Sudan University of Science and Technology
College of Graduate Studies

Automation of Waste Segregation Via Sensors by Using PLC

أتمتة عزل النفايات بواسطة الحساسات بإستخدام الـمتحكم المنطقي القابل للبرمجة

A Thesis Submitted in Partial Fulfillment to the Requirements for the Degree of M.Sc. in Electrical Engineering (Microprocessor and Control)

Prepared by: Mazza Mergani Elhag Eljack

Supervised by: Dr. Mudathir Abdallah O. fagiri

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الآيـــــــة

قَالَ تَعَالَىٰ:

﴿ إِنَّا عَرَضْنَا ٱلْأَمَانَةَ عَلَى ٱلسَّمَٰوَٰتِ وَٱلْأَرْضِ وَٱلْجِبَالِ فَأَبَيْنَ أَن يَحْمِلْنَهَا وَأَشْفَقْنَ مِنْهَا وَحَمَلَهَا ٱلْإِنسَٰنُ ۖ إِنَّهُۥ كَانَ ظَلُومًا جَهُولًا ﴿٧٢﴾ ﴾

صدق الله العظيم

سورة الأحزاب الآية 72

Dedication

To my soul, the meaning of the life, who suffered difficulties to bring me what I want and make me happy… …lovely mother.

To the light that enlightens me path of success, who keeps looking after me ……Dear father.

To the person who supported me and encouraged me to do this work ……..... Dear uncle.

To who supported me and cared about my needs …….. my elder brother.

To those who are waiting for my success……my sister and youngest brother.

To the rest of my family whom gave me their blessing.

To whom I walked with them in the way of education…..friends.

To any person wished to get what I am but his situations avoided him.

Acknowledgment

All praises to Allah, The Most Gracious and The Most Merciful, Alhamdulillah, thanks Allah for endowing me with health, patience and knowledge to complete this work.

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Abstract

With the growing population rate, the amount of waste being produced is also increasing at a very fast rate. These days in our environment waste management is one of the major problems, the best solution has been proposed to solve this problem is segregating this waste and recycle it. But segregating it manually is complex, dangerous and utilizes more human efforts, cost and time.

The proposed system designed to separate five types of wastes into respective bins automatically by the sensing of different sensors (capacitive, inductive, proximity and photoelectric sensors) to detect any object which is moving on a conveyor belt with the help of hydraulic cylinders.

The programmable logic controller (PLC) used as main component and proposed system is simulated using Siemens Semitic S7-200 simulator and the results show that the system has been programmed successfully.

المستخلص

مع تزايد المعدل السكاني كمية النفايات المنتجة أيضاً متزايدة بمعدل سريع جداً. في هذه الأيام في بيئتنا إدارة النفايات من أكبر المشاكل، وأفضل الحلول المقترحة لحل هذه المشكلة هو عزل هذه النفايات وإعادة تدويرها. لكن عزلها يدوياً معقد، غير آمن ويحتاج المزيد من الجهود البشرية والتكلفة والزمن.

النظام المقترح صمم لعزل خمسة أنواع من النفايات الى السلات المناسبة لها أوتوماتيكياً بواسطة حساسات مختلفة (الحساسات السعوية، الحثية، التقاربية والكهروضوئية) موضوعة على حزام ناقل للحركة تقوم بإكتشاف أي مادة تمر فيه وذلك بمساعدة الأسطوانات الهيدرولكية.

المتحكم المنطقي القابل للبرمجة تم استخدامه كعنصر أساسي والنظام المقترح تمت محاكاته بواسطة سيمنز سيمتك (S7-200) والنتائج أثبتت أن النظام تمت برمجته بنجاح.

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Chapter One

Introduction

Chapter One

Introduction

1.1 Overview

Waste and rotten things will end up in landfill but uncontrolled dumping of waste on outskirts of towns and cities has created overflowing landfills which are not impossible to reclaim because of the haphazard manner of dumping. One possible solution for this problem could be managing the waste [1].

Waste management is the process of treating wastes and offers variety of solutions for recycling items that don't belong to trash. It is about how garbage can be used as a valuable resource. Waste management disposes of the products and substances that you have use in a safe and efficient manner.

Segregation is the process of separating biodegradable waste from non-biodegradable waste for proper disposal and recycling and it is the first step of waste management [2]. Efficient sorting of waste is a major issue in society. Selective sorting is another approach which is often implemented to improve recycling and reduce the environment. When the waste is segregated into simple stream such as plastic bottles, glass bottles, metal cans, tetra packs it in just doing that, separating this recyclable solid waste and putting them into individual bins so that they can be distinguished and used separately [3]. Nowadays there is an increasing awareness in society of the need to protect our fragile environment to ensure a healthy, safe and secure environment for all. So, it is very important to have some system to manage waste automatically. This thesis proposed an automatic waste segregator for segregating the waste at the disposal level itself. PLC helps us just doing that under harsh conditions.

1.2 Problem statement

The rising population rate causes a fast increasing in the amount of waste being produced, traditional way of manually monitoring the wastes in waste bins is a hazardous, unhealthy, complex, cumbersome process and utilizes more human effort, time and cost which is not compatible with the present day technologies in any way.

1.3 Objectives

This study aims to have developed control for waste segregation which results in energy savings, safety improvements, better environmental performance, consistent product quality, minimizes raw materials wastage and reduces manufacturing costs. The main objectives of this study are to:

- Design a PLC circuit, embedded with the waste segregation system.
- Simulate the system so as improve performance hardware to be implemented and tested.

1.4 Methodology

Objectives will be achieved by using programmable logic controller (PLC) as the main controller of the system with the help of five sensors, Hydraulic cylinder and conveyor belt to separate the waste.

System software simulation will be done using ladder diagram language software.

1.5 Thesis Layout

This thesis consists of five chapters including this chapter. Chapter two gives theoretical introduction about waste and literature review of many methods used to segregate it. Chapter three is about methodology of the system which describes over all work that has been successfully operated and the components used in this work. Chapter four discuses the simulation of system design and results, this chapter describes how the input and output circuit of plc should be understood and system approach

of control system design using programmable logic controller. Chapter five includes the conclusion and recommendations. References are in the end of this thesis.

Chapter Two

Background and Literature Review

Chapter Two

Background and Literature Review

2.1 Introduction

wastes are unwanted or unusable materials which involve any substance discarded after primary use, or it is worthless, and of no use, such as dusts, papers, glass, plastic, metallic materials and wet waste such as vegetables and fruit.

Due to modernization the amount of waste generated is increasing day by day. In the era of technology, new techniques are applied in almost every field but the basic areas of sanitation are left out. In most cases the garbage collection is still carried out in same traditional ways. Waste can be categorized such as mineral waste, organic/inorganic waste, radioactive waste, biomedical waste, agricultural domestic waste, etc. It is very difficult to segregate various types of waste. All the waste ultimately is being dumped into municipal bins, irrespective of its type.

The waste collection centers from where it is collected by the municipalities to be further thrown into landfills and dumping areas. Non biodegradable waste causes landfills. Improper disposal and management of solid waste affects all aspects of the society, namely physical, economical and environment.

Cleaning of garbage bin at proper intervals is necessary solution but manually monitoring them at regular intervals is a tedious job [4].

2.2 Waste Healthy Problems

Ignored waste in the surroundings invites flies, mosquitoes, rats etc. This leads to unhygienic conditions. Animals grazing on this waste or near such areas can pass on diseases through food chain. The waste which is not collected can clog storm water run-off leading to formation of sluggish and stagnant water bodies. These water bodies then become breeding space for

disease causing bacteria. Throwing waste near water bodies leads to contamination of water [4].

2.3 waste management

Considering the fact that the problem of efficient waste management is one of the major problems of the modern times there is an utmost need to address this problem. The proper waste management system is must for the hygienic society in general and for world as a whole. Solid waste which is one of the sources and causes of environmental pollution has been defined under Resource Conservation and Recovery Act as any solid, semi-solid liquid or contained gaseous materials discarded from industrial, commercial, mining or agricultural operations and from community activities. Solid waste also includes garbage, construction debris, commercial refuse, and sludge from water or waste treatment plants or air pollution, control facilities and other discarded materials [5].

Waste management is an important part of the urban infrastructures as it ensure the protection of the environment and of human health. It is not only a technical environmental issue but also a highly political one. Waste management is closely related to a number of issues such as urban life styles, resource consumption patterns, jobs and income levels and other socio-economic and cultural factors. One characteristic feature of sustainable waste management is that it is achieved by using the technical, organizational and financial resources available in a particular locality [6].

2.4 waste disposal

The vast majority of countries are busy struggling with such basic issues as ensuring sufficient collection services and implementing a minimal degree of control at disposal sites at the same time as they are facing increasing waste amounts due to the trend of urbanization. They also lack the technical and financial resources to safely manage solid

wastes which includes adequate provisions for sorting the waste at the point of generation as well as efficient and sufficient collection services. Final disposal in those countries is usually a matter of transporting the collected waste to the nearest available open space and then discharging them. The most improvement is the increased level of awareness among both the public and politicians. This is the first step to ensure that action is taken and resources are allocated accordingly. On the other hand the availability of resources is closely connected to the economic situation and waste management still holds a weak position in this context compared development is also closed linked to the generation of waste [6].

2.5 Pulverization

Pulverization is the name given to the mechanical treatment of solid wastes to break down the larger material and reduce the average particle size. Pulverization has been in use as a form of refuse treatment since the beginning of the 20th century. It has to be recorded that it is not a final treatment prior to some further process for example compositing, incineration, hydrolysis, recycling, refuse derived fuel, or landfill. The process has the effect of reducing the voids in solid wastes so that if the waste is used for landfill, the latter should be subject to far less settlement that formed from untreated waste. The result should be that in filled land will become stable in a shorter period and can therefore be put to use in a shorter time. There are two distinct types of process used to pulverize solid waste [6]. In the first, sometimes called the "dry" process in which the waste is broken down in hammer mills and in the second, sometimes called the "wet" process, the waste is broken down in a rotating drum with measured quantities of moisture.

Incineration is the name given to the practice of burring refuse under controlled conditions this method is a way of disposal waste but it is not a way to reused it. This method of waste disposal has been used early [6].

2.6 Composting

Composting is the name given to the method of speeding up the aerobic degradation of organic matter in refuse and as a method of refuse treatment for centuries. The process is biological and involves encouraging the growth of a biomass by conditioning the waste with moisture and nutrients. In some cases heat may also be added. The objective is to produce a stable product which has been useful as a soil conditioner. The mechanical composting of refuse has been used for many years. However, in the last 20 or 30 years there has been a dramatic reduction in the use of composting as a refuse treatment. This is due to the considerable costs of purchasing and running the equipment, and of the labor required to operate it. In addition to this, many local authorities having installed composting plants have discovered that there was no market for the sale of product [6].

2.7 Recycling

Most refuse contains a wealth of valuable raw materials that can easily reuse or recycle, to produce, new products. In general, recycling conserves not only material resources but fuel reserves as well. For example nearly twenty times as much fuel is needed to produce aluminum from virgin are as from scrap aluminum, and much energy is needed to manufactures steel and paper from virgin materials as from scrap [6].

In many cases, recycling operations also emit less pollution than the original Process. Significant quantities of contaminants are released when paper is manufactured form wood pulp or when metal is refined from ore. For example, both pulping plants and smelters discharge various sulfur compounds that foul the air and water. The Environmental Protection Agency recently estimated that recycling all the metal and papers in municipal trash. But not all items are reparable or reusable. A tire can be recapped only once with safety. At best recycling processes conserve both

energy and materials. However, not every item can be recycled efficiently. Recycling operations despite their theoretical appeal lose their effectiveness if waste is widely dispersed [6].

Minimization of waste requiring disposal is increasingly important as Available disposal options become more and more constrained, and particularly as more substances enter everyday use that are not readily decomposed in the natural environment and that can present long term hazards. The problem is typically associated with non biodegradable or bio accumulative substances such as waste pesticides, solvents, heavy metals, and chemical sludge. The need to avoid or minimize the release of complex organic or inorganic substances into the environment is all the greater because of uncertainty about their effects on human health and the natural environment and the very high costs of retrofitting or cleanup. Waste minimization comprises both avoidance and utilization. Avoidance refers to actions by producer to avoid generating the waste [6]. Utilization includes range of actions that make the waste a useful input to other processes, eliminating the need for disposal. Processes that reduce the toxicity or potentially harmful impacts of a waste can in some cases be regarded as minimization, although in other circumstances such changes represent treatment before disposal. Although the terminology used may vary, a number of important activities can be distinguished. Reuse refers to the repeated use of a "waste" material in a process (often after some treatment or makeup). Recycling refer to the use by one producer of a waste generated by another. Recovery is the extraction from a waste of some components that have value in other uses like biogas plant which gives gas as a result to be used in cooking. it uses vegetables and fruit market waste, fruit and food processing industries waste, domestic and institutional kitchen waste, paper, garden waste, animal and abattoir waste etc however the waste that cannot be treated and to be strictly avoided are

like plastic, glass, metal, and building materials, wood and cloth etc. therefore, have to ensure segregated waste before setting up the biogas plant [6].

2.8 literature Review

Literature survey says that the methods followed the traditional way play an important role in the collecting and disposing of urban solid waste. This process has its limitation and it waste time consuming as well. Rag pickers and conservancy staff have higher morbidity due to infections of skin, respiratory, gastrointestinal tract and multisystem allergic disorders, in addition to a high prevalence of bites of rodents, dogs and other vermin (This system is still in Sudan). Also there was no emphasis on waste segregation ,so segregating recyclable items from amongst other became a tedious task [3].

One of the automated works proposes an economic automated waste segregator using Arduino which is a cheap and easy to use solution for a segregation system at households, so that it can be sent directly for processing. It is designed to sort the refuse into metallic waste, wet waste and dry waste. The system uses two type of sensing mechanism to segregate waste into three different categories. An inductive proximity sensor is used to detect the metallic garbage and resistive plates segregate the waste into wet and dry category. This system can be made more efficient by using different sensors for different type of waste. More bins can be added to this project as per the demand of user [7].

Another system applies radio frequency identification (RFID).

Each waste material will have identical types of RFID tags that stores the information about the object along with which travels on conveyer belt. So whenever waste comes near the RFID reader it sends the vital information to the RFID reader [5].

Commands and information are exchanged between the RFID reader and RFID tags. This information is used to drop the each waste material in their respective bins. Later this information is conveyed to the arduino microcontroller for further processing. After interpreting the data received from the RFID reader it will be forwarded to remote master embedded system wirelessly. The Zigbee receiver is interfaced with the personal computer which the corresponded Waste material having the RFID tag which contents the all information about the product to be coded during manufacturing in the passive tag placed as there are a variety of the tags available to be attached with the material.

It is not viable as not all companies would add to their cost of applying RFID tags to their products thus implementation of such system is difficult and not economical [5].

Also we are dealing with waste products so to use RFID scanner like devices in such harsh and non-suitable condition would only add to the difficulty[5].

A simple 8051 microcontroller suggests segregating the waste into three major classes: dry, wet, metallic. The permanent magnets placed within the metallic bin further sorts ferrous and non ferrous metals.

The inlet section is provided with open and close mechanism to regulate the flow of waste on to the conveyor. Inductive proximity sensor is used to detect the metallic waste and signal from it initiates the push mechanism to discard the metallic waste. A blower mechanism is used to segregate dry and wet waste. The timing and movement of the conveyor belt is controlled by 8051 microcontroller. Continuous and unnecessary operation of any particular section is thus avoided [1].

But this work has limitations: Segregation of the waste consumes time, Size of the waste must be less than or equal to the dimension of the funnel E waste and Sanitary waste and medical waste cannot be segregated by the

proposed system as there are certain rules and regulations specified by government to be followed for their segregation. The magnetic metals attached to the permanent magnets must be scraped out manually from the metallic bin [1].

