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line block, axle counter, programmable controller

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LINE BLOCK WITH APPLICATION OF AN AXLE COUNTER AND A PROGRAMMABLE CONTROLLER

This paper presents a concept of construction of a line block based on axle counters and programmable (PLC) controllers. Both construction of the line block and its advantages and drawbacks have been discussed.

BLOKADA LINIOWA Z ZASTOSOWANIEM LICZNIKA OSI I STEROWNIKA PROGRAMOWALNEGO

W referacie przedstawiono koncepcję budowy blokady liniowej w oparciu o liczniki osi i sterowniki programowalne. Omówiono budowę blokady oraz jej zalety i wady.

1. LINE BLOCK BUILT WITH USE OF INDUSTRIAL CONTROLLERS

Together with the development of technology and especially computer and microprocessor techniques there arise a need to construct a line block to take over the role of semi-automatic relay based and electromechanical line blocks.

When compared with its relay based version, the digital method of line block control introduces many additional functions and greatly simplifies the construction of the block, mainly due to the fact that many relationships resulting from the purpose of line block are being realized by the software.

Among functions to be fulfilled by the digital control of the line block we may name:

- Control function, consisting in:
  - ✓ Good visualization of the present condition of railway traffic control equipment included into the system and working with them,
  - ✓ Efficient (quick) realization of train routes that considerably influence the trunk line throughput,
- System status function, describing:
  - ✓ Setting of direction,,
  - ✓ Change of direction,

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- ✓ Canceling of direction setting,
- ➢ Diagnostic function, realizing:
  - ✓ System operation monitoring,
  - ✓ Efficient detection and removal of malfunctions.

The advantages of computerized control of line block include:

- ➢ Increased safety and reliability of operation,
- ➢ Reduced operating costs during railway traffic control,
- ➢ Easier operation during normal work and during possible malfunction,
- ➢ Easier fault-finding,
- ➢ Easier implementation of modernization's and adaptation to other digital equipment,
- ➢ Reduced energy consumption,
- ➢ Utilization of the DC power supply sources 24 V only.

Drawbacks of computerized version of line block:

- ➢ A necessity to route a separate transmission line for communication between the neighbor traffic posts,
- ➢ Training of employees in operation of new equipment.

The operating statuses of a device should include also (or rather, above all) the safe status, that may occur during detection of a malfunction in the entire system. This status is characterized by setting a "STOP" aspect on all signals cooperating with the block and showing occupancy of all track sections cooperating with this device. In this case, in order to restore the block to its normal operation, agreement of both operating control points is necessary.

An additional important feature of the safe status is a possibility of its occurrence at any moment of system operation, contrary to other statuses having a strictly limited order of occurrence.

2. SOFTWARE REALIZATION

In the considered line block, all input and output variables are of binary type. Due to this fact, only the digital I/O modules have been used as input/output modules. Besides input/output variables we have to indicate also internal variables enabling memorizing of block statuses.

Programming of block controller is performed in two languages:

- Automation Basic,
- LD (ladder language).

For comparison of both programs a software comparator was used, made in Automation Basic language. The role of this comparator is to compare output signals from particular programs.

In the control program for the considered model of the line block, the interpretation of block status at any moment takes place based upon the input and output data read out and a value of the 4-bit internal variable called "Stage".

Block operation software for the controller was written based on flow diagrams of the line block.

One program was written using Automation Studio software and Automation Basic language [2] and consists of four routines.

First routine "Normal" is responsible for realization of all block relations related with its normal operation i.e. block switching on, granting or receiving a permission etc. Second routine "Release" („Zwolnij") contains instructions that are realized during release of the block i.e. its return to the normal condition. Next procedure „Error" informs about the malfunctions in the block. From the safety of block operation this is the most important part of the program, thus it is assigned a performance priority. This priority was assigned using a condition instruction enabling operation (power factor) "Normal" and "Release" routines only when no information is present about occurrence of an emergency situation. The last part of the program is a routine "Signal" ("Sygnał") responsible for a correct operation of the light and acoustic signal of the line block. This routine operates independently of the block status, whether it is the emergency, release or normal operation.

