PROGRAMMABLE BLOCK FOR CONTROLLING THE COAL SHEARER AND CONVEYOR IN MINING UNITS WITH EXPLOSION HAZARD

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Abstract: *In research projects in the field were conceived and developed new equipment for controlling processes in coal mining units. This paperwork describes the results of the research and several details on the implementation of hardware into specific equipment which includes also proper control software. Electrical equipment operating in potentially explosive atmospheres have to be designed in compliance with specific standards, Therefore, equipment programmed for controlling these activities have been designed in compliance with intrinsic safety and positive safety standards. The software of the equipment is specialized software manufactured by Schneider-Telemecanique.*

Key words: *safety barrier, equipment, interface, PLC, explosion hazard, List*

1. Introduction

In coal mining units from our country, the control of machinery from mechanized coal faces, coal shearer and rake conveyor, is performed using equipment based on dynamic logic with contacts and relays, type BCTC3 manufactured in the country or BUPS manufactured in Russia. These equipment are old, technologically outdated, less reliable and generators of accidents. Faults which occur in exploitation implicitly have negative effects upon the productivity of the coal exploitation process.

The solution would be to import a mechanized complex, a solution which is quite expensive.

Based on these aspects and taking into account the technological progress in programmable controlling, there is imposed the design of a new generation of equipment to replace the old ones and which have to have at least the functionalities which the old ones have. [1]

2. Equipment presentation

In this article is presented electronic equipment with programmable logic controller intended for the automation of exploitation and transportation processes in underground mining units with explosion hazard. These processes involve controlling the coal shearer and the rake conveyor driven by two engines.

Currently, the exploitation process in firedamp mines from our country is controlled manually for each machine or by using command blocks in dynamic logic with contacts and relays, old and technologically outdated. Their failure leads to a decrease of underground work productivity and to work accidents due to short-circuiting, by staff, of switch-boxes confirmations which serve the engines of the machinery.[3], [4]

Worldwide, large companies which manufacture electrical equipment intended to be used in the mining industry produce long wall mechanized complexes, for which the part for controlling the shearer and conveyor cannot be acquired independently.

The equipment fulfils the following functions

- distance command (coupling-uncoupling) the shearer's switch box with contactor;
- distance command (coupling-uncoupling) the switch boxes of the conveyor;
- command for automatically emitting a 5 second acoustic signal for preventing the start of the shearer or conveyor, through a signalling installation located in the coal face, provided with command circuit with intrinsic safety and a normally open contact for confirming the emission of the signal;

The presented equipment has the following operational characteristics:

- it has a high reliability level, being developed in static commutation, the only dynamic relays are encapsulated and are not exposed to highly corrosive underground atmosphere;
- it has an intrinsic safety property and it is safe to any faults of the shearer's, conveyor's or programmable logic controller's command circuits;
- it cancels the command for starting machineries if there is not received the confirmation signal of the preventive signal confirming the integrity of the signalling line;
- it commands the emission for 5 seconds of the preventive signal in case in which during operation a confirmation from one of the commanded switch boxes disappears. In this case, after 8 seconds from its disappear, there

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are cancelled the starting commands for all machineries, the system locks in this state, making the emission of any type of starting command impossible;

- in case of short-circuiting the confirmation circuits of commanded switch boxes (situation which generates accidents and of which underground workers frequently make use), after 8 seconds from the power-on, this locks, making the emission of any type of starting command impossible;
- it optically signals through a display digit, the operation regime of the block, faults (disappearance of confirmations) and it makes its' starting impossible in this case. The display digit is located in front of a viewfinder on the enclosure of dimensions regulated by firedamp-proof standards.
- it ensures protection to accidental starting generated by faults or anomalies in the management program.

