Creating programmable logic control program for a storing station

LAB University of Applied Sciences
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Abstract

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Abstract

The automation is an industrial field in which the manufacturing process is implemented under controlling and following up by computer-aided application. The computer system demands a program to instruct the manufacturing system where programmable logic control (PLC) is a popular application in this industrial automation. Controlling an automatic system becomes simple with PLC because it instructs the system through a program written by standardized languages such as Ladder Diagram, Function Block Diagram, Sequential Function Charts, Instruction List, and Structured Text. Out of all language supporting PLC, Ladder Diagram is used much because it is easy to write sequences for automation. Thus, the purpose of this thesis is the programming for storing station controlled by PLC with Ladder diagram. Since disadvantages of laboratory's situation in pandemic, the model of storing station is built by SOLIDWORKS software to explain the construction of the station as well as necessary automatic equipment for controlling the process of storage. The PLC program is written by TIA portal with CPU S7-1500 to load to PLCSIM simulator which is used to check the operation of the PLC diagram. The result of thesis is that the PLC program of storing station was finished and checked by PLCSIM simulator. However, the assessment of PLC program in a storing station is the further research in a laboratory to adjust the technical parameters and construction of station conforming actual manufacturing environment.

Keywords

PLC, ladder diagram, storing station.

Contents

1 Introduction

Automation is the process of computer-aided application in manufacturing system to decrease the level of human involvement in working task. The process is executed via a collection of programmed instructions integrated with a control system that implements the instructions. An automation process required power to guide the process itself as well as control system operation. Automation is possible to applied in many areas, and it is the most used application in industrial manufacture. The automation is often referred to decrease human labour by using mechanical machines, so the aim of automation is the optimization of producing efficiency. The automation and control technologies are an important unit in a large production system.

To operate an automation process, a manufacturing system requires a program of instructions. The efficiency of production depends on the structure of its automation program which can include one or many steps during its work cycle. The automation system controls both manufacturing and supporting systems through transferring instructions from a controlling centre to targeting units of a production system. For instance, in material handling process, the automation is applied for the movement and storage of raw or secondary materials. The utility of automatic handling process helps to reduce labour cost since it decreases the time of movement of materials significantly. An importing system with conveyors and storing stations is the best solution for handling the input material in a flow manufacturing system. Conveyors with supporting sensors, in addition, are always used for the packing process of almost manufacturing factories because it reduces the time of package movement and production cost. Therefore, automation can support to improve manufacturing efficiency since it productively assists the logistic process in production activity.

In the machining or assembling processes, automatic systems are obligatory to operate the processes in a modern factory. An example for this machining operation is automatic turning process where a workpiece rotates with a stable spindle speed to ensure the good quality of products. The automation usually uses lathe machines with programs to control turning process. Furthermore, a robot arm is often utilized in assembling process such as car or motorcycle build where the instructions of robotic program are run continuously for machinery connection or painting surface.

2 Automation is the application of computer technology to make automatic in manufacturing process

Some applications in automation include computer-aided manufacturing (CAM) software, computer-aided design (CAD), and computer – integrated manufacturing (CIM). CAD and CAM are used to support the design and manufacturing of products.

There are 3 standard types of automation for manufacturing process.

- Programmable automation
- Fixed automation
- Flexible automation

Fixed automation equipment is a system containing process stations linked together for the progressive movement of work pieces. Programmable automation can adjust the process of product manufacture because it is controlled by computer programs. The process operation can be repeatedly every manufacturing cycles. The programmable automation is possible to reprogram and change equipment for distinct products. Flexible automation includes the features of fixed and programmable automation, which can produce distinct part types by process flexibility. This process is also controlled by programming in a computer system. (Groover 2019)

An automatic system contains three basic units including power, a program, and a control system (Figure 1).

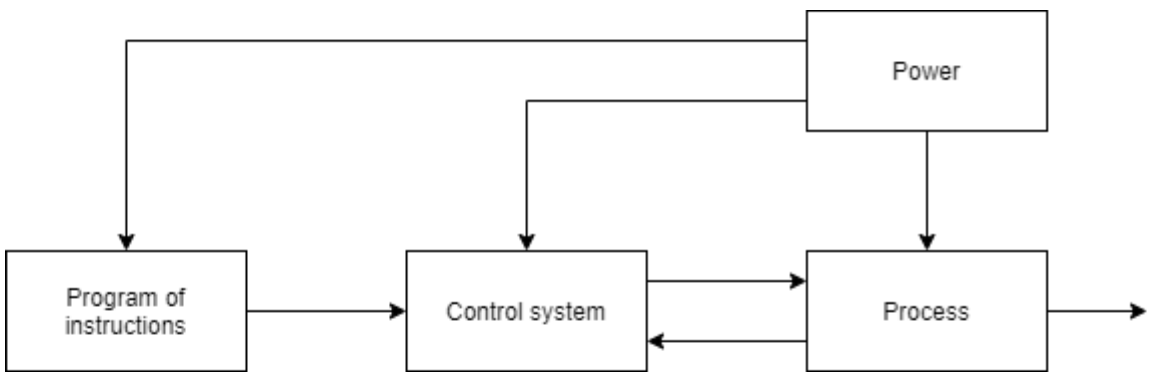

Figure 1. The organization of power supply

3 Power source of the automation process

In operation of an automation process, power is the most important component to supply for others in the same unit. Electricity is the popular source of power in automated system, which has many general benefits in manufacturing processes:

- Electric power is broadly profitable at inexpensive price.
- Electric power can be easily transferred to other energy types: hydraulic, thermal, mechanical, acoustic, light, and pneumatic.
- The flexibility of electric power is showed at its voltage. It can be used to implement functions such as signal and information transmission, and data storage.

Otherwise, the alternative power sources such as oil, petrol, atomic, solar, water, and wind are rarely used because of their inconvenience or expensive properties. (Zhao, Huo, Flynn & Yeung 2008)

In industrial manufacture, the manufacturing operation is often called by the term “process” that includes all stages of production. The power requirements for manufacturing processes are the popular types of power listed in the below table: (Groover 2019)

Table 1. Types of supplying power for manufacturing process

Process	**Power type**	**Executing process**
Welding	Thermal	Thermal energy is often used to merge metal parts at contact surfaces.
Electric discharge machining	Electrical	A tool using electrode to remove metal from workpiece by discharging operation.
Casting	Thermal	Thermal energy is used to melt metal to pour into a mold
Forging	Mechanical	A workpiece is formed between facing dies by applying pressure force.

There are several types of energies which are utilized for various manufacturing processes (Table 1). Generally, electricity is a common source to supply for each manufacturing operation.

Furthermore, power is also a necessary requirement for the other handling functions of material, such as loading and transporting materials.

In loading and unloading the work piece, most of the processes recorded in Table 1 are performed on distinct parts, so these parts need to be transported into the right orientation and location in a continuous process. That movement also requires power to operate via function controller, and the work piece have to be removed at the end of process. If the removing process is finished automatically, it requires mechanized energies, too. In case of manually or semi-automated process, the movement of work piece to correct position or location is often accomplished by human power.

In manufacturing process, the work piece requires to transfer between operations along with loading and unloading operations. The horizontal movement of work piece between operations usually requires some kind of devices or transportation equipment, such as trucks and similar vehicles. The equipment needs power like fossil fuel or electricity to horizontally moving material. In addition, the equipment for lifting and lowering material are also used for vertical transportation requirement in manufacturing process. The devices adapt the demand of laterally or vertically material packages in a narrow area of width and height. Devices like trucks or tractors can also move easily work piece from one location to the other in a small manufacturing space. The demanding power of the vertically movement devices is popular fossil fuel or electricity.

The basic power requirement for automation is power source for the following components:

- Controller unit: industrial manufacturing controllers are followed up by computers, which demand electrical power to instruct work task commands via programmed instructions, to complete control calculations, and to accomplish the commands by transferring the proper information or data to targeting actuators.

- Targeting devices: the programmed instructions from a controller unit are admitted by devices known as actuators, such as switches and motors. The automatic central unit commonly transmits instructions through low-voltage electric signals.

The actuators also demand more power to execute commands sent by the automatic controller, and the amplified control signals to supply the power level for the targeting actuators.

- Data and information transmission: the central unit collects input data to execute algorithms. Moreover, some automatic system requires the record of the process performance and quality of product legally. Thus, power is needed for data acquirement and functional record. (Koza, Bennett, Andre, Keane & Dunlap 1997)

4 Programmable logic controller

4.1 Overview of programmable logic controller (PLC)

PLC operates mechanical devices by using computer. PLC is engineered in manufacturing factory where the implementation of machines makes mechanical vibration and noise. PLC controls electromechanical systems by programmed sequential logic instructions with suitable programming languages. Any computer can communicate external devices through input and output interfaces. However, several disadvantages are instantly faced when using a standard microcomputer to control industrial mechanical devices. The first drawback is that most computers are easily damaged when run in factory environment because they are not often hardened design for industrial operation. Therefore, factories need to install special microcomputers which must be hardened for industrial purpose. The second disadvantage is that the I/O interfaces of standard microcomputers is never designed to be tolerable the voltages and currents of PLC's electric transmission. An external device, such as a relay, must be controlled in which a circuit at 120 volts, so that the computer output port must be far away from electricity to keep away from destruction.

Eventually, microcomputers generally provide programming abilities, containing the reading function of some languages to compile code. When semiconductor logic functions may be applied to control the manufacturing operation, the languages are obligatory to be standardize for programming purpose. Languages without standardization may be difficult for engineers to write programs or solve code problems. The language used in factory control should be relay logic ladder diagram by which technicians can launch the programmable controller with spending less time for training.

During late 1960s, control systems in manufacturing factory required a conveyor to build up a chain of contacts and relays that carried out on/off actions in a determined logical sequence to control the equipment work cycles. These control panels used significant space and demanded a lot of working time to change the manufacturing system when reconfiguring the factory work cycle. To decrease the cost of equipment and time, PLC was used to create programs which execute Boolean equations saved in the memory of the PLC. The PLC system performed the execution relays through the hard-wired contacts, so PLC help factories to reduce the cost of hardware and rewiring problem with its reprogramming ability.

4.2 PLC Hardware

A microcomputer must contain basic components including a microprocessor, input-output interface (I/O), memory, and a programming interface. Memory hold on programs by its battery to maintain program in the course of power loss. The binary signals are often read as an on/off (0.1) situation in memory via single bit contacts. The microcomputer needs input/output circuits to keep safe these I/O from damage by isolating the voltages from PLC processor.

Some PLC systems can control external devices through analog ports and other advanced applications. Generally, it means that the PLC systems use "analog modules" which have capability of A/D and D/A converters designed to communicate with the PLC interface. Each analog channel can communicate with the processor by assigning signals in memory location of the processor. (Boucher 2013)

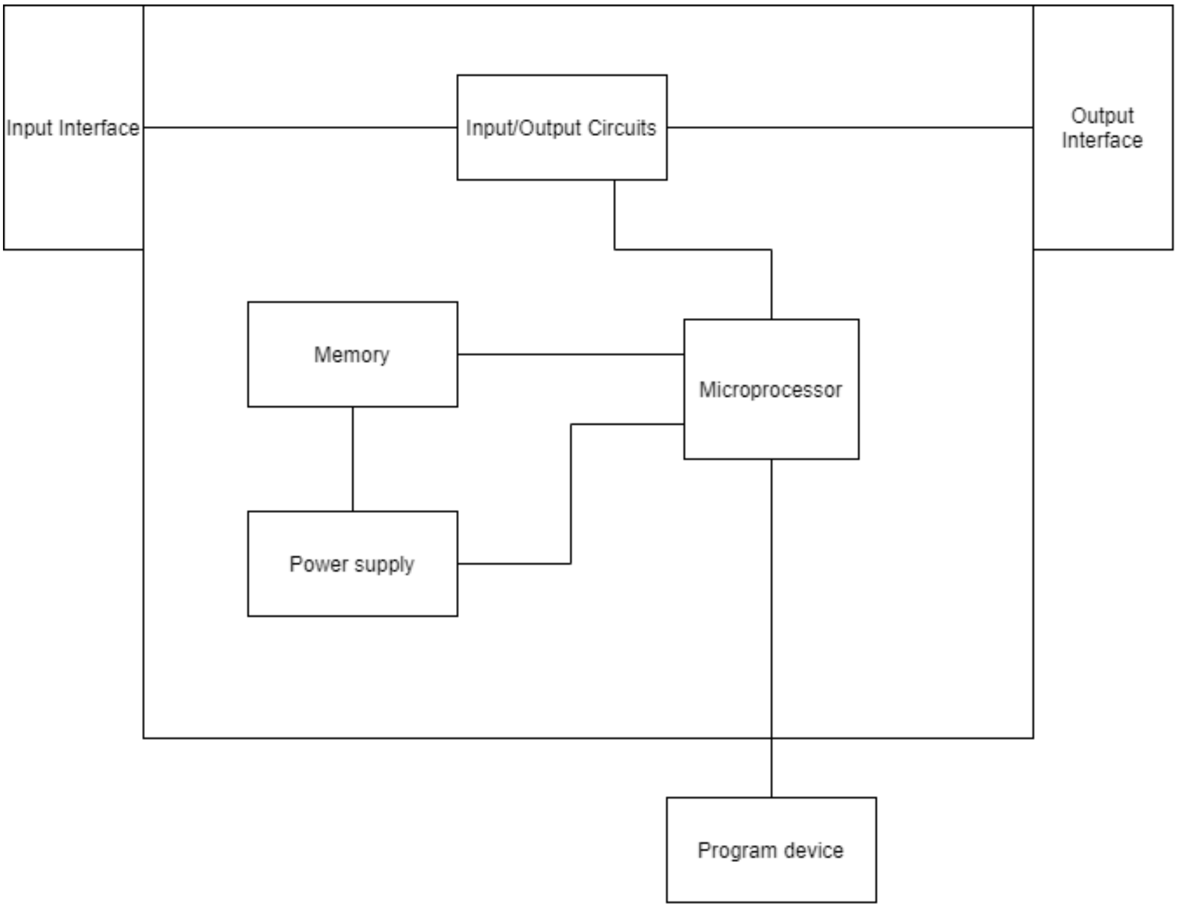

Figure 2. The organization of PLC central unit processor

PLCs have common ability containing independent self-programs to control activities in a factory. The currently interested tendency is that factories are often built with multiple PLCs which transfer information and instructions together to get more efficiency for comprehensive manufacturing control. Thus, modern PLCs are usually installed with local area network port to have communications capabilities.

4.3 Relay circuits and ladder diagrams

The circuit diagram illustrated in below figure is to control a motor using switches (A1 and A2) (Figure 3). A1 and A2 are contact push buttons at normally closed and opened conditions, sequentially. It means that the circuit open at A1 when A1 is pressed, whereas the circuit closes again at the normal situation of A1. The circuit is closed at the A2 point when A2 is pressed, and vice versa.

Moreover, contact C and coil C run simultaneously. Coil C, which contain a core in an electromagnet, is a relay. The core of coil C moves in order to close the contact C when the relay is charged energy. Contact C keeps closed situation until the energy in the coil is shut off, the contact then will open again.

However, a different format of circuit diagram called ladder logic diagram is often applied in factory control. Figure 4 presents an example of a ladder diagram. The vertical columns of the ladder illustrate power source, such as voltage differential, that supplies power to the circuit through the horizontal ladder.

The coil C is charged energy when A1 * (A2 + C) is true. It means that A1 and A2 are simultaneously closed, then the coil C is turned on (Figure 4). The motor M is run by the energized coil C because the coil C charged energy may turn on the contact C. Because the contact C is activated before the M, M = A1*(A2 + C) is an incorrect programming statement. The M is run after it received electrical signal from the contact C (Boucher 2013).

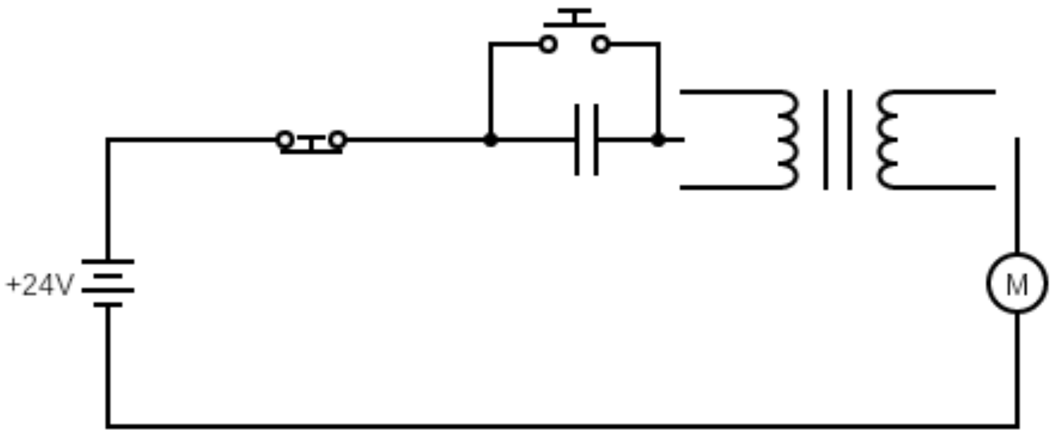

Figure 3. A circuit diagram for motor M

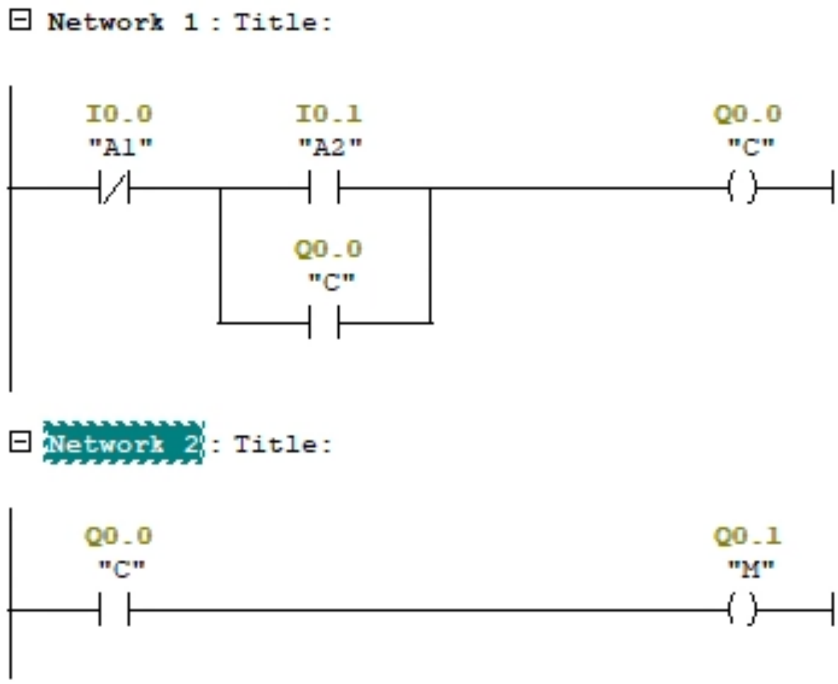

Figure 4. Logic ladder diagram of the circuit in Fig. 3

By IEC61131-3 standard, PLC controller is programmed by languages, such as ladder diagram, instruction list, structural text, and block function diagram to operate external devices. These languages result equal consequence as the language of sequential function chart diagram (SFC). SFC language also needs a particular programming environment of PLC. Thus, SFC diagrams are unusable for microcontrollers because the small controllers do not contain programming environments.

4.4 Sequential control using PLCs

The programming of PLC systems can adopt the ladder logic concepts. The symbols of logic concepts (Figure 5) are simplified and determined by PLC manufactures, but this difference is not significant.

Generally, rounded brackets represent energized components, which includes internally or externally controlled components. The internally controlled components may be coils while externally controlled outputs are often motor, lamps, or solenoids. The specific devices are recognized by the number or the series of letter-number combination.

In below figure of basic PLC symbols, the relay is controlled by bits declared by the code B10 while the normally open contact is controlled by bit B10 (Figure 5). The ladder diagram needs the bit number indicated by programmer to control components. Every bit number is stored in memory address by PLC manufacturer. The external inputs are indicated by I1 and I2 to determine as signals 1 and 2, accordingly. Therefore, PLC reads input bit of 1 or 0 when the contacts I1 or I2 are closed. These input devices are activated through PLC program to be enable or disable output objects. The output devices must be set or reset to have a communication with input PLC components. In the special case, an output device is set either SET or RESET, designated by S and R inside the rounded parentheses. The “SET” output is energized even if the switch is open. The energy in output remains until “RESET” is enable. Thus, the latch and unlatch output exist side by side in the same system. (Miroslaw 2003)

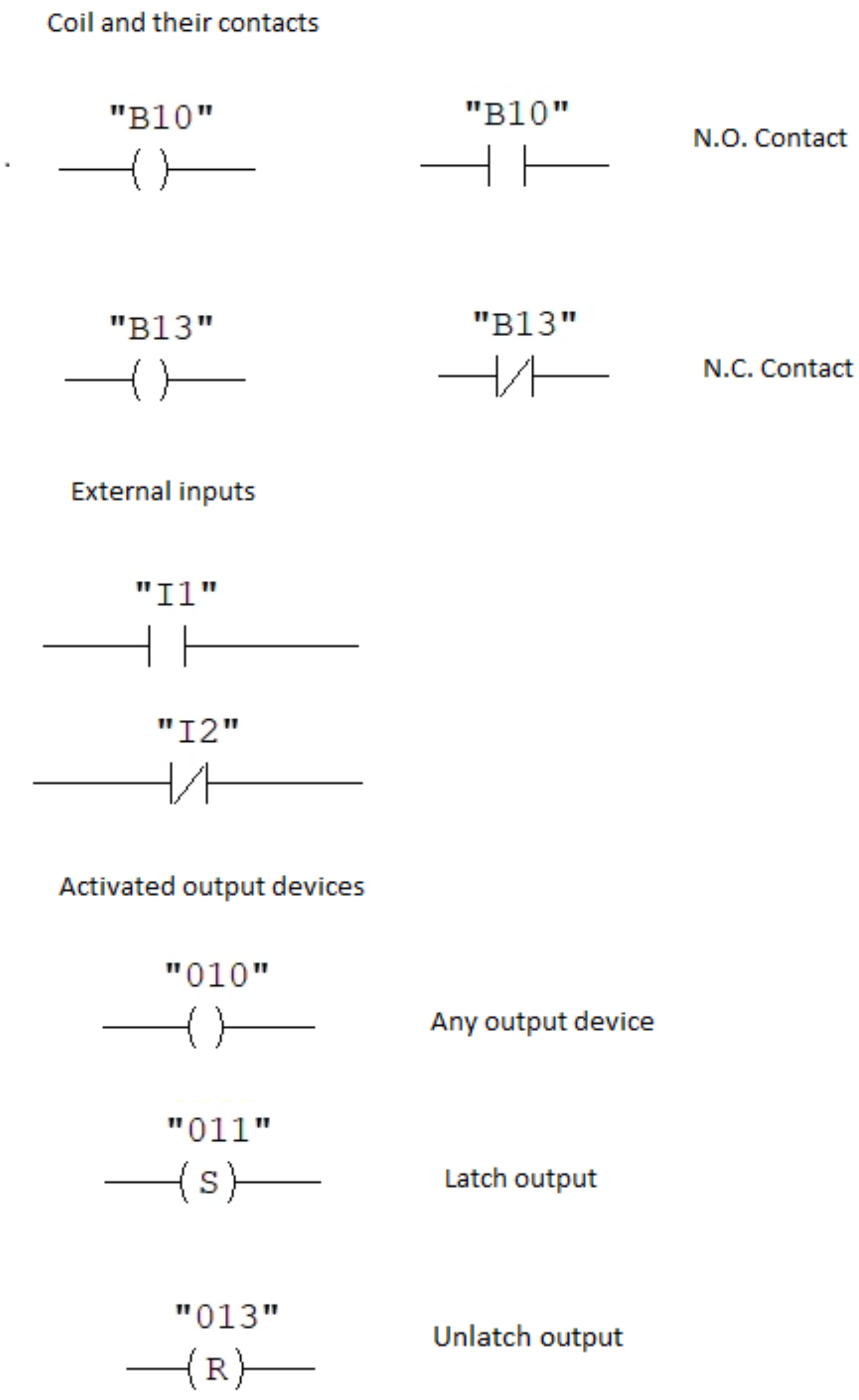

Figure 5. The popular basic symbols of PLC programming

5 STEP 7 station

5.1 S7-1200 station

The SIMATIC S7-1200 (S7-1200) system includes the four controllers such as S7-1211C, S7-1212C, S7-1214C, and S7-1215C. In these systems, data can be interchanged with each other via platforms to configure and program the devices, such as SIMATIC HMI Basic Panels, or SIMATIC NET.

