Telemetry in the life support system of an intelligent building

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Abstract. The automated system of control and management of life cycle of an intelligent building and, in general, of the Smart City requires high-quality supervision, control and preventive maintenance to handle water supply networks, delineation of operating balance and responsibility for engineering networks functioning and structures between suppliers and consumers, ensuring water analysis.

This article discusses the advantages of a module that sends data to telecontrol in real time and allows to solve problems such as: continuous and comprehensive monitoring of the state of a remote DWI (Drinking Water Intake) object; remote control of the object; remote control of the actions of the staff; automatically preventing personnel from incorrect actions; increasing the level of organization of energy accounting, efficiency and reliability of obtaining information; improving safety, production culture and improving working conditions; obtaining detailed information about the parameters of the power grid, the electrical equipment operation and the implementation of dispatching control in real time; optimization of technological modes of operation.

The study can help reduce the number of accidents at facilities and improve work efficiency as well as solve the issues of work by providing the equipment with new devices, such as MCU series controllers.

1. Introduction

Through communication channels telemetry and telecontrol systems carry out such connection as: a remote object and controllers, a dispatching point (DP) and objects, between stations with information transfer from one station to another. The controllers include several measuring channels that collect information from primary sensors, convert and transmit it to the Control Center (CC), as well as broadcast commands from the CC to the actuators. MCU series controllers are designed to solve monitoring and control problems in automation systems, they are used both as distributed input / output modules and as programmable logic mini - controllers. A feature of the module is the built-in Fractal-BASIC-PIC interpreter. Placing the interpreter directly into the module allows you to get by with minimal software and hardware for creating / editing / debugging programs.

Most industrial automation systems are provided today with add-on web components for telecontrol [1]. The program interpreter of the algorithmic language Fractal-BASIC-PIC is intended for use in modules of the MCU16 series as resident software.

Communication between the DP and the CC is carried out via any of the possible types of communication channels: an assigned physical line, a radio channel, a dial-up ATE(automatic telephone channel), a mobile communication channel, etc.

An example of the structure of remote interaction and the algorithm of the server station operation is considered in the work as a model of a unified remote access control system [2].
A smart city, and in particular an intelligent building, is a complex of design, organizational, engineering, technical and software solutions that provide a flexible and efficient technology to maintain a building that meets the needs of the XXI century, in compliance with modern technologies [3].

Nowadays, the issues of energy saving and energy efficiency are of great importance. At many levels of the federal government, measures and programs are being developed for energy saving and energy efficiency [4].

2. Methods

2.1 Automation and dispatching of water intake units

Automation and dispatching of water intake units (ADWIU) is intended for collecting, processing, archiving and transferring data to the central DP of information about the parameters of operating modes and the state of energy metering devices and engineering systems of the DWI facility. This paper presents a signal analysis methodology to check the coherence of the flowmeters data [5] and the use of optimal control techniques in water distribution networks [6].

The dispatch service monitors the continuity of supply and the handling of accidents in the provision of water supply, sewerage, power supply to the Smart City facilities.

The tasks of the ADWIU also include the visualization of parameters, automatic control and operational control of the technological subsystems (engineering systems) of the object by the operator who carries out the operational control of the ADWIU using a workstation.

The purposes of creating ADWIU are as follows:

- Improving energy efficiency, reliability, safety and quality of the equipment of engineering systems;
- Exercising central control and getting operational information about the status and parameters of energy metering devices and engineering systems;
- Ensuring security on the territory, video recording of illegal intrusions into the territory;
- Optimization of operating modes of the equipment used to increase the service life;
- Identification of incoming / outgoing workers;
- Change of settings and time programs of operating equipment;
- Remote control of executive mechanisms with the possibility of automatic control;
- Reducing operating costs as a result of energy savings and reducing the cost of maintaining additional technical personnel;
- Ensuring operational interaction of operating services, planning of preventive maintenance and repair works of engineering systems;
- Security, fire and emergency signaling of the facility;
- Control of access to the system;
- Documentation and registration of outages of the set parameters of technical processes of engineering systems and actions of dispatching services;
- Operational monitoring of the technical process current parameters, the parameters of the engineering equipment, electrical equipment;
- Pre-emergency diagnostics of equipment in order to reduce costs and time for repairs;
- Self-diagnostics of the software and hardware complex;
- Creation and implementation of information and technical database of the system and used technical equipment for further development;
- Ability to look through historical archives.

