DECISION SUPPORT SYSTEMS IN PROJECT AND PROGRAM MANAGEMENT

EIROPAS SAVIENĪBA

Riga – 2024

DECISION SUPPORT SYSTEMS IN PROJECT AND PROGRAM MANAGEMENT

Collective monograph
edited by I. Linde

European University Press
ISMA University of Applied Sciences
Riga (Latvia) 2024

LĒMUMU ATBALSTA SISTĒMAS PROJEKTU UN PROGRAMU VADĪBĀ

Kolektīvas monogrāfija
I. Linde zinātniskajā redakcijā

Eiropas Universitāte Press
Informācijas sistēmu menedžmenta augstskola
Rīga (Latvija) 2024

ISBN 978-9984-891-33-0
UDC 658.012.32

Decision support systems in project and program management, [Text]: Collective monograph edited by I. Linde. European University Press. Riga: ISMA, 2024. 256 p.

Recommended for publication by the Scientific and Technical Council Kharkiv National University of Radio Electronics (protocol No. 9 of September 26, 2024)

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The monograph presents the achievements of Ukrainian scientists in the field of business management, use of economic and mathematical modeling, information technologies, management technologies and technical means in the field of functioning, development, and project management at enterprises.

The publication is recommended for professionals in the fields of economics, information technology, project and program management – for undergraduate and graduate students, as well as academics and teachers of higher education.

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ISBN 978-9984-891-33-0
UDC 658.012.32

DOI: https://doi.org/10.30837/MMP.2024.152

CONVEYOR LINE DEVELOPMENT FEATURES FOR PHARMACEUTICAL PRODUCTS INDUSTRIAL LOGISTICS

Nevliudov I., Yevsieiev V., Maksymova S., Klymenko O.

This section of the monograph examines the key stages of designing and creating an automated sorting system in the pharmaceutical industry. The main focus is on developing the scheme and selecting the supporting modules for assembling the line layout, as well as creating a control system based on the Siemens S7-1200 programmable logic controller (PLC). The work presents detailed photographs of the assembled layout, which allows visualizing the final design result. In addition, an electrical circuit for connecting the PLC, a functional diagram for connecting the conveyor sections, and a plan for their placement have been developed and presented, which ensures a comprehensive understanding and implementation of the project for automating sorting processes in the pharmaceutical industry.

Introduction

In modern conditions, the pharmaceutical industry faces increased demands for product quality and efficiency of production processes. One of the key elements of automation in this area is a conveyor line for sorting pharmaceutical products. The importance and relevance of research related to the development of such lines is due to the need to ensure high sorting accuracy and minimize the human factor, which is critical to maintaining quality standards and increasing productivity. The use of automated systems allows you to optimize sorting processes, increase the speed and accuracy of task performance, and ensure flexibility in adapting production lines to various types of products. The development of a scheme and the selection of supporting modules for the conveyor line layout, as well as the creation of a control system for this line, are key stages that determine the efficiency and reliability of the entire system. These tasks require deep analysis, a systematic approach and the use of modern technologies, which emphasizes the relevance and importance of the research presented in this collective monograph.

1. Development of a scheme and selection of supporting modules for a pharmaceutical product sorting line layout

Designing an automated control system layout for a pharmaceutical sorting conveyor line requires careful justification of the technical parameters selection in relation to the specifics of the industry.

Here are some key factors that need to be taken into account during the design development process:

– standards and regulations – the selected technical parameters comply with all applicable standards and regulations in the pharmaceutical industry; this includes safety requirements, production cleanliness, as well as traceability and quality control requirements;

– sorting requirements for pharmaceutical products; this may include different packaging shapes, sizes, weights and other parameters that may affect the selection of technical solutions for effective sorting;

– a high standard of cleanliness and hygiene; the pharmaceutical industry requires selection of such technical parameters that ensure ease of cleaning, disinfection and maintaining sterility during operation.

– speed and throughput requirements; it is necessary to determine the required sorting speed and line throughput in accordance with production needs; considering the possibility of scaling the system for higher productivity in the future;

– traceability and quality control systems; implementation of product traceability and quality control systems at each stage of sorting; this is important to ensure compliance with quality standards in the pharmaceutical industry;

– integration with other systems; compatibility and ease of integration of the automated control system with other production systems, such as packaging, labeling and warehousing systems;

– energy saving and sustainability; technical parameters that can ensure energy saving and reduce environmental impact, which is important for pharmaceutical companies that adhere to the principles of sustainable development.

Based on the analysis of the selection of technical parameters, the following industrial conveyor line for sorting pharmaceutical products scheme was developed, which is shown in Figure 1.

The general scheme of the conveyor line for sorting pharmaceutical products is shown in Fig. 1. Let us note the following main elements of the conveyor belt in the scheme:

1 – vertical elevator for moving packages between floors (Fig. 1b), it acts as an actuator for sorting identified packages on the transportation floors;

2 – rollers, as an element of the roller conveyor, serve to move the package in space;

3 – conveyor zone with a belt element – a table, in this zone the presence recognition and identification of the package will be performed using the computer vision system;