The SIMATIC S7-1200 is controller systems which are programmable logic controllers (PLC) applied as automation systems for low range industrial control.

SIMATIC NET can connect all SIMATIC stations and transfer data together. PROFINET port on the SIMATIC S7-1200 is used to connect stations, such as PLC, HMI, or controller devices to exchange data via the Ethernet network.

The STEP 7 is the programming software developed by SIEMEN to provide programming environment for an automation system called Totally Integrated Automation (TIA). TIA is used to configure hardware, create programs, and manage data. The SIMATIC components are configured and programmed via STEP 7 software. The TIA has the central user interface called Tia Portal used as a tool to manage and control automation system.

SIMATIC S7-1200 is used as a controller system in automatic industrial factory where its manufacturing scale is low or medium. The station central processing unit (CPU) of S7-1200 includes the operating system and user applications saved in local memory. The user programs are ready to execute with rapid accessing action.

The S7-1200 consists of three basic components including CPU, signal, and communication modules. The CPU, the most important component, can connect input/output channels (I/O) through a bus system. Basing on the support ability of CPU, the station can be extended by added up to eight signal modules to increase I/O channels. The CPU of station can connect to programming devices, such as SIMATIC or HMI, to load programs or instructions. By owning ability to handle automatic algorithms, S7-1200 is able to operate complex control system. Furthermore, the data and firmware of S7-1200 can be loaded and updated from an external memory called SIMATIC Memory Card. (Berger 2016)

5.1.1 CPU modules

There are four types of CPU of S7-1200, which are 1211, 1212, 1214, and 1215. The CPU versions of S7-1200 are different by the power supply for digital input, output, and onboard operation. This difference is distinguished by series like DC/DC/RLY, DC/DC/DC, or AC/DC/RLY in which the first item mentions the input power supply with DC meaning 24 V direct current electronic as well as AC meaning 120/230 V alternating current. The middle item is the voltage of the onboard digital input while the last item is the kind of digital outputs. The mean of RLY is direct current or alternating current with their voltage up to 30 V or 250 V, respectively. The S7 -1200 CPU versions is also different by the ability of supply voltage, the number of input-output ports, or memory size.

The CPU can be connected through connecting port with RJ45 socket. The standard Ethernet cable can be used to transfer data between CPU and external devices with the transmission rate of 10 or 100 Mbit/s. There are some standards for Ethernet connection, like Transmission Control Protocol (TCP), User Datagram Protocol (UDP), or ISO Transport over TCP (ISO-on-TCP).

5.1.2 Signal modules (SM)

The signal modules consist of two kinds of signal transportation such as digital I/O and analog I/O modules. The number of signal modules in the S7-1200 station depends on the type of CPU with up to eight I/O modules plugged on the CPU.

Digital input modules are responsible to convert external binary signals of 24V DC or 125/230V AC into internal signals. The input signals are also delayed by filter on transmission process. Some CPUs can support the high-speed input channels to control the signal transmission with high speed. This process is known as the integral high-speed counter with its frequencies of 100 kHz and up to 200 kHz. Furthermore, digital outputs are the contradictory process of input because they transform internal signals into resulting information represented by the voltages and the current in data transmission process. The frequency of digital output module is similar with that of input.

Meanwhile, analog input modules transform the analog variables in some voltage range ± 1.25 V, ± 2.5 V, ± 5 V, ±10 V and current 0 or 4 to 20 mA. The numerical value of analog signal from –27 648 to +27 648. The speed of analog transmission is around 10, 50, 60, and 400 Hz and its response time is about 4, 18, 22, and 100ms. Moreover, analog output signals transform digital values to analog signals in the transmission process.

5.1.3 Communication modules (CM)

The communication modules support the connection and data transport of CPU. There are four popular types of communication modules used in S7-1200 station such as Point-to-point communication, PROFIBUS DP, actuator/sensor interface, and GPRS transmission. Point-to-point connection supports fast data transfer through RS232 and RS422/485 interface. Profibus DP modules allow the connection of S7-1200 to programming devices or other station with high-speed transmission of up to 12 Mbit/s. GPRS transmission supports the communication of S7-1200 to mobile phone, or other stations through wireless transmission with the rate of 86 Kbit/s download and 43 Kbit/s upload. (Berger 2013)

5.2 S7-1500 station components.

An S7-1500 station can consist of several components such as rack, power supply, central processing unit, Input/output modules, technology modules, communication modules and one rack with up to 32 slots.

5.2.1 CPU modules

S7-1500 CPUs are different by specific versions, but they have the general control functions of a PLC CPU where it is possible to implement binary logic operation or floating-point arithmetic. CPU also contains PROFIBUS and PROFINET interface to connect to other devices. All CPUs use TIA Portal of STEP 7 to program and configurate the system.

5.2.2 Signal modules

Signal modules in the S7-1500 station are responsible to transfer signal from CPU to external devices or process systems. Signal modules are possible digital or analog input/output modules.

Digital input modules are used to process binary logical signal presented by voltage difference from 24 to 230 V for DC or AC, respectively. The size of digital input modules is either two or four bytes correlating with 16 or 32 positions of input signals. Otherwise, digital output modules are port connection between CPU and other devices. Amplified digital signals are sent to external machines through output modules by current and voltages ranges.

Analog input modules have ability to convert digital values into analog measured variables. The analog input modules can contain 4 or 8 channels to process input signals with the size of 8 or 16 bytes. The analog output modules transfer analog setpoint to actuator with a current value in the range of -20 to +20 mA or a voltage value in the range -10 to +10 V. (Berger 2017)

6 Actuators and sensors

6.1 Sensors

Sensors play an important role in measurement input signal to transfer to electronic signal in an automatic system. Sensors are also installed to follow up the status of the system during its operating process. The difference of sensors is characterized by their various physical properties and functions of signal transfer. The transfer function of sensors may be illustrated by a diagram presenting the correlation between the physical input and electronic output signal. Some sensors, however, may not detect the small change of input signal, in case their sensitiveness is low. The sensitiveness of sensor, therefore, is an important ratio between the change of physical input signal and output voltage. The sensitivity parameter is described by either the change of input value to outcome a certain output change or the output value resulted by a standardized input change. (Elsevier 2005)

Although, sensors are able to be highly or lowly sensitive, it always exists dynamic range for sensors. Dynamic range is a range of input signal that sensors can detect to transfer to electronic signal. It means sensors cannot detect signal outside their dynamic range. In addition, another parameter presenting the sensor's ability is the difference between the measured and true value. This parameter called by accuracy is important for the recognition of the object's shape or material. For example, the general activity of a capacitive sensor is based on the transmission of electric flux on sensor face. The internal layout of sensor contains four components including probe, oscillator, filter, and output circuit (Figure 7). The presence of object will drive the electric flux from central electrode to second electrode (Figure 8). The electric flux caused by object will increase capacitance that creates input signal for the internal process in sensor. The input signal is filtered for output circuit to produce output value. Otherwise, the capacitance will decrease when the object is taken away as the electric flux is interrupted.

Figure 6. A proximity sensor

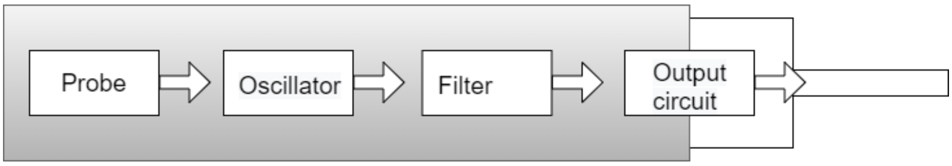

Figure 7. Internal layout of sensor

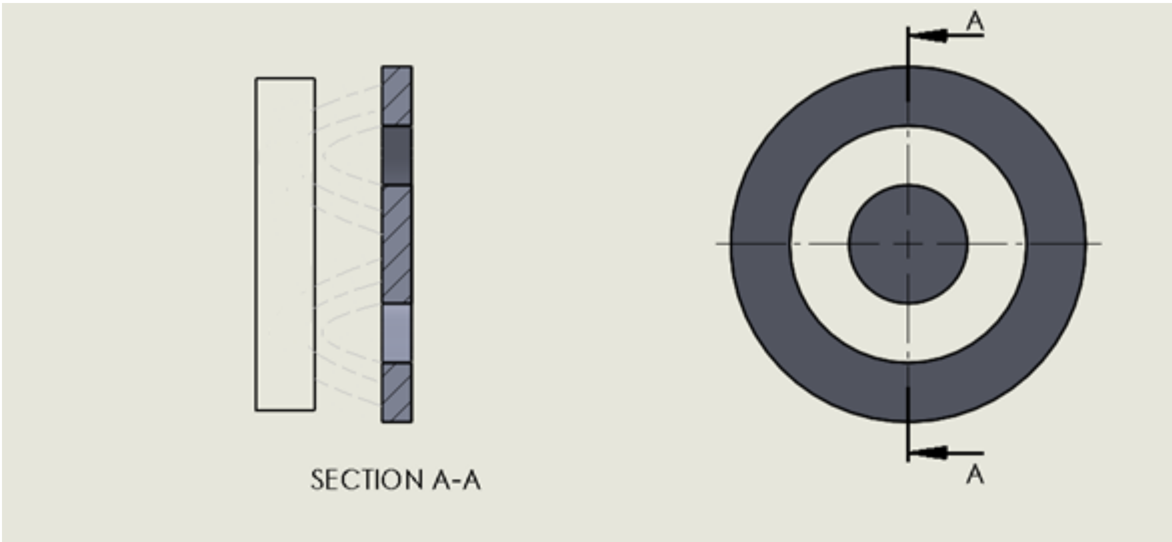

Figure 8. Presence of an object in front of sensor face

According to the difference of basic physical mechanism, sensors are classified into various types such as capacitive, inductive, resistive, or magnetic sensors based on the changing electrical capacitance, inductance, resistance, or magnetic of conductor material. Moreover, another type of sensor called photoelectric sensor or optical sensor uses the occurrence of light to detect the presence or distance of objects. Depending on the kind of output electric value including the change of resistance, voltage, or current, optical sensors are also classified into several types such as photoconductive, photovoltaics, or photodiodes. In popular optical sensing system, the light is always transmitted from the emitter to the receiver through a medium which is often air (Figure 9). The input signal changes when the light is interrupted by an object presenting in the middle medium, so the sensor will be activated when there is no signal coming to the receiver.

Figure 9. Organization of optical sensing system

6.2 Cylinders

The ordinary pneumatic cylinder moves by the motion of its piston and rod gathering to transform the compressed air flow kept in cylinder into linear movement. The mechanically stable material such as cast iron, aluminium, steel, and bronze, is applied to construct the cast of cylinder sleeve which is supported by a sleeve cover. Polished stainless steel or nickel are suitable materials to construct piston rob because of their strength while pure polytetrafluoroethylene (PTFE), nylon, vesconite, and acetal are used to make the rod bearings. PTFE has properties to become a perfect material for rob slide ring. To prohibit dirty particles pervading into pneumatic cylinder, a scraper ring made of specific materials owning wear-resistant and durable properties is installed into cylinder. The scraper ring integrates one lip to solve the friction problem in the motion of piston. In general, stainless steel is often utilized to construct cylinder components for anti-corrosion and clean purpose.

In addition, a pneumatic cylinder is also equipped seals produced by rubber to assure the stable of pressure inside cylinder. There are two types of seals which are static and dynamic seals. A static seal is often an O-ring located between two immovable components, while a dynamic seal is equipped between movable parts to avoid the leakage by relative movement.

A thermoplastic elastomer derived from polyurethane (PUR) is applied to produce standard pneumatic components due to its good mineral oil resistance, perfect elasticity as well as rapid molding injection whereas its hydrophilic properties are disadvantages for PUR material. Furthermore, PUR has properties against metal, so it is a good material to use in pneumatic durably. The stability of PUR requires temperature range between −35 and +120°C to operate well.

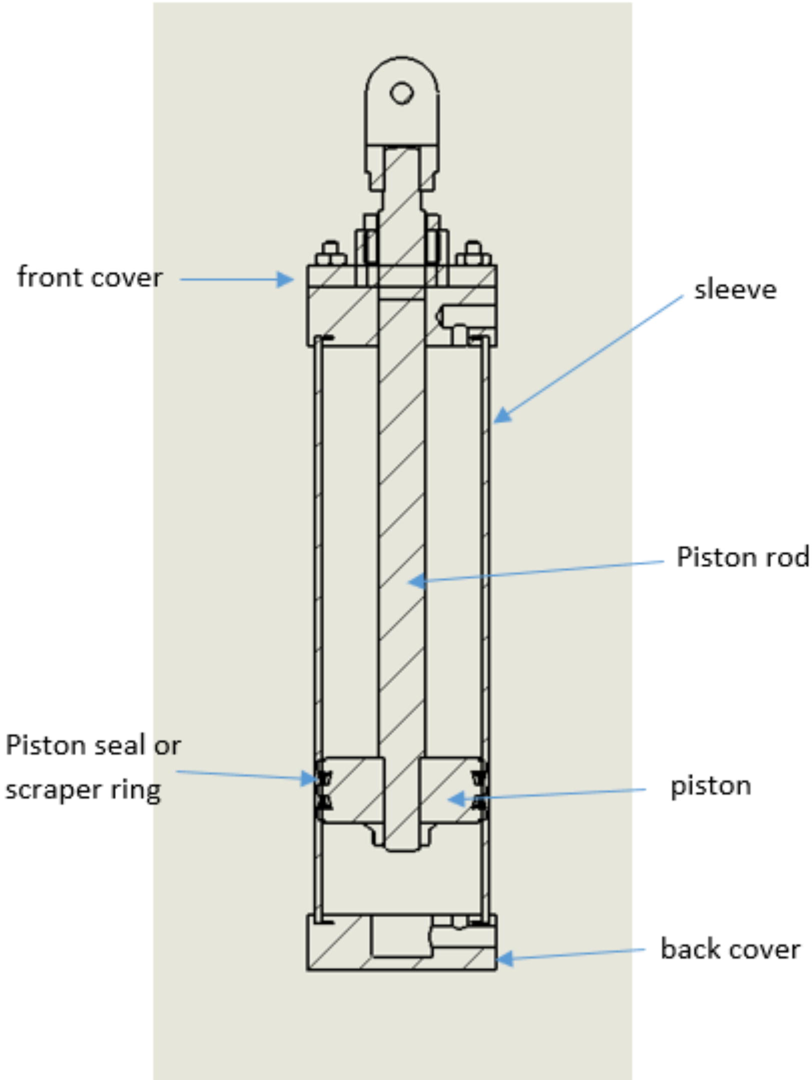

Figure 10. Pneumatic cylinder structure

Other materials owning similar properties with PUR are acrylonitrile-butadiene rubbers (NBR) utilized to produce static or dynamic seals. If NBRs are manufactured basing on accurate formula and process, they will present advantages such as the resistance to non-water liquids or mineral oils and fuels, aging stability, low gas permeability, and good abrasion resistance. The optimal temperature range for the stability of NBR is around from 20 to 80°C. Fluorocarbon polymers are also alternative compounds to use for pneumatic cylinder because of their suitable chemical and physical properties. Fluorocarbon works well in the temperature range -30 to +200°C. PTFE is normally applied to use as dynamic seals since its extreme wear resistance and low coefficient of friction. (Krivts & Krejnin 2006)

To obtain a perfect pneumatic cylinder with good qualities such as lightweight, and high efficiency, manufacturers make an effort to get below goals:

- Assuring cylinder pressure stability in operating process by excellent sealing.
- Decreasing friction and adhesiveness
- Warranting a long working time of cylinder
- Avoiding leakage.

6.3 Stepper motors

Stepper motors are attractively used in automation because they can be controlled by computers through instructive pulse transmitted from oscillator. A stepper motor basically consists of two components including a fixed stator and a rotatable rotor. The stator is often electromagnetic parts which attract the poles or teeth of rotor to make rotative motion. Otherwise, the rotor is either a magnet or a steel part. The pulse from the oscillator controlled by the computer identifies the turning angle of the rotor. Thus, the cycle of rotor's rotation is divided into a number of steps based on the turning angle.

Stepper motors are incremental-drive actuators which are distinguished from continuous-drive actuators in mechanics. Since the full rotation of a rotor consists of several steps, the status of the rotor can be determined by itself without receiving any signal from sensors. Stepper motors are classified into three types such as variable reluctance (VR), permanent magnet (PM), and hybrid synchronous stepper. The principal construction of PM stepper motor (Figure 11) consists of a two-electromagnetic rotor attracted by two permanent magnetic poles on the stator. The movement of PM rotor has three status which are clockwise (CW), counter-clockwise (CCW) rotation, and stop. VR motor (Figure 12) includes four-teeth steel rotor and magnetic stators. The operation of VR motor bases on the attraction of the teeth on the rotor to magnetized poles on the stator. Furthermore, the hybrid stepper motor (Figure 13) includes both the magnetic rotor and stators. The rotor of hybrid motor also has teeth to attract magnets of stators. Since the magnetic potential between the rotor and the stator in hybrid motor is strong, the hybrid motor works with superior performance and high efficiency. (Chirikjian & Stein 1999)

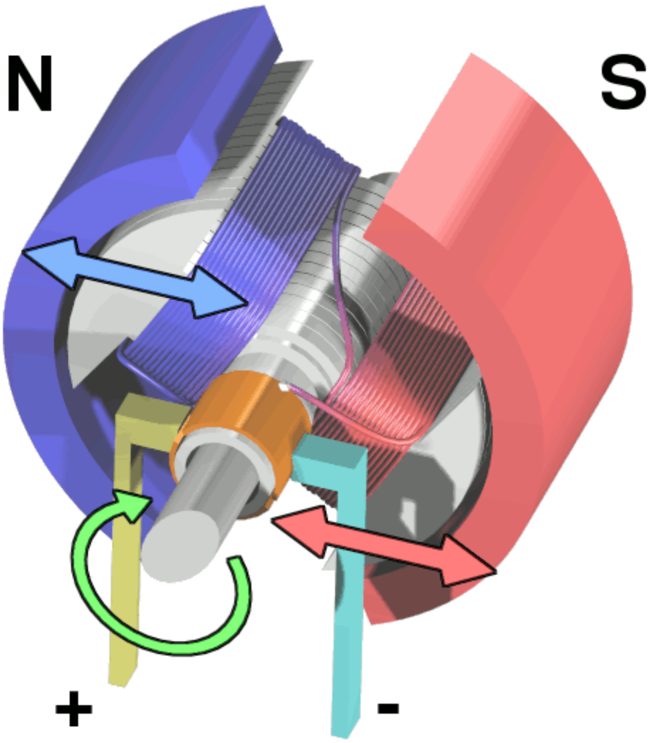

Figure 11. Permanent magnet (PM) motor (Wapcaplet 2004)

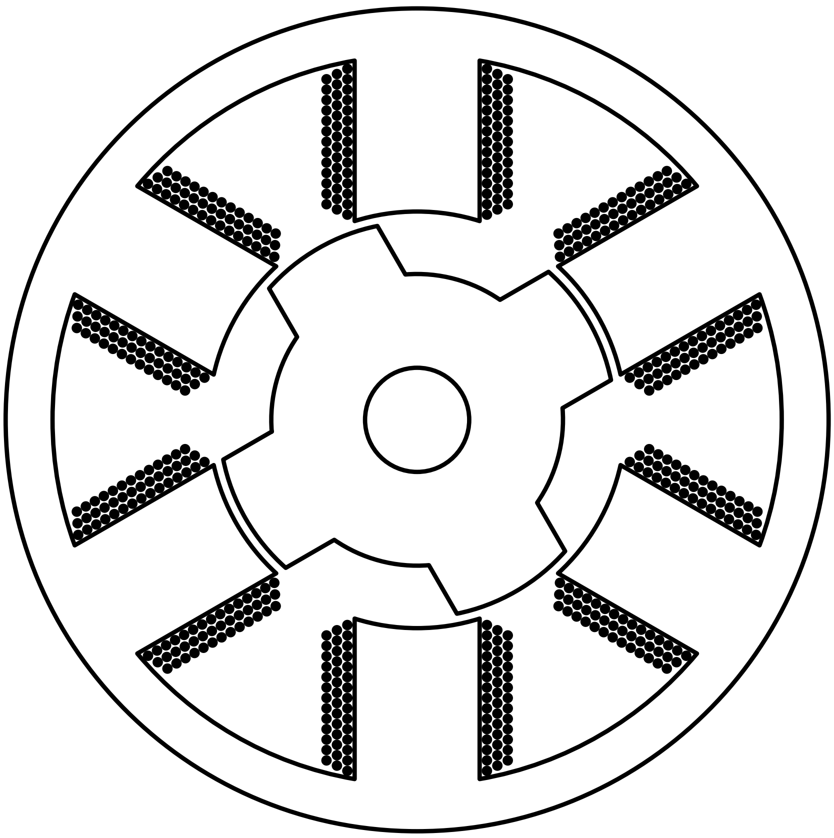

Figure 12. Variable reluctance (VR) motor (Senf 2015)

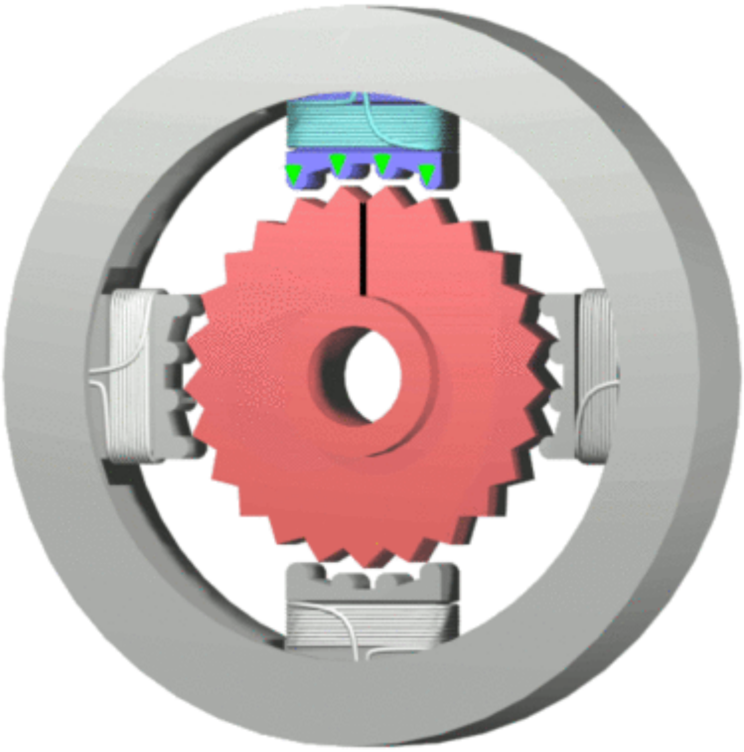

Figure 13. Hybrid synchronous stepper motor (Wapcaplet 2010)

7 Method

7.1 The programming controlling storing station

This thesis is focused on the build of PLC sequence for the automatic storing station, so the structure of hardware is chosen flexibly. To describe the operation of the store, I use the SOLIDWORK software to illustrate the simple 3D-model of station and PLCSIM V15.1 to explain the result of the PLC program. The program of the station is written by ladder logic language via TIA Portal to be easily connect to PLCSIM simulator.

