THE STUDY AND EXEMPLIFICATION OF THE USE OF A MINI-PROGRAMMABLE LOGIC CONTROLLER IN THE COMMAND AND CONTROL OF A COAL TRANSPORT SYSTEM

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Abstract: In a modern economy, any automation or control aims to increase the competitiveness of a product, either directly, through cost and quality, or indirectly, through improving working conditions.

Control implies the management of some dynamic systems having continuous states. These systems are described by differential equations and generally have analog inputs and outputs. The mining industry cannot be an exception to this and in this paper the authors came up with an idea of a simple automation of a coal transport system using a mini- PLC. This idea consists in the development, with the help of the Ladder Diagram programming language (LD), of a simple program for the command, control and signaling of a transport system composed of three belt conveyors.

Key words: automation, PLC, Ladder Diagram, belt conveyors.

1. THE EVOLUTION OF AUTOMATION IN THE CONTEXT OF THE EMERGENCE AND EXPANSION OF PROGRAMMABLE LOGIC COMPUTERS

1.1. General

The industrial revolution of the late 19th and early 20th centuries led, among other things, to an exponential development of the electrotechnical industry. The use of

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electricity has become indispensable in all sectors of human activities. The advantages of using electrical equipment in industrial automation were soon discovered. A series of electrical and electromechanical command, control and protection elements were created and developed: relays, contactors, sensors, switches, limiters, controllers, actuators, fuses, circuit breakers etc [26]. Thus appeared the first fully electric automation panels that served to command and control various processes. Depending on the complexity of these processes, an automation panel could occupy surfaces of the order of tens or even hundreds of m^2. Electrical schemes have become more and more complex, which has led to difficulties in their practical implementation, but also in the maintenance of automation panels and cabinets [3].

Changing the control logic of a certain process was a difficult task to achieve, as it required extensive reconfiguration of electrical schemes and automation panels structures [1]. On the other hand, the tens or hundreds of coils in relays, contactors or actuators get warm during operation and, being in a relatively small space, raised serious problems regarding ventilation in order to ensure operating temperatures within permissible limits. The hundreds of meters of conductors and cables laid out in bundles, also contributed to the heating. Discovering an error in the automation systems required a lot of time, directly proportional to the complexity of the automation installation. Among the top causes of automation system failure is the electromagnetic relay, with a limited lifespan due to its construction and operating mode [20]. Therefore, the disturbances occuring in the installation were predominantly caused by the low reliability of the relays in the automation panel, a fact that required their frequent replacement, resulting in frequent production stoppages. Maintenance was expensive, overtaxing even the best trained electricians in detecting and removing defects.

Considering the emergence of more and more complex technological processes, sometimes situations were reached when implementation of their control through classical schemes, using electromechanical equipments, became almost impossible. Thus, the efforts of researchers and engineers to develop new alternative solutions to electromechanical equipment were absolutely natural, solutions that would simplify the schemes, facilitate the implementation of control solutions and thus allow the realization of more sophisticated control processes [2]. Equipment using programmed rather than hardwired logic has been the solution to all problems and to removing many of the impediments and limitation of classical hardwired logic made with electromechanical equipment. The use of electronic and Boolean logic in process control immediate showed its advantages over classical automation. A large amount of the physic electromechanical equipment have dissapeared as it became virtual, being implemented through the programming of the logic control devices, which are the Programmable Logic Controllers [7].

Programmable Logic Controllers (PLC) are simple microcomputers, specially built for solving, by program, sequential logic problems and to replace classic relays. They work with Boolean variables and have a simplified central unit. PLCs usually offer fewer options than process computers, but they can be used very easily by less specialized personnel, thanks to simple programming languages, such as relay language, Boolean equations language or graphic languages [26], [33].

Programmable Logic Controllers are today considered the main element of any automation. With their help, the most diverse and complex automation task can be implemented.

Considering the above, we can mention some PLCs advantages:

- compared to a classical automation panel, the number of necessary conductors is reduced by up to 80%;
- electricity consumption is substantially reduced, considering that a multitude of electromagnetic relays are replaced by a single electronic device with low energy consumption;
- changing the operating sequences within the application differs from one process to another and it can be easily done by modifying or changing the program written in the PLC's memory with the help of a computer, This operation does not involve changing the cables and redoing the connections, as in a classic automation panel, but only summarizes to the interconnection of the corresponding devices at the PLC's inputs and outputs;
- the operation of PLCs is very precise;
- the error detection function in the PLCs is very fast and easy to use;
- putting a PLC back to operation is much easier than in the case of any type of electromechanical relay;
- a control system with PLC is cheaper than the classic one with electromechanical relays, as it is equipped with a large number of inputs and outputs to which many control and execution elements can be connected to implement complex functions [5].

In addition to the mentioned advantages, there are also some disadvantages of PLCs [5]:

- fixed operation. This refers to the fact that, if no changes occur within the controlled process, the use of a PLC may become more expensive than a use of a classic automation system;
- some application have a very low degree of complexity, and in such cases the purchase of a PLC can be an uneconomical solution. However, for such situations, simpler and cheaper PLCs have also been developed, known as "mini-PLCs";
- there are some industrial applications with harsh environmental conditions, where PLCs cannot be used, due to the high risk of damage.