2.2 Description of the automation object

The main functions of treatment facilities in the sewerage system consist on receiving, purifying water effluents, decontaminating them and removing them from the facilities in accordance with the required
parameters and effluents treatment. This includes: drinking water intake units (DWI), artesian wells, and sewerage and water supply networks.

On the territory of the water intake there are buildings with pumps, wells with pumps. Frequency starters (FS) are used to control pumps in buildings. To control pumps in artesian wells, soft starters (SS) are used. To account for water amount in artesian wells, flow meters are installed. A signal analysis methodology to estimate missing and false data of a large set of flow meters in a water distribution network telecontrol system has been developed. [7] This paper presents a signal analysis methodology to detect and reconstruct the missing and false data of a large set of flow meters in the telecontrol system of a water distribution network [8].

Electricity metering is carried out on three-phase electricity meters.
ADWIU is performed on the basis of a software and hardware complex for telemechanics, automation, dispatching and telecommunications.

To implement the functions of monitoring and controlling the pumps, frequency starters(FS), soft starters(SS), with remote signaling, telecontrol, and data exchange via interface buses are used.

To implement control functions, contact groups of mechanisms are also used, which have two states, closed / open (door sensor, flood sensor).

To implement the function of telemetry of electricity, a counter is used.

Two-channel meters are used to carry out the functions of telemetry of room temperature and water level in the tank. A flow meter is used to measure water metering.

The buildings located on the territory of the DWI are intended for telemechanization.
The following functions are performed:

• data request and control of FS in charge of the building condition;
• taking readings of electricity meters;
• control of contact groups of executive mechanisms;
• data request and management of the video surveillance system that controls the territory of the air intake.

The metering cabinet set performs the following functions:

• data request of the soft starter control in charge of the status and parameters of the pumps;
• data request of electricity meters;
• data request of flow meters;
• control of contact groups of executive mechanisms.

ADWIU is a flexible, open, scalable system that provides horizontal and vertical integration

2.3 Functions of the telemechanic system

The telemechanics system, intended to solve dispatching issues, is designed for automated control of the technological process of water production and its transportation to the consumer.
The telemechanics system includes a control panel located in the information collection center, including controllers and communication equipment installed at remote sites - well pavilions and pumping stations for water intake and water supply. At water intakes, the Control Center (CC) of the system is usually set at pumping stations or at a control room. It includes a computer connected to the channeling equipment. Automatic control equipment installed at all pumping stations allowed for a reduction from 3-shift to single shift manning, resulting in considerable resources economy [9]. The control center is designed to perform the functions of monitoring and controlling the state of equipment and technological processes at remote well facilities. It is connected by a communication channel with remote objects on which telemechanics controllers and sensors are installed. With their help, measuring channels are organized for measuring the parameters of controlled objects - pressure, current consumption of pump motors, water flow, etc. The forecast error solving is important in the control and management of water supply systems [10].

Telemechanics systems (TM) by the nature of the functions performed are divided into tele-signaling (TS), telemetry (TLM) and telecontrol (TC). The systems transmit to the control center (CC): TS are signals about the position and state of equipment and systems, TS is information about the measured parameters. TC systems transmit commands to objects from the control center [11].

The system is designed for round-the-clock real-time operation. Cyclic polling of objects with a period of 5 to 99 minutes, accumulation and storage of the information received is provided. The system provides the ability to issue the accumulated information for any date on the display screen and for printing.

Information values can be presented in graphical or tabular form. In the course of a cyclical survey, an alternate survey of the CC (wells and pumping stations) is performed. The complex is automatically controlled by a controller and a personal computer.