In accordance with Fig. 1, the equipment comprises a programmable logic controller (1), a block of interfaces and supply circuits (2), an intrinsic safety barrier (3) through which there are transmitted commands and received confirmations from the coal shearer's switch box (4) and from the conveyor's switch boxes (5), (6). The commands for starting the shearer and conveyor are given by the ferro-resonant distance command blocks (7) and (8). Starting the machinery is preceded by the emission of a preventive acoustic signal lasting for 5 seconds through an acoustic start prevention installation (9), which emits towards the block an electrical confirmation signal related to the integrity of the signalling line

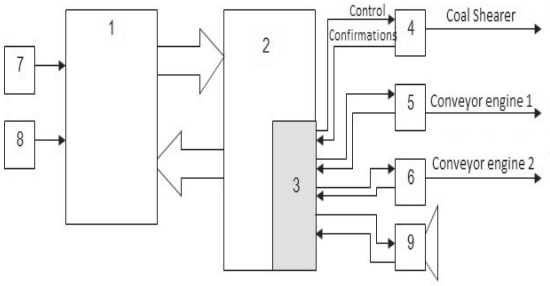

Fig. 1 *Block diagram of the equipment*

3. Equipment component blocks

Because the equipment is designed in flameproof enclosure, it has inside the steel enclosure the plug-in assembly which includes all electronic and electrical blocks. These blocks are the following:

- two distance command blocks with related command buttons. A block for commanding the coal shearer and the other one for the conveyor;
- programmable electronic block;
- block of circuits and interfaces;
- block for supply;
- intrinsic safety barrier.

These blocks are connected in accordance with the electrical diagram presented in Fig. 2.

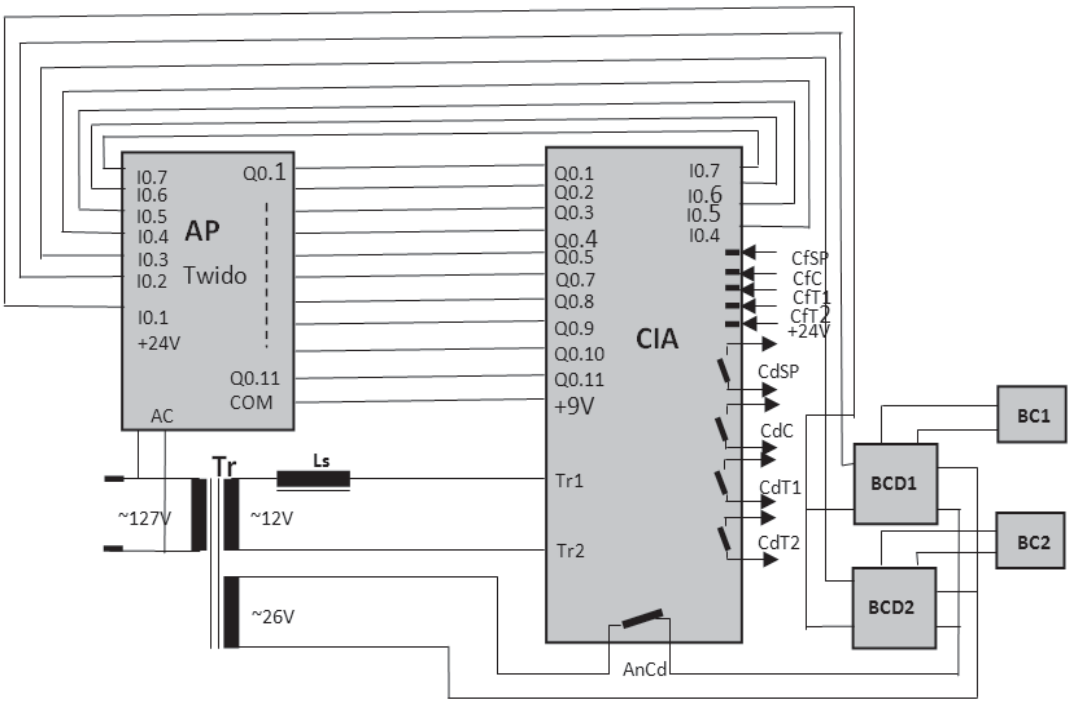

Fig. 2 *Diagram for components connection*

Notations used in Fig. 2 have the following significations:

- AP – programmable controller;
- CIA – interfaces and supply circuit (Fig.3);
- BCD1 – shearer command block (Fig.2);
- BCD2 – conveyor command block (Fig.2);
- BC1 – shearer command button (Fig.2);
- BC2 – conveyor command button (Fig.2);
- Tr – distribution transformer;
- Ls – shock inductivity;
- CfSP – preventive signal confirmation;
- CfC – shearer confirmation;
- CfT1 – conveyor 1 confirmation;
- CfT2 – conveyor 2 confirmation;
- CdSP – preventive signal control;
- CdC – shearer command;
- CdT1 – conveyor 1 command;
- CdT2 – conveyor 2 command;
- AnCd – commands cancellation.

