

DEVELOPMENT OF TELEMETRY SYSTEM OF POWER-INTENSIVE OBJECTS USING ICP DAS INDUSTRIAL CONTROLLERS

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Key words and phrases: monitoring system; power-intensive object; programmable logic controller; remote control; telemetry.

Abstract: The problem of remote monitoring and control of processing equipment was considered. The authors proposed and implemented the system to monitor the extrusion machine temperature using programmable logic controllers with possibility of remote control via networks. The block diagram of the telemetry system was developed; the configuration of interaction between the system components was formed.

Introduction

The importance of resource-saving problems sets new requirements to control system structure of power-intensive objects. The creation of power-intensive algorithms, the complexity of modern equipment, geographical dispersion – all these factors need to be taken into account in the development of modern control systems.

Modern telemetry covers a wide range of problems, related to receiving, transformation, transmission and processing of information used in remote object control, state determining, studying of physical processes in some locations, where observation of these processes is very hard.

Using telemetry resources, especially for power-intensive objects, permits to check the object state in real time and provide remote identification. It gives an opportunity to develop an optimal control algorithm for different dynamic modes of a functional object without any presence of an expert at the object.

The task of this work is the creation of effective monitoring system for industrial power-intensive objects using telemetry resources.

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The monitoring system of temperature of the power-intensive object, in our case – the extrusion machine, was suggested and realized, based on programmable logic controllers (**PLC**), with remote control opportunity via networks based on stack of TCP / IP protocols, including the Internet.

Approach Rationale

From the perspective of technical realization of the developed monitoring system there are a few approaches to its development. The first is in use of PC with connected sensors via converters for solving the given task. The given approach wide used in tasks, where processing of huge data array and respond quickly on input data changing is required. The approach is flexible to the reconfiguration under the changing control tasks, but in addition to this extremely high cost. Thus, for the stated problem, this approach is inappropriate due to the inefficient use of the hardware. The second is the initial development of the system with discrete elements, including the circuit diagram and existing devices. The given approach enabled to obtain the maximum appropriate system, but not suitable for modification if the requirements for monitoring system change. Also, the resources spent on the development and production can be significantly high.

The suggested approach is the creation of the monitoring system based on PLC. The concept of creation telemetry system on PLC fully satisfies the design principles of electronic systems. The given approach allows configuring the system under the stated task simply and shortly by adding new or replacing old blocks with more suitable technical characteristics. The one advantage of this approach is a rapid mastering of PLC programming by using ISaGRAF software [1] and opportunity of visual imaging of program processing and variable's status in the environment debugging mode. ISaGRAF is a control software environment that enables to create local or distributed control systems. It offers a combination of a highly portable, robust control engine (Virtual Machine) and an intuitive application development environment (Workbench) [1].

Block diagram and hardware

As the sensor of thermoobject temperature we selected chromel-alumel thermocouple owing to its low cost and a wide range of measurable temperatures [2]. The thermocouple usage requires using a signal amplifier. We chose the type of the thermocouple signal amplifier with cold junction compensation AD595. As the controller on an observed object PLC i-7188EGD made by ICP DAS was chosen. The main characteristics of mentioned PLC are given below:

Processor	AMD, Am188™ES, 16-bit, 40 MHz
ROM, KB	512
RAM, KB	512
Communication	RS-232, RS-485, Ethernet 10 Mbps
Supply voltage, V	10...30
Power Consumption, W	3
Operating Temperature Range, °C	-25...+75
Features	Real-time clock, operation system MiniOS7 (MS-DOS based), four-digit seven-segment LED, support the development environment ISaGRAF

Due to the fact, that the controller does not have connection interface with analog sensors, the converter between PLC and thermocouple amplifier is 8-channel module of an analog input i-7017 by ICP DAS, representing an eight channel analog-to-digital converter, connected to the controller via interface RS-485 and controlled by DCON protocol. The main module characteristics are as follows:

Ranges of measured voltage	$\pm 10\text{ V}; \pm 5\text{ V}; \pm 1\text{ V}; \pm 500\text{ mV}; \pm 150\text{ mV}$
Ranges of measured current, mA	± 20
Sampling rate, samples/sec	10
Accuracy, %	$\pm 0,1$
Data width, bit	16
Input Impedance, M Ω	20
Supply voltage, V	10...30
Power consumption, W	1,3
Operating temperature range, °C	-25...+75

Due to the fact, that the PLC enables to connect via serial port and WLAN, for system access via the Internet, providing opportunity to arbitrarily large distance from the observer of the object, an optimal way is in the usage of the router, also providing the basic security level when working through a global network. DIR-300 developed by D-Link was chosen as the system router.

