Stabilizing the Temperature and Humidity of Testing Samples in the Stability Room-Beit Jala Pharmaceutical.

By

Khalil Adi

Mohammad Al-Alama

Supervisor: Prof. Dr. Sameer Hanna

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المقدمة

على امتداد خمس سنوات جامعية، كنا قد تعبئنا نظرياً وعملياً، وقرأنا العديد من الكتب والأوراق العلمية، في شتى مواضيع الهندسة الكهربائية، وانتقلنا إلى مستوى الإنتاج بدءاً بالتقارير مروراً بالأبحاث ، وصولاً إلى هذا الكتاب .

لم تشغلنا يوما ضوابط البحث العلمي، خاصةً في أبعاده الشكلانية، وإنما أغرتنا الكتابة التحليلية وإنتاج الحلول الجديدة في إطار متطلبات العمل الهندسي. وبطبيعة الحال أتاحت لنا الظروف الإطلاع وتفحص البعض من الكتب لمشاريع طلاب خاضوا تجربة تحليل وكتابة مشاريع تخرجهم من قبلنا، وما أن جاءت لحظة الاختبار... حيث أتممنا التحليل ووضع الحلول الهندسية السليمة وتجهيز الخطة العملية التي نفذناها كما يجب للتحكم في غرفة تخزين الأدوية في مصنع بيت جالا للأدوية، وذلك للحفاظ على عينات الأدوية من تغيرات درجة الحرارة والرطوبة... وكل هذا الجهد والعمل الضئيل هو تنفيذاً لوصية القائد الذي أمضى طوال عمره لنصرة القضية الفلسطينية العادلة، الرفيق جورج حبش الذي أوصى بأنه علينا أن نصنع شيئاً لشعبنا وأن نكون بعدالة عمر ، وثورية علي ، وأصحاب رسالة كمحمد وعيسى .

الإهداء

إلى من زرعناهم في رحم هذا التراب المثخن بالنزيف حاملين للبندقية، حامين للقضية، رافضين للمساومة، شهدائنا الأبطال، وقود ثورتنا ، ومهندسين صمودنا وكرامتنا.

إلى من يخوضون الصراع بين الكولونيالية العنصرية بما تتسلح به من وسائل قوة وبين التطلعات التحررية بما تملكه من عدالة أخلاقية وتصميم على بلوغ الهدف، أسرانا الأبطال، العاشقين للحرية، المتحدين للتنكيل الممنهج، وللسجان العنصري الجائر.

إلى بؤرة النور التي عبرت بي نحو الأماني والمعاني الجميلة، وإتسع قلبه ليحتوي حلمي، وسار في حلكة الدرب ليغرس الأمل والصفاء في قلبي، وعلمني أن أعيش من أجل الوطن والعلم، لنظل أحياءً حتى لو فارقت أرواحنا أجسادنا، أبي الحبيب لقد آثرت من تحب على ما تحب، من أجل أن أمثل أمامك بشهادة تعترف كل قصاصة فيها على أنك السبب الأول في وجودها، لقد كنت جزءاً من طموحي لترى اليوم طيب غرسك في ثمرة جهدك، فقد أرضاني الإله فيك يا أبتي، فهلا رضيت عني؟

إلى من تمتهن الحب وتزرع الأمل والصفاء في قلبي، عصفوراً يتلألئ فوق ناصية الأحلام، يا من كانت دعواتها عنوان دربي، وكانت أحلامي دائماً على وشك التحقق طالما يدها في يدي، أمي الحبيبة أهديك شهادتي، لتهديني رضاكي.

إلى بحر العلم الذي لا ينضب، البحر الذي لم يسمح لاتساعه بأن يضيعنا يوما، فما جئناه يوما غارقين إلا وأتانا بقارب نجاة يكون قد نسجه لنا من عظيم قلبه، إلى البروفسورالرائع سمير حنا الذي رافقنا مذ كان مشروعنا فكرة تتبلور في رؤوسنا إلى أن أصبح الآن علما وحبرا وورقا، إليك يا من حولت الفكرة إلى أسلوب بحث، وحولت أسلوب البحث إلى إنجاز وعمل، نهدي إليك العمل وأنت صاحبه، فماذا يأتي ما قدمناه نحن أمام ما قدمته لنا؟ أنت الذي عرف سر العطاء فأغدق به علينا طوال سنوات حياتنا الجامعية كلها!

