PROGRAMMABLE BLOCK FOR COMMAND IN TIMING STAGGERS OF THE CONVEYORS IN MINING UNITS WITH EXPLOSION HAZARD

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Abstract: *The research projects in the field comprise a new equipment for controlling conveyor processes in coal mining units This paperwork describes the results of the research regarding 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 a specific program.*

Key words: *Command, Equipment, PLC, List, Interface, Explosion hazard, Coal, Safety barrier*

1. Introduction

In firedamp coal mines from our country, the control of the conveyance from the gateways is performed using equipment based on dynamic logic with contacts and relays. This equipment is old, technologically outdated, less reliable and generators of accidents.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.

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, enhanced with new ones, in agreement with the possibilities of new technologies used in their manufacturing.

2. Equipment presentation

In this article is presented electronic equipment with programmable logic controller intended for the automation of transportation processes from the gateways of the underground mining units with explosion hazard. These processes involve the controlling of four conveyers in timing staggers respecting the logic control and standards from the field.

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manually for each machine or by using command blocks in dynamic logic with contacts and relays, old and technologically outdated.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.

The equipment fulfils the following **functions:**

- distance command (coupling-uncoupling) of the group of conveyers from which on the first of them the coal face conveyer discharges;
- the starting of the four conveyers is carried out at intervals of 5 sec. The first conveyer that starts is the most distant from the coal face, then start in order the other ones, the last one being the conveyer on which the coal face conveyer discharges;
- 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 equipment has the following **operational characteristics:**

- it has an intrinsic safety property and it is safe to any faults of the command circuits or signal circuit;
- 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 stops the conveyers in case of a confirmation disappearance of a switch boxe, which acts an conveyer engine, to avoid agglomeration of the coal on the conveyor stopped. In this case after 30 seconds from the stopping conveyer in question, there are cancelled the starting commands for all conveyers, the system locks in this state, making the emission of any type of starting command impossible;
- locks the block after 30 seconds after application of power, in case of short-circuiting the confirmation circuits of commanded switch boxes

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(situation which generates accidents and of which underground workers frequently make use), making the emission of any type of starting command impossible;

- has the intrinsic safety property of the distance circuits remote control;
- has the possibility of interlocking the conveyers between them, the absence of confirmation of a switch box during starting leading to stopping of the other conveyers and cancellation of starting command in case if during 30 seconds this confirmation hasn't arrived;
- is optical signalling through electroluminescent diodes the state of the operating mode of the block and damages;
- It shows protection against accidental impulses generated by faults or anomalies in program command.

In accordance with Figure 1, the equipment according to the invention 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 conveyor's switch boxes (4), (5), (6), (7).

The commands for starting the conveyor are given from the distance command blocks (9).

Starting the machinery is preceded by the emission of a preventive acoustic signal lasting for 5 seconds through an acoustic start prevention installation (8), which emits towards the block an electrical confirmation signal related to the integrity of the signalling line.

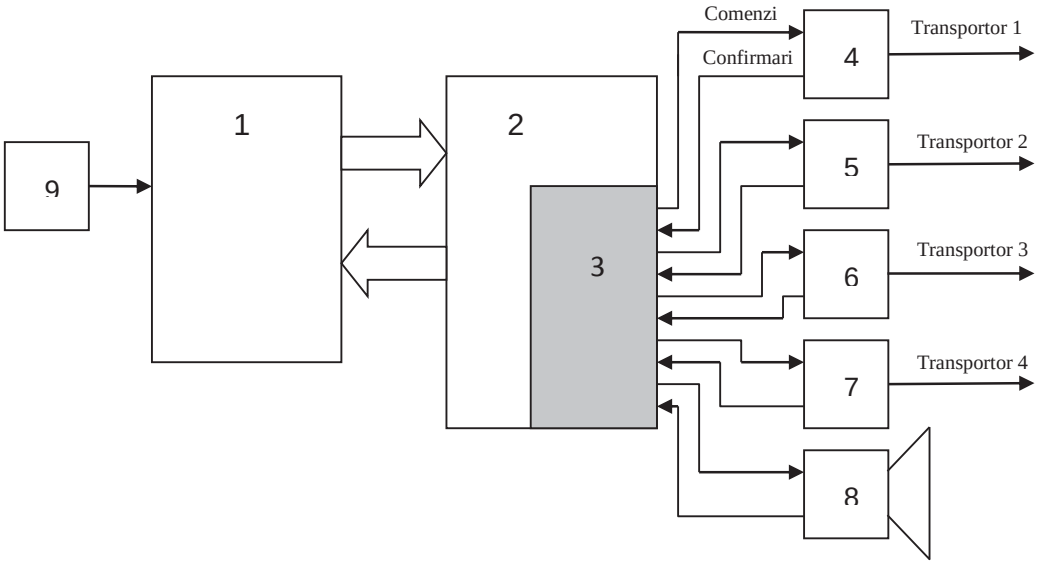

Fig 1. **Block diagram of the equipment**

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:

- the distance command block with related command button;
- 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 Figure 2.

