T.C.
KIRSEHIR AHI EVRAN UNIVERSITY
INSTITUTE OF SCIENCES
DEPARTMENT OF ADVANCED TECHNOLOGIES

PLC SYSTEM DESIGN FOR MANAGEMENT AND CONTROL OF RIVER WATER TREATMENT SYSTEM

WALEED MOHAMMED ABED ABED

MASTER'S THESIS

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ASSOC. PROF. DR. MİKAİL KOÇ

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DECLARATION

Tez içindeki bütün bilgilerin etik davranış ve akademik kurallar çerçevesinde elde edilerek sunulduğunu, ayrıca tez yazım kurallarına uygun olarak hazırlanan bu çalışmada bana ait olmayan her türlü ifade bilginin kaynağına eksiksiz atıf yapıldığını bildiririm.

Waleed Mohammed Abed Abed

20.04.2016 tarihli Resmi Gazete’de yayımlanan Lisansüstü Eğitim ve Öğretim Yönetmeliğinin 9/2 ve 22/2 maddeleri gereğince; Bu Lisansüstü teze, Kırşehir Ahi Evran Üniversitesi’nin abonesi olduğu intihal yazılım programı kullanılarak Fen Bilimleri Enstitüsü’nün belirlemiş olduğu ölçütlere uygun rapor alınmıştır.

PREFACE

I would like to thank my esteemed supervisor Assoc. Prof. Dr. Mikail KOÇ for the contributions that he has made throughout the study. I would also like to thank my esteemed jury members, Assist. Prof. Dr. Murat IŞIK and Assist. Prof. Dr. Selçuk EMİROĞLU. Finally, I dedicate my thesis to my family, especially to my parents.

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LIST OF ABBREVIATIONS

Symbols	Explanation
$po1$	: Feed pump
$po2$	: Backwash pump
$co1$	: Air comperoer
v	: valve
KB	: kilobytes
Ms	: Milli seconds
$s.f$	: Fault System:
rpm	: round per minute
Mv	: Milli volt
MA	: Milli ampere
Ω	: ohm
PPI	: point to point intrface
EM	: Analog input and output modules

Abbreviations	Explanation
PLC	: Programable logic controlar
HMI	: Human Machine İnterface
DP	: Difrinshal prissure siwich
B.K	: Backwash process
CPU	: Cinteral prossing uint
EPROM	: Electrical Programmable Read-only memory
EEPROM	: Erasable Electrical Programmable Read-only memory).
RAM	: Random memory is read and write memory
ROM	: Read only memory where the program is saved
NPN	: Negative positive Negative
PNP	: Positive Negative positive
DI	: Digital inpot
DO	: Digital outpot
TON	: Timer on Delay
TOF	: Timer of Delay
TONR	: Retentive Timer on Delay
DC/DC/DC	: Power supply /Dc input/output transistor
AC/DC/RLAY	: Power supply /Dc input/output relay
CTU	: Counters UP
CTD	: Counters Down
CTUD	: Counters UP and Down
NTU	: Nephelometric Turbidity Unit
FIQ	: Flow Meter
SCADA	: Supervisory control and data acquisition

ABSTRACT

MASTER OF SCIENCE THESIS

PLC SYSTEM DESIGN FOR MANAGEMENT AND CONTROL OF RIVER WATER TREATMENT SYSTEM

WALEED MOHAMMED ABED ABED

Kirsehir Ahi Evran University
Institute of Science
Department of Advanced Technology
Supervisor: Assoc. Prof. Dr. Mikail KOÇ

Sand filters are one of the types of filters that are used to purify water, especially river water which are not suitable for public use but in the end, it depends on the specifications of the water to be treated. This requires the design of treatment systems with specific commensurate with the nature of the work in terms of the work environment, such as large factories that emit various vapors and gases such as large oil refineries as well as the natural factors of high temperatures up to 50 degrees Celsius. In the subject of this study, a model was presented for a sand filtration system used to purify the waters of the Tigris River with certain specifications and turn it into water suitable for public use and very close to one of the largest oil refineries. The material specifications for the system were appropriately selected. The subject of the study focuses on the communication, control, and management of this system using the (PLCs) logic controller, the study dealt with choosing the best types of components and devices for designing PLC control systems according to cost, work environment and technical specifications.

March 2023, 81pages

Keywords: Programmable Logic Controller, Water Purification, PLC

ÖZET

YÜKSEK LİSANS TEZİ

NEHİR SUYU ARITMA SİSTEMİNİN YÖNETİMİ VE KONTROLÜ İÇİN PLC SİSTEM TASARIMI

WALEED MOHAMMED ABED ABED

Kırşehir Ahi Evran Üniversitesi
Fen Bilimleri Enstitüsü
İleri Teknolojiler Anabilim Dalı
Danışman: Doç. Dr. Mikail KOÇ

Kum filtreleri, umumi kullanıma uygun olmayan nehir sularını arıtmak ve umumi kullanıma uygun hale getirmek için kullanılan filtre türlerindendir. Bunu yaparken suların doğaları ve özellikleri göz önünde bulundurulur. Özellikle de büyük petrol rafineleri gibi endüstriyel fabrikalara yakınlığı sebebiyle çeşitli gazların ve buharların salındığı yerlerde ve yine yüzde ellilere varan ısı derecesinin yüksekliği gibi doğal faktörler ve çalışma çevresinin doğasına uygunluğu dikkate alınır.

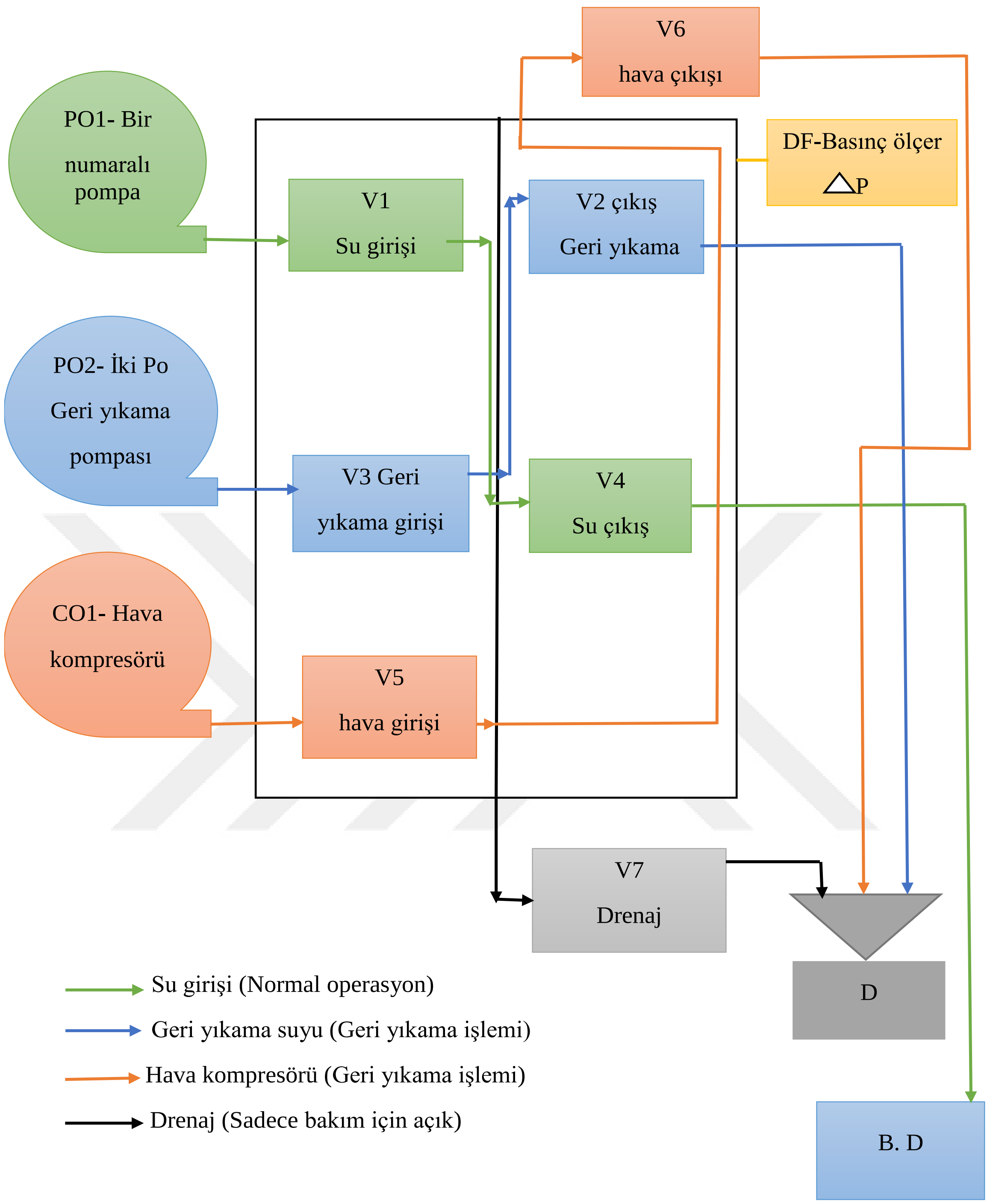
Bu çalışmanın konusu kumlu suların arıtılması işlemini yöneten bir örnek sistem tasarlamaktır. Çalışma PLC programına elverişli bir yönetim sistemini tasarlamak üzerine odaklanmaktadır. Dicle nehrinden alınan numuneler üzerinde bulanıklık derecesi ve sudaki katı maddelerin oranları gibi hususların belirlenmesinden sonra sistemin çalışma yazılımının algoritması, bulanıklık derecesi ve sisteme giren suyun basıncı ile sistemden çıkan suyun basıncı arasındaki ilişkiye bağlıdır. Bulanıklık, basınç, zaman sistem çalışma verileri arasındadır.

Suda bulanıklık derecesi arttıkça nefelometrik bulanıklık artar ve bu değer 50 NTU'ya vardığında sistemin aksi yöndeki yıkama işlemi otomatik olarak başlar.

Her filtrenin yıkama işlemini tamamlamak için 10 dakikalık bir zamana ihtiyacı vardır. Eğer sudaki bulanıklık miktarı kabul edilebilinen bir miktara gerilememişse her bir filtrenin aksi

yıkama işlemi için müddetin artırılması mümkündür. Sistemin yazılımı Siemens firmasının ürünlerinden biri olan Simatic Manager S7300 ile yapılmaktadır. Kullanımın kolaylıkla yapılması için sistem yazılımında bölgesel Ladder dili kullanılmıştır.

Sistemi oluşturan filtrelerin her biri 7 adet valf içermektedir. Su, valflere özel pompalarla basılmaktadır. Şekil 1'de bir numaralı valften filtreye su basan pompalar vardır. Bu pompalar normal kullanım içindir. Her filtrede işlemin yürütülmesi amacıyla ters yıkama suyunun giriş ve çıkışı için vanalar bulunmaktadır. Filtre ihtiyaç duyulduğunda otomatik olarak temizlenir. Geri yıkama suyu, geri yıkama pompaları adı verilen özel pompalar vasıtasıyla filtrelere pompalanır. Her filtre ayrıca havanın filtreye girişi ve çıkışı için valfler içerir. Böylece hava, geri yıkama pompasının çalışmasıyla bağlantılı olarak hava kompresörü aracılığıyla filtreye doğru itilir. Bu nedenle hava kompresörü, geri yıkama pompası ile aynı anda çalışacak şekilde programlanmıştır. Her filtre ayrıca, filtrenin tamamen boşaltılması işlemine tahsis edilmiş bir valf içerir ve yalnızca bakım işlemi sırasında kullanılır.



Şekil 1. Sistemdeki bir filtrenin blok diyagramı

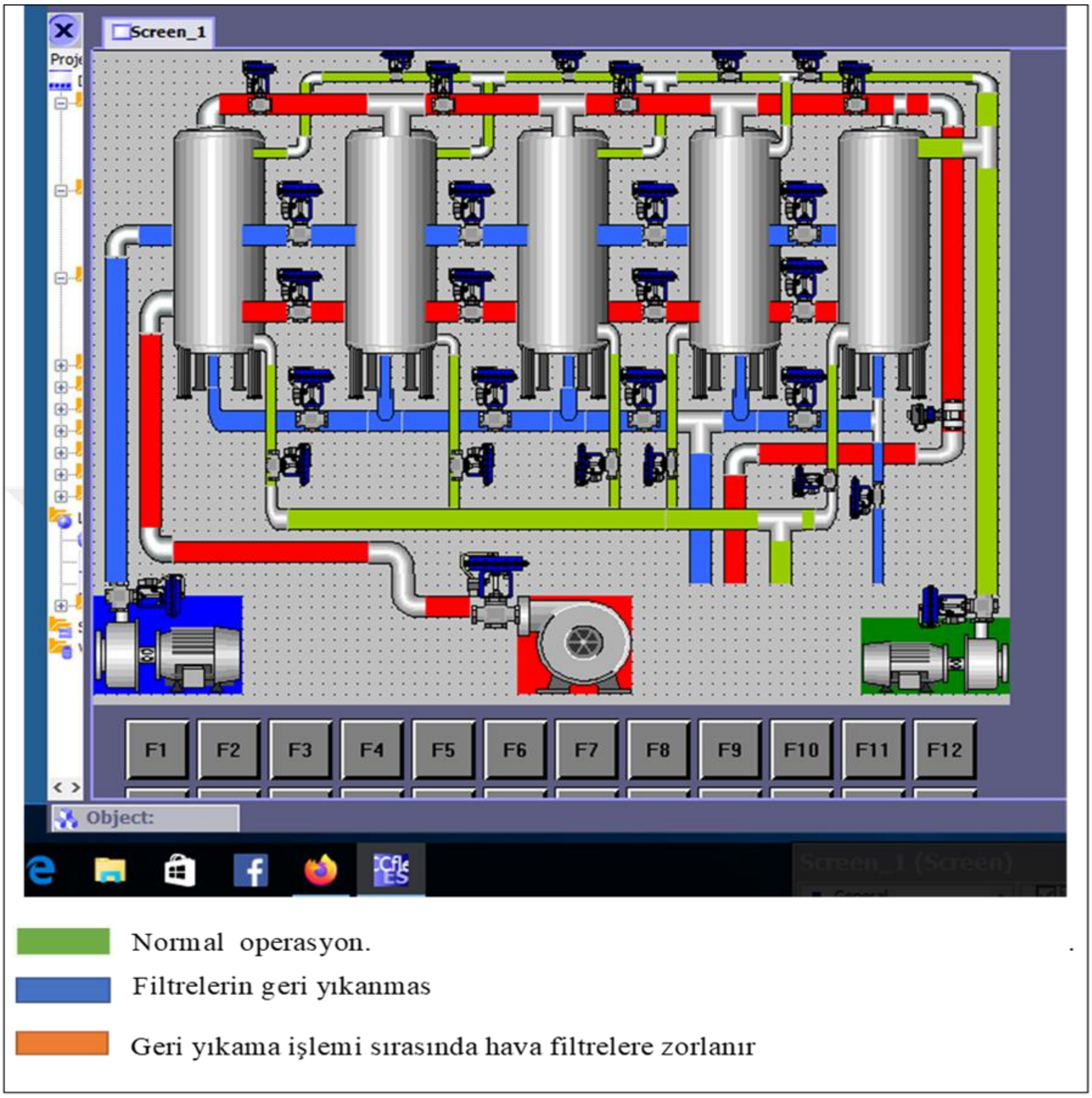
Şekil 1'de pompaların ve filtrelerin ana filtre parçaları ile fark basınç göstergesi gösterilmektedir. B.D; sistemin normal çalışmasında arıtılan su tanklarını D; geri yıkama suyunun tahliyesi için menholleri temsil eder.

Şekil 1, iki hatta dağılmış on filtreden oluşan sistem hatlarından bir satırı oluşturan toplam beş filtreden birinin modelini göstermektedir. Birinci vana yeşil renkli V1 numaralı vanadır. Süzülecek suyun filtreye giriş vanasıdır. Sistemin normal çalışmasında yani bulanıklık derecesi izin verilen limitler içindeyken açıktır. Su, PO1 numaralı pompa tarafından vanadan filtreye pompalanır ve yeşildir ve sistem normal çalışırken de çalışır durumdadır. İkinci vana V4 numaralı vana olup yeşil renklidir. Arıtma işleminden sonra suyun filtreden çıkışını sağlayan vanadır. O da sistemin normal çalışmasında açılır ve üretim vanası olarak adlandırılır. V3 nolu vana sisteme geri yıkama suyunun girişini sağlayan vana olup mavi renklidir. PO2 nolu pompadan vanaya su basılmaktadır ve yine mavi renklidir. V2 nolu vana geri yıkama suyundan çıkış vanasıdır ve mavi renklidir. Normal çalışma durduktan sonra bu vanalar çalışmaya başlar. Sudaki 50 NTU civarındaki yüksek bulanıklık derecesi sonucu basınç farkının 0,05 bara yükselmesi sonucu sistem çalışmaya başlar. Sisteme giren hava için valf numarası V5 ve turuncudur. Hava yine turuncu olan CO1 hava kompresörü vasıtasıyla filtreye itilir. Hava V6 valfi vasıtasıyla filtreden çıkar ve yine turuncudur. Sistemdeki her filtrede, suyun filtreye girdiği andaki basıncı ile filtreden çıkan su basıncı arasındaki basınç farkını ölçen bir fark basınç göstergesi vardır. Göstergenin rengi sarıdır. Gri renkli vana V7 normal sistem çalışmasında ve geri yıkama işleminde her zaman kapalıdır ve vana sadece sistem bakımı sırasında açılır.

Aşağıdaki tabloda, sistemin normal çalışmasında vanaların ve pompaların durumu ile geri yıkama işleminde sistemin durumunun bir örneği gösterilmektedir

VALF FONKSİYONLARI			
Pompalar ve valfler		Döngü Adımları	
		normal çalışma 0,05 bar'dan az	geri yıkama 0,05 bar'dan büyük
PO1	Servis pompası	Açık	Kapalı
V1	Servis Girişi	Açık	Kapalı
V4	Servis Çıkışı	Açık	Kapalı
PO2	Geri yıkama (pompa)	Kapalı	Açık
V2	Geri Yıkama Çıkışı	Kapalı	Açık
V3	Geri Yıkama Girişi	Kapalı	Açık
CO1	Hava kompresörü	Kapalı	Açık
V5	Hava girişi	Kapalı	Açık
V6	Hava çıkışı	Kapalı	Açık
V7	Drenaj valf	Kapalı	Kapat: bakım gerektiğinde aç

Wincc Flexible 2008 kullanılarak beş filtreden oluşan sistemin özel tasarımı aşağıda gösterilmektedir.

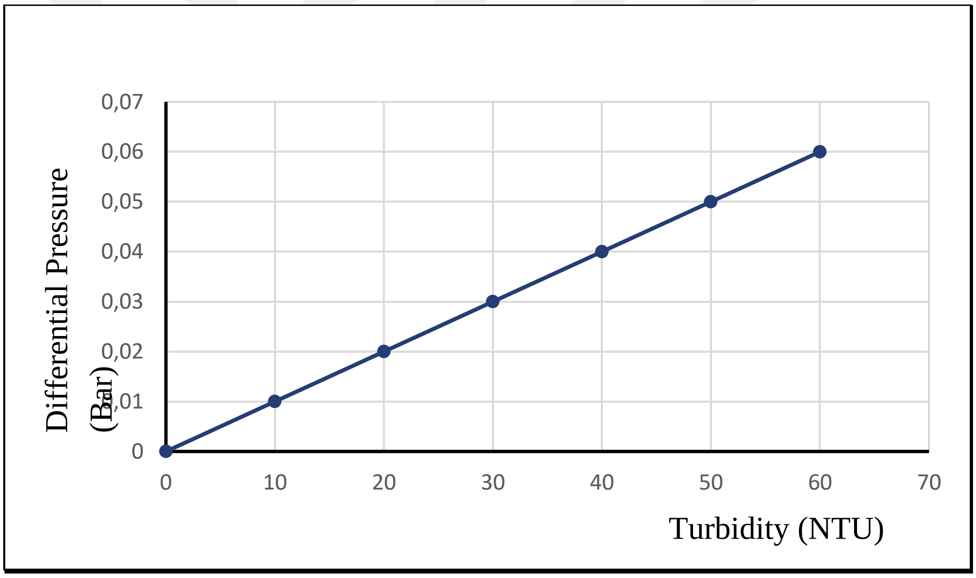


Şekil 2. Beş filtreden oluşan sistem hatlarından birinin tasarımı

Wincc flexible 2008 programı kullanılarak tasarlanan beş filtreden oluşan sistemin bu tasarımında yeşil renkle belirtilen üretim hatlarını ve sistemin normal işleyişini göstermektedir. Her filtrenin yedi valf ve bir basınç farkı göstergesinden oluştuğuna dikkat çekilerek valflerin durumu bağımsız olarak açıklanmış ve üretim pompası, filtreye su giriş valfi ve filtreden su çıkış valfi referans alınmıştır. Sudaki bulanıklık derecesi 50 NTU'dan az ise ve bu bulanıklık yüzdesi diferansiyel basınç farkını 0,05 bar'dan az yapıyorsa, sistem normal çalışma durumundadır ve yeşil renkli sistem aktiftir. Sistemin mavi ile gösterilen ikinci durumu ise filtrelerin geri yıkanması durumudur. Bu işlem sudaki bulanıklık oranı 50

NTU'nun üzerine çıktığında başlar. Bu oran basınç farkı oranının 0,05 bar'a yükselmesine neden olur. Bu da her filtre için normal çalışmanın durdurulması ve geri yıkama işleminin başlatılmasına neden olur. Her filtre için on dakikalık bir süre verilir. Böylece her filtrenin temizleme işlemi tamamlanmış olur. Havayı geri yıkama suyuna karıştırmaya zorlayan hava kompresörünün çalışması, filtre içinde su ve basınçlı hava karışımı oluşturacak şekilde programlanmıştır. Hava kompresörü, filtreye giden hava giriş valfi ve valfin üstündeki hava çıkış valfi kırmızı ile gösterilmiştir.

Bulanıklıktaki artış ile bunun basınç farkına etkisi arasındaki ilişki aşağıdaki grafikte görülebilir. Bulanıklık oranı 50 NTU olduğunda 0,05 bara kadar olan yüksek basınç farkından dolayı sistemin kritik duruma girdiği görülmektedir. Bu noktada sistem normal çalışmasını durdurmakta ve ters yıkama işlemine geçmektedir. 50 NTU, bulanıklık yüzdesi için üst sınır olarak bulanıklığı temsil eder.



Şekil 3. Bulanıklık yüzdesi ile diferansiyel basınç farkı arasındaki ilişkiyi gösterir.

PLC, her bir filtreye giren ve çıkan suyun durumunu sürekli olarak tarar ve suyun giriş basıncı ile su çıkış basıncı arasındaki basınç değerini karşılaştırır. 50 NTU'nun üzerindeki yüksek bulanıklık nedeniyle basınç farkı 0,05 bar'dan büyükse, PLC her filtre için on dakikalık bir süre boyunca birbiri ardına bağımsız ve sıralı olarak geri yıkama işlemini çalıştıracaktır.

Mart 2023, 81 sayfa

Anahtar kelimeler: Programlanabilir Mantık Kontrolcüsü, Su Arıtma,

1. INTRODUCTION

As a result of the great scientific progress and the great technological revolution in recent years, the so-called programmable controller has been developed. (PLCs). Its development led to a real revolution in control engineering, as the logic controller (PLCs) is a multi-purpose control system used in many applications. As most of the automated factories use logic controllers to control the production lines and all the processing that is done on the produced materials. The first logic controller was developed in 1968 by General Motors, and then several Japanese companies developed this device as a low-cost, high-performance device [1]

A PLC is a microprocessor-based digital electronic device that uses programmable memory to store instructions and perform functions such as logic, follow-up, timing, and counting. As this is done by controlling different machines and processors, this machine uses logic to perform its operations, as programming is linked to logic and its realization in various operations. The inputs for this device are switches and sensors, such as photovoltaics and temperature, pressure, or flow sensors. The output devices are actuators and valves, and all these devices are connected to the logic controller. In the subject of this research, will using the PLC system to manage the sand filtration system that purifies the river water, the field of this study is the water of the Tigris River and converting it into the water for public use. This system using the Ladder logic programming language and using the SIMATIC MANAGER S7300 software.

1.1 Aim

The study aims to identify widely the types of (PLC) which has become the best way to manage and control factories and various production lines and production processes. The study also aims at how to choose the type of PLC systems in practice through the correct and optimal selection of the devices used in line with the geographical and environmental nature of factories and laboratories. As well as looking at the economic aspect of building the system through the use of equipment with low economic value and high practical performance.

1.2 Motivation

The importance of the study lies in knowing the quality of the equipment used in the system in terms of technical and scientific specifications that were used in such systems to benefit from them in the future, easily and scientifically identify the design of similar systems in operation and environmental conditions similar to the working conditions of the system in question.

The subject of thıs study is a sand filtration system that purifies river water that is not suitable for public use and turns it into water suitable for public use. The field of our study is the water of the Tigris River after determining the specifications of the appropriate type of PLC to manage the system. The study focused on the selection of a PLC system that we can use to control a sand filtration system that purifies river water that is not suitable for general use into water suitable for general use, after knowing the specifications of the water before and after purification, by installing a system of ten filters spread over two lines A and B, with five filters per line. To ensure that the system is installed and built correctly, the type of controller is selected, calculate the cost of the system, and the type of programming we will use in the system. The study focused on the mechanism of selecting the best equipment that can be used in a work environment characterized by special conditions such as the high temperature, which sometimes reaches fifty degrees Celsius, and the high emission of hydrocarbon gases resulting from crude oil refining, and thus the high percentage of sulfur in the work environment surrounding the system This requires choosing the quality and specifications of the technical equipment that make up the PLC system in a more compatible way to ensure that the system operates stably.

The study also focused on the impact of the work environment, especially the sulfur content on data transmission cables and the signal from equipment to the input units in the PLC system, which leads to problems from time to time, and to get to know the research focused in detail on the knowledge of the devices used, their types, the nature of their work, and their suitability to the nature of the system's work.

1.3. Layout

This thesis consists of five chapters which can be summarized as follows:

Introduction: The chapter dealt with the objective of the study, as well as the importance of the study, as well as previous studies that dealt with the design of control systems.

General Sections: The second chapter dealt with the history and stages of development of PLC microcontroller systems, in addition to the hardware and software used as well as examples of input and output devices for PLC systems, as well as the types of memory found in PLC in addition to the software components such as timers, counters, comparisons, mathematical operations, and PLC programming methods.