The Atmel AT89C52 introduced with the help of IR sensor and metal detector to control automatic waste separator. The proposed system sorts wastes into three different categories, namely metal, dry and the wet waste. The program Developed for functioning of microcontroller 8051 and build in vision with no errors. Dumped code after the preparation of hardware required for the proposed system using flash magic software. The detector of waste as metal or non metal is done by dumping them into hardware design kit and verified for many objects call into the system [8].

A programmable logic controller proposed to control sorting machine this work is a fundamental approach to modeling a manufacturing and automated machines. the sorting sensors, conveyors and other accessories were proper for sorting machine modeling In general, it is recommended that capacitive sensors be used for sorting of complex manufacturing of objects with different chemical properties.. It is also observed that the PLC is necessary for the logic programming of the sorting machine. Each object was sorted correctly into plastic, wood and steel objects respectively. The driving range and the speed of the object depend mainly on the control of the PLC and the sensitivity of the sensor that could be adjusted to a suitable distance between object sensor detection distances.

It is recommended that this model be extended to include other types of sensors and objects of different material to ensure repeatability and model consistency [9].

This paper proposes implementation of an automated waste segregator at household level using PIC16F877 microcontroller, to control the entire process with ease and simplicity. The sensing unit consists of an IR

(Infrared) sensor, a moisture sensor and a metal sensor and the segregation bin. Results have presented segregation of waste into metal, wet and dry waste The mechanical assembly is quite elementary. It consists of vertical arrangements with three subdivisions i.e. waste detection, metal sensing/moisture sensing section (for metal and dry/wet waste) and the segregation section. Foremost of all, IR sensor marks the introduction of waste when waste comes in proximity of it. After identifying the entry of waste, metal sensing section starts with a 'flap opening' through which garbage goes into the assembly. The waste to be segregated comes in contact with the inductive oscillator circuit mounted in metal sensing section which monitors high frequency current loss in the coil [10].

Also another system proposes to segregate the dry waste and wet waste at the household level. The level of the garbage collected in the container is monitored using ultraviolet sensor. This is monitored at the control system office. Adding to it, a zonal area around the roadside garbage container is created using the load sensor concept, to monitor if garbage spills out of the container. In the result the sensor at the container unit detects the levels of the garbage collected in the container. The garbage level in the container is displayed at the control unit. The control unit carries out regular monitoring of the garbage level and accordingly empties it when full. Also indication at the container that garbage has been spilled out is given by using the concept of weight sensor. when the garbage in the container is full a message to the control unit is sent through RF and is displayed at the control unit. The indication of dry and wet waste is also given at the society unit. Also, when garbage spills out of the container in the zonal area created, a buzzer indication is given to clean the zonal area [11].

Another work proposes An Economic Automated Waste Segregator (AWS) used LPC 2138 with the help of IR sensor, capacitive sensor, metal detector, and LDR + laser glass detector. Waste is pushed through a flap

into the proposed system. An IR proximity sensor detects this and starts the entire system. Waste then falls on the metal detection system. This system is used to detect metallic waste. After this the object falls into the capacitive sensing module. This module distinguishes between wet and dry waste. After this the object falls into LDR+LASER for sensing plastic waste. After the identification of waste, a circular base which holds containers for dry. Wet and metallic waste is rotated. The collapsible flap is lowered once the container corresponding to the type of garbage is positioned under it. The waste falls into the container and the flap is raised. The waste in the containers now can be collected separately and sent for further processing. From the result the designed system sorts the refuse into metallic waste, wet waste, dry waste, plastic waste [12].

To overcome the drawbacks from all these methods PLC based system is proposed due to inherent advantages like modular design, provision to make required short-term adjustments without having a large impact on the whole system, flexibility, cost, less wiring etc. The proposed work presents automatic system using PLC where IR, moisture, photo-electric, inductive and capacitive sensors are interconnected with PLC in such a manner so that they function in a proper sequence to detect the materials moving continuously on the conveyor belt. Hydraulic cylinder will push the waste to different collecting bins which are placed exactly opposite to sensor position so as collect the wastes which can be further used as organic powder or recycled [2].

Chapter Three

Methodology

Chapter Three

Methodology

3.1 Introduction

The process begins with the waste collection and dumping all this into a large funnel.

At the output of this stage, the waste starts moving on to the long conveyor belt installed. Initially, conveyor starts moving only when the IR sensor is sensed. Further, upon sensing of individual sensors attached at different locations along the belt, the conveyor belt halts for about 10s and then respective hydraulic cylinders are energized and waste material is pushed to respective bin. Note that at a time only one sensor can sense. Fan will help in collecting the small dust particles and other minute things into a chamber fixed exactly opposite to it but it is out of the programming system. There is an additional bin at the end of the conveyor belt will consist any material does not affected by the sensors.

This section, will describe the block diagram of the system. Figure 3.1 shows the proposed block diagram based on which the interfacing of various inputs and outputs is done with the PLC.

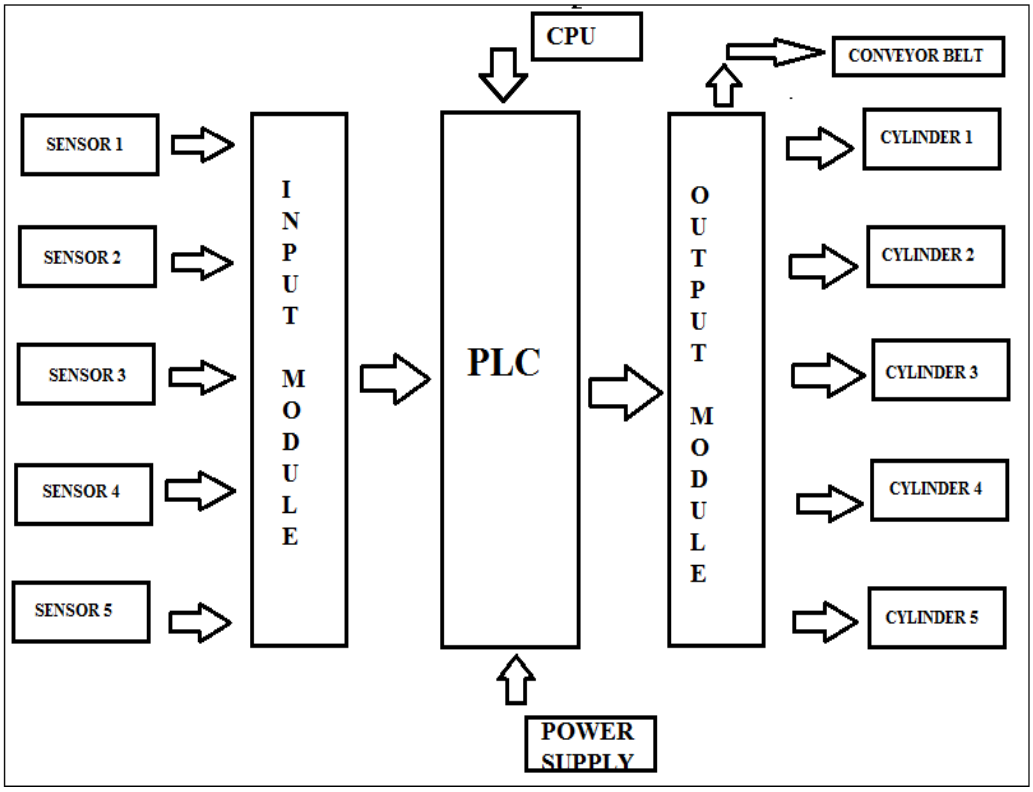


Figure 3.1 proposed network model

According to the previous mentioned figure, there are three main systems involved. One is the input module to which the wet waste detecting, object detecting, metal, plastic, glass and paper detecting sensors are interfaced. Along the conveyor belt these all are appropriately arranged with the respective hydraulic cylinders below them and the collecting bins in-front. High speed blowing fan is also used to blow away the dust particles and other light weight materials into a collector placed exactly opposite to it. Second one which is the heart of whole system is PLC which processes the signals from input modules and performs actions according to the logic diagram written for it.

The last one is the output module interfaced with the output giving devices. In our case, conveyor belt which starts running as soon as the IR sensor is actuated and cylinders which will expand to act as a flap to push waste into bin.

3.2 Hardware in the system

Here are the components of this work.

3.2.1 Programmable Logic Controller (PLC)

A Programmable Logic Controller (PLC) is a standard industrial control device that provides a simple yet robust method of controlling, manufacturing and dynamic processes. PLCs were first developed by Information Instruments, Inc. (acquired by Allen-Bradley in 1969). The compact physical structure of PLCs significantly reduced the space taken by previous physical components (relays, timers, etc.). Instead of building a large mechanical setup of components to control a process, the same "components" could be dragged-and-dropped in a computer interface, saving setup cost and time as well as long-term maintenance and simpler wiring. The software language created for PLCs, called "ladder logic", retained a very similar look to the wiring diagrams that were used for the physical components it replaced. PLCs are heavily used by industry because of their low cost, adaptability, and reliability, PLCs are by far the most common control mechanism used by manufacturing businesses of all sizes for environment control, food processing, motion control, and automated test equipment [13].

Figure 3.2 Onboard input/output modules of PLC.

3.2.2 IR Sensor

An infrared sensor is a device (usually with supporting circuitry) that can detect infrared light for use to a purpose. Most of the remote controls for TVs

and other entertainment equipment use infrared energy as the transmission medium to carry information between the control and the equipment to be operated. Infrared sensors also have important scientific, military, security and rescue applications since they can "see" the "radiant heat energy" which is infrared radiation. The "heart" of the system per the question is a photo detector or photo sensor. And it does its thing based on black body radiation, which it the emission of energy based on the temperature of the object. As the radiant energy is a direct function of temperature, even the slightest difference in temperature results in the radiation of a slightly different wavelength of infrared light. The infrared radiation falls on the sensor (there are a bunch of different kinds and a range of operating frequencies and bandwidths depending on application) and, through photoelectric effect, changes the "nature" of the chemistry/physics of the

photosensitive material. This is seen by supporting electronics as a change of resistance which changes current or voltage in the circuitry according to the way it was designed.

An IR proximity sensor works by applying a voltage to a pair of IR light emitting diodes (LED's) which in turn, emit infrared light. This light propagates through the air and once it hits an object it is reflected back towards the sensor. If the object is close, the reflected light will be stronger than if the object is further away. The sensing unit in the form of an integrated circuit (IC) detects the reflected infrared light, and if its intensity is strong enough, the circuit becomes active. When the sensing unit becomes active, it sends a corresponding signal to the output terminal which can then be used to activate any number of devices [14].

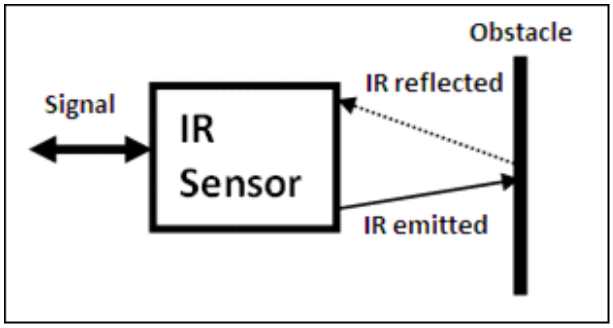


Figure 3.3 Working of IR sensor

The main motto of this sensor in this work is to detect the presence of any object on the conveyor belt by emitting the infrared radiations. When the object is detected, it will signal the PLC to start the conveyor if the start button is made on already.

3.2.2 Moisture Sensor

This sensor is used basically to separate the organic waste (wet) from dry waste.

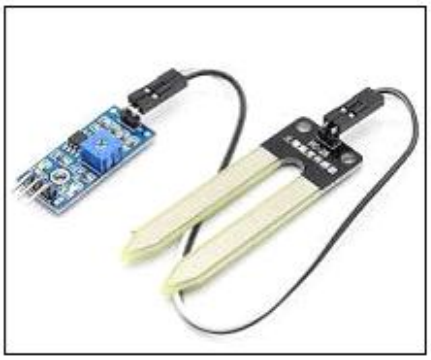


Figure 3.4 Moisture sensor

Therefore, it is placed at the beginning of the conveyor belt. It measures the change in electrical impedance. When the water vapor is absorbed, the ionic functional groups get dissociated and the electrical conductivity will increase due to conductive polymer [2].

3.2.3 Inductive Proximity Sensors

Inductive proximity sensors operate under the electrical principle of inductance. Inductance is the phenomenon where a fluctuating current, which by definition has a magnetic component, induces an electromotive force in a target object. To amplify a device's inductance effect, a sensor manufacturer twists wire into a tight coil and runs a current through it. Inductive Proximity Sensors being contactless sensors can be used for position sensing, speed measurement, counting, etc. They can be used in extreme conditions, such as oily, dusty, corrosive environment. Their application ranges from Automobile Industries to Steel Industries, from CNC/NC machines to material handling equipment, process automation, conveyor systems, and packaging machines.

The inductive proximity sensor can be used to detect metallic targets only. The main components of the inductive proximity sensor are coil, oscillator, detector and the output circuit. The coil generates the high frequency

magnetic field in front of the face. When the metallic target comes in this magnetic field it absorbs some of the energy. Hence the oscillator field is affected. This is detected by the detector. If the oscillation amplitude reaches a certain threshold value the output switches.

The inductive proximity sensor works better with ferromagnetic targets as they absorb more energy compare to non-Ferromagnetic materials [14].

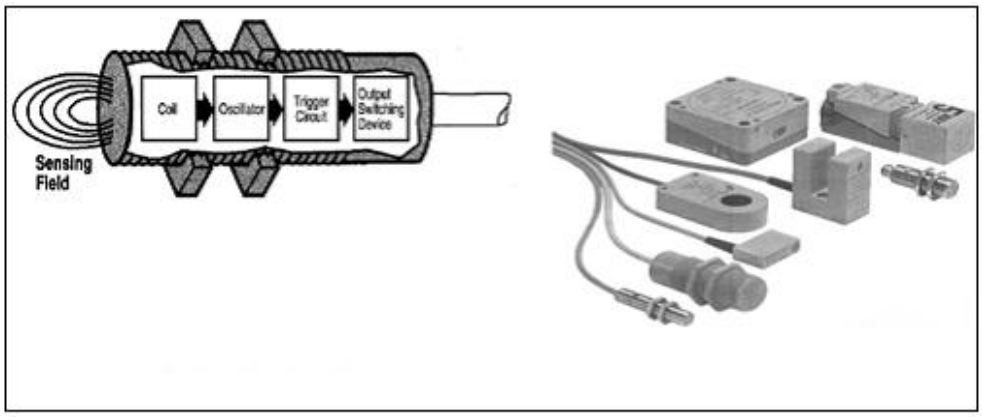


Figure 3.5 Inductive sensor

Inductive proximity sensors operate on the principle that the inductance of a coil and the power losses in the coil vary as a metallic (or conductive) object is passed near to it. Thus, is used to sense the metallic wastes and is Insensitive to non-metallic waste.