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إلى شركة بيت جالا لصناعة الأدوية بشكل عام، وقسم الهندسة بشكل خاص، الذي احتضن الفكرة ويقدمون الغالي والنفيس من أجل إنجاحها.

إلى من يفوح منهم عطر الياسمين، يحملون في قلوبهم ذكرياتنا، ويتقاسمون معنا أفراحنا وهمومنا، إلى من كانوا السند لنا، إخواننا أخواتنا، أصدقائنا وصديقاتنا.

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Abstract

Beit Jala Pharmaceutical Company saves samples of all drugs that the company produces for observation and to check its industrial quality. These samples must be saved at a stability room with specific conditions (temperature and humidity) to prevent samples spoilage. This project discusses improving controlling process inside stability rooms using programmable logic controller (PLC). PLC will have the ability to make the suitable decision to ensure temperature and humidity not being changed comparing with the reference values. This mechanism will operate by run the suitable unit of central air conditioning and cooling system inside the stability room, on the other hand, this project will also provide monitoring for the system using human machine interface (HMI) that link between the stability room observer and the system, and these data will be displayed on the HMI by a function graph showing temperature and humidity over the time intervals, also it will show temperature and humidity in ten different points inside the stability room according to the good allocation of sensors. This process will guarantee the optimized distribution of temperature and humidity all over the stability room.

الملخص

يقوم مصنع بيت جالا بحفظ عينات من الأدوية التي يصنعها ويوزعها على الصيدليات، وذلك للرقابة و التحقق من جودة التصنيع في أي وقت. تحفظ هذه العينات في غرفة خاصة، ويجب الحفاظ على درجة الحرارة والرطوبة المناسبة للأدوية في هذه الغرفة لضمان عدم فساد العينات.

يتناول هذا المشروع تطويرعملية التحكم داخل غرف التخزين بإستخدام وحدات التحكم المنطقي المبرمج (PLC). تقوم (PLC) باتخاذ الإجراء المناسب لضمان عدم تغير درجة الحرارة و نسبة الرطوبة عن القيمة المرجعية وذلك بتشغيل الوحدة المناسبة من وحدات التكييف والتبريد المركزية بالغرفة، كما سيوفر المشروع مراقبة النظام باستخدام شاشة لمس (HMI) تربط بين المستخدم المراقب للغرفة والنظام، وتظهر في مخطط بياني درجة الحرارة ونسبة الرطوبة مع الزمن، كما سيظهر درجة الحرارة والرطوبة في عشرة نقاط مختلفة داخل غرفة التخزين وفقًا للتوزيع الجيد لأجهزة الاستشعار، للتأكد من تجانس درجة الحرارة ونسبة الرطوبة في جميع أنحاء الغرفة.

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Abbreviation Table

Description	Abbreviation
Beit Jala Pharmaceuticals	**BJP**
Humidity	**RH**
Programmable Logic Controller	**PLC**
Human Machine Interface	**HMI**
Proportional Integral Derivative	**PID**
Negative Temperature Coefficient	**NTC**
Temperature and humidity sensor	**DHT22**
Air Change per Hour	**ACH**
Cubic Feet per Minute	**CFM**
Multi-Point Interface	**MPI**
Central Processing Unit	**CPU**
Universal Serial Bus	**USB**
Supervisory Control and Data Acquisition SCADA	**SCADA**

Chapter One

Introduction

1.1 Introduction

1.2 Project Idea Description

1.3 Project Objectives

1.4 Project Added-Value

1.5 Literature Review

1.6 Project Scope

1.7 Time Schedule

1.1 Introduction

Beit Jala Pharmaceuticals (BJP) manufactures a lot of medical products, such as painkillers and antibiotics, both solid and liquid. The Pharmaceutical has a stabilization chamber where samples of medicines are kept under temperature range (23-27) ^{o}C and humidity range (55-65) % as requested7 by BJP. All locations inside the room must have a stable temperature and relative humidity (RH). Therefore, and due to machine instability, chillers are used to maintain these values. Moreover, since temperature and humidity change suddenly leading to cause unexpected results, these changes must be kept between reference ranges. Therefore, a stabilizing system should be designed to fulfill these requirements.