Materials and Method: The third chapter dealt with the materials used in creating the system, in addition to its technical specifications, as well as the program used in programming the system.

Results: The fourth chapter dealt with the most important results that are reached. The results are represented in clarifying the results of the programming process of the system using the simulation program accompanying the SIMATIC MANAGER S7300 program. Through this program, the results of the programming steps and the possibility of changing them can be seen before downloading the program to the CPU.

Discussion: This chapter discussed the most important results that have been reached through the chapters of the study, as well as the most important recommendations and suggestions that the study can recommend.

The chapter also dealt with future studies in the design of control systems using PLC, for the wide use of these systems in all industrial fields because the design of these systems is not limited to water purification systems.

1.4. Literature Review

Hind Adel Sami [2020]. PLC logic control system is designed to classify water dissolved solids by adjusting and the number of chemical additives and the amount of discharge pilot system. This system consists of a steam boiler connected to a control circuit containing an electrical conductivity meter was designed and manufactured as well as the percentage of dissolved solids, in addition to the ratio of PH to boiling water. The importance of PLC is to protect commercial boiler tubes from sedimentation and corrosion due to dissolved salts.

The results showed that the PLC circuit is designed within a certain range, and the reason is to control the conduction amount 3900 micro-Scion/cm. The percentage of dissolved solid salts in water of 20 parts per million besides, the amount of sediment is controlled by adjusting the amount of boiler water discharge while keeping the PH within the requirements [2].

Hala Helal Hadi [2019]. Design a production line control system with a supervision and follow-up system to access, process, control and monitor production line data to help make important decisions related to the production process. The study presented the possibility of monitoring the pneumatic systems used in industrial applications and calculating the lost air pressure in transmission lines. In addition to a kind of graphical user interface, the first is to display data on a computer screen and a separate one on the touch panel. The production line was designed and simulated using FACTORY IO TIA PORTAL S7 1200 V15 software [3].

Athraa Sabeeh Hassan [2015]. Designed and construction of a control system for a pneumatic electric lift using PLC. To move in three floors with a height of about 126 meters, the model was automated using a PLC controller Its control depends on the inputs receiving requests from the operator as well as the sensors. The PLC consists of eight inputs and twelve (LS/GLOFA- G7M- DR20A) type outputs. The system is programmed in ladder language according to the elevator traffic management algorithm. This elevator system can be used for educational purposes in addition to serving the current research work [4].

Sysala and Thomas [2010] This study focus, on describing the scientific models that were used in the educational process so that the models are linked to the PLC system and through this device the models were controlled. This Students had to connect the models to the PLC system and create a model control program to check the results, it is a depiction of the control process of some Supervisory Control and Data Acquisition (SACAD/HMI) systems. Description of the educational elevator model outputs to illustrate the PLC programming method, So it can be concluded that it is possible to learn PLC programming using real equipment through the use of remote control capabilities via a PC or PLC. Models look very similar to real equipment and students use the simulation software that accompanies PLC software of all versions Through it, system operation can be viewed, debugged and added before downloading the software to the central consol, providing an easy and integrated way to design any PLC system [5].

By reviewing previous studies on the topic of research designing programmable control systems, it is found that there are several ways to design and program controllers to reach the possibility of designing and programming a stable system and high reliability. PLC systems provide a wide space for the designer to choose the form of programming that he deems appropriate for the system through the fewest, easiest, and fastest programming steps. Thus, the design of these systems provides for reducing human effort and providing a safe work environment by keeping people away from dangerous places in the machine and relying entirely on the automation of machines, thus, industrial automation can provide very economical control systems by reducing the number of hardware components used in classical control systems and can be replaced by programs stored in PLC memory which are much broader and faster than conventional control. Which is often intended for a single operation, which requires large numbers of hardware components, this achieves a multi-use control system that is not limited to one control process but can be used in other operations by removing the programming of the system from the PLC memory and reprogramming it again according to the new require.

2. GENERAL SECTIONS

The word (PLC) is an abbreviation of programmable Logic Controller.The first programmable controller was made by General Motors in 1968. Initially, the device only replaced conventional relays, Except that it could not meet the requirements of the manufacturer, but in fact it was the beginning of a new generation in the manufacture of programmable devicesm,Which later developed and spread widely in all industrial fields 4In the period between 1970-1974, as a result of technological advances in the microprocessor industry, programmable devices became more flexible and intelligent and made it easier for technicians and engineers to handle digital electronics. These devices are now able to perform arithmetic and logical operations and can be controlled using different languages, easier than those used before. As for the period between 1975-1979, there was significant progress in the manufacture of programmable devices, and this development such as an increase in memory capacity and the number of digital inputs and outputs, as well as an increase in the ability of the microprocessor to perform operations. It also became easy to store any program in an external memory unit, and it became possible to change previously-stored data during operation. Therefore, the programming unit can change programmed timers, program counters, shifts of variable values , and comparators without stopping industrial production lines. At the same time, in some areas of the industry, the PLC module cannot stop modifying the data, so these problems were later overcome by high-efficiency PLC modules. Industrial fields have seen a great demand for intelligent PLC programming modules, which has led to competition from manufacturers in hardware development. The result of these tremendous developments in technology was the manufacture of logic controllers with several advantages, the most important of which are [4]

- The cost of the device has become so low that it can be used instead of tens of riyals,
- It is now possible to use small-scale controllers in analog control,
- It became possible to connect controls from temperature sensors and stress meters,
- Various sizes of programmable logic units appeared, some with only out ten inputs and outputs, and some with several thousand inputs and output.

2.1. PLC Evolution

Use programming languages more easily in programming processes and the ability to identify malfunctions and adjust internal data during the operation of the industrial process as well, the response time of the programmed controllers is very fast, even reading the program to the reach about 3000 times per second, thus using Cables to transfer information to and from the programming unit at a very high speed of up to 1875 kbps [1, 6]

2.1.1. Advantages of PLC Devices

It is characterized by flexible control so that it is easy to change the performance of the industrial process to keep pace with any expansions by modifying the program as well as Maintenance and Troubleshooting In addition to the fact that the control devices are electronic devices, so they do not require maintenance and aim to clarify their malfunctions, whether they are minor faults or serious malfunctions, and one of their most important features Its size is small with very high capabilities compared to other control circuits, so it can be said that the programmed controller with dimensions of 10cm * 15cm * 20cm can replace hundreds of relays, hundreds of counters and timers, in addition to its high ability to perform calculations, it also has many operations which have no equivalent in control [4, 6]

As for comparing them to regular computers, the programmed controllers are intended to operate in an industrial environment characterized by significant changes in temperature, humidity and high noise, as they are designed to be installed, maintained and programmed by the site engineer and, It can work within a network that can assemble a set of logical programming units, by linking the logical programming units in a local network through which data is exchanged, and each of them is controlled by a computer, and data is exchanged between the computer. and PLC through a mini communication network in addition to those devices, The PLC contains a central processing unit (CPU), which reads and executes the program by reading the input and processing it on the program, and then running the output [1, 6]

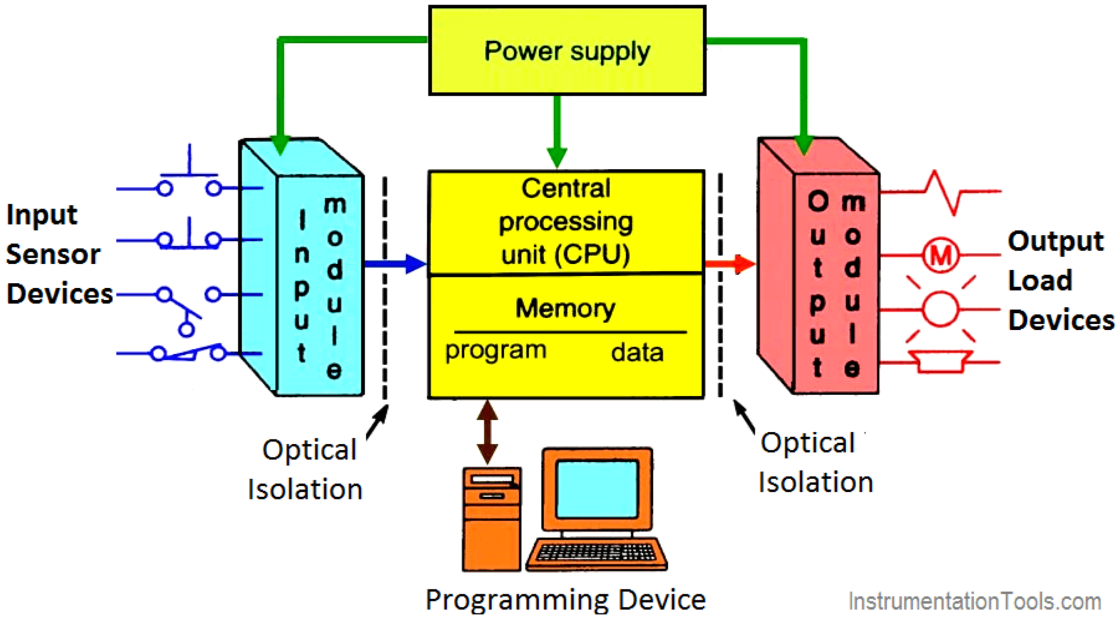


Figure (2.1) The main components of PLCs [1]

2.1.2 Using PLC

A PLC is a high-tech device, so a PLC does a lot of complex exercises, but in very simple ways compared to the control, and also do some exercises that can't be designed with the control. Other than that, there are hundreds of timers, counters, and some other commands that have no equivalent or similar control [7]

2.1.3. PLC Module Components

1. Power supply: It consists of a step-down transformer and a rectifier with a step-down transformer that converts the AC voltage to another AC voltage of lower value as well as The unified circuit that converts alternating current to direct current without changing the voltage value, Where it is necessary to focus on an aspect in which the use of the power supply unit depends on the type of PLC [8].

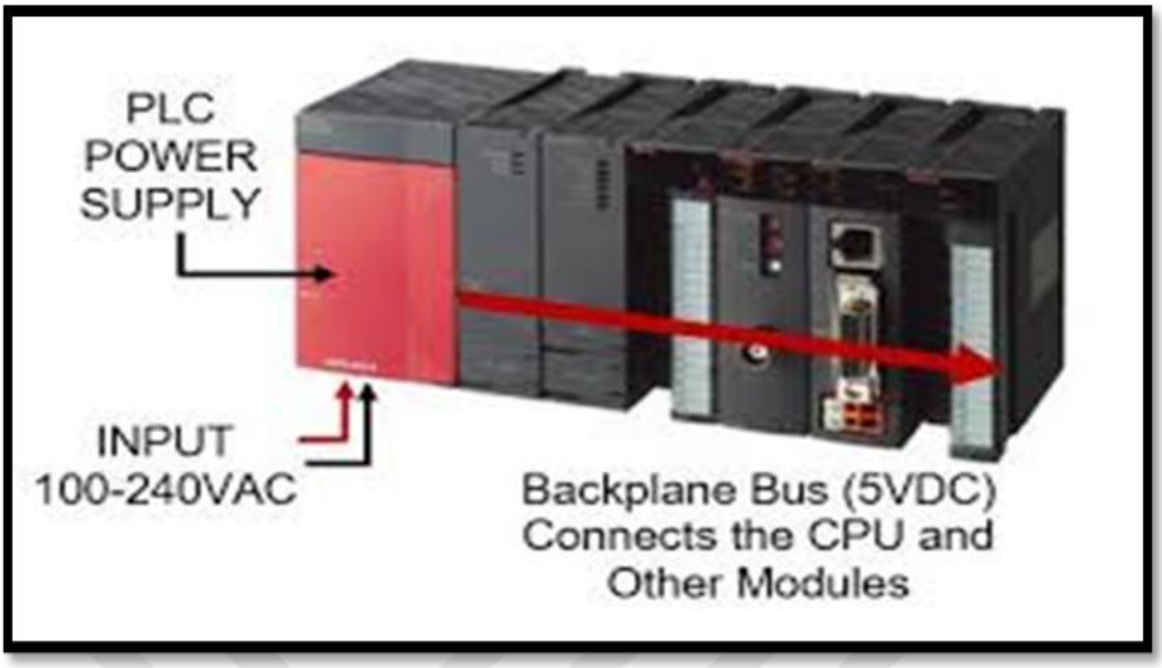


Figure (2.2) Power [1, 2]

If these types operate at a voltage of 220 volts, i.e., in this case the electricity source is connected directly and the power source is not used due to the presence of a standard rectifier circuit inside the PLC to convert to DC, In some cases while connected, you may need to use more than one power supply at the same time, In this case, it is preferable to connect the negative terminal of all the feeders used together to ensure equality and equilibrium of the voltage coming out of the feeders, In this case, it is preferable to connect the negative terminal of all the feeders used together to ensure equality and equilibrium of the voltage coming out of the feeders [8].

2.Cpu (central processıng unıt).

It is the thinking mind of a PLC that reads the program and performs the calculations in a very fast way so that the output is turned on or off at the right time.

Each processing unit has its specifications that affect its speed in executing operations, for example.

CPU 313:12KB program reads in 0.6MS.

CPU 314: 24KB program reads in 0.3Ms.

The processor always needs memory to hold the program while reading and executing. Memory inside a PLC is always volatile [9]

3.Input and output unıt.

As for the input, it is the place where only one end of the switch is connected so that it sends the signal to the PLC and this applies to switches with a digital signal of all kinds.

As for the output, it is where only one terminal of the load is connected so that it receives the signal from the PLC. This applies to loads containing a digital signal of all kinds [10]

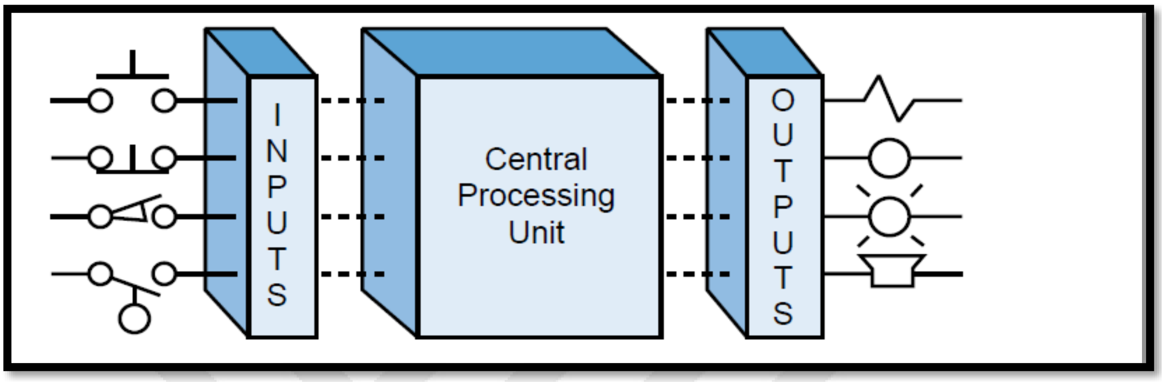


Figure (2.3) Input and Output Units [3]

The other end of the switches is connected to the mains, taking into account the value of the voltage written on the PLC, with Inputs and outputs that are divided into digital and analog inputs [11]

2.2. Inputs/Outputs

2.2.1. Digital Signals

Digital inputs: The digital input is connected to the digital input units of the logic controllers. the digital input unit controls the value is 0 or 1, and the electrical value changes to and from these two values depending on the state of the switch

Digital outputs: The interface is connected to the digital output modules of the logic controllers, the digital output module controls the outputs, and all these outputs have only two states: an ON state and an OFF state [1, 12]

2.2.2. Analog Signals

Analog signals: Analog input devices are connected to the analog input units of logic controllers, and the analog input unit converts any measured quantity into an electrical quantity, such as voltage and current (usually, the electrical value is two values, the maximum and the minimum, and the electrical value varies between these two values)

Analog outputs: Analog output devices are related to the analog outputs of the logic controllers, the analog outputs deal with the changing values caused by the outputs of the logic controllers, and all these devices have more than one state (the output state usually changes according to the electrical value of the analog output and the electrical value changes between the maximum and minimum) [13].

2.2.3. Throwing Inputs

1.Bush Buttons: These devices reflect the state of the feathers they touch, which means that an open feather closes naturally and vice versa when pressed against its head.

Figure (2.4) Bush Battens [9]

The figure (2.4) represents a model of the RUN and STOP switches.

2. Limit switches: These devices change their contact state when the moving element is pushed to them by a moving lever [14]

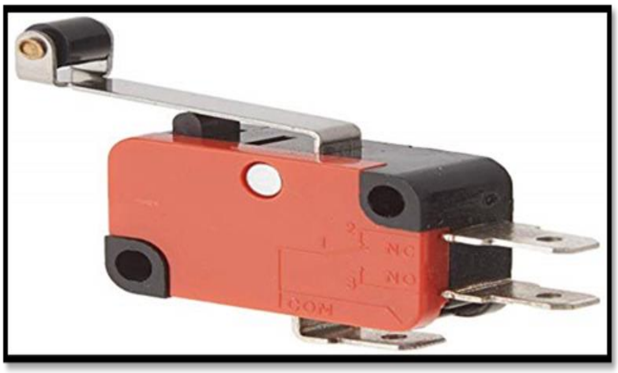


Figure (2.5) Limit Switches [9]

The Figure (2.5) represents a model of limit switches, which is one of the models, and there are other different models.

3. Proximity switches: In such devices, their contact position is reversed when a foreign object approaches them for a certain distance depending on how far the proximity switch is operated [15]

Figure (2.6) Proximity Switches [2, 9]

Figure (2.6) represents typical proximity switches, which are widely used and manufactured within special specifications, (sensing sensors).

4. Photocell switches: The state of the blades touching these devices is reversed when a foreign object passes to cut off the beam emitted by the transmitting unit of the photocell. Regarding how it works, when any foreign object passes between the receiver and transmitter of the photovoltaic cell, the contacts of the photovoltaic cell change.

Figure (2.7) Photocell Switches [9]

The Figure (2.7) represents a model of Photocell switches, which are switches with special uses and different models.

5. Floating switches: These switches are used to keep track of the question level in the tanks, as the state of the icons for these switches is reversed when the liquid level in the tanks reaches the required level. The scope of its use is to know the level of liquid in tanks [16]

Figure (2.8) Float Switches [10]

The Figure (2.8) represents a model of foat switches, which are switches with special uses and different models,(Level Metrics).

6. Pressure switches: These are devices in which the contact blades are reversed when the pressure in pipes and tanks reaches the predetermined pressure. These switches are used to track liquids and gases [17]

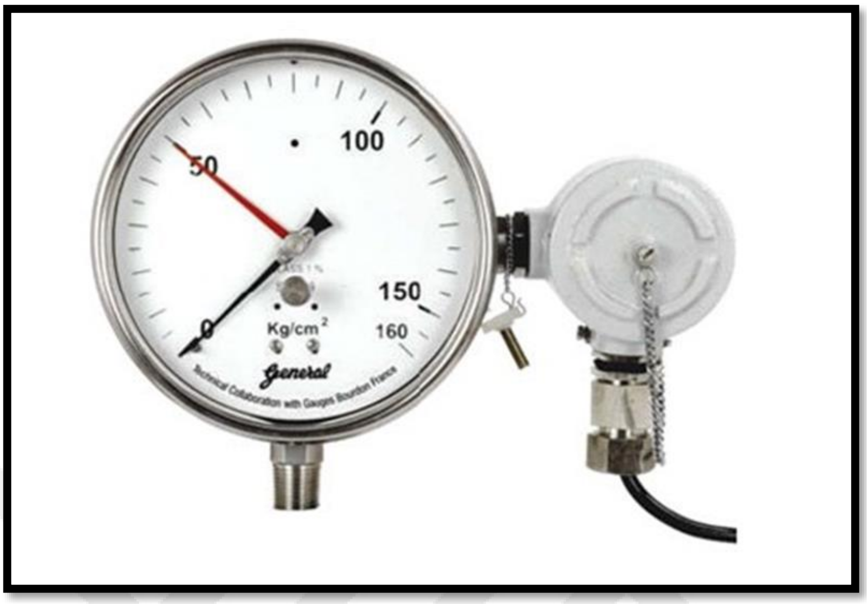


Figure (2.9) Pressure Switches [10]

Figure (2.9) represents one of the most commonly used models of pressure switches.

7. Thermos states: They are devices that reflect the state of the blades they are touching when the temperature of the surroundings of their sense element rises to the design temperature [18]

Figure (2.10) Thermos States [12]

The figure (2.10) represents an exampleof temperature sensors and gauges.

2.2.4. Outputs with a Digital Signal

1. Contactors: The conductor conducts the electric current to the loads when the voltage reaches its coil and vice versa. The conductor consists of an electric coil and a magnetic core with a fixed slit and a movable one carrying the main contact blades. When the voltage reaches the conductor coil, the moving slit of the core is attracted towards the stator slit, and thus the conductor blades are reversed.

Figure (2.11) Static Relays [1, 10]

A conductor connects and disconnects electrical current to loads, just like conductors, and is preferred to be used in place of conductors when the number of connection and disconnection times per minute [19]

Figure (2.12) Solid and Electromagnetic Relay [10]

The Figure (2.12) represents two models of Contactors, used in PLC, namely, solid state Relay and Electromagnetic Relay.

2. Solenoid valves: It opens or closes the passages for the passage of fluids in the tubes, and consists of an electric coil, a stationary magnetic core, and a movable magnetic core that opens or closes the stopcock [20]

Figure (2.13) Solenoid Valves [9]

3. Indıcatıon Lamps: It is located in control rooms to help operators perform industrial operations and troubleshoot faults.

4. Horns**:** It makes loud noises when something unusual occurs in the industrial process to alert the operators and works when an electric current reaches the coil because it depends on the flow of compressed air inside the horn [21]

2.2.5. Analog Input Examples

1. Thermocouple: The thermocouple converts the temperature into a voltage signal. The thermocouple consists of two different metals (A - B) joined together to form a metering

valve. The value of the generated voltage depends on the degree of contact, so the voltage on both ends of the thermocouple is directly proportional to the temperature.

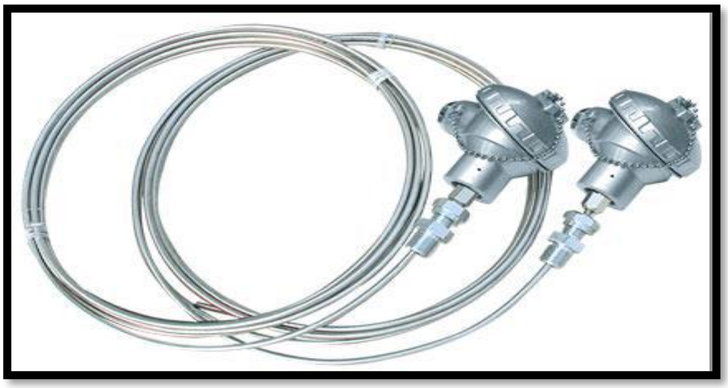


Figure (2.14) Thermocouple [10]

2. Taco generator: This generator is installed on the shafts of the motors whose speed is to be measured. The output of the taco generator is linear, which means that the voltage of its terminals is directly proportional to the speed. If the conversion ratio of the taco generator is 1 volt per 3000 rpm, for example, if the voltage at the end of the generator is 5 volts, then the motor speed is 1500 rpm.

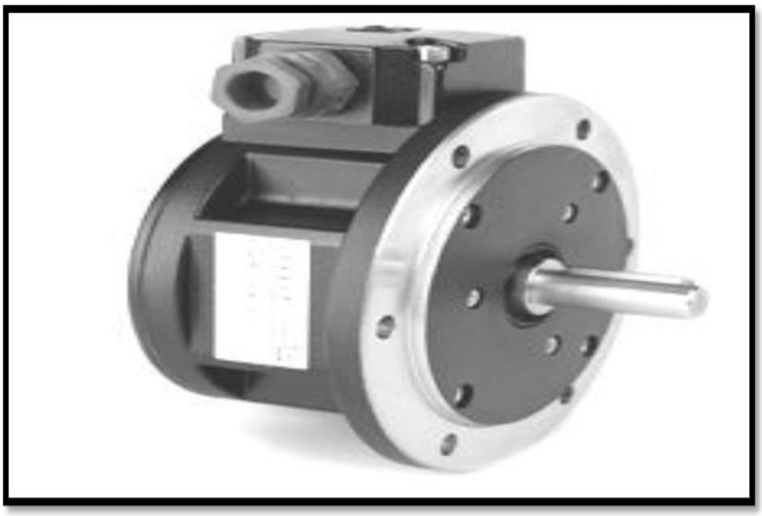


Figure (2.15) Taco Generator [12]

2.2.6. Analog Output Examples

1. Driver: The driver is used as an example of the analog output where an electrical value (MV - Ma- V- `Ω) is received from the logic programming unit and by the driver the motor speed is controlled by changing the frequency value [22]

Figure (2.16) Driver [12]

2. Damper Motor: The damper motor is used as an example of the analog output, where an electrical value (MV-MI-V-Ω) is received from the logic programming unit, and the degree of cooling of the air conditioner is controlled by the damper. Where the gate opens for the passage of cold air as needed [23]

Figure (2.17) Damper Motor [12]

2.3. Memory

The memory inside the PLC is the most important part because it contains the program that the CPU reads and that's why the computer can be separated from the PLC after downloading the program to the memory. Therefore, if the memory containing the program is of a volatile type, the PLC must be connected to a direct current, such as (battery plug) to save the program. But if the memory containing the program is of a non-volatile type, it is not necessary to connect the PLC to a constant current source [24]

2.3.1. The Two Types of PLC Memory

1. The memory inside the computer is always volatile: random access memory (RAM) is a memory that can be drawn and modified and the program can be erased more than once, but it has drawbacks, and one of its drawbacks is that when the power is cut off, the entire program (if without a battery) is erased.

2. The memory added to the PLC is always of a non-volatile type, the other type of memory is the read-only memory (ROM), one of its most important features is that it does not lose the program when the power is cut off (even if it does not have a battery), and the main disadvantage of this type is that it does not the program can be modified or deleted again [25]

2.3.2. Various Types of Rom

1. Eprom: **(**Electrical Programmable Read-only memory), The program is transmitted from the computer to the EPROM through a programming card where the memory is placed inside it, and the programming card is connected to the computer, and pressing the "Lode" button the program is downloaded to the memory, The program of this type of memory can be erased from memory usıng UV rays, so that the memory is placed inside the UV device for a limited time, and this operation is performed by an experienced person to avoid memory corruption, no more than one program can be stored in memory at the same time. [26]

2. EEprom: (Erasable Electrical Programmable Read-only memory). The program is written and transferred from the computer to memory, and the programming card is connected to the computer by pressing the (Lode) button. The program can be erased from the memory (Memory cartridge erase [27]

3. Flash memory: The program can be easily written to this type of memory without any problem and without using the programming card, that is, controlling the memory without separating it from the PLC. The program can be easily erased on this type of memory without any problem and without using the programming card, i.e., controlling the memory without separating it from the.