3.2.4 Photoelectric Sensor

Photoelectric sensor with built- in amplifier for detecting clear plastic bottles. Reliable detection of transparent objects including thin walled clear, plastic bottles. Uses OMRON's unique optical system ("Inner View") that can detect various shapes of clear, plastic bottles

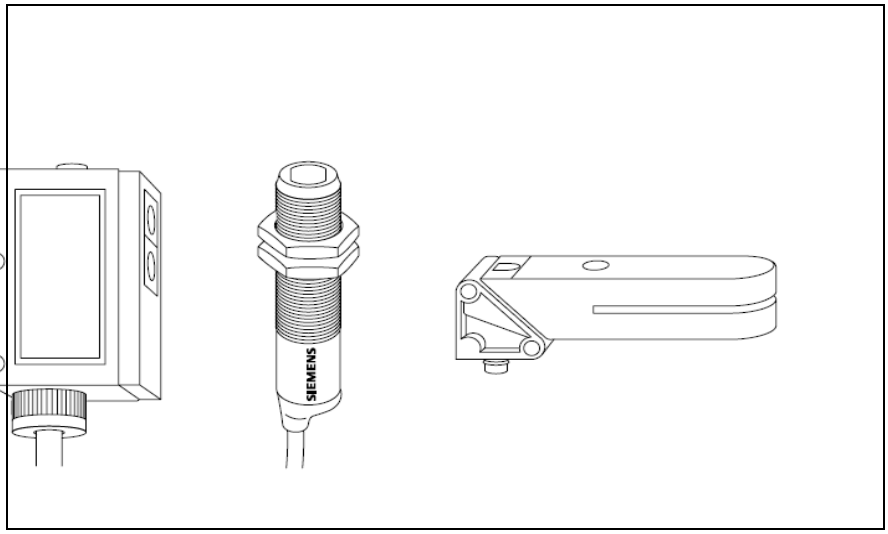


Figure 3.6 photoelectric sensor

Here in this system it used to detect plastic, it detects a wide range of bottles from 500-ml bottles to 2-l bottles, and from single bottles to sets of stocked bottles. Provides a high degree of protection (IP67) mutual interference prevention and EN standard compliance [3].

3.2.5 Proximity Capacitive Sensor

Capacitive proximity sensors use the face or surface of the sensor as one plate of a capacitor, and the surface of a conductive or dielectric target object as the other.

The capacitance varies inversely with the distance between capacitor plates in this arrangement, and a certain value can be set to trigger target detection. The sensing surface of a capacitive sensor is formed by two concentrically shaped metal electrodes of an unwound capacitor. When an object nears the sensing surface it enters the electrostatic field of the electrodes and changes the capacitance in an oscillator circuit. As a result, the oscillator begins oscillating. The trigger circuit reads the oscillators amplitude and when it reaches a specific level the output state of the sensor changes.

As the target moves away from the sensor the oscillator's amplitude decreases, switching the sensor output back to its original state [14].

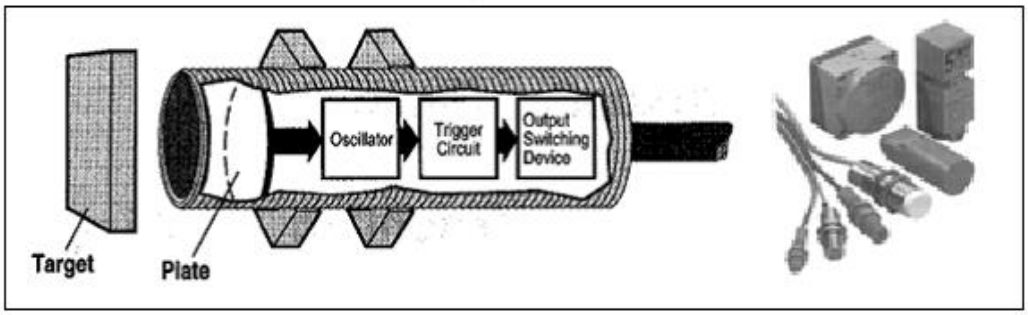


Figure 3.7 Capacitive proximity sensor

The principle of operation of the sensor is that an internal oscillator will not oscillate until a target material is moved close to the sensor face. The target material varies the capacitance of a capacitor in the face of the sensor that is part of the oscillator circuit.

3.3 Conveyor Belt

A continuously moving conveyor belt is used to which the different object detecting sensors are attached. The materials move over this and are put into respective bins after the sensing mechanism is over with the help of hydraulic cylinders [2].

3.4 Hydraulic Cylinders

The hydraulic pressure in these cylinders is in the form of hydraulic fuels that are stored under pressure in. The energy stored in these oils is converted into motion. In a complete hydraulic system, a hydraulic motor consists of one or more hydraulic cylinders. A pump regulates the oil-flow in the hydraulic system. The hydraulic cylinders initiate the pressure of the oil, which cannot be more than that required by the load. In single acting cylinders the fluid is pressurized from only one side of the cylinder during both the expansion as well as the retraction process. A spring or an

external load is used to return the cylinder top to its original position i.e. when pressure of the fluid is cut off. We are using this hydraulic cylinder as mechanical flap to route the particular waste to its respective bin [3].

Fig 3.8 Hydraulic cylinder

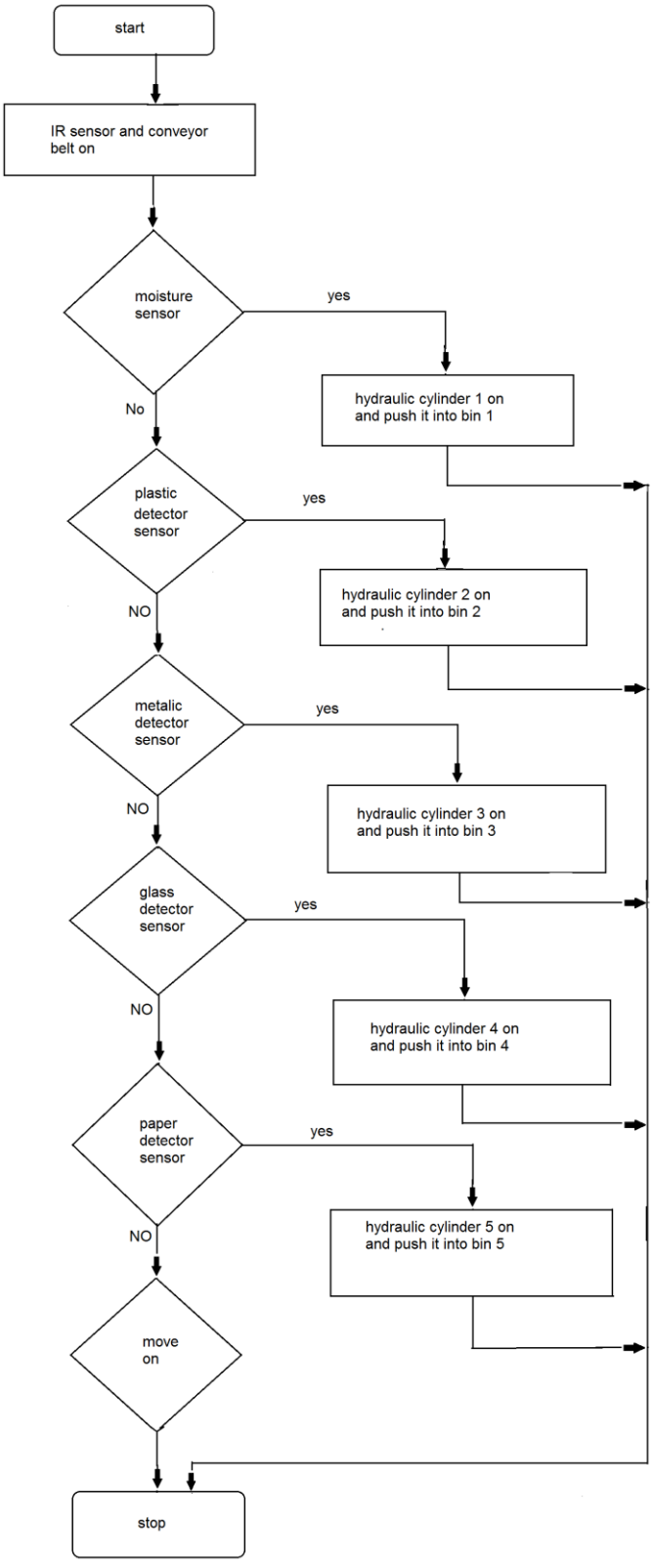


Figure 3.9 flow chart of the system

3.3 Software Programming

Software used for programming this work is Micro Win 32 Step 7 Version 4.0 -Siemens Semitic Industrial Software PLC Programming (Ladder Logic). Micro Win program shape is like figure 3.11 which appears after open the program.

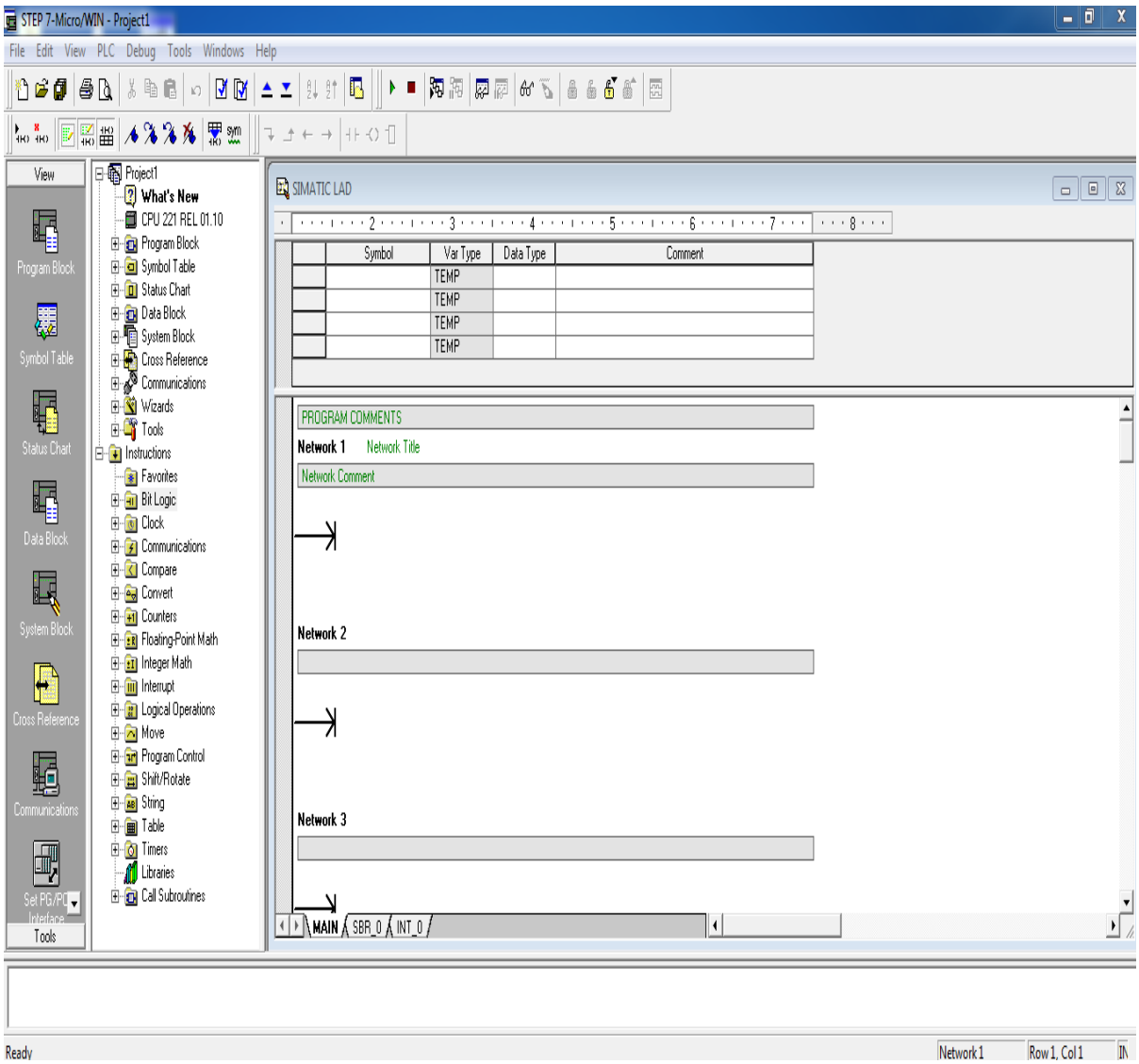
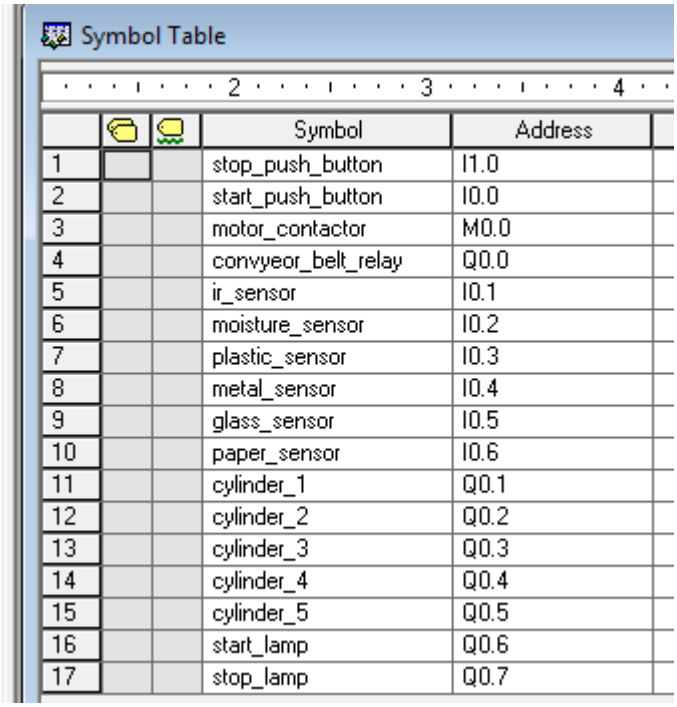


Figure 3.10 the main page of the program

Writing structures in ladder diagram depends on networks which starts with line from the DC voltage source (24v) and ends with the neutral line (0v) in between single or multi inputs.

Siemens has a specific way for addressing inputs and outputs, Inputs start with the letter (I) followed by two numbers (byte, bit in series) and dot between them like (I0.0) and the same for outputs with replacing the letter (I) by (Q) like (Q0.0) and figure 3.12 consists addresses of all inputs and outputs (except timers) in this work.



Symbol Table

	Symbol	Address
1	stop_push_button	I1.0
2	start_push_button	I0.0
3	motor_contactor	M0.0
4	convyeor_belt_relay	Q0.0
5	ir_sensor	I0.1
6	moisture_sensor	I0.2
7	plastic_sensor	I0.3
8	metal_sensor	I0.4
9	glass_sensor	I0.5
10	paper_sensor	I0.6
11	cylinder_1	Q0.1
12	cylinder_2	Q0.2
13	cylinder_3	Q0.3
14	cylinder_4	Q0.4
15	cylinder_5	Q0.5
16	start_lamp	Q0.6
17	stop_lamp	Q0.7

Figure 3.11 Inputs and outputs addresses in the program

Other items work as output are timers and in this study needed two types, the first one is off delay timer which is normally active after running the system on but it will start calculating the set time only if the power cut off from it. The second type is on delay timer which will start calculating the set time when the current deliver to it.

Figure 3.13 explain how on and off delay timers work.