Most PLCs are built to replace relays, working with Boolean variables and having a simplified central unit. Thanks to the technological progress of the last decades, high-performance PLCs have been produced with a complexity similar to that of process computers, usable in very complex automations [25]. Fig.1 illustrates the range of use of different command and control equipment depending on the complexity of the commanded process and the number of identical equipment. It can be seen that the range of use of modern PLCs interferes in the lower part with the range of use of electromagnetic relays and in the upper part with the range of use of process computers [6].

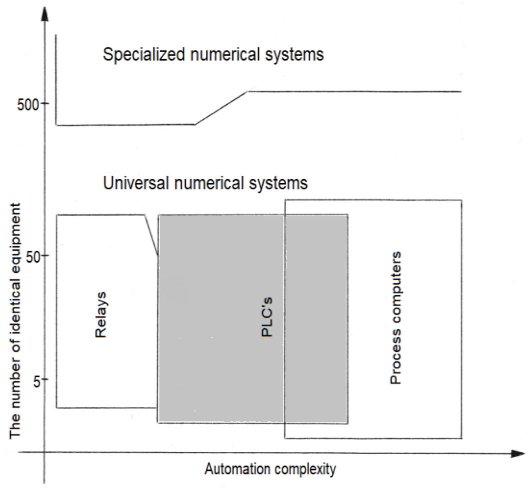


Fig.1. The range of PLC's use

The first PLC was designed in the USA in 1968 by a group of engineers led by Richard Morley, who is considered ”the father of PLCs” [26]. Their first creation was used in 1969 in the automotive industry, at General Motors, under the name of MODICON (MOdular DIgital CONtroller).

Around 1973, PLCs began to have communication facilities, one of the first such system being the MODICON MODBUS [11]. Through these facilities, PLCs could communicate with each other and could be located remotely from the controlled process.

Since their appearance, PLCs have spread rapidly across all industries, representing some of the most widely used equipment today. Their succes is primarily due to their affordable price and the fact that they can be commisioned and programmed by personnel without advanced IT training [9].

1.2. Mini- Programmable Logic Controllers

Mini- PLCs, also called ”*low-class PLCs*” are hardware structures with the same operating principle al PLCs, but with a smaller number of inputs and outputs [8]. These small PLCs are adapted for use in applications of low complexity level or where the programming logic does not change frequently. They can be programmed directly on their own mini-LCD screen, with the help of a small keyboard located on the front panel. The programming languages used are LD and FBD. All mini-PLCs have basic logic blocks (AND, OR, NOT) and types of timers and counters. The manufacturers of these mini-PLCs usually provide console programs free of charge, through which PLC programming and program simulation can be performed using a personal computer (PC) connected to a PLC via a serial interface.

Most of the mini-PLCs produced nowadays have the possibility of configuring the inputs so they can also take analog signals, having a built-in analog-digital converter.

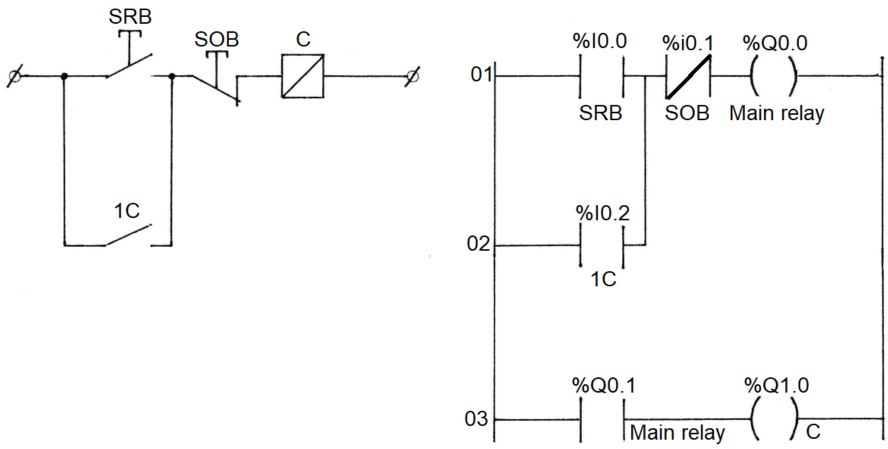
In order to facilitate the use of mini-PLCs by individual users, their prices are low and usually they do not take into account the profit brought by their use, as in the case of ordinary PLCs. Also, the programming soft is, most often, free of charge [15].

1.3. Standardization of programming languages. Ladder Diagram programming language

The continuous development of PLCs has led, in just a few years, to the emergence of hundreds of PLC manufacturers. The programs they wrote for different systems were similar, but the instructions sets varied from a manufacturer to another. This situation tended to tie a user to a specific manufacturer, especially when creating complex applications.

To eliminate this dependence, a working group of the International Electrotechnical Commission (IEC) was created in 1979, which proposed a complete standardization of PLCs. This group elaborated the IEC 1131 standard, which later became IEC 61131, which became to be followed by the vast majority of PLC manufacturers [29].

Since the early days of PLCs, most manufacturers adopted the Ladder Diagram (LD) programming language. This language, included in IEC 61131-3 standard, was developed around schematic representations of classic contactors and relays circuits. LD is ideal for low to medium complexity automations because it is intuitive and requires only a short training period to be understood.



a) b)

Fig.2. The starting of an electric motor with self-maintaining of the starting command: a) Classic hardware diagram; b) Ladder Diagram

LD is a graphical language, actually being a graphical representation of Boolean equations, making a combination of contacts (input variables) and coils (output variables). The graphic symbols of the language are placed in the diagram similar to the placement of contacts and relays in an electric schematic (hardware diagram) [24].

