Automated Monitoring and Control System for Water Distribution Networks

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Abstract: - A modern management, based on the economical performance, impose, in principal, the knowledge, in every moments of the report between costs and profits, and of the control level that can act on this report to bring him to a subunit value. The implementation of modern solutions in an efficient functioning of the pumping stations within the public water supply services implies the existence of some proper systems based on computational technology. 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 SCADA system for the monitoring and control 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: - SCADA, data acquisition, analysis, monitoring, control, PLCs, data transmission

1 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 DMS/SCADA type informatics system which to allow an optimum drive of the technological process and a greater safety regarding the drinkable water distribution with the purpose to continuously improve the quality of the services offered to people [1], [2], [9].

In the making of the architectural model for the DMS/SCADA system, the following principles have been considered:

- implementing of open systems with distributed processing;
- principle of modularity;
- principle of autonomous and integrated working of equipment;
- principle of mutual settlement of the equipments to provide the essential working of the system;
- principle of transparency in using and working;
- principle of best cost/performance ratio;
- principles destined to provide:
  - effective monitoring, control and management of real-time and extended-time installations, based on the data acquisition from installations;
  - management of installations besides the real-time;
  - the required information for analyzing the behaviour in operation and working out the statistics related to the working of the existing networks, installations and equipments, for establishing the technical and economic solutions to improve the technical conditions of installations, equipments and development strategies;
  - the information for the superior dispatcher levels.

The proposed system uses a distributed architecture, in which there are distinguished two levels:

- a local level corresponding to the water distribution stations;
- a central level corresponding to the dispatcher.

The local level is based on the usage of the programmable logic controllers and of computers, and the central level contains high speed PC computers for the 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 fibber, 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.

2 The Architecture of the SCADA System

The information tracking in real time and the range enlargement of this information, the tracking of the working parameters comparatively with the accepted limits, storing the data from the process and its continuous processing, examining the technical state of the equipments and early preventing the future averages, automatic providing of the parameters settings and last but not least, providing the linking with the dispatch level for possibilities of two-sided data and controls transmission, make it necessary the large-scale introducing and distribution of the digital technologies.

From an architectural point of view, the system will be developed on a equipments distributed network model based on the present standard level of computational technique, in order to fulfill the requests for fast processing of an important quantity of information, the requests for high viability and the necessity of open access to the informatics system.

2.1 System functions

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 centred administration;
- interfacing possibilities with other existing informatics systems.

2.2 System components

The informatics system (Fig.1) uses a distributed architecture hierarchical [4], [6], [10], [11], which contains the following blocks:

- Transducers signals adapting block.

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;

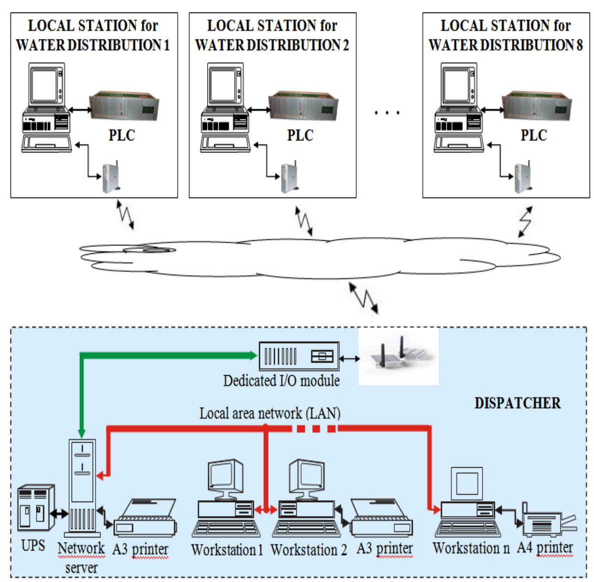

Fig.1 The Block Diagram of the SCADA System

- Local data acquisition and command equipment - Programmable Logic Controller (PLC).

Each local water distribution station is provided with a data acquisition and command equipment (PLC) associated with a PC which does:

- 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 limits;
- communication with the superior hierarchical level.

• Dispatcher

At the Water Staging level there is the Dispatcher which does:

- supervising the entire system;
- superior data process;
- displaying the system's scheme;
- displaying the synoptic schemes with real time supervision for each local equipment;
- elaborating the general monitoring bulletin.

The communication between the dispatcher and the local systems is done 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.

2.3 System functioning

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 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 soft - starters/invertors (Fig.2). Usually, there are used soft-starters until the engine reaches the nominal revolution, and through the inverter the evolution is adjusted according to the measured pressure. The invertors supply with variable voltage and frequency the asynchronous water pumps drive engines, and so assuring the change of the evolution between zero and the nominal voltage [5], [7], [12].