The storing station is a part of an automatic warehouse to manage items by first in first out procedure (FIFO). The process demands the twenty of items stored on shelves from position 1 to 20 sequentially, while items must be taken out from position 20 to 1 automatically. The PLC program ensures that the sequence of instruction smoothly runs during operating process including storing and leaving processes.

The storing process begins after the power of station and start conveyor buttons are on, then an item will be put on the conveyor. The sensor C0 at the initial conveyor position is activated, so the conveyor runs to bring the item toward the middle of the conveyor until sensor C1 is activated and the conveyor then is paused.

Otherwise, the arm moves its initial position where both sensor A0 and B0 activated when the power of station is on. When the sensor C1 is on the first time, the memory word is declared by 1, the arm is let down until the K0 is on. At this position, the gripper closes to hold the items, then the arm is lifted to position 1 to prepare for bringing the item onto the right first position. At the position 1, the cylinder extends, then the gripper opens to leave the item onto rack. After that, the cylinder is retracted to return to the initial status of the arm.

When the next item is put on the conveyor at initial position, it comes to the middle position of conveyor to activate the C1 declaring the value of 2 on memory word and pause conveyor. The item is picked up to move to the position 2 on the rack. The similar process will run from item 3 to 20 to fill all racks of the storing station. The next items cannot activate the conveyor when the station is full.

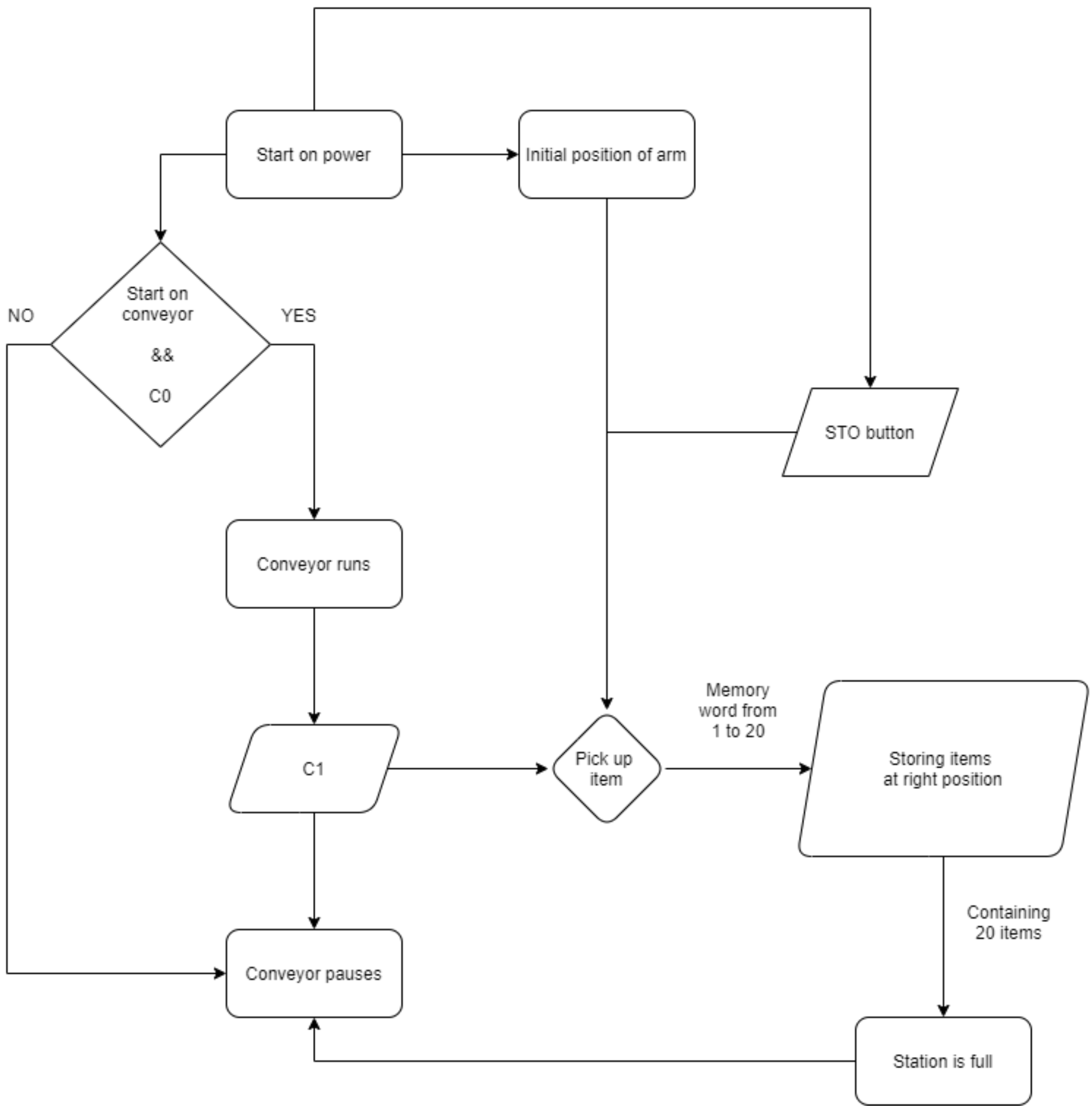

Figure 14. Flow chart of sequential program for storing operation

The leaving item process will be launch after the storing station is full and the LEA button is turn on. The memory word stores the value of 20 directing the arm to go to position 20 for picking up the item. The next process is the extension of the cylinder to bring the gripper toward the item on rack, followed by closed gripper to keep the item. After holding the item, the arm will retract its cylinder to move the item onto the conveyor. The conveyor will bring the item toward the end location for moving it out of the station. The leaving process will continue from item 20 to 1 sequentially until the station is empty.

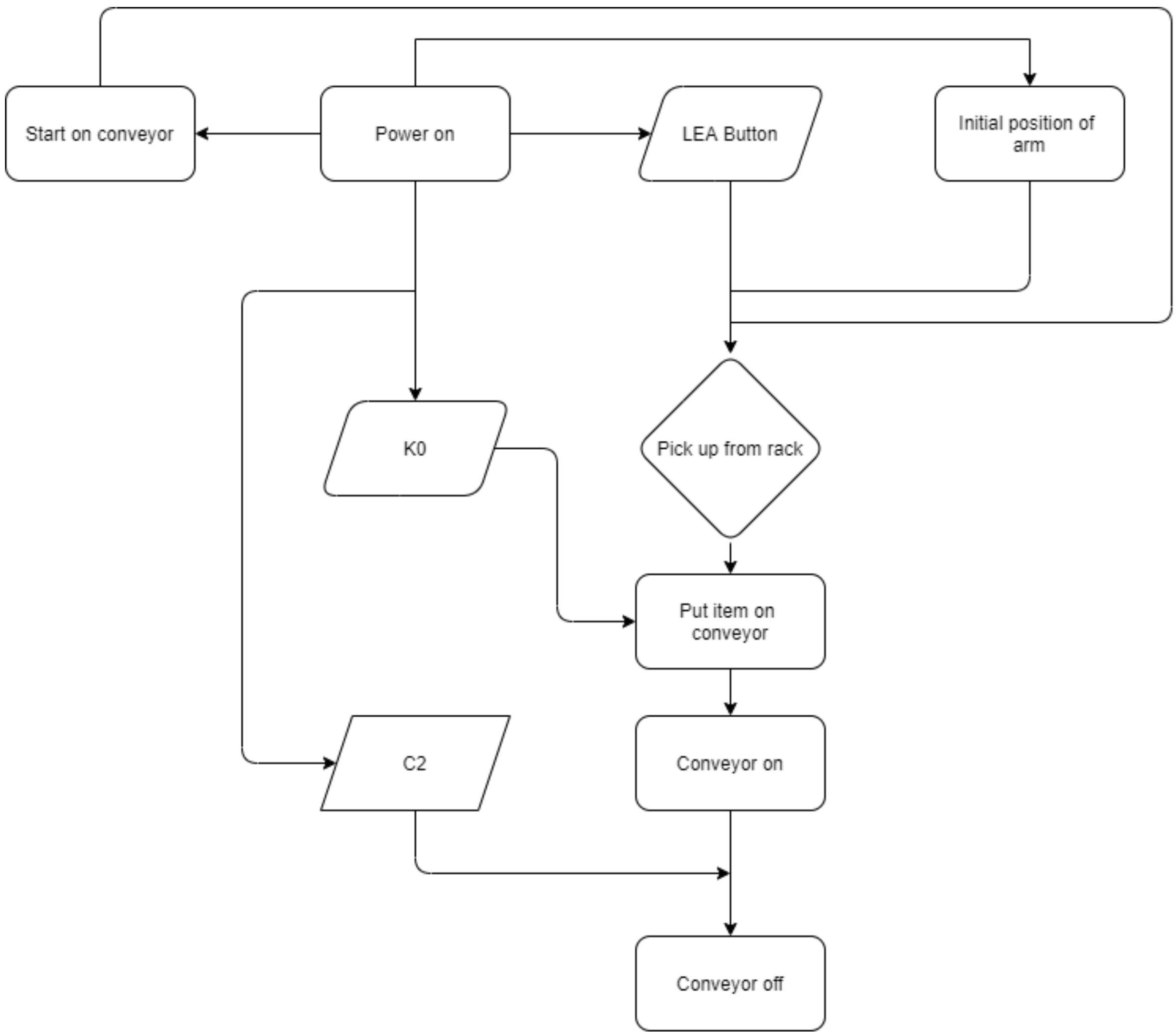

Figure 15. Flow chart of sequential program for leaving operation

7.2 The model of storing station

The storing station includes 4 level of racks to hold pallets of packages. On every rack, there are five spaces for items, so the station can store the maximum of 20 items. The station needs the conveyor to provide input items for the arm responsible to lift items into racks as well as to take them out to the conveyor again. The conveyor also moves items out of station after receiving them from the station's arm. Since the conveyor only move one way from left to right, the added items come in from the left and go out from the right of the station.

To pick up and lift the items, the movement of the station's arm is driven by two racks and pinion systems. One gear wheel touches a rack or linear gear to turn the arm to left or right by x-axis, while another gear wheal helps the arm go up or down. The arm has a pneumatic cylinder to able to extend and retract when it brings and picks up items.

There is a gripper connected the head of piston to hold and release items in the operation of the station.

The station has sensors to detect the status of items and the arm to run PLC program of the station. There are ten sensors arranged along the front horizontal and vertical bars of the station to define the position of the arm and items. There are three sensors to control the action of the conveyor and define the position of items on conveyors. The type of sensor should be through-beam to define the arm's position due to its high accurate and longest detection. Otherwise, the sensors supporting the conveyor may be magnetic or diffuse sensors because these sensors are inexpensive and they can detect items at near positions.

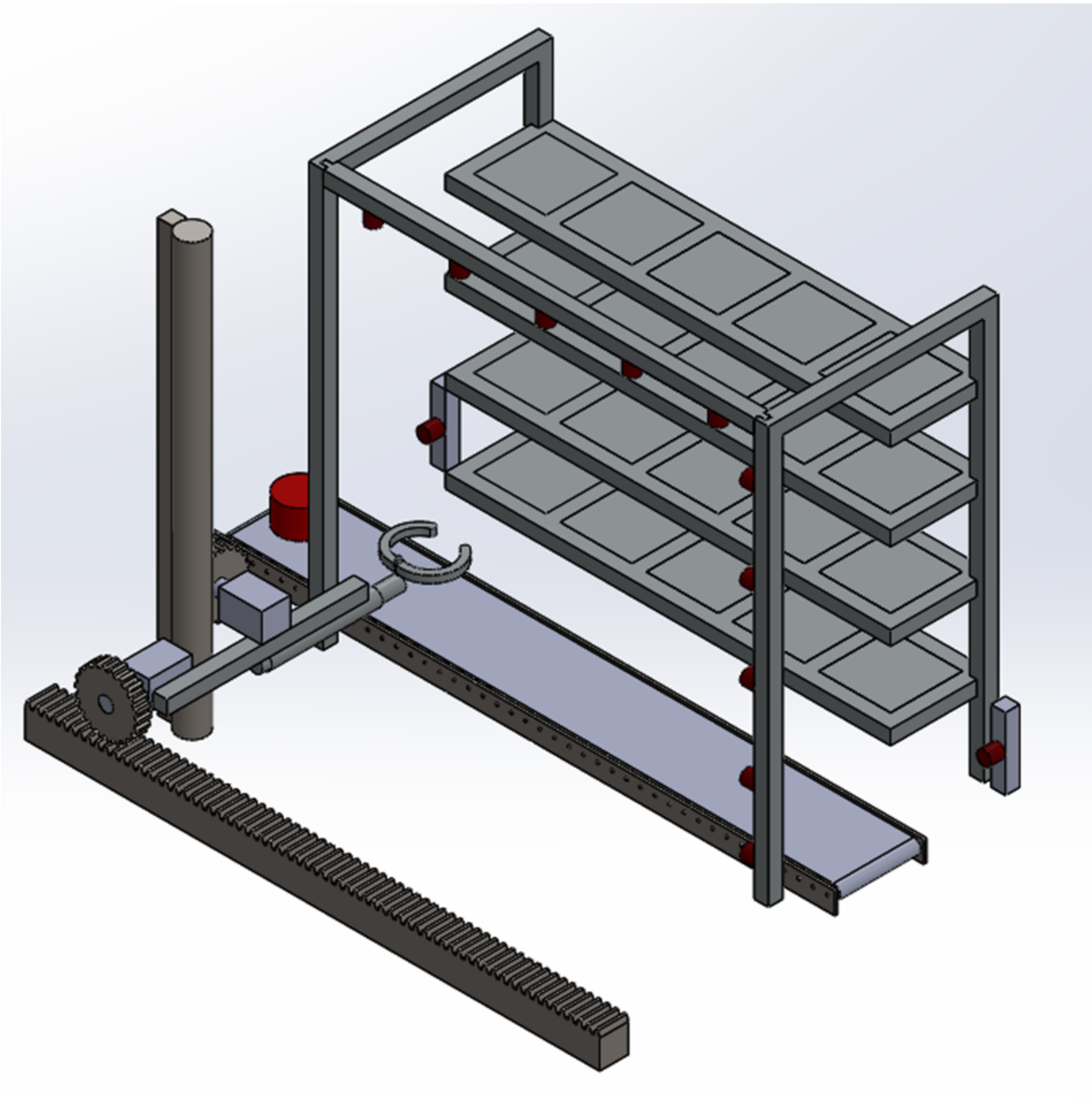

Figure 16. Design of storing station

An important part of the station is the arm system consisting of a pneumatic cylinder and a gripper. The cylinder can extend and retract to bring items onto racks, while a gripper connected the head of piston rod can hold items. These movements of the cylinder are controlled by a pneumatic control. The cylinder of the arm does not extend at initial status to help picking up the item on conveyor, while the gripper cylinder is extended. The cylinders are activated by solenoid valves named Z and G. The arm cylinder will be extended to bring the item onto rack, whereas the gripper cylinder is retracted to close the gripper for keeping an item.

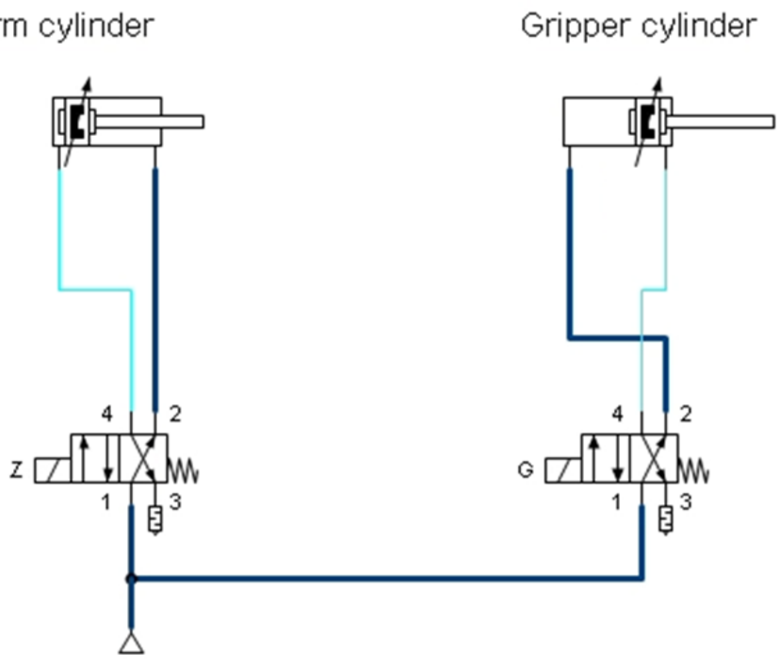

Figure 17. Status of inactivated cylinders

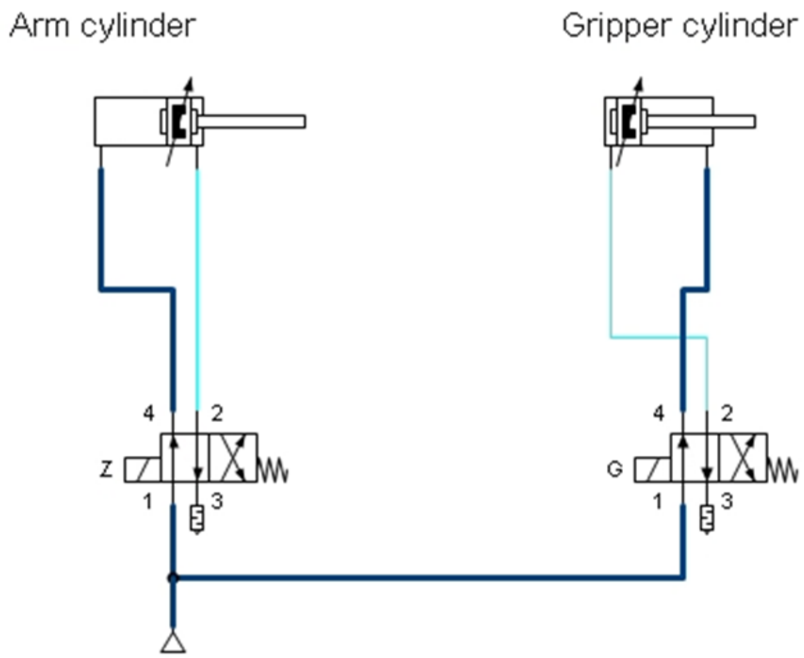

Figure 18. Status of activated cylinders

To operate the station smoothly, the coordinates of item on rack and the arm are determined by sensors during the operation of station (Figure 19), (Figure 20). The position of items is defined by the support of a couple of sensors mentioned in the following table.

Table 2. The correlative sensors of item position

Position	**The couple of sensors**
1	(A0, B0)
2	(A1, B0)
3	(A2, B0)
4	(A3, B0)
5	(A4, B0)
6	(A0, B1)

7	(A1, B1)
8	(A2, B1)
9	(A3, B1)
10	(A4, B1)
11	(A0, B2)
12	(A1, B2)
13	(A2, B2)
14	(A3, B2)
15	(A4, B2)
16	(A0, B3)
17	(A1, B3)
18	(A2, B3)
19	(A3, B3)
20	(A4, B3)

The sensors supporting the determination of coordinates should be diffuse sensors which can detect the centre line of arm cylinder to convert its status from 0 to 1.

