RESEARCH ON THE MODERNISATION OF EQUIPMENT FOR CONTROLLING THE COAL SHEARER AND CONVEYOR USED IN MINING UNITS WITH EXPLOSION HAZARD

Dragoș PĂSCULESCU, Vlad Mihai PĂSCULESCU***

Abstract: *Starting from the logic wired scheme that uses logic integrated circuits, it is conceived and performed a control block in a programmable logic for a coal shearer and a conveyor, used in mines with danger explosion. After presenting the functions that it should accomplish, there are described component blocks of the equipment as follows: remote control block, programmable electronic block, interface circuits and power supply. The equipment presents an intrinsic safety property for the output control against defects. The running conditions and the breakdowns are optical signalled by a digital display and acoustic by a signal circuit and a communication from the stope.*
Keywords: *coal shearer, control block, conveyor, explosion hazard*

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1. Block for the control of the coal shearer and conveyor in a wired integrated circuit

An intermediate step to achieve this type of equipment is their implementation in a wired integrated circuit, using integrated logic circuits. From the analysis functions that this equipment must accomplish, which are the same with those from the control block type BCTC-3, it was developed a logic scheme described in Fig. 1. [2,5].

From the analysis organization chart, it is noted that the control of the conveyor is different from a coal shearer only by the fact that it presents an additional opportunity to start conveyor in three different ways, namely:

- starting with a single engine;
- starting and operation with two engines;
- starting in automatic control with two engines, after a predetermined time of about 30 seconds, going to a control with a single engine.

With this exception, the two main branches of the organization chart are identically.

Starting from the logical functions, it was developed the experimental model according to the electrical scheme described in Figure 2, where it was written [3, 5]:

- CdCpr – start command coal shearer (contact control block type BCD);
- CdTpr – start command conveyor (contact control block type BCD);
- CdC - logic signal control of a coal shearer;
- CdT – logic signal control of conveyor;
- CS - control signal of preventive confirmation;
- CC – control signal of coal shearer electric switch box;
- CT – control signal of a conveyor electric switch box;
- CLK – clock frequency (2 Hz);

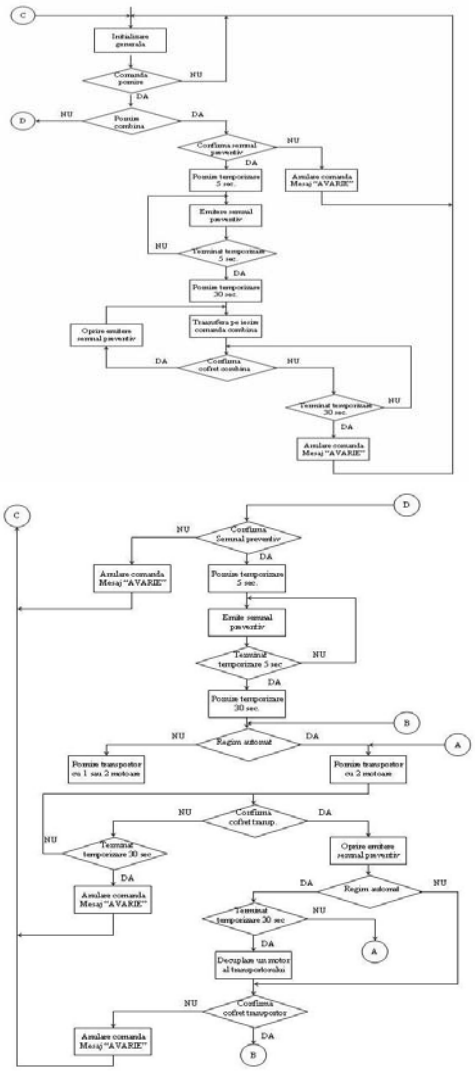

Fig. 1 *Logic diagram of the block for controlling the coal shearer and conveyor in wired integrated circuit*