Notations used in Figure 2 have the following significations:

- **AP** – programmable controller;
- **CIA** – interfaces and supply circuit (Fig.3);
- **BCD** – conveyor command block (Fig.2);
- **BC** – command button pornire/oprire (Fig.2);
- **Tr** – distribution transformer;
- **Ls** – shock inductivity;
- **CfSP** – preventive signal confirmation;
- **CfT1** – conveyor 1 confirmation;
- **CfT2** – conveyor 2 confirmation**;**
- **CfT3** – conveyor 3 confirmation**;**
- **CfT4** – conveyor 4 confirmation;
- **CdSP** – preventive signal control;
- **CdT1** – conveyor 1 command;
- **CdT2** – conveyor 2 command;
- **CdT3** – conveyor 3 command;
- **CdT4** – conveyor 4 command;
- **AnCd** – commands cancellation.

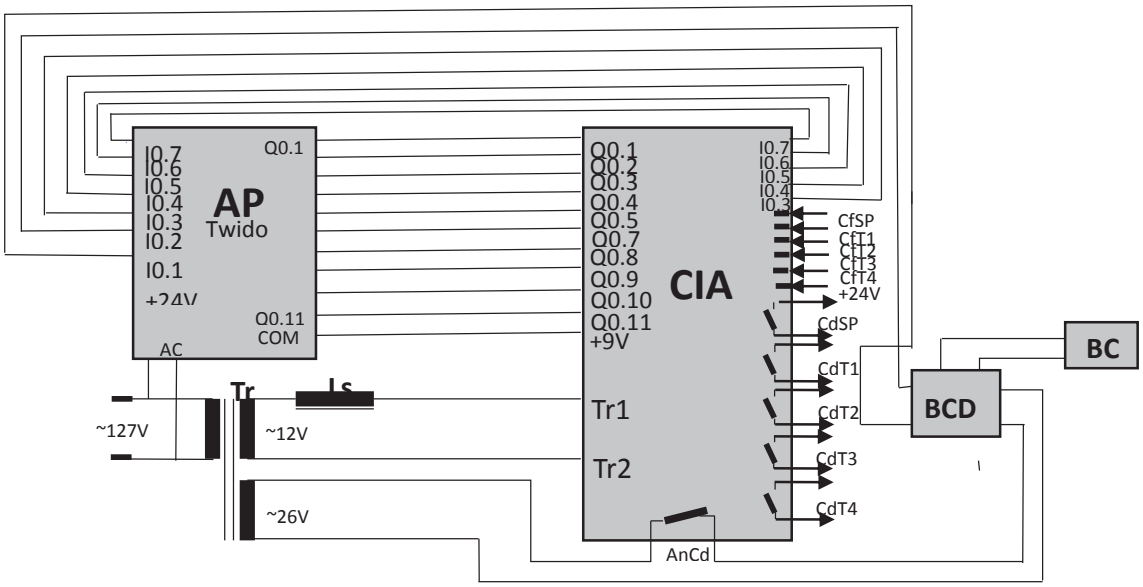

Fig. 2. **Diagram for components connection**

a. Distance commands block (9) are of BCD type are currently used for controlling underground machinery**.** 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.

The equipment is fitted with such block, which sends start signals over the inputs I0.2 of the programmable controller.

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 transport 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 controller's memory.

c. Interfaces and supply circuits block comprises seven relays which receive signals from the programmable controller (Q0.1-Q0.7) and send the commands to the machinery.

The integrated circuit $\mathbf{CI_1}$ 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 $\mathbf{R_{i6}}$ relay maintains closed the normally open contact of $\mathbf{R_{i6}}$ 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 transportation processes.

Operating states and faults are signaled by optical diode LED DL_1-DL_5, ordered directly by outputs Q0.7-Q0.11 of the programmable controller.

The electronic board also contains an electronic voltage stabilizer which is physically achieved with the $\mathbf{CI_2}$ integrated circuit, **C1**, **C2** capacitors and the rectifier bridge. It supplies the electronic interfacing circuits and the relays for commanding the switchboxes of the conveyers.

