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Technological parameters monitoring and control system for water distribution stations

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Abstract

The implementation of the data acquisition, monitoring and control systems in the public utilities supply domain (water, heat, methane gas) and also in industry, has a major impact for the user because in an economy in which profitableness represents the only way to cope the competition, there is imposed the consumption analysis and implicit the working efficaciousness analysis. The informatics systems present the possibility of preventing some phenomenon, by analyzing and processing the data, leading to an optimum functioning and to important financial economies. In this way, the paper presents a monitoring and control system of the technological parameters in the water distribution stations, which will allow the optimum functioning of the pumping system, safety and endurance growth in the equipments and installations exploring, and so obtaining efficient energy usage and optimum administration of the drinkable water.

Key words: *water distribution stations, monitoring and control system, pumping system, endurance.*

Introduction

Water supply represents a vital problem for people, and this imposes the need to know the information regarding consumptions, resources and production. In this way, to obtain this information, based on analyses of the technological process, of the driving and exploiting mode, there is proposed an integrated SCADA (Supervisory Control And Data Acquisition) type informatics system which to allow an optimum drive of the technological process and a grater safety regarding the drinkable water distribution with the purpose to continuously improve the quality of the services offered to people, and also to grow the life standard according to settlements and recommendations made for the European integration of Romania. Through efficient functioning of the pumping stations there will be assured a greater water necessary, with a correct administration and a continuous supervision of the water consumptions, so that people can benefit from water a longer time program at a real cost.

The proposed system uses a distributed architecture, in which are used data acquisition equipments, smart controllers for processes control, sensors, drive modules and industrial process computers, data servers, PC computers for supervision or operative drive of remote processes. The communication between the dispatcher and the local monitoring and control systems is done by the help of some data sending techniques, according to the type of the communication

environment between these points (cable, optical fiber, telephone line, radio channel/wireless, GSM). Considering a base characteristic of the SCADA systems – flexibility, the main concept fallowed in the development of this system is modularity, in the idea of an easier configuration and maintenance and to assure ulterior extension possibilities of the system.

The architecture of the monitoring system

The monitoring and control system has the role to supervise the evolution of the technological process, to measure exactly the consumptions and production, respectively to optimize the technological process, assuring the fallowing *functions*:

- acquisition of data taken from the transducers and their process;
- framing between the technological limits of the acquisitioned data, warning in case of crossing these limits;
- pumps command, the regulation being made according to the debit or pressure in the drinkable water supply network;
- realization of the supervision bulletin and of the specific reports;
- assuring the informational support by creating and maintaining a secure and complete database;
- elaboration of synthesis reports using data from the databases and from archives and presenting them on display or printer, with the possibility of completion or modification by the user;
- presenting the measures taken from the dispatcher, by:
  - synoptic, general or on sectors schemes, for rapid evaluation of the momentary process functioning situation;
  - virtual instruments (bar-graphs, instruments with pointing needle);
  - evolution diagrams on selectable time ranges.
- informing the decision factors in order to take the optimum measures that impose;
- system centered administration
- interfacing possibilities with other existing informatics systems.

The informatics system (fig. 1) uses a distributed architecture, hierarchical, which contains the following *functioning blocks*:

- Adapting signals block – which realizes the bringing of the signals taken from the process through the transducers in the unified signals range compatible with the inputs of the computing systems interfaces;
- Local data acquisition and process equipment (local dispatcher) – which to allow:
  - automat acquisition of the specific parameters;
  - primary processes (filtering, validation of the values from the transducers, framing between limits);
  - local display;
  - warnings in case of crossing the

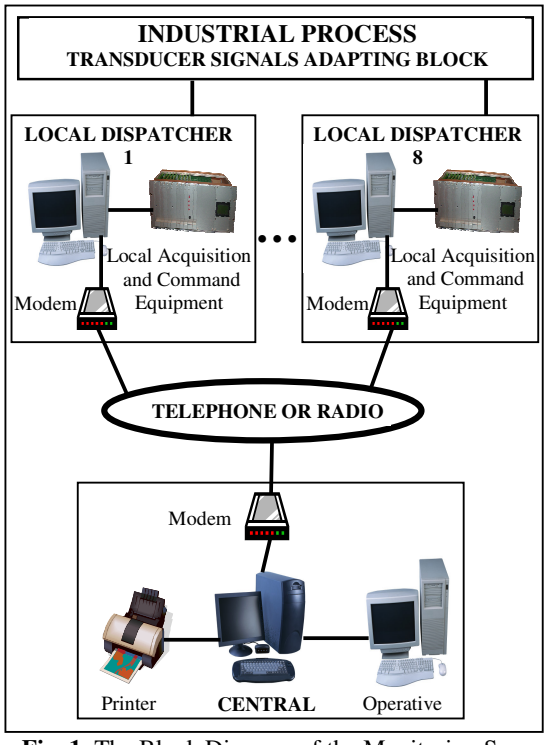

Fig. 1. The Block Diagram of the Monitoring System.

limits;
  - communication with the superior hierarchical level.
- Central equipment (central dispatcher) – which realizes:
  - supervising the entire system;
  - superior data process;
  - displaying the system's scheme;
  - displaying the synoptic schemes with real time supervision for each local dispatcher;
  - elaborating the general monitoring bulletin.