The second version of the software was produced in ladder language LD. It was written in the Automation Studio v. 1.4. program. This program consists in the network of diagrams connected between each other with logical dependencies. This program uses the same input variables that the one written in Automation Basic.

Output variables from both programs are compared in the supervisory program. This program fulfills the role of a software comparator. It issues dependency information using AND operation (i.e. both programs have to produce identical command to make it happen), and information about errors using OR operation (i.e. if one of the programs produces an error message, the supervisory program issues also an error, resulting in halting the operation of controllers at both control points).

3. HARDWARE REALIZATION

In order to comply with all the requirements concerning the line block operation we have to pay particular attention to the hardware solutions. It is important to select hardware that fulfills all standards of acceptance for operation in railways (safety, reliability, environment protection, etc.) enabling cooperation with other railway control equipment and at the same time being cost-efficient.

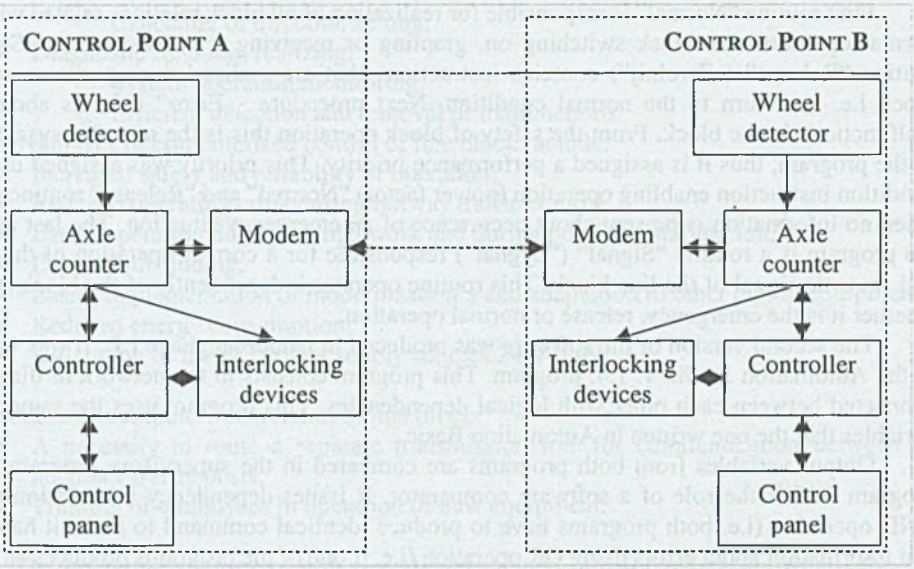

Fig.1. General diagram of line block [Source: Own study]

3.1. AXLE COUNTER ACS 2000 FRAUSCHER MANUFACTURING

Safety of railway traffic is based upon the reliable operation of many components. For this reason it is necessary to provide protection devices that may operate conflict-free in team. Reliable information about occupancy or non-occupancy of the track sections is supplied through the occupancy detection equipment that contributes largely to the reduction of number of operational disturbances.

The issues related with construction and operation of track circuits with the line block are multiplied by a necessity to provide high power and to secure power supply synchronization. Complicated power supply and necessary large cross sections of power cable cores raise significantly the cost of the line block construction. Maintenance of the line block requires in addiction reliable synchronization of track circuit power supply and appropriate order of phases. Utilization of axle counters instead of traditional track circuits provides a good solution to these problems. The total cost of construction of the line block with axle counters proves to be lower in spite of higher unit prices of the axle counters in comparison with installation of track circuits, especially when taking into account the savings on cables and power supplies.

The ACS 2000 axle counters together with cooperating devices have been developed using state-of-the-art. Technology, featuring above all the high reliability of operation and full liability in traffic safety (the fourth – the highest – safety level). They are used for checking the non-occupancy of tracks of the modern railway traffic control systems, that high efficiency in detection and counting of rolling stock's wheels is a must. The concept of axle counter safety is based on two-channel processing and comparison of two independent signals produced in each axle detector, as well as through an application of extensive diagnostic and control functions, including among others a continuous self-control of detectors' status of

adherence to the tracks and check of short-circuits or breaks in the cables connecting wheel detectors with the axle counter.