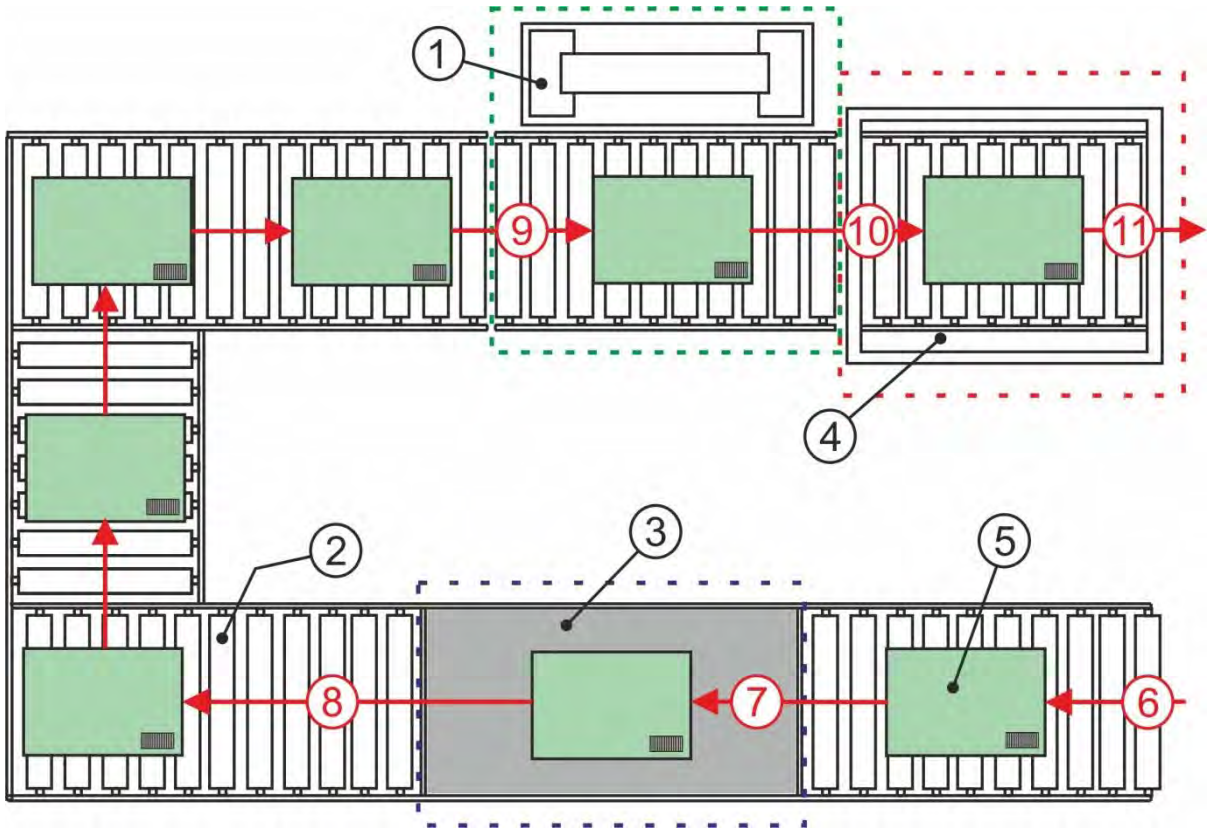

Fig. 1. Industrial Conveyor Line for Sorting Pharmaceutical Products Scheme

4 – vertical conveyor on the 3rd floor for sorted packages;

5 – packaging on the conveyor line. It is also necessary to consider the main events affecting the package, for ease of rendering we will present them as red arrows;

6 – arrival of an unidentified object on the conveyor line from the accumulator;

7 – identification of an object using a computer vision system;

8 – movement of the identified object along the conveyor;

9 – sorting of the identified object using a vertical elevator by levels;

10, 11 – movement of the identified object to a specified storage facility.

There are several key reasons for including a vertical lift in an industrial conveyor line layout for sorting pharmaceutical products:

– space optimization; vertical lifts allow for the efficient use of vertical space in production facilities; this is especially important in the case of limited space, where maximizing every square meter plays a key role; vertical lifts allow for the efficient transport of products between different levels, reducing the need for large horizontal spaces;

– product safety; in the pharmaceutical industry, product safety is a priority; vertical lifts ensure gentle movement of products between floors, which is especially

important for fragile or vibration-sensitive pharmaceutical products; this helps prevent damage and maintain a high standard of product quality;

– sorting to different levels; vertical lifts allow for the organization of a sorting layout at different levels of production; this can be useful if pharmaceutical products require different processing or sorting steps at different floors of the conveyor line; such a structure reduces the movement of products along the horizontal conveyor, improving the efficiency and speed of the process;

– compliance with cleanliness and hygiene standards; vertical lifts can be easily integrated into pharmaceutical cleanliness and hygiene systems; they provide quick access for maintenance and cleaning, which meets the strict standards set in this industry.

– flexibility in line setup; vertical lifts provide flexibility in setting up the conveyor line to adapt to different production needs; this allows for quick changes to the sorting line in case of changes in the product range or production processes.

In accordance with the developed scheme (Fig. 1) of the industrial conveyor line for sorting pharmaceutical products, we will select the main elements.

Drive roller conveyor is designed for automated transportation of the product along its working surface. The general view of the drive zones in the automated conveyor system is shown in Figure 2

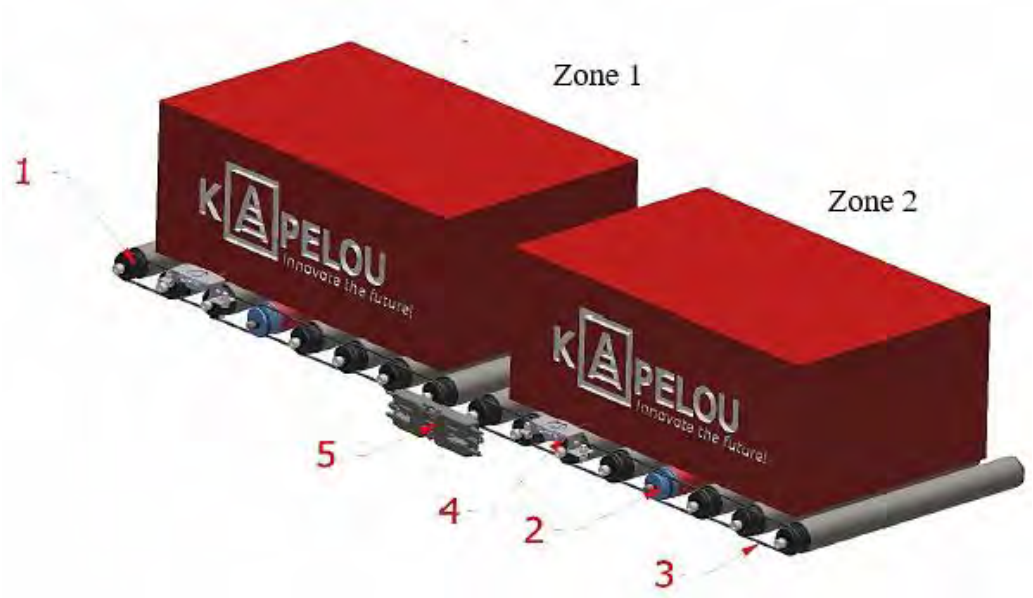

Fig. 2. General view of drive zones in an automated conveyor system

It consists of the following elements: a set of driving rollers (2) with an electric drive and driven rollers (1), connected synchronously by belt drives (3). The control of the inclusion of drive zones is provided with sensors (4). The operating principle of the driven accumulation roller conveyor is alternately switching on/off the drive

rollers in the logical zones of the conveyor by means of control boards (5) connected to each other, representing a network for ensuring the exchange of information through the main controller of the system. The main feature of the accumulation conveyor is that only those logical zones that are currently involved in the transportation of the product operate. Zones that are not currently involved in the transportation of the cargo are in standby mode. The main technical parameters of the drive zones (Fig. 2) are given in Table 1