The communication between the dispatcher and local systems is through telephone modems or radio.

The *technological parameters* that are monitored are: pressures, debits, levels, pumps state, electro-vane state, filters state, active/reactive energy.

The SCADA system assures the acquisition from the transducers of the characteristic parameters of the functioning of the technological installations within the water distribution stations, the monitoring and command of the pumps at the local stations level, the taken of the acquisitioned data, sending the data to the central dispatcher level, monitoring the stations functioning through the synoptic schemes, elaborating the monitoring bulletin and stations balance sheets, sending the results to the decision factors. In this way each station has its own data acquisition and command local equipment which has associated a local PC and which communicates with the local dispatcher PC. The equipment is questioned at a constant period of time fixed by the local PC and so all the analogical/digital inputs and outputs are registered at the level of the local computer. The equipment realizes the drive of the pumps driving engines within the respective station, through softstarters/invertors (Fig. 2).

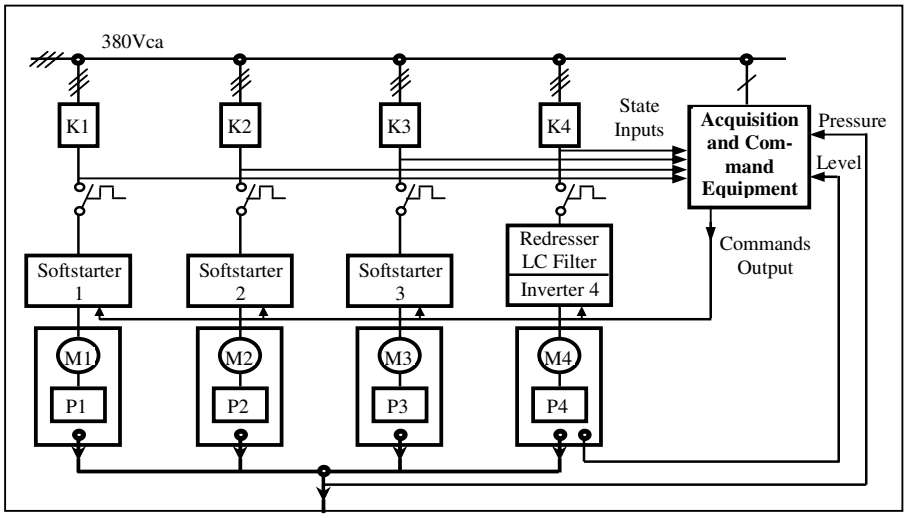

Fig. 2. The Block Diagram of a Water Distribution Station.

Usually, there are used softstarters until the engine reaches the nominal revolution, and through the inverter the evolution is adjusted according to the measured pressure. The invertors supply with voltage and variable frequency the asynchronous water pumps drive engines, and so assuring the change of the evolution between zero and the nominal evolution. The local computer realizes the following functions:

- questioning the data acquisition and command equipment;
- data register in the local database;
- generating states of warning/pre-warning;
- communication with the superior hierarchical;
- local display of the functioning parameters in a format specified by the user;

- access to the general database within the central dispatcher for obtaining reports and statistic information at request.

All local computers are questioned by the central dispatcher regarding the stored data, until it receives the necessary data (through a communication protocol that assures 10 questions). In case a local computer detects the warning/pre-warning state, in generates a special message which is sent to the central dispatcher in order to inform about the special state. The warning/pre-warning state refers to the crossing of some limits imposed by the system's user on analogical channels or the activation/deactivation of some digital inputs. The special events are stored in a local archives (at the local computer) and in a general one (at the central dispatcher). The general and special data (warning/pre-warning) are used by the central dispatcher to generate different functioning reports or for generating of evolutions in time of some parameters requested by the user. All reports are sent to a printer defined by the user, local or in a network.

Local acquisition and command equipment

In each pumping and drinkable water distribution station will be placed:
- Local acquisition and command equipment;
- Local dispatcher;
- Data communication system;

The local acquisition and command equipment (fig. 3) has the following functions:

- acquisition, filtering, validation of the values from the transducers;
- local programming the transducer's domain, the warning limits;
- local programming the command logic;
- supervising the functioning state (flaw), supply absence, etc…;
- supervising the "short circuit" or the "broken cable" state for transducers;
- data sending in RS 485 network to the local dispatcher associated PC type.