The controller receives information signals from all devices and sensors, converts them into a digital code, calculates the parameters for controlling pumps with dispensers in real time and transmits all information to a computer (stored on the hard disk for subsequent issuance at the request of the operator in the way of text or graphic reports for the selected time period).

The multifunctional controller, which collects, stores and transfers information about the state of technological equipment, uses the EnLogic executive system, under the control of which all technological actions with the controller are carried out such as loading the configuration, controller data request from various external devices, communicating with the upper level and etc.

To request data from external devices, the EnLogic executive system supports a large number of different protocols, the main ones are:

- Universal implementation of the Modbus RTU / TCC protocol;
- Universal implementation of IEC 60870-5-101 / 103/104 protocols;
- Universal implementation of the DNP 3 protocol;
- 1/ O modules with DCON protocol (Tekonik, ADAM, RealLab);
- Various electricity meters including Mercury 230, SET4-TM, etc.

Flexible universal implementation of the standard Modbus, IEC, DNP3 protocols in EnLogic allows to easily integrate new devices with similar exchange protocols into the system.

Water meters are installed on the pipeline. Signals from flow meters (measuring the volume of incoming water) are continuously fed to the controller and personal computer.

Also, devices are designed for taking data from a potentially defective section of the pipeline. With its help, ADWIU of heat supply receives the necessary data, analyzing which, it is possible to establish the presence or absence of a flown in the examined section of the heat supply system [12].

The results of the applied systems comparison in the cities of the Russian Federation and neighboring countries are presented in the table [11].
2.4 Complex control system

- "Complex" is a set of equipment, instruments, automation and computing technology, related to each other by a common name and a solution to a common problem.
- The complex control system consists of the following blocks:
  - Personal Computer,
  - dosing controller,
  - secondary measuring transducers of scales,
  - control unit for pumps and ventilation,
  - cabinet for coordination with power supply and stabilization units.

![Block diagram of the automated system of supervisory control and management of the water intake unit](image)

**Figure 2.** An example of a block diagram of the automated system of supervisory control and management of the water intake unit

A personal computer is installed in the VNS operator station.

The controller is designed to receive signals from devices and sensors, process them, communicate with a personal computer and issue control signals to dosing pumps. The controller consists of a set of modules. The controller modules are controlled by the MCU module, in which the control program is written and to which a debug computer can be connected via the DB-9 RS-232 connector. The RS module receives signals from the flow meter about the amount of incoming water, communicates with a personal computer via the RS-485 channel. Selection of communication subsystem for telemetry network may have a crucial impact on system performances and reliability. The optimal solution will match the timeresponse requirements, also providing that system is not reaching the limit of its possibilities [13]

The sources of input information are:

1) sodium hypochlorite (SH), dosing pumps (number of strokes per minute, current state); 2) electronic scales (availability and consumption of GN from working containers); 3) residual chlorine meter (at the exits to the city network); 4) flow meters for water flow from artesian wells; 5) water
flow meters (water consumption at the outlet of the units); 6) current sensors installed on pumps of the 2nd lift (monitoring of operating currents); 7) current sensors installed on deep pumps (monitoring of operating currents); 8) level sensors in clean water tanks; pressure sensors at main outputs. All devices and equipment are divided into three groups.

Each group forms a separate digital data transmission network.

The first group includes a metering pump controller and a valve controller. Each controller includes several interface modules. One pair of such modules from each controller is used to transfer data to a computer. The rest are used as "gateways" between networks.

The second network is formed by the input flow meters and the metering pump controller. This is done primarily due to the fact that the data on the flow of water from artesian wells are the initial data for calculating the required amount of disinfectant in accordance with a given dose. Therefore, it is the metering pump controller that generates requests using the industrial protocol, one by one for each of the available four input flow meters. And then, in turn, already upon request from a computer, it transmits the collected information as part of a package along with other data on the state of external equipment and the parameters of the chlorination process.

The third network functions similarly, which includes the valve controller, output flow meters and a whole group of analog sensors (current, pressure, level). By the nature of their output signals, these sensors cannot be directly connected to a digital network without first being digitized.