In Fig.2a we have illustrated the diagram for starting an electric motor with self-maintaining of the starting command and in Fig.2b the transposition of this diagram into LD. The Boolean operation performed by this diagram is as follows:

$$C=(SRB\ \textbf{OR}\ 1C)\ \textbf{AND}\ (\textbf{NOT}\ SOB) \tag{1}$$

A program in LD is made up of network, which use graphic symbols. Each network consists of several language objects connected to each other, having several branches. The start of a network occurs at the left power bar and closes at the right bar using a coil object.

2. PROGRAMMABLE LOGIC CONTROLLERS OPERATION

The basic function of a PLC is to continuously scan the state of the executed program. This scan means continuously checking the conditions of the program over a period of time [23]. A scan cycle comprises the following three steps, as shown in Fig.3:

- *Step 1- Inputs testing*. The PLC probes each input to detect its ON or OFF status (active/inactive in case of discrete inputs or the value of an analog input). In other words, the PLC checks which sensor or switch is connected to which input and copies the information in binary form into the input registers, storing int for use in step no. 2;
- *Step 2- Program execution.* The PLC executes the program instruction by instruction. Depending on the state of the inputs stored in the previous step and the program logic, the PLC changes the configuration of the output registers in binary form;
- *Step 3- Outputs activation.* In this step the PLC also updates the state of the physical outputs based on the states of the inputs memorized in the previous step.

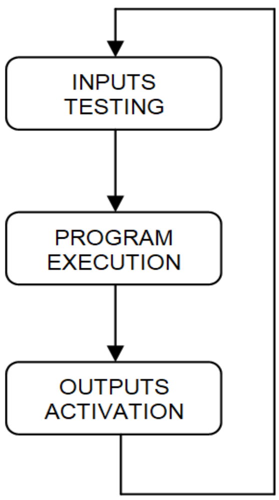


Fig.3. The duty cycle of a PLC

After executing the third step, the PLC returns to step no. 1 and repeats the entire cycle described above. A scan cycle is defined as the time during which the three steps are executed. Concurrent with the duty cycle, the PLC also performs system verification and updates the current internal clock and counter values [10].

3. THE CONTROL AND SIGNALING SYSTEM OF A COAL CONVEYING SYSTEM WITH 3 BELT CONVEYORS USING A MINI-PLC ZELIO SR2 B121FU

3.1. Mini- Programmable Logic Controller SR2 B121FU

In this chapter we did not intend to fully explore the features and possibilities of use of the PLC SR2 B121FU, as they are very vast and this is not the purpose of the paper. We will briefly refer only tot the information that concerns the topic of this paper.

The PLC SR2 B121FU is part of the „Zelio" range of smart relays manufactured by the French manufacturer Schneider Electric [28], [30], [31]. All of the PLCs belonging to Zelio range can be programmed in LD and FBD languages, with the help of Zelio Soft 2 software, which can be downloaded for free from the manufacturer's website [18].

Zelio SR2 B121FU is a compact mini-PLC that works in alternating current, at voltages from 100 to 240V and frequences of 50 and 60 Hz (Fig.4). This PLC has a LCD display, 8 discrete inputs and 4 relay outputs.

Fig.4. The SR2 B121FU Zelio PLC

In order to illustrate how the mini-PLC connects within the controlled process, in Fig.5 we will exemplify the hardware configuration of the scheme presented at the beginning of the paper, in Fig.1b. The operation of this hardware configuration is as follows (see Fig.1b and Fig.5):

- the a.c. voltage of 100…240 V is supplied to the PLC's power terminals L (live) and N (neutral);

- when pushing the Start button SRB, the voltage is applied to input I1, the line 01 becames TRUE, the main relay Q0.0 is activated and its contact Q0.1 is closed, the line 03 becames TRUE and the output Q1 is activated and thus the coil of contactor C is energised and the self-maintaining contact of control 1C in line 2 closes. The system is now in function;
- when pushing the Stop button SOB, line 01 becomes FALSE; the main relay Q0.0 de-energizes and its contact Q0.1 opens; line 03 becomes FALSE, output Q1 is disabled; contactor C is no longer supplied with voltage and contact 1C in line 02 opens. The system is now shut down [32] [34].

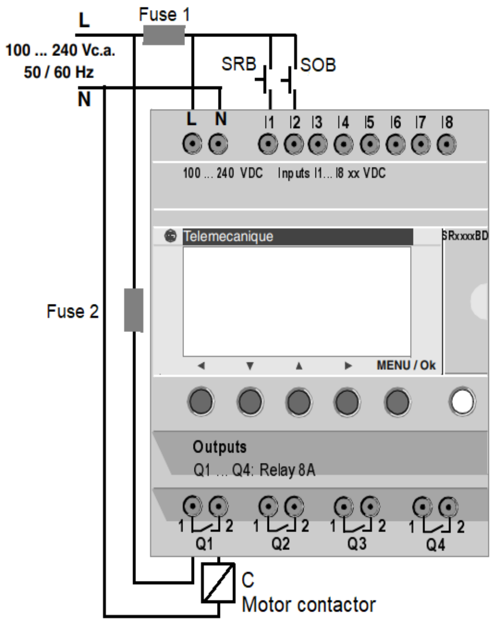


Fig.5. Hardware configuration of the scheme shown in fig.1

3.2. Defining the system and requirements for control

In order to be able to automate the coal transport system consisting of 3 belt conveyors, it was first necessary to define the requirements for command and control of the system [4].