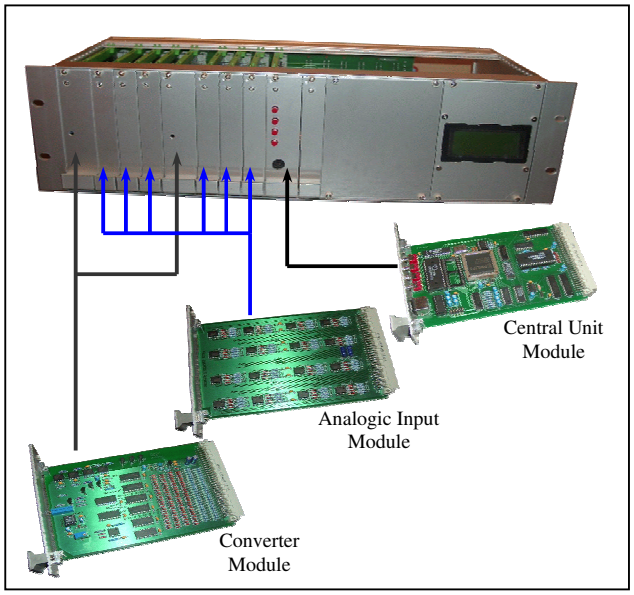

Fig. 3. Local Data Acquisition and Command Equipment.

This equipment is designed to acquisition a maximum of 96 analogical measure, to process them and through the serial interface (RS232 or RS485) the communication with a centralized supervision and control system. It contains the following modules:

- Central unit module – build around a Philips 80C552 microcontroller, which assures the control of maximum 2 conversion modules, of maximum 2 graphical or alpha-digital LCD display circuits and of maximum 6 analogical or digital input modules. There can be entered commands with the help of 4 buttons placed on the front panel of the module. The module has 32kB EPROM memory for program and 32kB RAM memory for data and program. The connecting scheme of the C is classic: 8 bits latch for de-multiplexing the inferior addresses, reset generating circuit, quartz crystal, internal serial interface, external data and

program memory, internal and external ports etc.

- Conversion module – is designed to convert 48 analogical signals in 12 bits digital code, also assuring the galvanic isolation of the analogical signals and the digital processing mode. The input analogical signals are send to ADC with the help of 2 analogical multiplexing levels witch are driven by a counter controlled by the central unit. The multiplexing block assures the transfer of 48 input signals and of 2 signals for auto-zero and internal auto-calibration. After multiplexing, the resulted signal is applied a the ADC's input through an operational amplifier in voltage repeater assembly, which assures the impedance adapting between the CMOS circuits from the multiplexer and ADC, also heaving a input voltage value limiting circuit in ADC.
- Signal adapting module with 16 differential inputs in voltage or current – is designed to condition 16 input voltage signals in [0...5V] range or by optionally mounting a precision resistor, to condition current signals in [4...20mA] or [2...10mA] range. The module is designed using operational precision circuits in differential amplifier assembly with unitary gain, each of the 16 amplifiers having input protection circuits in differential mode and of commune mode.

Conclusions

- The local acquisition and command equipment presented in this paper is integrated in complex monitoring system of the distribution parameters for water supply in Craiova.
- The obtained monitoring system puts at the beneficiary's disposal a powerful working instrument which allows:
  - pumps command and energy consumptions reduction;
  - permanent real-time monitoring the technological parameters state and the energy consumptions;
  - offering information to the decision factors for taking optimum decisions;
  - assuring informatics flows needed for management.
- Through the features that it offers, the system can work interconnected with other monitoring system and also with computing systems from the network, and so allowing access to information, at different decisional levels.

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Sistem de monitorizare şi control al parametrilor tehnologici în staţiile de distribuţie a apei

Rezumat

Implementarea sistemelor de achiziţie a datelor, monitorizare şi control în domeniul furnizării de utilităţi publice (apa, căldura, gaz metan) precum şi în industrie, are un impact major pentru utilizator deoarece într-o economie în care rentabilitatea reprezintă singurul mod de a face faţă concurenţei, se impune, analiza consumurilor şi implicit a randamentului cu care se lucrează. Sistemele informatice prezintă posibilitatea de a prevedea din timp anumite fenomene, prin analiza şi procesarea datelor colectate, conducând la o funcţionare optimă şi la importante economii financiare. În acest sens, lucrarea prezintă un sistem de monitorizare şi control al parametrilor tehnologici în staţiile de distribuţie a apei, care va permite funcţionarea optimă a sistemului de pompare, creşterea siguranţei şi anduranţei în exploatare a utilajelor şi instalaţiilor, obţinându-se astfel utilizarea eficientă a energiei şi gestiunea optimă a apei potabile.