Table 1

Main technical parameters of drive zones

Characteristic	Value
Standard conveyor zones length (mm)	1000
Minimum conveyor zones length (mm)	800

The direct drive roller conveyor is an effective technical solution for transporting pharmaceutical products. It is characterized by a simple design, high reliability and cost-effectiveness. Direct drive eliminates the need for complex mechanisms and moving parts, which reduces the risk of breakdowns and facilitates maintenance. Due to the direct transmission of torque from the motor to the rollers, the conveyor ensures precise and smooth movement of goods, as well as efficient use of energy. Fewer moving parts reduce noise levels, which is important in conditions where compliance with noise standards is required. The general appearance of the direct drive roller conveyor model 487 is shown in Figure 3, and its main technical characteristics are given in Table 2.

Fig. 3. General view of the direct drive roller conveyor model 487

Table 2

Main technical characteristics of the direct drive roller conveyor model 487

Characteristic	Value
Purpose	Product transportation
Conveyor type	Cumulative
Conveyor motion type	Roller
Operating speed range	from 0,5 up to 1,0 m/s
Max. load	35 kg/good
Normal width between profiles	487 mm
Product transport side	Short
Type of rollers	Cylindrical
Roller coating	Galvanized steel
Roller diameter	50 mm
Step between rollers	100 mm
Belt type	2 PJ 336
Color of metal structures	Galvanized steel
Zone motor control element	Dual-zone controller
Zone control sensors	Optical

The straight drive roller conveyor (Fig. 4) is designed for automatic transportation of products along its working surface in a straight-line direction. The general appearance of the straight drive roller conveyor model 687 is shown in Figure 4, and its main technical characteristics are in Table 3.

Fig. 4. General view of direct drive roller conveyor model 687

Table 3

Main technical characteristics of direct drive roller conveyor model 687

Characteristic	Value
Purpose	Product transportation
Conveyor type	Cumulative
Conveyor motion type	Roller
Operating speed range	from 0,5 up to 1,0 m/s
Max. load	35 kg/good
Normal width between profiles	687 mm
Product transport side	Short
Type of rollers	Cylindrical
Roller coating	Galvanized steel
Roller diameter	50 mm
Step between rollers	100 mm
Belt type	2 PJ 336
Color of metal structures	Galvanized steel
Zone motor control element	Dual-zone controller
Zone control sensors	Optical

A diverter (or diverter valve) in a conveyor line is a device designed to direct the flow of materials or products in a certain direction on a conveyor. Its main purpose is to divide the flow into two or more parts to redirect materials to the desired location or to another part of the production process. Within the framework of the developed layout, it is proposed to use a diverter 90^{o} model DU90-W36L38-2-SS, the general appearance of the diverter is shown in Figure 5, and its technical characteristics are in Table 4.

Fig. 5. The diverter 90^{o} model DU90-W36L38-2-SS general view

Table 4

Main technical characteristics of diverter 900 model DU90-W36L38-2-SS

Characteristic	Value
Purpose	sorting of products
Conveyor type	lifting
Conveyor motion type	ribbon
Dimensions, (Length x Height x Width)	430.6 x 385 x 168,3 mm
Operating speed	max 1 m/s
Max. load	2,5–30 kg
Control module	dual zone controller
Color of other metal elements	galvanized steel
Number of engines	2 шт.
Number of tape strips	2 шт.
Conveyor base	487 mm
Drop angle	90º
Body color	RAL 9005 (black)
Color of ribbons	RAL 5012 (blue)
Work surface	ribbon
Ribbon, (Д x Ш)	15 x 888 mm

The vertical conveyor is a lifting mechanism. It is a static frame with a power drive for moving the lifting carriage with a straight drive roller section of the conveyor along a straight frame guide by means of a belt transmission. It is designed for vertical movement and sorting of products in the conveyor system. The general appearance of the vertical conveyor is shown in Figure 6, and its technical characteristics are in Table 5.

Table 5

Main technical characteristics of the vertical conveyor

Characteristic	Value
Purpose	Vertical transportation, sorting of products
The conveyor type on the carriage	Roller
Transport mode	1 продукт/цикл
Productivity	Up to 300 cycles/hour
Minimum possible loading height	+0,50 m
Maximum weight of transported product	Up to 35 kg
Type of transmission	Toothed belt
Engine	NORD
Engine power	3,0 kW
Engine color	RAL 9006 (grey)
Voltage	220…242 V(Δ) / 380…420 V(Y) 50 Hz

Fig. 6. Vertical conveyor general view

The straight drive roller section on the vertical conveyor plays an important role in ensuring efficient transportation of goods or materials in the vertical direction. The straight drive roller section on the vertical conveyor moves by a lifting carriage connected to the drive via a belt transmission. The general appearance of the straight drive roller section on the vertical conveyor is shown in Fig. 7, and its technical characteristics are in Table 6.