We have considered a transport system composed of 3 conveyor belts, denoted with *CB1*, *CB2* and *CB3*, operating in cascade. Each of the three conveyors is driven separately by an electric motor controlled by a contactor. At the same time, each conveyor belt is equipped with safety rope pull switches (*SRPS*) and belt misalignment switches (*BMS*). The requirements we have proposed for command and control of transport system are as follows (see Fig.6 and Fig.7) [22]:

a) starting and stopping the transport system under normal conditions is done centrally from a dispatcher unit, by means of start (B_p) and stop (B_o) push buttons;

b) the ”OFF” state of the transport system will be signaled on the synoptic panel located at the dispatcher unit by lighting some red lamps (OFF) *RL1*, *RL2*, *RL3*, one for each conveyor;
c) when the start push-button B_p is pressed by the operator in the dispatcher unit, after a 2 seconds pause a sound pre-warning consisting of a series of 6 pulses, each lasting 1 second, will be emitted with a cadence of 2 seconds. On the synoptic panel in the dispatcher unit, the audible pre-warning will be doubled by the lighting of a yellow lamp, *YL7*. This audio and visual pre-warning sequence will have a total duration of 20 seconds and its purpose is to warn workers in the conveyor system area that the conveyors are about to start moving;
d) after 2 seconds from the end of the last pre-warning signal, the motors of the three belt conveyors will start in cascade, in the order *CB1*-*CB2*-*CB3*, with a delay of 10 seconds between them. The start of each motor will be signaled on the synoptic panel in the dispatcher unit by the corresponding red lamp *RL1*, *RL2* or *RL3* (OFF) turning off and the corresponding green lamp *GL1*, *GL2* or *GL3* (ON) turning on;
e) apart from the normal shut down of the transport system, carried out by the dispatcher operator by pressing the B_o push-button, the system can be stopped in two different emergency situations, independently of the will of the dispatcher operator. These emergency situation are as follows:
    - in case of a danger observed by any worker, this can activate the safety rope pull switch (*SRPS*) by pulling from any point the emergency steel rope installed along the conveyor [24]. The actuation of a conveyor’s SRPS must instantly stop the entire system and one of the corresponding yellow emergency lamps *YL1*, *YL3* or *YL5* will light up on the dispatcher’s synoptic panel. In this way, the dispatch operator will know where the dangerous situation occurred;
    - in the event of an abnormal lateral movement of any of the rubber belts on the rollers, a belt misalignment switch (*BMS*) will activate and cause the entire transport system to stop instantly. As in the case of SRPSs, the actuation of one of the BMSs must be signaled on the synoptic panel by the lighting of one of the yellow emergency lamps *YL2*, *YL4* or *YL6*;
    - the start-up of the transport system after the removal of the danger situations listed above must be done exclusively by the operator in the dispatch unit, following the steps described above in paragraphs c) and d).

3.3. System operation

Based on the requirements set up in the previous paragraphs, we designed the hardware configuration and then the Ladder Diagram for the command and control of the transport system using the Zelio SR2 B121FU mini-PLC. The hardware configuration is shown in Figure 6 and shows only the command circuits of the three

