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Power Consumption Control System in Copper Tubes Factory - Majdanpek

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Abstract **–This paper shortly describes realization of the computer network, and SCADA software used for monitoring and peak power and energy distribution control in transformer station at Copper Tubes Factory (FBC) in Majdanpek. Some specific details of hardware and software (own made) implementation were specially noted.**

Keyword **– monitoring system, peak power, energy**

I. Introduction

Department of Industrial Informatics, at the Copper Institute in Bor has been designing real-time systems for monitoring and control of industrial processes since 1990. As a result, three generations of UMS (Universal Measuring Station) have been developed. UMS is industrial PLC (Programmable Logical Controller) fully designed at the Department of Industrial Informatics and it is a core of process control system. Main objectives of such systems are real-time data processing and displaying of results on dynamic synoptical schemes, real-time graphs or tables, database forming, and automatic process control.

The unified SCADA software [3] has been modified and used for monitoring of power consumption and peak power control at Copper Tubes Plant (FBC) in Majdanpek.

II. System configuration

The main reason for introduction of PC based control system at the plant transformer station is the reduction of the peak power, which is directly related to lower expences of electrical energy. The monitoring project predicts measuring of active and reactive power on each input and output cell at the plant transformer station, and automatic control of main power consumers (switching based on given criteria).

As the power consumers are dislocated, all signals, (analog signals from power transducers, and digital control signals) had to be concentrated at one place, were measuring station is placed.

All analog signals are inputted to UMS as standard current signals (0-20 mA). Monitoring computer (PC) is placed at plant transformer station control room. Monitoring workstation (standard PC) communicates with UMS over serial communication port (RS-232 interface connector), and the physical link is full-duplex line. To overcome the distance between PC and UMS, Line Amplifyers are used. The standard bit rate of data transfer is 9600 bps. Communication protocol is ASP (Asynchronous Serial Protocol) [1]. Monitoring computer is connected over Local Area Network to other PC's and acts as a data server. Server software, which drives communication with UMS, also has an interactive role and lets the user change parameters of the monitoring process, like sampling rate, number of measuring channels, parameter limits, type of data archiving etc. However, client software has only the ability to monitor process, without any interactivity. Diagram of realized monitoring system is given in Fig. 1.

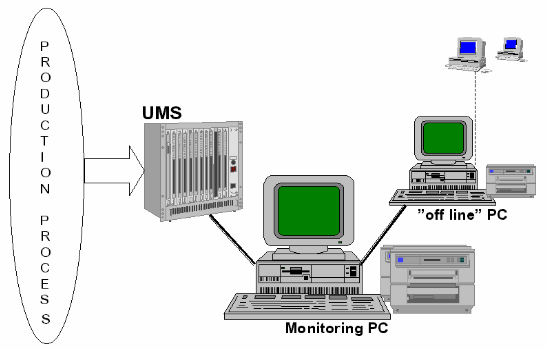

Fig. 1. Overall system configuration diagram

III. Hardware

UMS is a device for data acquisition based on Motorola 68HC11 microprocessor. Main characteristics of UMS (standard configuration) are:

- microcontroller Motorola 68HC11E
- intern eight channel, 8-bit A/D converter (conversion time less than 40 µs),
- 64 differential analog inputs,
- 64 + 64 digital state signals (input + output) with mutual point (or independent). All digital signals are galvanicly isolated.
- RS232 communication port,
- 48 (56) KB for data (RAM)
- 16 (8) KB for software (EPROM)

Local display and functional keyboard gives a possibility of device control, correction of the time, and start of measuring. UMS can work independent of PC, and can control the

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process itself. It can also work like data logger, and memorize about 2000 data messages in local RAM, and later, when connection with a PC is established, transfer them to PC. Minimal demands for monitoring computer are: Windows 98 OS, Intel Pentium 3 processor, at 450 MHz or higher, 128 MB RAM, SVGA graphics (800x600).