The above characteristics of ACS 2000 axle counter and hitherto experience of Frauscher company in the railway automation systems are sufficient to justify the selection of this axle counter to be used in line block model construction.

Hardware configuration of an axle counter in the line block.

The tasks of axle counter include information of track occupancy (variable "zaj") to the controller and transmission of data between the neighbor control points in order to determine the line block status (variables it1 – it6 and ot1 – ot6).

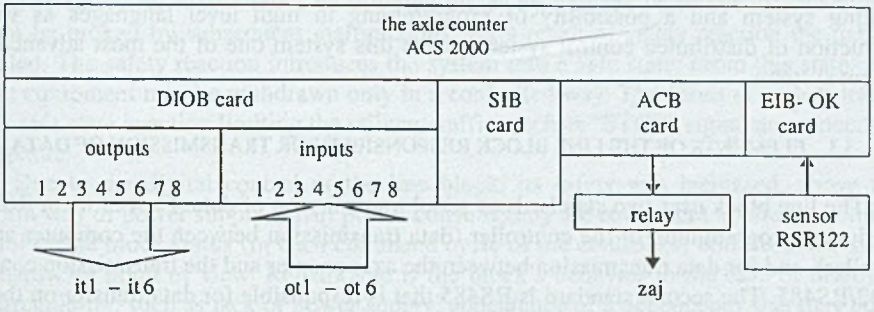

Fig.2. Detailed diagram of ACS 2000 axle counter [Source: own study]

3.2. MICROPROCESSOR CONTROLLER 2003 SERIES OF BERNECKER&RAINER MANUFACTURING

Bernecker&Rainer series 2003 controllers have been selected for realization of line block for their high technical parameters and low operating costs.

The modular construction of controllers enable adaptation of system configuration to the application needs. A typical system consists of a passive bearing bus bar (available widths from 1 to 10 modules), central unit (CPU with power supply and input/output modules).

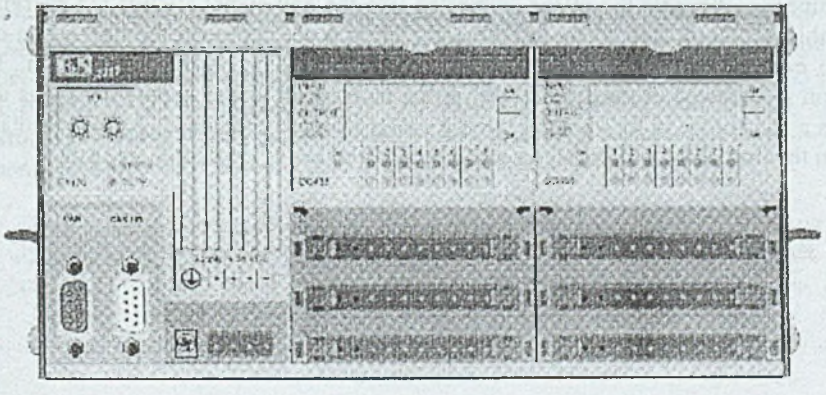

Fig.3. Applied configuration of the Bernecker & Rainer controller [Source: 1]

B&R 2003 controllers are characterized by:

- Multi-task operating system (programs are assigned to various levels of tasks related with such parameters as performance cycle time, priority),
- A possibility to expand systems with remote I/O points (CAN I/O or RIO),
- Uniform programming environment for each controller family (software PG2000 and Automation Studio),
- Programming compliant with IEC1131 (Ladder Diagram, Statement List, Function Blocks, SFC) and high level languages (PL2000, ANSI C, Structured Text, Automation Basic).

Characteristic features of B&R2003 controllers in connection with the multi-tasking operating system and a possibility of programming in high level languages as well as construction of distributed control systems make this system one of the most advanced and efficient systems.