<u>Note</u>: no more than one program can be stored in memory at the same time.

2.4. PLC Unit Classifications

There are tow types of Bipolar Transistor

❖Bipolar junction transistor: Positive Negative Positive (PNP) hyju

If the PLC is PNP, all switches are fed a positive signal while the negative is connected to the input unit.

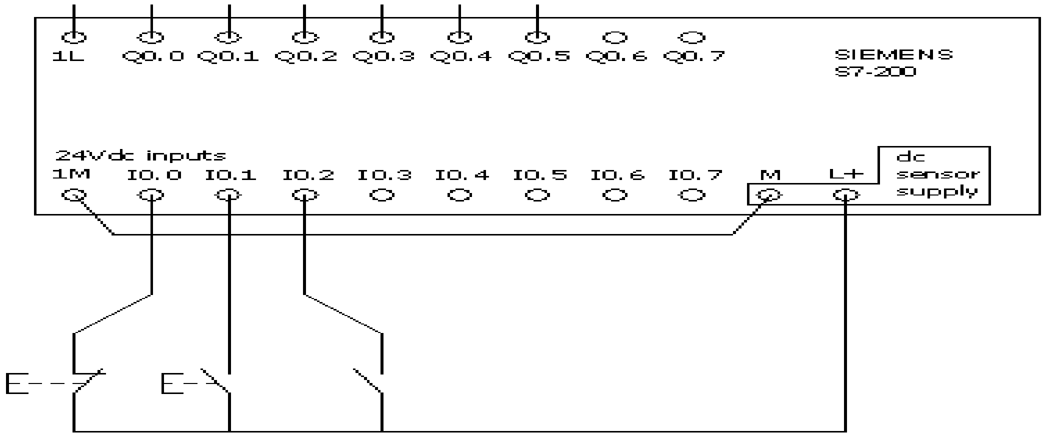


Figure (2.18) PNP [6]

❖ Negative positive Negative: (NPN): NPN In a PLC, all switches are fed to a negative while the positive is connected to the input unit where the letter is (L+).

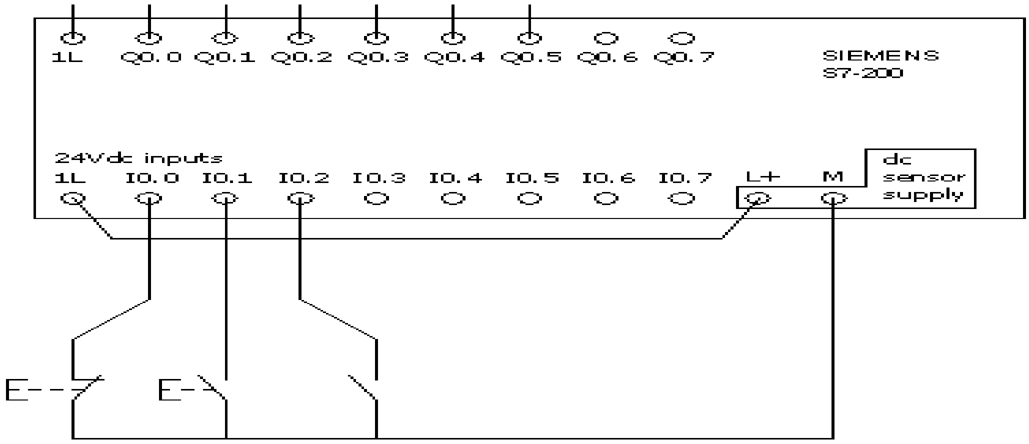


Figure (2.19) NPN [6]

Preferably NPN type PLC and not PNP, because if using NPN type PLC, the positive terminal must be connected to the switches, so if a worker on the positive system accidentally touches the terminal while his feet are in contact with the ground, the worker Figure 2.19 **(**

follow) will receive an electric shock. For the second type, if the PLC is NPN type, then the negative terminal must be connected to the switches, so if the worker accidentally touches the negative terminal and his foot touches the ground, he will not be subjected to electric shock because the potential difference between the negative and the ground is zero.

The type of PLC, whether it is PNP or NPN, refers to the method of input connection and has nothing to do with the method of output connection because a PLC always gives a positive output signal regardless of the type of PLC device.

Note: The letter L written on the PLC means the location of the positive terminal, while the letter M means the location of the negative terminal, and this, if it indicates something, indicates that this type of device works with (DC).

2.4.1. Digital and Analog Signals

Digital signal: What is meant by a digital signal is a digital signal that contains only two states, either the signal is equal to one or zero, if we talk about the state of the digital input, for example, If the key is open, it will be represented by one (YES -TRUE-ON), But if the switch is closed, it will be denoted by zero (NO-FALSE- OFF), Similarly, the digital output is denoted if (YES -TRUE-ON) is one, But if the output does not work (NO-FALSE-OFF) it will be indicated by zero, and an example of a digital input (normal switch - bell switch - push-button switch), an example of a digital output (bulb - bell - motor - pump) [28]

Analog signal: An analog signal is any signal that has more than two states, the signal has variable values other than zero. for example, if we talk about analog inputs, and if there is a signal, then it may be (1-2-3-4- …..etc.). But if there is no sign, the value is zero, this applies to the case of analog output, analog input signal axample of analog inputs(thermometer resister - encoder), Valeur’s multi-lectures, for analog output examples (heater - voltmeter).

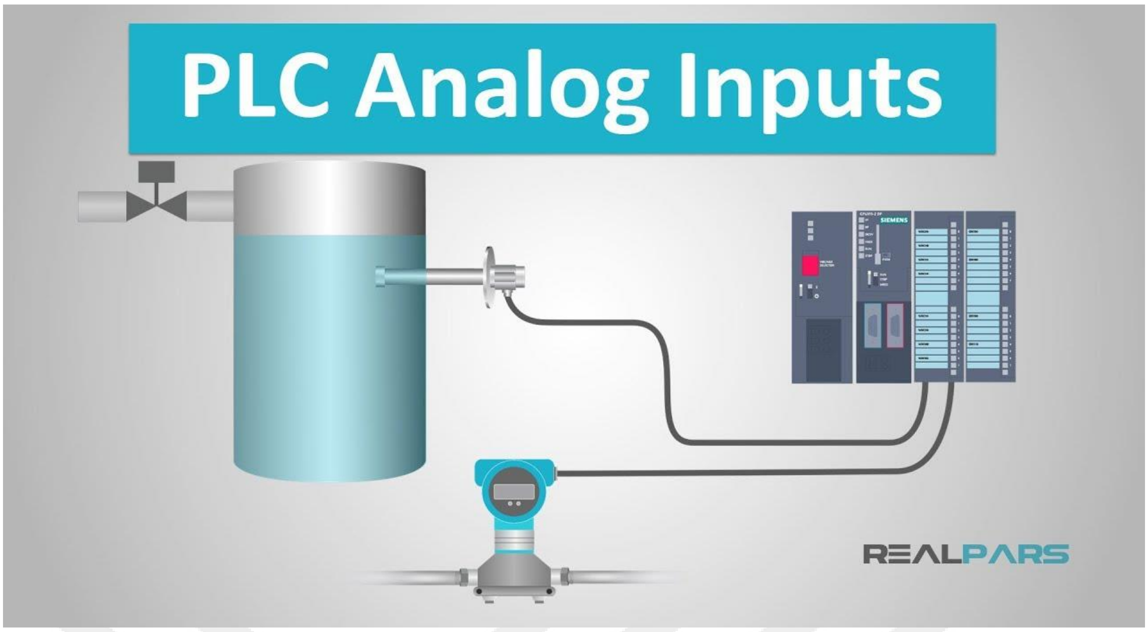


Figure (2.20) Analog Input [6]

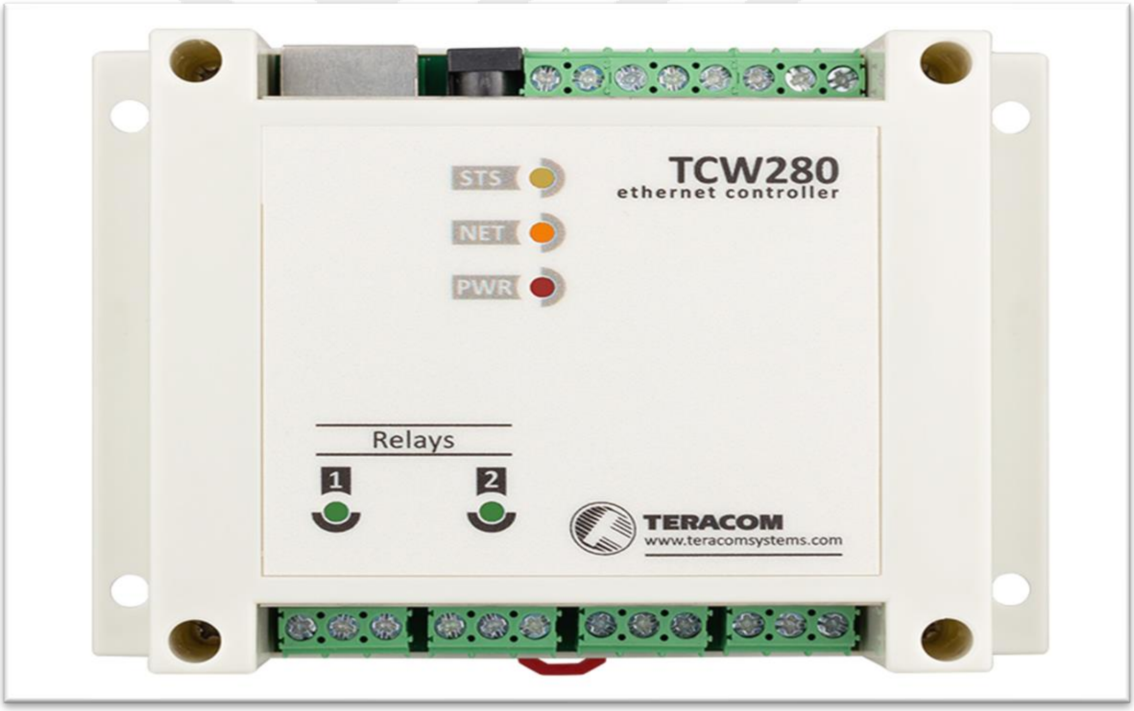


Figure (2.21) Analog Output [6]

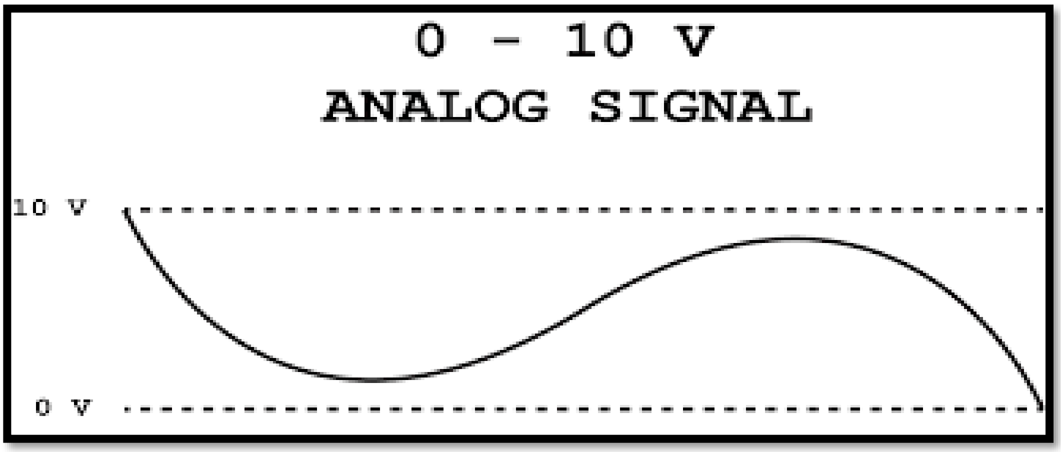


Figure (2.22) Signal Format in Analog Output [29]

2.4.2. Types of Outputs in PLCs

1. Transistor: If the PLC is of the transistor type, this does not make the connection method different, but it has some advantages and disadvantages compared to another type of output relay, and this type of output is characterized by its ability to send fast signals in a short time, as it may send more than a thousand signal per second. as for its drawbacks, the output voltage is constant and its value is 24 V DC, and one of its drawbacks is that it cannot handle a current of more than 0.3 - 0.5 A. [30]

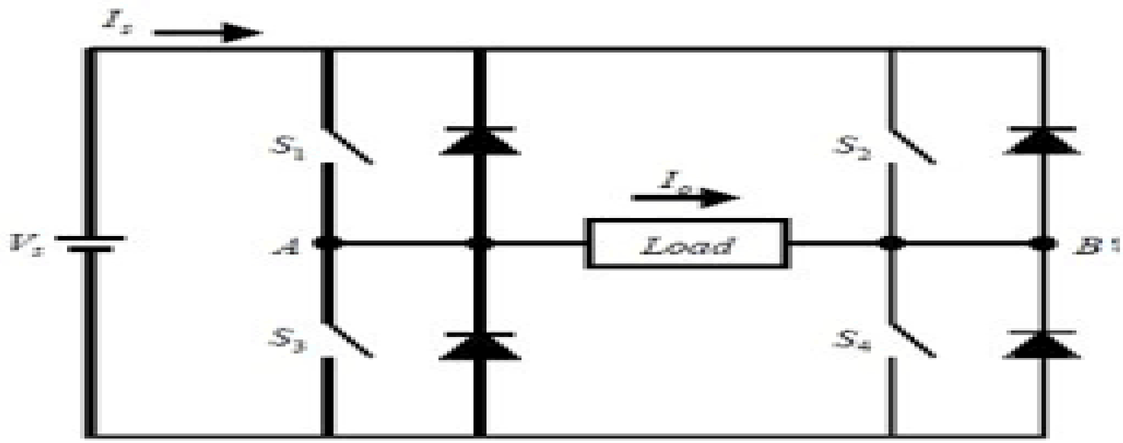


Figure (2.23) Transistor Type. [9]

2. Relay: If the PLC is of the Relay Output type, then it does not make the connection method, but it has some advantages and disadvantages, the most important of which is that the output voltage is not specified, but it is possible to connect any value within the permissible voltage, for example, 12VDC, 110VAC, 24VDC, 220VAC, also operates with

Figure 2.23 (follow) a current of up to 2A - 2.5A, the most significant drawback is that it cannot transmit fast signals in a short time like a transistor [31]

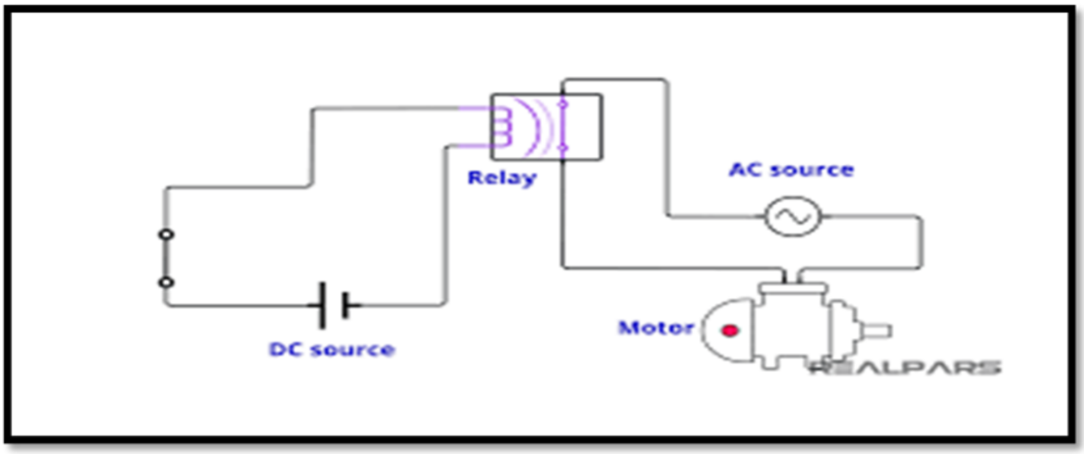


Figure (2.24) Relay Type [9]

If a relay is used, it becomes possible to feed any load with any voltage and draw any current within the limits of the type of relay used, if the motor draws excessive current, there is no danger to the PLC, the relay will be affected, not the PLC, so the relay is chosen to operate at the same output The voltage from the PLC, the selection of the relay points so that it resists the current drawn from the load, the load may be drawing excessive current from the relay point, the overcurrent from the PLC because the relay is nothing but a coil.

Some may find it problematic to use a mechanical relay because it consists of a coil and contact points that act mechanically, so it may require time between signals for the contact points to open and close. Therefore, if the PLC emits fast signals, it is preferable to use an electronic relay instead of a mechanical one, as it is characterized by auxiliary points that change state very quickly.

2.4.3. The Use of Relay

To be able to operate loads which are operated at a voltage different from the output voltage of the PLC, and also to be able to operate loads which draw a current of greater value than that which is drawn by the PLC, in addition, it provides protection to the PLC from overcurrent which may be drawn by the load at any time [32]

If the loads differ in current or voltage with the PLC, and if the load is compatible with the PLC in terms of current and voltage, it is possible if this load is a motor to draw excess current to increase the torque of the motor, The mechanical relay can be used as an intermediary between the PLC and the load wherein the PLC operates the relay, the relay operates the load to be driven by the contact points [4, 10]

2.4.4. Relay Selection Criteria

Coıl specıficatıons: The voltage of the relay coil must operate at the same value as the output voltage of the PLC unit, and the current drawn from the relay coil must be within the permissible limit so as not to damage the PLC [1, 25]

2.4.5. Contact Specifications

To withstand the load carrying points that will be powered by the auxiliary points, the relay points must carry the value of the current drawn from the load that will be powered by this relay [33]

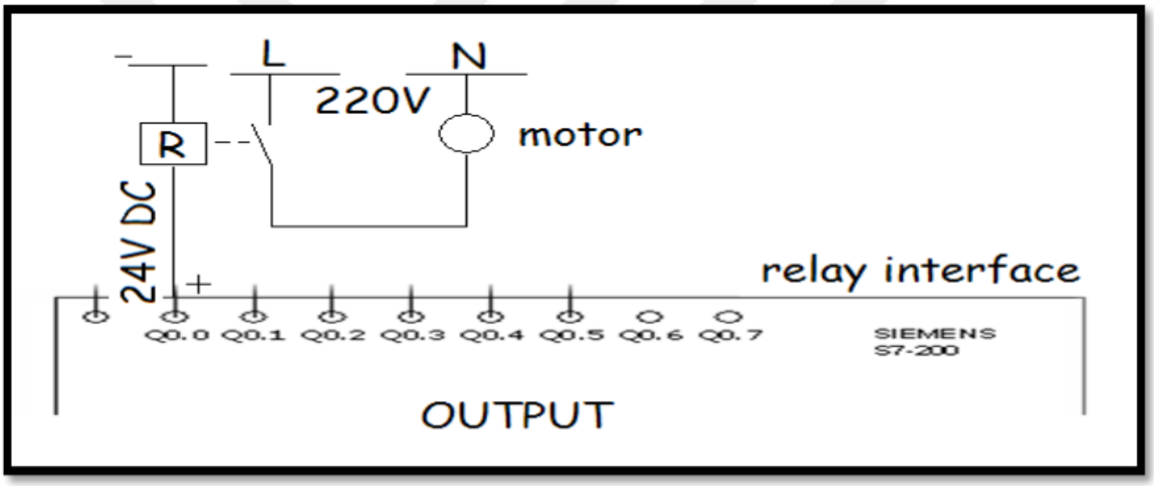


Figure (2.25) Explains How to Connect the Relay [6]

2.5. PLC Connection Methods

❖ DC/DC/DC

DC The first word: for CPU feed,

DC The second word for input feed,

DC The third word for output feed,

❖ AC/DC/RLY

AC The first word: for CPU feed,

DC The second word: for input feed,

RLY The third word: for output feed,

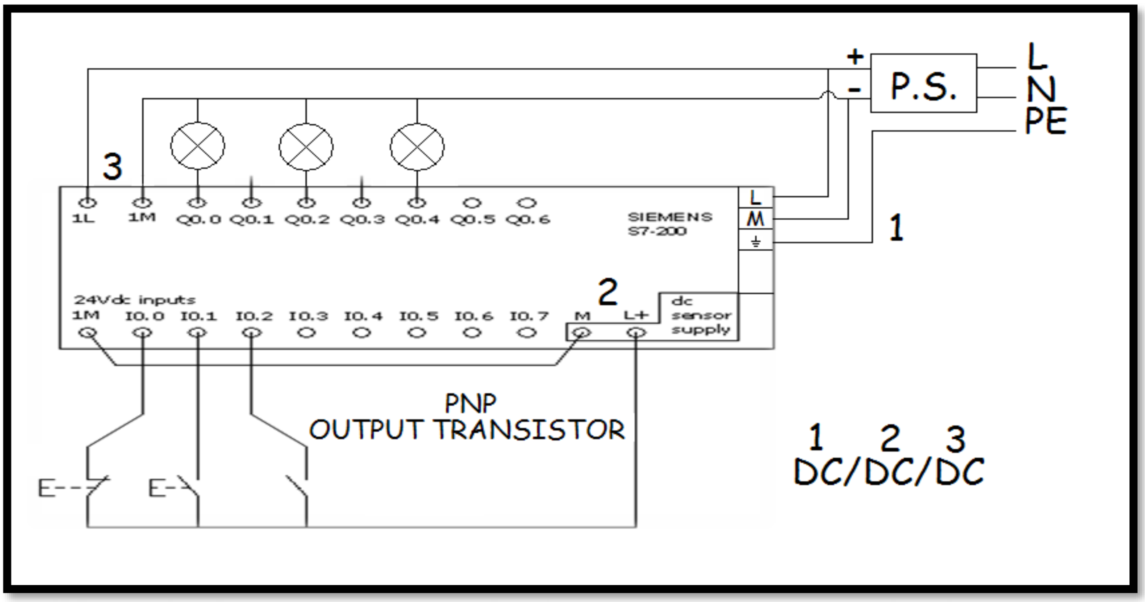


Figure (2.26) DC, DC, DC, DC [6]

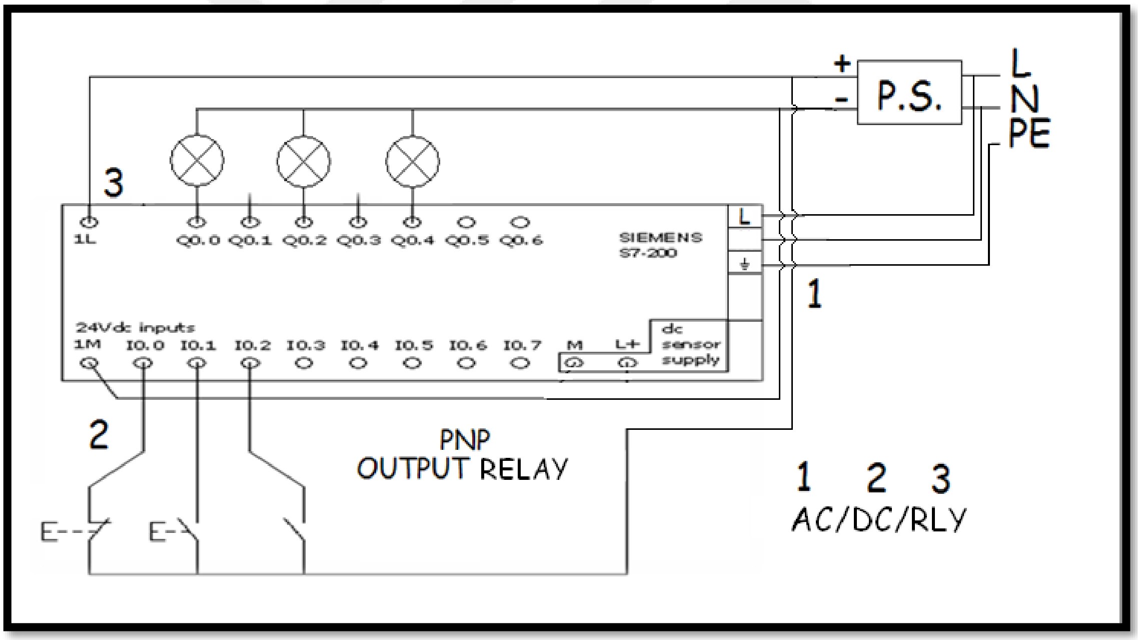


Figure (2.27) AC, DC, Relay [6]

2.5.1. Types Available on All PLC Models

Table (2.1) Showing Examples of Both Types (DC/DC/DC, AC/DC/Relay) [1]

Model Description	Power supply	Input Types	Output Types
221 DC/DC/DC 221 AC/DC/Relay	20.4-28.8 VDC 85.264 VDC 47 – 63 HZ	6 DC Inputs 6 DC Inputs	4 DC outputs 4 Relay outputs
222 DC/DC/DC 222 AC/DC/Relay	20.4-28.8 VDC 85.264 VDC 47 – 63 HZ	8 DC Inputs 8 DC Inputs	4 DC outputs 4 Relay outputs
224 DC/DC/DC 224 AC/DC/relay	20.4-28.8 VDC 85.264 VDC 47 – 63 HZ	14 DC Inputs 14 DC Inputs	4 DC outputs 4 Relay outputs
226 dc/dc/dc 226 AC/DC/Relay	20.4-28.8 VDC 85.264 VDC 47 – 63 HZ	24 DC Inputs 24 DC Inputs	4 DC outputs 4 Relay outputs

2.5.2. PLC Internal Self-Protection

Inside the PLC there is a photocoupler for each input so that if any excess voltage is accidentally connected then the photoelectric isolator and not the PLC will be damaged because the photoelectric isolator is used as an insulator between two circuits. The electrical signal comes in. The first circuit turns into a light signal, and then the second circuit converts this light signal into electrical again. This isolator works with digital signals as well as with analog or analog signals [34]

Figure (2.28) Photoelectric Isolator [12]

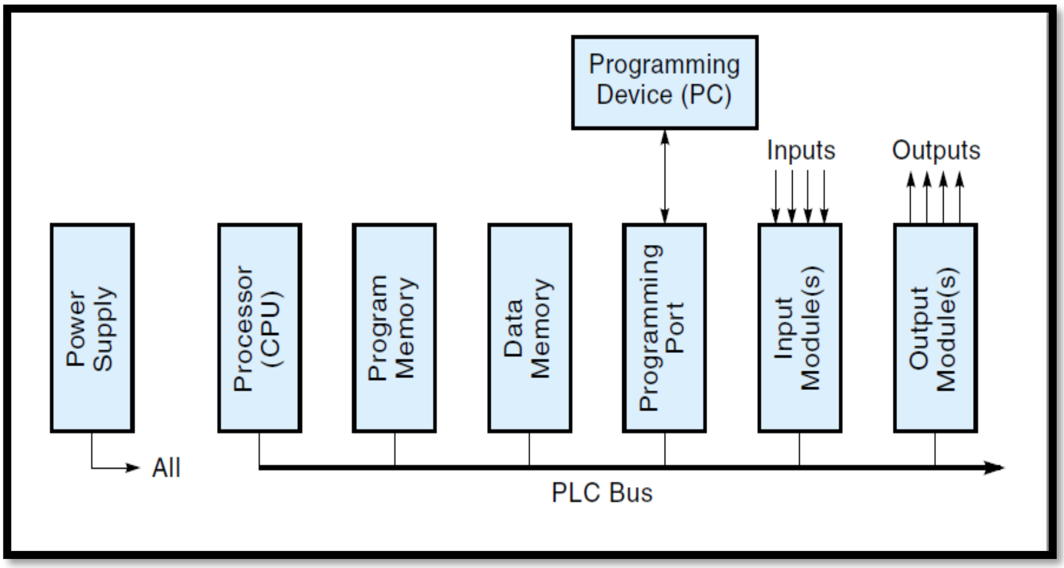


Figure (2.29) General Shape of PLC Components [17]

2.6. Parts of PLCs

1. Signal light.
2. PLC control switch. (mode switch).
3. Analog adjustment.
4. Programming cable input.
5. Battery location.
6. Memory location.
7. Extension module.