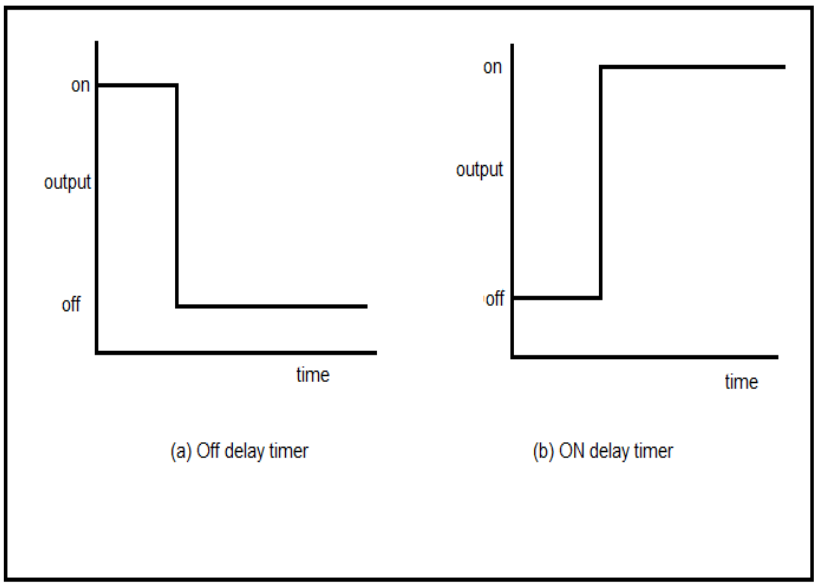


Figure 3.12 on and off delay timers working

Timers have time base it can be (1ms, 10ms, 100ms,…etc) to adjust the set time choose the preset time that in need and multiple it with the time base, for example if time base is 100ms and 5s in need for preset time that means set (PT) equal 500s. Shape of the timers in ladder diagram (step 7 200) is like figure 3.14.

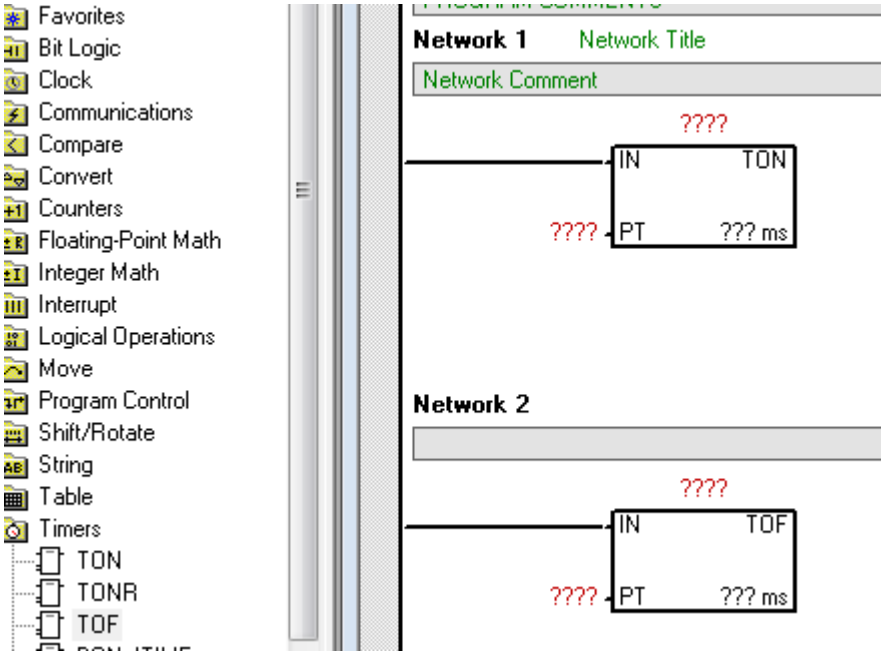
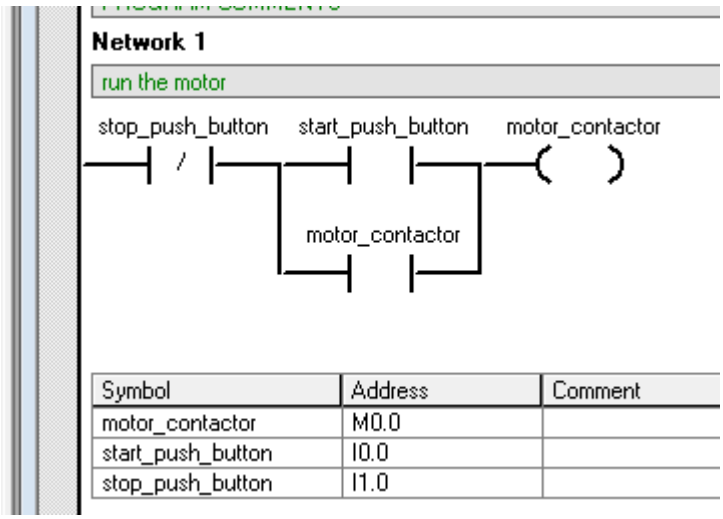


Figure 3.13 Shape of timers in the ladder diagram

The program consists of twenty networks in parallel begins with the motor coil as the first output which all of the sequences depend on it and it will run when we switch on the start push button with latch from its coil to keep it on except if we switch it off like figure 3.15.



Symbol	Address	Comment
motor_contactor	M0.0	
start_push_button	I0.0	
stop_push_button	I1.0	

Figure 3.14 Network 1 start and stop the motor

Then if the IR sensor detects any material the conveyor belt will run and if we switch the motor off the conveyor belt will delay switching off for

short time (about 30s) because of the off delay timer which in the second network. This timer to make sure that the last substance on the conveyor belt has been arrived to its respective bin and that is clear in figure 3.16.

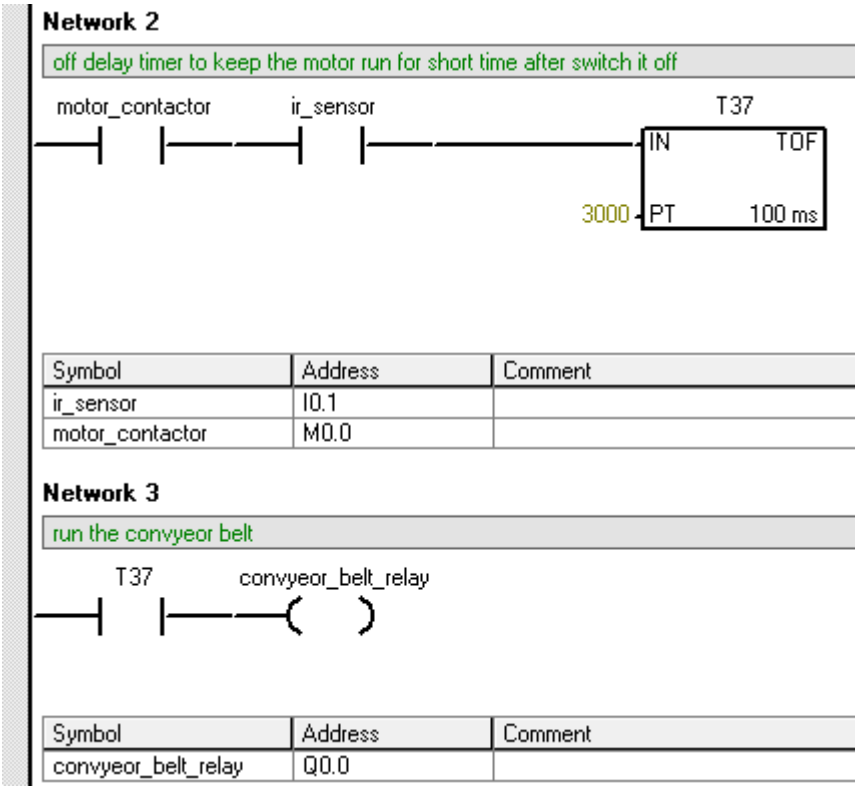


Figure 3.15 Networks for running the conveyor belt relay

After detecting existence of any substance and the conveyor belt moved on, every other sensor in the system senses a special type of material and sends signal to its respective cylinder to open and push the specific material into the opposite bin. The signal from sensor will arrive to an on delay timer first the timer halts about 5s and then the cylinder will be active with activating an off delay timer at the same time to wait for the specific material to arrive to the cylinder position

and fell down in the respective bin, that time is about 10s because there is a short distance between sensor and its respective cylinder position about

10cm .the method of running and stopping every cylinder by its sensor and timers is clear in figure 3.17.

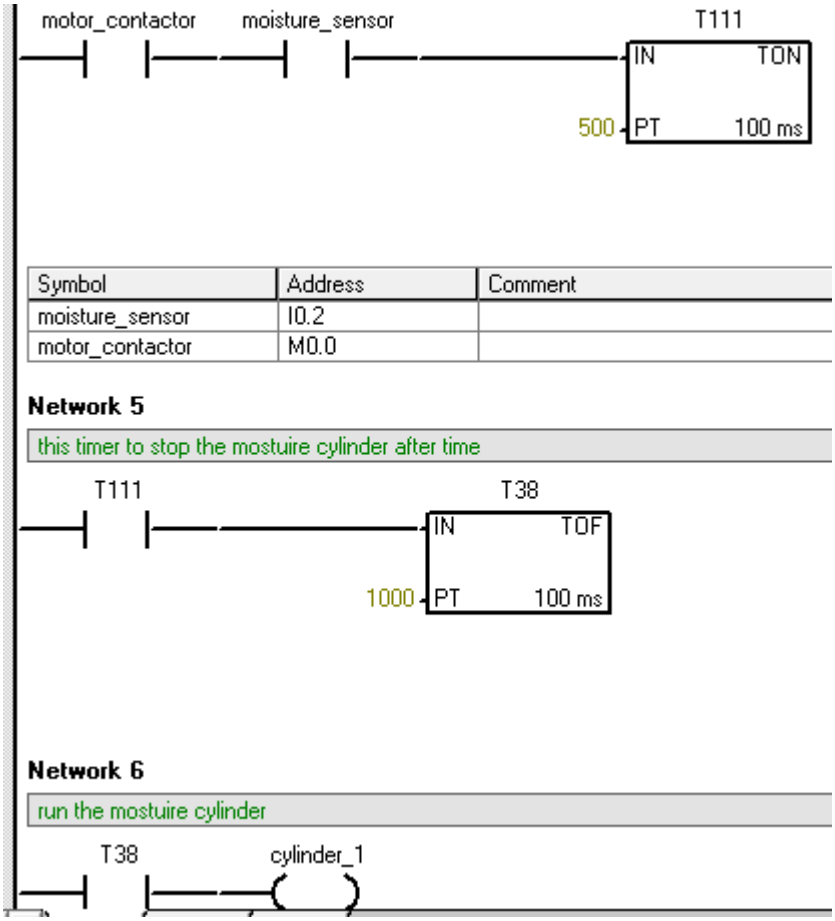


Figure 3.16 Networks for run the moisture cylinder

The same sequences will be for all cylinders (2, 3, 4, 5) as shown in appendix (A, B, C, D) respectively.

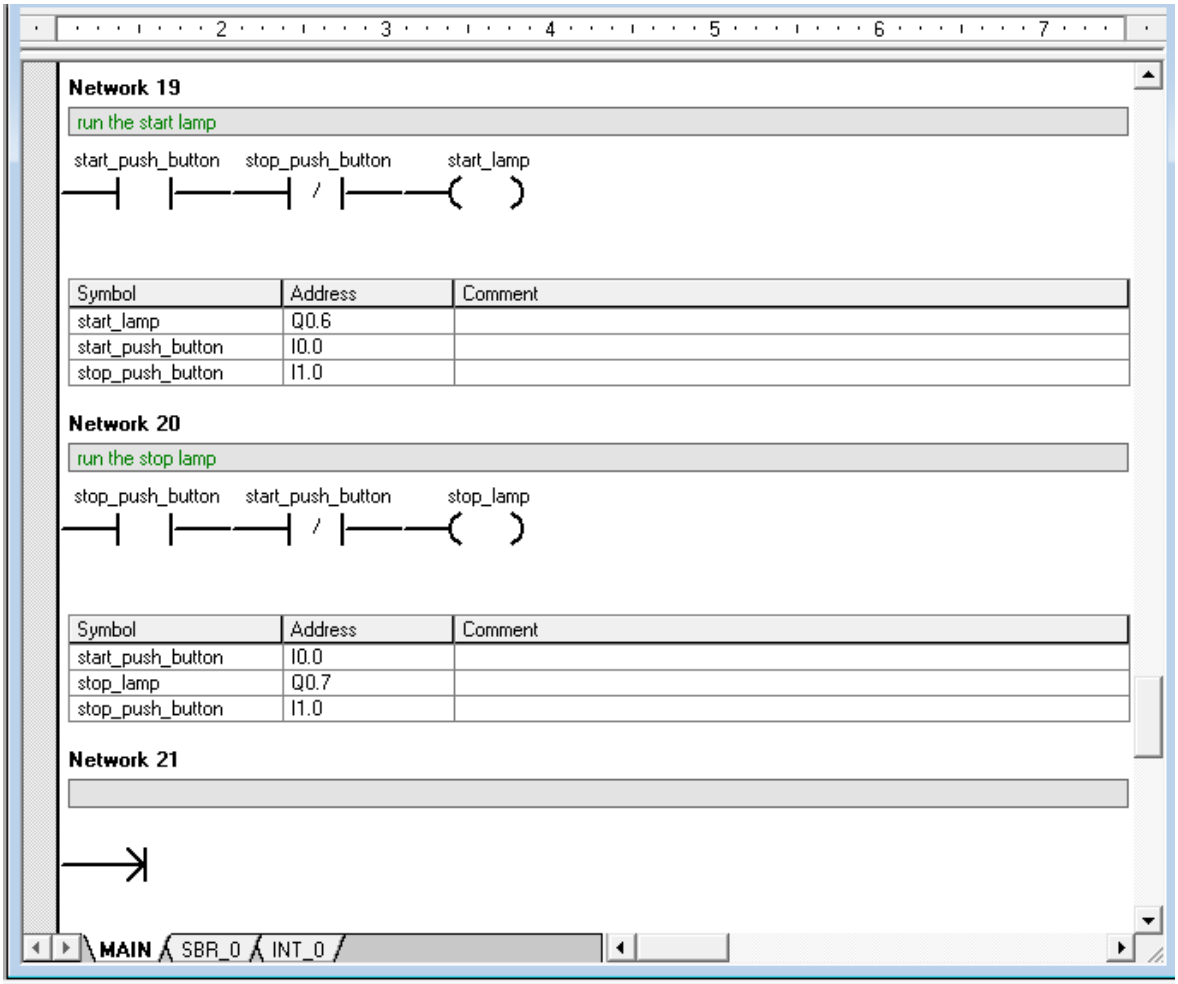


Figure 3.17 start and stop indicators programming

There is starting lamp to indicate that the motor start push button is on, it programmed with normal open contact from start push button and normal closed contact from stop push button. Stop lamp programmed with normally closed contact from start push button and normally open contact from stop push button as shown in figure 3.17 above.

Chapter Four

Results and Discussions

Chapter Four

Results and Discussions

4.1 Introduction

After programming the system it must save and compile the errors, if there is an error program must be corrected till total errors will be zero, then export it to step7- 200 simulator to test it and show the results.

This section discus all outputs reactions which happened according to specific actions have given to the inputs before.

These reactions made the outputs either active or not active, in another word either on or off.

Changing outputs situations happen immediately or may take time because major of inputs depend on timers.

4.2 Inputs and Outputs Addresses

The table 4.1 below shows the whole addresses in the program.

Table 4.1 inputs and outputs addresses:

Input / output	Address
Stop push button	I1.0
Start push button	I0.0
Motor contactor	M0.0
Conveyor belt relay	Q0.0
IR sensor	I0.1
Moisture sensor	I0.2
Plastic sensor	I0.3
Metal sensor	I0.4
Glass sensor	I0.5
Paper sensor	I0.6
Cylinder 1	Q0.1
Cylinder 2	Q0.2
Cylinder 3	Q0.3
Cylinder 4	Q0.4
Cylinder 5	Q0.5
Starting lamp	Q0.6
Stopping lamp	Q0.7
On delay timers	T111, T112, T113, T114, T115
Off delay timers	T37, T38, T39, T40, T41, T63

On the simulator first load the program then put the PLC in the run mode; the program will open as in the figure 4.1.