a. Distance commands block (7) and (8) are of BCD type are currently used for controlling underground machinery (Fig. 2). Their operation is based on the ferro-resonance phenomenon and has the property that the command circuits are circuits with intrinsic safety and there are safe to their interruption or short-circuiting. Their command is performed from BC type command buttons as presented in Fig. 2. The command buttons can be located on the block, on the shearer or in another point of the longwall.[5]

The equipment is fitted with two such blocks: one for controlling the shearer and one for controlling the conveyer. These send start signals over the inputs of the programmable controller:

- Shearer start command (BCD-shearer) – input I.02 of the controller;
- Conveyers start command (BCD-conveyor) – input I.03;

These types of command blocks are currently used in firedamp mines, being certified for working in potentially explosive atmospheres.

b. Programmable logic controller block is developed using a Twido type programmable controller manufactured by Schneider-Telemecanique. The full code of the used controller is TWDLCAA40DRF, it has 25 inputs and 15 outputs of which two are static (on the transistor), the other 13 being dynamic outputs (on relays). Using specialized software provided by the manufacturer there has been developed and tested the program for conducting the entire exploitation process. The programme has been developed on a PC, in a specialized language (List). After its' analysis and testing through simulation, it has been transferred into the controllers memory.

c. Interfaces and supply circuits block (Fig. 3) comprises six relays (Ri1-Ri6) which receive signals from the programmable controller (Q0.2-Q0.7) and send the commands to the machinery.

