PROGRAMMABLE LOGIC CONTROLLERS FOR SYSTEMS OF AUTOMATIC OF THE LEVEL CROSSING

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Summary The railway crossings are vulnerable to incidence of high number of accidents often deadly. In order to face this problem, the modern systems of automatic of the level crossing have been introduced. These systems are based on Programmable Logic Controllers, which allow the designers to exploit self-control mechanisms, events acquiring, technical diagnostic which in turn enable remote control and acquisition of faults.

1. INTRODUCTION

An application of modern information technology and more effective microprocessor systems has a large influence on development of railway transport.

At the beginning of 90, modern level crossing systems based on microprocessor controllers have been introduced. These systems possess sophisticated self-control mechanisms, events recording, technical diagnostic allowing remote capturing information concerning events and faults. These systems are made by: Bombardier Katowice, Siemens, Scheidt & Bachmann and KOMBUD S.A Radom. These systems exploit programmable logic controllers.

In this paper the configuration of safe computer systems in crossing level systems has been presented. These systems belong to safe systems, they have the highest forth classification level CENELEC, thus the configuration principles and software installed in them are determined by the norm CENELEC EN 50 128 and EN 50 129.

2. CONTROL THE USE OF PLC CONTROLLER

PLC controllers are industrial computers, which under the control of real time operational software realize following tasks:

- Collect the measurements with the help of IO modules from analog and discrete sensors and measuring devices.
- Send data with the help of modules and communication connectors
- Execute application programs on the basis of admitted parameters obtained data of controlling processes or machine.
- Generate steering signals according with calculation results and send them through IO modules to executing elements and devices.
- Realize the hardware and software diagnostic.

The main feature of utilizing PLC controllers to the industrial processes control is the placement of operational logic of device in the PLC memory of free access, usually RAM or EEPROM, which are the part of controller's memory. The operation of the controller consists in monitoring of digital and analog inputs, making decisions based on user's program and controlling outputs.

The main task of the controller is reaction on changes of inputs through calculating the outputs according to programmed controller rules. This reaction can be dependent on arythmetic-logic operations outcomes executed for actual inputs of controller, its internal variables and programmed time conditions. [1]

2.1. Construction and organization of PLC Controllers

PLC Controllers are built in many versions depending on envisage application and the experience of the manufacturer.

Controlling circuit, program memory and supplier constitute the central unit of the controller. Besides program memory, controllers possess also data program and intermediate results memory. Presented circuits constitute the basis structure of controller. In most application communication devices serving as communicators to other controllers or operator's stations supplement this basis structure. Other commonly used extension of the structure is initial input signal processing units.

The operation of controller consists in cyclic fetching and executing instructions constituting the user's program. These tasks are realized by controlling circuit. Realization of the program is shown in the Fig.1

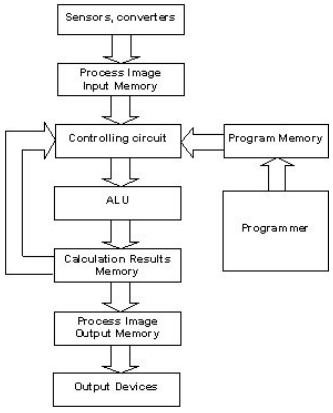

Fig.1. Realization of the program by PLC controller

Read at the beginning of each operating cycle inputs signals are written to input process memory. User's program instructions are loaded in order manner to program memory. Instructions are placed in introduction order, in other solutions according to numeration of program lines. Controlling unit fetches subsequent addresses from program memory, call corresponding to them commands and processes signals memorized in process image inputs.

Obtained results are given to process image output memory. After executing instructions from user's program the controller checks state of ports and realize communication tasks. Next stage of operation is test and diagnostic of the device. Operation cycle is finished during writing the controller's outputs. After finishing the cycle the next cycle is commenced. [1]

3. PRINCIPLE OF OPERATION OF AUTOMATIC CROSSING LEVEL SYSTEM

In order to show the organization of the operation of crossing level systems we use the fig.2 in which their geographical layout is presented.

Switching on the warning is carried out at incoming the train. At the certain distance from roads crossing the switching on circuits W1 and W3 are placed. Incoming the train to crossing level system is dependent on direction of the movement and is recorded by one of these devices.

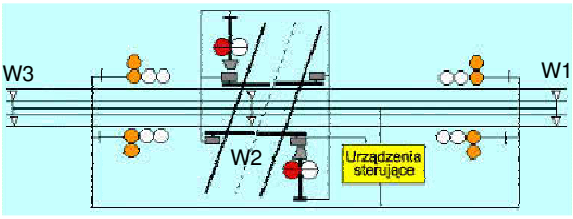

Fig. 2. The layout of automatic crossing level systems

Signal of incoming of the train to roads crossing is being recorded by W1 and W3 and is being sent to steering devices, which cause switching off light and acoustic signals and closing the railway barrier. On the basis of input signals from sensors, steering devices recognize the direction of the train movement with the help of special sensors.