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.

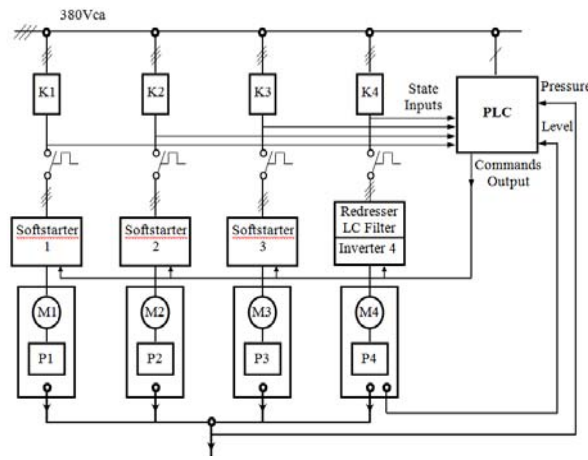

Fig.2 The Block Diagram of a Water Distribution Station

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 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 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.

3. Data Processing Software Tables and Diagrams Obtained Experimentally

The data processing software specific to the SCADA system implemented in Water Staging Craiova [3], [7], [8], [9], [11], is developed on a model of a distributed network composed of equipments and contains the following application software packs:

- Software packs for acquisition and control – run at the local level: PLC and inverter;
- Software packs for local monitoring – run at local level: PC;
- Software packs for communication – assure communication: PLC–inverters, PLC–local PC, local PC–dispatcher PC;
- Software packs for dispatching – run at PC level and at PC dispatcher level.

The SCADA system offers information to the compartments which participate to the operative drive, supervision and decision making of the technological process.

3.1 Synoptic scheme

Synoptic scheme (Fig.3), for rapid evaluation of the current functional state of the process. This highlights a number of parameters, considered essential, with the name and value. When placing the mouse over the tags, a message appears describing the position of the transducer used for measuring the respective parameter.

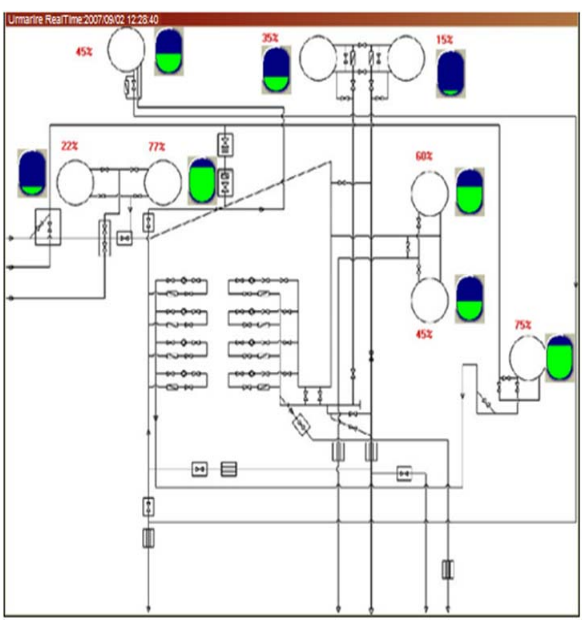

Fig.3. Synoptic Scheme for the Water Level in Tanks

3.2 Reports

Reports that underline the tabular or graphical evolution of the parameters selected, using the data form the database and/or from archives and displaying it on screen or printer, the user having the possibility to complete/modify it. In this way there is called a window that allows selection from a list of a parameter and for this there is established the visualization channel (Fig.4) and respectively the corresponding period selecting the year, month, day and hour (Fig.5).