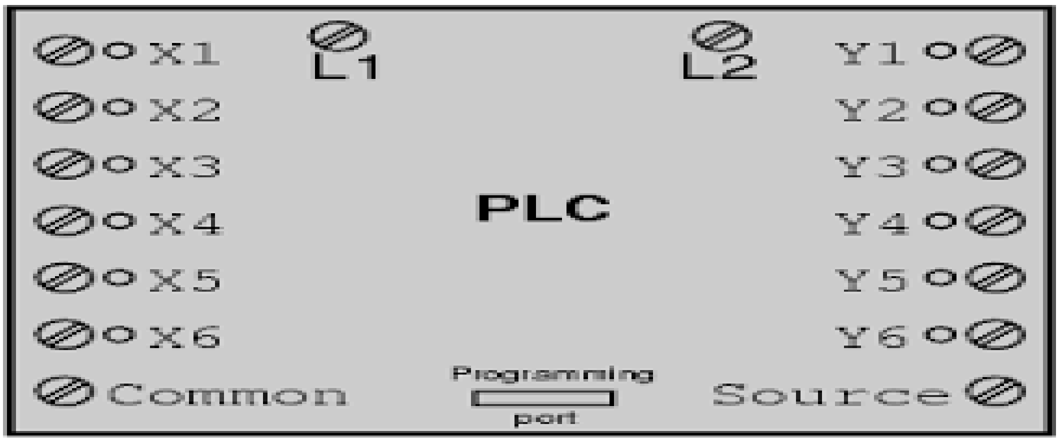


Figure (2.30) PLC Input, Output, and Programming Ports [25]

2.6.1. Types of Signal Lamps

1. Run lamp: It lights green when the PLC is turned on.

2. Stop lamp: It lights green when the PLC stops working.

3. Fault System: It lights up red when the PLC stops due to a problem. It is noted that if the S.F bulb is lit, the stop lamp will be lit as well because if there is a problem with the PLC, it can't continue to work, which means that it is not logical to keep working [35]

2.6.2. Plc control swıtch. (Mode Swıtch)

1. Run: If the switch is set to the run position, the PLC operates automatically, and the operating lamp lights green.

2. Stop: If the switch is set to the OFF position on the PLC automatically, the stop lamp lights up green.

3. Terminal: If the switch is set to the terminal position, it becomes possible to control a device in the PLC via the computer, and the stop lamp or the running lamp lights up, depending on the choice.

Analog adjustment: The analog signal tuning key is used as an example of analog input, the key value can be changed with a screwdriver to be used for programming (the value can be changed from zero to 255), to be Programming cable input, where the cable is connected between the PLC and the programming device, which is the computer in this case, and the connection between them is called PPI (Point to Point Interface) and is used to transfer information to and from the PLC, and there are several types of cables with different data transmission speeds [25, 36]

1. speed cable 9.6 Kbps: It transmits 9.6 kb of information in just one second, speed cable 19.

2. 2Kbps: It transmits 19.2kb of information in a size of 19.2 kb in just one second.

3. speed cable   18.7 Kbps: t transmits 187.5 kb of information out of 187.5kb in just one second.

Figure (2.31) Programming Cable Input [6]**c**

2.6.3. The Battery

The types of batteries used are lithium, and most of the battery voltage is 3.6 V, and it is preferable to charge the battery every two years, and the electric current of the battery is constant current, but it is a disadvantage to leave the battery current at zero because it leads to the end of battery life without warning [37]

There are extension modules: Since in some cases the programmer may need a set of additional inputs or outputs to be used in programming, it is possible to purchase modules with only an unlimited number of inputs, or modules with only a set number of outputs, or modules with several inputs and output [38]

Figure (2.32) Extension Module [9]

2.6.4. Further Digital Input and Output Modules

1. EM221: Additional input unit contains eight inputs.

2. EM223:Additional module with eight outputs.

3. EM223:The auxiliary unit has four inputs and four outputs.

4. EM223:The auxiliary unit has eight inputs and eight outputs.

5. EM223:The auxiliary unit contains sixteen inputs and sixteen outputs [39]

Example of addıtıonal analog ınput and output modules.

1. EM231: The input and output unit has four inputs.

2. EM232: The auxiliary input and output unit has two outputs.

3. EM235: Additional analog input and output modules with four inputs and one output [40]

The additional units are connected to the PLC via If the CPU224 auxiliary unit is connected to the PLC, the additional unit is connected to the PLC via a cable, but if the CPU214 auxiliary unit is connected to the PLC, the additional unit is connected to the PLC by installing the two together using a direct connection, it is preferable to use the connection between the PLC and the additional units Via cable because the two can be placed under each other or at great distances.

2.6.5. PLC Interface

- ❖ By computer.
- ❖ By HMI (Human Machine Interface).

The computer: It is easy to make any program in any programming language and download the program on the PLC. The program is taken from the PLC device for modification in the program by adding or scanning, as well as knowing the status of the program and how it works, and changing some data without stopping the program.

HMI: Where the modification is easily done in the program within certain limits. Know the status of the program and how it works. Change some data without stopping the program. See the alarms on the screen and know the type of malfunction and turn off the alarm.The computer is used initially only to run the entire program , and it is preferable to replace the computer with the control screen. Given that some PLC only have one output, so useıng a computer or HMI monitor to program, and other types have two outputs for programming, it is possible to connect the computer and the HMI monitor.

2.7. Memory Sizes in PLCs

BIT: It is the smallest memory unit inside a PLC, and it contains 0 or 1.

1

BYTE: It is a memory inside a PLC device that may contain 0 or 1 and consist of 8 bits [1].

1	0	1	0	0	0	1	1

WORD: It is a memory inside a PLC device and it may contain 0 or 1 and consists of 2 bytes or 16 bits [1]

0	1	1	1	0	1	0	0	1	0	0	1	0	1	1	1

D. WORD: It is a memory inside a PLC device and it may contain a 0 or 1 and it consists of 2 words, 4 bytes, or 32 bits [41]

1	1	1	0	0	1	0	1	1	1	0	1	0	1	1	1	0	1	1	1	0	1	0	0	1	0	0	1	0	1	1	1

BIT 0, BIT 1, BIT 2, BIT 3, BIT 4 ……………………

BYTE 0, BYIT 1. BYTE 2, BYTE 3 …………………

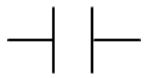
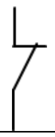
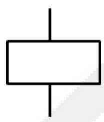
WORD 0, WOED 2, WORD 4, WORD 6…………….

D.WORD 0, D. WORD 4, D. WORD 8, D. WORD 12

2.8. System Programming Methods (Ladder Language Features)

The language used in the system programming is Ladder Language (Ladder Diagram Method) which is one of the programming languages of logic controllers and is the most used than the rest of the other programming languages [42]

Table (2.2) Ladder key Symbol [1]

NO.	Symbol name	Electrical circuit symbol	Symbol name	Ladder code	Main work
1	**S1**		**I0.3**		Power key (Normally open)
2	**S2**		**I1.7**		stop key (Normally close)
3	**H1**		**Q1.1**		outputs

2.8.1. Must Knows in Programming with Ladder Language

1. Cycle time: It is the time taken by the PLC to complete a closed loop i.e., going from any network until back to the same network again and it ranges from 1ms to 0.3ms [43]

2. Scan time: It is the time when the PLC needs to read the input and execute the program as well as modify the output.

According to the law: Scan time = Cycle time x Program size [Kbps]

Markers: It is a relay used inside the PLC for programming [1, 25]

Relay names:

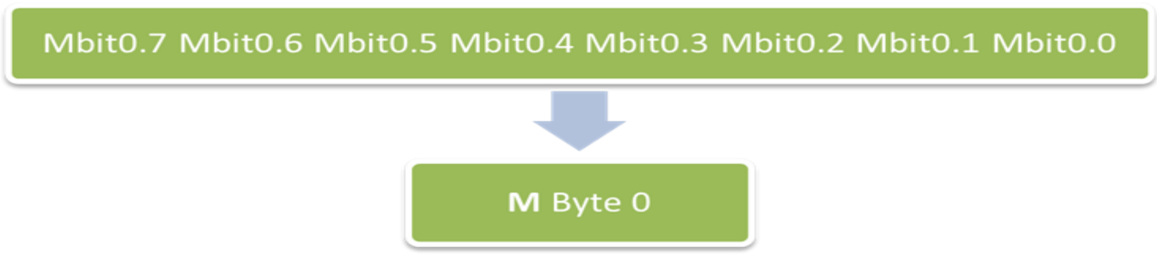


Figure (2.33) Example of the Name and Size of the Relays.

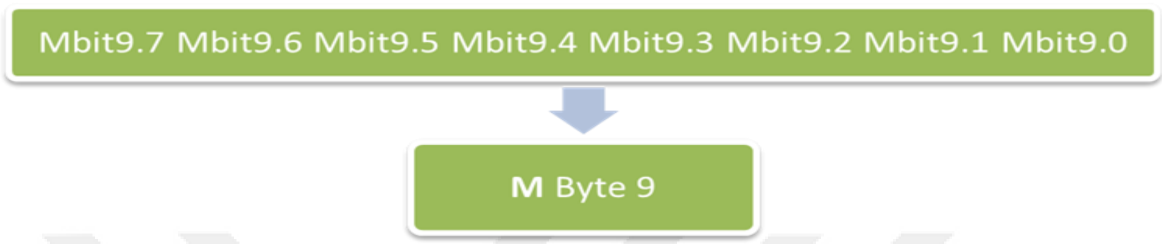


Figure (2.34) Second example of the name and size of the Relays.

Positive Edge Switch: It is a switch connected in series after any other switch so that when we close the switches which precede the Post Age switch, the signal is delivered for a time equal to the cycle time and to repeat this signal, i.e., the switch which precedes the positive lifetime switch must be opened and closed again.

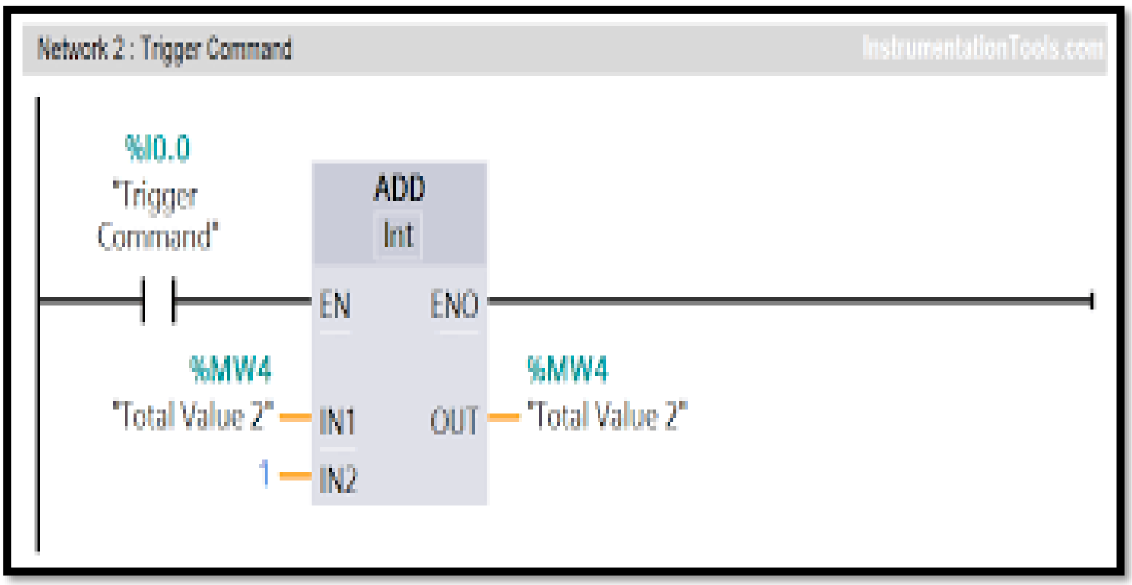


Figure (2.35) Positive Edge key [16]

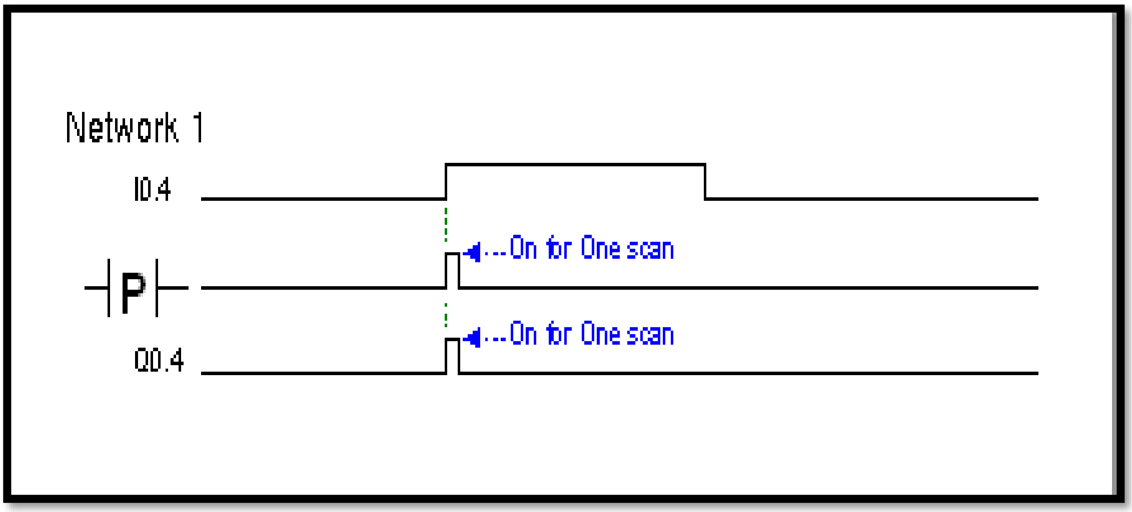


Figure (2.36) Schematic Diagram of Making Positive key [30]

Posıtıve edge key types:

1. Pulse catch off to.

2. positive edge.

3. positive pulse.

4. positive irisation.

Negative edge key: It is a sequentially connected switch after any other so that when we close the switches preceding the.

Negative edge key, the switch does not transmit the signal. But when any or all of the switches preceding the negative edge key are opened, the converter delivers the signal for some time equivalent to cycle time. To repeat this signal, any key that precedes the negative edge key must be closed and then opened again [1, 44]

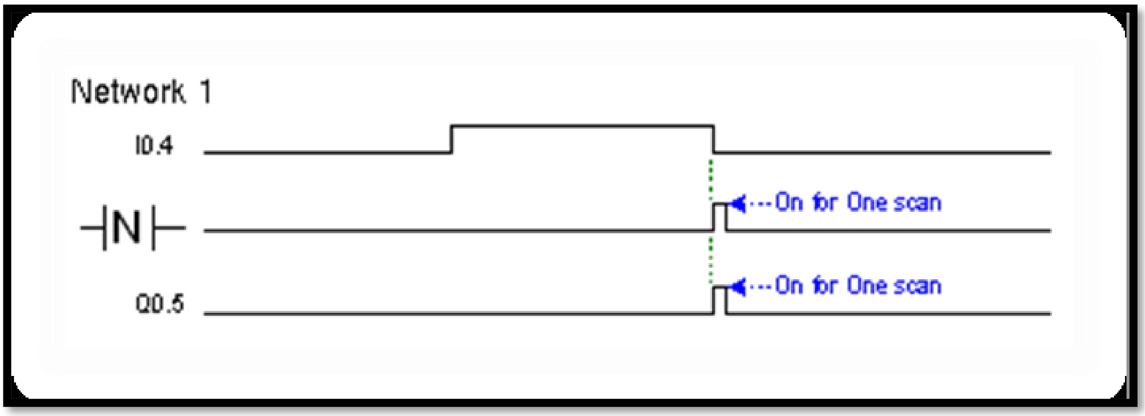


Figure (2.37) Schematic Diagram Df Making a Negative key [1]

Negatıve edge key types:

1. Pulse catch off to

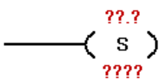
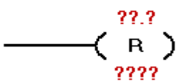
2.. Negative edge.

3. Negative pulse.

4. Negative irisation.

Set/Rese**t:** It's a switch used in the on oprating, when a signal is sent to the Set outpot array, it works. The Reset key is used in class. When a signal is sent to the Reset point, it is disconnected [16]

Table (2.3) Set/Reset [1, 9]

NO.	Name	Symbol	Clarification
1	Set		It is used for operation, that is, if a signal is sent to set any output, it will be turned on.
2	Reset		It is used to disconnect, that is, if it is sent to reset any output, it is disconnected or turned off.

Boolean ınput: It includes several separate entrances to the module and must be in the form of keys and can be programmed in the following way.

Input and output labels [45]

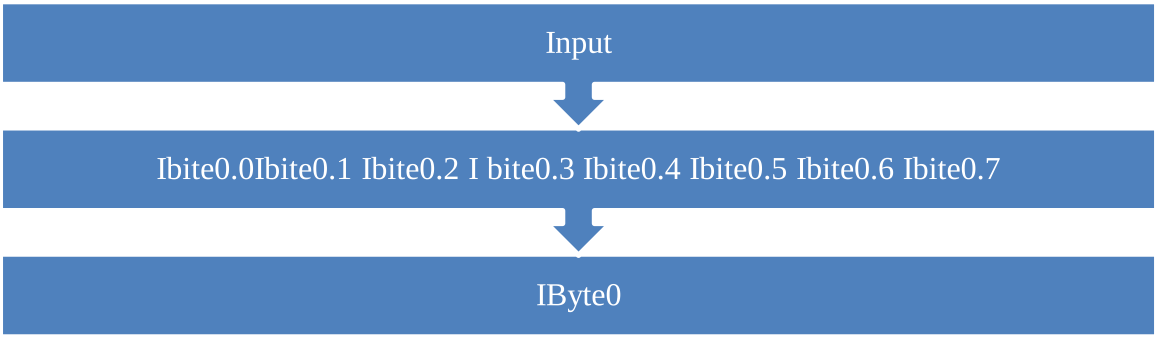


Figure (2.38) Logical Input Size.

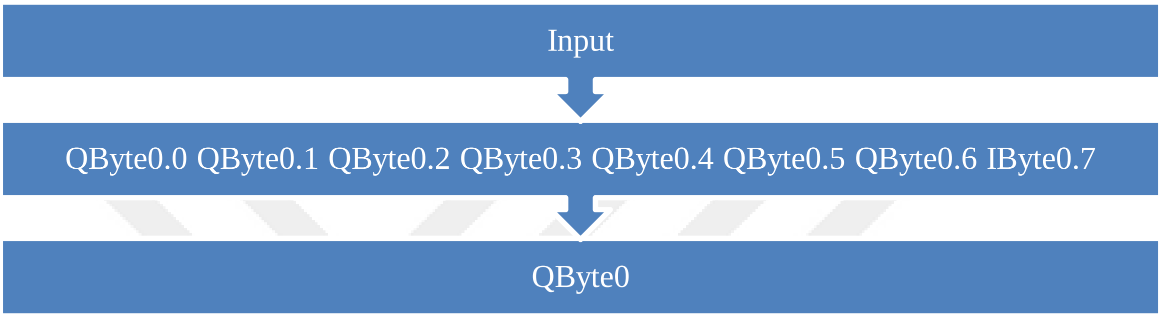


Figure (2.39) Logical Output Size.

Tımers**:** It is used to timing the start or end of any process that needs a specific time.

1. Timer on Delay (TON): It changes the position of its electrodes after a time of operation, that is, it depends on the preset time.
2. Timer off Delay (TOF): It changes the position of its poles when it is turned on, and after the signal cut-off time, it starts working until it reaches zero, then the position of the poles returns to the way it was.
3. Retentive Timer on Delay (TONR): Returns the position of the electrodes to their original position.

Table (2.4) Names of timers: (TON /TOF) [1, 27]

NO.	Type	Time	Accuracy	Maximum time	Temporary name
1	TON/TOF	1 sec= 1000	MS 1	32,767 sec	T32,T,6
2	TON/OF	1 sec= 100	MS 10	327,67 sec	T32 – T36 T97 – T100
3	TON/TOF	1 sec= 10	MS 100	3276,7 sec	T37 – T63 T101 – T255

Table (2.5) Names of Timers: (TON R) [1, 9]

NO	Type	Time	Accuracy	Maximum time	Temporary name
1	TONR	1 sec= 1000	MS 1	32,767 sec	T0 - T64
2	TONR	1 sec= 100	MS 10	327,67 sec	T1-T4-T65-T68
3	TONR	1 sec= 10	MS 100	3276,7 sec	T5 - T31-T69-T95

2.9. Timer’s

Timer (ON) It changes the position of its electrodes after the time of operation, which means that it depends on the present time, if the timer feed is cut off, it will return to zero and by pressing it again it will start from the beginning. Timer points can be repeated infinitely, either use the timer's (TOF) key. Changes the position of its poles when turned on, after a while the signal is interrupted the timer starts working until it reaches zero, then the position of the poles returns to what it was at the beginning before the timer worked.

Repositioning the electrode to its original position depends on the present time, and the timer points can be repeated infinitely. As for the use of the timer's (TONR), it changes the position of its electrodes after the on-time, which means it depends on the preset time. If the timer feed is interrupted, it will not return to zero, by pressing again, it will continue to work from the same point, timer points can be repeated infinitely, to separate the timer, we send a signal to reset the timer [17, 45]

2.10. Variables

It is a memory inside the PLC that is used to write any numbers for later use, whether in arithmetic or comparison operations, it is very important to consider that if the information is written in bits, the writing should start from left to right, but if the information is written in bytes, word or de word, writing should start from left to right, as well as in the case of reading data.

Bit: It is the smallest memory unit inside a PLC, and it may contain zero or one.

Byte: It is a memory inside a PLC containing 0 or 1 and consists of 8 bits.

Word: It is a memory contained within a PLC containing 0 or 1 and consisting of 16 bits or 2 bytes.

D word: It is the largest memory unit inside a PLC containing 0 or 1 and consists of 32 bits, 4 bytes, or 2 words.

2.11. Counters

Counters are used to know the number that was, Manufactured, and there are several types of counters, the most important of which are.

- ❖ Counters UP (CTU).
- ❖ Counters Down (CTD).
- ❖ Counters UP and Down (CTUD).

Mechanism of work of the counters. (CTU), Counter properties:

Integer: That is, the numbers used with the counters must be integers only.

Signed: That is, the numbers used with counters can be positive or negative, noting that all that can be written on the comparison keys, and values that are written during programming not subject to change while prog. Running .

The maximum counter number is the maximum number that can be written into Word's memory [45]

- ❖ It changes its polarity when it reaches the preset value.
- ❖ If the counter feeding is interrupted, it does not return to zero but rather sends a signal to R, it returns to zero to start from the beginning.
- ❖ Counterpoints can be repeated without limits.
- ❖ Counts from zero until it reaches or exceeds the preset value.
- ❖ It changes the position of its poles when it reaches zero.

Mechanism of work of the counters, (CTD).

- ❖ If the counter feed is interrupted, it does not return to the present value, but by sending a signal to LD, it returns to the present value to start from the beginning.
- ❖ Counterpoints can be repeated without limits.
- ❖ Counts down from the present value until it reaches zero.

Mechanism of work of the counters. (CTUD) [1, 17]

- ❖ Changes the position of the electrode when it reaches the preset value from the start.

- ❖ If the counter feed is interrupted, it does not return to zero, but instead, by sending a signal to R, it returns to zero to start from the beginning.
- ❖ Counterpoints can be repeated without limits.
- ❖ Counts and down from zero until it reaches or exceeds the preset value.

Table (2.6) Names of the counters [1, 25]

NO.	Type	Counters	Accuracy	Maximum positive	Maximum negative	Counter name
1	CTU	1 Counting=1	1:1	-32768	+32767	CO – C255
2	CTD	1 Counting=1	1:1	-32768	+32767	CO – C255
3	CTUD	1 Counting=1	1:1	-32768	+32767	CO – C255

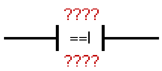
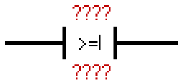
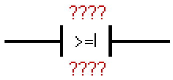
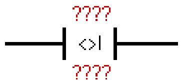
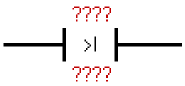
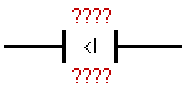
Table (2.7) What is Written Below the Comparison keys [1, 12]

NO.	Type	Clarification	NO	Type	Clarification
1	IB	It is a set of eight keys.	9	MD	A set of Thirty-two riyals.
2	IW	It is a set of sixteen keys.	10	VB	A set of variables with a byte size.
3	ID	A set of thirty-two keys.	11	VW	A set of variables with a word size.
4	QB	A set of eight outputs.	12	VD	A set of variables with a D word size.
5	QW	A set of sixteen outputs.	13	SMB	A group of eight special relays.
6	QD	A set of Thirty-two outputs.	14	SMW	A group of sixteen special relays.
7	MB	A set of Eight riyals.	15	SMD	A group of eight special relays.
8	MW	A set of sixteen riyals.	16	AC	It is the content of arithmetic operations.