For initial configuration of PLC and analog input module we chose network media converter Moxa DE-211. It supports interfaces RS-232/422 and 3/2 – wired RS-485, has integrated terminators and can be used for any types of industrial devices and all types of serial communications. After modules configuration the converter is turned off and not required in future.

Figure 1 shows the block diagram of designed monitoring system based on the modules above.

Thermo-EMF, coming from thermocouple, was amplified by AD595. Afterwards, this analog-to-digital conversion was complemented with the analog input module i-7017. From the output of i-7017 the digital code is read by controller i-7188EGD, and on its basis the temperature is measured and stored in the internal variable. After the start of the ISaGRAF software on PC, it is necessary to choose the project file and execute it in debugging mode. Next, the environment is connected with the router directly via the network interface

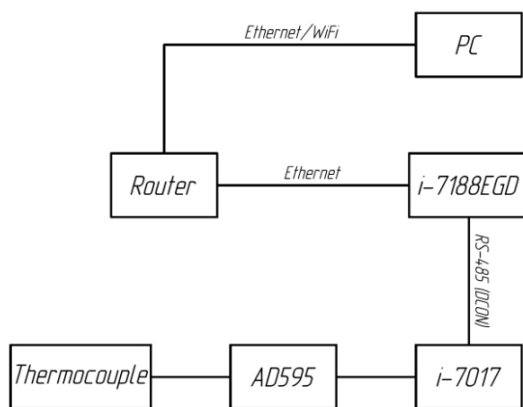


Fig. 1. Block diagram of telemetry system

or the Internet. Further, the router connects with the executive environment (ISaGRAF Runtime) i-7188EGD. In such a way the internal variables from PLC are read and their values are displayed in a visual form on PC monitor.

Configuration of interaction between system components

Configuration process is as follows:

1. i-7188EGD and i-7017 configuration is arranged via RS-232 and RS-485 interfaces, respectively, after the system elements are connected as in Fig. 2.

2. To connect the utilities and modules, we installed the program NPort Management Suite (included in Moxa DE-211 software) on the PC. Afterwards, the converter is selected and connected to virtual COM-port.

3. For PLC configuration, network media converter DE-211, with DIP-switches, located on its hull, was turned to converter mode to RS-232 interface.

4. The terminal INIT on switched off controller is connected with the terminal GND, then the power is on with usage of 7188xw.exe utility, included in i-7188EGD software. Network configuration of PLC is as follows:

IP address	10.0.0.62
Mask	255.255.255.128
NET-ID	1

After configuration is over the controller is switched off from the power supply and jumper between INIT and GND terminals is put off.

5. Moxa DE-211 Network media converter is turned to the converter mode to RS-485 interface.

6. The limits of measurement and connection parameters of analog input module i-7017 configured by DCON Utility are as follows:

Protocol	DCON
Address(dec)	17
Baudrate	9600
Checksum	Disable
Dataformat	Engineering
Input range	+/-5V
Filter Settings	50 Hz
Mode	Fast Mode

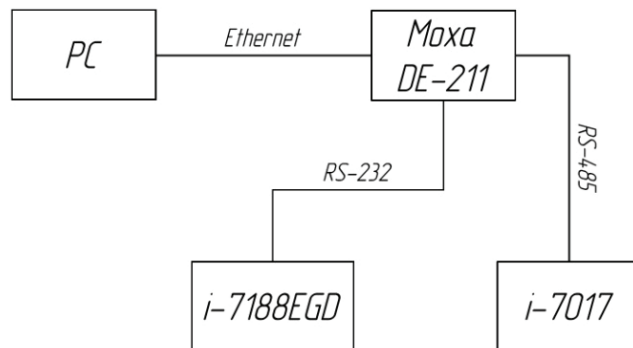


Fig. 2. Block diagram of component configuration

7. Connection of the components is shown in Figure 1.
8. According to PLC network configuration the NAT (Network Address Translation) service is configured, allowing external connections. The results are given below:

External port502
 Internal IP address10.0.0.60
 Internal port502

9. In connection options PC to PLC project the parameters are as follows:

Target Slave Number1
 Communication PortETHERNET
 IP10.0.0.62 or External IP address
 of the router in the Internet
 Port502

Software for PLC

The selected controller has ISaGRAF Runtime executive service, which clearly defines development environment – ISaGRAF Workbench 3.xx.

The working interface of the suggested monitoring system is shown on Fig. 3.

ISaGRAF Workbench 3.xx has editors of all 5 standard programming languages: IL – Instruction List; ST – Structured Text; LD – Ladder Diagram; FBD – Function Block Diagram; SFC – Sequential Function Chart.