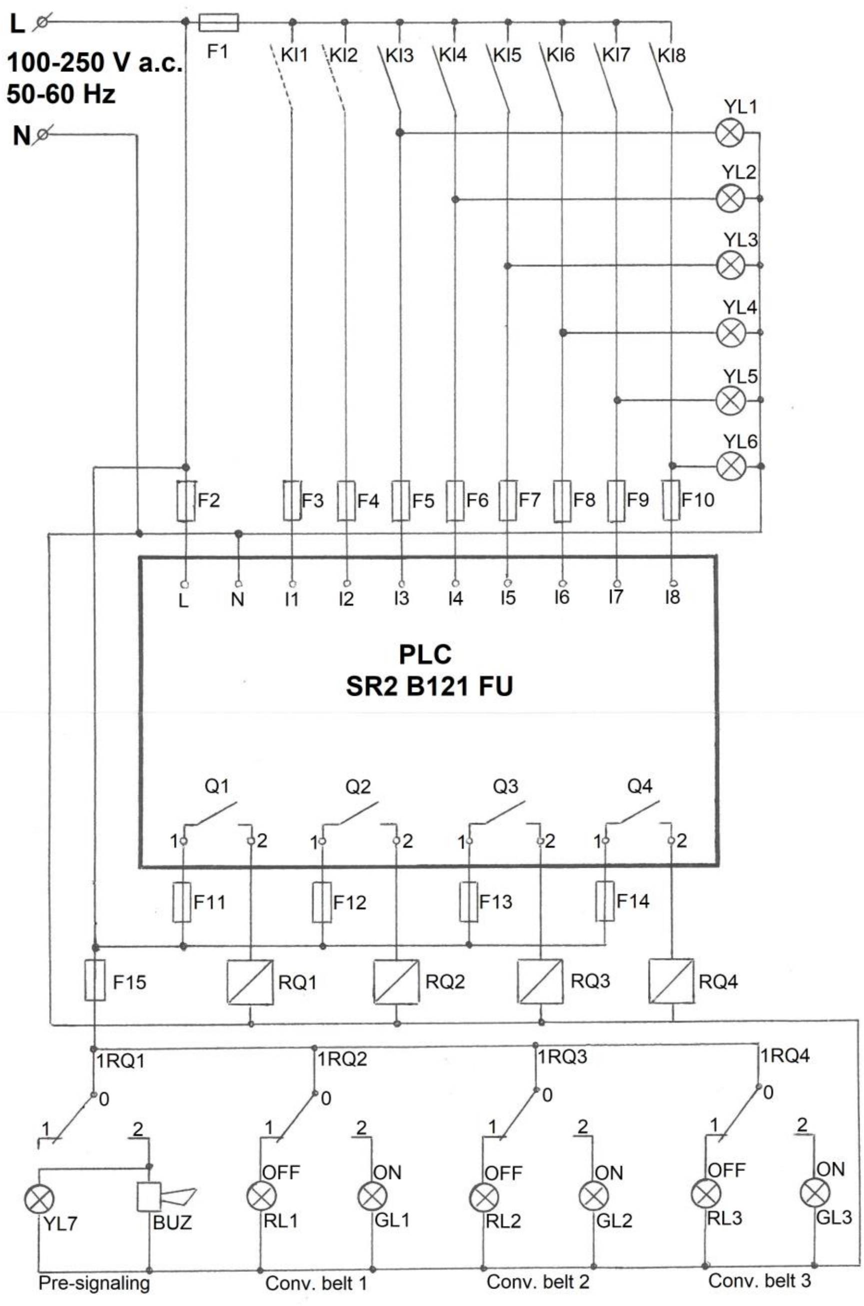


Fig.6. The hardware configuration of the command and control system

conveyor belts, without also illustrating the power circuits (conveyors contactors and motors) [12]. This hardware configuration contains the following components:

- F1…F15- fuses;

- KI1- start push-button (B_p)[7];
- KI2- stop push-button (B_o);
- KI3, KI5, KI7- contacts of the safety rope pull switches (*SRPS1*, *SRPS2*, *SRPS3*);
- KI4, KI6, KI8- contacts of the belt misalignment switches (*BMS1*, *BMS2*, *BMS3*);
- L, N- PLC's power terminals for 100…250V, 50-60 Hz;
- I1…I8- PLC's discrete inputs terminals;
- Q1.1, Q1.2…Q4.1, Q4.2- PLC's relays terminals (*Q1…Q4*);
- RQ1…RQ4- electromechanical intermediate relays, connected to the corresponding outputs of the PLC Q1…Q4;
- 1RQ1…1RQ4- pairs of NO/NC contacts of the corresponding relays RQ1…RQ4;
- YL1, YL3, YL5- yellow lamps on the synoptic panel, for signaling emergency stops caused by safety rope pull switches (*SRPS1*, *SRPS2*, *SRPS3*) actuation by workers;
- YL2, YL4, YL6- yellow lamps on the synoptic panel for signaling emergency stops caused by belt misalignment switches (*BMS1*, *BMS2*, *BMS3*) actuation by the accidentaly lateral movements of the rubber belts on the conveyor's rollers;
- YL7- yellow lamp on the synoptic panel, for optical presignaling;
- BUZZ- bell on the synoptic panel and horns on the route of the belt conveyors, for acoustic presignaling;
- RL1, RL2, RL3- red lamps on the synoptic panel, for signaling the ”OFF” state of the corresponding conveyor belts CB1, CB2, CB3;
- GL1, GL2, GL3- green lamps on the synoptic panel, for signaling the ”ON” stare of the corresponding conveyor belts CB1, CB2, CB3.

After completing the hardware configuration, the next step is to draw the LD diagram [22]. To do this, we first defined the PLC inputs and outputs as follows, capitalizing the direct contacts (NO) and lowercase negating (NOT) contacts (NC):

a) The inputs:
  - I1- start button B_p;
  - i2- (NOT) contact- stop button B_o;
  - i3- (NOT) contact- safety rope pull switch of CB1 (SRPS1);
  - i4- (NOT) contact- belt misalignment switch of CB1 (BMS1);
  - i5- (NOT) contact- safety rope pull switch of CB2 (SRPS2);
  - i6- (NOT) contact- belt misalignment switch of CB2 (BMS2);
  - i7- (NOT) contact- safety rope pull switch of CB3 (SRPS3);
  - i8- (NOT) contact- belt misalignment of CB3 (BMS3).

b) The outputs:
  - Q1- contactor for optical and acoustic presignaling of the start of the transport system;
  - Q2- contactor for operating the conveyor belt CB1;

[7] *Italic notations in parantheses are those of the Ladder Diagram shown in Figure 7*

- Q3- contactor for operating the conveyor belt CB2;
- Q4- contactor for operating the conveyor belt CB3.

