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Experimental Stand for Checking of Serviceability of Logical Control System Integrated in the Composition of the Numerical Program Control System

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ABSTRACT. The article covers the stand, which is a quick-reconfigurable object, in which there are permanently plugged and pluggable elements. These are permanently plugged elements, which also include the terminal computer with the installed programming medium. The experimental stand is designed for checking the operability of the logic control system integrated into the numerical program control (NPC) system.

KEYWORDS: programmable logic controllers, software, complex stand, servo drive, control object, network model, logic controller.

I. INTRODUCTION

The development of the logical control system at the hardware level until recently was based on specialized modular computing devices - PLC. At present, the design moves on from strict binding of software and mathematical support of systems to *conceptual* instrument of basic electrical circuits. In this regard, it is possible to use modern unified solutions (personal, tablet, single-board computers, etc.) as a hardware computing platform, which allow applying standard tools of design and implementation of mathematical support of control systems (for example, Visual Studio, Code Blocks, etc.).

The adequacy of the developed principles of system construction was initially tested on experimental stands, which allowed adjusting the software and hardware before the implementation of the working version of the control system. The concept on which the development is based involves both autonomous use of systems for controlling individual technological units or processes, and an integrated solution for working as part of a complex of control systems (for example, within the framework of NPC).

Programmable logic controllers (PLC) are today the basic elements of industrial automation systems. They are base of all automated control systems of technological processes, monitoring, performance control, telemetry, security and many others. In addition, modern PLC is of great importance in NPC systems. The modern level of development of numerical program control systems allows using the software-implemented logic controller (SoftPLC) to solve a logical problem in frame of common software of NPC systems without using additional hardware and system software of programmable controllers, which are integral part of almost any modern NPC system [1]. This approach reduces the cost of the control system and provides a number of benefits, including adding new functionality and upgrading the controller in a short time; creation of the cross-platform application depending on the technological task to be solved; possibility to reduce time of launching in operation, etc.

II. MATERIALS AND METHODS

During the experimental studies that were carried out in order to obtain practical experience in application of logical control systems based on Soft PLC controllers [2, 3], the structures of individual software and hardware components of control systems have been improved and defined, as well as experience in setting up and debugging

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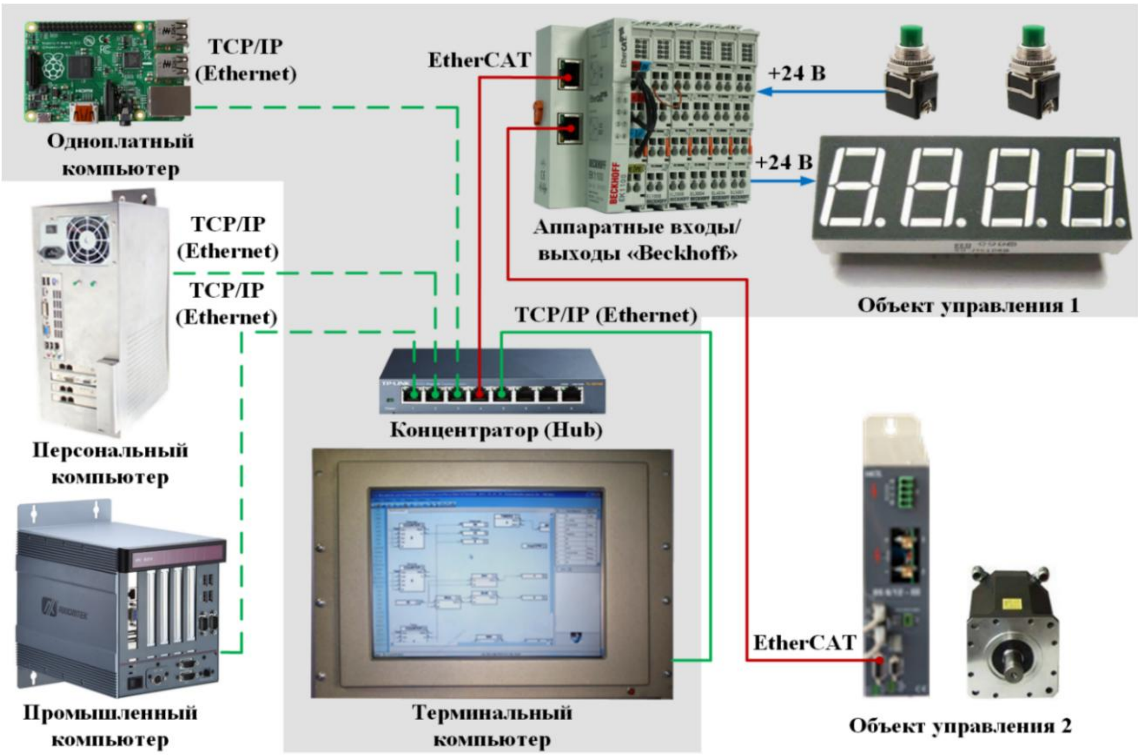
control systems of new class has been gained. The possibility and expediency of industrial operation of the systems has been established.