In the general case, the structure of the telemechanics system of the power facility is as follows:

- Lower level is primary automation equipment (sensors, measuring transducers, local control devices, executive devices);
- Medium level are object interface devices (USO), telemechanics controllers;
- Upper level is information and computing complex (operator's workstation, database servers);
- Channels and equipment for information transmission [14]

![Figure 3. An example of a telemetry and telecontrol system](image)
The control of the flow rate of the liquid entering the control and measuring tank using various flow meters, as well as the control of the liquid supply and the regulator is described in the source [15]. By the way, the idea of a telecontrol centre for managing a group of factories is gaining popularity. [16]

3. Result

3.1 Embedded modules

3.1.1 Flow meter module

The embedding of flow sensors into automated process control systems ensures high metering accuracy and increases production efficiency.

So that the dispatcher (responsible for water indicators) can track the consumption in real time, a module has been created that outputs data to the telecontrol in real time. Telecontrol system availability is provided by its high performance [17]. The monitoring and control systems represent the source of decisions for real-time control of processes [18].

Fragment of flowmeter code

; consumption request №1 (AC18 – address 4)
; Flowmeter Dniepr-7 (taking readings of register group)
1989 12C#A6, (19H)=4,3,0,0,15,5,98H;

; waiting for the answer 200 MC
1989 TIME=0:DO:WHILE TIME<0.2

; Processing data obtained from controller
1990 S10=I2C#A6, (4EH):A=I2CA:IF A=1 THEN F26=0:GOTO 2100;
1991 IF S10=0 THEN F26=2:GOTO 2100
1992 IF S10 < 6 THEN F26=3:GOTO 2100; ERROR CODE

; Reading and indicating dataset obtained from the flowmeter
1993 FOR I3=0 TO S10-1;
1994 MEM(MR+I3)=I2C#A6, (IAH) ; PHB MEM(MR+I3),
1995 NEXT I3;

; control sum counting
1996 MEMW(3)=0FFFFH; S10=S10-2;
1997 CRC=CHSMR% MR, S10 ; PHW CRC;
1998 IF CRC <> MEMW(MR+S10) THEN F26=3:GOTO 2510;

; converting the value of current consumption
; from float form
2010 S10=MEM(MR+31):S10=S10.AND.07FH:S10=ROT1 (S10)
2011 S11=MEM(MR+32)
2012 IF (S11.AND.128)=128 THEN S10=S10.OR.1:S11=S11.AND.7FH
2013 S12=MEM(MR+29): S13=MEM(MR+30)
2014 S14=(S11*65536)+(S12*256)+S13:S14=(S14/8388607)+1
2015 S15=S10-127
2016 S16=(2**S15)*S14:IF (MEM(MR+5).AND.80H)=80H THEN S16=-S16;
2017 PRINT "Incoming wave from AC18, M²= ", S16
2018 F26=1; OK

The introduction of an integrated automation and dispatching system at heat and power facilities has shown that this approach to solve problems in the field of energy saving is the most effective and allows, at the lowest cost, to minimize the payback period of the system. [19]
Ultimately, the key point is the organization of rational interaction between dispatcher and computing system that allows to monitor and control the technology hazardous objects in real-time. Modules automate the work of the station, reducing the number of accidents at sites and increasing work efficiency.

4. Conclusions
Providing the equipment with new devices, thanks to telemetry and remote control which is available [18], allows for automatic monitoring and control of pumping equipment with displaying data on their actual. Each controller is configured for a specific task, which makes the system the most optimal, because it is formed taking into account what is really needed. And the use of the proposed method for monitoring and transmitting data allows for continuous diagnostics of communication channels, the operability of all systems and there is no longer any need to send specialists directly to the object every time: parameterization and calibration of devices is carried out remotely. Fast setting of limit levels and operating modes makes it possible to flexibly control the production process, reconfigure it according to changing tasks. The dispatcher responsible for the water indicators monitors its consumption in real time, while the operational indication of the identified malfunctions is performed with automatic entry into the event log.

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