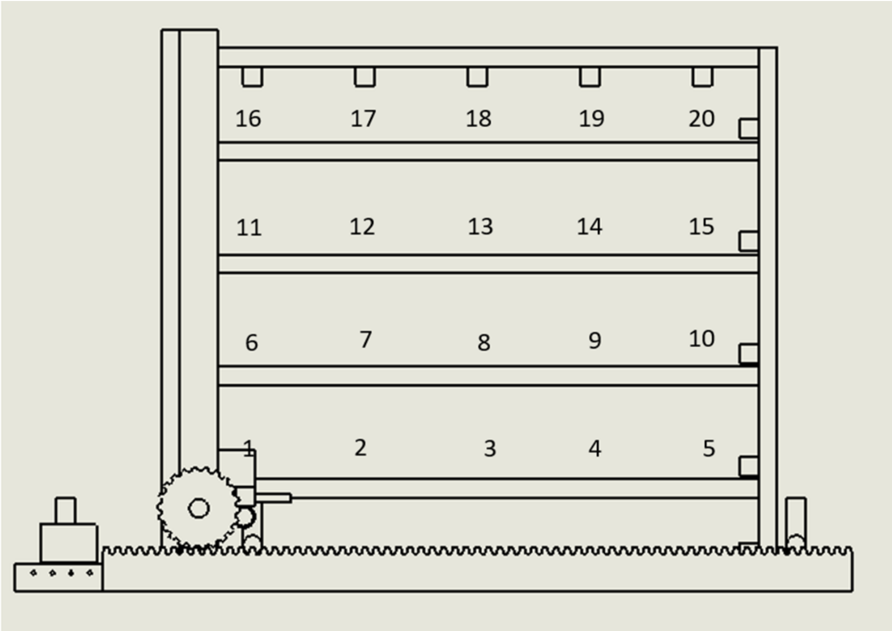

Figure 19. Position of items is presented by numbers from 1 to 20 on the station racks

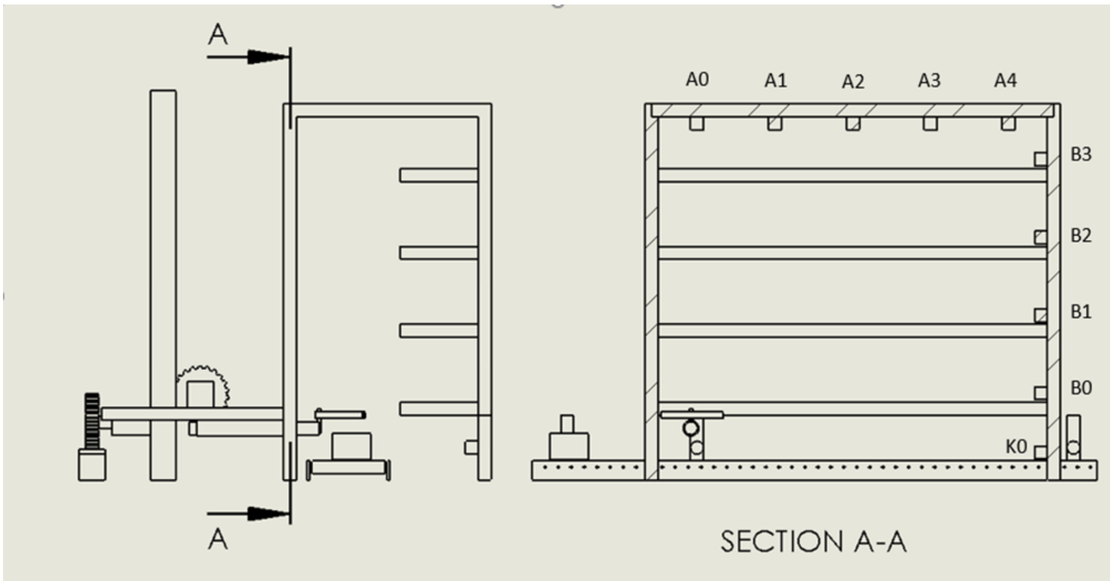

Figure 20. Position of sensors in storing station

Furthermore, there are three sensors supporting the execution of the conveyor named by C0, C1, and C2 (Figure 21). These sensors are activated by the presence of items, which helps the system to determine an item on conveyor, especially when counting items at sensor C1 position.

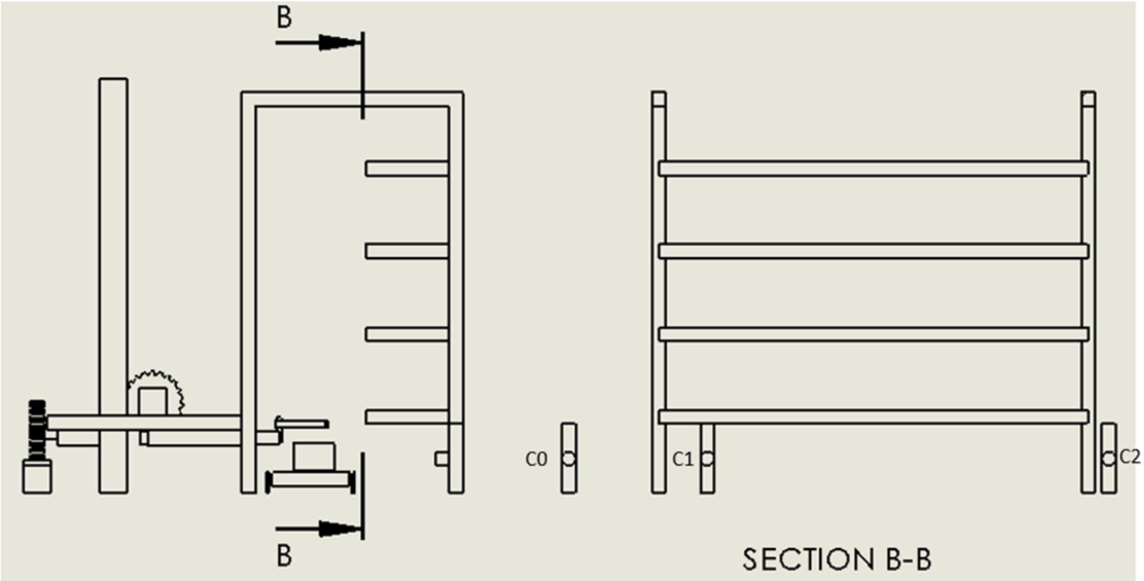

Figure 21. Sensors supporting conveyor

The arm can move by the operation of two motors moving along the x and y axis. The motors have three statuses of rotation, such as clockwise (CW), counterclockwise (CCW), and stop. The stop status of the motor is instructed by sensors in the station. In following figure, the arm with its cylinder and gripper above the item is illustrated at initial situation (Figure 22).

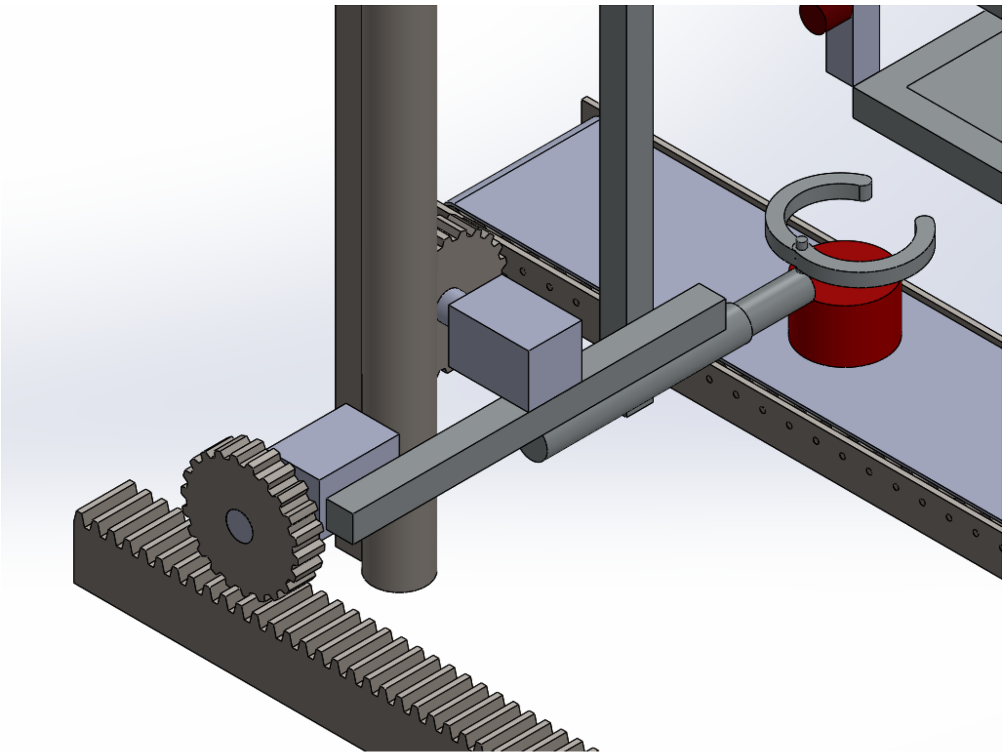

Figure 22. Model of the arm and its gripper at initial position

8 Result

8.1 The variables of PLC program

Table 3. The memory used in program

Name	Data Type	Logical Address	Comment
M1	Bool	%M0.0	Power
M3	Int	%MW1	Position
M4	Int	%MW4	Counting block
M5	Bool	%M0.2	Destinating right position
MD1	Int	%MW2	Dropping stage memory
MD2	Int	%MW3	
MD3	Int	%MW6	
M7	Int	%MW8	
M8	Bool	%M0.4	

There are two data types of memory variables used to make programs for the storing station. One type is Boolean (bool) containing Boolean value of 0 or 1 such as M1 and M5, while another type is integer (Int) containing signed decimal number value in the range from -32768 to 32767. Otherwise, the variables for orientation and position only use Boolean type to declare variables.

Table 4. Valuables of actuator control

Name	Data Type	Logical Address	Comment
CM	Bool	%Q2.0	Conveyor motor
X0	Bool	%Q2.1	motor 1 counterclockwise or go to left
X1	Bool	%Q2.2	motor 1 clockwise or go to right
Y0	Bool	%Q2.3	motor 2 counterclockwise or go down
Y1	Bool	%Q2.4	motor 2 clockwise or go up
G	Bool	%Q2.5	gripper closed
Z	Bool	%Q2.6	extended Z cylinder
S	Bool	%I2.0	Start system
Power	Bool	%I2.1	Power of system
STO	Bool	%I2.2	Storing status
LEA	Bool	%I2.3	Leaving Blocks

Table 5. Variables supporting arm position

Name	Data Type	Logical Address	Comment
A0	Bool	%I0.0	X0
A1	Bool	%I0.1	X1
A2	Bool	%I0.2	X2
A3	Bool	%I0.3	X3
A4	Bool	%I0.4	X4
B0	Bool	%I1.0	Y1
B1	Bool	%I1.1	Y2
B2	Bool	%I1.2	Y3
B3	Bool	%I1.3	Y4
K0	Bool	%I0.5	Y0
C0	Bool	%I0.6	Initial point
C1	Bool	%I0.7	preparing for lift
C2	Bool	%I1.4	End of conveyor

8.2 PLC program of storing station

The PLC system of the storing station consists of one S7-1500 CPU with 3 PROFINET and 1 PROFIBUS DP ports and two signal modules containing I/O address (Figure 23). Each of signal modules (SM) operates with voltage difference of 24V and has 16 input and output locations to store I/O variables.

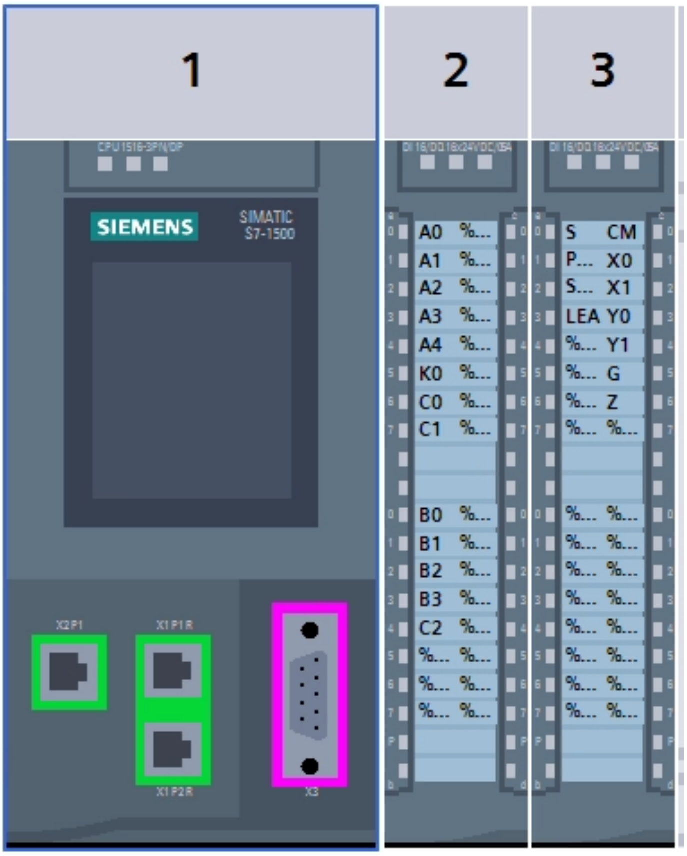

Figure 23. Model of S7-1500 station

The PLC program is written in TIA Portal by Ladder logic language. The structure of PLC project in TIA Portal consists of device configuration containing PLC hardware information, program blocks including Ladder diagram and functions to control the automatic system, PLC tags storing variables and memories for PLC program (Figure 24). The implementation of PLC code is illustrated by PLCSIM v15. The PLCSIM simulator is used to change the status of variables and to show the result of ladder diagram immediately. The change of value is implemented by checking a tick box for each value. The management of variables (Figure 25) shows the status of the variables Power, S, and STO are “TRUE”. The status of variables can be easily changed by either checked or unchecked box in Bits column.

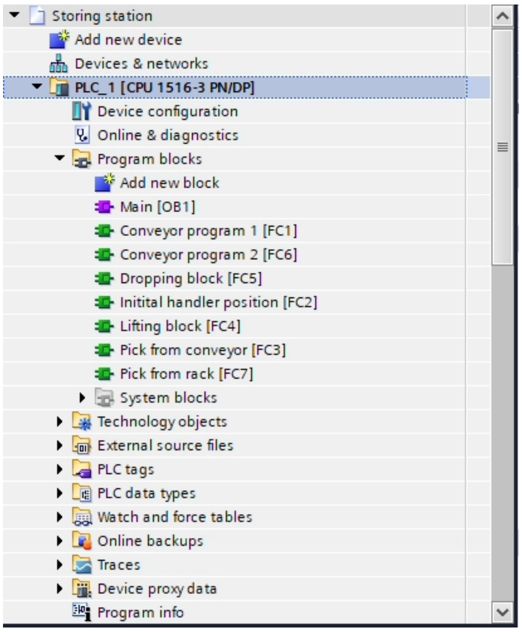

Figure 24. Structure of PLC program controlling the storing station

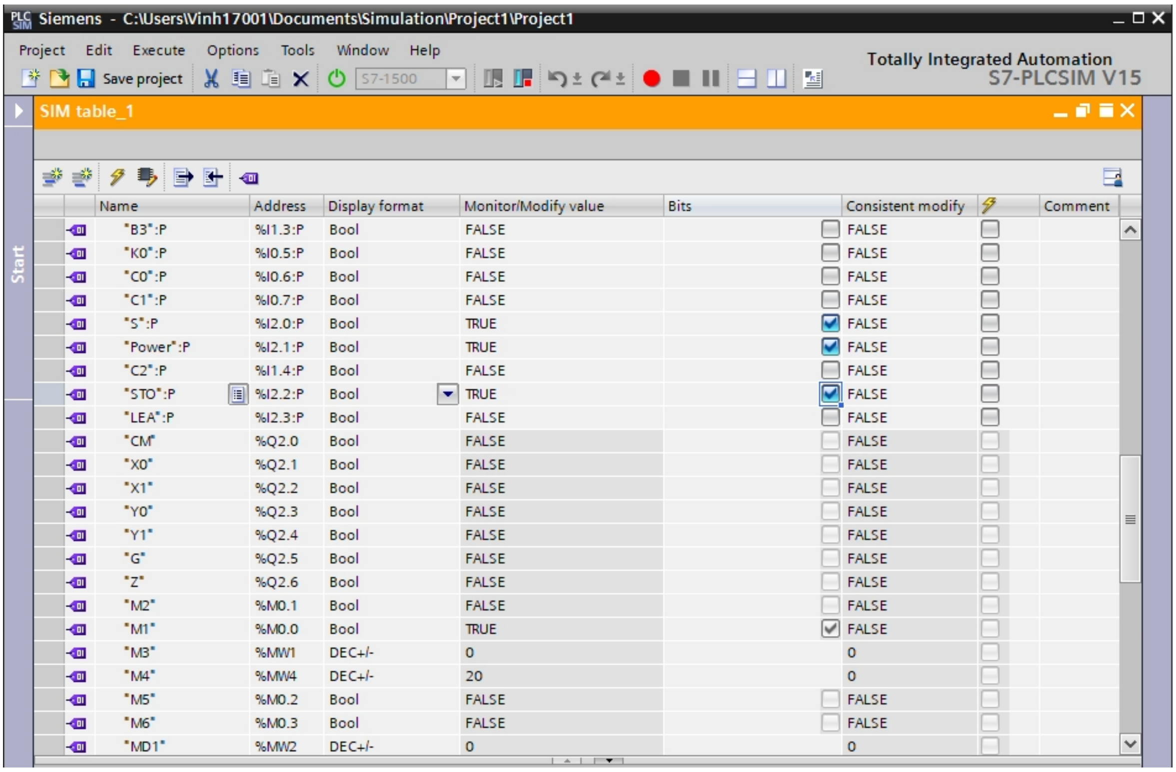

Figure 25. The display of variable management in PLCSIM.

To start the storing station, the power button is turned on, followed by turning on the conveyor motor. Because the racks of station are empty, the variable “STO”, which represents the storing function, needs to be turned on.

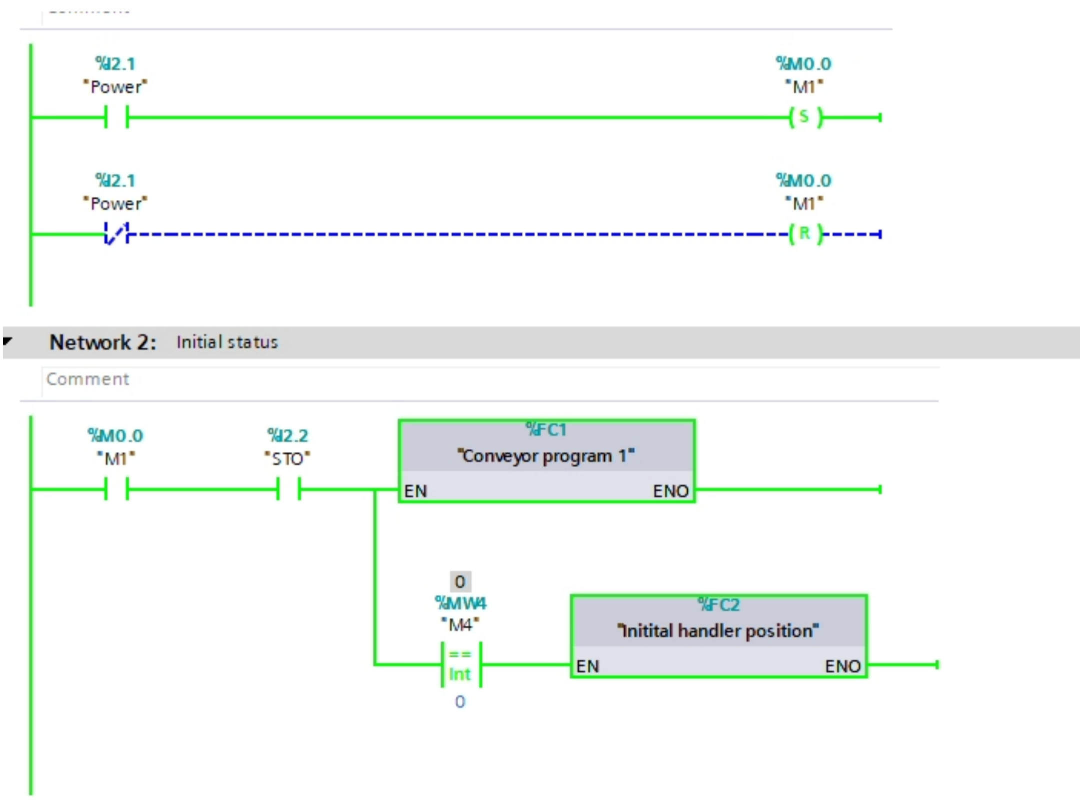

Figure 26. Ladder diagram status after the power turned on

After the power and the STO turned on, the functions controlling conveyor (FC1) and arm motion (FC2) is called by Network 2 (Figure 26). Because the value of M4 is 0, the function FC2 is called to move the arm to Position 1 with inactive cylinders. The Ladder diagram of the function FC2 is showed in the following figure. The sensors A0 and B0 are active with the presence of the arm (Figure 27).

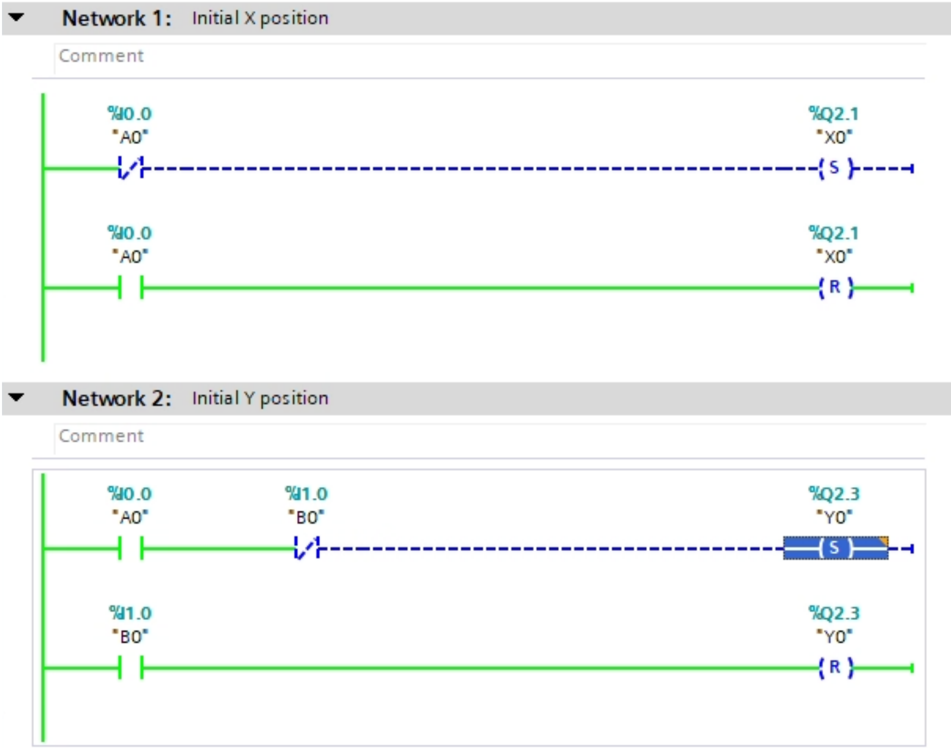

Figure 27. Ladder diagram of FC2 after the arm comes position 1

The coil CM is the output variable of conveyor motor activated by sensor C0 and the presence of items at the initial conveyor. The conveyor will be paused when the item meets the sensor C1. The conveyor motor does not run when the station is full or when the value of M3 is 20 (Figure 28).