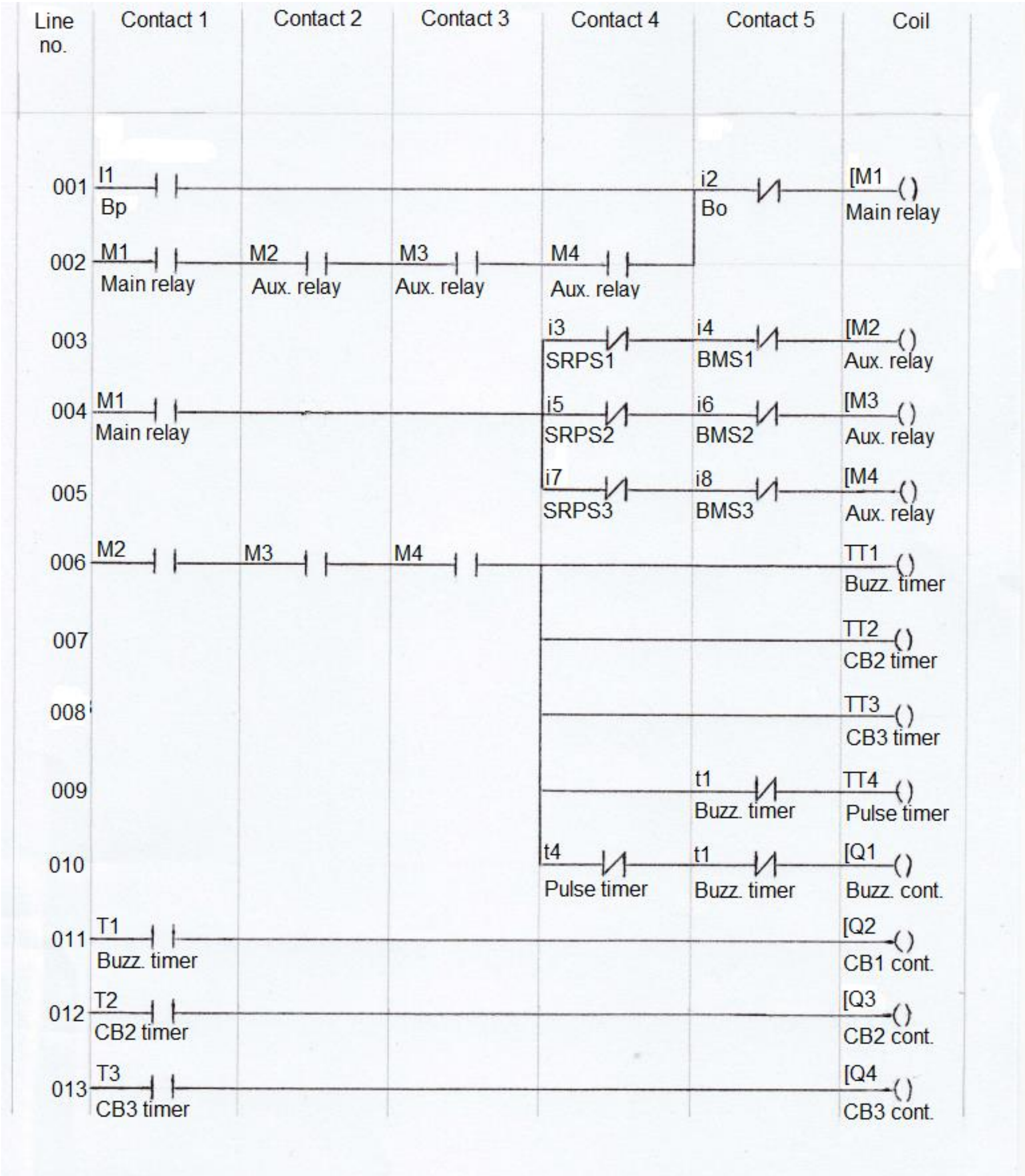


Fig.7. LD diagram for conveying system command and control

After establishing all the program reqirements and defining the PLC inputs and outputs, we practically implemented all of them, resulting in the LD diagram in Figure 7. The diagram consists of 13 program lines, including the following elements [13]:

a) *Elements of the controlled process that physically exist within it and are connected to the mini-PLC by wires:*

- the start button B_p connected to input I1: by its actuation, the transport system is started from the dispatcher unit;
- the stop button B_o, connected to input i2: by its actuation, the transport system is stopped under normal conditions, from the dispatcher unit;
- the contacts of the system's safety elements SRPS and BMS, connected to inputs i3…i8: they ensure the stop of the entire transport system in conditions of abnormal operating, preventing work accidents and technical breakdowns.

b) *components physically present in the mini-PLC housing:*
- output miniature electromagnetic relays, whose NO contacts are connected to the mini-PLC's output terminals, Q1…Q4.

c) *Command and execution elements created virtually by the program:*
- the main relay M1: executes start and stop commands received from the inputs I1 and i2;
- auxiliary relays M2, M3, M4: execute the commands received from the main relay M1 and from SRPSs and BMSs connected to inputs i3…i8;
- timers TT1…TT4, whose operation will be explained below in Fig.8 and Table 1.