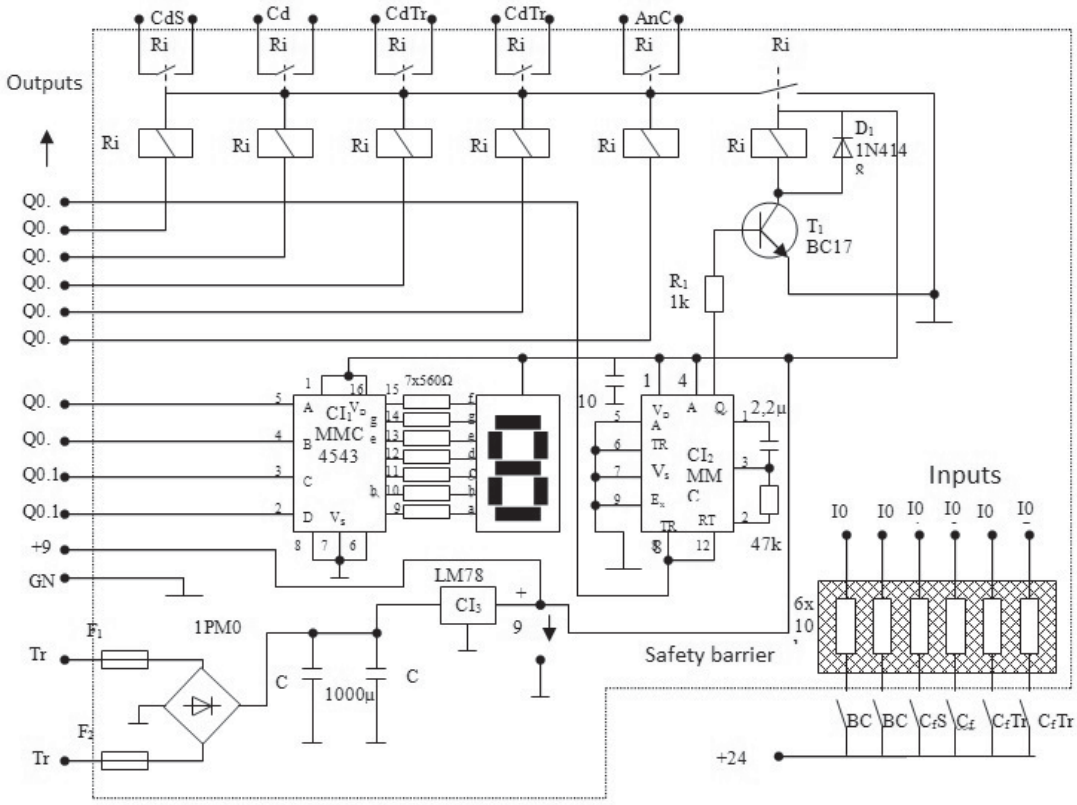

Fig.3 *Electrical diagram of interfaces and supply circuits*

The integrated circuit CI2 is a mono-stable which invalidates the start commands in case of faults occurrence within the programmable controller or in the conducting programme. In the presence of a start command it receives from the programmable controller on the output Q0.1 (static output) rectangular impulses lasting for 0.2 seconds, which through the T1 transistor and Ri6 relay maintains closed the normally open contact of Ri6 relay, thus being validated the commands towards the machinery. Potential fault or blocking of the programmable controller in the operation of machinery, leads to the lack of these impulses, which immediately leads to the total stopping of exploitation and transportation processes. The display block is achieved using CI1 circuit (BCD-7 segments decoder) and the LED display which presents codified the operation and fault states of the equipment.[7]

The electronic board also contains an electronic voltage stabilizer which is physically achieved with the CI3 integrated circuit, C1, C2 capacitors and the rectifier bridge. It supplies the electronic interfacing circuits and the relays for commanding the switchboxes of the shearer and conveyers.[6]

An important role is played by Ri5 relay which receives on the Q0.7 output of the programmable controller the command for total stop of machineries in case of faults (lack of confirmations). Also, it invalidates the start of machineries if the confirmation contacts of the switchboxes are short-circuited. The normally closed contact of Ri5 relay (AnCd) is serially connected with the joint supply of the two distance command blocks BCD (Fig.2).[8]

The signification of the connections of the programmable controller in the electrical diagram presented in Fig. 3 is the following:

Programmable controller inputs:

I0.1 - +24V;

I0.4 – Preventive signal confirmation;

I0.5 – Shearer start confirmation;

I0.6 – Conveyor 1 start confirmation;

I0.7 – Conveyor 2 start confirmation;

Programmable controller outputs:

Q0.1 – Commands validation signal (static output);

Q0.2 – Preventive signal emission;

Q0.3 – Shearer command;

Q0.4 – Conveyor 1 command;

Q0.5 – Conveyor 2 command;

Q0.7 – Starting commands cancellation;

Q0.8 – Unused;

Q0.9 – Optical signalling bit 1;

Q0.10 – Optical signalling bit 2;

Q0.11 – Optical signalling bit 3;

d. The Tr transformer ensures the supply with electrical power from the low voltage network in the underground and has two secondary: one of 12V for supplying the interfaces and supply circuits (CIA), and the other one of 26V for supplying the distance command blocks type BCD. The Ls inductivity diminishes the transitory regimes with high wave stepness which may occur when starting heavy machinery.

e. The intrinsic safety barrier developed for this equipment, BSI-01UP is certified by INSEMEX Petrosani for operation in potentially explosive atmospheres. The electrical diagram of the safety barrier is included in the electrical diagram of the interfaces and supply circuits presented in Fig. 3.

The equipment has been designed and developed as a plug-in assembly which follows to be inserted into a metallic enclosure which ensures flameproof-ness. It has been teste in the laboratory and it this phase it has been concluded that it responds to the requirements and exigencies imposed for this types of equipment intended to operate in atmospheres with explosion hazard. [2]

Manufacturers of mining equipment tend to replace the electrical command equipment with these types of devices which have obvious advantages compared to the ones which are currently used in firedamp mines. Besides the advantages related to reliability, flexibility, display manner and constructive modulation, such products can send information to the surface to a central dispatch unit from where the exploitation activity in long walls can be monitored.

References

1. Niculescu, T.
Upgrading electrical control equipment used in the mining industry, Doctoral Thesis, University of Petrosani

2. Păsculescu, D.
Using programmable electronic systems for the development of electrical equipment for the mining industry, Doctoral Thesis, University of Petrosani, 2007

3. Technical data sheet – BCTC3

4. Technical data sheet – BUBS

5. Technical data sheet – BCD

6. Integrated CMOS circuits – Catalogue

7. User Manual Twido – Hardware

8. User ManualTwido – Software