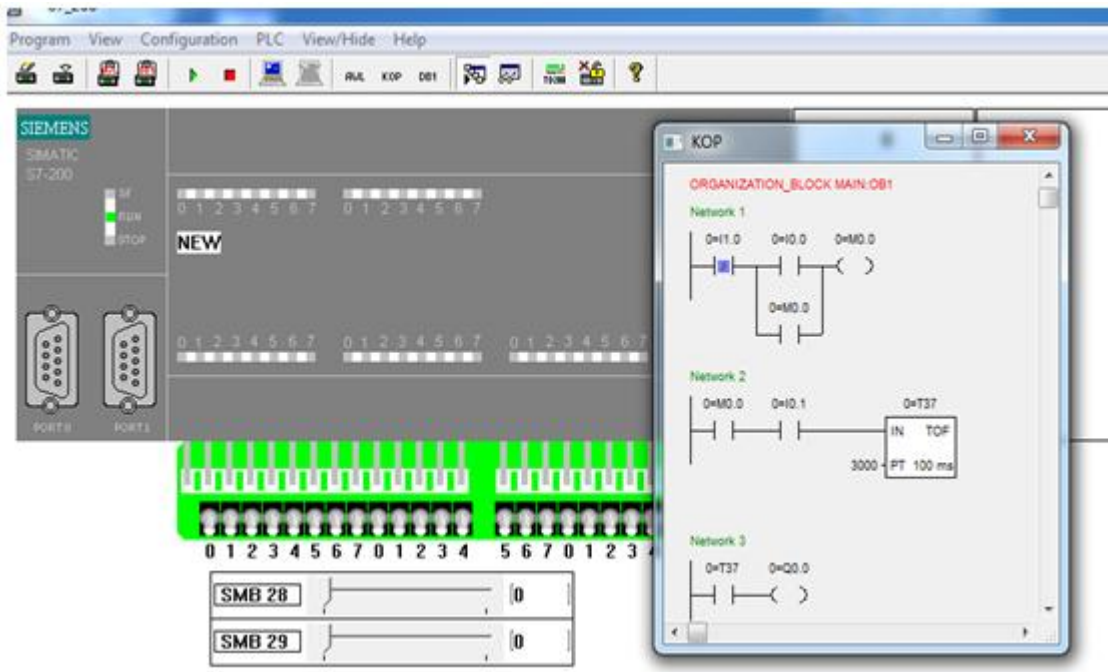


Figure 4.1 S7-200 simulator after load the program

Outputs are on the upper left side affected by inputs under them (the green panel). By defaults outputs activate with the number one plus blue color inside the program on the right side and green color outside.

4.3 Activating the Conveyor Belt

For testing first press the switch number one which refers to the start push button (I0.0) and the result is activating the motor coil (M0.0) and figure 4.2 shows that.

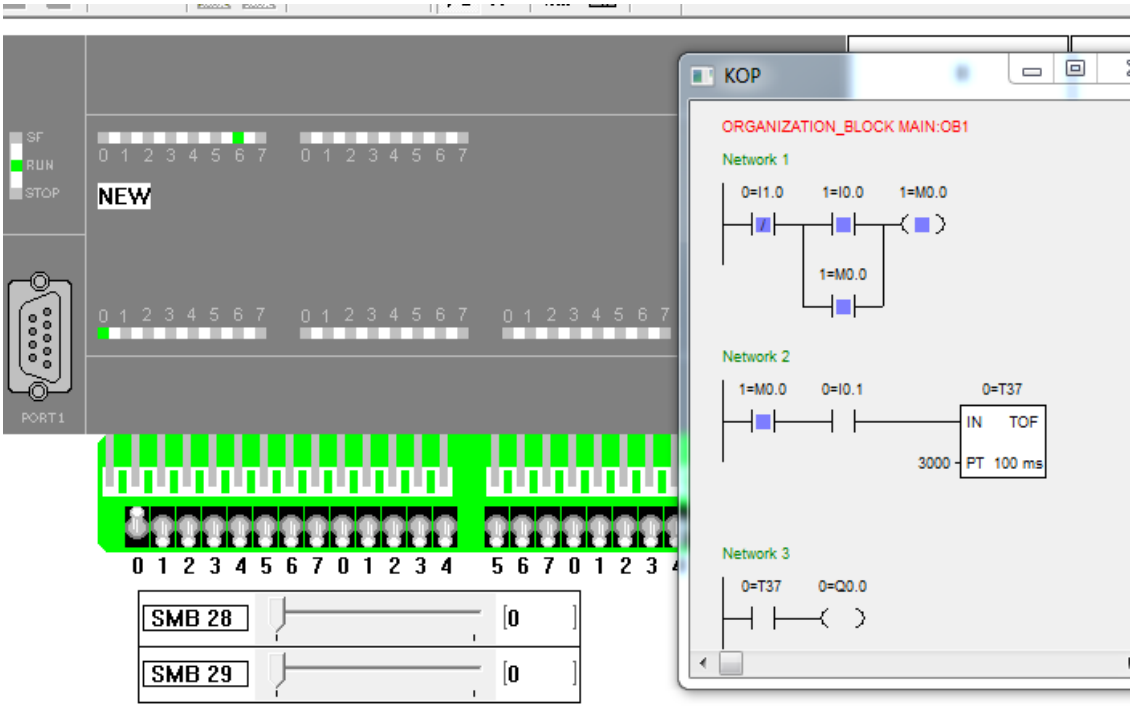


Figure 4.2 activating the motor coil

It became on but the conveyor belt (Q0.0) still off, it must be on after IR sensor (I0.1) gets any material and we test that by pressing the contact number two (I1.0) and make it on. The result is (Q0.0) will be active as in the figure 4.3.

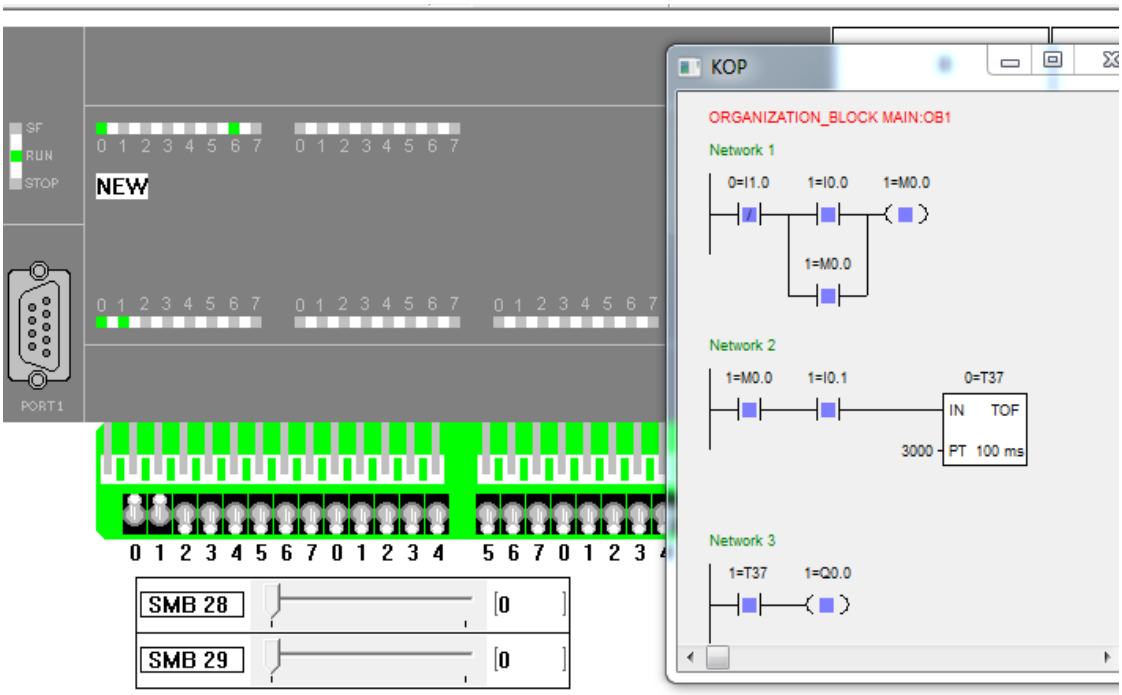


Figure 4.3 activating the conveyor belt relay

4.4 Moisture Cylinder

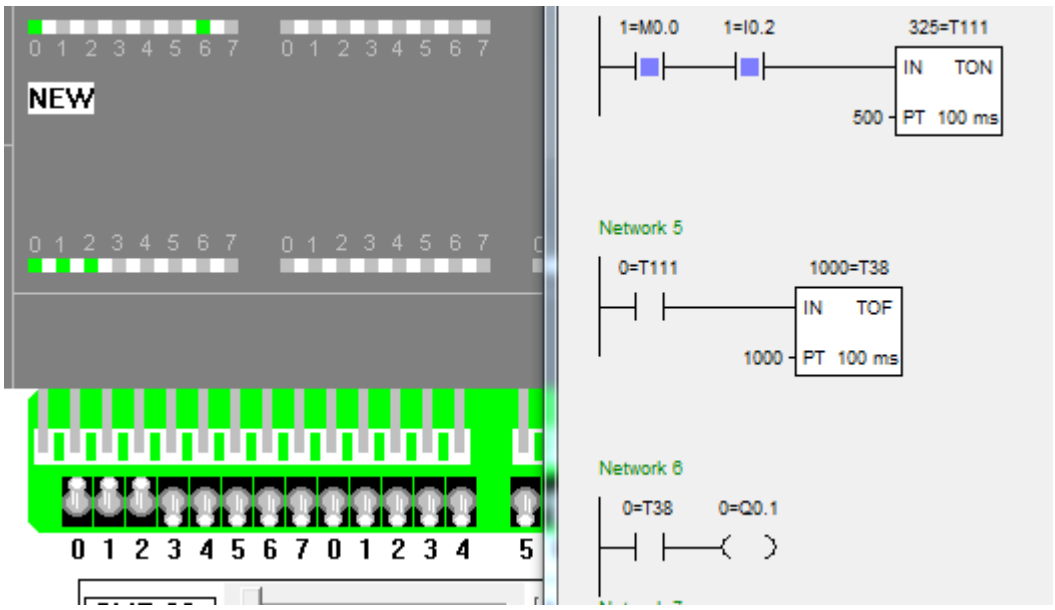


Figure 4.4 Activating T111 for the moisture cylinder

If the detected material is wet, the on delay timer (T111) will start counting and nothing will change till complete its time. This will test by pressing (I0.2) and put it on and the result as in figure 4.4 above.

After on delay timer (T111) completes its calculating, off delay timer (T38) will activate and deliver the current immediately to the cylinder (Q0.1) as shown in figure 4.5.

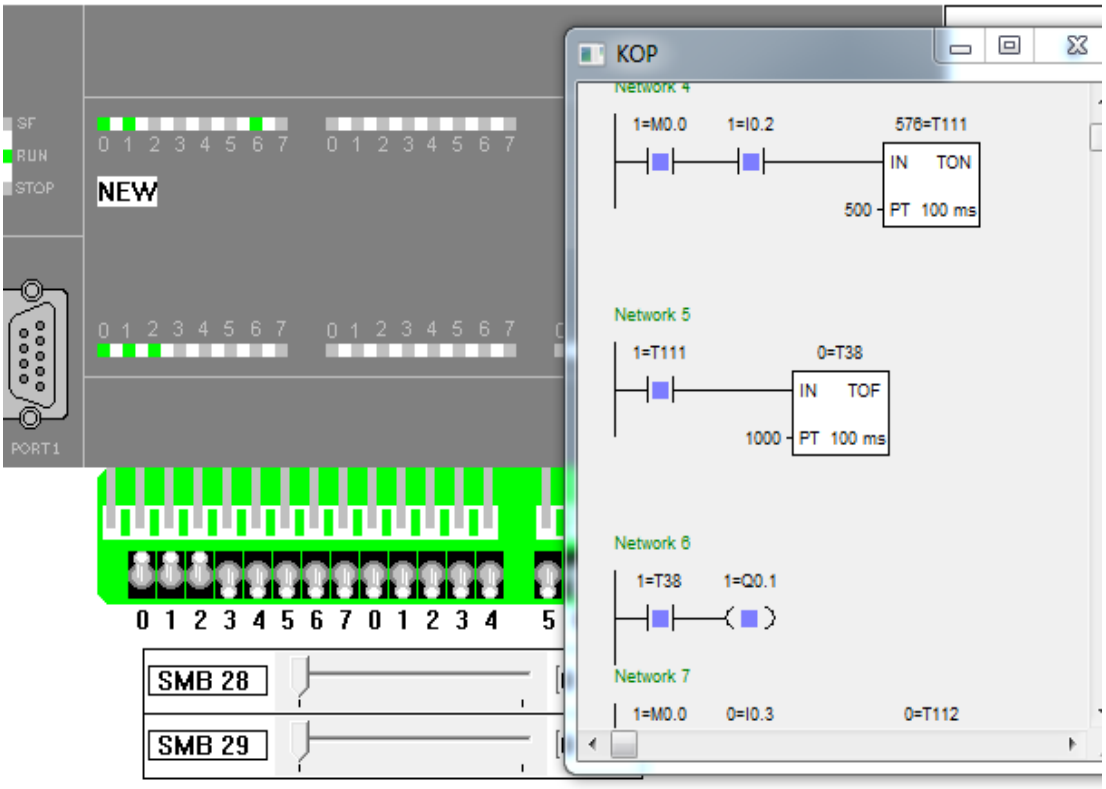


Figure 4.5 Moisture cylinder is on

When the wet material becomes out of the sensor region T38 will start counting its time. This case tested by press (I0.2) again and put it off as in figure 4.6.