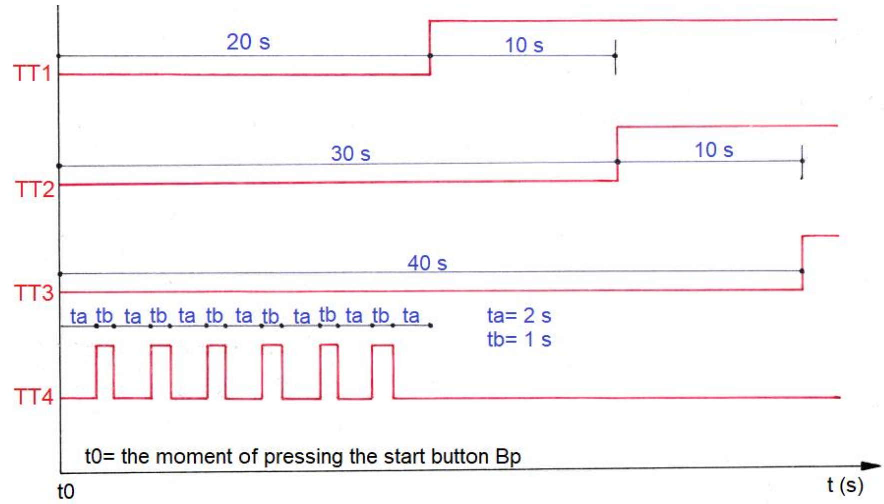


Fig.8. Diagram of timers parameters

*Table 1. **Timers configuration and executed sequences***

Timer	Configuration	Executed sequence
TT1	Active, control held down	After the time t is elapsed since activation, it changes the state of the contacts and remains in that state as long as it is activated
TT2		
TT3		
TT4	Flasher unit; control held down asynchronously	When activated it changes the state of the contacts for time duration t_a, then returns to the initial state for time duration t_b and repeats the cycle as long as it is activated

The program drawn up for commanding the transport system can be divided into several sequences, as follows [19]:

a) Presignaling

The purpose of presignaling is to alert the workers in the path of the conveyor belts that they must move away from moving items as the conveyors are about to start. The presignaling starts when the B_p start button is pressed by the operator at the dispatch point [14]. The sequence of operations performed by the mini-PLC is as follows:

- line 001 is energized through B_p-B_o-M1;
- the main relay M1 goes from logic level 0 to logic level 1;
- the contacts of relay M1 in lines 002 and 004 close, having the effect of simultaneously energizing the lines 003, 004, 005 through the SRPSs and BMSs NC contacts, connected to the inputs i3…i8;
- auxiliary relays M2, M3, M4 pass from logic level 0 to logic level 1;
- contacts M2, M3, M4 in line 002 close (command self-maintaining). By releasing the start button B_p, the main relay M1 remains energized through M1-M2-M3-M4 (line 002)-B_0 (line 001);
- the contacts M2,M3, M4 in line 006 close, having the effect of energizing lines 006, 007, 008, 009, 010;
- the timers TT1, TT2, TT3, TT4 become energized;
- the timer TT4 starts the pulsing control sequence of contactor Q1. Therefore, 2 seconds after pressing the start button B_p, the presignaling buzzer and horns emits 6 acoustic signals of 1 s duration each with a 2 s pause between the signals. The acoustic signals are duplicated by the optical signals of the warning yellow lamp YL7 on the synoptic panel at the dispatcher's point.

b) Starting conveyor belt no.1 (CB1)

- in the 21^{st} s after pressing B_p, timer TT1 goes from logic level 0 to logic level 1;
- contacts t1 in lines 009 and 010 interrupt the energization of these lines;
- timer TT4 and contactor Q1 turn from logic level 1 to logic level 0 and the acoustic and optical presignaling sequence ends;
- contact TT1 in line 011 closes, energizing the line and switching output Q2 from logic level 0 to logic level 1. CB1 motor is energized ant the conveyor starts moving.

c) Starting conveyor belt no. 2 (CB2)

- after 30 s from pressing the start button B_p and 10 s after starting CB1, timer TT2 turns from logic level 0 to logic level 1;
- contact T2 in line 012 closes, energizing the line and changing the logic level of output Q2 from 0 to 1. CB2 motor is supplied with voltage and the conveyor starts moving.

d) Starting conveyor belt no. 3 (CB3)

- after 40 s from pressing the start button B_p and 10 s from starting CB2, timer TT3 turns from logic level 0 to logic level 1;
- contact T3 in line 013 closes, energizing the line and changing the logic level of output Q3 from 0 to 1. CB3 motor is supplied with voltage and the conveyor starts moving.

e) Stopping the transport system in normal conditions

Stopping the transport system in normal conditions is done from the dispatcher point by pressing stop button B_o as follows:

- the energization of the main relay M1 is interrupted and the relay turns from 1 to 0;
- contacts M1 in lines 002 and 004 open, turning the two lines from 1 to 0;
- auxilary relays M2, M3, M4 turn from 1 to 0;
- contacts M2, M3, M4 in lines 002 and 006 open, turning the lines from 1 to 0;
- contacts T1, T2, T3 in lines 011, 012, 013 open and outputs Q2, Q3, Q4 turn from 1 to 0 and the conveyor belts stop moving.

f) Emergency stopping of the transport system

The emergency stopping of the transport system can be done either by the workers in the conveyors area, by pulling the steel ropes that actuate the system rope pull switches (SRPS), or by the belt misalignment switches (BMS), independent of the will of the personnel [16]. We will exemplify this sequence by asuming that an abnormal lateral displacement of the rubber belt on the rollers occur at CB2, sensed by the belt misalignment switch no. 2 (BMS2) whose contact is connected to PLC’s input i6. The sequence of operations performed by the PLC is as follows:

- contact BMS2 closes, turning the logic level of line 004 from 1 to 0;
- auxiliary relay M3 turns from 1 to 0;
- contacts M3 in lines 002 and 006 open, turning the two lines from 1 to 0;
- the self-maintaining of the starting command in line 002 is also turned from 1 to 0;
- the main relay M1 is turned from 1 to 0;
- next, the sequence of operations performed by the PLC is identical as in point e) and the entire transport system stops.