IV. SOFTWARE

EPROM of UMS is consist of executable versions of test, control, operational and communication software modules. These modules are optimized in space and time and they are global solution for standard configuration. Operational program module is responsible for measuring of analog channels and checking states of digital inputs. Type of measuring, sampling rate and other parameters can be changed using local keyboard, or commanded from a monitoring PC (more often case). The results of the measuring form the message, which is transferred to monitoring PC, or memorized in local RAM (if PC is disconnected), so it can be transferred later when the connection is established. UMS may work independently from monitoring computer, so local process control is also possible. If any parameter exceeds given limits, it causes alarm message, or even better, if any parameter shows trend of reaching limit value, it firstly can cause warning message, which is more effective, so the operator, or the system itself can react on time.

Appropriate process control application is installed on monitoring computer. This real-time based application is developed using Microsoft Visual C++ 6.0 [2,3,4], and it's main characteristics are: communication with UMS, data processing, data presentation, command and process control (interactive), data archiving and off-line analysis and interpretation of data.

Most important class of this software contains driver for communications with UMS as secondary network node (PC is a master). Communication protocol is ASP (Asynchronous Serial Protocol) [1]. Main objectives of this class are:

- request for communications
- connection establishment
- data transfer
- control of transfer quality
- state indication of network nodes

Member functions of this class control main parameters of UMS: sampling rate, type of measuring, number of analogue and digital channels, correction of time on UMS based on PC time etc.

Other classes are used for displaying of data on dynamic synoptical schemes, real-time graphs or in tables. They analyze and process data and display them in adequate manner. Fig. 2. shows the look of one synoptic screen and Fig. 3. shows measuring results presented in tabular form.

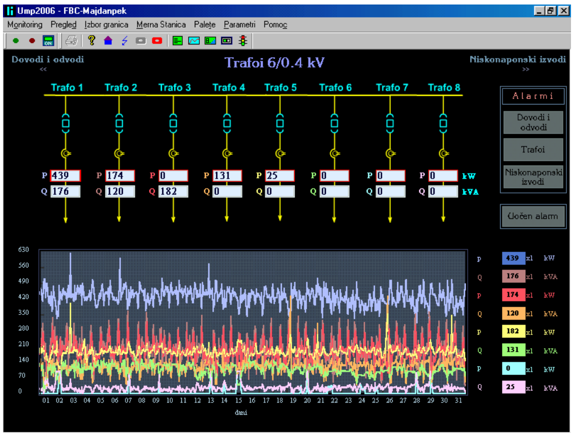

Fig. 2. Synoptic screen

Data are memorized in different buffers, until the moment of archiving. Further processing is consist of number of actions:

- data processing for graphic display on the screen,
- data processing for alert system,
- data processing for distribution over LAN,
- forming of daily archives and
- forming of monthly archives.

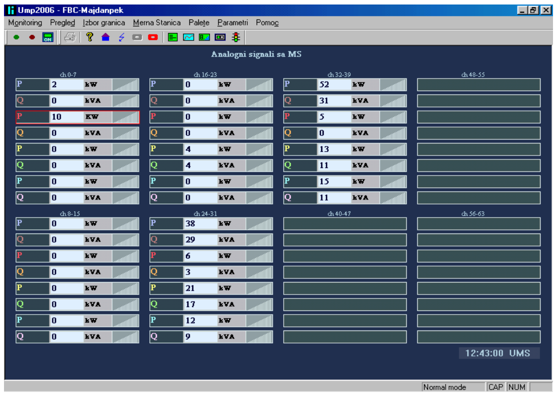

Fig. 3 Measuring results in tabular form

In order to display data in the user demanded way, independent of channel's order in a message, channel switch class has been created. Other classes enable additional facilities to the users like: changing the range of measuring, changing the alarm limits, scaling the axes at the real-time diagram etc. Software is user-friendly, and all this can be done easily using dialog boxes.

