generated by liquid flow is very weak and largely affected by various interference factors, the function of the converter is to amplify and convert the induced potential signal into a unified standard signal and suppress the main interference signal. The core of the converter uses STMicro’s STM32L151C8 low-power consumption single-chip computer, which has fast calculation speed, high precision and reliable performance. The NB-IoT wireless communication module uses BC26 module to achieve the following functions:

(1) Has two-way flow measurement function, able to display forward flow and reverse flow, with three cumulative calculator inside;
(2) Has RS485 digital communication interface and supports MODBUS and HART communication;
(3) Converter has the function of self-test and self-diagnosis, able to monitor the running status of the instrument automatically;
(4) Has remote alarm and low power alarm function;
(5) In case of power failure, EEPROM is able to protect the parameters setting and accumulated values;
(6) Has input control function to control the instrument remotely;
(7) Collecting data of electromagnetic flow meter regularly;
(8) Electromagnetic flow meter sends data to the data center at a fixed time (1 hour by default,
and the timing interval can be set remotely);

4. Conclusion
After the construction of the DMA monitoring system, the flow data can be monitored in real time to help detect leaking and other problems, putting an end to the occurrence of water stolen, reducing the failure rate and maintenance time, decreasing the difference between production and sale, diminishing water loss, improving the service level and economic benefits of enterprises. Water supply enterprises can find out the areas that affect the high difference between production and sale, and also can analyse the yield of water supply. If the sales volume is close to the water supply, it means that the yield of water supply is increasing, and the economic benefits of enterprises will also be improved. In addition, we can also analyse the water utilization law of the community, which can provide reliable data for optimizing water supply scheduling, decreasing energy consumption, ensuring efficient operation, maintenance, and leakage detection of water supply network, so as to achieve the safety, information, modernization and intelligence of water supply.

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