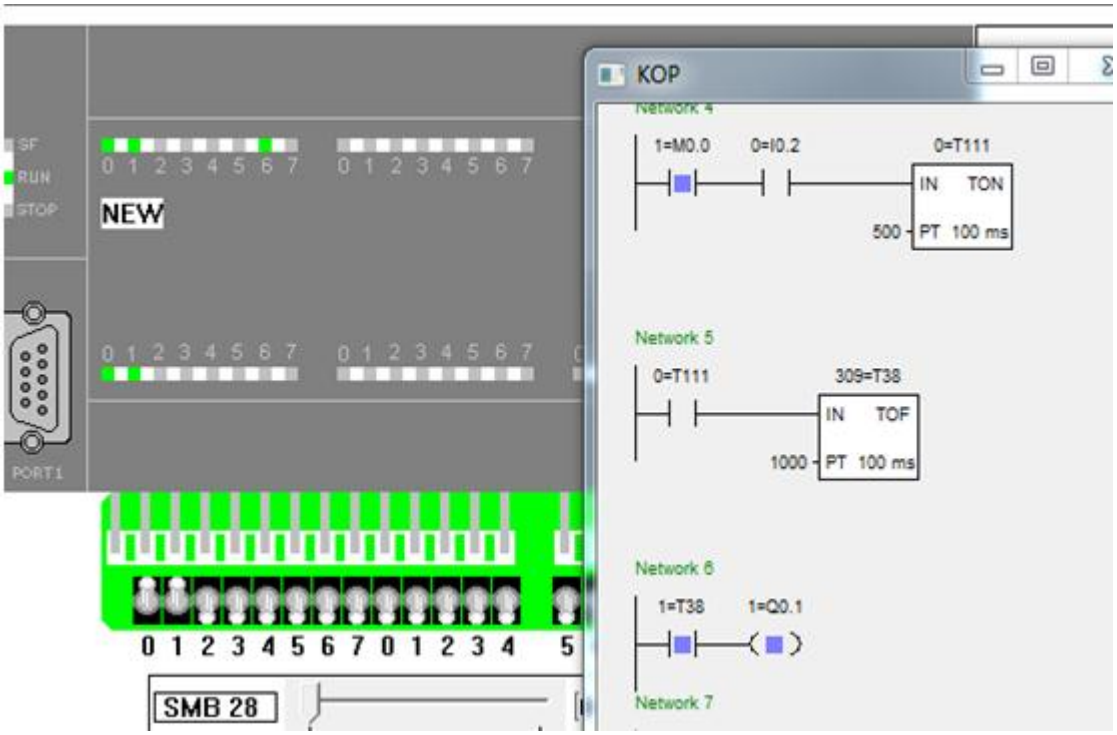


Figure 4.6 Activating T38 for stopping cylinder 1

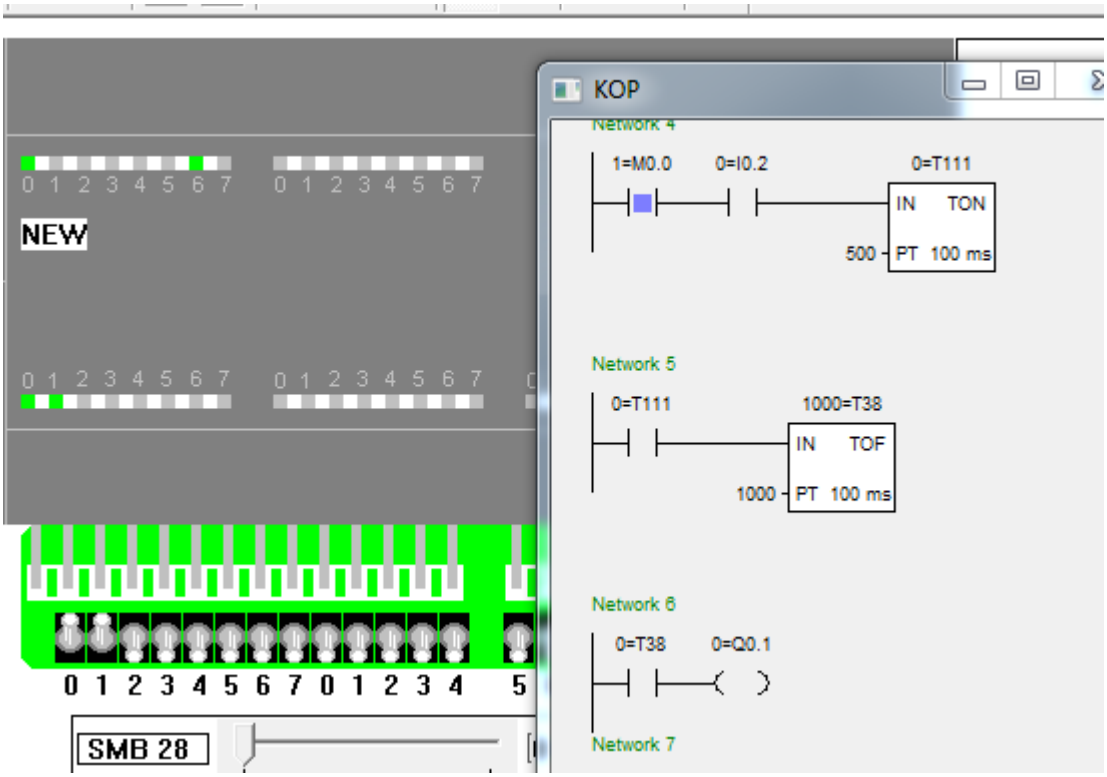


Figure 4.7 Moisture cylinder is off

4.5 Plastic Cylinder

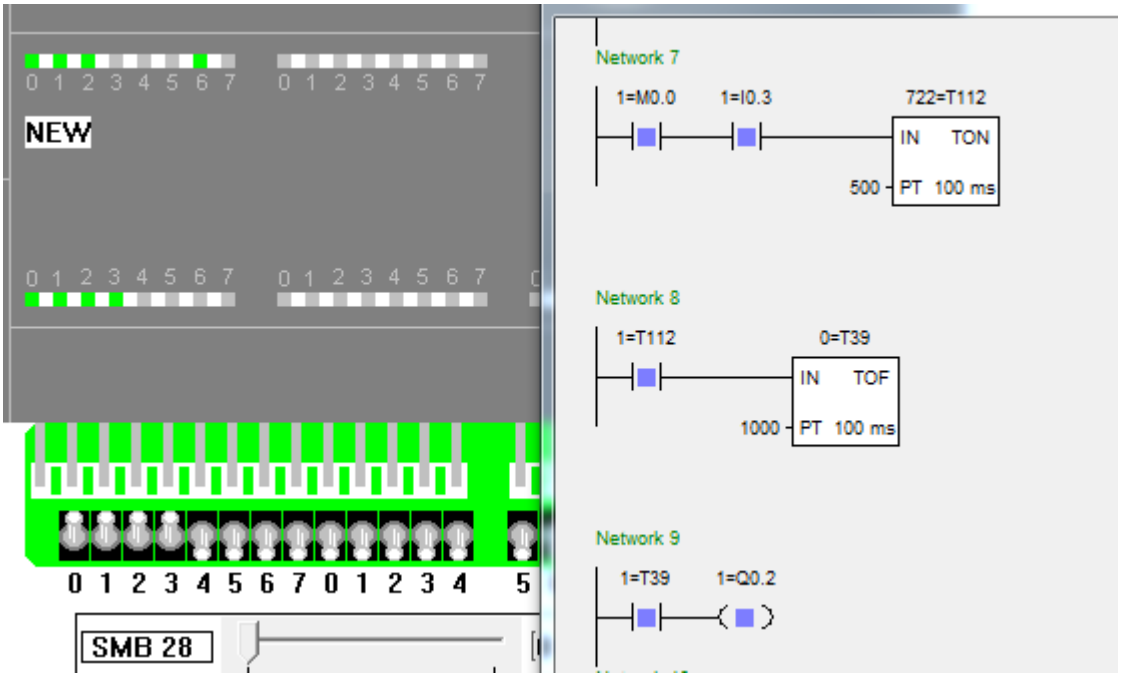


Fig 4.8 Plastic cylinder is on

This process repeated for the other types of materials with the same sequences.

If the substance is plastic it will test by (I0.3) and cylinder two will be on after on delay timer (T112) completes its time as shown in the above figure 4.8.

The plastic cylinder will stop working after off delay timer (T39) completes its time as shown in figure 4.9.

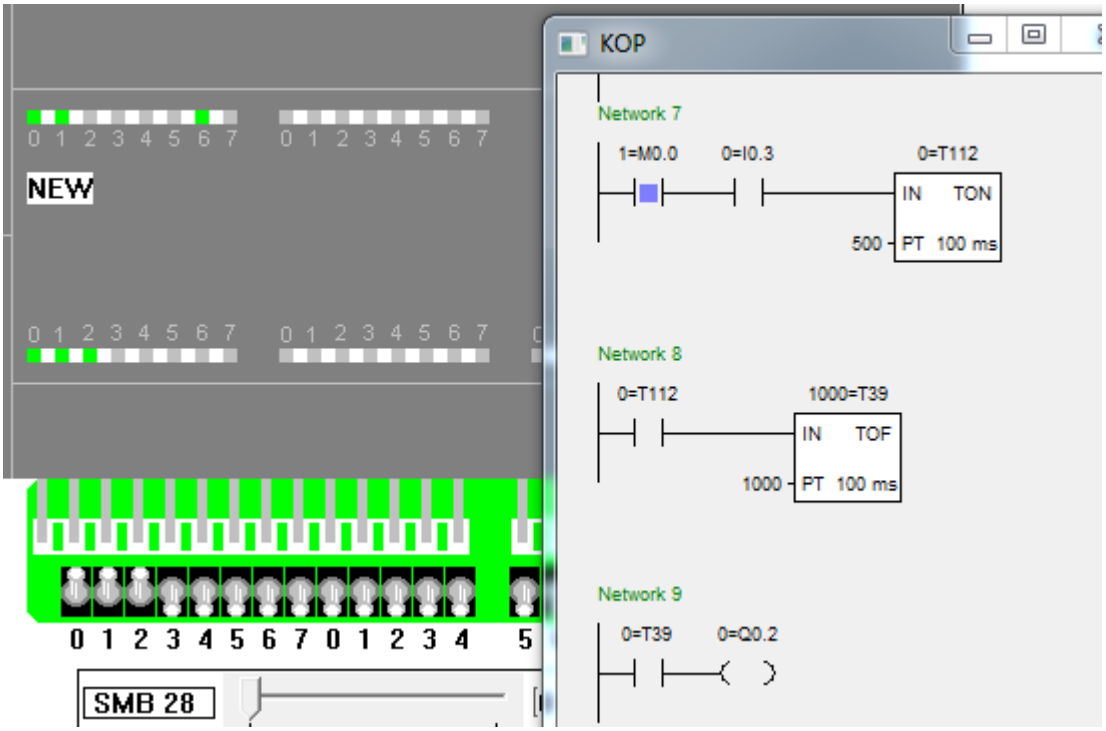


Figure 4.9 Plastic cylinder is off

4.6 Metallic Cylinder

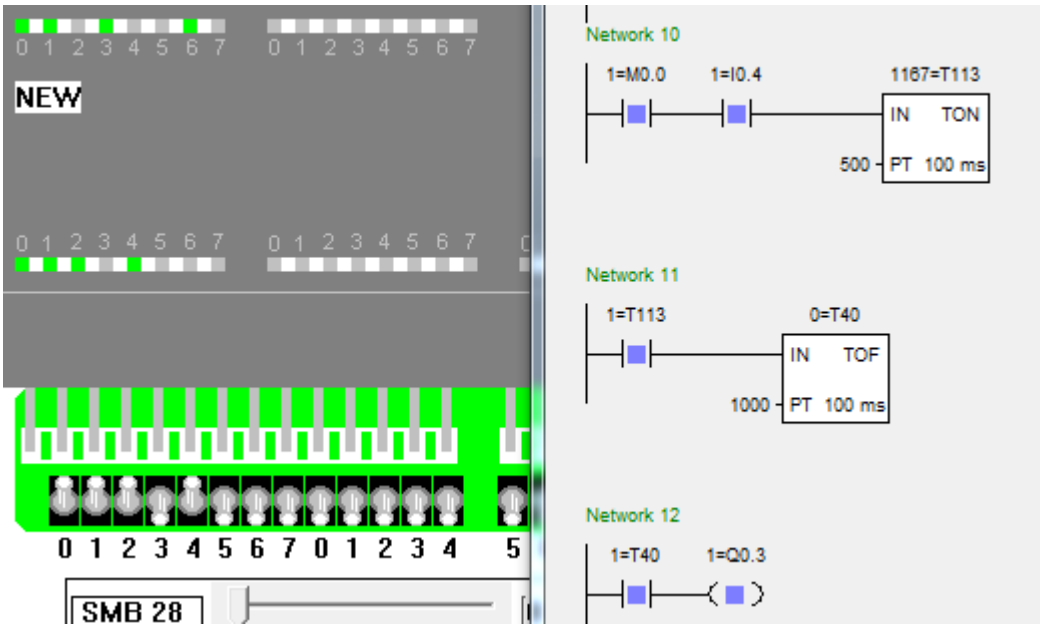


Figure 4.10 Metal cylinder is on

Metallic material it tested by (I0.4) and cylinder three will be on after on delay timer (T113) completes its time as shown in figure 4.10 above.

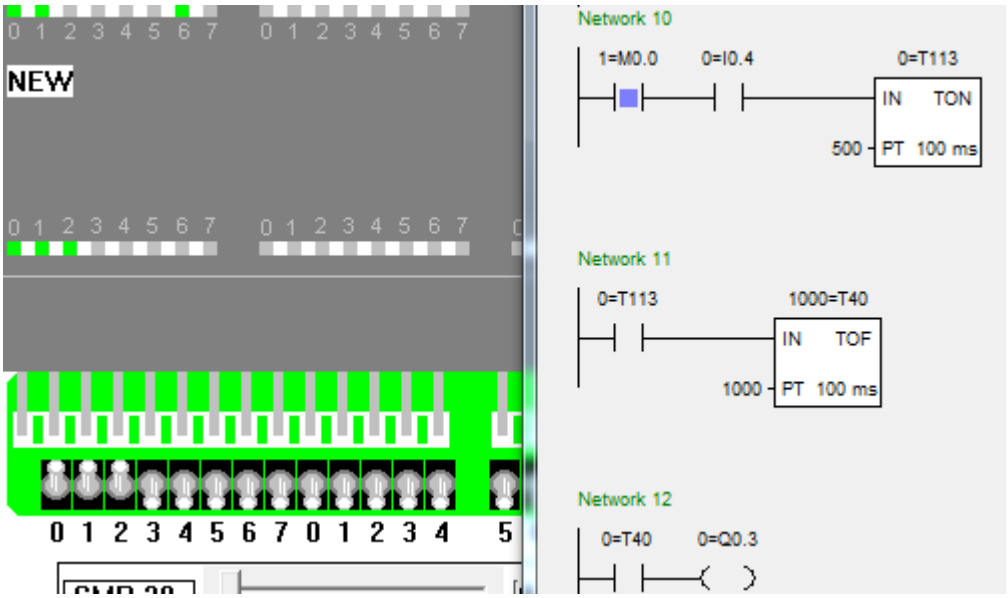


Figure 4.11 Metal cylinder is off

Metal cylinder will be off after press (I0.4) off and (T40) complete counting as shown in figure 4.11 above.

4.7 Glass Cylinder

The glass material tested by (I0.5) and output cylinder (Q0.4) four will be on after on delay timer (T114) completes its time as shown in figure 4.12 bellow. And glass cylinder will be off after press (I0.5) off and (T41) complete counting as shown in figure 4.13.