In order to solve the problem of hardware platform selection and hardware and software compatibility, a complex stand has been developed, which can be reoriented to work with different hardware platforms in a short period of time [4]. The following were selected as basic computing modules on which the core of the logical control system can be installed: a) single-board computer; b) personal computer; c) industrial computer (Fig. 1). The same platforms were laid as a hardware base for the design of the experimental stand.



TCP/IP single-board computer TCP/IP TCP/IP Personal computer Industrial computer	EtherCAT “Beckoff” hardware input/output TCP/IP Ethernet Concentrator (HUB)	Control object 1 EtherCAT Control object 2

Fig. 1 Network model of the experimental stand for testing the functionality of logical control systems

The following objects were selected as control objects:
- group of eight segment indicators with control elements (buttons) – “Control object 1”. This control object verifies the operation of the logic control system with discrete input (control buttons) and output (segment indicators) signals;
- servo-drive based on protocol EtherCAT – “Control object 2”. This control object allows checking functional units and algorithms of motion control of the logical control system.

The described stand is the quick-reconfigurable object, in which there are permanently plugged and pluggable elements. The main task of logic control systems is to control electrical automation systems, in which more than 70% of signals are discrete, therefore hardware “inputs/outputs” and “Control object 1” are permanently plugged elements, to which also belongs the terminal computer with the installed programming environment [5].

Depending on the tests carried out, one of three hardware platforms with an installed control core is plugged to the stand: a) single-board computer; b) personal computer; c) industrial computer. All equipment is integrated into a single network through a network concentrator (Hub). To check the functionality of the logical control system in tasks of motion control, the “Control Object 2” is used.

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Terminal computer (see Fig. 1) contains the environment for developing logical control programs, in which, before performance, a program in the language of functional blocks is developed. The terminal computer is connected via Ethernet to the base computing module on which the core of the logical control system is installed. [6] The developed logical control program is transferred to the core of the system, the program is debugged and the debugged version of the logical control program is subsequently launched. In the sequel, communication with the terminal computer is necessary only to visually display the operation of the logical control program during the operation of the stand.

III. RESULTS AND DISCUSSION

In accordance with the testing methodology for experimental research, one of the options for the developed distributed stand model was selected. During stand tests, the variant of the experimental stand with a single-board computer based calculator and control object in the form of a group of 8-segment indicators was selected. The stand is additionally equipped with power elements: a) for hardware “inputs / outputs” the power supply has the characteristics + 24V, 10 A; b) for single-board computer the power supply has the characteristics + 5V, 5 A.

On this modification of the stand were checked:

- possibility of the logical control system based on single-board computer with discrete “inputs/ outputs”;
- speed of operation of the selected system configuration.

Stand tests were performed in accordance with the testing methodology, during which the following results were obtained:

- conformity and stability were achieved during the joint operation of the development environment for logical control programs and the core of logical control, which allows downloading and debugging programs of even a large size (over 20 thousand functional blocks);
- the correct operation of the logical control system with hardware inputs / outputs is confirmed in processing discrete and analog external signals;
- error-free running time of logic control core more than 1000 hours, which corresponds to the requirements for industrial systems;
- execution time of the logic control cycle in the real-time operating system is less than 10 ms.

These results are within the framework of the requirements for industrial systems operating in hard real-time mode.

One of the possible application of the logic control system is a software-implemented *logic controller integrated into the NPC system*. At the same time, the core of the logic control system is integrated into the software and mathematical support of the core of the NPC system. The developed programming environment of logic control systems can both be integrated into the NPC system terminal, and operate independently [7, 8].

The logic control system is integrated into the NPC system in the form of software-implemented controller. In this case, the architecture of NPC system becomes as shown in Fig. 2.