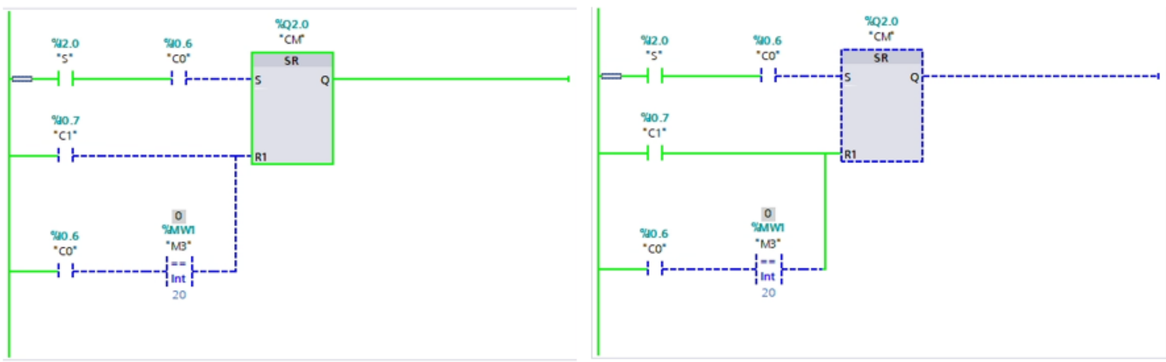

Figure 28. Status of FC1 before and activating sensor C1

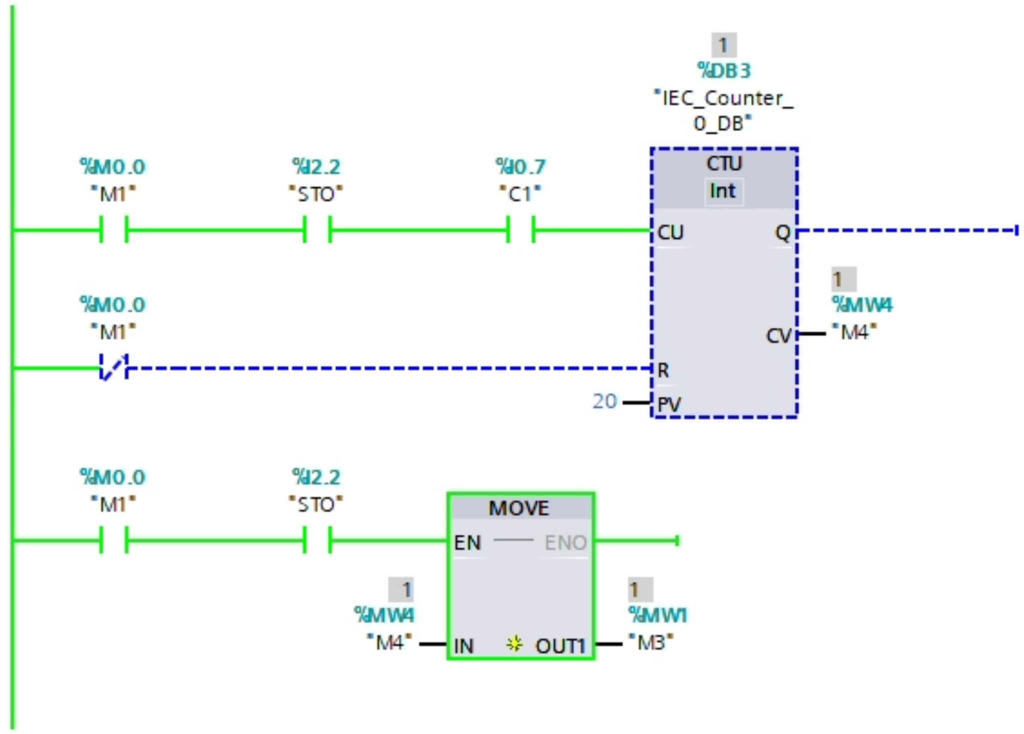

Figure 29. Diagram for sequence of counting item and transferring data from M4 to M3

After the item passes the C0, the conveyor will continue running until the item meets the sensor C1. The sensor C1 also takes on a role as the counter of items, so the counter will write the value 1 into M4. The data in M4 will be transferred to M3 to define the position of item on racks (Figure 29). Since the A0, B0, and C1 are active at same time, the memory M8 also changes value from 0 into 1 to start implementing the Network 5 in order to bring the first item onto the rack.

The process of storing the first item is illustrated in below figure clearly, when the memory of M3 is 1. The M8 is activated to call the FC3 function to pick up the item in front of sensor C1 at the middle of conveyor, followed by storing the value of 1 into MD2. The value 1 in MD2 will call the function FC5 to bring the item to the position 1 on rack by extending the arm cylinder, then the item is dropped by retracting the gripper cylinder. In the final step, the value of MD2 is 2 to call the FC2 function and to “RESET” the M8 in order to pause the Network 5 (Figure 30).

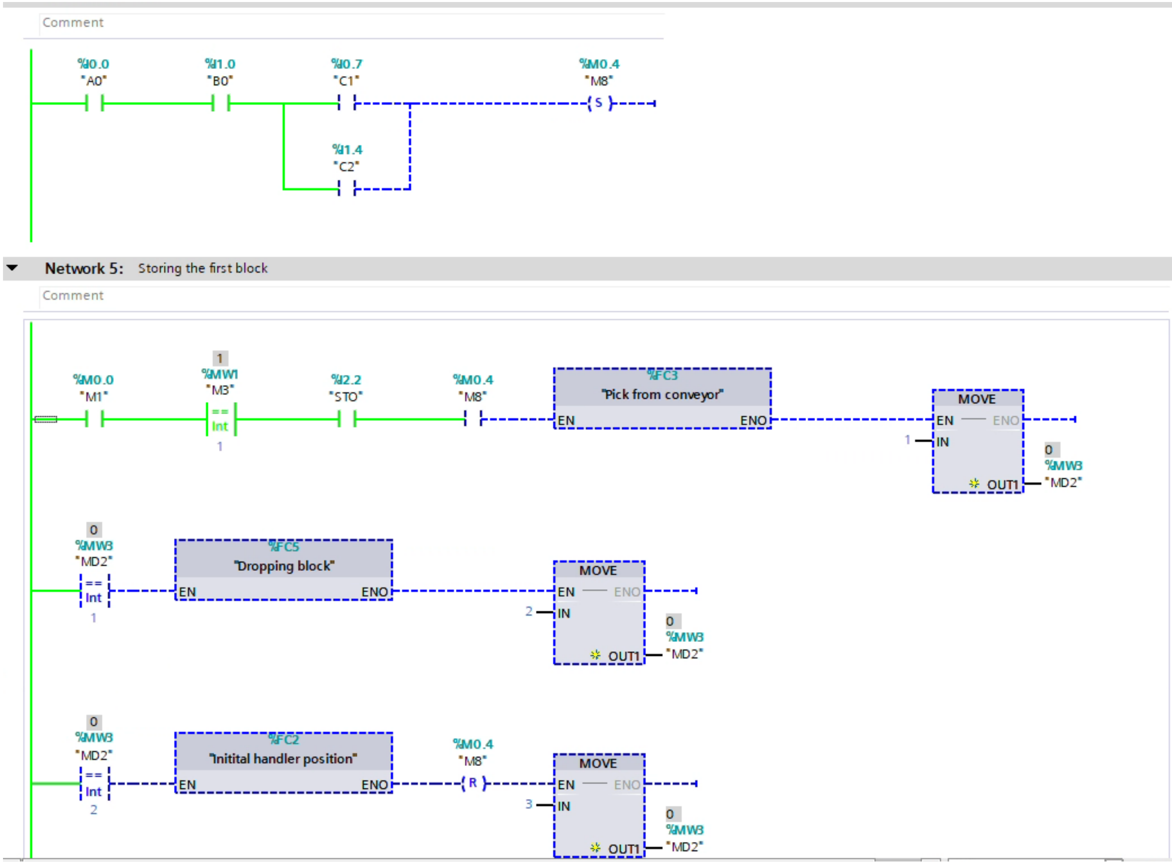

Figure 30. Ladder diagram for the process of bringing an item onto rack from conveyor

The function FC3 (Figure 31) shows the picking up function an item on the conveyor. At network 1, the motor Y goes down until the K0 is activated. The gripper will close by receiving signal from K0 to activate the variable G. The activated G will SET the coil of Y1 to make the arm go up until B0 is activated again. In addition, the dropping item function or FC5 diagram (Figure 32) shows variable Z controlling the arm cylinder. After two seconds since Z is set, the variable G is reset to release the item on the rack, which will inactivate Z to retract the arm cylinder in the last step of the process.

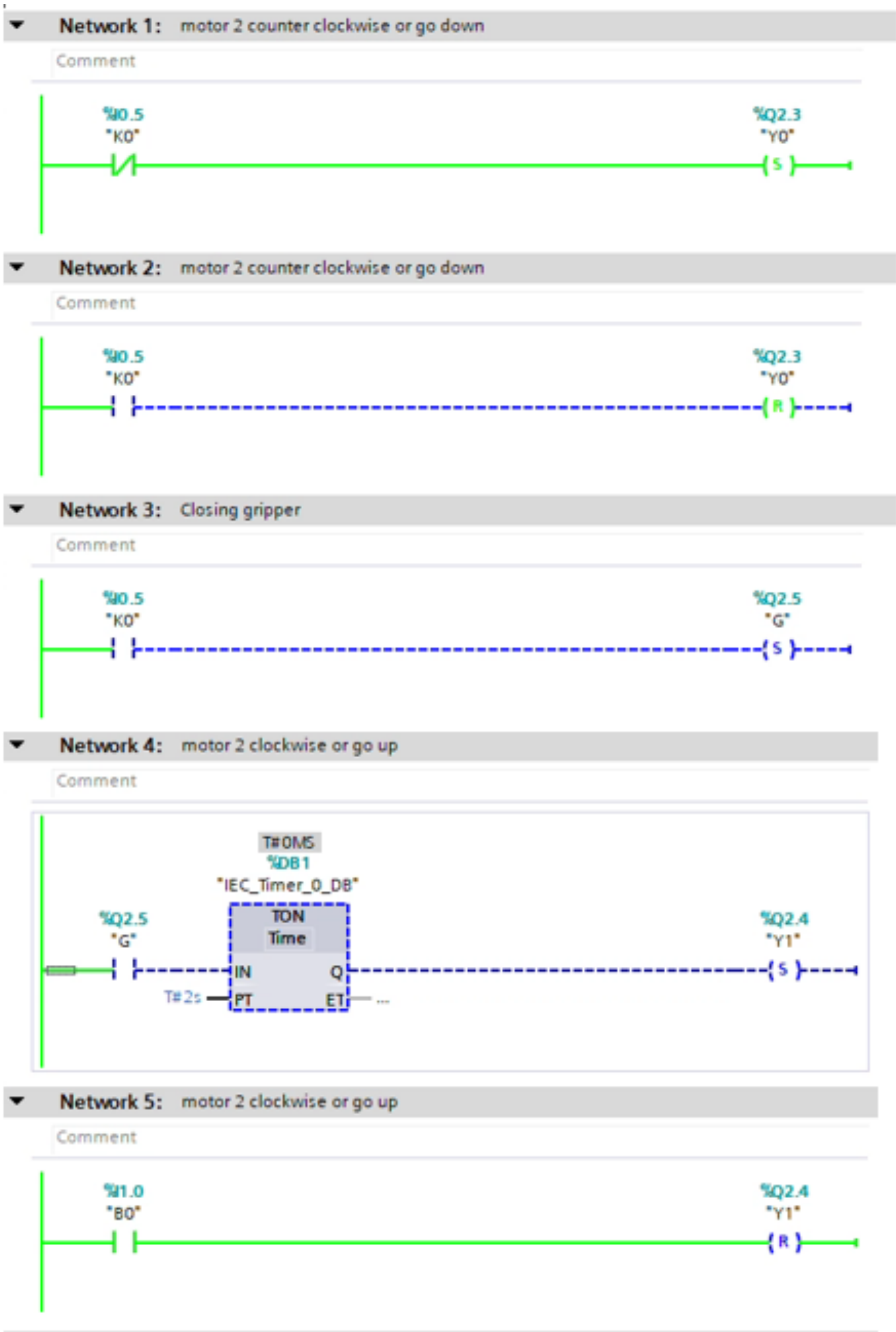

Figure 31. Operation of the picking up item process (FC3)

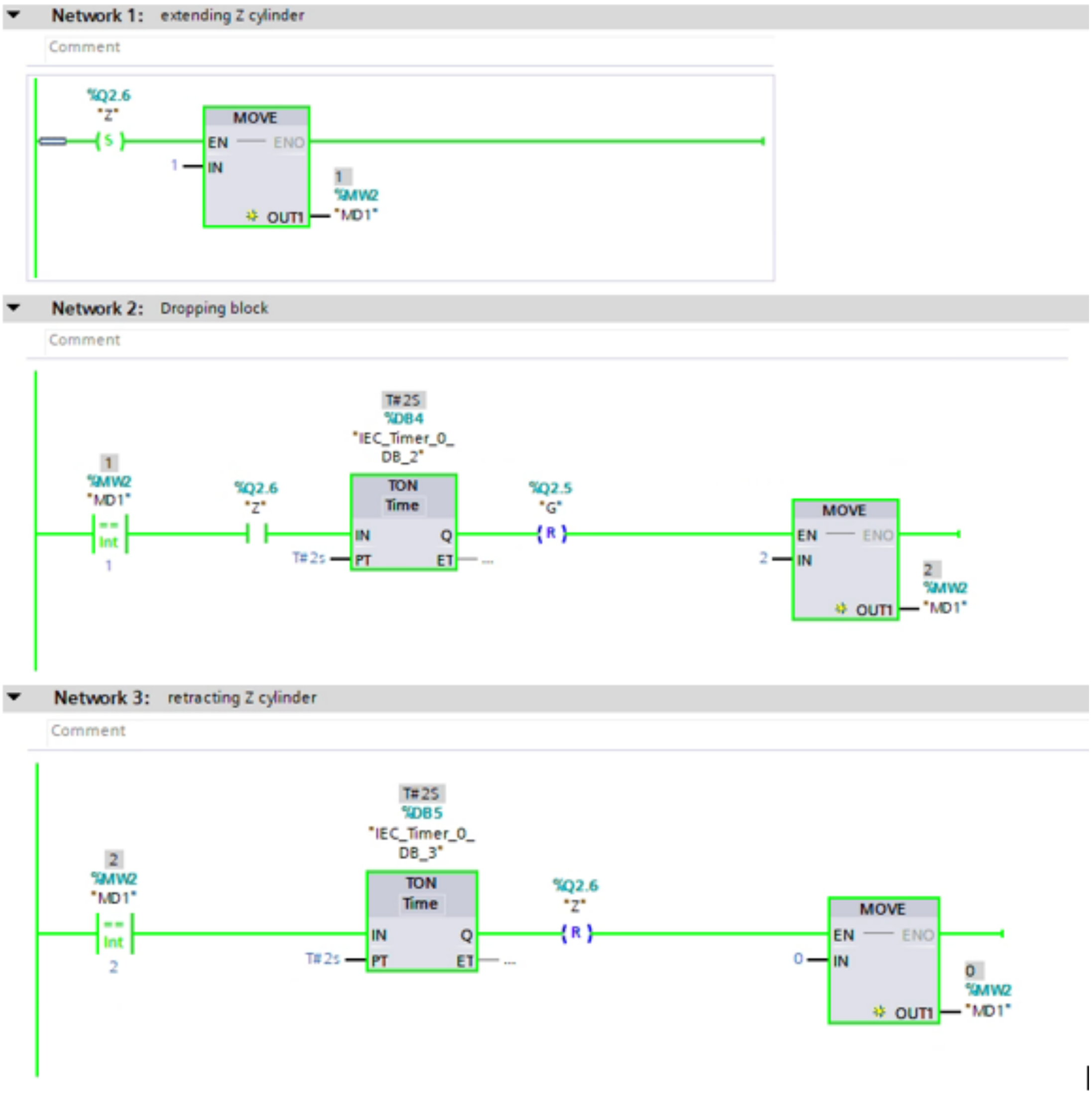

Figure 32. Function of dropping item (FC5)

After the first item placed on a rack, then next item is put on the conveyor. When the C1 is switched on, the counter operates to declare the value 2 into M4 as well as moves it into M3 (Figure 33). The M3 value means the position of the item on the rack of the station. The arm will move to the position of item basing on the value of M3. It means that the arm will go to the right of its initial position until stopped by sensor A1. The second item storing process implements with 2 as the value of M3 in Network 6 (Figure 34). The process of the second item storage is similar as the first item process except the lifting block function (FC4) called to move the storing arm to Position 2 on rack after the implementation of FC3. The FC4 contains the input condition stored in M3 to define the network executed to move the arm to the right position. Furthermore, the value of M3 is 2 in order to activate the variable X1 to move the arm to the right until the sensor

A1 knows the presence of the arm (Figure 35). The FC4 is a long Ladder diagram, and the full sequence of FC4 is illustrated in the PLC program appendix.

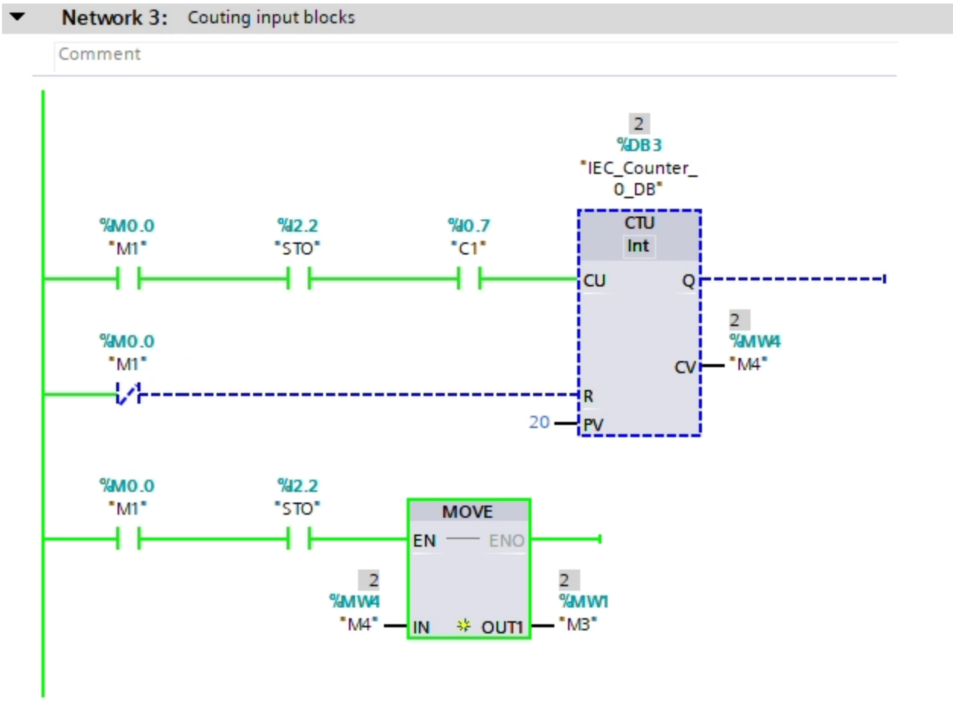

Figure 33. Status of counting diagram after the C1 activated by the second item

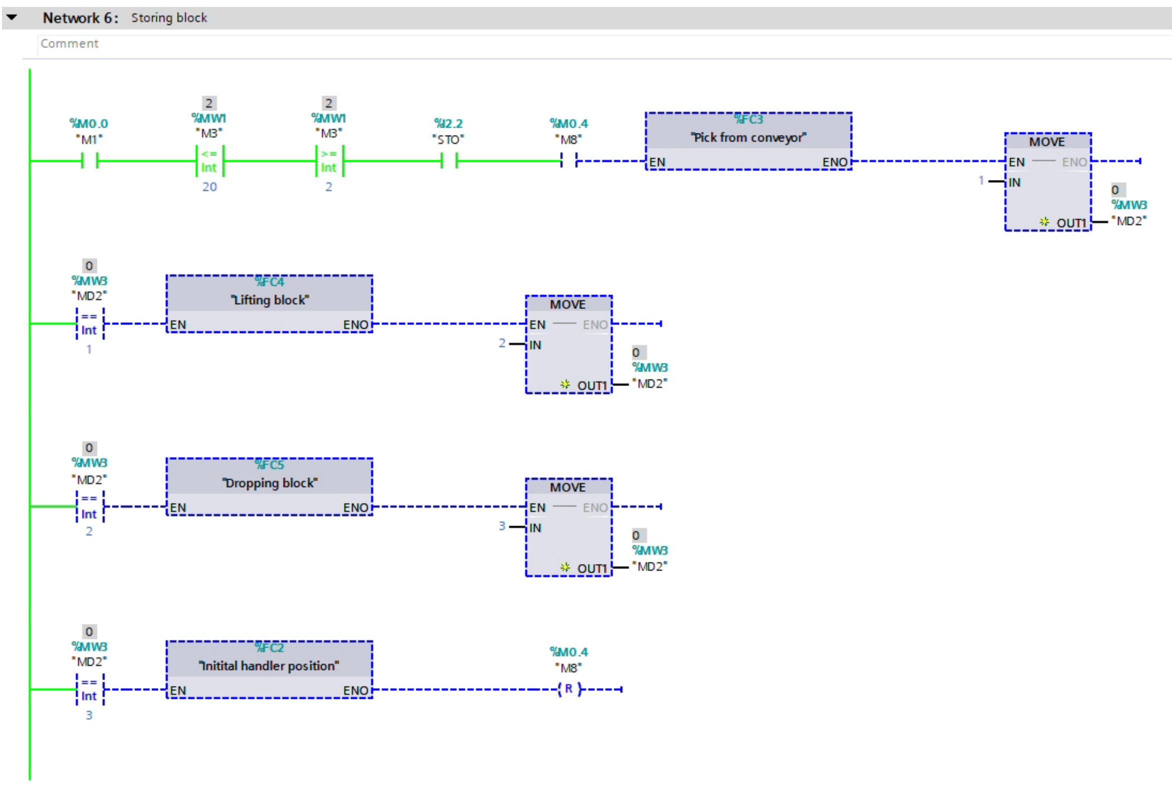

Figure 34. Result of the second item storing process

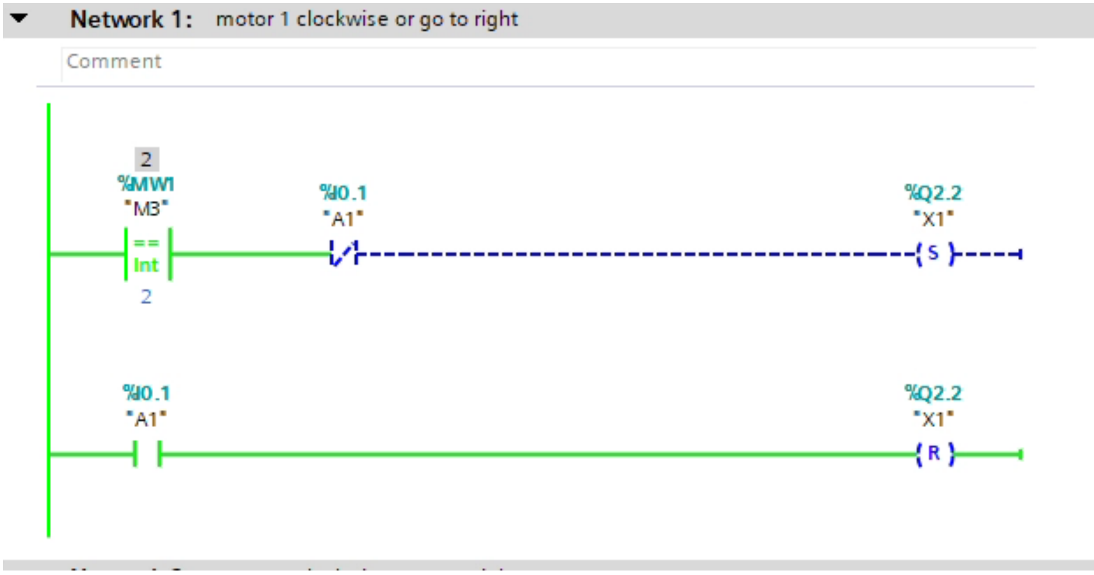

Figure 35. The Network 1 of lifting block implements when the value M3 is 2.