Besides, software includes one more graphic language – FC (Flow Chart), describing serial logic transformations and visual repeating method of graphic representation of block diagram algorithms.

In this environment with the usage of ST and FBD languages the software was developed, enabling to visualize the sensor values directly from project editor ISaGRAF Workbench.

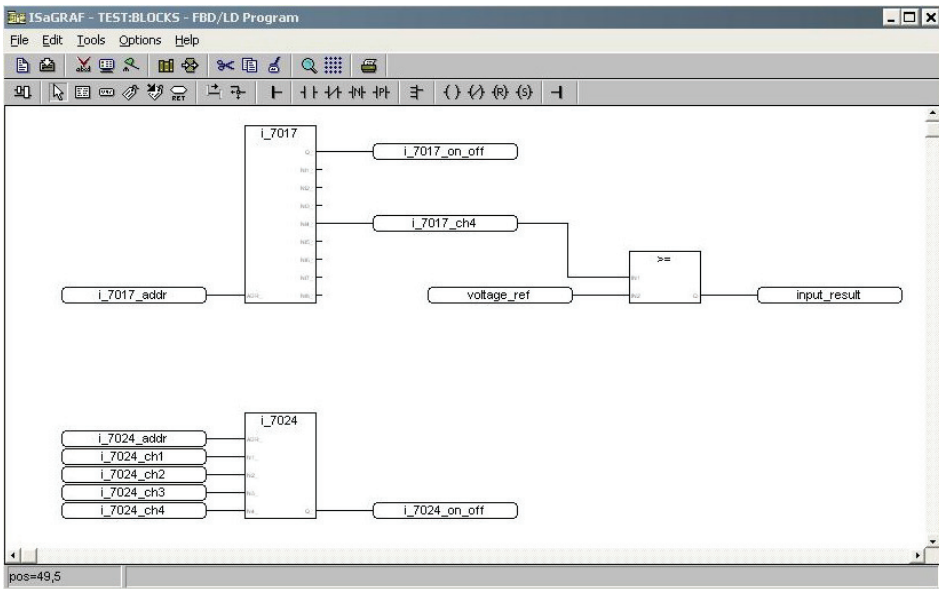


Fig. 3. The working interface of monitoring system

Conclusion

As the result of this work the effective monitoring system of power-intensive objects based on programmable logic controllers by ICP DAS was developed. The given monitoring system can be used in control systems, diagnostics systems to prepare initial data for solving identification problems of dynamic model of power-intensive objects. As the way forward the suggested monitoring system can be integrated into the control system of power-intensive objects by adding output modules and some functions into the software.

References

1. Official website ICS Triplex ISaGRAF Inc. – URL : <http://www.isagraf.com/> (дата обращения: 22.09.2014 г.).
2. ГОСТ 6616-94. Преобразователи термоэлектрические. Общие технические условия. – Введ. 1999-01-01. – М. : Изд-во стандартов, 1998. – 15 с.
3. Goodwin, G. Control System Design / G. Goodwin, S. Greabe, M. Salgado. – N.J. (USA) : Prentice-Hall, Upper Saddle River, 2000. – 908 p.
4. Chernyshov, N. G. Features of creation of power saving control systems on set operation conditions / N. G. Chernyshov, D. Yu. Muromtzev // Automatic Control and Computer Sciences. – 2008. – Vol. 42, No. 3. – P. 163 – 168.

References

1. <http://www.isagraf.com/> (accessed 22 September 2014).
2. Interstate Council for Standardization, Metrology and Certification (ISC), *GOST 6616-94: Preobrazovateli termoelektricheskie. Obshchie tekhnicheskie usloviya* (Russian Interstate Standards 6616-94. Thermoelectric converters. General specifications), Moscow: Izdatel'stvo standartov, 1998, 15 p.
3. Goodwin G., Greabe S., Salgado M. *Control System Design*, Prentice-Hall, Upper Saddle River, N.J. (USA), 2000, 908 p.
4. Chernyshov N.G., Muromtzev D.Yu. *Automatic Control and Computer Sciences*, 2008, vol. 42, no. 3, pp. 163-168.

Построение системы телеметрии энергоёмкими объектами с использованием промышленных контроллеров

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Ключевые слова и фразы: программируемый логический контроллер; система мониторинга; удаленное управление; энергоёмкий объект.

Аннотация: Рассмотрена проблема удаленного мониторинга и управления технологическим оборудованием. Предложена и реализована система мониторинга температуры экструзионной машины, построенная на программируемых логических контроллерах с возможностью удаленного управления через интернет. Была построена структурная схема системы телеметрии и сформирована конфигурация между компонентами данной системы.

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