Switching off signalization and opening the barriers occur at the moment when the moving train finishes the interaction on W2 placed in the vicinity of the roads crossing. Moving away train should not cause the warning, interacting on the last W3. If the one direction movement is planned then device W3 is redundant. [3]

In modern microcontrollers crossing level systems it is possible to additionally apply the warning lights for driver and remote control devices for monitoring and checking online parts included in the crossing level system.

4. PLC CONTROLLERS APPLIED IN POLISH RAILWAY LINES IN MODERN CROSSING LEVEL SYSTEMS

4.1. MINICONTROL Controllers

MINICONTROL controllers Austrian manufacturer Bernecker & Reiner are used in crossing level system of SPA-4. Each controller checks the state of toll gate and warning signal lights. The goal of controllers is generation of safe controlling signals of level crossing system and output devices based on incoming controlling signals of railway sensors. The information about the state of level crossing system is transmitted in cycling manner to the remote control unit. The software (subsequent modules) contains function testing all elements of level crossing system.

Single controller consists of electronic modules encased in the plastic case. Modules (electronic boards) are placed in the case in suitable places (according to required configuration). Controller MINICONTROL in system SPA-4 contains following elements:

- the case MGCE33-0,
- the supplier NT33,
- processor CP-31,
- Input boards MCE16A-1,
- Output boars MCA12B-0,
- I/O boards MAEA,
- Interface board MCPIFA-3.

In the fig3. the view of the single PLC controller has been presented, which configuration corresponds to standard crossing level system with redundant number of sensors allowing steering 4 warning signals. Presented configuration assumes existence certain number digital inputs and outputs which destination can depend on the particular application.

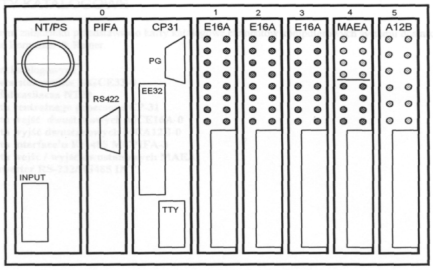

Fig. 3. Configuration of MINICONTROL controller for signalization SPA-4

Controlling program was written with the use of the development system of PROSYS. The program is executed in cyclic- sequence manner. The length of the cycle dependent upon the number of warning devices, sensors and additional elements of particular application is equal to 15÷25ms. Programs have been written the use of assembler compiler of 6303 processor and ladder schematics.

Controlling system of SPA-4 consists of two identical controlling channels. Each channel consists of PLC controller, interfaces allowing receiving of input signals and amplifiers of output signals amplifying these signals to level required by output devices. [2, 3, 4]

4.2. SIMATIC S5 Controllers

Controlling system of NE BUE 90E is based on Siemens SIMATIC S5 PLC controllers. Controlling system consists of two independent controlling channels TAI and TAII executing the same program. Each channel is fitted with CPU 103 microprocessor controller with RAM of 10240 instructions. Every controller can collaborate with 28 I-O boards steering output devices and railway sensors. The number of sensors depends on configuration of level crossing system and devices used to protect its.

Controlling devices are connected to each other with the use of parallel connector. This connector realizes checking of proper realization of functions (difference of states and synchronization of controlling programs). [2, 4]

4.3. Modular processors of SCHEIDT & BACHMANN GmbH

In microprocessor automatic level crossing level system of BUES 2000 (Scheidt & Bachmann) the control of the devices and correct operation of signals are performed in three levels. These levels are:

– diagnostic level,
– supervising level,
– executing level.

Diagnostic level consists of :

1. Diagnostic module (Container),
2. Diagnostic hub.

Elements of management level supervising all processes relevant to protection functionality of crossing level are:

1. Central modular processors,
2. Light, barrier modular processors,
3. Line modular processors,
4. Service keyboard,
5. Main program memory ZPAS.

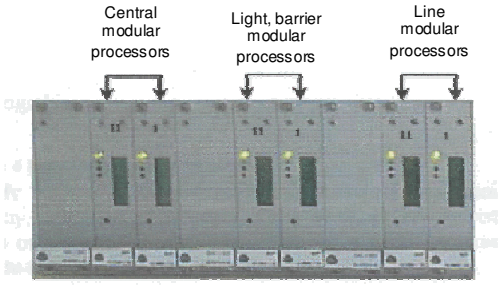

Fig. 4. Modular construction of management level of signalization BUES 2000

Executing level consists of:

1. I/O boards (railway line sensors, connecting to Railway traffic controlling devices, pulpits to control outdoor devices),
2. Signal boards,
3. LSR boards,
4. CAN boards 10/200 (barrier drivers).