** Lecturer Eng. PhD., University of Petroșani*
*** Scientific researcher Eng., PhD. Student,*

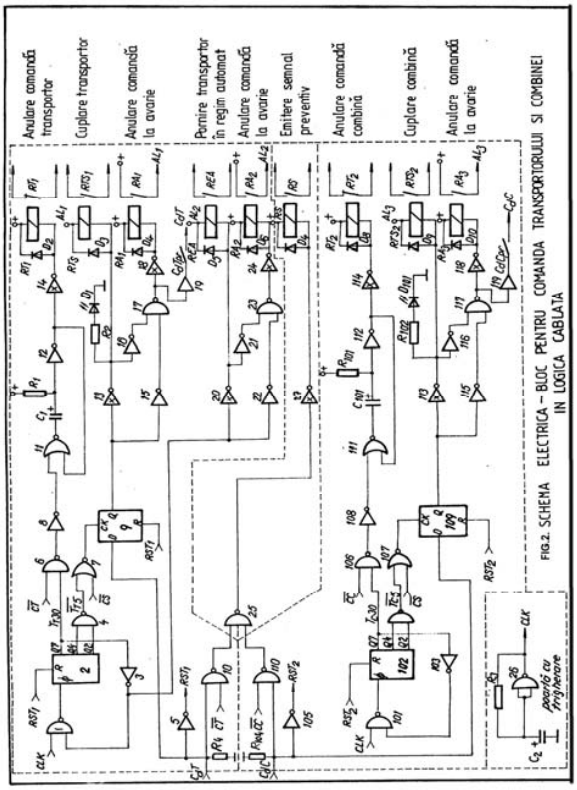

Fig. 2 *Block for controlling the coal shearer and conveyor in wired integrated circuit*

- RST1, RST2 - reset signals;

The electrical diagram presented has been using:

- asynchronous binary-counter for timer delay;
- D-type bistables to memorize the starting;
- logical counters inhibition after 30 s of start-up;
- logical memory-type 0.5 seconds of the signal cancellation of the commands, in case of missing confirmations ;
- diode LED for optical signalling defects, damage and status of control equipment;
- relay with vacuum contact Reed for controls to electric switch box.

2. Block for the control of the coal shearer and conveyor in a programmable logic

2.1. General presentation and fulfilled functions

In the coal mines from our country the control equipment from the mechanical stopes, the coal shearer stope and the scraper conveyer from the stope, is done with equipment based on dynamic logic, with contacts and relays, type BCTC3 of internal Production or Russian BUPS.

The equipment is old, technologically outdated, are less reliable and generate accidents. Defects that occur during the operation involve a negative impact on productivity in the coal mining process. [6]

Concerning these issues and given the technological progress in the field of the controlled commands should be scheduled a new generation of equipment to replace the old and have at least the functions at their old equipment.

The research made in this field led to realize new control equipment based on programmable logic, with programmable logic controller PLC. [7,8] Such equipment that has been developed and tested is presented in the work.

The PLC type used is Schneider-Telemecanique.

This equipment has the following functions [1,4,5]:

- remote control (coupling-decoupling) of electric switch box with relay switch of a coal shearer from its control panel;
- remote control (coupling-decoupling) from the coal shearer, or local control from another point of stope conveyors.
  The transition from local control to remote control (or vice versa) is made from the internal block by opening the cover;
- the possibility to drive conveyor with three or four engines permanently operated;
- automatic control for 5 seconds of an acoustic signal to start the coal shearer prevention or conveyor, by a signal light located in the stope, equipped with an intrinsic safety control circuit and a normally open contact to confirm the signal;
- has intrinsic safety and property security against any defect of control circuits from coal shearer and conveyor or signalling circuit;
- order cancellation to start equipment controlled when the confirmation signal of the preventive signal is not received to confirm the integrity signal line.
- the issue over 5 seconds, of the preventive signal if during the operation disappears a confirmation from one of the controlled electric switch box.
  In this case, after 8 seconds from its disappearance, there are cancelled the starting control for all equipment and the system is blocked in this state, making it impossible to issue any kind of starting control;
- for confirmation of shunting circuits of the controlled electric switch box (situation when the miner use this), after 8 seconds from the power-on of the block, it is blocked, making it impossible to issue any orders start;
- it presents the intrinsic security property of the remote control circuits;

- the possibility of interlocking of the conveyor with that which this discharges;
- optical signal by a digital display of the operation system of the block, the faults (loss confirmations) and unable to start it in this case;
- protection against accidental starting caused by defects or anomalies in the management program.

2.2. Component blocks of the equipment

Because the equipment is in the flameproof enclosure, this has in the interior of the steel case the assemble that includes all electrical and electronic blocks.

Component blocks are:
- remote control block;
- electronic programmable block;
- the power and interface circuits block.