2.12. Comparators

Each comparator key is an equation such that the key is closed when this equation is satisfied, otherwise the key remains open [46]

Table (2.8) Comparison keys [1, 9]

NO.	Name	Figure	Function
1	Equal to		When the value above the key is equal to the value below the key and vice versa, the key is closed, otherwise, the key remains open.
2	Greater than or equal		When the value written above the key becomes greater or equal to the value under the key and vice versa, that is, the value written below the key is less than or equal to the value written above the key, the key becomes closed, otherwise the key is still open.
3	Less than or equal		When the value written above the key becomes less than or equal to the value written below the key and vice versa, that is, the value written below the key is greater than or equal to the value written above the key, the key becomes closed, otherwise the key remains open.
4	Not equal to		When the value written above the key is not equal to the value written below the key and vice versa, the key is closed, otherwise, the key remains open.
5	Greater than		When the value written above the key becomes greater than the value written below the key and vice versa, that is, the value written below the key is less than the value written above the key, the key is closed, otherwise the key remains open.
6	Less than		When the value written above the key becomes smaller than the value written below the key and vice versa, that is, the value written below the key is greater than the value written above the key, the key becomes closed, otherwise the key remains open.

2.13. Moves

Move value transfers are used to transfer any value from within any memory to any other memory, bearing in mind that the size of the memory to which the value will be transferred is the same as the size of the memory from which the value will be moved. Black Move mass transfers are used to transfer any number of bytes, Word, or D Word, bearing in mind that the size of memory to which the value will be transferred is the same as the size of memory from which the value is transferred.

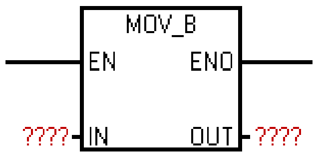
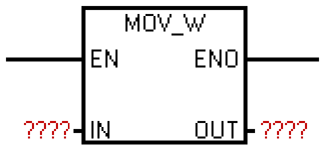
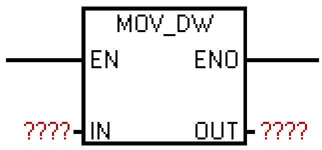
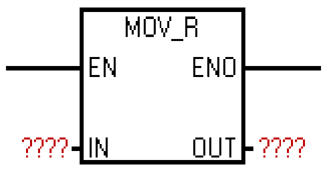
There is an arrow to the right of the Move or BLK Move that acts as a key that closes when the desired operation is performed. they can be arranged as follows.

- ❖ Byte: Byte transfers are used to transfer any constants (integers) or byte-derivative variables to any other byte-derivative variables.
- ❖ Word: Word transfers are used to transfer any constants (integers) or variables from word derivatives to any other word derivative variables.

- ❖ D word: D Word transfers are used to transfer any constants (integers) or variables from D Word derivatives to any other D Word derivatives.
- ❖ Real: D Word transfers are used to transfer any constants (decimals only) or variables from D Word derivatives to any other D Word derivatives. [47]

The table (2.9) shows the types of moves.

Table (2.9) Move keys [1, 17]

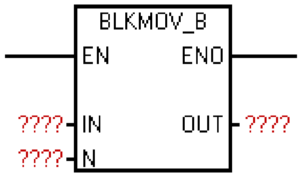
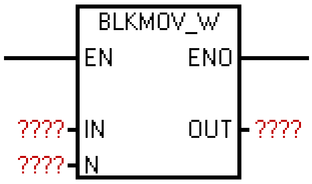
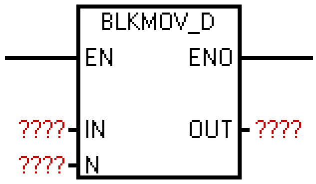
NO.	Name	Clarification	Figure
1	Byte	Byte transfers are used to transfer any constants (integers) or byte-derivative variables to any other byte-derivative variables.	
2	Word	Word transfers are used to transfer any constants (integers) or variables from word derivatives to any other word derivative variables.	
3	D word	D Word transfers are used to transfer any constants (integers) or variables from D Word derivatives to any other D Word derivatives.	
4	Real	D Word transfers are used to transfer any constants (decimals only) or variables from D Word derivatives to any other D Word derivatives.	

The most important types and sizes of data sent in PLC can be specified and the field of use of each of those types because these variables play a major role in completing the transfer process in the required manner to avoid data overlap. Table (2.10) represents the most important of these types and forms.

- ❖ Byte set transfers are used to transfer any number of bytes, provided they are consecutive in order, It can be a byte array containing constants (integer numbers only) or any variables. [48]
- ❖ Word set transfers are used to transfer any number of words, provided they are consecutive in order and can be a word set containing constants (integer numbers only).

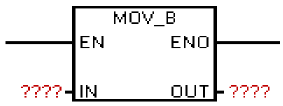
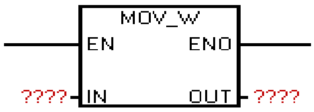
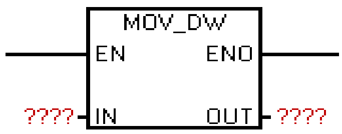
❖ D word set transfers are used to transfer any number of D words, provided they are consecutive in order and the D word set can contain constants (integer and decimal numbers) [49]

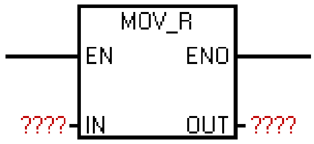
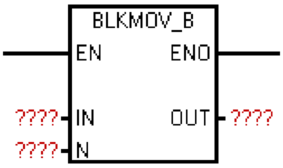
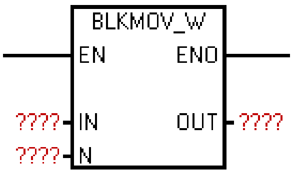
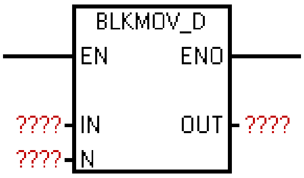
Table (2.10) Types and Sizes of Transmitted Data [1, 30]

NO.	Name	Clarification	Figure
1	Byte	Byte set transfers are used to transfer any number of bytes, provided they are consecutive in order. It can be a Byte set containing constants (integer numbers only) or any variables from Byte derivatives to any other Byte derivative variables.	
2	Word	word set transfers are used to transfer any number of words, provided they are consecutive in order It can be a word set containing constants (integer numbers only) or any variables from word derivatives to any other word derivative variables.	
3	D word	D word set transfers are used to transfer any number of D word, provided they are consecutive in order It can be a D word set containing constants (integer numbers and decimal Number) or any variables from D word derivatives to other word derivative variables.	

2.13.1. Inputs and Outputs in Moves

Table (2.11) What can be Written Under the Move keys [1, 43]

NO.	Type	Clarification	Figure
1	Input	(integer numbers only QB, IB AC ,SMB, VB , MB .	
	output	QB AC , SMB, VB,MB	
2	Input	(integer numbers only)QW, IW AC, SMW, VW , MW .	
	output	AC, SMW, VW , MW, QMW.	
3	Input	(integer numbers only QD, ID AC,SMD ,VD, MD .	
	output	QD AC,SMD,VD,MD .	

4	Input	Decimal numbers only,QD, ID AC, SMD, VD, MD.	
	output	QD AC,SMD,VD,MD.	
5	Input	SMB, VB, MB, QB, IB. AC	
	output	QB AC,SMB,VB,MB.	
		1 to 255	
6	Input	SMW, VW, QW, LW. AC,SMW	
	output	SMW, VM, MW, QW. AC	
		1 to 255	
7	Input	SMD, VD, MD, QD, ID.AC	
	output	QD AC,SMD,VD,MD.	
		1 to 255	

3. MATERIALS AND METHOD

Technical specifications of the materials used in the components of the system and the method of programming the system. The system is a sand filtration system with a capacity of 1800 m 3 / hour and the duration of action is 24 hours. the system Designed as follows according to the characteristics entry of raw water into it, Turbidity with a maximum of

- Turbidity a maximum of Unit (60) NTU.
- TSS (140) mg/L (total suspended solids).

3.1. Basic Components and Technical Specifications of the Proposed System

1. Flowmeter (FIQ – 101,102), is a device that calculates the flow of a substance.

Table (3.1) Flow Meter Technical Specifications [50]

Quantity	1 pc.
Min / Max full scalce value	180 – 5400 m^3 /h
Type	Promag 50W
Diameter	DN 450
Location	At the inlet and after sand filter

2 . Turbidity Meter (TU 101,102) A device used to measure the turbidity of water, These devices are connected to the inputs and outputs of the systemm, It is a measure used to find out the percentage of turbidity in the water entering the filter. Gives an indication that the filters are working as intended, There are types of these devices, including digital devices, and those with an indicator.

Table (3.2) Technical Specifications of Water Turbidity Meter [50]

Quantity	2 set
Measuring range	0-9999 FNU
Sensor Type	Turbimax -W CUS31
Transmitter type	CUM223
Holder	Flow fit -W- CUA250
Location	At the inlet and after the sand filter

3. Differential Pressure Switch (DP- 01……10). A device used to measure the pressure difference between the input and the output, Each filter contains a pressure gauge used to measure the pressure inside the filter as well as the pressure outside the filter and perform a comparison process to determine the pressure required to operate each filter.

Table (3.3) Technical Specifications of Differential Pressure switch [50]

Quantity	5 pcs
Type	Horizontal centrifugal Mega150-400
Flow rate	401m^3 /h
Total head	4.02
Motor	1450 rpm, Ex-proof
Power Supply	75 kw,380V,3PH,50Hz, IP55
Material	Body and propeller: GG25, Shaft: St.70.2 Bearing bracket: GG-25
Inlet/outlet	DN200/150

4. Filter Feed Pump (Raw Water Pumps-1), (PP-101A/B/C/D/S), the pumps are used to feed the system, and these pumps are distributed on two lines that are used to push the water drawn from the sedimentation ponds and push it to the filter with a certain pressure and flow, They are also used to extract water after purification and are called production pumps.

Table (3.4) Technical Specifications of PO1. Feed pump [50]

Quantity	10 pcs
Type	RT-262 A
Regulation Range (ΔP)	0.1-1.5 bar
Mech Differential	0.1 bar
Max. operation pressure	11ar

4. Sand Filter (T-101A/B/C/D/E/F/G/H/I/J), Sand filters are used to purify water. Sand is used in the filtration process, And the number of ten filters spread over two lines, five filters for each line. Each of these filters contains a certain amount of sand used to purify water from all kinds of impurities, solids and turbidity associated with water to convert it into water suitable for general use, especially water that is used in factories near rivers, especially oil refineries.

Table (3.5) Technical Specifications of the Filters [50]

Quantity	10 PCS
Type	ESF – 350 Automatic
Flow rate	180 m^3 /h
Diameter x Cyl. Height	φ3.500x2.500mm
Filtration rate	20 m/h
Design pressure	6 bar
Design temperature	Ambient
Construction material	St.37.2 inside-outside epoxy painted
Filling material	Sand :23.000kg /per tank
Filled weight	Approx. 55.000 kg
Manhole	3 pcs
PP nozzles	500 pcs
Pneum. Act. Butterfly valves	2 pcs Water inlet/outlet 2 pcs Backwash water inlet/outlet 1 pc. Air inlet 1 pc Air vent 1 pc Drainage
Manometer	2 pcs, (0-10 bar)
Solenoid valve box	1 pc
Sampling valve	1 pc
Nameplate	1pc

4. Analyzer to analyze and know the percentage of PH in water. It analyzes the percentage of PH in the water that has been treated, and knowing the percentage of PH helps to know the performance of the system.

Table (3.6) Technical Specifications of PH Analyzer [50]

Quantity	SERIES THREE PH AMPLIFIER
Type	RT-262 A
VOLTS	+ 15 VDC
AMPS	0.02
CLASS	I,GROUPS B,CD,DIU.2
NON	INCENDIVE
CLASS	I,GROUPS B,CD,DIU.2

5. Drinking-Water Pumps - II (PP- 104A/B/C/S), The pump is used to push filtered water.

Table (3.7) Technical Specifications of Drinking Water Suction Pump [50]

Quantity	4 Pcs
Type	Horizontal centrifugal, Beta 65-200
Flow rate	70 m^3 /h
Total head	4.02 bar
Motor	2900 rpm EX -Proof
Power supply	15 kw ,380v,3PH, 50HZ, IP55
Material	Body and propeller: GG-25, Shaft: St.70 .2 Bearing bracket
Inlet/Outlet	DN 80/65

6. Air compressor (C- 102 A/S) Air compressor pushes air into the system for backwash.

Table (3.8) Air Compressor Technical Specifications [50]

Quantity	2 pcs
Type	DKC 200
Flow rate	410 I/min
Pressure	8 bar
Connection	1/2"- 1/2" BSP
Power supply	2.2 KW, 380 V,50 HZ

7. Pressure Switch (PS – 01), A device used to measure the pressure inside the system.

Table (3.9) Technical Specifications of System Pressure Gauges [50]

Quantity	1 pc
Type	KP 36
Setting Range	2-14 bar
Differential	0,7-4 bar
Operating Pressure	17ar

8. Electric Control Panel and PLC Unit. An Integrated PLC system was used to manage the system. A Siemens S7300 PLC was used with Smatic Manager Virsoin 5.6 to program the system.

Table (3.10) Technical Specifications of PLC Logic Control System [50]

Quantity	1 Set
Type	Vertical- S7300
PLC	Siemens

3.2 The Theory of the Proposed System

The system consists of a total of ten filters spread over two lines, five filters per line. In the case of the normal operation of the system, water enters the filter from above. The water will be filtered through the sand in the filter. Then the water comes out from the bottom of the filter after a period. The sand in the filter needs backwashing because the pores between the sand particles are clogged with impurities, can also wash the filter by hand if the specifications coming out of the filter are not expected (manually), one of the filters is washed again, the rest of the filters remain in the normal operating position, and pure water enters them, when the pressure difference between the inlet and outlet reaches 0.05 bar the system stops working and the backwash process starts automatically. The process is done by stopping the feed pump PO1, (OFF) which is used to feed the system with raw water. At the same time, the inlet valve of material V1 will be closed (OFF), and at the same time, the outlet valve of material V4 will also be closed (OFF) until the filter stops supplying the material.

At that time, the V6 air relief valve will start to work (ON). Also, the backwash water inlet valve V3. is turned on (ON), As well as operating the backwash pump PO2 (ON) to pump the backwash water with the air coming from the air compressor CO1 to form a mixture of water and air. With open backwash water output valve V2 (ON)to exit and drain the water.

AT the same time, the CO1(ON) air compressor will operate with the V5 (ON) air inlet valve open to push air into the filter. When air mixes with backwash water, it will move sand particles upward, removing suspended impurities and opening pores to reactivate the filtration process. the air is discharged to the special manholes through the air discharge valve at V6. Backwash water is also drained to special manholes through the V7. drain valve.

The backwashing process takes ten minutes, and after the backwashing is over the water is emptied. The system returns to work automatically after the set period has expired, this is done by closing valve V6 (OFF) and valve V4 (OFF), turning off the PO2 pump (OFF) for the backwash, turning off the CO1 air compressor (OFF), and closing the air inlet valve V5 (closed) and the drain valve V7 closed (closed). Note that valve No. 7 is always closed, except in the case of system maintenance.

After ten minutes, the filter that follows the cleaned filter enters the backwash stage, and after the completion of the process on the filter, after ten minutes, the filter that follows it enters the backwash stage depending on the differential pressure difference, the process will continue sequentially until all system filters are completed.

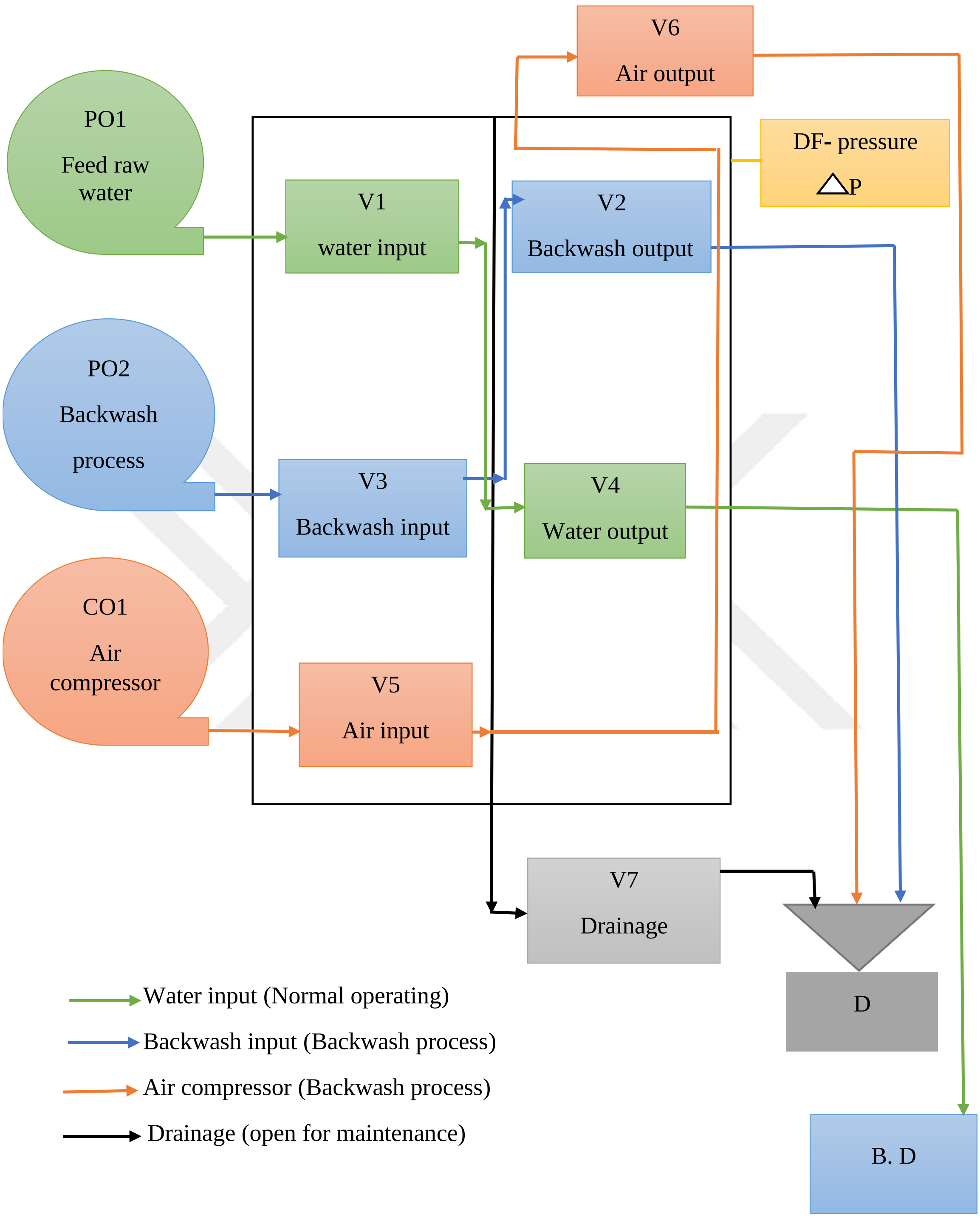


Figure (3.1) Diagram of a single filter showing the operation of the valves.

In the figure, the main components of one of the filters that make up the System is shown, showing the locations of the valves, PO1 feed pumps, PO2 backwash pump, CO1 air

Figure 3.1(follow) compressor and differential pressure switch. It is a model for all filters because the operations on it are the same as for the rest of the filters. Using Ladder Logic, one of the programming languages for programmable controllers, we will program the system using SIMATIC MANGIER a version of Siemens.

3.3. Valves Condition in Normal Operation and Backwash Process

Table (3.11) The Table Represents the Full Cycle of the System.

VALVE FUNCTIONS			
Pumps and valves		Cycle Steps	
		normal operating (service)	Backwash
PO1	Service pump (Feed)	Open	Close
V1	Service Inlet	Open	Close
V4	Service Outlet	Open	Close
PO2	Backwash (pump)	Close	Open
V2	Backwash Outlet	Close	Open
V3	Backwash Inlet	Close	Open
CO1	Air compressor	Close	Open
V5	Air Inlet	Close	Open
V6	Air Outlet	Close	Open
V7	Drain valve	Close	Close: open when the need for maintenance

The table (3.11) shows the status of valves and pumps designated for production and backwash pumps in normal operating conditions and the second case in the case of backwashing. The table represents the main functions and data that are relied upon in the process of analyzing and programming the system using ladder language, The ladder language was chosen in system programming for several reasons, the most important of which is the easiest and most widely used language and the wide spread in programming small and large systems.

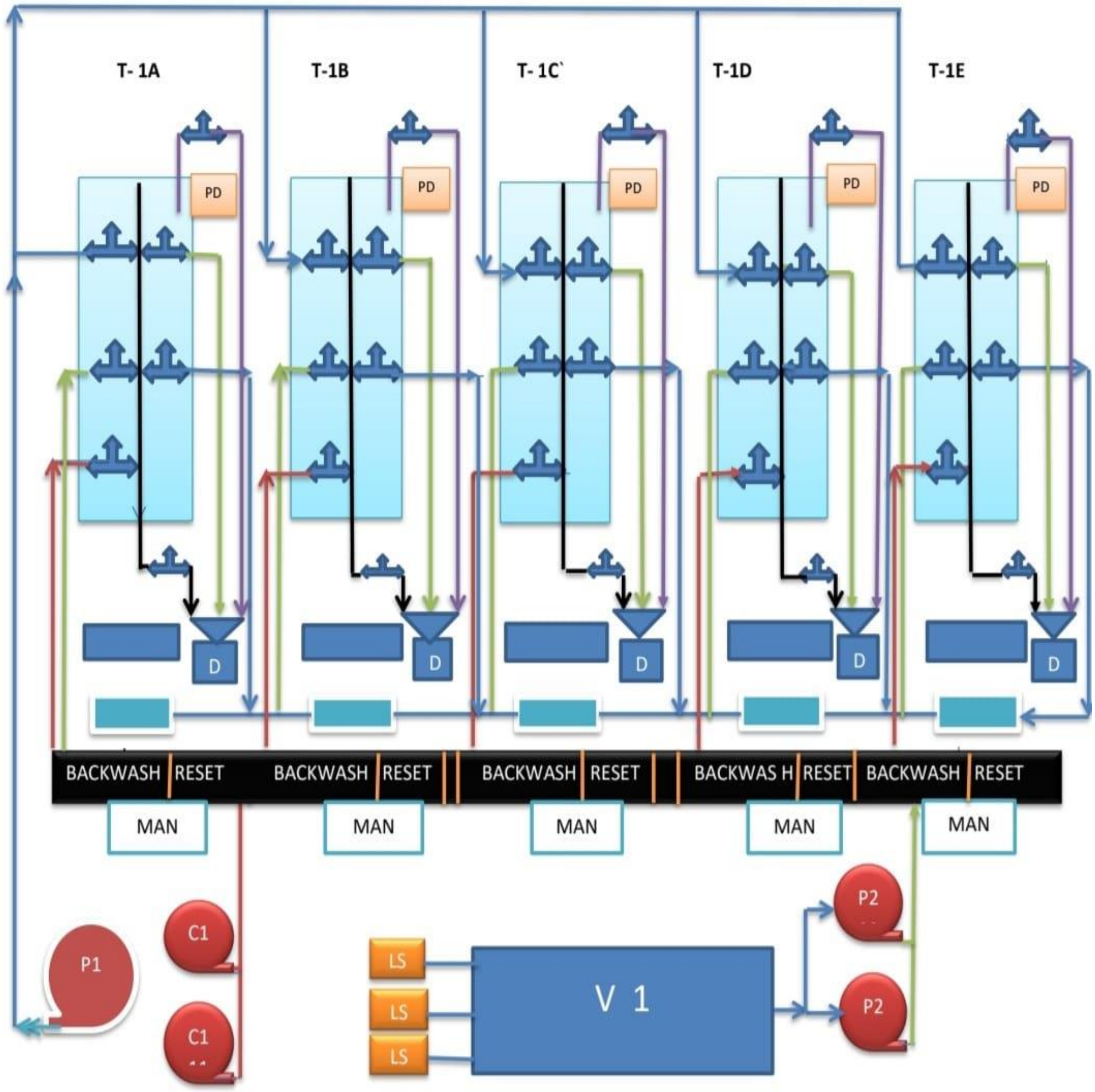


Figure (3.2) Block Diagram of Water Treatment Filter System.

In the figure (3.2) the system model is designed to show one of the lines of the system consisting of five filters, that is, five filters of line A and five filters of line B. It is the same second line showing the processes that occur in the system with an illustration of production lines and backwash drain lines with Explanation of the locations of feed pumps, backwash pumps, air compressors, and suction tanks. Backwash water and manual operation valves. One line was adopted, and it was adopted as a model for the second line because the two lines are completely identical and with the same special components, and the same operations that take place on the first line take place on the second line.