.

1.2 Project Idea Description

The main purpose of this project is to design a controlling system in the air-conditioning system for temperature and humidity-controlled environment by using programmable logic controller (PLC) and human machine interface (HMI).

1.3 Project Objectives

This project will achieve the following objectives:

1) Design a controlling system for air conditioning to control the temperature and humidity ratio to keep the temperature and humidity in the range inside the stability room (shelf life).

2) Display temperature and humidity readings and its changes with a graph on HMI display screen.

1.4 Project Added-Value

The importance of the project is summarized in the following points:

1) Provide an easy and convenient way to detect changes in temperature and humidity.

2) Save time and efforts of the factory workers to measure the temperature and humidity inside the stability room.

3) Provide a suitable environment for stored medicines in the stability room so they will not be spoiled.

4) Ensure that the control system works in a way that enables the worker to change the value of the set points and achieve the possibility of reading the curve shown on HMI.

1.5 Literature Review

PLC and PID together will form a controlling temperature system, that using PLC ladder figure programming language for implementing automated control of temperature [1]. This paper shows quick responses, stability, reliability and control preciseness, taking into account that this paper is focusing on:

-How the PLC and PID controlling temperature changes and how to be managed using them.

-Real time detection of the local temperature.

-Achieving fast dynamic response.

1.6 Project Scope

Improve the existing system in BJP by adding new control units to maintain temperature and humidity at a safe range.

1.7 Time Schedule

This table illustrates the tasks we have done and how long each task took to be finished:

Task \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Finding Project Idea	■	■																												
Proposal			■	■	■																									
Collecting data						■	■	■	■																					
Introduction project Documentation						■	■	■	■	■	■	■	■																	
Preparing for presentation														■	■															
Print Introduction project documentation															■															
Prepare Project Components																■	■													
Study for programing PLC and write the code																	■	■	■	■										
Study for programing HMI and Design the panels																		■	■	■	■	■								
Distribution the sensors in the Chamber																							■	■						
Connection the PLC and HMI and sensors																								■	■	■	■			
Preparing for presentation and Print documentation for final project																												■	■	■

Figure (1.1) Time Schedule

Chapter Two

System Components

2.1 Overview

2.2 Block Diagram

2.2 Project Components

2.4 Principle of The Work Components

2.1 Overview

In this chapter there is a brief review of all components used in this project, and how each component operates, and the output feedback by the whole system and how it used to make more improvements.

2.2 Block Diagram

Figure (2.1): This functional block diagram illustrates the relation between temperature and humidity sensor, and what action/operation is taken.