2.2.1. Remote control block

This block is BCD type and is currently used to control the underground machines.

The operation is based on the phenomenon of ferroresonance and has the property that control circuits are circuits with intrinsic safety.

The equipment is also equipped with two blocks: one for the coal shearer command and another one for the conveyor command.

2.2.2. Programmable electronic block

This block, that is the central unit of the equipment, is done with a programmable microcontroller made by Schneider-Telemecanique Twido TWDLCAE40DRF type.

The automaton has the following main electrical characteristics [3, 5]:
- power supply: (110-240) V;
- supply voltage limits: (85-264) W;
- number of digital inputs: 24;
- number of outputs: 14 relay outputs (dynamics) and 2 output on the transistor (statics);
- rated current output: 2A for dynamic outputs; 1A static outputs;
- maximum breaking current: 45 A;
- input current: (7-11) mA;
- input impedance: (2.1-3.4) kΩ;
- maximum absorbed power: 110 VA;
- analogue adjustments: 2;
- serial ports: 1xRS 485; 1xRS 232;
- possibility of extension: 7 modules;
- local display mode option attachment
- possible extension 32KB memory (approx. 3000 instructions)

The output connections diagram is described in figure 3:

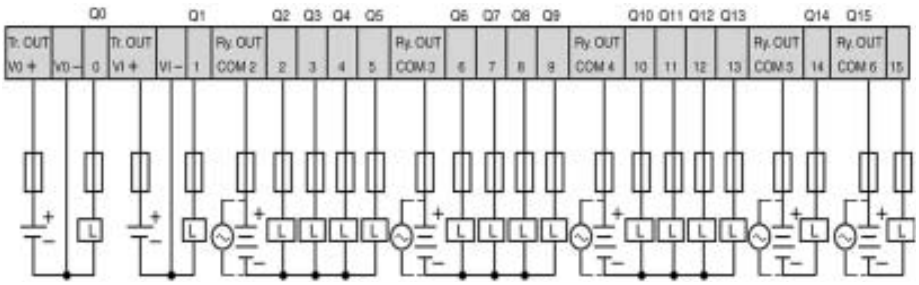

Fig. 3 *Output connections*

2.2.3. Interface and supply circuits block

This block contains six relays with vacuum contacts transmitting controls to external machines (Fig.4.), an integrated circuit (CI2) that invalidates starting controls in case of damages into the PLC or in the management program, an intrinsic safety barrier that receives confirmation from controlled electric switch box, and a display block that shows the running and fault states.

Electronic card also contains an UPS system made physically with an integrated circuit, condensers C1, C2 and a rectifier bridge.

This supplies the electronic circuits and the relays with vacuum contact for the control of the electric switch box of the coal shearer and conveyor stope.

The meaning connections and the notations of diagram from figure 4 is the following:

Inputs:
- I0.1 - 24 V;
- I0.2 –Start command coal shearer;
- I0.3 –Start command conveyors
- I0.4 - Confirmation S.P.
- I0.5 – Start confirmation coal shearer;
- I0.6 – Start confirmation TR.1;
- I0.7 - Start confirmation TR.2;

Outputs
- Q0.1 - Signal controls validation;
- Q0.2 - Preventive signals;
- Q0.3 –Start coal shearer;
- Q0.4 – Start TR.1;

- Q0.5 - Start TR.2;
- Q0.7 – Start cancel;
- Q0.9 - Optical signalling bit 1;
- Q0.10 - Optical signalling bit 2;
- Q0.11 - Optical signalling bit 3.

Notations:
- CdSP – Start preventive signal;
- CDC – Start coal shearer;
- CdT1 – Start conveyor 1;
- CdT2 – Start conveyor 2;
- AnCd – Start cancel;
- BCD1 – Start coal shearer (remote control block 1);
- BCD2 - Start coal shearer (remote control block 2);
- CfSP - Confirmation preventive signal;
- CfC – Confirmation of coal shearer electric switch box;
- CfT1 - Confirmation conveyor electric switch box 1;
- CfT2- Confirmation conveyor electric switch box 2.

Signalling:

The signal lights coded by a digital luminescent display located in front of the equipment are presented in table 1.