3.4 Flow Chart of the Filtering Strategy

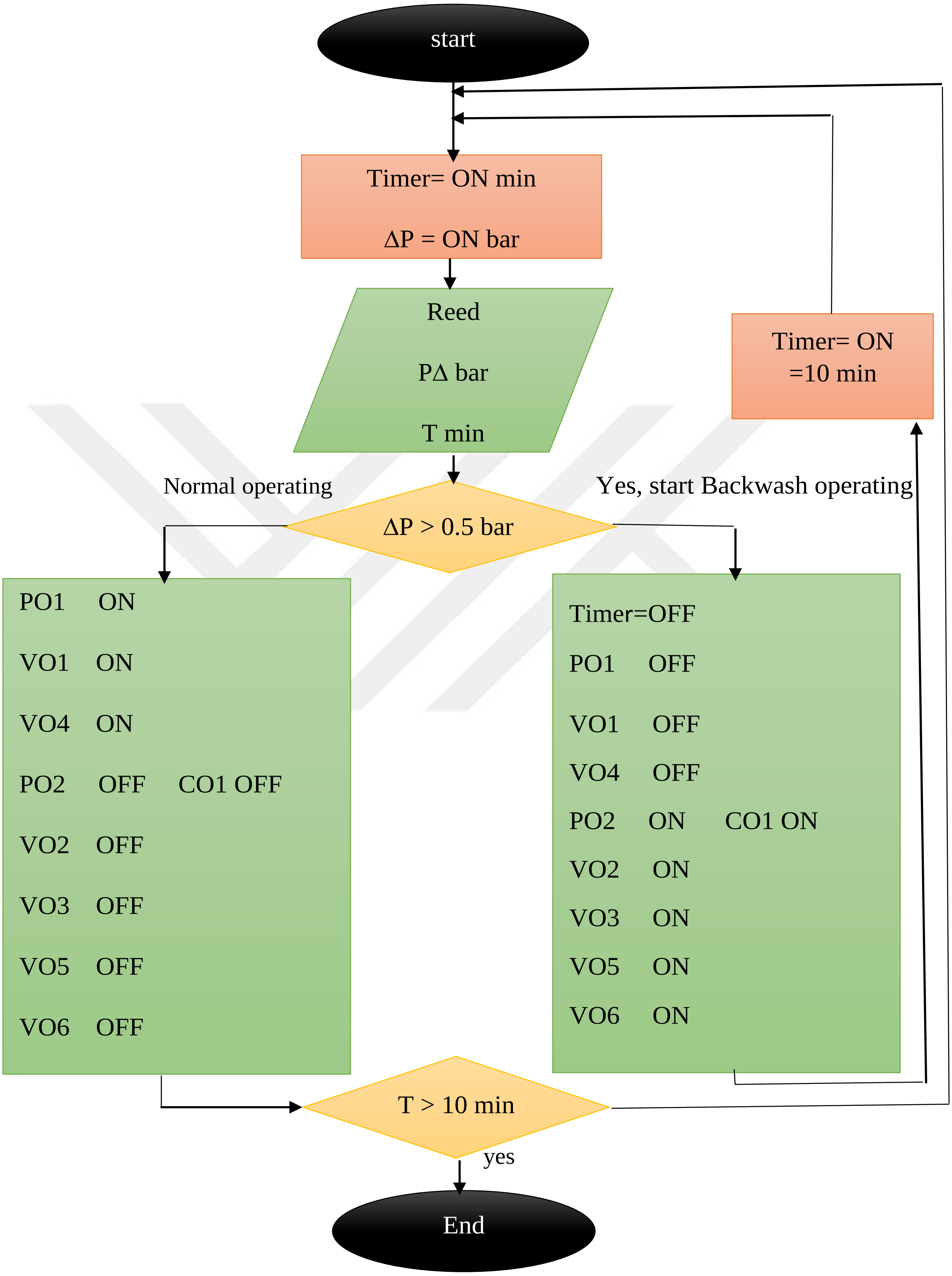


Figure (3.3) Sand Filter System Programming Flow Chart

3.4.1. Network 1 - Scale Value 105

It is one of the functions in the PLC programming tools that can be used to set the values to be programmed.

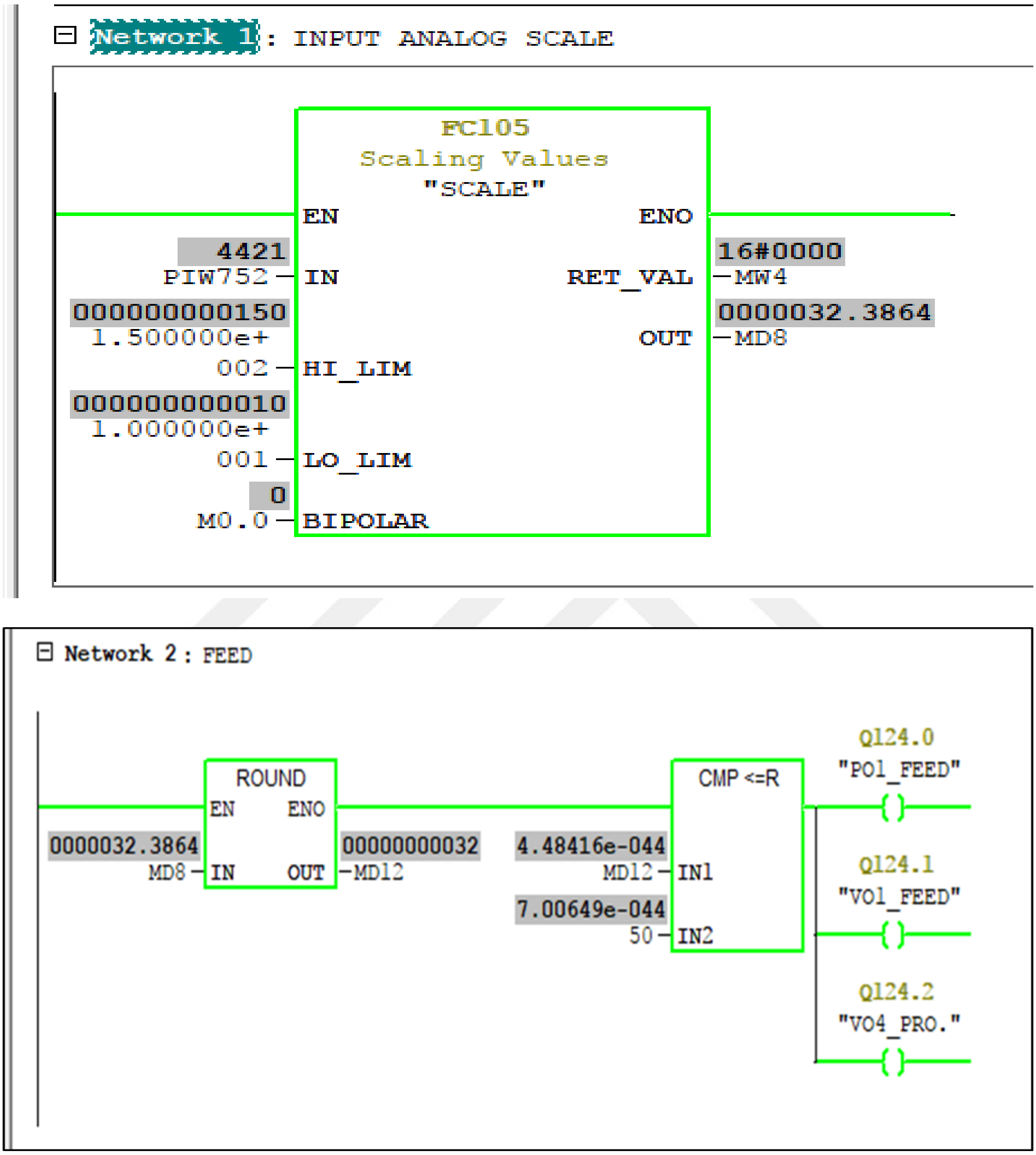


Figure (3.4) Network1: SCALE VALUE 105.

3.4.2. Simatic Manager S7300

software was used to program the system, and through scaling Values FC (105) the input and output values for the flow rate 150 – 4500 m3/h were entered and the system differential pressure reading was set at 0.05 bar. After entering the inputs, is entered the program through the simulation, where the output Q0, Q1 and Q2 can be run, where each output represents one of the valves in the system, The upper bound value and the lower bound value are entered, and an address is reserved in memory.

3.4.3. Network 2: Feed

Normal Operation Status The status of the feed pump PO1, as well as the output valves, V1 and V4, is shown through a simulation program.

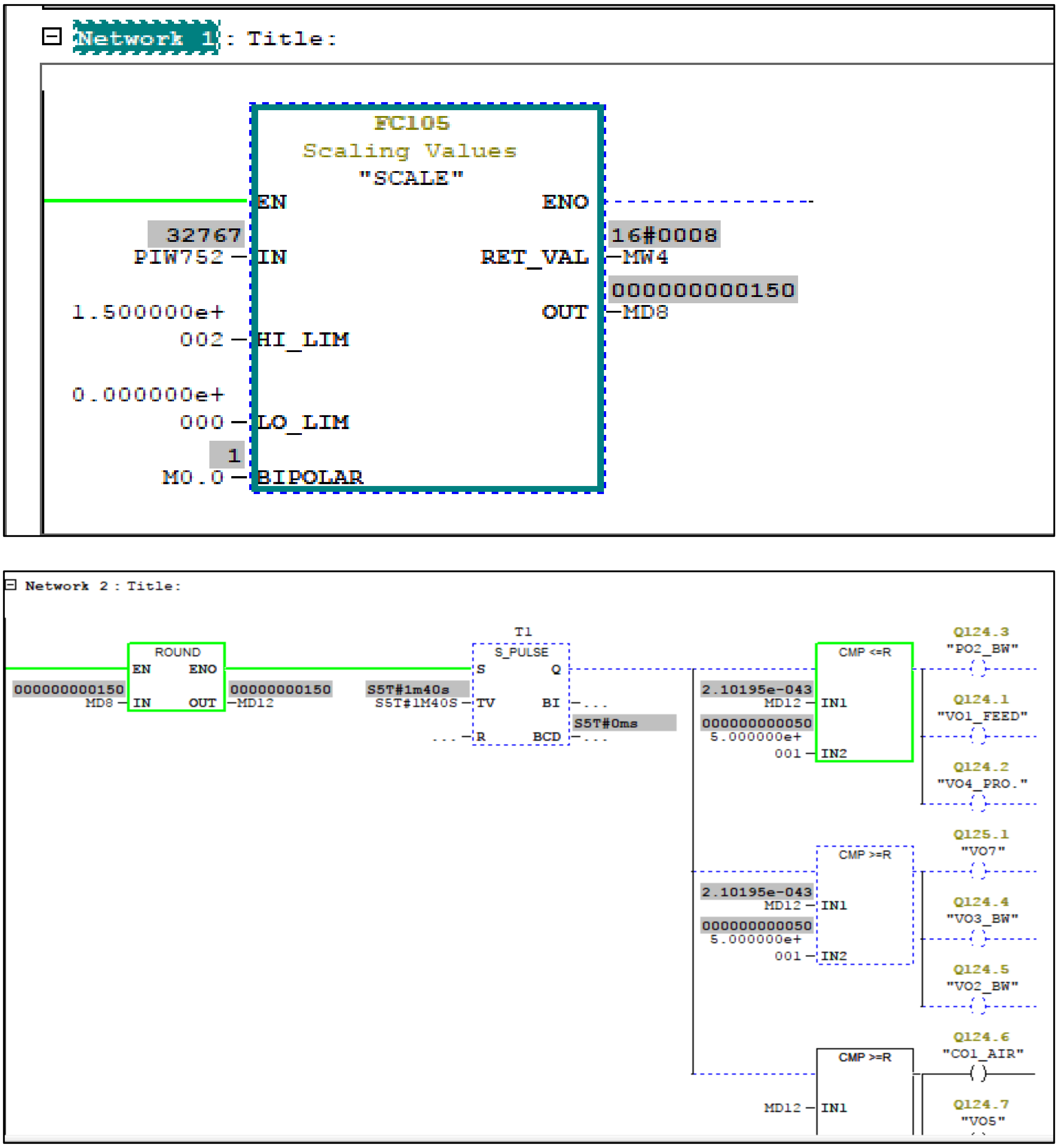
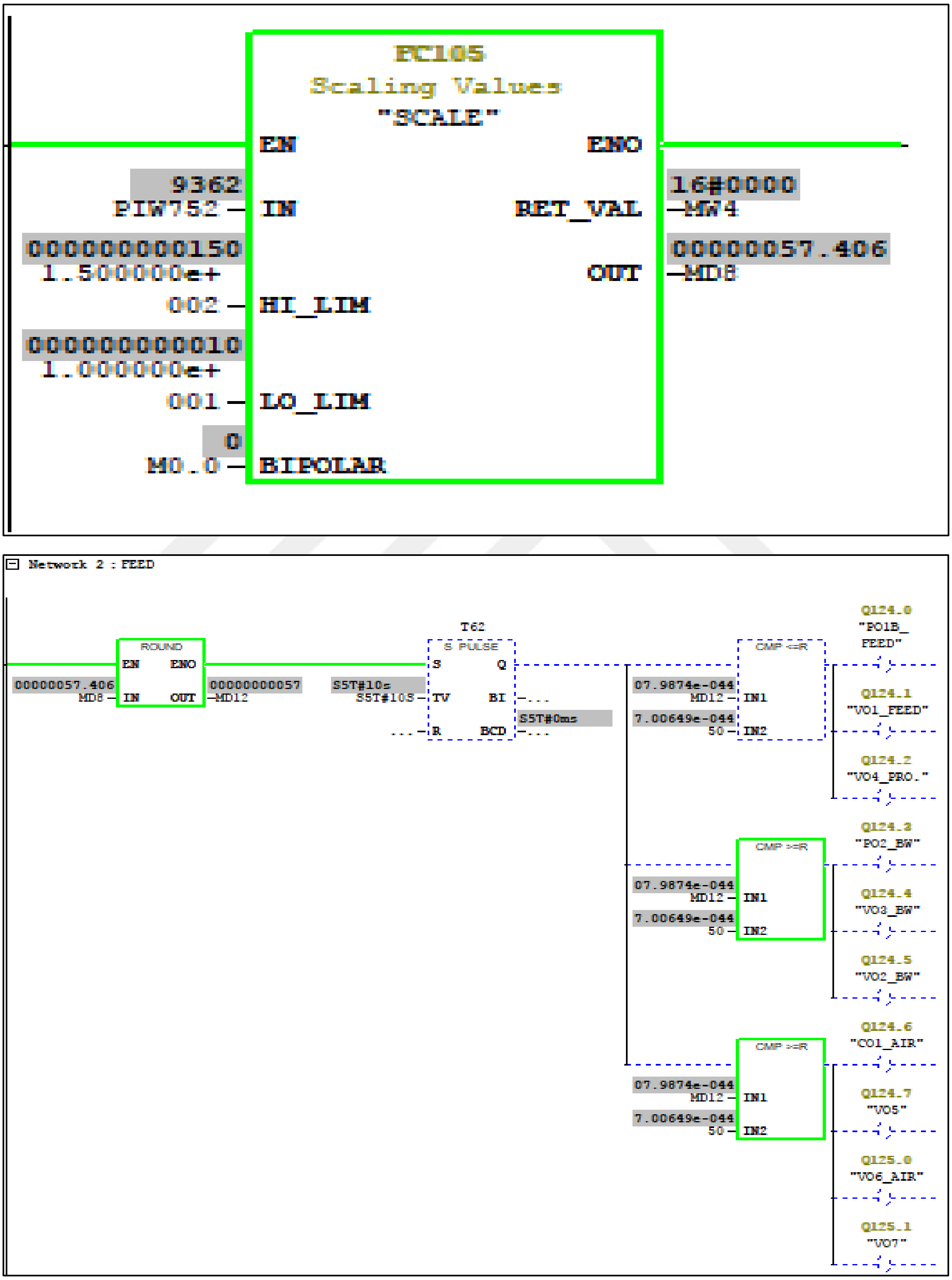


Figure (3.5) Network Feed Normal Operating.

3.4.4. Network 3: Backwash Process

The backwash is programmed into the filter system using several functions found in the SIMATIC MANAGER programmers, such as performing an approximation of the value and then using the comparator and timer.



Fieger (3.6) Backwash Braces.

Figure (3.6) shows the process of programming the backwash process by stopping the normal operation of the system by turning off the pump PO1, the feed valve V1 and the outlet valve V4 and entering into the backwash process by turning on the backwash pump PO2, the backwash water inlet valve V3 and the water outlet valve Backwash V2 and the Fieger 3.6 (follow) CO1 air compressor, V5 air inlet valve, and V6 air outlet valve are running. After approximating the quantity in grid 2, a reset timer (S-PULSE) has been added and a time of at least ten minutes to complete the backwash process has been added to the grid. A new function is also introduced, the comparison function, which compares a preset value that is the differential pressure value 0.05 bar to guide Valves to open by resetting the system to perform the opening and closing cycle of the valves respectively, when pump PO1 is turned off the feed pump is closed, valve V1 closes for material inlet, valve V4 closes for output, pump PO2 is turned on and the backwash pump is turned on, valve V3 opens for backwash water inlet and Valve V2 opens for the outlet of the backwash water, to continue the backwashing process for each filter for ten minutes, which is enough to open the pores of the sand, while valve V7 is used to drain the backwash water to move to the other filter in the same way as before its formation, at the same time, the operation of the CO1 air compressor is programmed with the start of the backwash process in conjunction with the operation of the PO2 backwash pump so that the air is forced through the V5 valve and the air inlet valve is a mixture of air and water and then the air is drained through the V6 air outlet valve (inlet ventilation) while the V7 valve remains closed and opens when maintenance or water draining is required. After completing the backwashing of the first filter, the next filter is inserted ten minutes after the first according to the timing of the timer and depending on the differential pressure difference.

Continuing the process sequentially and according to the condition of each filter and depending on the review of the inputs and their readings by the PLC, which depends mainly on reading the pressure difference and the time specified for the process.

3.4.5. Experimental Validation

The pressure gauge reading showing the beginning of the rise in the differential pressure difference as a result of the high turbidity rate in the filter system as shown in Fig. 3.10 and Fig. (3.11) shows the high turbidity reading measured in raw water near the permissible limit, Real equipment was used in the operational process of the system. The indicators of the devices show the amount of pressure specified for the filter to work with the permissible percentage, as well as the percentage of turbidity indicated by the digital indicators to know the percentage of turbidity of the water inlet and outlet.

Figure (3.7) Pressure Gauge (bar)

Figure (3.7) shows a gauge indicating the reading of the differential pressure difference between the water inlet pressure and the outlet pressure.

Figure (3.8) Turbidity Gauge (NTU)

3.4.6. Pressure Gauge

Reading the differential pressure indicator and its return to zero after backwashing one of the filters in conjunction with returning the reading of the turbidity level in the raw water to the permissible limit.

Figure (3.9) Pressure Gauge (bar).

Figure (3.10) Digital Turbidity Meter (NTU).

3.4.7. Sand Filter System

Figure (3.11) Model of a Backwash System of sand Filters Specific to the Specifications of the Tigris River water.

To connect the PLC to the computer to complete the program download from the computer to the PLC, there are several cables used to connect the PLC to the computer, produced by Siemens, Type 1: Point-to-Point Cable (PPI). Type II is a Type III (MPI) multipoint cable using a Prophy Pass Ethernet cable. In this system, a multipoint is chosen to connect the PLC to the computer because it is more suitable to connect the S7-300 type PLC. Ladder programming is transmitted to the PLC via the S7300's 2008 flexible WINCC software. And going to the computer option because we chose it as the SCADA control screen.

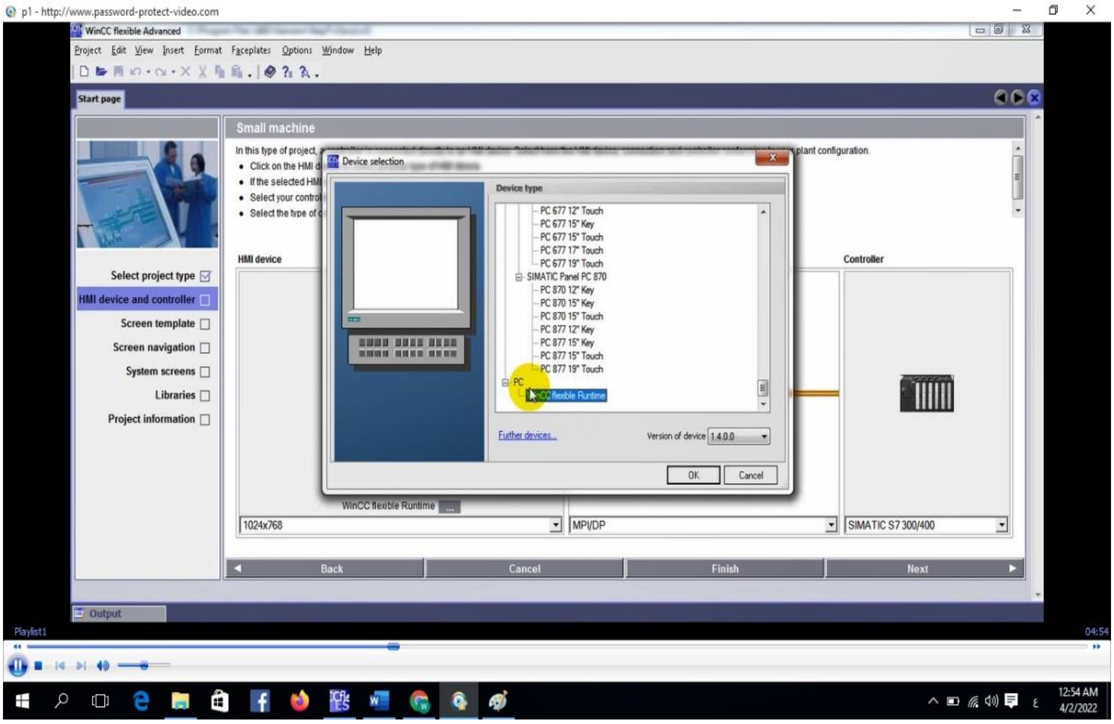


Figure (3.12) Choosing a SCADA Computer Control Screen.

going to the Connection option and choose to connect via MBI in order to add Tags to the new device with the name of the button. The connection type is Connect 1 S7 300, and we choose the data type Bool and address 0.0 and then goıng to the general option and choose Events, then Clic, then edit Bits, then Invert Bit, then add Botton Tax to make a connection to download Ladder to plc, 128GB MMC memory. Since the PLC S7-300 is an external memory stick from MMC, the PLC must be placed in a stop mode. Beware of the reset button because it will format the program, so it should be stop as well.

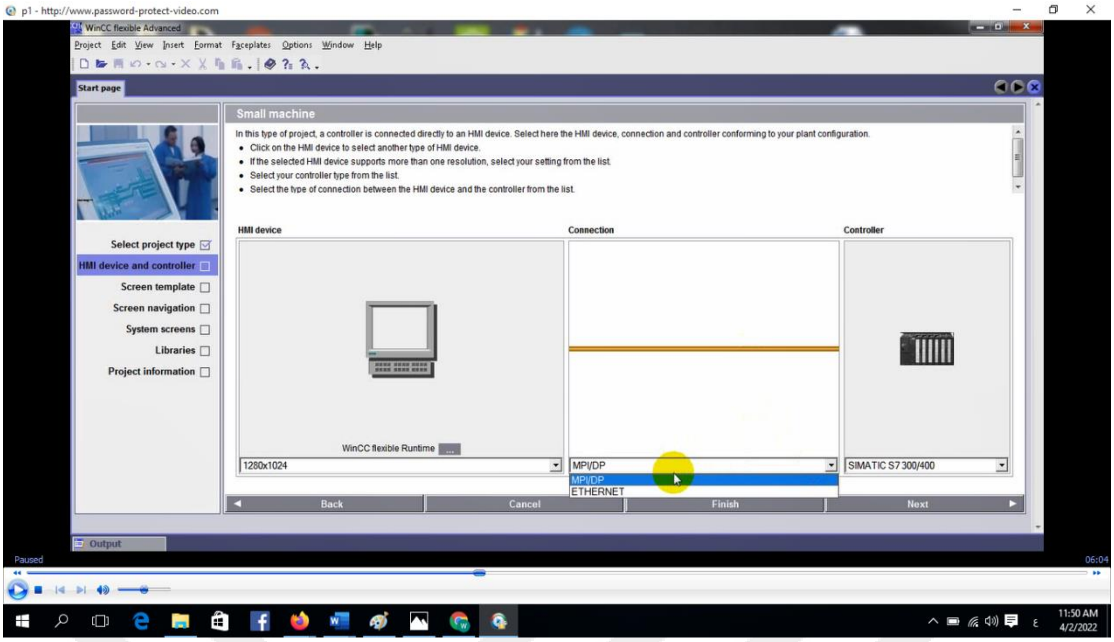


Figure (3.13) MBI Connection.

From Figure (3.13) The type of screen can be specified where the HMI screen or the computer screen can be selected. This option provides the ability to choose the type of control screen according to what suits the design of the system.

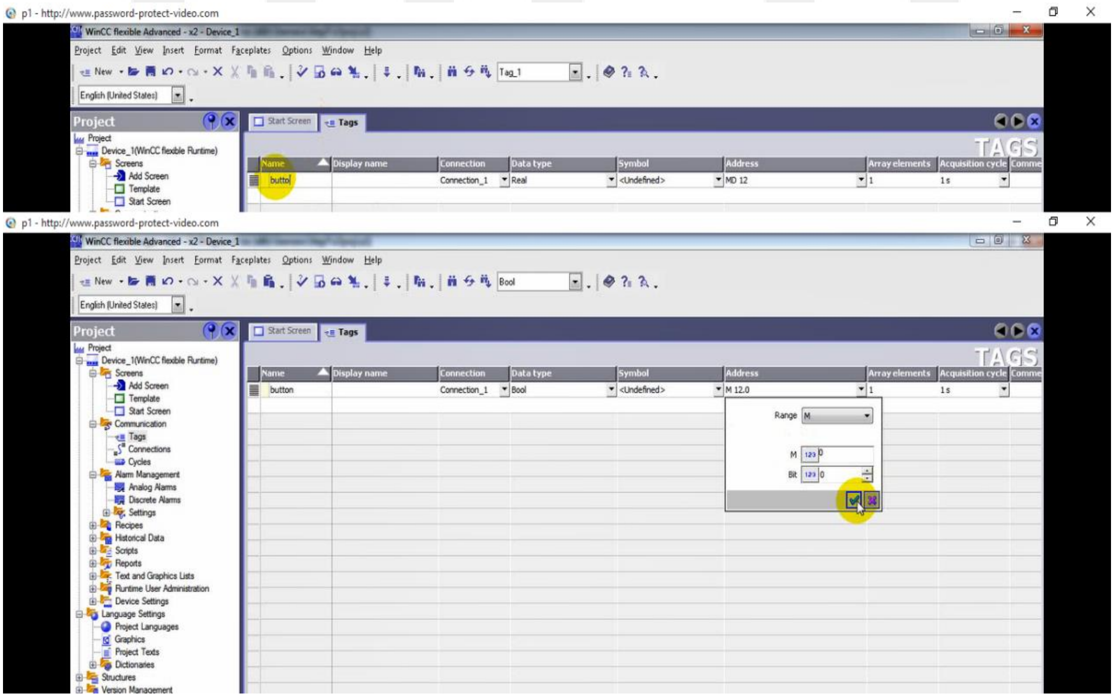


Figure (3.14) Address Edit.

From Figure (3.14) it is possible to choose and modify the input and output addresses and the method of linking to the screen.