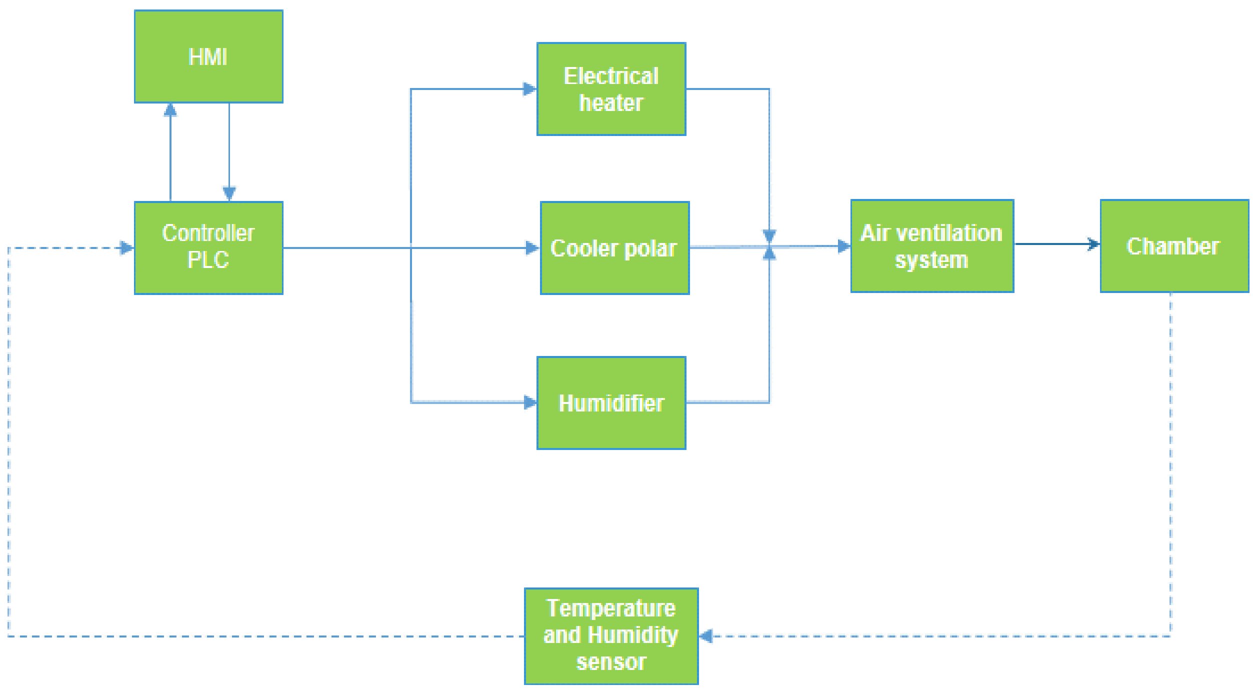

Figure (2.1) Block diagram

2.3 Project Components

The main project components can be stated as follows:

1) Human Machine Interface (HMI)
2) Programmable Logic Controller (PLC)
3) cooler polar unit
4) electrical heater unit
5) Humidifier unit
6) Fan
7) Temperature and Humidity Sensor
8) Accessorial as a wires
9) In addition to heeded power supply operation

2.4 Principle of The Work Components:

1) Human Machine Interface (HMI)

Allows the operators to interact with the system in order to modify, result, see and decide proper actions.[2]

Figure (2.2) SIMATIC HMI

2) Programmable Logic Controller (PLC)

This device is used to perform the decided actions for the HMI system based on sensed temperature and humidity.[3]

Figure (2.3) SIMATIC S7-300 CPU 313C

3) Cooler polar

It is used for cooling and drying by intensifying the steam particles in the air to reduce temperature and humidity. The cooling is achieved by using a special gas.

4) Electrical heater unit

It is used to increase or decrease the temperature in the surrounding space.

5) Humidifier

It is used as a vapor device that increases the relative humidity in the surrounding atmosphere, and we can increase or decrease the amount of steam output. [4]

Figure (2.4) Vapor

6) Fan

It is used for distributing the air all over the room with continuous operation.

7) Temperature and humidity sensor

This part is used to measure the temperature and humidity in the surrounding environment and send the readings values to PLC. We also used the GHU Room/Duct sensors.[5]

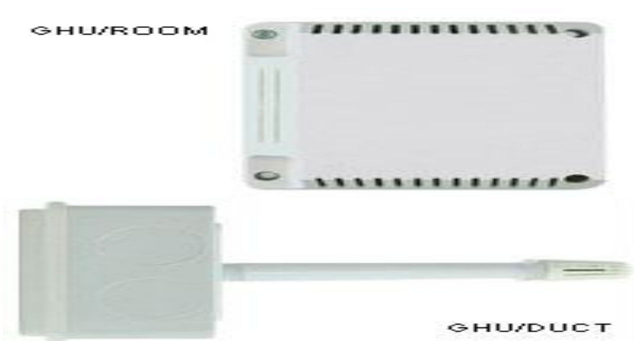

Figure (2.5) GHU Room / Duct sensors

Chapter Three

Mechanical Design

3.1 Overview

3.2 State Graph

3.4 Duct and Diffuser Design

3.5 Mechanical calculations

3.1 Overview

Regarding to figure (2.1) which illustrate the block diagram of the system. This Chapter will explain the mechanical design, its flowcharts, calculations and duct-diffuser design. Also, this chapter will illustrate the proposed flowchart in figures (3.1) & (3.2), and the main function of this chart is to monitor and control the temperature and humidity change.

3.2 State Graph

1. Chamber humidity affected by external factors such as climate degree temperature and internal factors like adding new samples or door opening. If humidity goes below 55% the system runs the humidifier and fan to increase the humidity, and if the humidity goes above 65% the system will run electrical heater and fan for decreasing humidity, as illustrated in state graph in figure (3.1).