The picking process for items similarly happens from item 2 to 20, then the conveyor motor will stop after the item 20 is lifted onto the last position of rack.

8.3 Leaving function of station

The number of leaving items is counted by the counter down block (Figure 36) after the LEA and sensor C2 are turned on. The leaving process operated by the Network 8 (Figure 37) for items from 20 to 2. The Network 8 does not require the memory M8 because the sensor C2 is at the end of the conveyor to count the ordinal of leaving items. Otherwise, the Network 9 (Figure 38) illustrates the process for leaving the last item out of the station, which demands the memory M8 to stop the leaving process.

In the leaving process, the “Conveyor program 2” functions or FC6 is called at the end of process to give items out of the storing station and to count down the number of remaining items on the rack. The detail of FC6 is also showed in PLC program appendix.

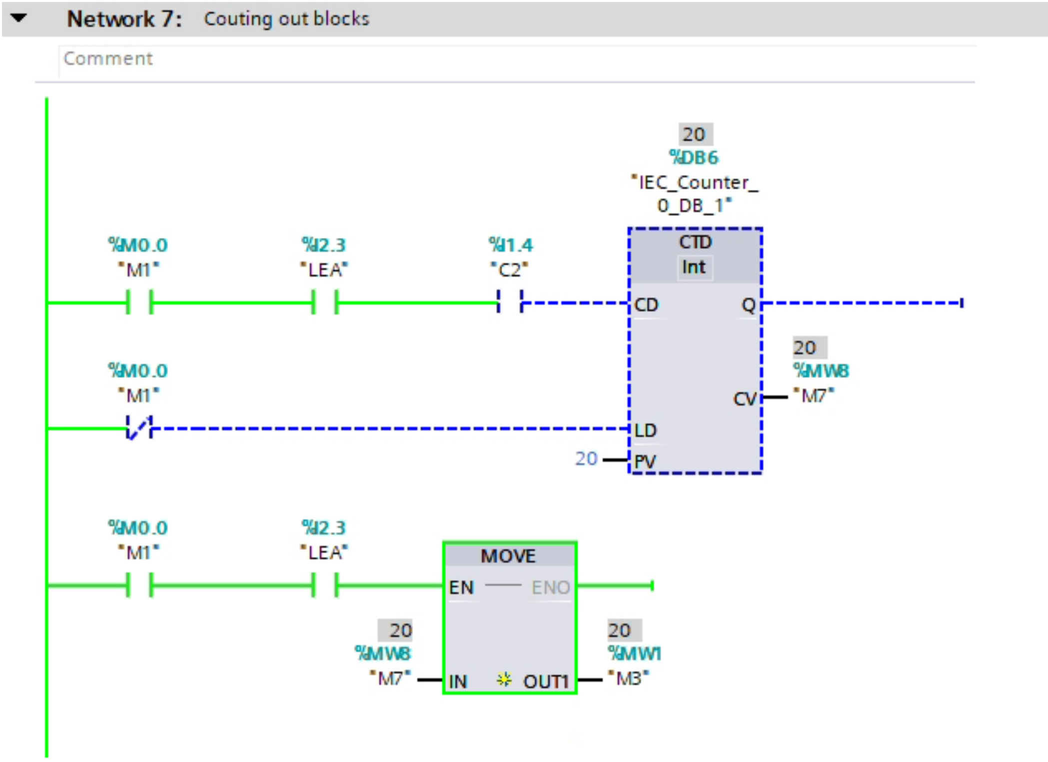

Figure 36. Counter function of leaving items

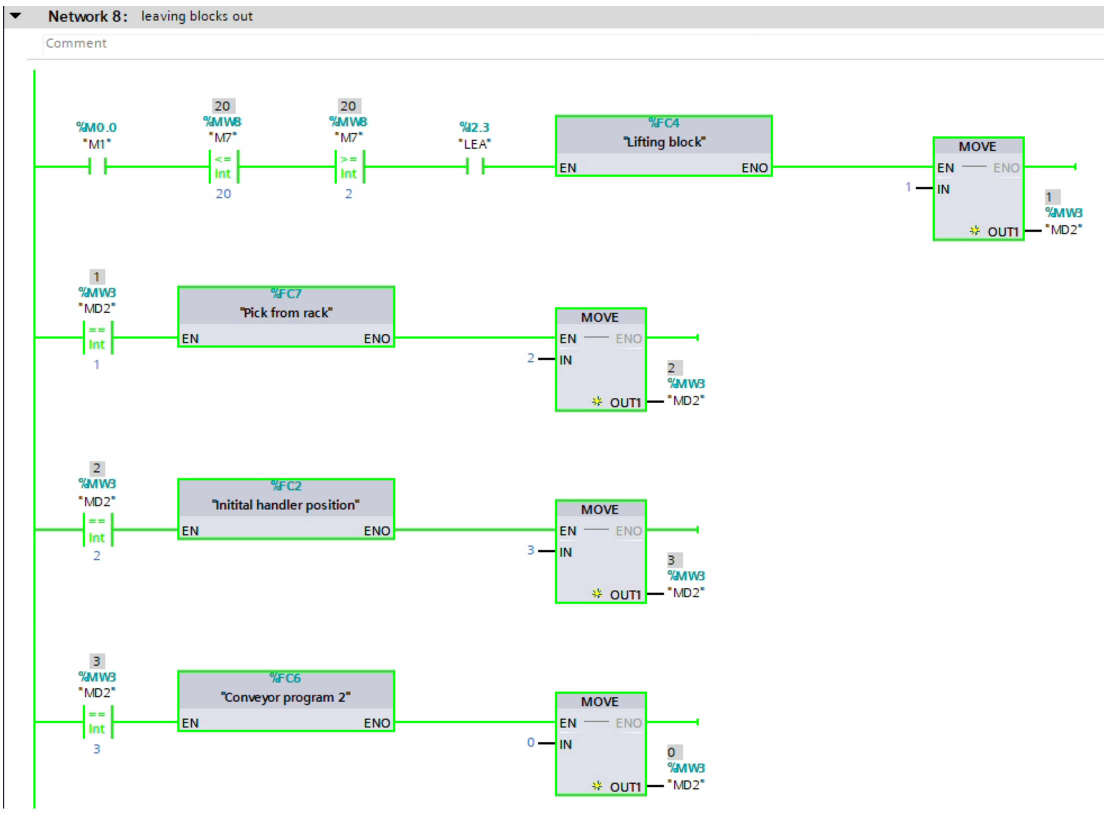

Figure 37. Leaving sequence diagram executing for items from 2 to 20

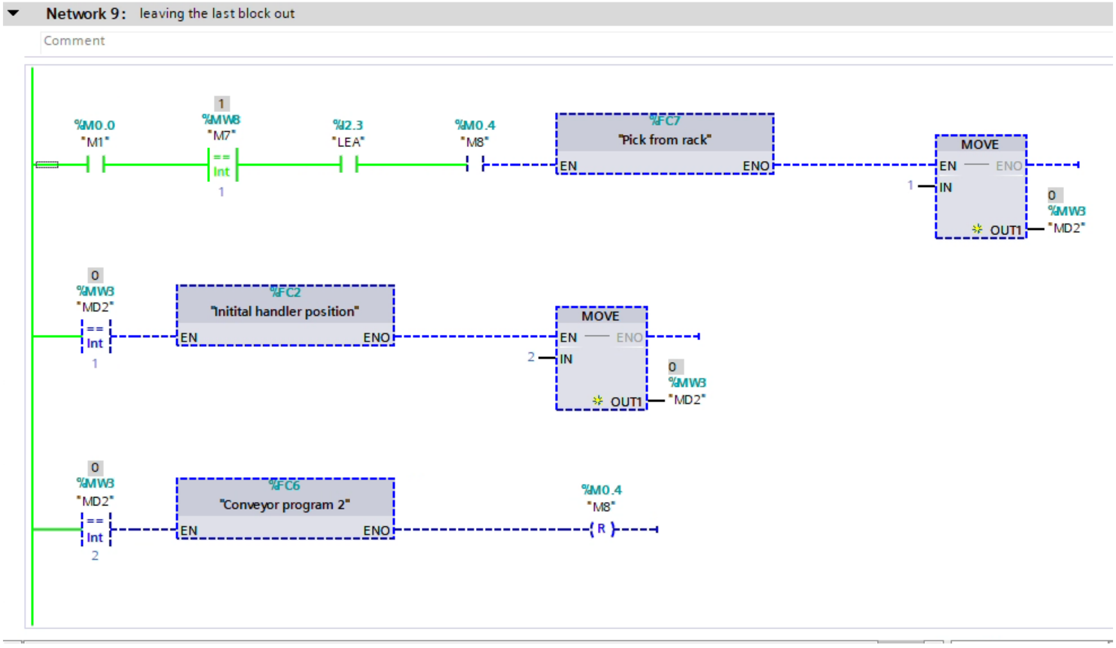

Figure 38. Sequence diagram for leaving the last item

9 Summary and conclusions

The main objective of this thesis is to create a PLC program for a storing station to control the station automatically. The 3D model of the station designed by SOLID-WORKS is used to explain the implementation of PLC program, so the model cannot run in a virtual environment. The components of station are assumed to describe variables declared in PLC program. For instance, sensors in the station are important detectors used to control the operation of the station arm, while stepper motors attached wheel gears are applied to drive the arm for storing and leaving items. Therefore, the sensors and motors are chosen carefully in the build of a storing station in an actual factory. There are many of various sensor types which can be applied in manufacturing, so the choice of sensor type depends on cost, its lifetime of use or efficiency. The stepper motors are selected basing on their efficiency and power consumption, while the lifetime of motors is also an important factor for machine choice.

To build a strong storing station, the technical dimension of parts is calculated exactly to ensure that the station operate smoothly. The material of parts is selected in the way that the operation of the station is not affected by the strength of chosen material. The station parts cannot be manufactured by platinum or titanium. The factor of material cost is a major consideration for a builder to construct a successful station. The mechanical properties of material have to be considered carefully, so that the station can be steady during operating process. The frames and racks, thus, should be machined by high density materials, while the movable parts, such as an arm and cylinders, are made of light materials.

For controlling the station operation, the PLC program is directed via a PLC system by Logic ladder language. The choice of a suitable CPU is a critical demand in the building stage of a storing station. There are many CPU manufactures for PLC CPU and additional equipment with the clear guideline for the programming and configuration of automation. Siemen may be the most popular manufacturer for PLC and automation with various CPU types for PLC such as S7-300/400, 1200/1500, etc. Each of CPU model have both advantages and limits when used in private automatic systems. However, there is no significant difference for the efficiency of these CPUs, so the choice of CPUs mainly depends on their cost.

In an automatic system, the program is the most flexible component since it can be adjusted or rewritten depending on the practical status of a factory or a system. The

Ladder logic language is used to write the PLC program of the station, but other languages, such as structured text, function block diagram, and instruction list can also be used to program for the purpose of development.

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Appendix. The full sequence program of storing station

Totally Integrated Automation Portal		

Table of contents

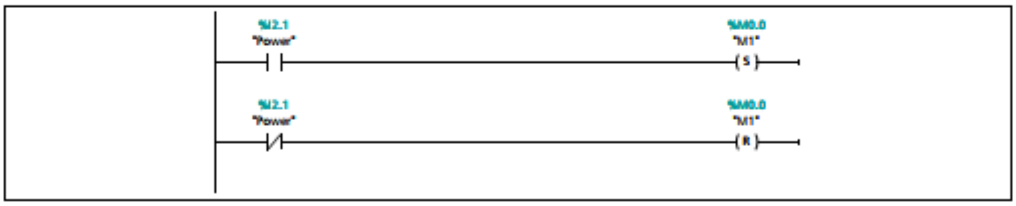
Program blocks

Main [OB1]

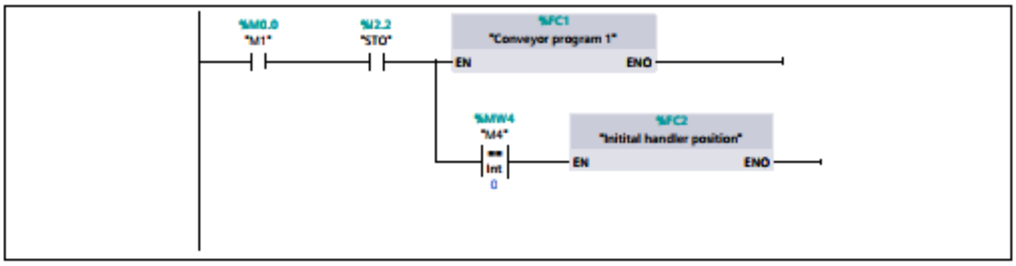
Main Properties					
General					
Name	Main	Number	1	Type	OB
Language	LAD	Numbering	Automatic		
Information					
Title	"Main Program Sweep (Cycle)"	Author		Comment	
Family		Version	0.1	User-defined ID	

Name	Data type	Default value	Comment
▼ Input			
Initial_Call	Bool		Initial call of this OB
Remanence	Bool		=True, if remanent data are available
Temp			
Constant			

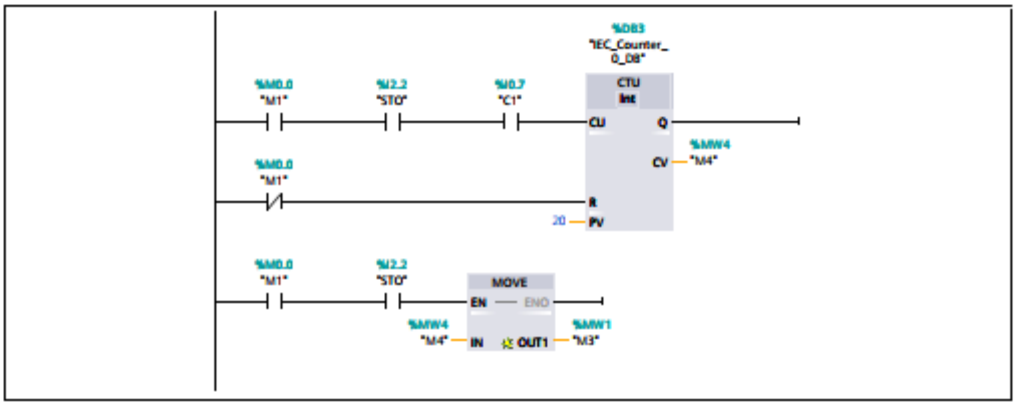
Network 1: Power on/off



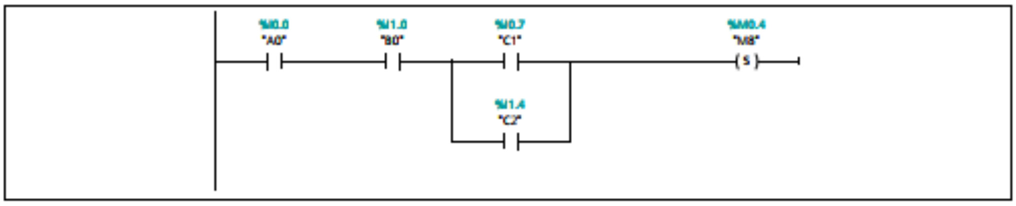
Network 2: Initial status



Network 3: Couting input blocks

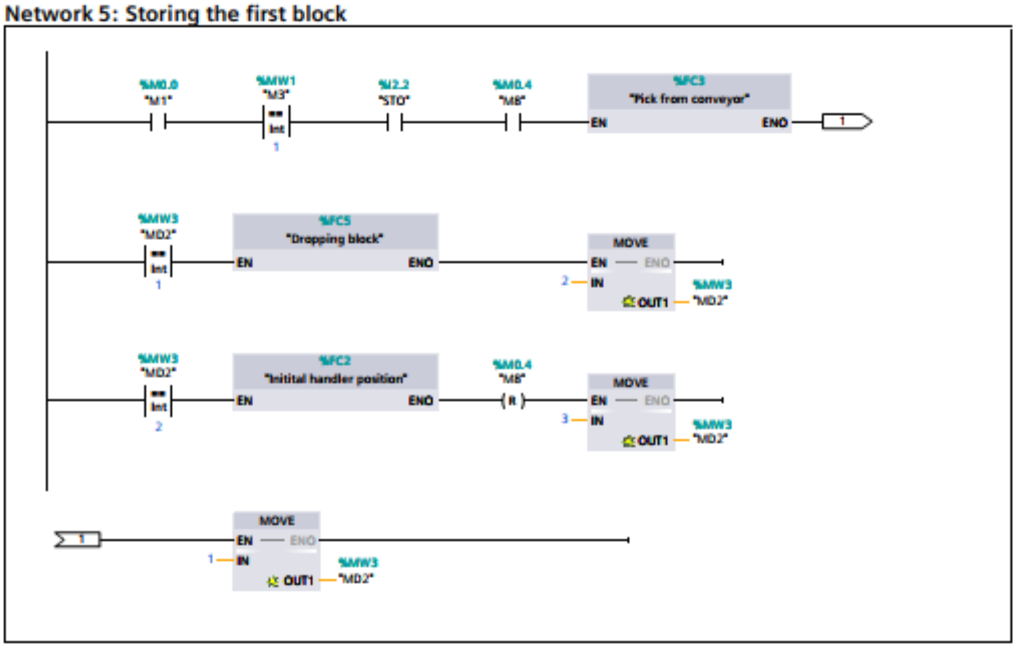


Network 4:



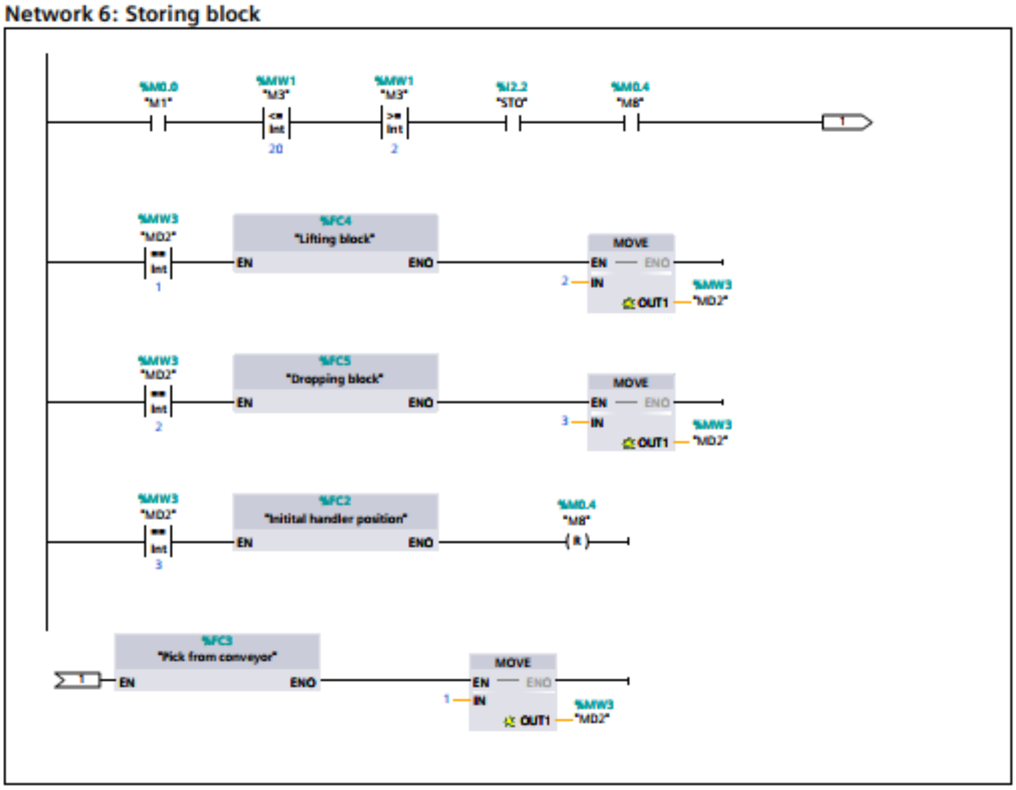
Network 5: Storing the first block

Network 5: Storing the first block

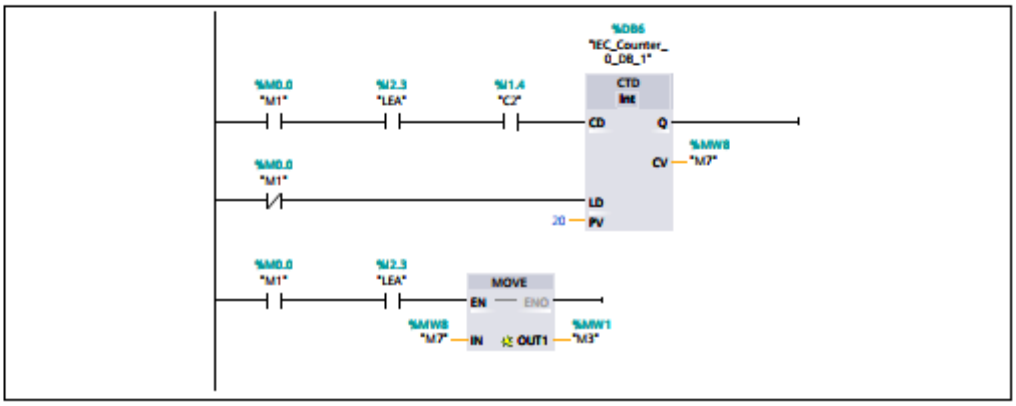


Network 6: Storing block

Network 6: Storing block



Network 7: Couting out blocks



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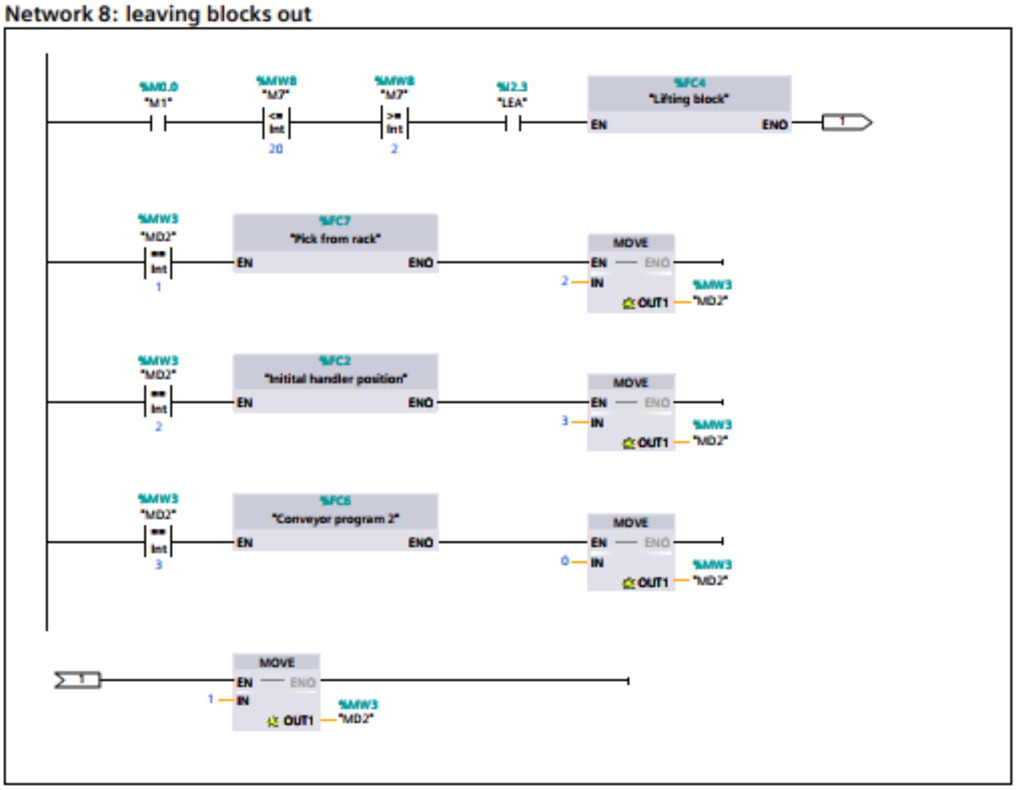
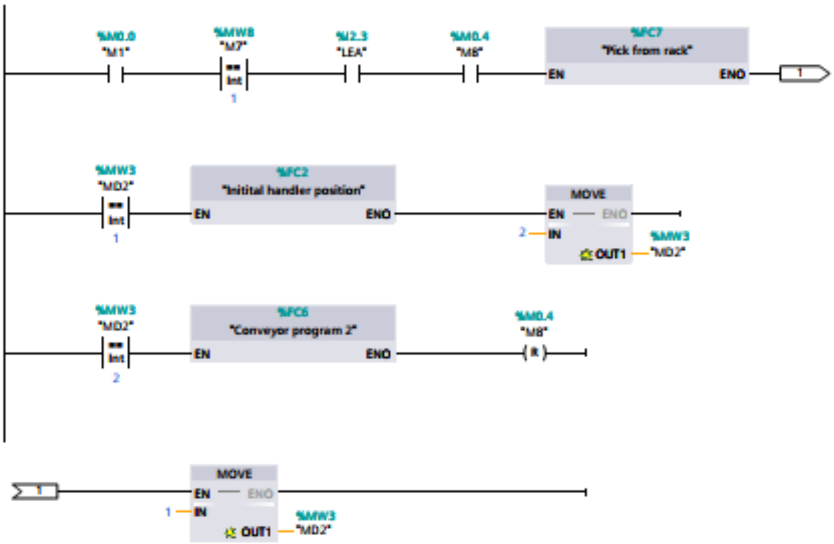
Network 8: leaving blocks out

Network 8: leaving blocks out



Network 9: leaving the last block out

Network 9: leaving the last block out



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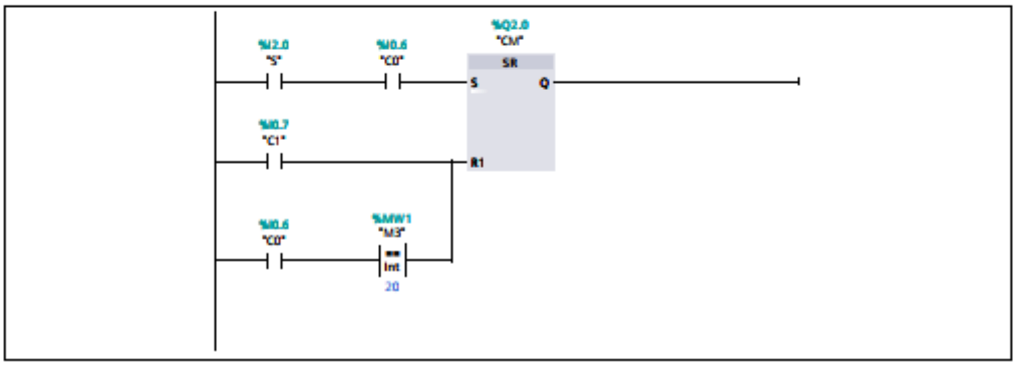
Program blocks

Conveyor program 1 [FC1]

Conveyor program 1 Properties					
General					
Name	Conveyor program 1	Number	1	Type	FC
Language	LAD	Numbering	Automatic		
Information					
Title		Author		Comment	
Family		Version	0.1	User-defined ID	

Name	Data type	Default value	Comment
Input			
Output			
InOut			
Temp			
Constant			
▼ Return			
Conveyor program 1	Void		

Network 1: Conveyor motor



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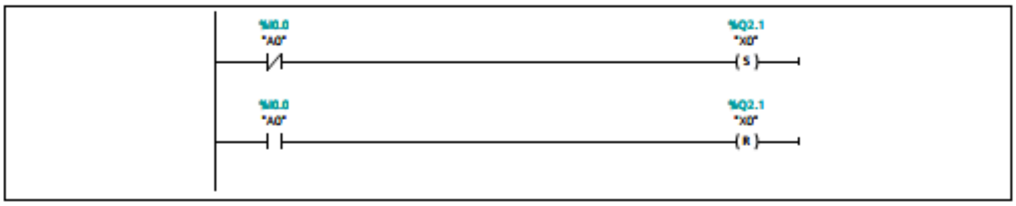
Program blocks

Initital handler position [FC2]

Initital handler position Properties					
General					
Name	Initital handler position	Number	2	Type	FC
Language	LAD	Numbering	Automatic		
Information					
Title		Author		Comment	
Family		Version	0.1	User-defined ID	

Name	Data type	Default value	Comment
Input			
Output			
InOut			
Temp			
Constant			
▼ Return			
Initital handler position	Void		

Network 1: Initial X position



Network 2: Initial Y position

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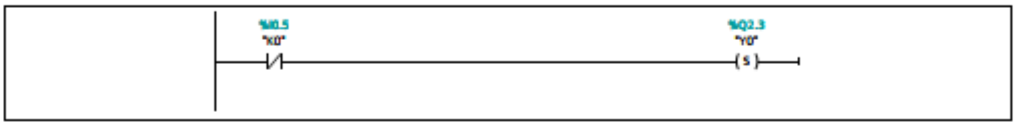
Program blocks

Pick from conveyor [FC3]

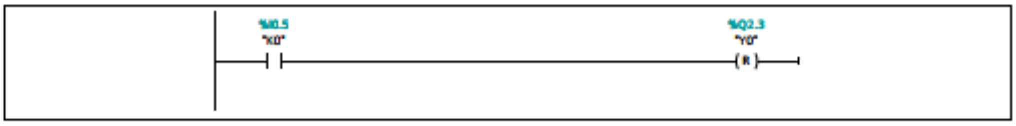
Pick from conveyor Properties					
General					
Name	Pick from conveyor	Number	3	Type	FC
Language	LAD	Numbering	Automatic		
Information					
Title		Author		Comment	Picking up a block from conveyor
Family		Version	0.1	User-defined ID	

Name	Data type	Default value	Comment
Input			
Output			
InOut			
Temp			
Constant			
▼ Return			
Pick from conveyor	Void		

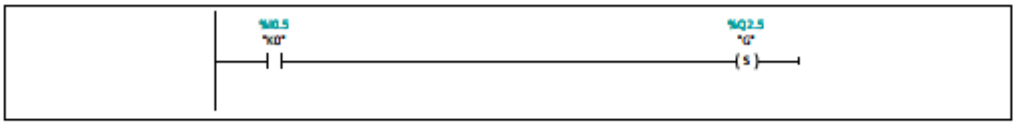
Network 1: motor 2 counter clockwise or go down



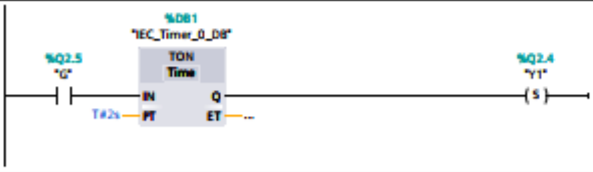
Network 2: motor 2 counter clockwise or go down



Network 3: Closing gripper



Network 4: motor 2 clockwise or go up



Network 5: motor 2 clockwise or go up

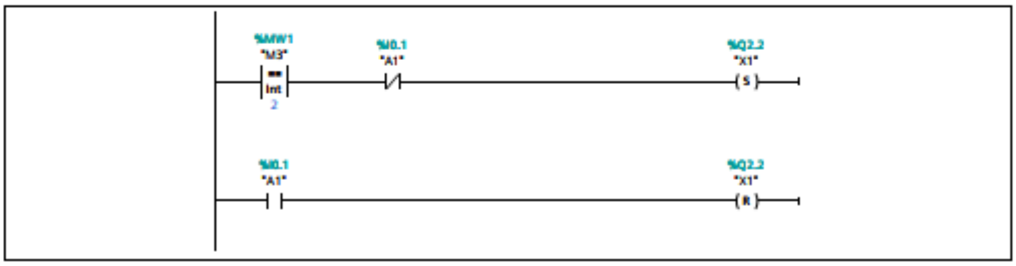
Program blocks

Lifting block [FC4]

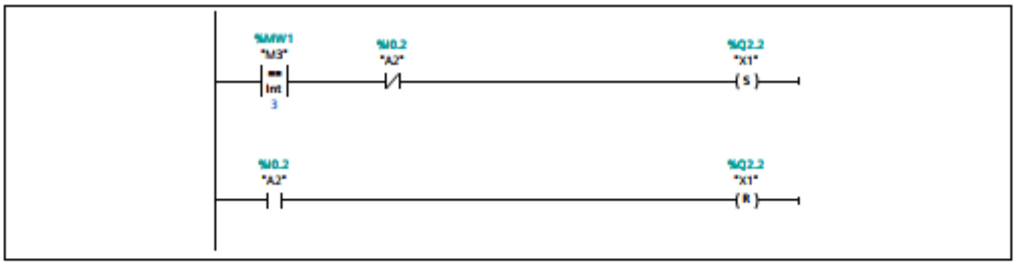
Lifting block Properties					
General					
Name	Lifting block	Number	4	Type	FC
Language	LAD	Numbering	Automatic		
Information					
Title		Author		Comment	
Family		Version	0.1	User-defined ID	

Name	Data type	Default value	Comment
Input			
Output			
InOut			
Temp			
Constant			
▼ Return			
Lifting block	Void		

Network 1: motor 1 clockwise or go to right



Network 2: motor 1 clockwise or go to right



Network 3: motor 1 clockwise or go to right

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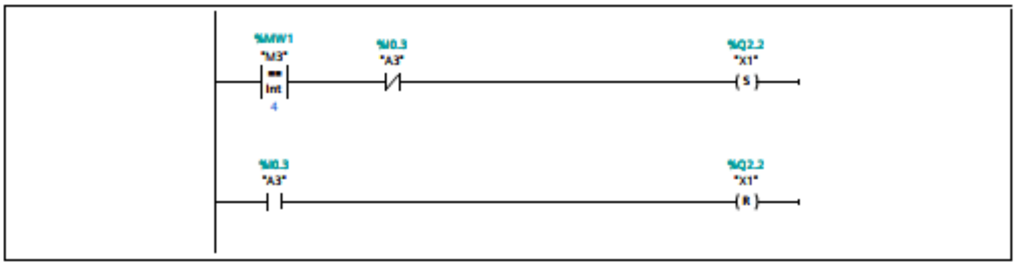
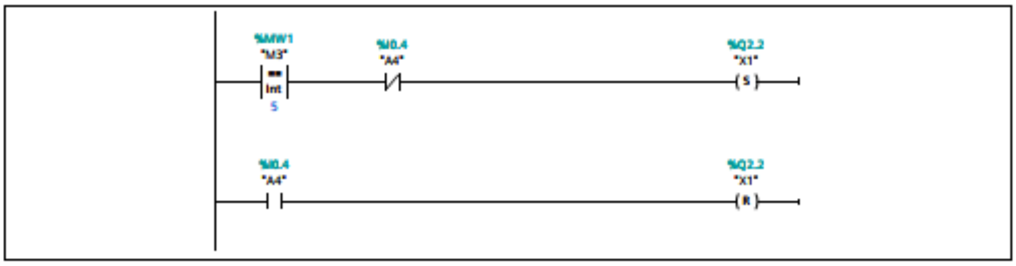


Network 4: motor 1 clockwise or go to right



Network 5: motor 2 clockwise or go up

Network 6: motor 2 clockwise or go up

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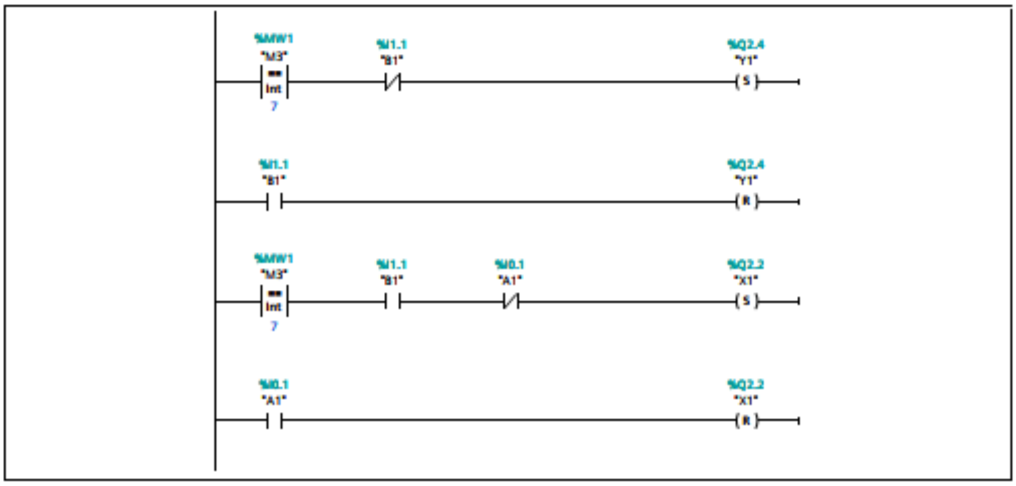
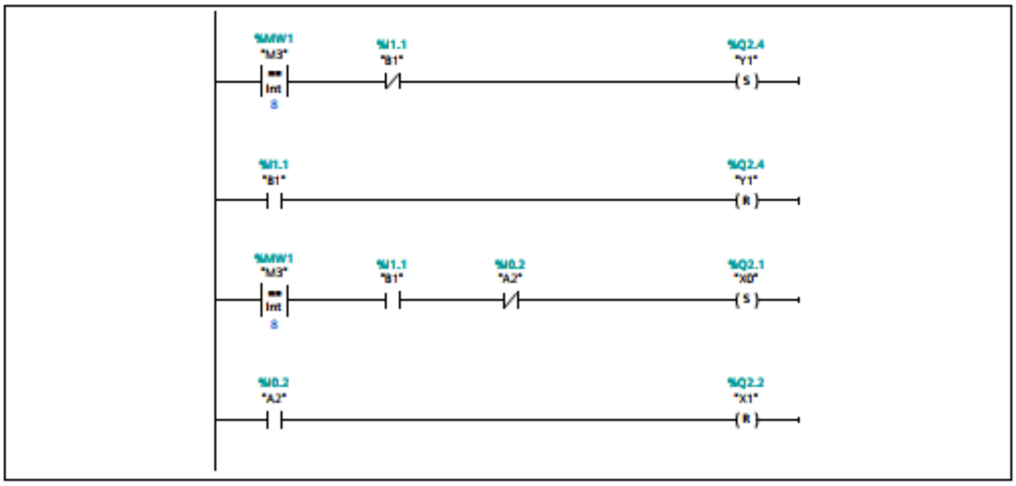
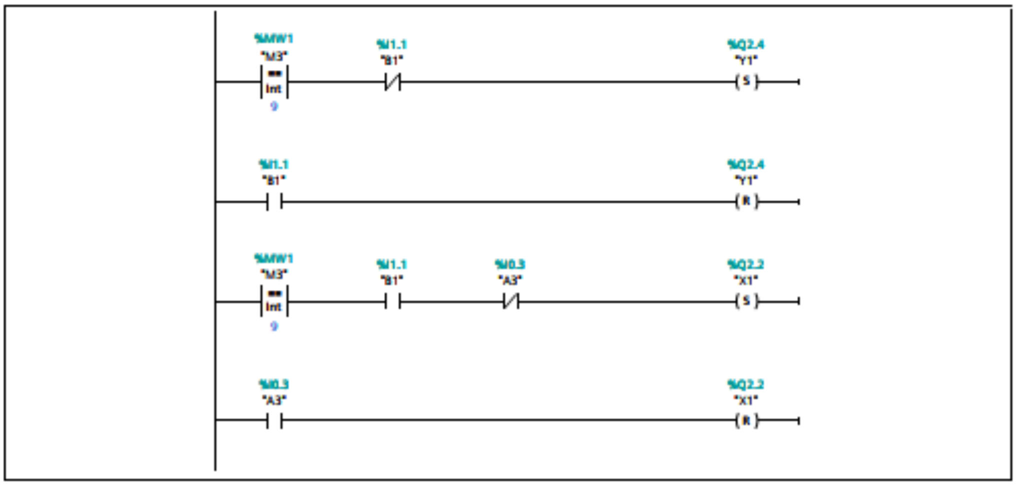


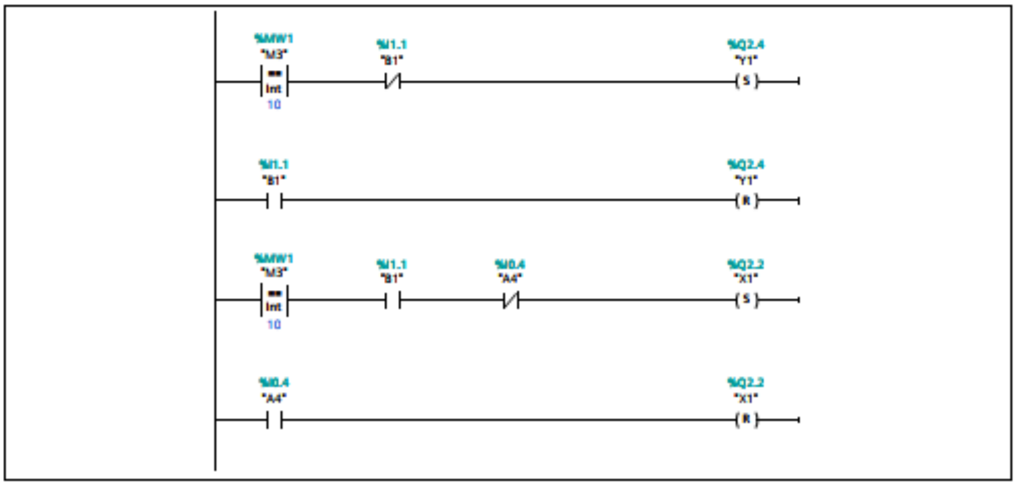
Network 7: motor 2 clockwise or go up



Network 8: motor 2 clockwise or go up



Network 9: motor 2 clockwise or go up



Network 10: motor 2 clockwise or go up

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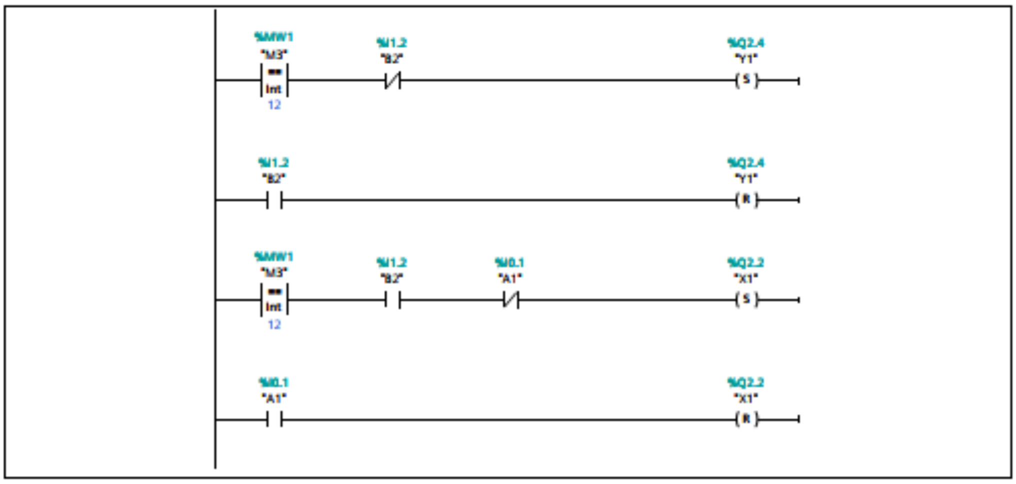
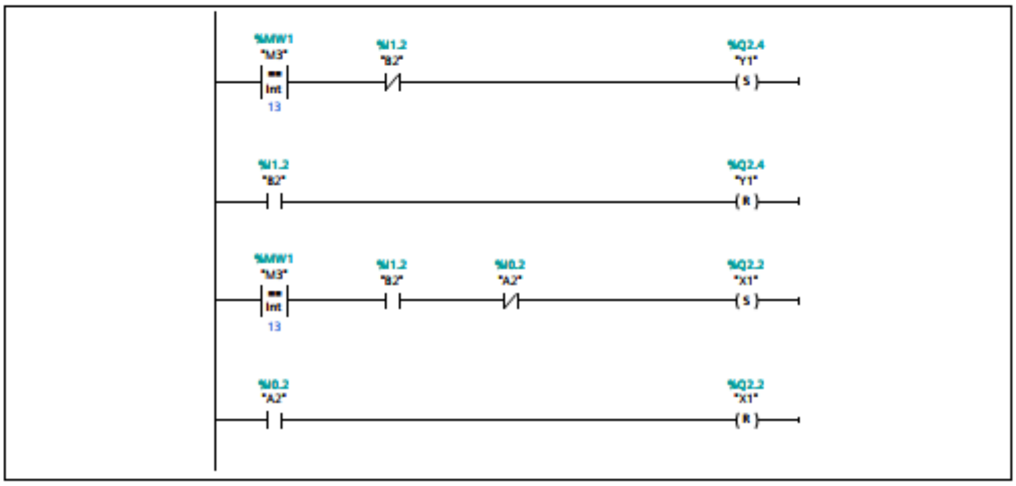
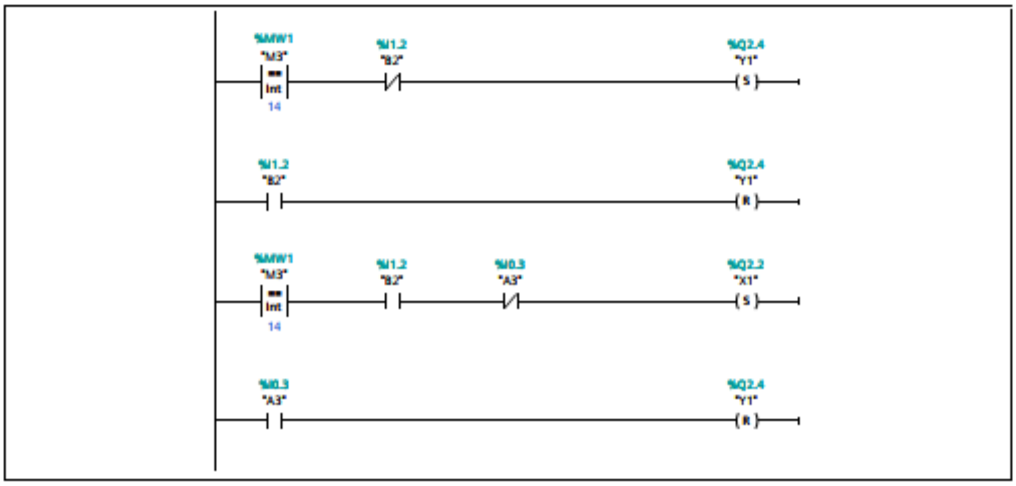
Network 11: motor 2 clockwise or go up