Steering of level crossing system is performed in two channel fashion using channels TAI and TAII. Each channel consists of central unit, lights and barrier module, diagnostic module and railway module. Modules have fully distinguishable functionality and devices controlled by them. Each module has the own doubled processors, which processes independent fragments of program in real time. An application of appriopriate software of modular processors ensures keeping required safety level of system. [2, 4]

4.4. Controllers of GE FANUC of series 90-30

The control of crossing level system of RASP-4 (KOMBUD Radom) is realized basing on PLC Controller GE FANUC AUTOMATION of series 90-30. Their operation is based on information exchange and synchronization of the work through two channels of data bus.

Every PLC Controller of series 90-30 consists of:

- main unit of IC693CPU350,
- coprocessor of IC693PCM301,
- two communication modules (controller of GBC bus) of IC693BEM331,
- communication module RS-232/485 of IC693CMM311,
- 8In/8Out module of IC693MDR390,
- DC supplier of IC693PWR322.

Fig. 5. The view of controller GE FANUC of series 90-30

An application of controllers of series 90-30 allows both executing the program and the realization other tasks such as: diagnostic, Input/Output scanning and alarms processing. System program also contains procedures to communication with the programmer. These procedures allows the user to read and erase controlling programs , read the status information and ensure the control of the controller.

In Controllers of series 90-30, controlling program written by the user (used to control the process) are services by the special coprocessor (ISCP). Occurrence of some kind of damages or circumstances having the influence on the operation of the system are indicated by error communicates.

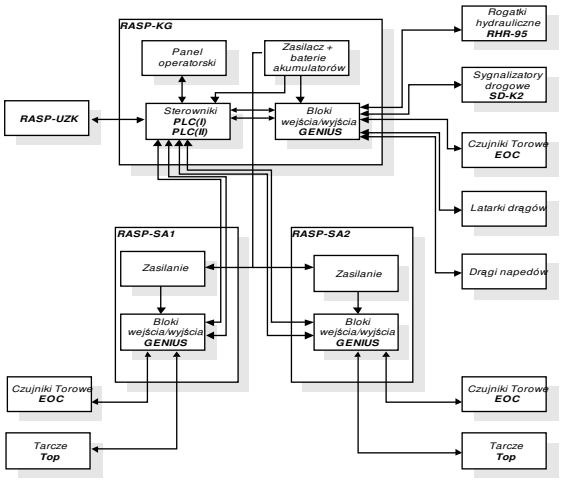

Fig. 6. Operation flow chart of RASP-4

Channels A and B being fitted with controllers STER1 and STER2 collaborate with duplicated I-O blocks through two independently operating buses. Each bus is simultaneously connected to two controllers. Modules installed in two chests create two independently operating controllers with mutual exchanging of data and synchronizing of buses M1 and M2. In the case of damage of the controller or any device connected to one of buses, the other controller detects the system error and takes over the control on all I-O devices through the second bus. Thanks to it, the device returns to the safe state. Central units of both controllers operate synchronously and check mutually their presence. In concerns logic states elaborated in the ce (faults of sensors, drivers, supplying) and physic state generated from I-O blocks determining incorrectness of their inputs or outputs (for example, discontinuities of electric circuits, overloads, short-circuits). [2, 3, 4]

6. CONCLUSIONS

Advantages of controllers such as the reliability, flexibility of the application and ability to build complex automatic systems causes the new and existing devices to be fitted with controlling circuits based on PLC controllers.

PLC controllers are also used in automatic level crossing systems, where the high level of safety and reliability is required.

The safety in automatic level crossing systems is achieved by:

- application of two channels,
- differences in programs of channels A and B,
- ability of prompt detection of failed operation of devices,
- ability of monitoring of operation of system and recording all events.

Software of railway traffic control systems allows taking into account different user's requirements and strict matching the operation of system to local conditions.

Monitoring the products offered by manufactures allows distinguishing some tendencies heralding further development directions of PLC controllers:

- small controllers of block case are made in different variants adjusted to individual requirements of the user,
- development of universal modules, configured to individual requirements of the user,
- the Large and medium controllers are always fitted with communication devices,
- tough safety requirements protecting critical devices (it is necessary to take into consideration automatic level crossing systems, where any interruptions of their operation can cause the life threat). Redundant circuits in which controllers meet such reliability requirements and modules are doubled,
- an increase of calculating power and capacity of central unit memory,
- compiler of controllers defined in norm IEC1131-3,
- subsequent standardization of solutions utilized in local network causes the controllers of different manufacturers to be used in one controller's network.

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