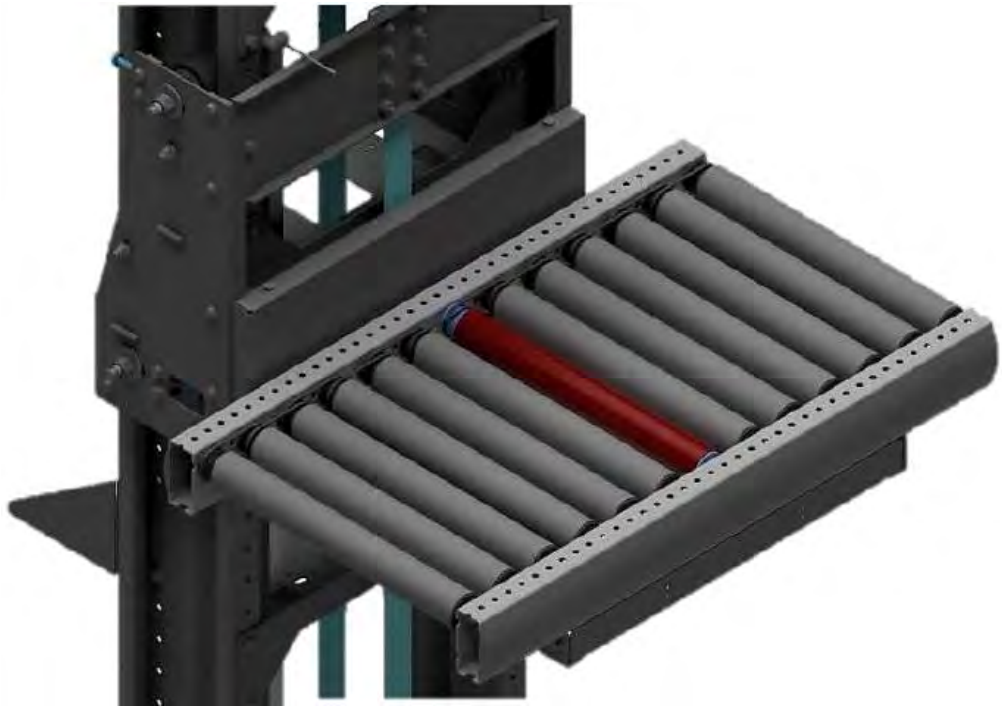

Fig. 7. The direct drive roller section on a vertical conveyor general view

Table 6

Main technical characteristics
of the direct drive roller section on the vertical conveyor

Characteristic	Value
Purpose	Product transportation
Conveyor motion type	Roller
Operating speed range	From 0,5 up to 1,0 m/s
Normal width between profiles	487 mm
Product transport side	Short
Type of rollers	Cylindrical
Roller coating	PVC
Roller diameter	50 mm
Step between rollers	75 mm
Belt type	2 PJ 286
Color of metal structures	Galvanized steel
Control element	Controller Eqube
Zone control sensors	Optic

The stop and start plates in a roller conveyor are designed to ensure the safety and efficiency of the material handling system. Stop plates prevent loads from rolling away and provide a controlled stopping area, which is important for safe handling and loading of materials. Start plates control the start of the load movement, preventing abrupt starts and increasing the efficiency of loading and unloading. Both elements contribute to compliance with safety standards and increase the durability of conveyor equipment. The general appearance of the stop and start plates is shown in Figure 8.

a) b)

Fig. 8. General view of stop and start plates for roller conveyor:
a) stop plate; b) starting plate

The stop plate (Fig. 8a) is used to prevent the transported product from falling at the blind ends of a driven or non-driven roller conveyor. The stop plate coating is galvanized steel. The starting plate (Fig. 8b) is installed in places where the product is loaded onto the conveyor and is used to protect a person from damage to clothing on moving parts of the conveyor and to prevent impact of the rollers when installing the transported product from the beginning of the line. The starting plate coating is galvanized steel.

2. Development of a control system for a conveyor line for sorting pharmaceutical products

After analyzing and selecting the main working elements for the conveyor lines for sorting pharmaceutical products, we can begin to develop an automated control system. At the first stage, we will develop a structural control diagram for the conveyor lines for sorting pharmaceutical products, which is shown in Figure 9.

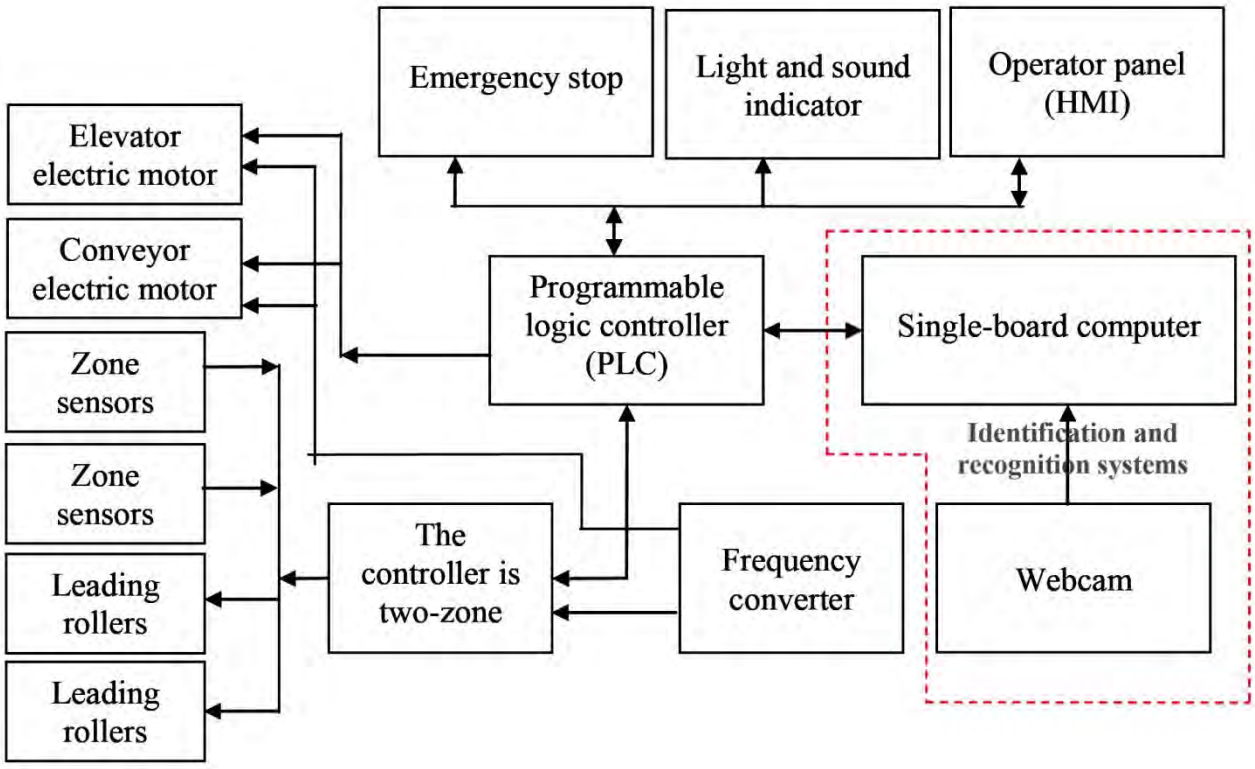

Fig. 9. Control diagram of the conveyor line for sorting pharmaceutical products

In the control scheme of the pharmaceutical sorting conveyor line, the following elements perform key functions:

– Elevator Electric Motor is responsible for the vertical movement of goods along the conveyor, ensuring efficient sorting into different levels;

– Conveyor Electric Motor is responsible for the movement of the conveyor belt, moving goods along the sorting line;

– Zone Sensors are used to detect the presence or absence of goods in different zones of the conveyor. This information can be used to activate other elements of the system;

– Leading Rollers ensure stable movement of goods along the conveyor belt and help to control their position.

– The controller is two-zone – it controls the entire system, including coordination of conveyor movement, activation of sorting zones and interaction with other control elements;

– Frequency Converter regulates the speed of the electric motors, providing flexibility in conveyor control and adaptation to various conditions;

– Program Logic Controller controls the logic of the entire system, ensuring coordination between the various elements based on pre-defined software rules;

– Emergency Stop provides a mechanism for immediate stopping of the conveyor in case of emergency situations or the need to safely stop work;

– Light and Sound Indicator is used to visually and audibly alert the operator to the system status, possible problems or events requiring attention;

– Operator Panel (HMI – Human-Machine Interface) provides the operator with the ability to interact with the system, displays information about the conveyor operation, allows you to configure parameters and respond to events;

– Single-board computer is the central control device that processes data and controls the entire conveyor system; it can process information from sensors, make decisions based on software algorithms and interact with other controls;

– Webcam is used for visual monitoring of the sorting process. It can be used to capture images of products, analyze them using computer vision or visual quality control; the webcam can also be used to identify products by their appearance.

We will analyze and select hardware modules for the implementation of the layout of the automated control system for the conveyor line of sorting pharmaceutical products, based on the developed scheme (Fig. 9). At the first stage, we will select the Program Logic Controller (PLC). During the analysis of the technical characteristics and requirements for the developed control system of the conveyor line of sorting, it was proposed to use the following PLC, the general appearance of which is shown in Figure 10, and a comparison of their basic characteristics is given in Table 7.

a) b) c)

Fig. 10. General view of selected PLCs:
a) PLC Siemens s7-1200; b) MELSEC iQ-F; c) CompactLogix 5370

Table 7

Comparison of the main technical characteristics of PLC Siemens s7-1200, MELSEC iQ-F, CompactLogix 5370

Characteristic	PLC		
	Siemens s7-1200	MELSEC iQ-F	CompactLogix 5370
Manufacturer	Siemens	Mitsubishi Electric	Rockwell Automation
Type	Microcontroller	Microcontroller	Microcontroller
Number of discrete inputs	32 – 256	8 – 128	16 – 256
Number of discrete outputs	24 – 256	8 – 128	16 – 256
Number of analog inputs	8 – 32	8 – 32	8 – 32
Number of analog outputs	4 – 16	4 – 16	4 – 16
Maximum frequency of discrete inputs	100 kHz	100 kHz	100 kHz
Maximum frequency of discrete outputs	100 kHz	100 kHz	100 kHz
Maximum analog input frequency	100 kHz	100 kHz	100 kHz
Maximum frequency of analog outputs	100 kHz	100 kHz	100 kHz
Maximum program memory	128 кВ – 1 MB	128 кВ – 1 MB	128 кВ – 1 MB
Maximum data memory	128 кВ – 1 MB	128 кВ – 1 MB	128 кВ – 1 MB
Operating temperature	–25 – 60 °C	–25 – 60 °C	–25 – 60 °C

To implement the layout of the automated control system for the pharmaceutical sorting conveyor line, the Siemens s7-1200 PLC was selected. This choice was made based on a comparison of the technical characteristics of the three PLCs under consideration: Siemens s7-1200, MELSEC iQ-F and CompactLogix 5370. All three PLCs have a wide range of inputs and outputs, which allows you to connect various sensors and actuators necessary for the conveyor line to them. The Siemens s7-1200 offers a wider range of inputs and outputs than the MELSEC iQ-F and CompactLogix 5370. This allows you to connect a larger number of sensors and actuators to it, which may be necessary in the case of a complex conveyor line. The PLCs support a high frequency of discrete and analog signals, which ensures high accuracy and speed of system operation. The Siemens s7-1200 supports a higher frequency of analog signals than the MELSEC iQ-F and CompactLogix 5370. This may be important for conveyor lines that require high control accuracy. To implement complex conveyor line control algorithms, a large amount of program and data memory is required. Siemens s7-1200 has a large amount of program and data memory, which allows creating complex control algorithms. MELSEC iQ-F and CompactLogix 5370 also have a large amount of program and data memory, but less than Siemens s7-1200.

Based on the comparison of the technical characteristics of the three PLCs under consideration, it can be concluded that the Siemens s7-1200 PLC is the optimal choice for implementing the layout of an automated control system for a pharmaceutical sorting conveyor line. This PLC has a wide range of inputs and outputs, high frequency of discrete and analog signals, large memory capacity of programs and data, a wide range of operating temperatures and a degree of protection against moisture and dust, as well as a wider price range than competitors.