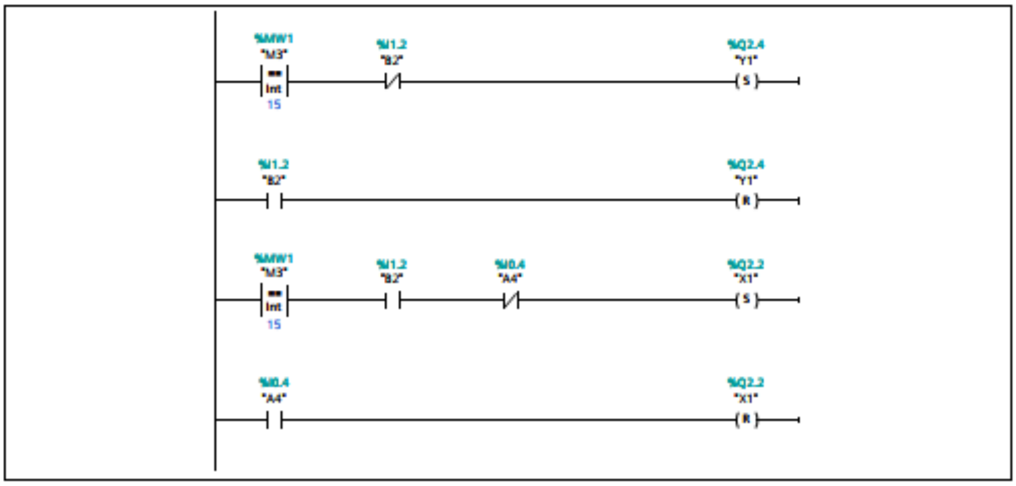
Network 12: motor 2 clockwise or go up



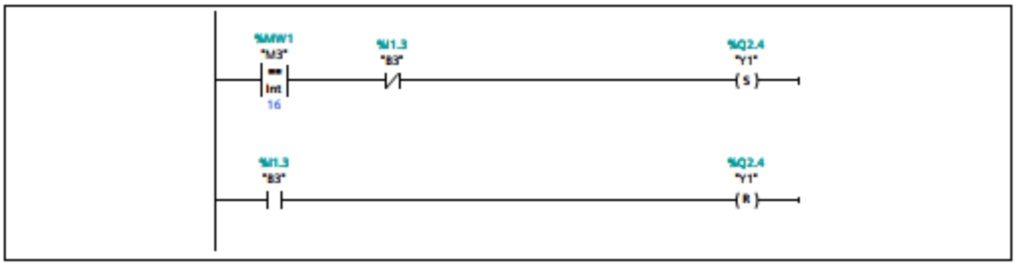
Network 13: motor 2 clockwise or go up



Network 14: motor 2 clockwise or go up



Network 15: motor 2 clockwise or go up



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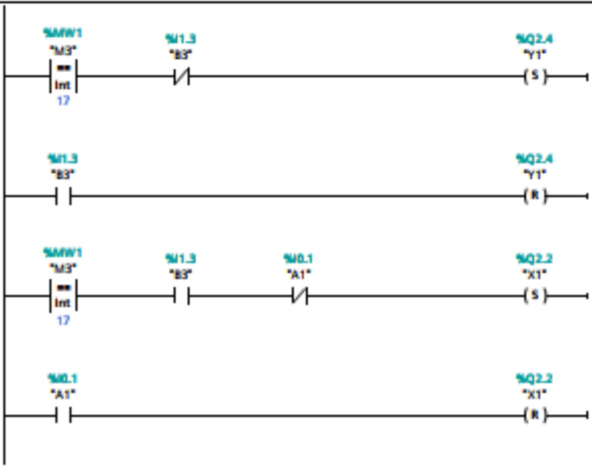
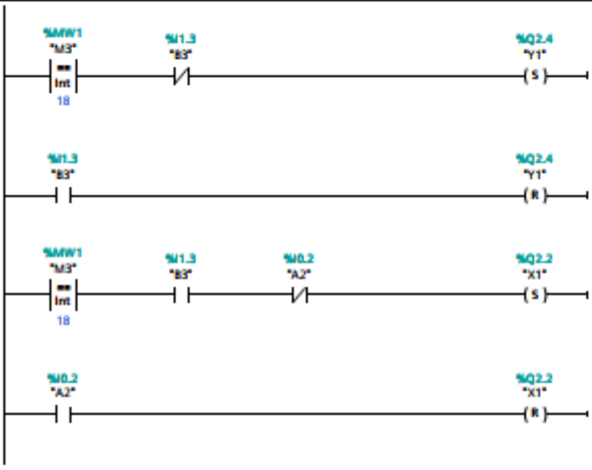
Network 16: motor 2 clockwise or go up



Network 17: motor 2 clockwise or go up



Network 18: motor 2 clockwise or go up

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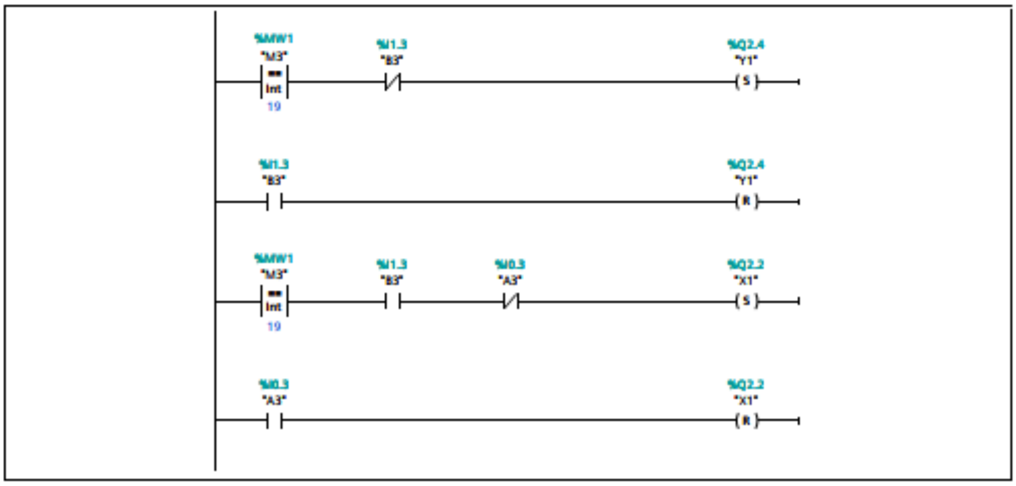
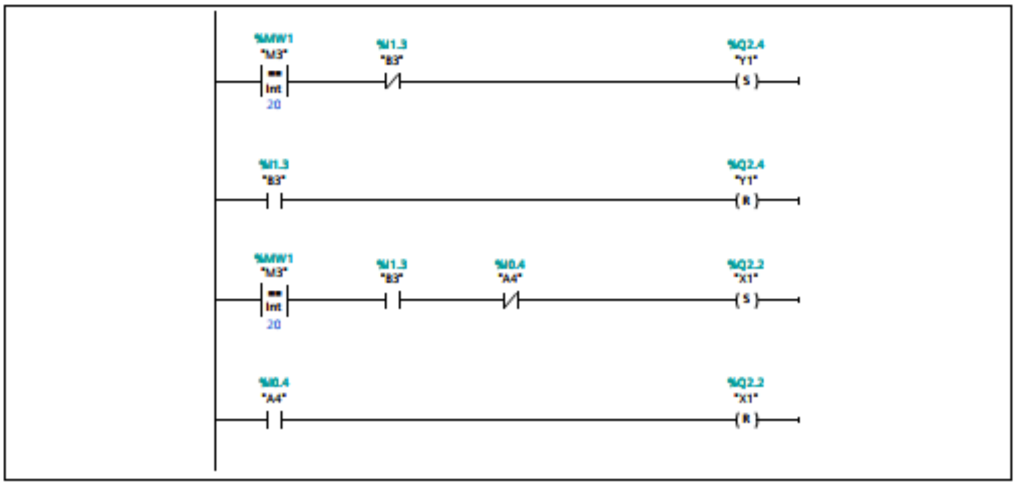


Network 19: motor 2 clockwise or go up



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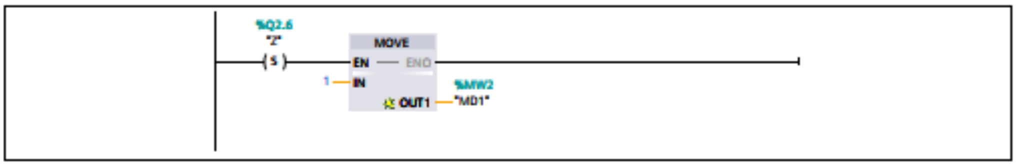
Program blocks

Dropping block [FC5]

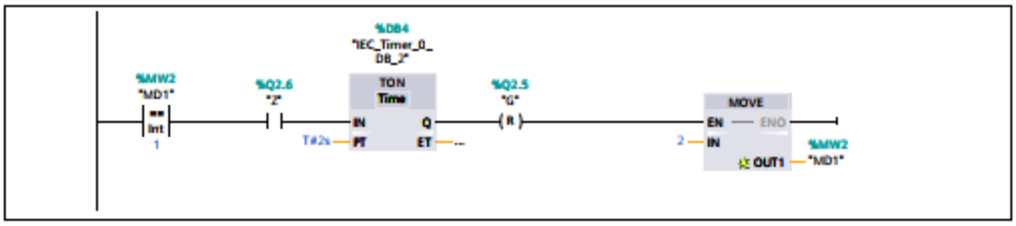
Dropping block Properties					
General					
Name	Dropping block	Number	5	Type	FC
Language	LAD	Numbering	Automatic		
Information					
Title		Author		Comment	
Family		Version	0.1	User-defined ID	

Name	Data type	Default value	Comment
Input			
Output			
InOut			
Temp			
Constant			
▼ Return			
Dropping block	Void		

Network 1: extending Z cylinder



Network 2: Dropping block



Network 3: retracting Z cylinder

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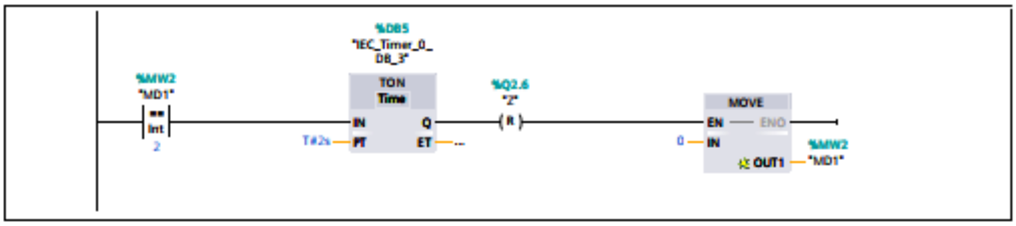


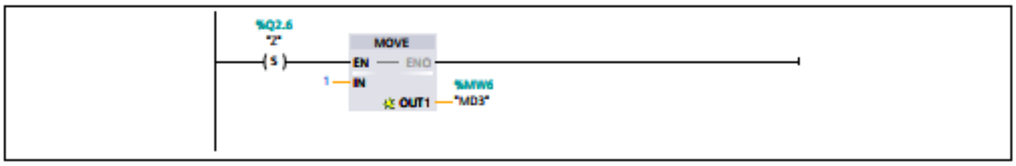
Program blocks

Pick from rack [FC7]

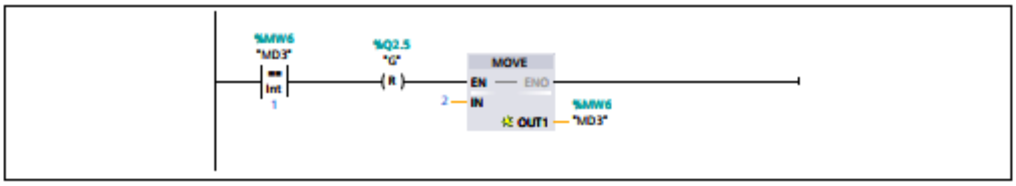
Pick from rack Properties					
General					
Name	Pick from rack	Number	7	Type	FC
Language	LAD	Numbering	Automatic		
Information					
Title		Author		Comment	
Family		Version	0.1	User-defined ID	

Name	Data type	Default value	Comment
Input			
Output			
InOut			
Temp			
Constant			
▼ Return			
Pick from rack	Void		

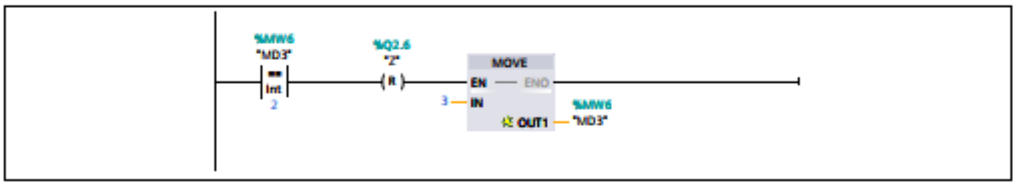
Network 1: extended Z cylinder



Network 2: gripper closed



Network 3: Retracting Z cylinder



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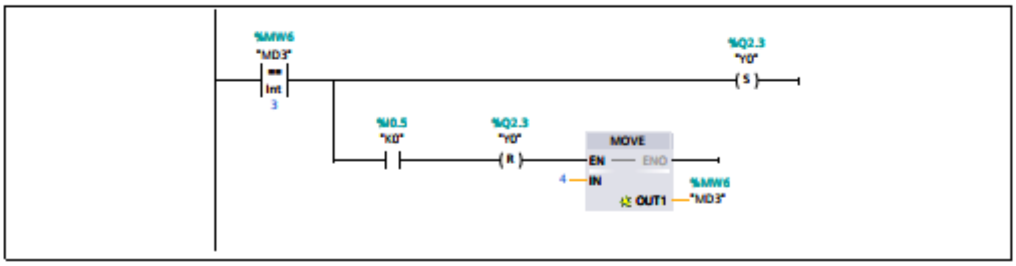
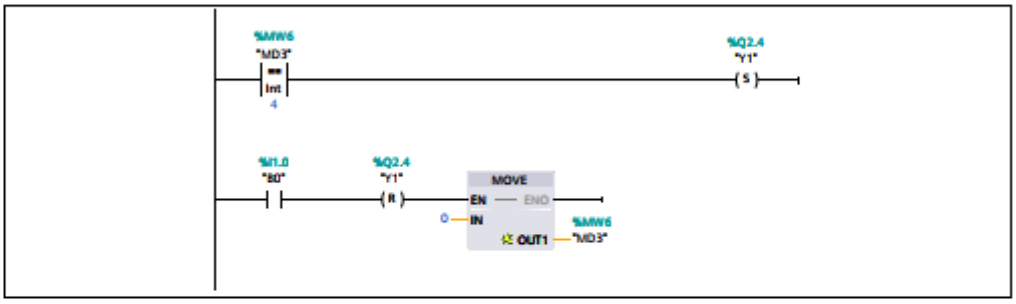
Network 4: motor 2 counter clockwise or go down



Network 5: motor 2 clockwise or go up



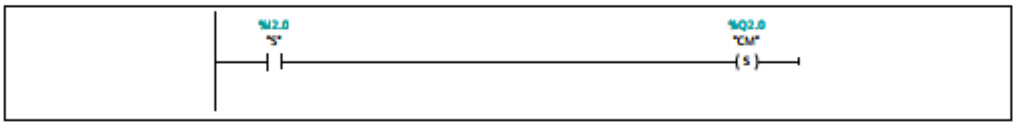
Program blocks

Conveyor program 2 [FC6]

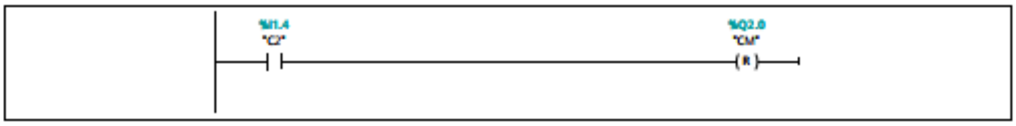
Conveyor program 2 Properties					
General					
Name	Conveyor program 2	Number	6	Type	FC
Language	LAD	Numbering	Automatic		
Information					
Title		Author		Comment	
Family		Version	0.1	User-defined ID	

Name	Data type	Default value	Comment
Input			
Output			
InOut			
Temp			
Constant			
▼ Return			
Conveyor program 2	Void		

Network 1: Conveyor motor



Network 2: Conveyor motor



Program blocks / System blocks / Program resources

IEC_Timer_0_DB [DB1]

IEC_Timer_0_DB Properties					
General					
Name	IEC_Timer_0_DB	Number	1	Type	DB
Language	DB	Numbering	Automatic		
Information					
Title		Author	Simatic	Comment	
Family	IEC	Version	1.0	User-defined ID	IEC_TMR

Name	Data type	Start value	Retain	Accessible from HMI/OPC UA	Writable from HMI/OPC UA	Visible in HMI engineering	Setpoint	Supervision	Comment
▼ Static									
PT	Time	T#0ms	False	True	True	True	False		
ET	Time	T#0ms	False	True	False	True	False		
IN	Bool	false	False	True	True	True	False		
Q	Bool	false	False	True	False	True	False		

Program blocks / System blocks / Program resources

IEC_Counter_0_DB [DB3]

IEC_Counter_0_DB Properties					
General					
Name	IEC_Counter_0_DB	Number	3	Type	DB
Language	DB	Numbering	Automatic		
Information					
Title		Author	Simatic	Comment	
Family	IEC	Version	1.0	User-defined ID	CNTR

Name	Data type	Start value	Retain	Accessible from HMI/OPC UA	Writable from HMI/OPC UA	Visible in HMI engineering	Setpoint	Supervision	Comment
▼ Static									
CU	Bool	false	True	True	True	True	False		
CD	Bool	false	True	True	True	True	False		
R	Bool	false	True	True	True	True	False		
LD	Bool	false	True	True	True	True	False		
QU	Bool	false	True	True	True	True	False		
QD	Bool	false	True	True	True	True	False		
PV	Int	0	True	True	True	True	False		
CV	Int	0	True	True	True	True	False		

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Program blocks / System blocks / Program resources

IEC_Timer_0_DB_2 [DB4]

IEC_Timer_0_DB_2 Properties					
General					
Name	IEC_Timer_0_DB_2	Number	4	Type	DB
Language	DB	Numbering	Automatic		
Information					
Title		Author	Simatic	Comment	
Family	IEC	Version	1.0	User-defined ID	IEC_TMR

Name	Data type	Start value	Retain	Accessible from HMI/OPC UA	Writable from HMI/OPC UA	Visible in HMI engineering	Setpoint	Supervision	Comment
▼ Static									
PT	Time	T#0ms	False	True	True	True	False		
ET	Time	T#0ms	False	True	False	True	False		
IN	Bool	false	False	True	True	True	False		
Q	Bool	false	False	True	False	True	False		

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Program blocks / System blocks / Program resources

IEC_Timer_0_DB_3 [DB5]

IEC_Timer_0_DB_3 Properties					
General					
Name	IEC_Timer_0_DB_3	Number	5	Type	DB
Language	DB	Numbering	Automatic		
Information					
Title		Author	Simatic	Comment	
Family	IEC	Version	1.0	User-defined ID	IEC_TMR

Name	Data type	Start value	Retain	Accessible from HMI/OPC UA	Writable from HMI/OPC UA	Visible in HMI engineering	Setpoint	Supervision	Comment
▼ Static									
PT	Time	T#0ms	False	True	True	True	False		
ET	Time	T#0ms	False	True	False	True	False		
IN	Bool	false	False	True	True	True	False		
Q	Bool	false	False	True	False	True	False		

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Program blocks / System blocks / Program resources

IEC_Counter_0_DB_1 [DB6]

IEC_Counter_0_DB_1 Properties					
General					
Name	IEC_Counter_0_DB_1	Number	6	Type	DB
Language	DB	Numbering	Automatic		
Information					
Title		Author	Simatic	Comment	
Family	IEC	Version	1.0	User-defined ID	CNTR

Name	Data type	Start value	Retain	Acces-sible from HMI/O PC UA	Wri ta-ble fro m HM I/O PC UA	Visible in HMI engi-neer-ing	Set-point	Super-vision	Comment
▼ Static									
CU	Bool	false	True	True	True	True	False		
CD	Bool	false	True	True	True	True	False		
R	Bool	false	True	True	True	True	False		
LD	Bool	false	True	True	True	True	False		
QU	Bool	false	True	True	True	True	False		
QD	Bool	false	True	True	True	True	False		
PV	Int	0	True	True	True	True	False		
CV	Int	20	True	True	True	True	False		