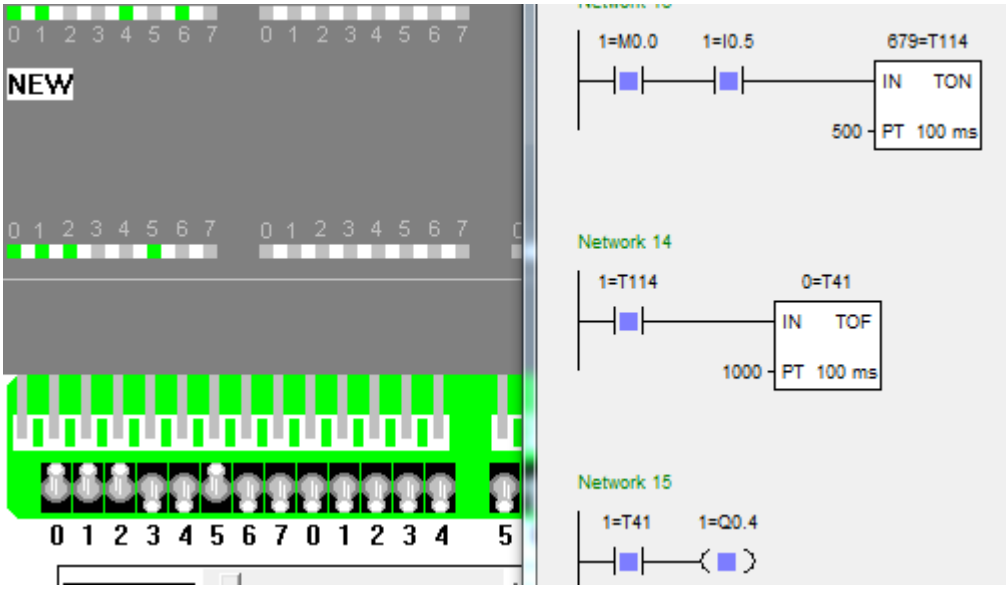


Figure 4.12 Glass cylinder is on

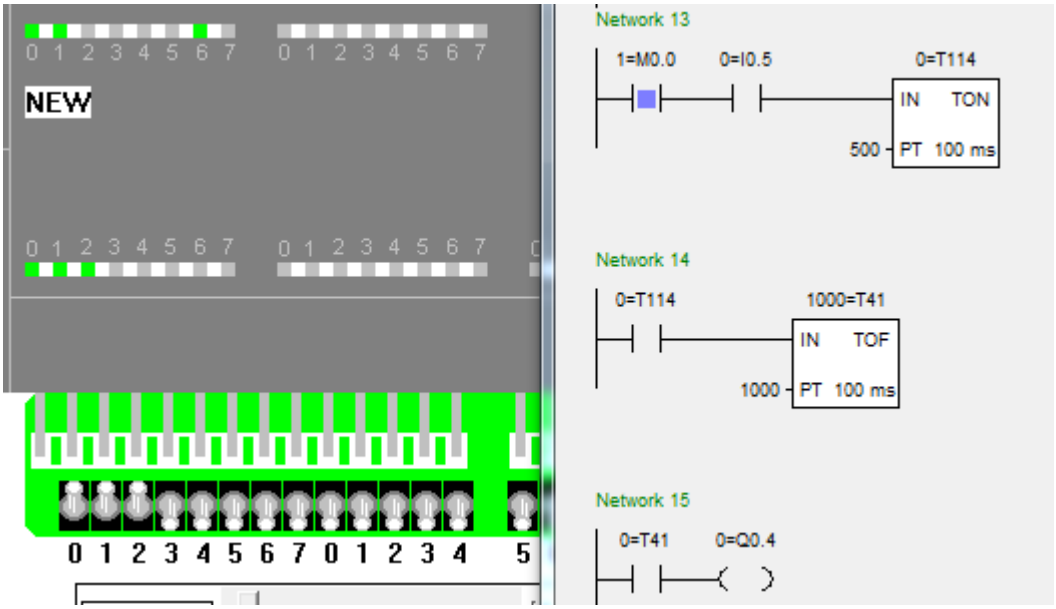


Figure 4.13 Glass cylinder is off

4.8 Paper Cylinder

Paper material tested by (I0.6), output cylinder (Q0.5) will be on after on delay timer (T114) completes its time as shown in figure 4.14 below.

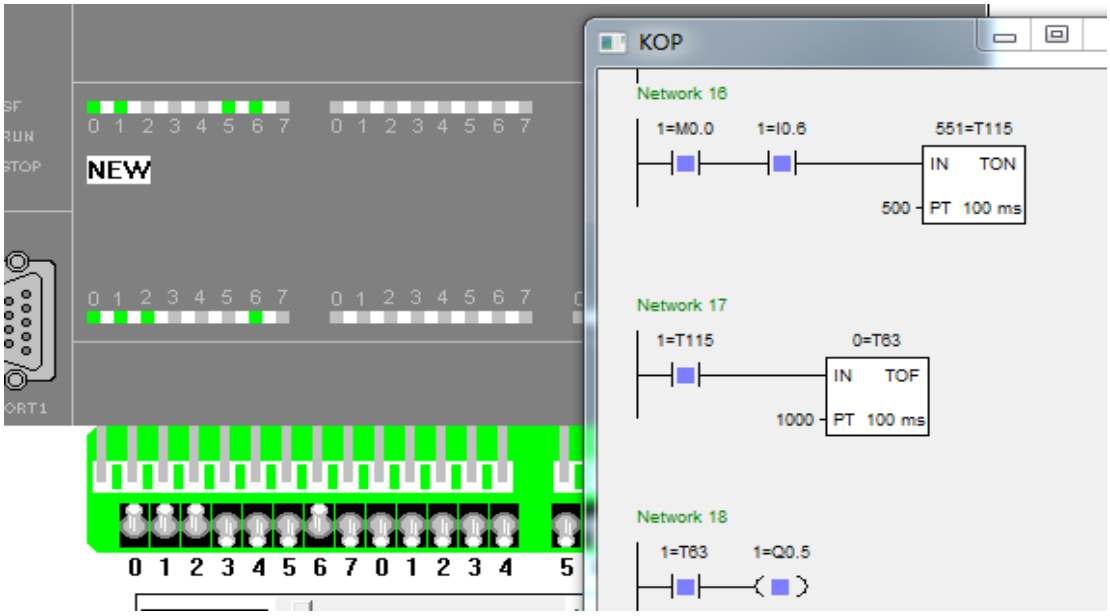


Figure 4.14 Paper cylinder is on

It will be off after press (I0.6) off and (T63) complete counting as shown in figure 4.15 below.

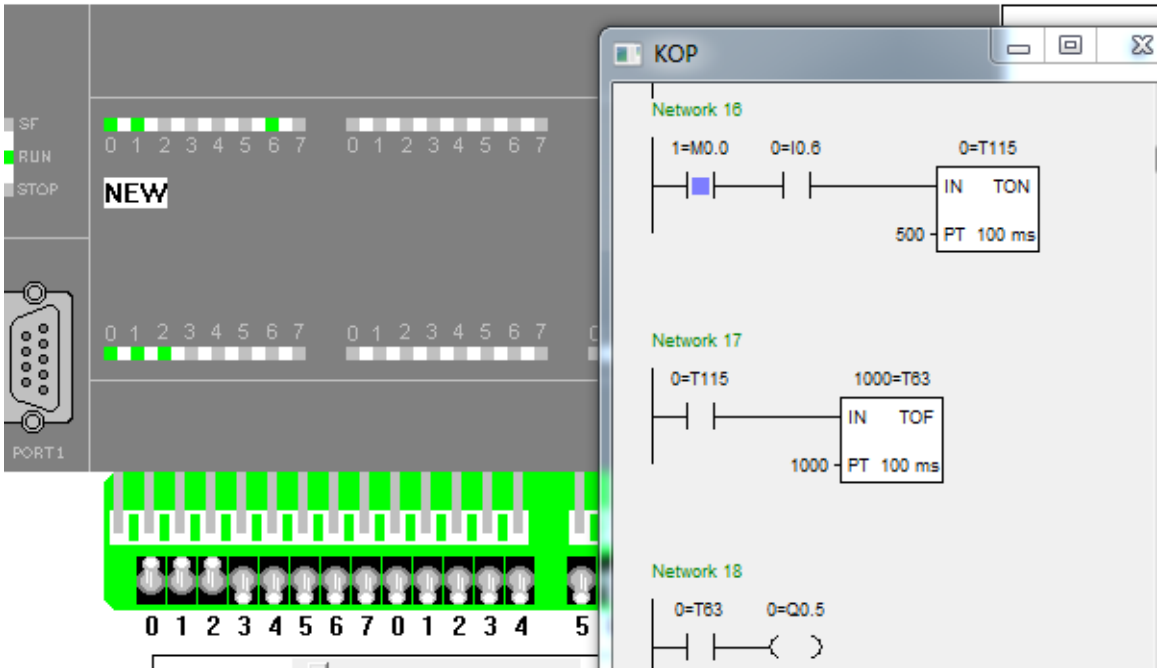


Figure 4.15 Paper cylinder is off

4.9 Start Indicator

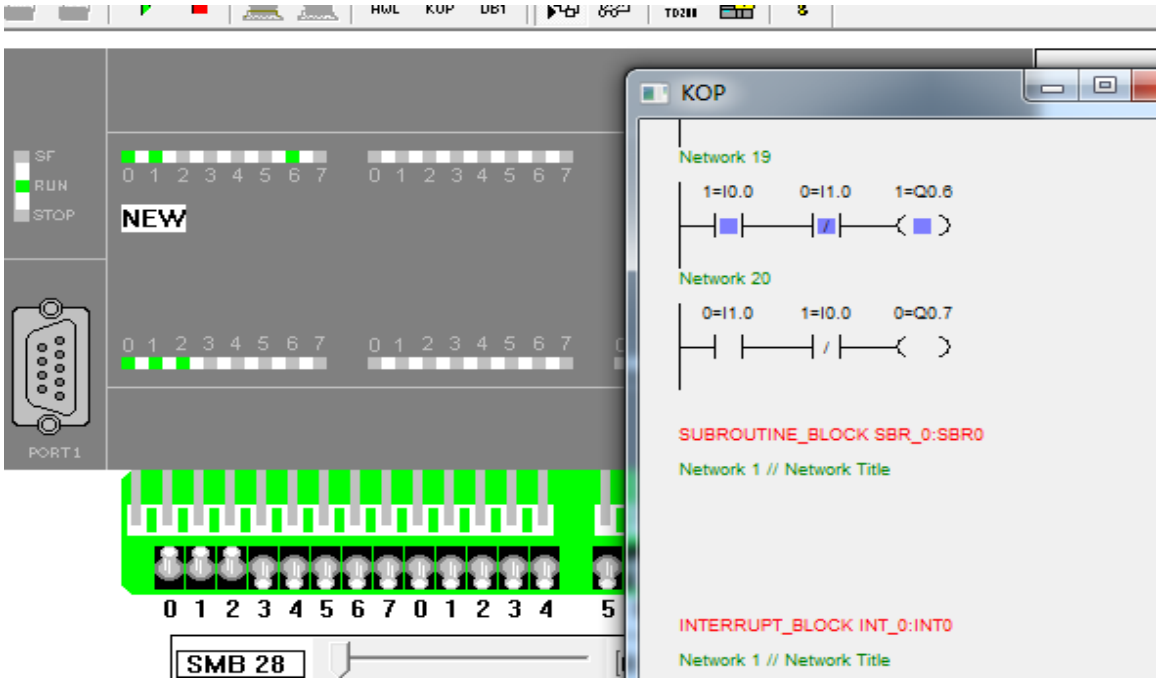


Figure 4.16 Start lamp is on

Start lamp (Q0.6) has been activated since (I0.0) has been on as shown in figure 4.16 above.

4.10 Stop Indicator

Finally stop indicator (Q0.7) tested by put the stop push button (I1.0) on as shown in figure 4.17 below.

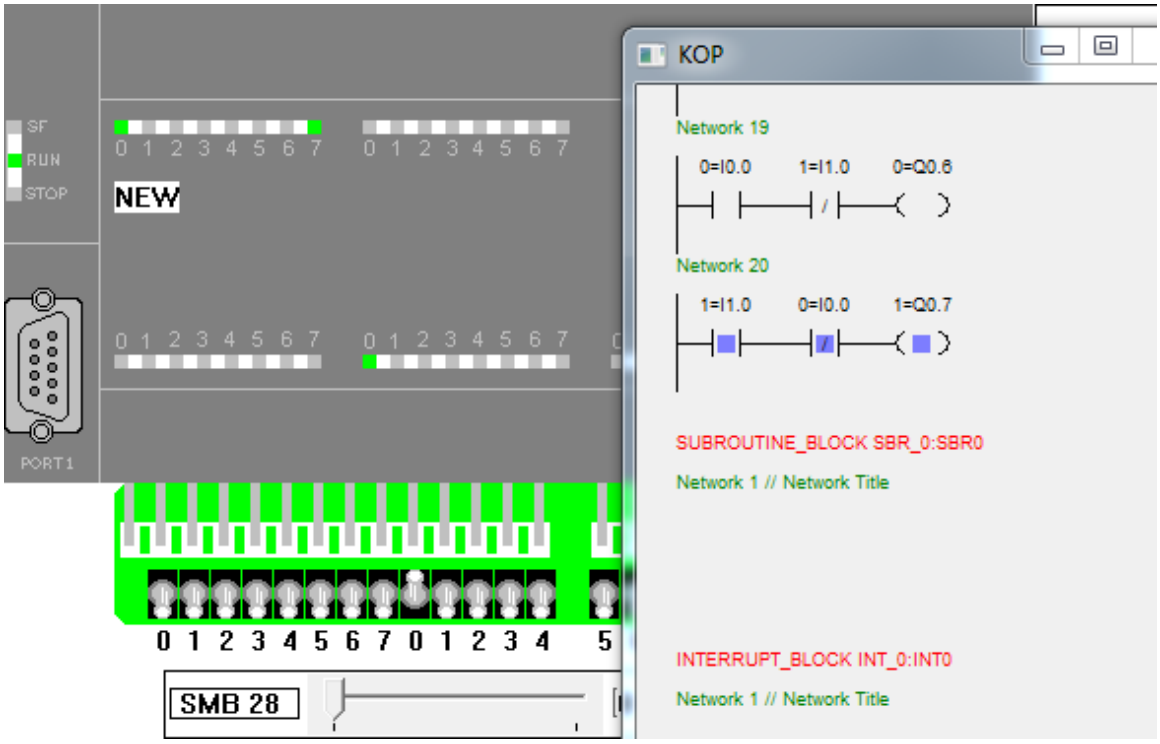


Figure 4.17 Stop lamp is on

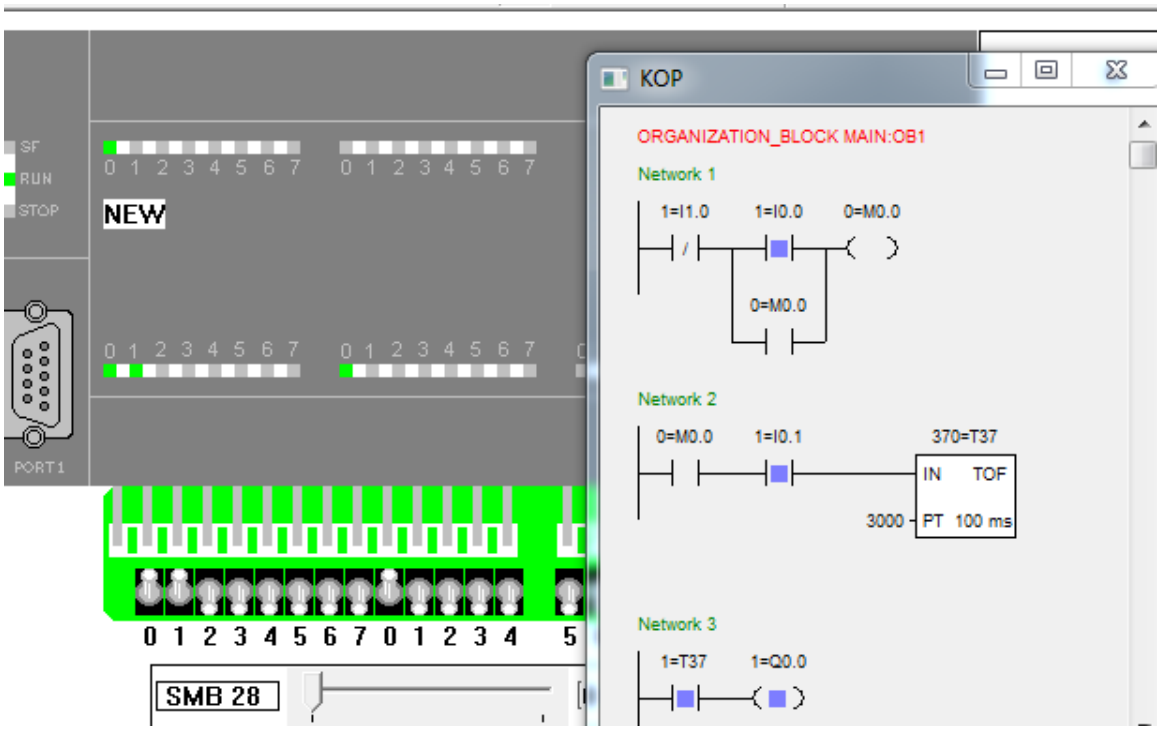


Figure 4.18 Conveyor belt did not stop immediately

Although (I1.0) has been put on but the conveyor belt (Q0.0) did not stop immediately as shown in figure 4.18 because it had an order to stop after (T37) complete its time.