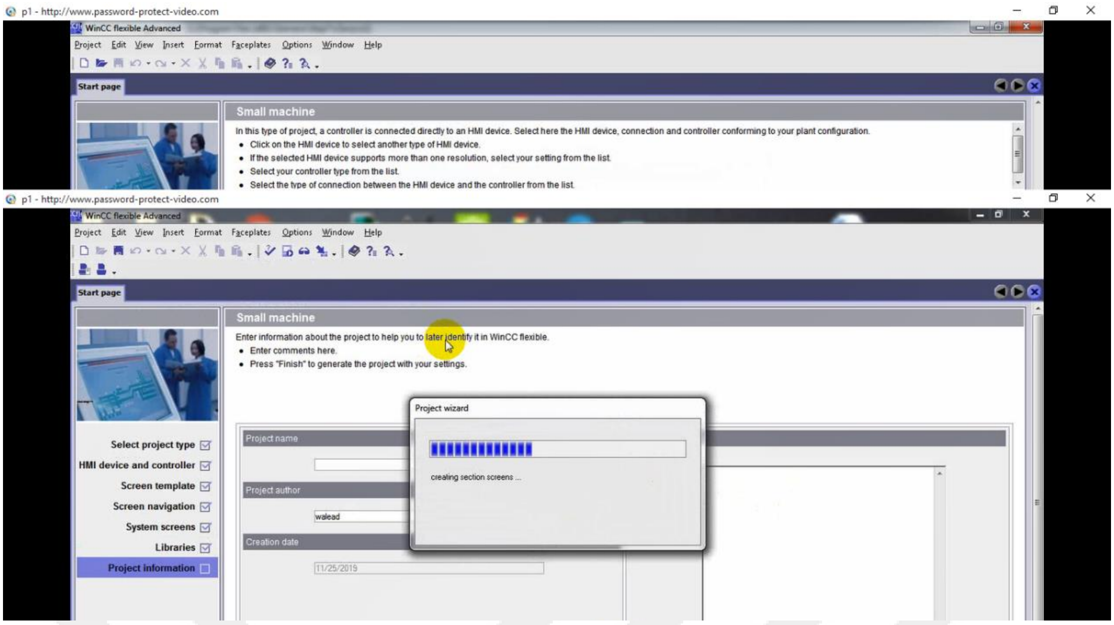


Figure (3.15) Download the Program to PLC Memory.

The figure (3.15) Explains how to download the program to the PLC memory, and through this option, the program can be downloaded after completing the programming process and making sure that it is executed correctly to the PLC, either to an internal memory or an external memory, since the PLC Simatic Manager S300 contains an external memory to be then Store the program in PLC.

3.4.8. Practical Implementation

After completing the process of downloading the ladder program to the PLC, the PLC power supply will be connected, since the PLC is AC / DC / Relay type and converts the voltage from 220V AC to 24V DC, the PLC must be connected to a connector with Optocoupler system) disconnect PLC circuit about the power circuit (and connected to protect the PLC from voltage imbalances to ensure high protection of the PLC) 1M + 2M + 3M negative points (PNP) are connected for the connection of the two terminals of the PLC and the positive conductor of L, a second power supply is added to the system to avoid voltage drop in If there is an increase in the I/O points and the input points are connected to 1MI 0.0+ 2M + 3M and the output points are connected to 1L Q0.0, the first connector is connected to L Q0.0 while the second connector is connected to the control points Q0.1.

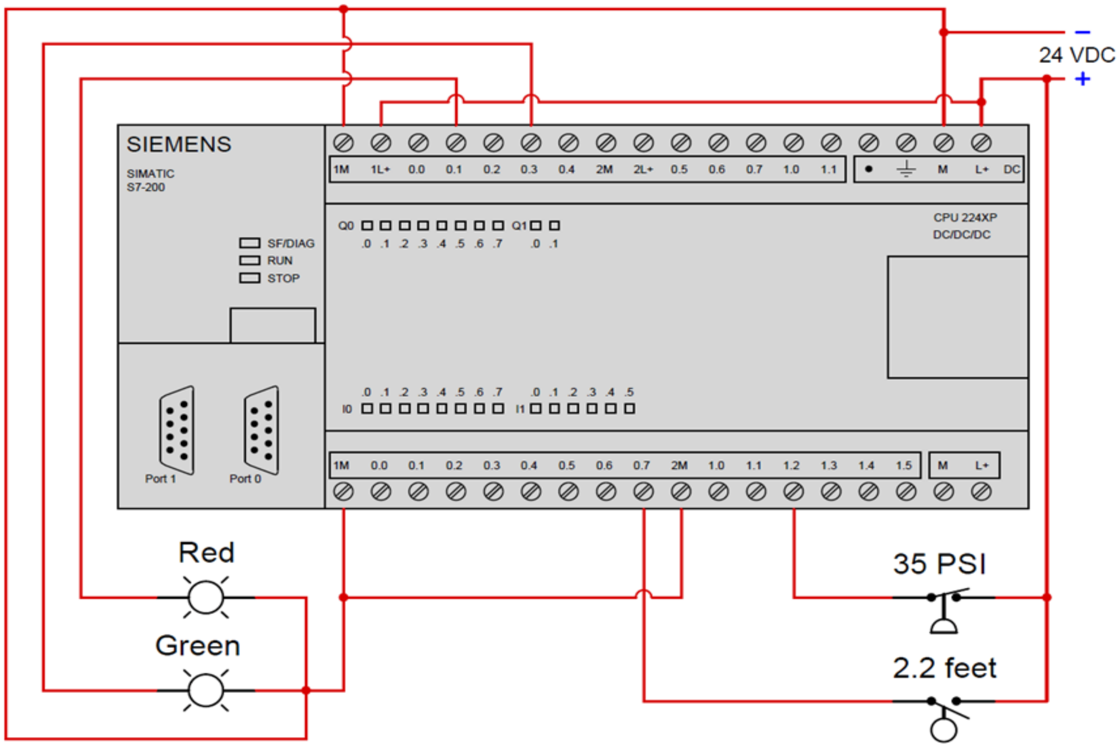


Figure (3.16) Power Supply Circuit Diagram for PLC [46]

PLC power supply circuit diagram, the figure (3.16) represents the Scheme of connecting PLC to the power source where the letter L represents the positive power source while the letter M represents the negative power source.

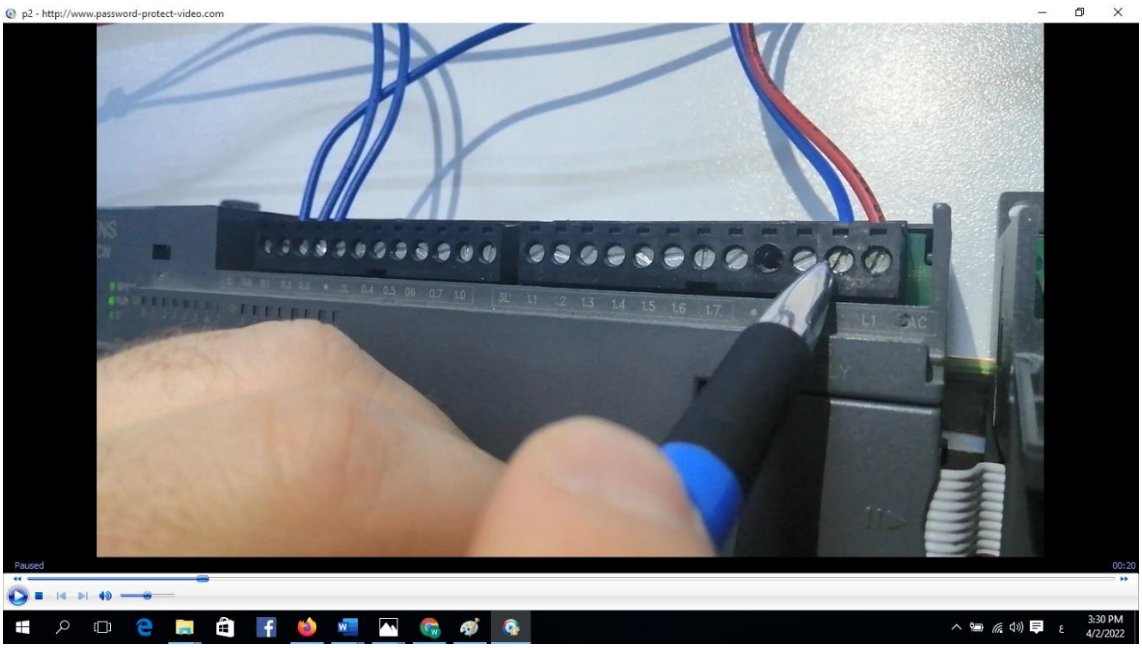


Figure (3.17) L (Positive) and M points (Negative) Input.

Figure 3.17 (follow) PLC power supply circuit diagram. Figure (3.17) represents the method of connecting the PLC to the power source in a practical way, showing the locations of the connection points in the device, where the letter L represents the positive power source while the letter M represents the negative power source.

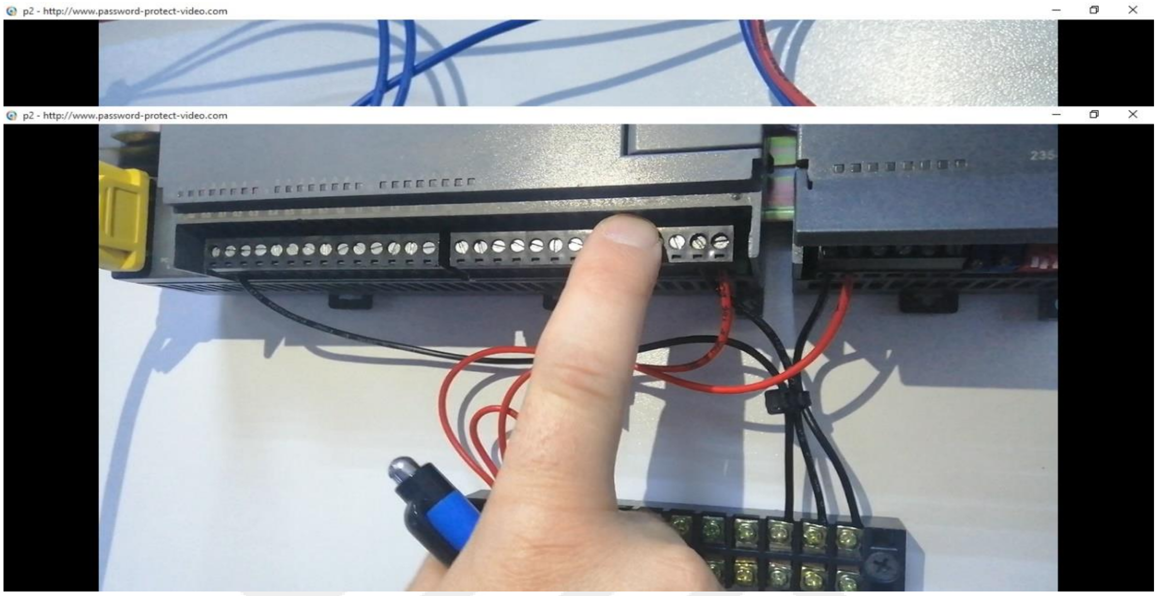


Figure (3.18) L and M Output Points.

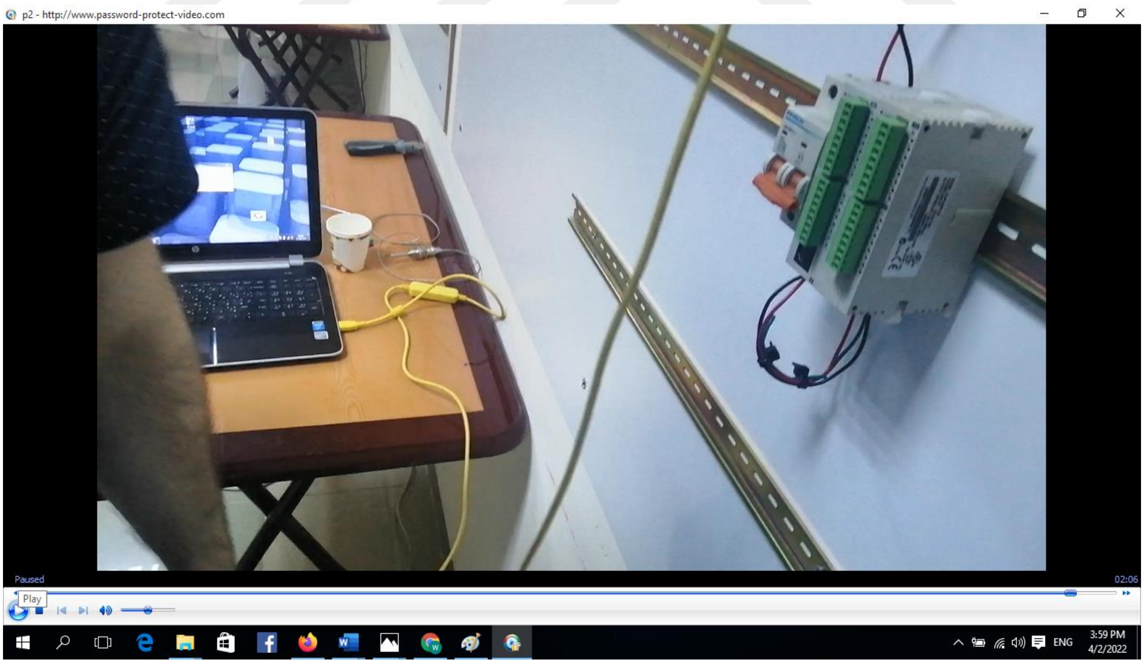


Figure (3.19) Connecting the PLC Computer Via the Dedicated Port.

Figure (3.19) shows the method of connecting the PLC to the computer, whereby the computer can program the PLC and after completing the programming, the program is downloaded to the PLC. The computer can also be used as a control screen.

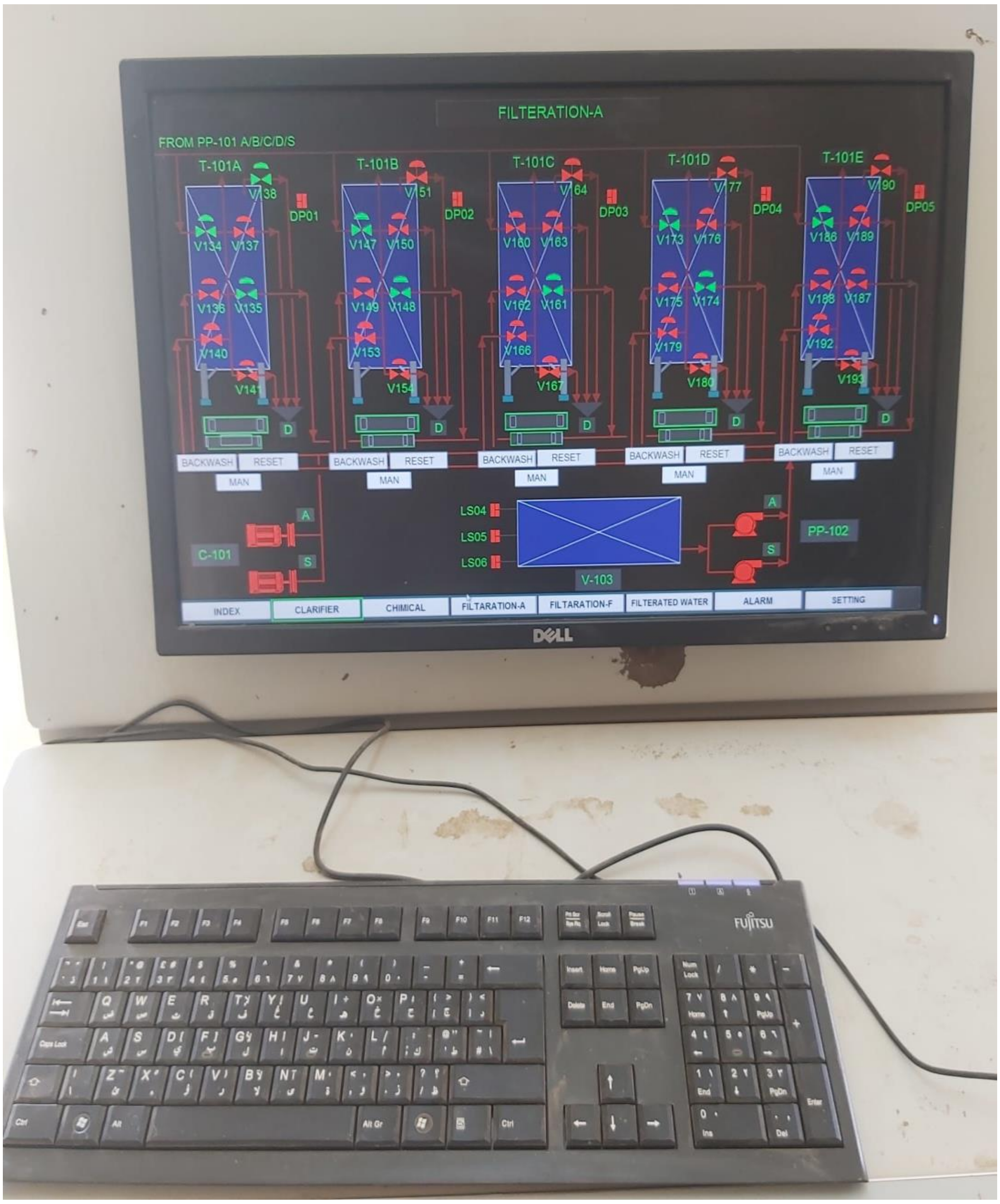


Figure (3.20) SCADA Control and Monitoring System.

A model of the SCADA system for the system, showing the components of the system, how the system works, and the special control keys, each of the SCADA screens shows a line of the system lines, so it is possible to scroll the first screen to display the second screen, which is a characteristic of the design of SCADA control screens, as it is possible to scroll more than one screen, the screen used to manage the system is the HMI screen.

4. RESULTS

4.1. Siemens Laboratory Simatic Manager S7300

In the Siemens laboratory, materials for the experiment are used, the main of which is the Simatic Manager S7300 PLC, as well as a multi-use digital measuring device such as measuring volts, amperes and resistance, it is used to find out the value of the voltage inside and outside the PLC if using voltage instead of current, as well as a panel with light bulbs installed on it, they are used to indicate the state of the circuit through lighting, After completing the programming process of the system, the program is loaded into the memory of the PLC, then the PLC is connected to the test board. After that Then the PLC can be run, and using a voltage measuring device, the specified amount of voltage is checked for entering and exiting the PLC. The test result can be seen on the way of lighting the lamps, the number of which here are two, is a reference to the system's entry and exit valves, which are in the state of normal operation before the start of the backwash process of the system.

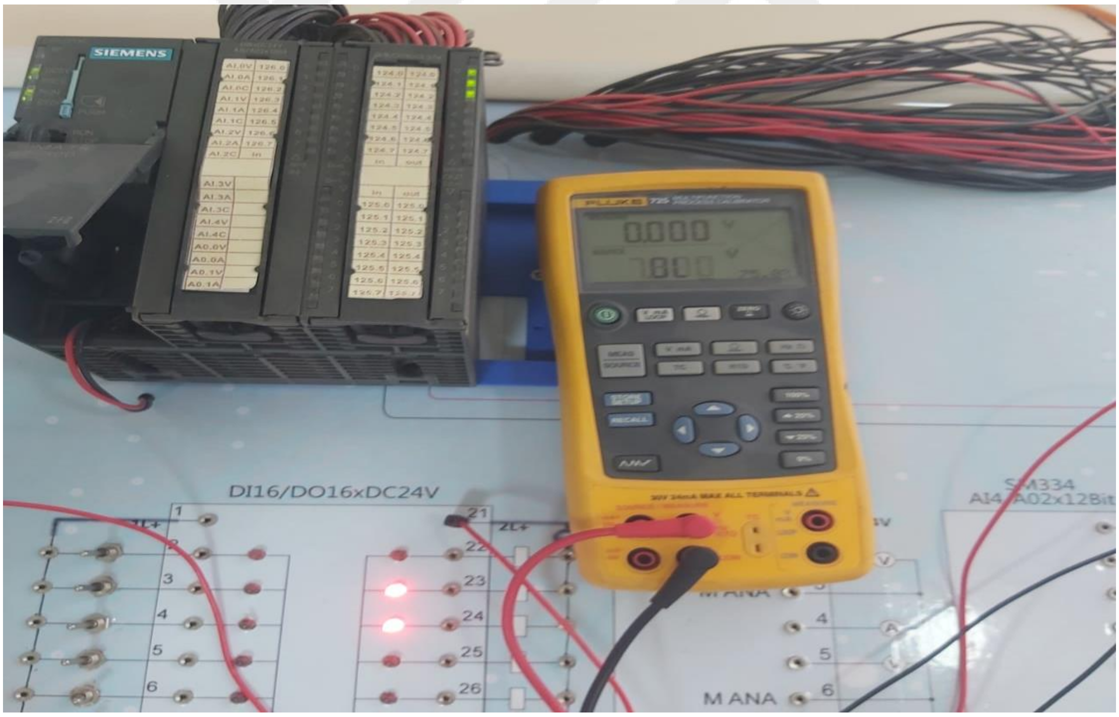
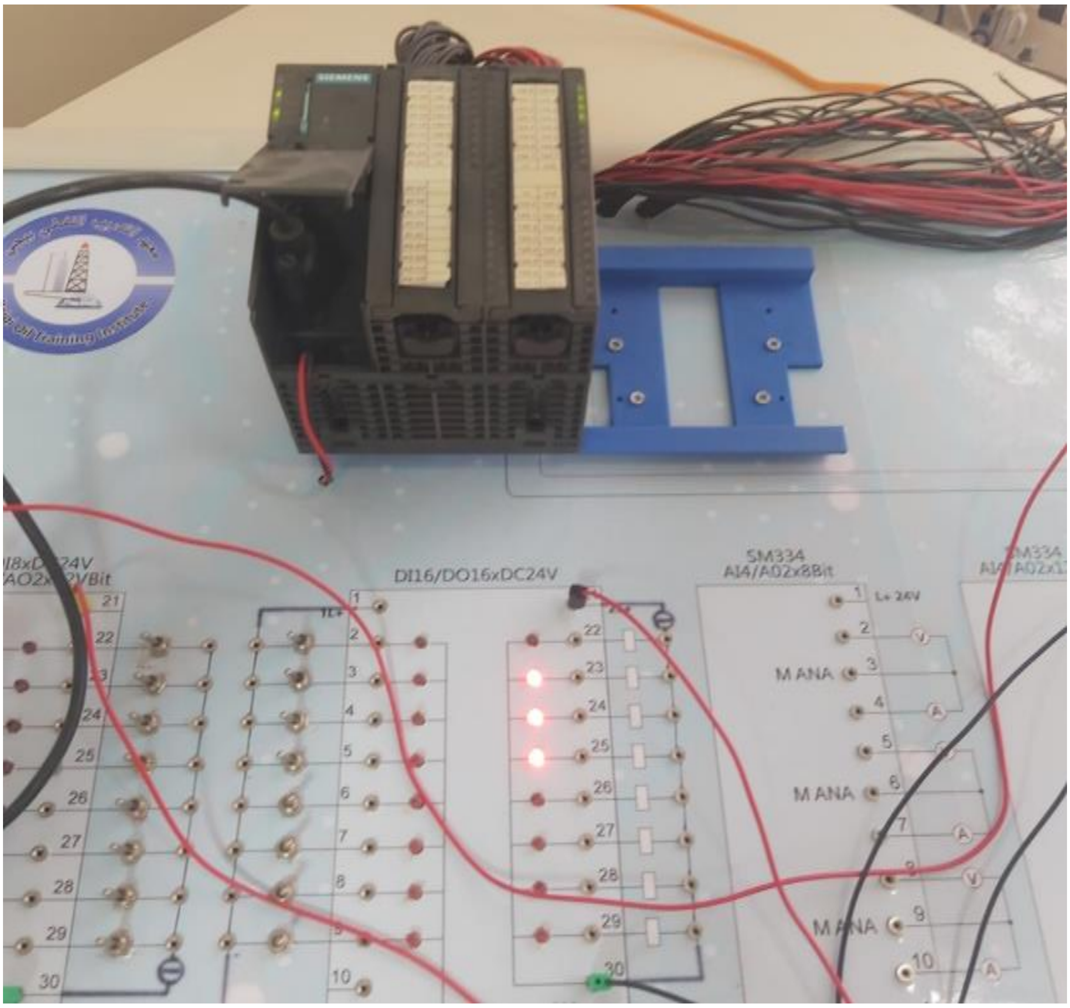


Figure (4.1) Siemen's Laboratory, System normal operation condition.

4.2. Backwash Process Using Leds in Laboratory Environment

At this stage and after making sure that the valves are working in the normal state, we will move on to a practical test of the system after connecting and downloading the software to program the system on the PLC SIMATIC MANGER S7300 and display the results using the laboratory lights. Instead of the real fuses to check the operation of the program, the. LEDS in this case indicate the status of the fuses in the process of backwashing the system, which can be observed by lighting three lamps indicating the number of fuses that are in the ON state.



Fieger (4.2) Implementation of the backwash process in the laboratory.

The Figure (3.9) Laboratory Siemens of the Department of Control and Systems Engineering is one of the petroleum institutes. The programming of the system has been practically implemented on the PLC Simatic Manager S7300.

4.3. Scada System

The SCADA system is a control screen management system through which the PLC is controlled. SCADA software provides monitoring of control buttons, such as on and off buttons, as well as monitoring of tanks, pumps and valves that are included in the configuration of the system components and are therefore linked to the PLC and therefore the system can be controlled from different places that may not be very close to the equipment and may move control rooms and monitor their work Online, they are usually called HMI control monitors, and the computer can also be used as a control monitor. After the programming process is completed, the program is loaded into the CPU (313) to save it in the system memory. The computer is then connected to the SCADA system previously downloaded on the computer and connected by an MPI Multipoint cable to control the system through a computer monitor that can be monitored and controlled by the SCADA system.

4.4. The Use of WINCC FLEXIBLE to Design the System

Using WINCC software for SIMATIC MANAGER S7300, control screens can be designed to control systems through a set of program library graphics where start and stop buttons, tanks, pumps and valves can be designed and called HMI if it is designed on special screens, but if it is designed on PC, it's called SCADA.

The sand filter system was designed using the WINCC FLEXIBLE program, where the filter shapes were designed valves, feed pumps, as well as backwash pumps, and this is a typical design The system is used to make preliminary and laboratory tests of the system before starting the real construction of the system, WINCC FLEXIBLE offers great capabilities in designing large and small systems, WINCC FLEXIBLE can be used to run systems in experimental and laboratory manner, and this gives ample space to make sure that the systems are working properly or not, Therefore, it is possible to work on the design of systems in a practical way using the WINCC FLEXIBLE program to design all types of control screens.

