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Title **THE APPROACH TO CONDUCTING EXPERIMENTAL STUDIES WITH LOGIC CONTROL SYSTEMS.**

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# THE APPROACH TO CONDUCTING EXPERIMENTAL STUDIES WITH LOGIC CONTROL SYSTEMS.

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**Abstract:** is devoted to solving practical problems of design and implementation of experimental studies with logical control systems. The research carried out to verify the possibility of commercial operation for logic control systems.

**Keywords**: logical part of control systems, PLC, NC, automation

## Introduction

Programmable logic controllers (PLCs) are the basic elements of industrial automation systems today. All industrial control systems, monitoring systems, performance, control, telemetry systems, accident prevention and many others were built based on them. Besides, modern PLCs are of great importance in NC systems. The modern level of development of programmed numerical control systems allows using the software-implemented logic controller (SoftPLC) to solve a logical problem in frame of the general software of NC systems without involvement of additional equipment and system software of programmable controllers, which are constitutive part of almost any modern NC system [1]. This approach reduces the cost of control system and provides a number of advantages, including adding new functionality and modernization of the controller in a short time; creation of cross-platform application depending on current technological task; potential to reduce start-up time, etc.

During the experimental research, which was carried out in order to gain practical experience in the use 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 specified, as well as experience in setting up and debugging control systems of a new class has been gained. The possibility and feasibility of industrial operation of the systems has been established.

## Main part

To solve the problem of choosing a hardware platform and compatibility of hardware and software, a complex test bench has been developed that can be reoriented to work with various hardware platforms in a short period of time [4]. The following were chosen as the basic computational modules on which the core of the logical control system can be installed: a) single-board computer; b) personal computer; c) computer of industrial version (Fig. 1). The same platforms were put as a hardware base when designing an experimental test bench.

The following were selected as control objects:

- group of eight segment indicators with control elements (buttons) – "Control object 1". This control object allows checking the operation of logic control system with discrete input (control buttons) and output (indicator segments) signals;

- Servo drive unit based on EtherCAT protocol – "Control object 2". The control object allows checking the function blocks and controlling motion algorithms of logic control system.

The described test bench is a fast-reconfigurable object in which there are permanently plugged and pluggable elements. The main task of logical control systems is to control electrical automation systems, in which more than 70% of the signals are discrete, therefore hardware "inputs/outputs" and "Control object 1" are permanently plugged

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elements, which also include a terminal computer with installed programming environment [5].

Depending on the tests being conducted, one of three hardware platforms with installed control kernel are connected to the test bench: a) single-board computer; b) personal computer; c) computer of industrial version. All equipment is aggregated into a single network through a network concentrator (Hub). “Control object 2” is used to check the operability of the logical control system in motion control tasks.

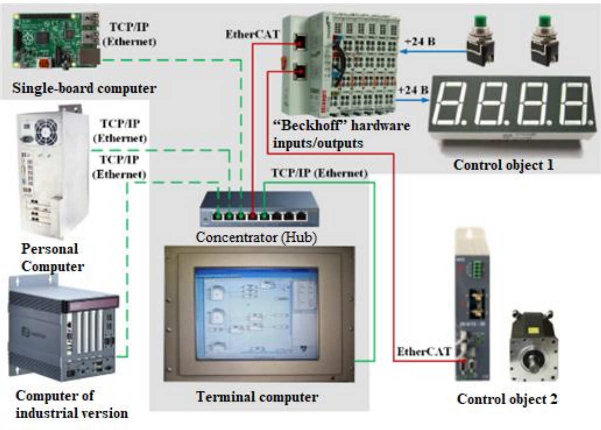


Fig. 1. Network model of the experimental bench for testing the performance of logical control systems

The terminal computer (Fig. 1) contains environment for development of logic control programs, in which a program is developed in the language of function blocks before starting work. The terminal computer is connected via Ethernet network to the basic computing module on which the kernel of the logical control system is installed [6]. The developed logic control program is send to the system kernel, and then the debugging of program and the subsequent launch of the debugged version of the logic control program is carried out. Then, communication with the terminal computer is necessary only for visual display of the operation of the logical control program during the work of the test bench.

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

On this modification of test bench, the following were tested:

- the ability to operate a logic control system based on a single-board computer with discrete “inputs/outputs”;

- performance of selected system configuration.

In accordance with the testing methodology, bench tests were carried out, during which the following results were obtained:

- conformity and stability during the joint work of the development environment for logical control programs and the logical control kernel was achieved, which allows loading and debugging programs of even large size (over 20 thousand functional blocks);

- correct operation of the logic control system with hardware inputs/outputs when processing discrete and analog external signals was confirmed;

- mean time between failures of the logical control kernel is more than 1000 hours, which meets the requirements for industrial systems;

- execution time of the logical control cycle when working in a real-time operating system is less than 10 ms.

These results meet the requirements of industrial systems working in hard real-time mode.

One of the possible variants for using logic control system is a software-implemented ***logic controller integrated into the NC system***. In this case, the kernel of the logical control system is integrated into the software-

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mathematical support of the kernel of NC system. The developed programming environment for logical control systems can be either integrated into the terminal of the NC system, or work autonomously [7, 8].

The logical control system is integrated into the NC system in the form of a software controller. In this case, the architecture of the NC system has the form shown in Fig. 2.

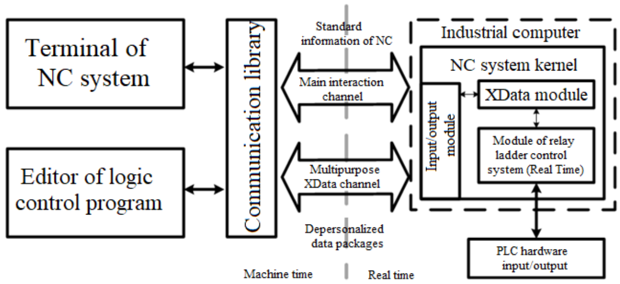


Fig. 2. The architecture of NC system with embedded software controller

System shown in Fig. 2 has the following features:

- editor of logical control programs can be either built into the terminal of NC system, or work autonomously;

- terminal of NC system and editor of logic control programs use a single communication library to communicate with the kernel of NC system. In this case, information about the operation of the NC system is transmitted through the main channel of interaction, and data from the logical control system is transmitted through an additional multipurpose channel “XData”;

- logical control system module is built into the kernel of NC system, which performs the main functions for solving the logical control problem.

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

## Conclusions

1. Logical control system built into NC mathematical-software is efficient, highly reliable, fault-tolerant, easily integrated into modern CNC systems. This allows considering the developed logical control system can be used on technological equipment in industrial environment.
2. Implementation of logical control cycle in separate thread does not lead to increase in the execution time of the cycle for solving a geometric NC task.
3. Integration of development environment for logic control programs into the terminal of NC system did not lead to emergencies during the operation of terminal. The terminal has a stable connection with NC kernel.
4. Environment for the implementation of logic control programs built into NC terminal allows reducing the time for debugging programs due to the rapid search and correction of minor errors and typos in the implemented functional blocks, without leaving the technological equipment.
5. Mean time to failure of NC system with integrated logic control kernel is more than 1000 hours, which meets the requirements for industrial systems.

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