File management class includes functions for data archiving. Buffered messages are written on hard disk based on time criterion defined by user. Data are saved as text files and can be used for further processing (Excel, Access). Three groups of files are formed: daily reports, monthly reports and log files. Log files are used to display the history of a controlled process. Those files contain informations about every user intervention (operator) with the exact time and date, time of alerts etc., which can be very useful for later analyses.

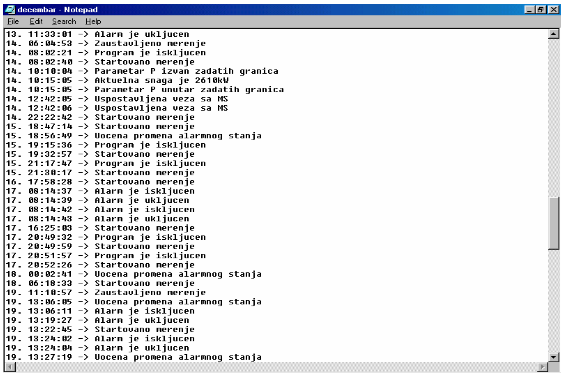

Fig. 4. Part of a log file

In order to get better performance, user can change process priority, comparing to other active applications on PC, from low to real-time priority. In high or real-time mode application performed very stable. Some of the functions are password protected.

V. Objectives and Performances

Main objective of the system is control of power consumption, intending to make significant financial effects by peak power reduction. System has the ability to predict trends of active power consumption based on 15-minute average values. User chooses the limits, and also the starting minute for power control (from 7^{th} to 14^{th}). From that moment, average power values are compared to given limits every minute, and up to eight consumers can be automatically turned off if the limit is exceeded, in order to reduce the power consumption.

As monitoring application is working in the multitasking OS, it is recommended to choose high or real-time priority to obtain stability. Communication between PC and UMS is based on master-slave principle, where PC is a master and requests communication, and UMS replays with the information about its state, quality of transfer and measuring data when they are present. PC gives a command to start measuring on UMS, transferring all parameters needed for its independent work, including real time from PC. UMS continuously measures defined parameters in a rhythm given by the user.

Monitoring PC receives the message, analyzes, displays and saves data. It also alerts if any parameter exceeded limits, both sound and visually. Operator must react on alert states, and exact time of alarm and his reaction are written in log file.

Each computer in Local Area Network (under Windows OS) can monitor the process using client application. This (client) version [2] of the software has only the ability to monitor process, without any interactivity.

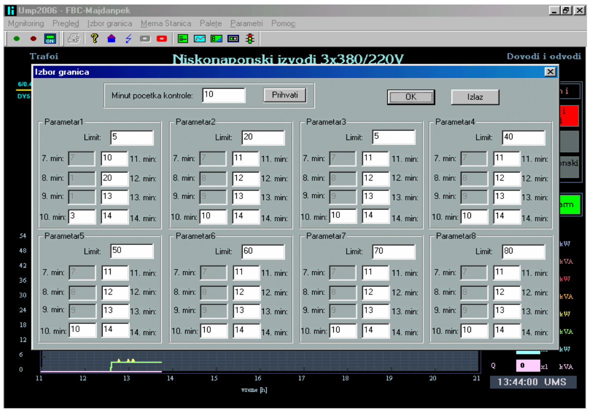

Fig. 5. Dialog box for changing parameters of process control (limits and starting minute of control)

VI. Conclusion

Electrical power consumers in FBC can be divided in 3 categories:

- High priority cosumers which must not be switched off by the process control system,
- Middle priority consumers - system alerts the operator both sound and visually about possible overload of peak power. Depending on operators decision, consumer should be switched off, or switching on of some other consumer should be postponed,
- Low priority consumers are automatically switched off if system predicts possible overload of peak power, without any bad effects on technological process.

Although system has been installed only few months ago, the financial effects are already visible. The effects are both technological and psychological. Technological effects are peak power reduction and rational use of electric energy. Psychological effects are reflected in better discipline at work due to operator's feeling of permanent and objective control of their behavior.

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