An important role is played by $\mathbf{R_{i5}}$ 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 $\mathbf{R_{i5}}$ relay (AnCd) is serially connected with the joint supply of the distance command block BCD.

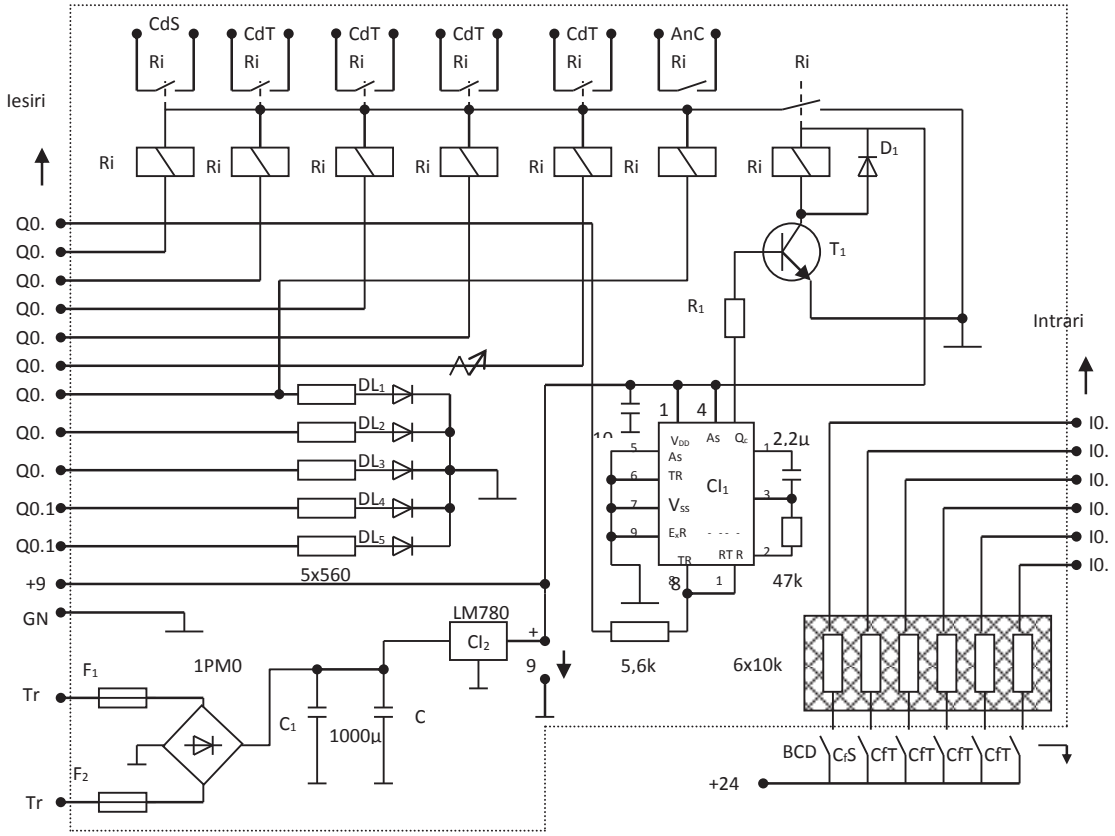

Fig. 3. **Electrical diagram of interfaces and supply circuits**

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

Programmable controller inputs:

I0.1 - +24V;
I0.2 – Comandă pornire
I0.3 – Preventive signal confirmation;
I0.4 – Conveyor 1 start confirmation;
I0.5 – Conveyor 2 start confirmation;
I0.6 – Conveyor 3 start confirmation;
I0.7 – Conveyor 4 start confirmation.

Programmable controller outputs:

Q0.1 – Commands validation signal (static output);
Q0.2 – Preventive signal emission;
Q0.3 – Conveyor 1 command;
Q0.4 – Conveyor 2 command;
Q0.5 – Conveyor 3 command;
Q0.6 – Conveyor 4 command;
Q0.7 – Starting command cancellation;
Q0.8 – Optical signalling;
Q0.9 – Optical signalling;
Q0.10 – Optical signalling;
Q0.11 – Optical signalling;

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 $\mathbf{L_s}$ 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.

4. Conclusions

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.

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. Their advantages are certain. In terms of reliability, it is obtained an

equipment based on static commutation, unaffected by the highly corrosive environment from underground.

The programmable logic offers a flexible device, that can be modified or added new functions by simply changing the program implemented in the microcontroller's memory. Other advantages include opportunities for display of the operating states and failure or constructive modularization of the block.

Such equipment can transmit information to a central dispatcher surface, from where it can be monitored the transport activity in the gateways of the gassy mine (firedamp mines).

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