The writing of the program for the command and control of the transport system was carried out in the LD language with the help of the Zelio Soft 2 programming software, which can be downloaded for free from the manufacturer’s website. In addition to the facilities for writing applications in LD and FBD programming languages, Zelio Soft also offers its users the posibility of simulating the operation of written programs [17].

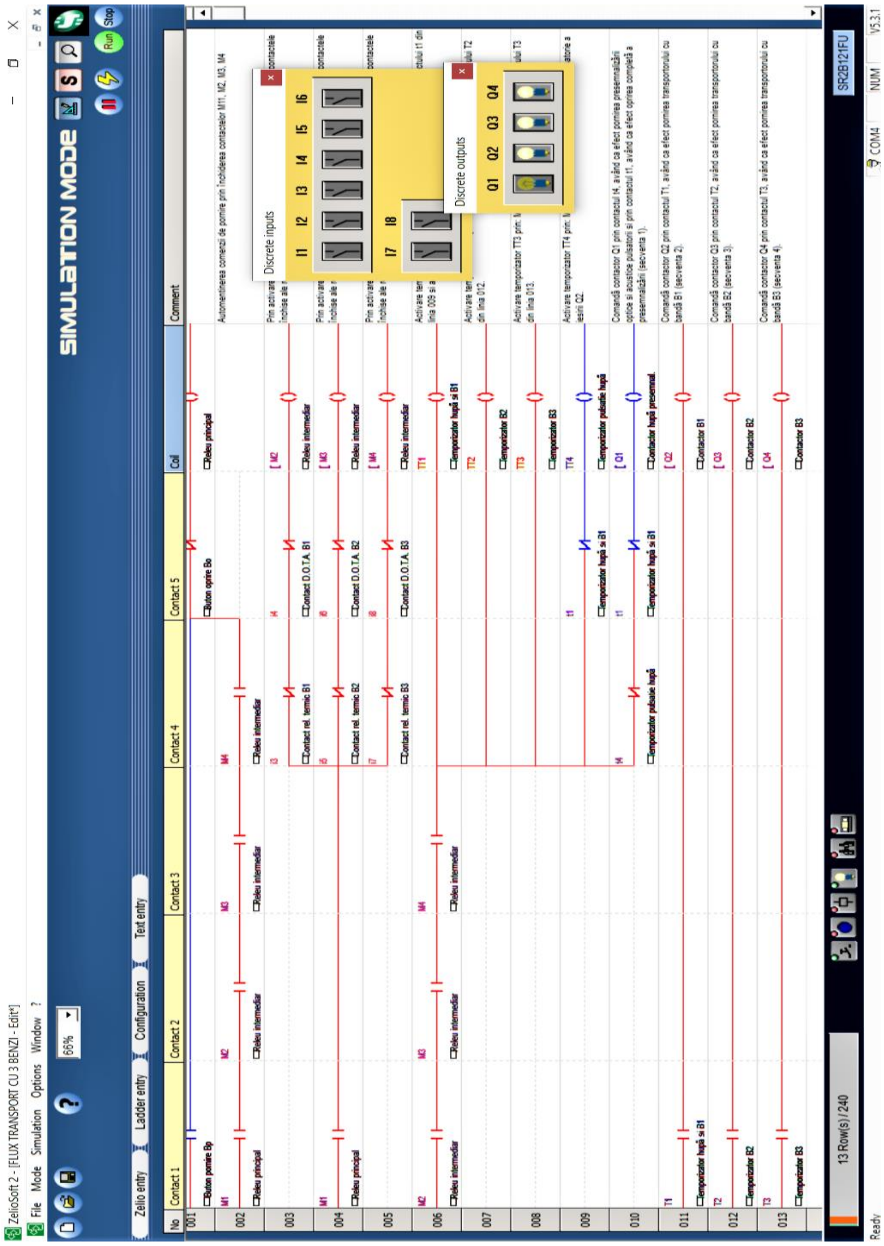


Fig.9. The simulation mode window of Zelio Soft 2

In order to illustrate how the simulation works, Fig.9 shows the Zelio Soft 2 simulation mode window at the CB3 conveyor start-up sequence.

4. CONCLUSIONS

It’s been half a century since we can’t even say the word ”automation” without thinking of Programmable Logic Controllers. PLCs have simplified automation schemes, increased the accuracy and safety of industrial automation systems and generated billions of dollars in savings. In these circumstances, it was imposible for PLCs not to make their way beyond the walls of large industrial plants and not to migrate to residential and even domestic applications, once the ”mini” variants of these PLCs appeared.

Considering only the application presented in this paper, we can see that a number of 4 electromagnetic relays and 4 electromagnetic timers have been replaced by a simple PLC, which occupies in the electrical panel a space equal only to that occupied by 6 single-pole circuit breakers. PLCs will continue to be widely used in the future as they are ideal solutions for small, medium or large complexity applications.

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