T37 completed its time then (Q0.0) stopped as shown in figure 4.19.

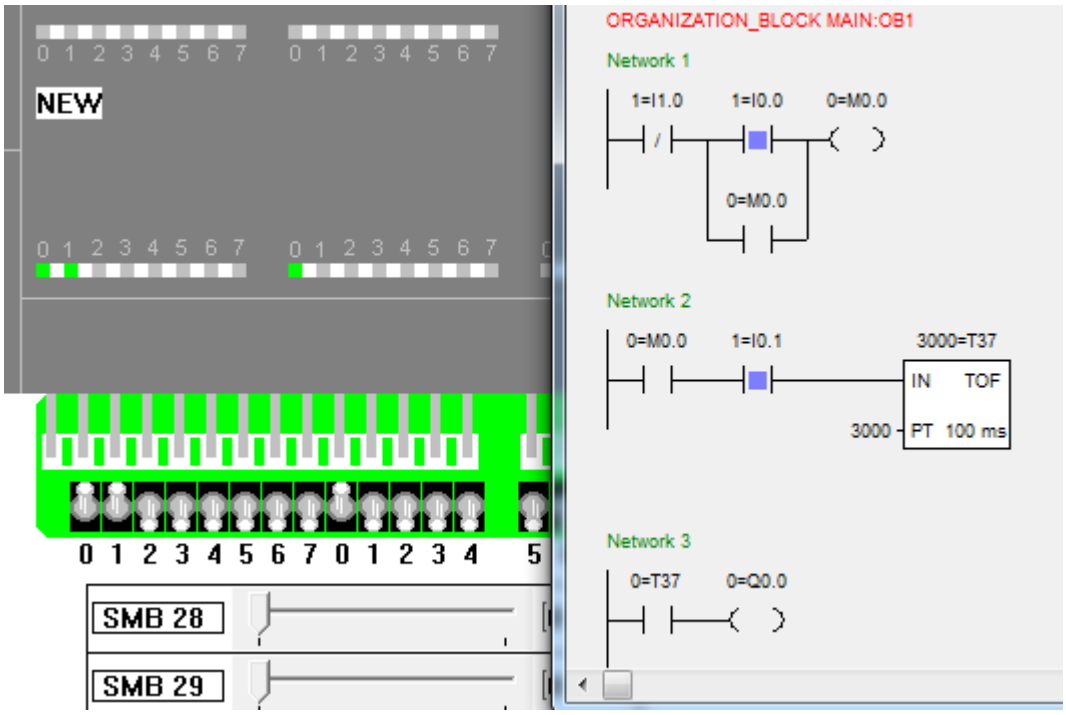


Figure 4.19 Conveyor belt is off

The results show that the system has been programmed successfully.

Chapter Five

Conclusion and Recommendations

Chapter Five

Conclusion and Recommendations

5.1 Conclusion

With the increase in population and the lake of good waste management systems, collection and detection of waste becoming a major issue.

In this study we proposed an automatic waste segregating system using the PLC. The proposed system segregates the waste into five classes wet, plastic, metallic, glass and paper. The system can segregate only one type of waste at time as the waste material object moves on a conveyor belt one at a time behind each other, some objects will not detect by sensors it will be in a special bin at the end of the conveyor belt. The software has been simulated with no errors. Automated waste segregation can be largely implemented in various municipal corporations or in some small scale industries. Using of PLC has added advantages like reduction in manpower with improved accuracy and speed of waste management, also avoiding the risk of working at hazardous. The overall method for the detection and management of waste becomes efficient and intelligent and is a step forward to make the manual collection of waste automated in nature and recycling of it easier.

5.2 Recommendations

In Future, this work can be implemented by making use of a robotic arm to pick and place certain materials which can be re-used. Also conveyor belts instead of bins carry out the detected materials to its suitable positions for recycling because the size of bin is limited and at last it will be full of wastes.

Additional sensors can be used to detect more objects (cloth, wood…etc) and segregate them according to the input output module of the PLC.

Camera sensors instead of analog sensors can implemented where the camera will detect an object depending upon the object defined in its program. A more modern version of PLC software program can be used to reduce the number of instructions (networks).

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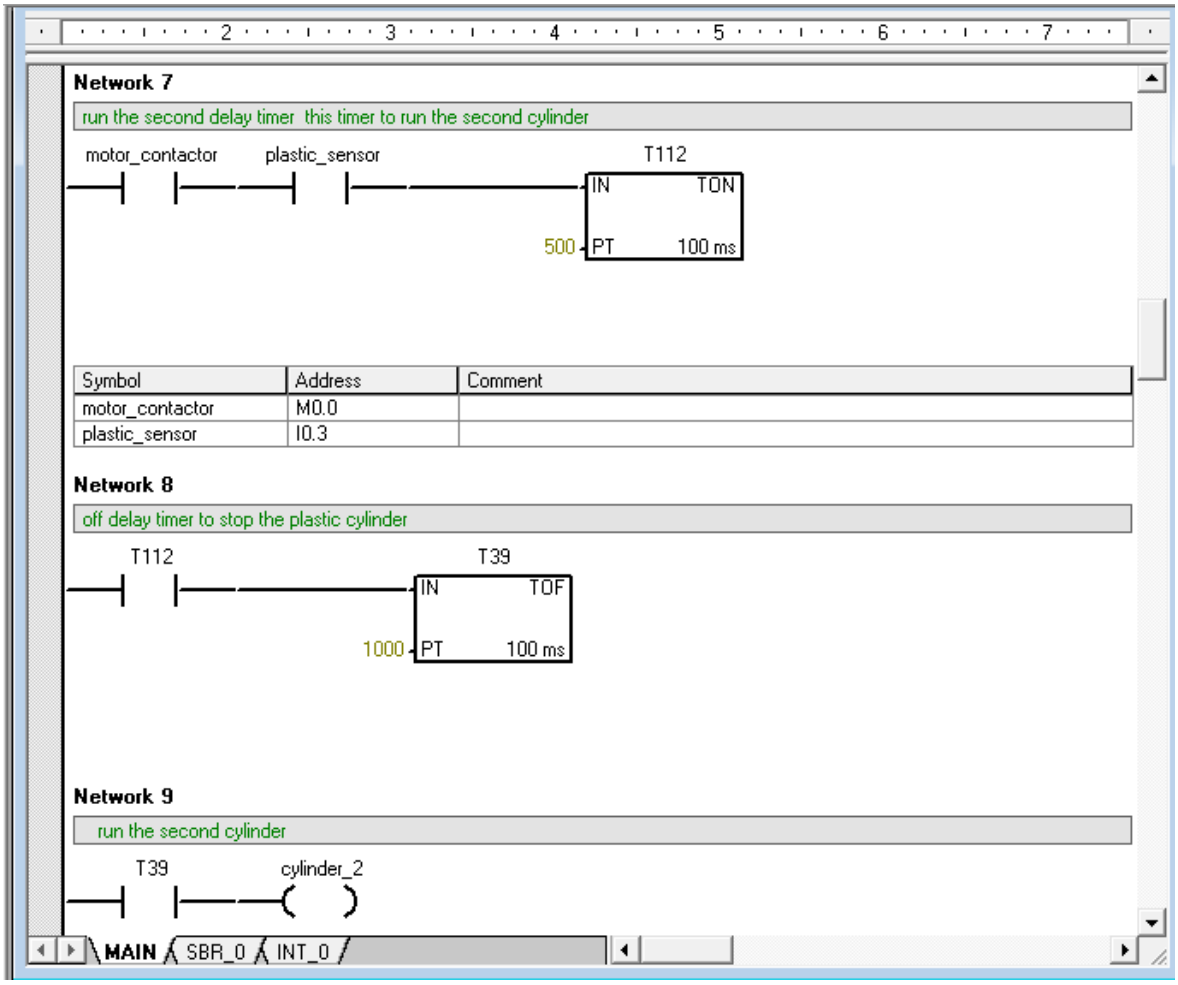
Appendix

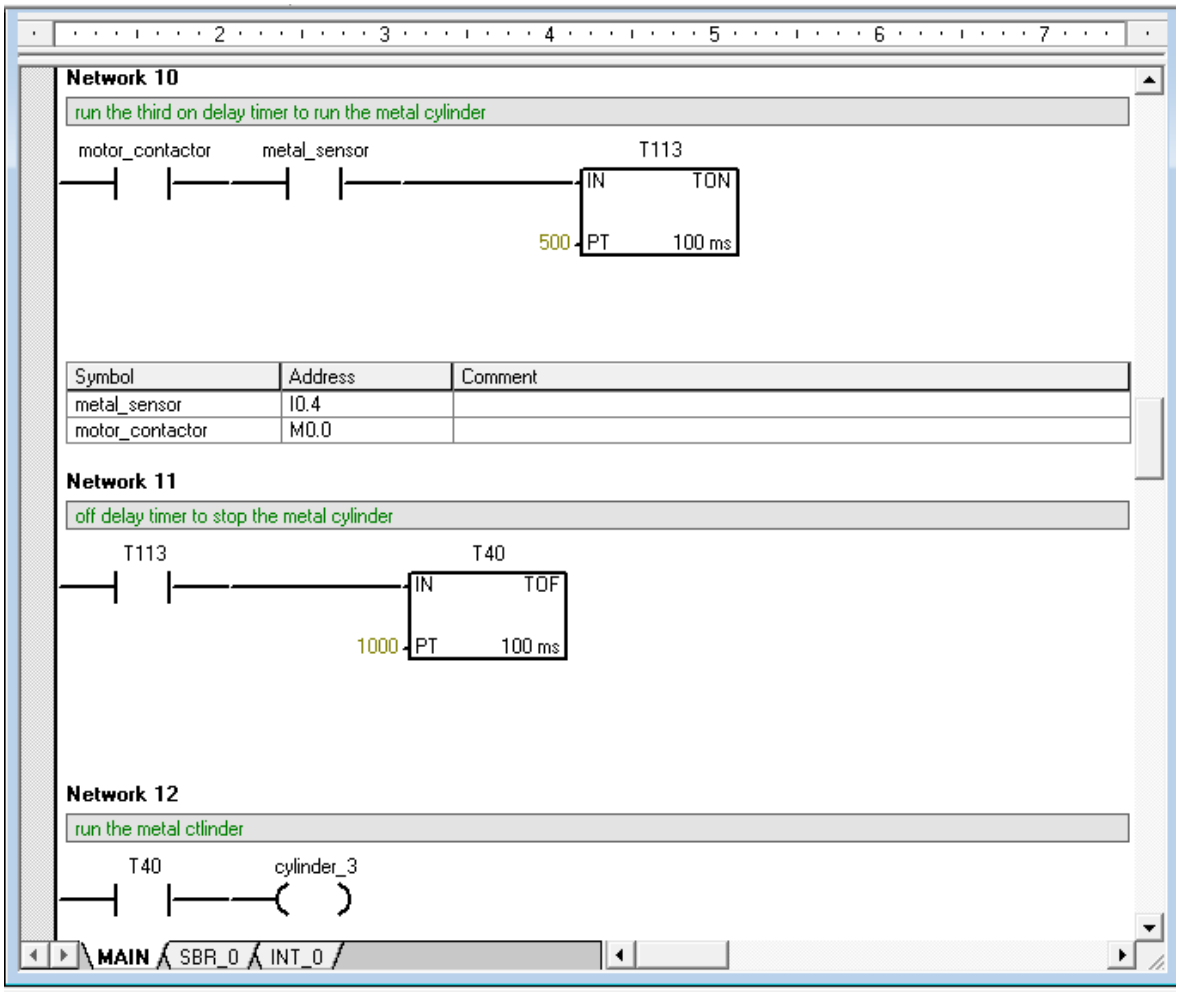
Appendix A

Activating the plastic cylinder



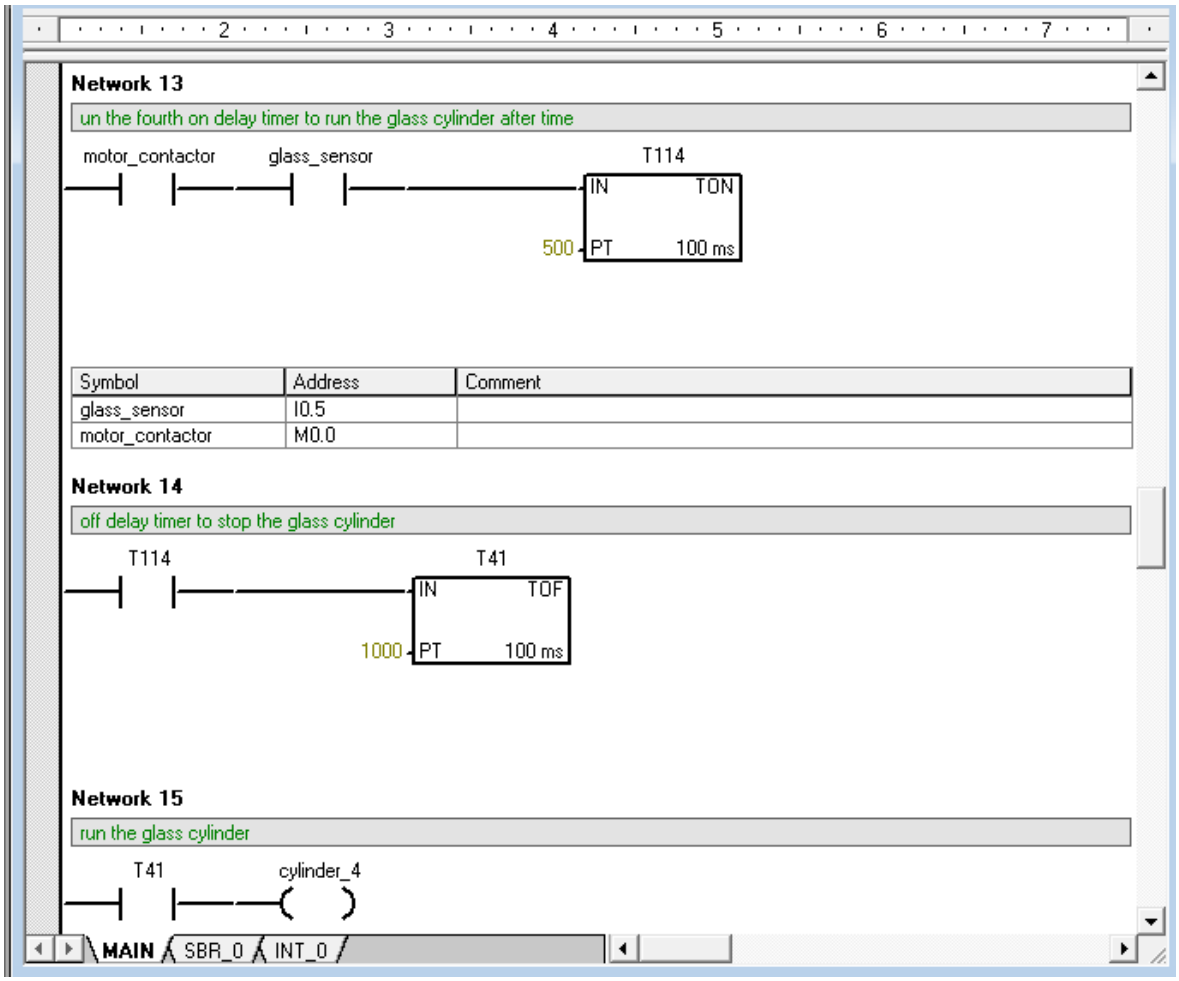
Appendix B

Activating the metallic cylinder



Appendix C

Programming of activating the glass cylinder



Appendix D

Programming of activating paper cylinder