The system in Fig. 2 has the following features:

- the editor of logic control programs can both be built into the NPC system terminal, and operate independently;
- the NPC system terminal and the logic control program editor use the single communication library to communicate with the NPC system core. At the same time, information on operation of the NPC system is transmitted on the main interaction channel, and data from the logical control system is transmitted on the additional “XData” multi-purpose channel;
- the module of the logic control system is built into the core of the PNC system, which performs the main functions for solving the logical task of control.

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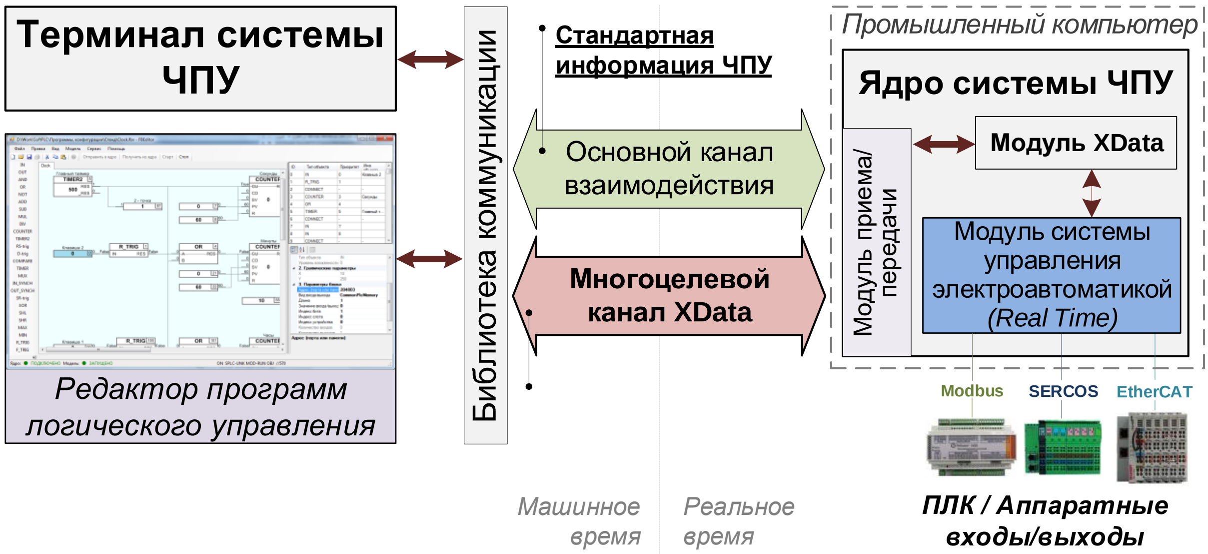

NPC system terminal editor of logic control programs	Communication library	Standard information of the NPC main interaction channel “XData” multi-purpose channel Machine time / Real time	Industrial computer Core of the PNC system Input/output module XData module Electrical automation control systems (Real Time) PLC / Hardware input/output

Fig. 2. NPC system architecture with built-in software-implemented controller

Experimental stand for verifying the operability of the logical control system integrated into PNC system with the described architecture [9] consists of two parts: a) the metal rack with terminal computer installed on it; b) industrial keyboard and control objects combined in one frame. The control objects used were complete electric drives (electric motor + drive controller) and hardware “inputs / outputs” (all of them were produced by “STANKIN NC”).

IV. CONCLUSION

1. The logic control system built into the software and mathematical support of PNC is operable, has high reliability, is fault-safe, and easily integrated into modern NC systems. This allows to consider that the developed logic control system can be used on technological equipment in industrial conditions
2. Performance of the logical control cycle in a separate flow does not lead to the increase in the execution time of the cycle for solving the geometric task of PNC.
3. Integration of the development environment of logical control programs into the terminal of PNC system did not lead to emergencies during the operation of the terminal. The terminal has a stable connection with the PNC core.
4. The environment for the implementation of logical control programs built into the PNC terminal allows reducing program-debugging time by quickly defining and correcting minor errors and typos in the implemented function blocks, without “leaving” the technological equipment.
5. Error-free running time of logic control core more than 1000 hours, which corresponds to the requirements for industrial systems
6. The mean time between failures of the PNC system with the integrated logic control core in it is more than 1000 hours, which corresponds to the requirements for industrial systems.

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