Let's analyze and select a dual-zone controller. During the review of technical characteristics, the following dual-zone controllers were selected: ConveyLinx Ai2, ConveyLinx Dual Zone, ConveyLinx Ai3, the general appearance of which is presented in Figure 11, and a comparison of their technical characteristics in Table 8.

a) b) c)

Fig. 11. General view of dual-zone controllers:
a) ConveyLinx Ai2; b) ConveyLinx Dual Zone; c) ConveyLinx Ai3

Table 8

Comparison of the main technical characteristics of ConveyLinx Ai2, ConveyLinx Dual Zone, ConveyLinx Ai3

Characteristic	Dual-zone controllers		
	ConveyLinx Ai2	ConveyLinx Dual Zone	ConveyLinx Ai3
Speed control range	from 0 up to 100%	from 0 up to 100%	from 0 up to 100%
Speed control resolution	0,10%	0,10%	0,10%
Maximum acceleration value	10 m/s²	10 m/s²	10 m/s²
Maximum deceleration value	10 m/s²	10 m/s²	10 m/s²
Input signal range	0–10V, 4–20mA, discrete signals	0–10V, 4–20mA, discrete signals	0–10V, 4–20mA, discrete signals
Degree of protection against moisture and dust	IP65	IP67	IP65

ConveyLinx Dual Zone also meets all the requirements, but has a higher price (from $ 1,500). ConveyLinx Ai3 has a wider range of input signals (HART and CANopen signals are added), but it has a lower degree of protection against moisture and dust (IP65). Thus, ConveyLinx Ai2 is the optimal choice for the implementation of an automated control system layout for a pharmaceutical sorting conveyor line. It has all the necessary technical characteristics, as well as an affordable price.

To save energy and the ability to regulate the speed of such mechanisms as a vertical conveyor, a SIEMENS G120 PM240-2 frequency converter is used (Fig. 12). A frequency converter is an electronic device for changing the frequency of electric current (voltage). It converts the input sinusoidal voltage of a fixed frequency and amplitude into an output pulse voltage of variable frequency and amplitude using PWM (pulse width modulation). Thus, by smoothly increasing the frequency and amplitude of the voltage supplied to the stator windings of an asynchronous electric motor, it is possible to ensure smooth regulation of the rotation speed of the electric motor shaft.

The main technical characteristics of the SIEMENS G120 PM240-2 frequency converter are presented in Table 9.

The operator panel is designed to display information about the system status, control and handling of emergency situations. The operator panel also allows the

system settings to be changed by qualified personnel of the system supplier during service and/or warranty maintenance of the equipment. The general appearance of the selected Siemens SIMATIC HMI operator panel is shown in Figure 13, and the main technical characteristics are in Table 10.

Fig. 12. Frequency converter SIEMENS G120 PM240-2

Table 9

Main technical characteristics
of the SIEMENS G120 PM240-2 frequency converter

Characteristic	Value
Supply voltage	Three-phase design
Power	Up to 4 kW
Power frequency	47…63 Hz
Output frequency	0–200 Hz
Torque overload	150% during 1 minute
Protection class	IP20
Operating temperature range	–5 … +40 °C
Relative humidity	Up to 95%, without condensation

The conveyor system operates in a fully automatic mode and requires human intervention only in case of emergency and abnormal situations. As a result, it is necessary to include signaling and control devices located on the panels and along the conveyor line in the conveyor system.

Sound and light indicators are placed on each floor of the vertical conveyor and along the conveyor line in such a way as to provide sound and light notification

to all personnel involved in working with the conveyor system. It is also necessary to implement an emergency stop of the system if there is an immediate threat to human life and health, since its activation leads to an immediate stop of the system.

Fig. 13. General view of the selected Siemens SIMATIC HMI operator panel

Table 10

Main technical characteristics of the Siemens SIMATIC HMI operator panel

Characteristic	Value
Nominal supply voltage	24V DC
Сеть	Profinet
Built-in interface	USB-Host
Configuration languages	32
Availability of vector graphics	yes
Number of colors	65536
Data archiving	USB Stick
Protection class	IP20
Operating temperature range	–20 … 60 °C
Relative humidity	10…90 %, without condensation

During an emergency on the conveyor line, you must press any emergency stop button "Emergency stop". The Emergency stop buttons are located on the yellow push-button posts along the conveyor line, as well as on the control panel. The general appearance of the sound and light indicator and the emergency stop button "Emergency stop" is shown in Figure 14.

a) b)

Fig. 14. General view of the light and sound indicator and the emergency stop button "Emergency stop": a) Light and sound indicator; b) Button "Emergency stop"

Based on the selected equipment shown in Figures 3–8 and the diagram of the conveyor line for sorting pharmaceutical products (Fig. 1), the following plan for the placement of conveyor sections was developed, which is shown in Figure 15.

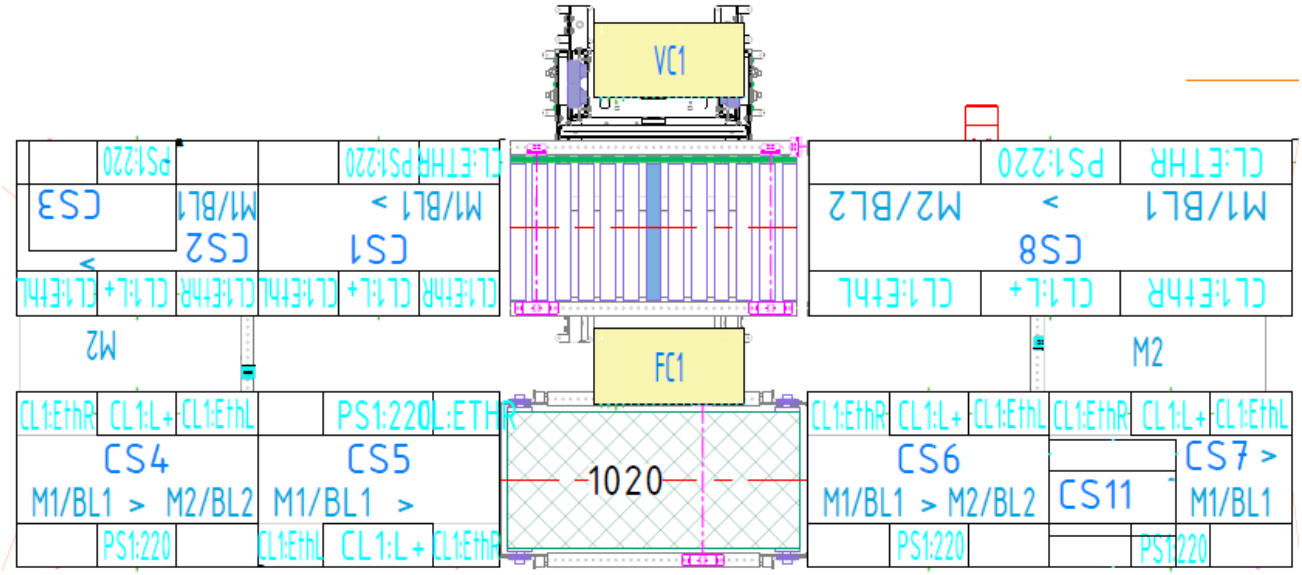

Fig. 15. Conveyor section layout plan

Based on the technical characteristics and specifications of the selected hardware modules for the implementation of the automated control system layout for the pharmaceutical conveyor sorting line, a functional connection diagram of the conveyor sections was developed, which is shown in Figure 16.