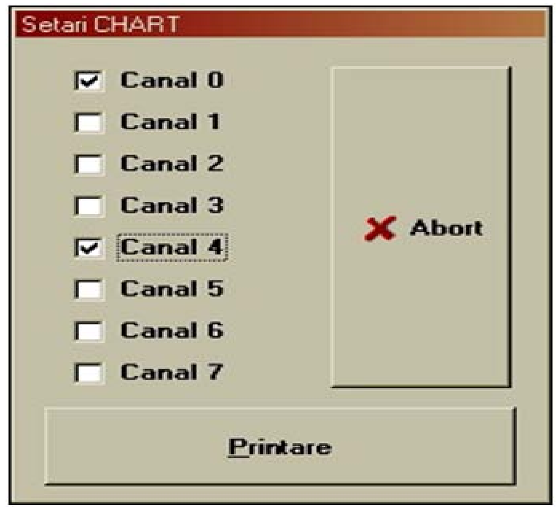

Fig.4 Channel 0 and Channel 4 Selection for Report Visualization

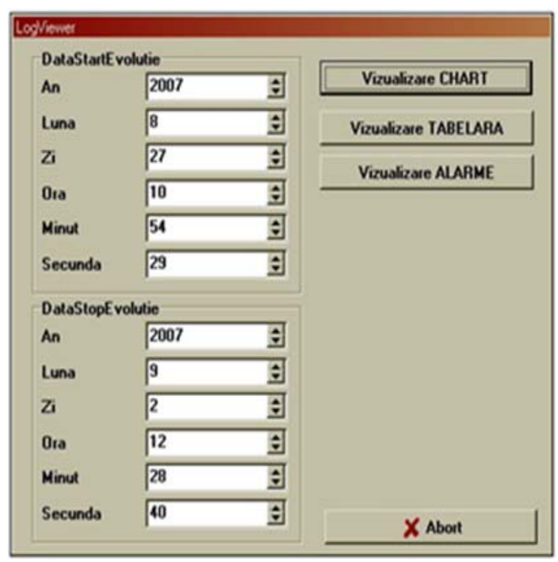

Fig.5 Setting a Year, Month, Day for Report Visualization

There is presented the evolution in a table style mode (Fig.6) or graphic mode (Fig.7) for the selected parameters.

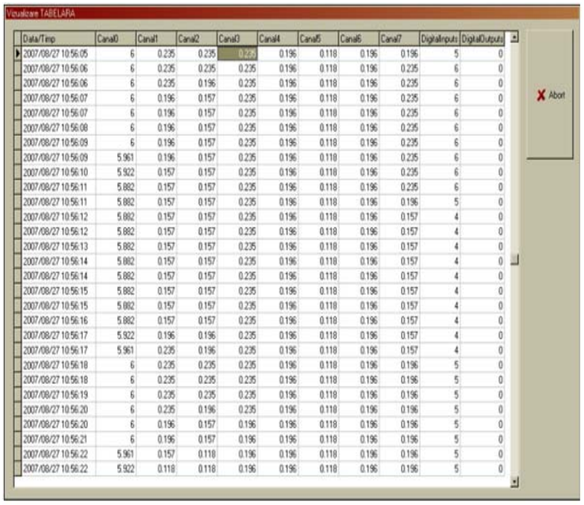

Fig.6. Table Style View of the Selected Parameter

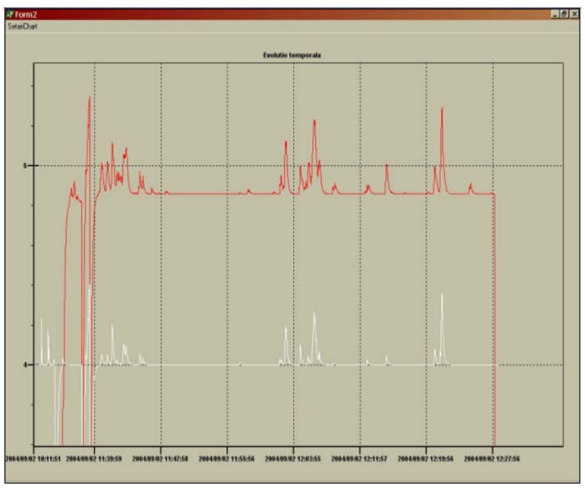

Fig.3 Graphic Visualization of the Temporal Evolution of the Fig Selected Parameter

Events report allows the recording of the changes of the process state in event journals ordered and shown on the screen or sent to a printer (Fig.8).

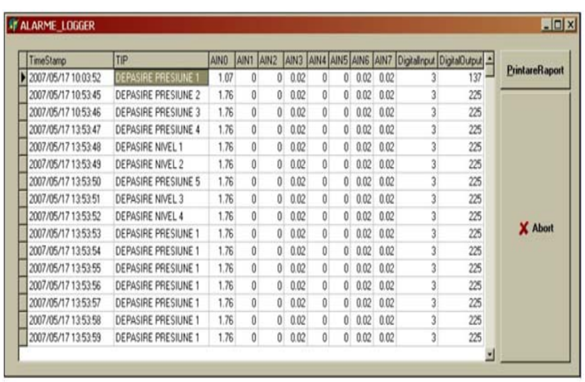

Fig.8. Events report

4 Conclusions

- The SCADA system presented in the paper is a complex monitoring and control system for the water supply parameters, implemented in Craiova.
- The monitoring and command 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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