3.3. ELEMENTS OF THE LINE BLOCK RESPONSIBLE FOR TRANSMISSION OF DATA

The line block uses two standards of serial transmission of data. First of them RS232 is used during programming of the controller (data transmission between the computer and the controller), and for data transmission between the axle counter and the transmission converter RS232/RS485. The second standard is RS485 that is responsible for data transfer on the line, between the converters as application of this type of transmission increases its range.

3.4. RELAYS COOPERATING WITH LINE BLOCK

The relays have been included into the line block model in order to transmit information about the track occupancy to other traffic control devices and to have a possibility to block the release signal on the exit signal, thus increasing block operational safety and making easier its adjustment to the existing railway traffic control equipment.

Because of higher safety level the relays used in the block are DC ones (24V) with high internal resistance, class N. In the case of track occupancy relays they are energized at the moment of line release, as they are de-energized at the moment of voltage decay, indicating the occupancy. Whereas the relays connected into the exit signal circuits are energized only during this period of time where the block direction is set onto exit, the line is non-occupied and the exist signal either does not give release signal or during its duration. The safe condition is achieved in the similar way at the moment of power supply decay, as this relay disables a possibility to forward the release signal when de-energized. As intermediate relays between the line block and the signal circuits NAIS relays of type SF-4 are used.

4. TRAFFIC SAFETY AND LINE BLOCK SAFETY

Fulfillment of traffic safety requirements in a dependent way consists in the check of its correctness being performed by the operating personnel of railway traffic control devices. This personnel is liable for correctness of realization of given traffic safety conditions.

The safety of railway traffic control devices is determined as its ability to exert a braking action upon the railway traffic in the case of malfunctions of these devices or their parts and exclusion of situations potentially dangerous for railway traffic with adequately high probability.

The safety reaction should be initiated either by damage or erroneous operation that cannot be broken by subsequent malfunctions. As a result of safety reaction the damage is revealed. The safety reaction introduces the system into a safe state. From this state, railway traffic equipment may be withdrawn only in a controlled way. The result of system transition into a safe state is action limiting the railway traffic, such as "STOP" signal announced on the semaphore.

Due to the digital control of the line block, its safety was increased, above all, by uniform way of power supply, small power consumed by the equipment applied, a continuous control of the block status (in each command cycle of the controller) both from the software and hardware point of view. Remarkable is the block's behavior in the case of discovery of any irregularity, such as lack of power supply, appearance of a dependency that may be result of erroneous block operation. This causes a safety reaction of the system, rendering impossible to send a release signal at the exit signal and return to the neutral state without approval of the neighbor post, blocking use of pushbuttons (pReset is an exception) indicating occupancy of the track and recording the existing event.

5. OPERATING RELIABILITY

An important parameter characterizing the line block is its operating reliability. Due to the use of computerized line block control, the number of elements has been reduced, thus increasing the reliability. Also high quality of components such as Frauscher axle counters and Bernecker & Rainer controllers, or class N relays results in enhanced reliability.

The speed of data processing by the controller is also of considerable importance for the reliability. This results in the fact that the interlocking functions and those checking the status of control devices are performed several times and the result is processed only after their successful comparison. This operation reduces occurrence of various types of errors in the equipment operation.

6. CONCLUSIONS

The present situation on the market enforces reduction of operating costs for transport companies with simultaneous increased quality of services. Restructuring of Polish State Railways (PKP) that is going on right now serves namely this purpose. Companies that cooperate with Polish State Railways (PKP) have to implement modern technologies both during realization of control, protection and traffic management processes and in other areas, such as actions result in economical profits. Instances of such behavior may be companies that bind their development with the awareness of new solutions in the railway automation area, achieving their goal in cooperation with companies' abroad.

The project of the line block presented above is based on microprocessor controllers and axle counters. It is a much better solution that the relay-based equipment remaining presently in operation, as similar financial outlays give much larger opportunities and reduces costs of further operation.

The designed line block enables an optimum use of the trunk line, ensures high quality, safety and reliability of operation and gives opportunities for further development and integration with other railway traffic control equipment.

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Reviewer: Ph. D. Jerzy Mikulski