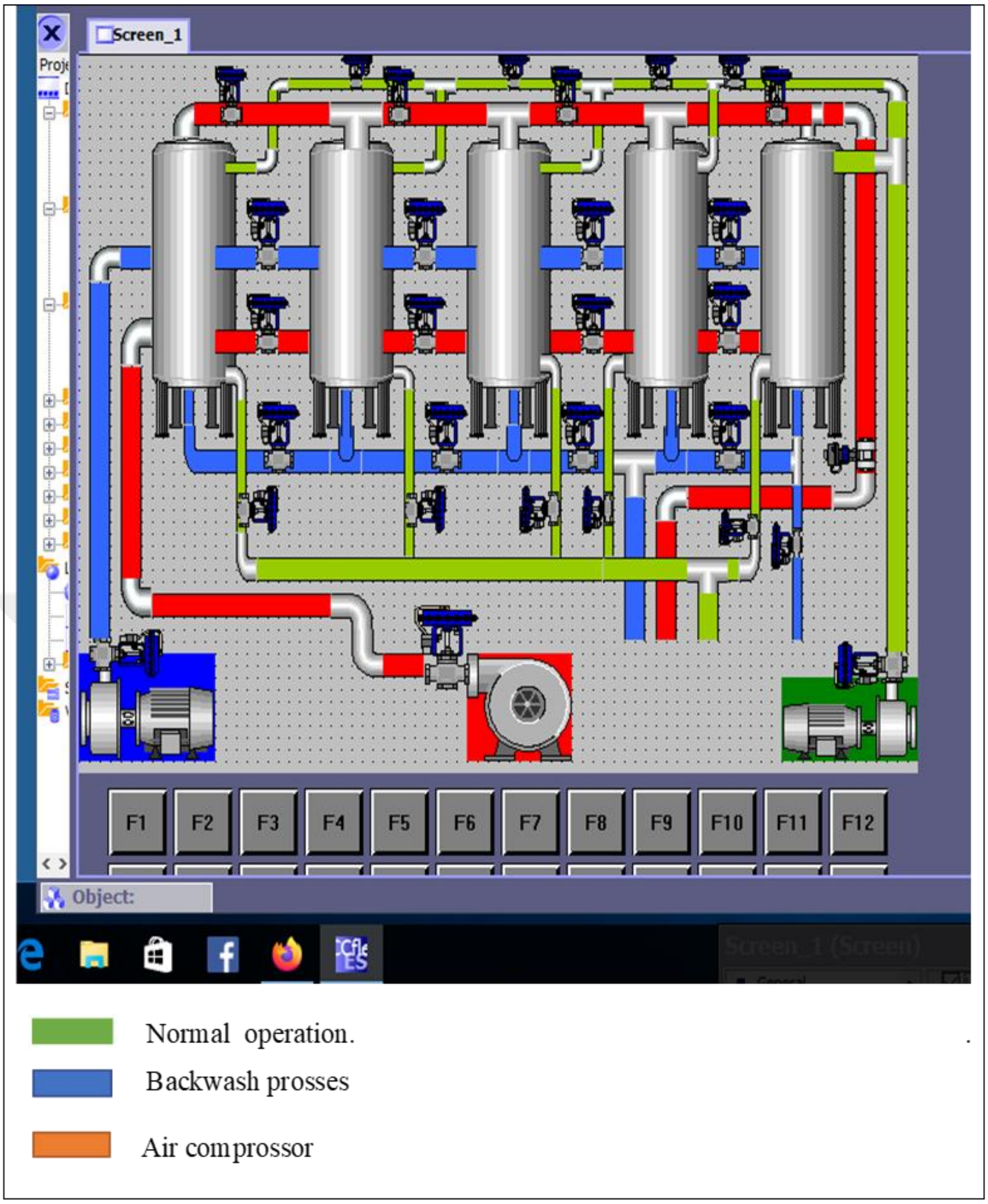


Figure (4.3) Designing a SCADA system to control the system using the WINCC FLEXIBLE program.

4.5. The Relationship Between Pressure Variation And Turbidity Ratio

Recording the effect of turbidity in raw water (Tigris River water) on the differential pressure difference between the input and output of the substance to reach the critical point.

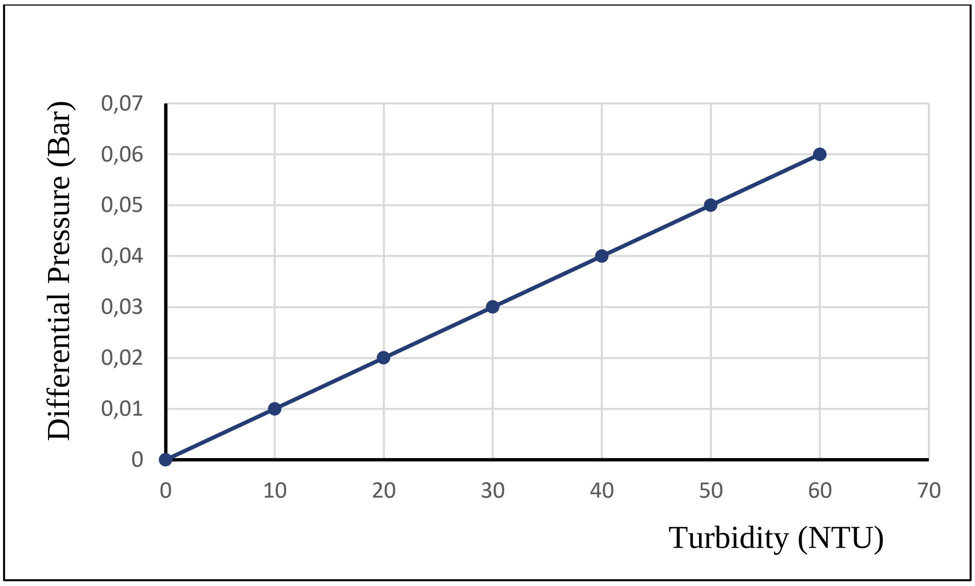


Figure (4.4) The Relationship Between Pressure Variation and Turbidity.

The experimental results obtained by entering the values of the variables represented in reading the effect of the turbidity percentage in the raw water and according to the specifications of the Tigris River water were entered. And by taking multiple samples and readings of the turbidity ratio, which leads to a high percentage of the differential pressure difference between entry and exit to the critical point. It was found that when the turbidity ratio reaches 50-60 NTU the differential pressure difference is at 0.05 bar, which leads to the system stopping its normal work and entering the stage of backwashing the filters. It was found that the relationship is direct between the percentage of turbidity present in the water with the differential pressure difference and according to the change of raw water specifications, as the higher the turbidity, the greater this differential pressure difference on the one hand, and on the other hand the time spent in the backwashing process increases as shown in the figure (4.2).

4.6. The Relationship Between the Time Duration and the Rate of Turbidity

The results and readings of the time variables compared to the percentage of turbidity and the indication of the time taken to carry out the backwashing process for each filter.

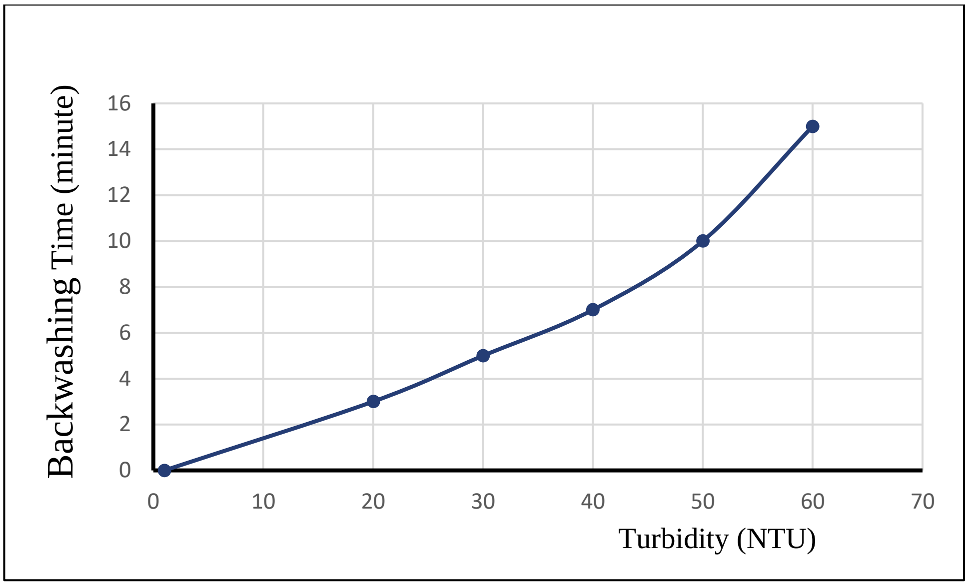


Figure (4.5) The Relationship Between Time and Turbidity.

The values of the obtained variables are entered by entering the value of the time taken to carry out the backwashing process for each filter compared to the turbidity percentage. The results showed that ten minutes is the time required for the backwashing process for one filter. The results also showed that there is a direct relationship between the turbidity rate in the raw water and the time spent in the backwashing process. The higher the turbidity rate in the raw water, the longer the time taken for the backwashing process, due to the change in the specifications of the water to be treated for several reasons as in the figure. Through these results, the time from ten minutes to fifteen minutes of the backwashing process is sufficient to reduce the turbidity rate confined between 50 NTU to 60 NTU to the permissible percentage, and consequently, the reading of the differential pressure difference decreased and returned to the permissible limit, which is determined in the programming time in plc systems.

5. DISCUSSION AND CONCLUSION

From the current research work, some of the basics have been completed.

A PLC control system was proposed and implemented for the sand filtration system that purifies the waters of the Tigris River.

The system is designed to perform the backwash process automatically without the use of manual labor which is characterized by inaccuracy, time-consuming and constant monitoring.

It should be noted that the use of PLC-based control technology in the management of the system was very effective and achieved very reasonable, smooth, and reliable control.
These systems are widely used in many countries through which the waters of the Tigris River pass, especially places that are usually far from city centers.

The study relied on several variables that were the main data in the inputs and outputs and the relationship between them, such as the effect of the turbidity in the water of the Tigris River and the change of water specifications according to natural conditions on the high differential pressure index between input and output and thus the effect of the relationship between pressure and turbidity on the time required to complete the process Backwash properly.

It is characterized by ease and simplicity of design and implementation, especially when using the PLC control system.

System design can be used to train and develop university and college students to operate PLC systems.

Reaching the simplest designs in the programming of the system is accompanied by a decrease in the cost of the components of the system, which eventually leads to the expansion of the use of this type of system, which provides water suitable for public use for residential complexes and factories, which are usually far from city centers and spread mainly on the banks of the Tigris River.

It can be concluded from the results that the increased turbidity and high impurities of the Tigris River water during rainy and flood seasons lead to a change in the properties of the filtered water, which means that the PLC system may be insufficient. Tigris River, and therefore this can lead to an increase in the time it takes to backwash the filters, because the duration may be ten minutes is not enough, so it can be increased to fifteen minutes, and this requires changing the programming time, it takes to match the turbidity rate, as well as increasing and decreasing the rate Turbidity, the presence of solids in the raw water which negatively affects the optimal performance of the system, to solve this problem connect a second PLC system that protects the system and works non-stop for 24 hours continuously. The second system is programmed in the same way as the previous programming. Also, the system can be reprogrammed in a new way. It offers greater control and a new distributor easily by programming three filters together in isolation through a single differential pressure gauge, thus providing lower cost and higher workflow.

REFERENCES

[1] K. Raymond, programmable logic controller, cilt 2nd ed., Italian Salesian Institute, 2011, pp. 9-37.

[2] H. A. Sami, Experimental study of a steam boiler with chemical additives using a PLC system, 2020, pp. 50-53.

[3] H. H. Hadi, Design a production line control system with a supervision and follow-up system to access, process, control and monitor, 2019.

[4] A. S. Hassan, implementation of plc based on electro pneumatic elevator system., 2015.

[5] Electronic Vilage, «programmamable logic controller and ladder logic ,» 2020.

[6] SEMENS, «SIMATIC, Engineering Tools S7-PLCSIM V5.4, Operating Manual, 04.,» 2017.

[7] DALGAKIRAN, «DALGAKIRAN Compressor,» Turkey, 2017.

[8] I. Elkhatib «Electrical control Engineer at Eqypt Kuwait Holding »2021 Available online.

[9] «Elecmit Electrical Co. photocell sensor switch. smart switch,online.,» 2015.

[10] WIKA, «Pressure switches,» https://www:wika,com., - Available online.

[11] M. A. Oleiwi, Al-Timimi ve A. Abdalhusein, «Design and Simulation of PLC control and Electro Hydraulic.system for apunching Machine,Received on.,» 2008.

[12] HONEYWELL, «DAMPER MOTOR,» Available online firstsupply.com.

[13] M. J. Walker, «The Programmable Logic Controller: its prehistory, emergence, and application,» 2012.

[14] K. Hanı, «Modeling of a ladder logic processor for high performance programmable logic controller,» Tech. report, Universiti Teknologi Malaysia., 2009.

[15] T. Yuval, «Tingfan Wu, Javier Movellan and Emanuel Todorovy, "Modeling and Identification of Pneumatic Actuators,» IEEE, Conference ICMA., 2013.

[16] L. A. Bryan, «Programmable Controllers Theory and Implementation, Printed and bound in the Library of Congress Cataloging in Public Data in United States of America,» 2002.

[17] I. Al-SHAMMARI, «microcontrollers Cataloging of King Fahd National Library.,» King Fahd National Library, 2019.

[18] M. M. Abu Hajar, «programmable logic control PLC,» 2002.

[19] O. Nour ALddine , «Industrial automation and programmable automation.,» 2001.

[20] H. Talal, «programmable control systems, university of Damascus PLC.,» 2018.

[21] N. ABU Karda, Programmable Logic Controllers PLC, Dar Al-Buraq for Publishing and Distribution., 2011.

[22] A. Suresh, study of programmable logıc controllers (plc) ın control systems for effectıve learnıng, 2015, pp. 104 -105.

[23] A. R. Krikr, Controlling a smart traffic light using Programmable logic controller PLC, 2019, pp. 2-3.

[24] «SIMENS.SIMATIC programmable controller system, manual.Edition,» 2008.

[25] D. Al-Massry, «PLC Fatek,» Noor.Book.com, 2014.

[26] J. Hugh, Automating Manufacturing System Chapter 3. PLC Hardware, Chapter 8. PLC Operation, 2004, pp. 27-28-29.

[27] M. J. Atta, Process control and automatıon of a pu mouldıng machıne, processreglerıng och automatıon av en, pu-gjutnıngsmaskın,, 2012, pp. 19-23.

[28] S. Adhikari, Operator Machine Control using Siemens PLC and HMI, 2018.

[29] SEMENS, «SIMATIC,Programming with STEP 7, Function Manual A5E41552389-,» 2017.

[30] W. T. Evans, PLC Handbook, Noor.Book.com, 2015.

[31] PLC Communications-Coming of Age. (n.d.). Retrieved from library.automation-direct.com, https://library.automationdirect.com/plccommunications-coming- of-age/17, 2011.

[32] S. v. a. A. vosough2, PLC and its Applications. international journal of multidisciplinary sciences and engineering, 2011.

[33] R. M, Student Projects in PLC Networking", Proceedings of the American Society for Engineering Education Annual Conference & Exposition, 2005.

[34] T. H. H, «Design of Graduate Projects in the Subject of Programmable Logic Controllers (PLC) for Students of Technical Institutes.,» 2012.

[35] A. Khattak, PLC Based Intelligent Traffic Control System," International Journal of Electrical & Computer Sciences IJECS-IJENS, cilt 11, 2011, p. 69.

[36] S. D. D. M. P. A. B. C. T. a. T. L. Barz, Intelligent traffic control system using PLC," IOP Conference Series: Materials Science and Engineering,, 2016.

[37] A. Khattak, PLC Based Intelligent Traffic Control System," International Journal of Electrical & Computer Sciences IJECS-IJENS, 2011, p. 144.

[38] M. D. Srıvastava, "SMART TRAFFIC CONTROL SYSTEM USING PLC and SCADA," International Journal of Innovative, International Journal of Innovative Research in Science, Engineering and Technology, 2012.

[39] Y. Liu and Chen, Design of traffic lights controlling system based on PLC and configuration technology," 1st International Conference on Multimedia Information Networking and Security, 2009.

[40] SIEMNS,SIMATIC, S7-SCL V5.3 for S7-300/400, Manual, Edition 01, 2005.

[41] L. K. Sudhs .Devabhakuni, "PLC based Smart Street Lighting Control," International Journal of Intelligent Systems and Applications, cilt 1, 2013, pp. 60 -70.

[42] H. T. THABET, Design of Graduate Projects in the Subject of Programmable Logic Controllers (PLC) for Students of Technical Institutes., 2005.

[43] Hugh, Automation of manufacturing systems using PLCs, a , www.archive. org/details/ost-engineering-plcbook5_1, 2008.

[44] I. E. E, Development of a Real Time Monitoring and Control System for PLC based Elevator, Power Electronics and Applications,, 2011.

[45] S. M, PLC Exercises, Ladder Diagram Programming", Mechatronics Engineering Mechatronics Engineering Dept., Hashemite University, 2015.

[46] T. H. H, Basics of Programmable Logic Controller (PLC), LAP- Lambert Academic Publisher, Germany, 2017.

[47] L. G. L, Northern Illinois University", DeKalb, IL, 60115, USADesign Projects in a Programmable Logic Controller (PLC) course in Electrical Engineering Technology", The Technology Interface Journal, Department of Technology, lguo@niu.edu 10(1)., 2009.

[48] H. Ernıe, «GICSP, CISSP, CEH | Michael Assante | Tim Conway Industrial Control Systems and Cybersecurity. Retrieved from ics.sans.org,» https://ics.sans.org/media/An-Abbreviated-History-of-Automation-and-ICS-C., 2014.

[49] D. a. A. Vosoughl, PLC and its Applications. international journal of multidisciplinary sciences and engineering, cilt 2, 2006.

[50] E. Hauser, «Mani wall technical specifications of the equipment of the sand filters system in the North Refineries Company of Baiji,» 2017.

APPENDICES

Appendix 1: SIMATIC MANIGER S7 – 300: Ladder Language Diagram Of The Backwashing Process.

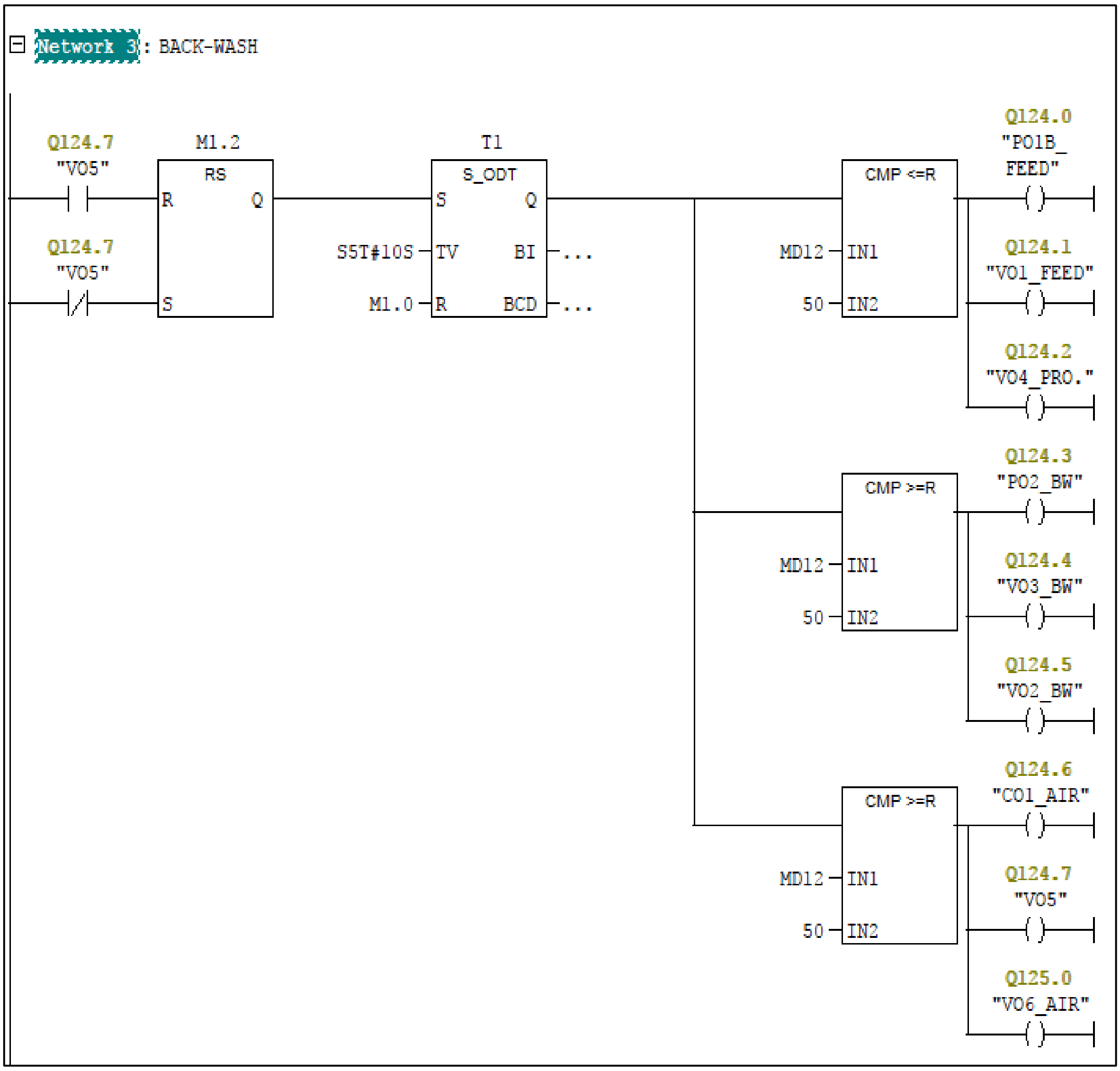


Figure (A.1) Backwashing Process Network.

In the figure (A.1) there is an illustration of the programming of the backwashing process for the system, showing all valves and pumps using the language of peace.

Appendix 2: Air composer Network. Program diagram in ladder language for the process of introducing the air compressor into work in conjunction with the start of the backwash process.

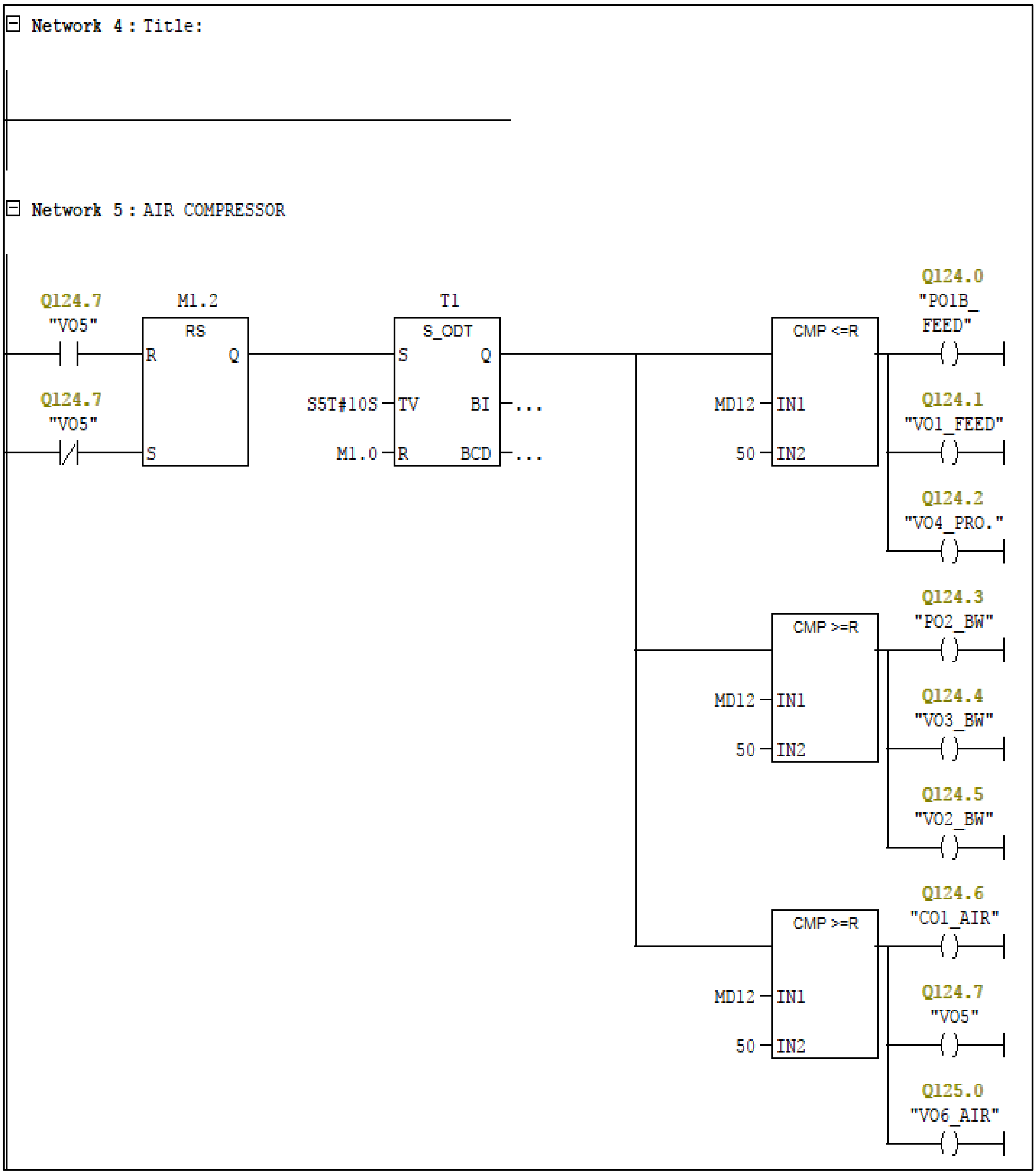


Figure (A.2): Air Composer Network.

In the figure (A.2) that is the programming of the work of the air compressor (CO1) is inserted to push the air from the bottom of the filter and be a mixture of water and air in conjunction with the opening of the air inlet valve V5 and the air outlet valve V6.

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