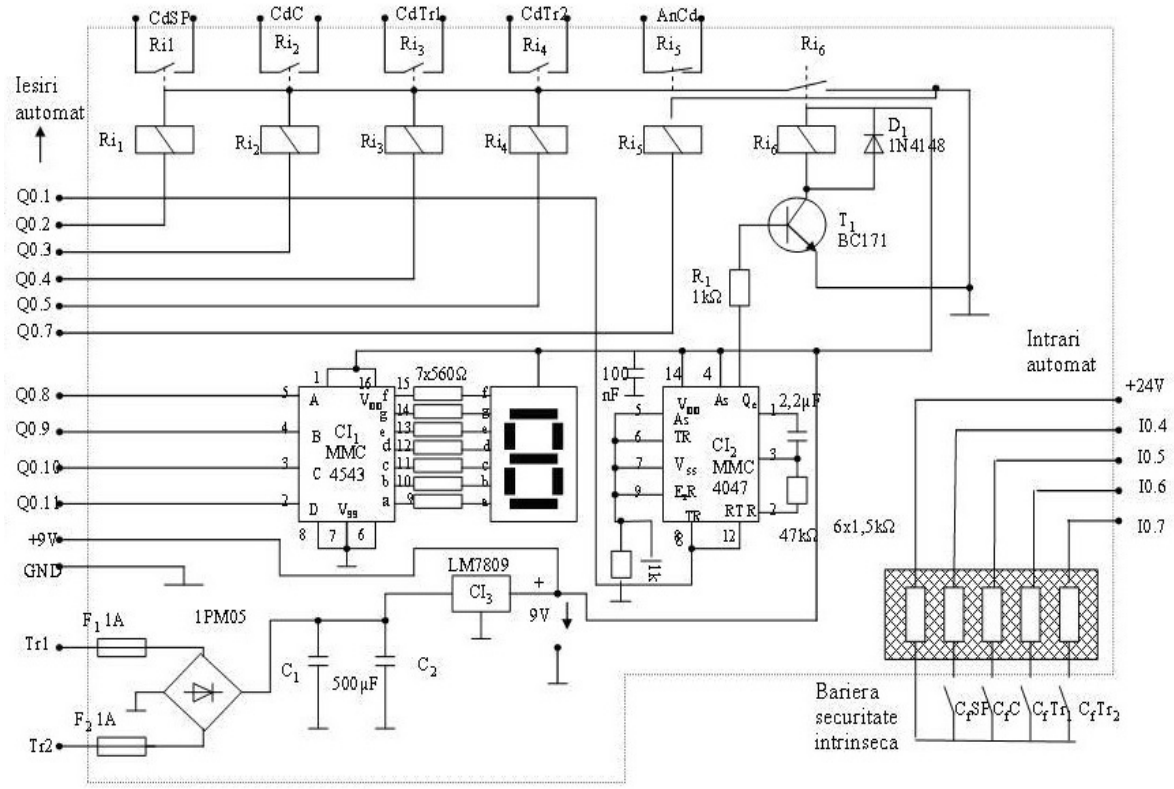

Fig. 4 *Interface and supply circuits block*

Table 1 *Signalling*

Number display	Significance of the number displayed
0	Waiting commands
1	Coal shearer operation
2	Loss confirmation coal shearer and engine conveyor 2
3	Loss confirmation engine 2 conveyor
4	Loss confirmation coal shearer and engine conveyor 1
5	Loss confirmation engine 2 conveyor
6	Operation conveyor with 2 engines
7	Operation coal shearer and conveyor with 2 engines

3. Conclusions

Using the static switching to achieve automatic control blocks have many advantages towards the dynamic switching, mainly in terms of increased reliability, reduced price, no moving components, lower gauge (ie lower consumption of materials and energy), opportunities to increase the number of functions.

The proposed equipment has the advantage to present the optical signs in case of faults (no confirmation from the electric switch box), defects and operating.

The control block for conveyor and coal shearer is achieved in a static switching based on the PLC made by Schneider-Telemecanique Twido TWDLCAE40DRF type.

The equipment presents an intrinsic safety property for the output control against defects.

The running condition and the breakdowns are optically signalled by a digital display and acoustic by a signal circuit and a communication from the stope.

Any damages on the control circuits lead to stop the control equipment.

The way to implement (programmable logic) gives equipment flexibility.

Change or increase of the fulfilled functions number can be performed on the same variant design, by changing only the program from the memory of the controller.

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