The electrical connection diagram of the PLC Siemens s7-1200 is shown in Figure 17.

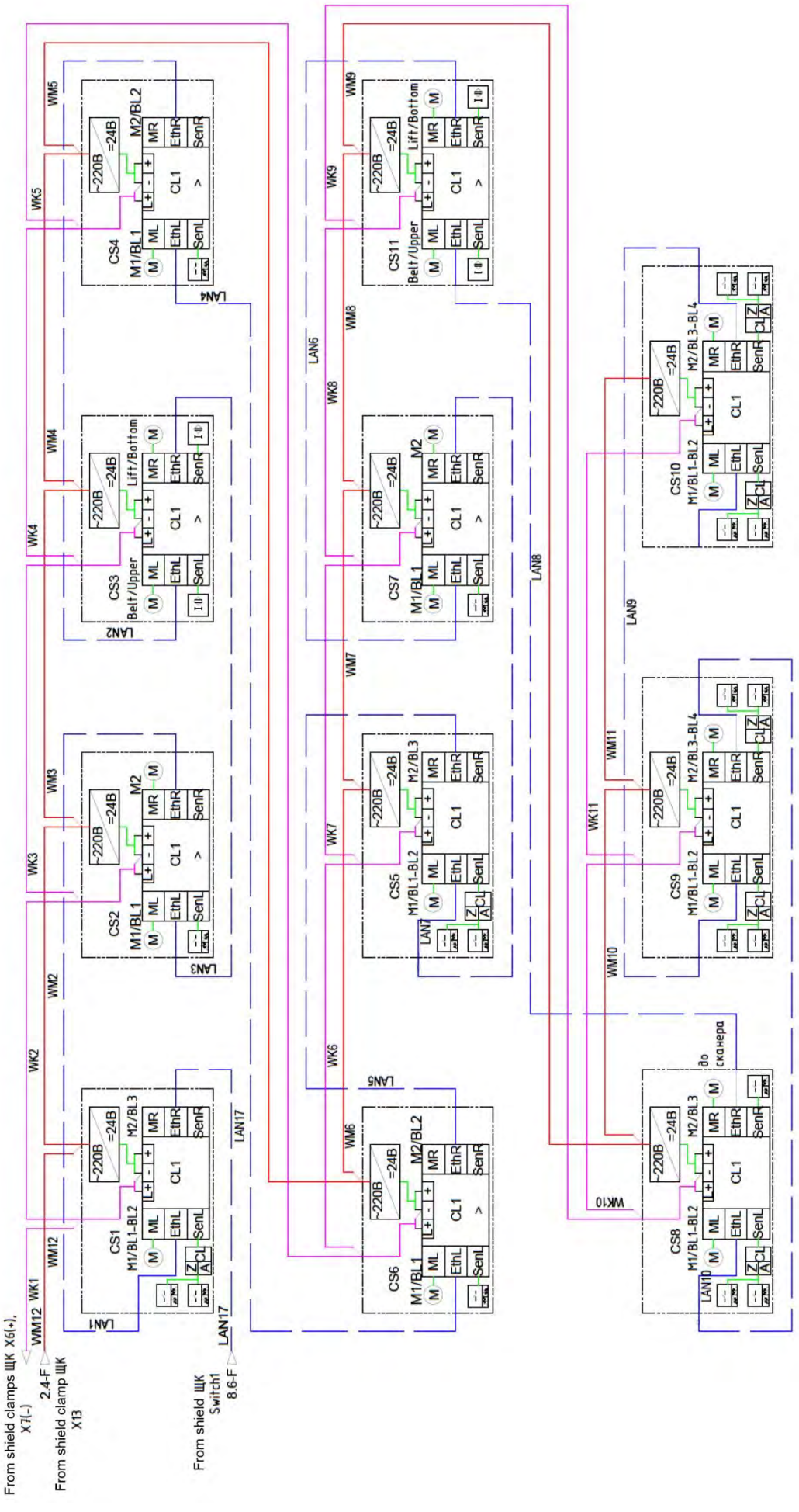

Fig. 16. Functional diagram of the conveyor sections connection

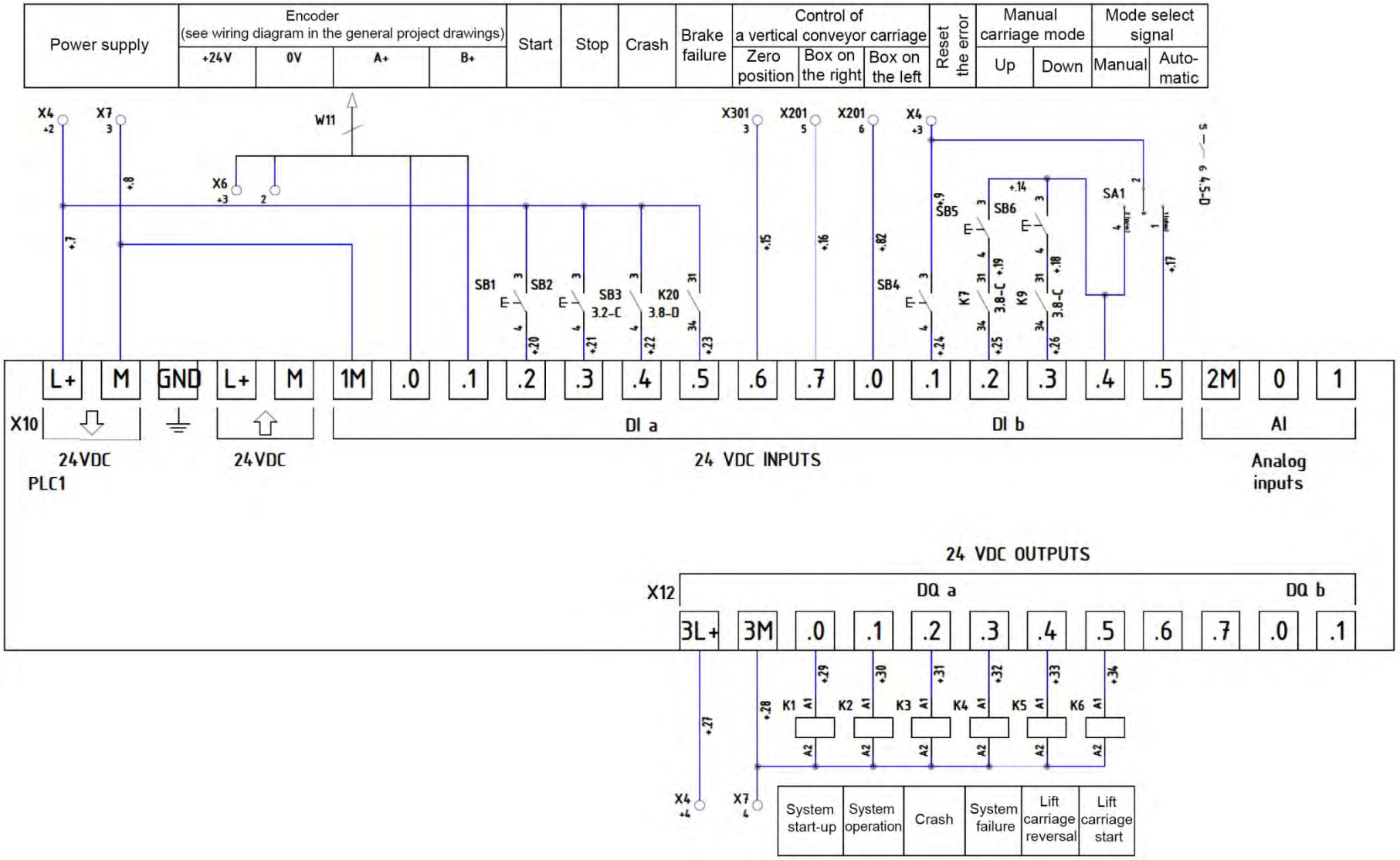

Fig. 17. Electrical connection diagram of PLC Siemens s7-1200

On the basis of the conducted work a model of a pharmaceutical conveyor line for sorting was assembled, implemented on the PLC Siemens s7-1200 control system. The general appearance of the model is presented in Figure 18.

a)

b)

c)

d)

Fig. 18. General view of the layout of the pharmaceutical conveyor line for sorting:
a) general view of the layout; b) type of tiers for sorting;
c) conveyor control system; d) vertical elevator in the general conveyor system

Conclusions

As a result of the conducted research and development presented in this work, important results were achieved in the field of creation of conveyor lines for sorting pharmaceutical products. The layout diagram of the line was developed and implemented taking into account the requirements for reliability and efficiency, which allowed to optimize the choice of supporting modules and ensure their interconnected operation. Particular attention was paid to the creation of a control system based on PLC Siemens S7-1200, which ensured a high level of automation and flexibility in managing the sorting process. The developed electrical circuit for

connecting the controller, the functional diagram for connecting the conveyor sections and the plan for their placement made it possible to create a complete and reliable system that meets modern standards in the pharmaceutical industry. Photos of the assembled layout confirmed the correctness of the adopted engineering solutions and their successful implementation. Thus, the work made a significant contribution to the development of automation technologies for sorting pharmaceutical products, which helps to increase the productivity and quality of production processes.

References

1. Nevliudov, I., Yevsieiev, V., Maksymova, S., Klymenko, O. (2023). Features of Wave Algorithm Application in Warehouse Logistics Transport Systems. Information systems in project and program managemen : Collective monograph edited by I. Linde – European University Press. Riga: ISMA, 2023. – P. 251–261.
2. Nevliudov, I.S., Yevsieiev, V.V., Maksymova, S.S., Omarov, A.O.M., Klymenko, O.M. (2023). Conveyor Belt Object Identification: Mathematical, Algorithmic, and Software Support. Applied Mathematics & Information Sciences: An International Journal. – 2023. – Vol. 17, No. 6. – P. 1073–1088.
3. Maksymova, S., Nevliudov, I., Yevsieiev, V., Klymenko, O., Vzhesniewski, M. (2023). Shuttle-based storage and retrieval system 3d model improvement and development. Journal of Natural Sciences and Technologies, 2(2), 232–237.
4. Nevliudov, I., Maksymova, S., Nevliudova, V., Vzhesniewski, M., Klymenko, O. (2023). Software development for small details production warehouse automated system. Scientific Collection «InterConf». – 2023. – P. 320–323.
5. Nevludov, I., Yevsieiev, V., Maksymova, S., Klymenko, O., Vzhesnievskyi, M. (2022). Analysis of Software Products for Simulation Modeling of the Operation of the System of Shuttles for Warehousing. Manufacturing & Mechatronic Systems 2022 : proceedings of the VIst International Conference, Kharkiv, October 21–22, 2022 : thesises of reports / [ed. by I. Sh. Nevlyudov (chief editor)]. – Kharkiv : [electronic version], 2022. – P. 24–26.
6. Nevliudov, I., Yevsieiev, V., Maksymova, S., Klymenko, O., (2023). Using Mecanum Wheels for Radio Shuttle. Multidisciplinary Journal of Science and Technology, 3(3), 182–187.
7. Nevliudov, I., Yevsieiev, V., Maksymova, S., Klymenko, O., (2023). Development of a Hardware Module for Programming Microcontrollers Based on the Cortex-M Architecture. Multidisciplinary Journal of Science and Technology, 3(3), 171–181.
8. Nevliudov, I., Maksymova, S., Klymenko, O., Bilousov, M. (2023). Development of a mobile robot prototype with an interactive control system. Системи управління, навігації та зв’язку. Збірник наукових праць, 3(73), 128–133.
9. Salawu, G., Bright, G., Onunka, C. (2020). Modelling and simulation of a conveyor belt system for optimal productivity. International Journal of Mechanical Engineering and Technology (IJMET), 1(11), 115–121.