2. Chamber temperature affected also by the same factors mentioned in the previous point (1). If the temperature the goes below 23^0C or above 27^0C the system reacts by running cooler with fan for decreasing temperature or by running electrical heater with fan for increasing temperature, as illustrated in state graph in figure (3.2).

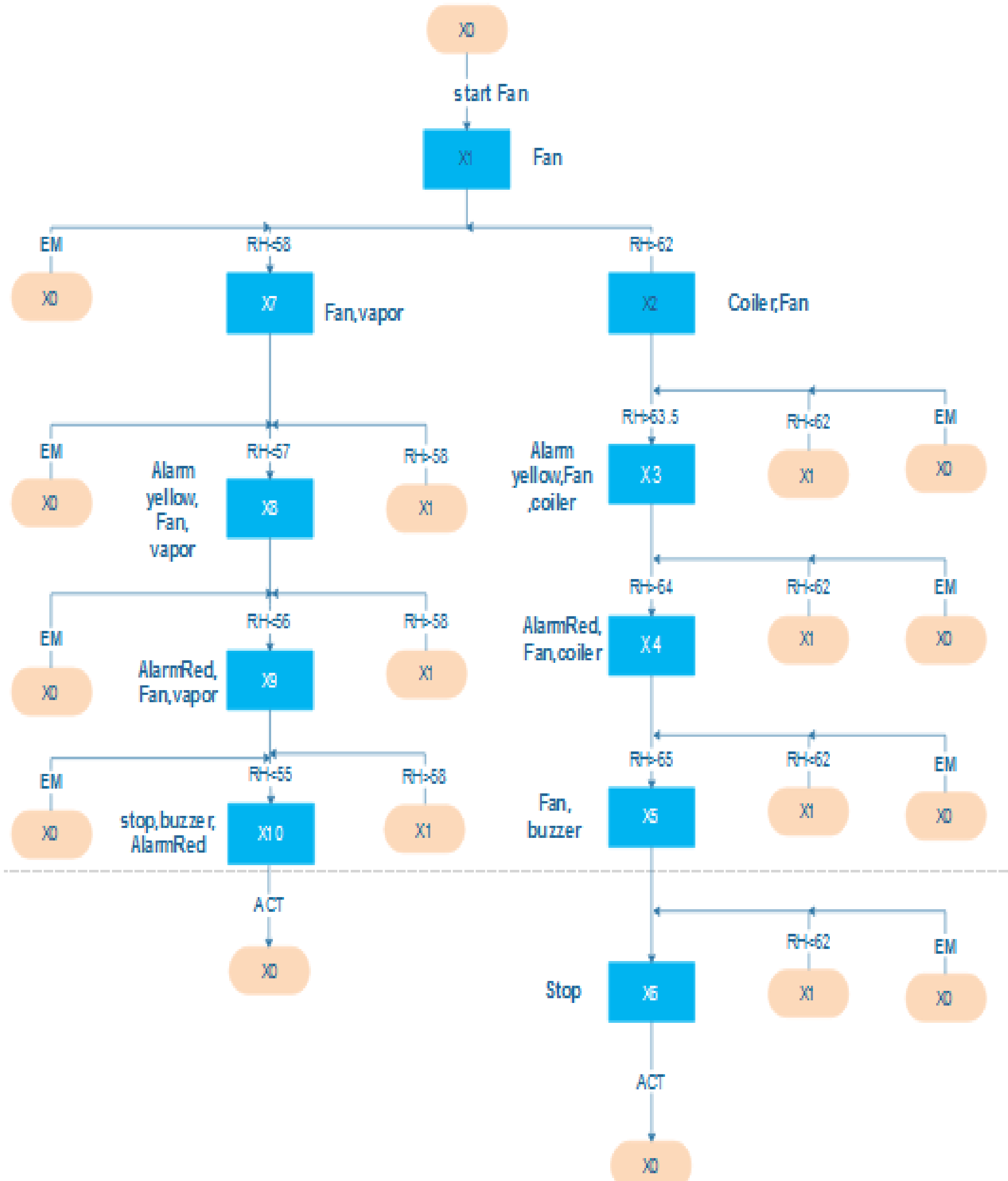

Figure (3.1) State graph for humidity

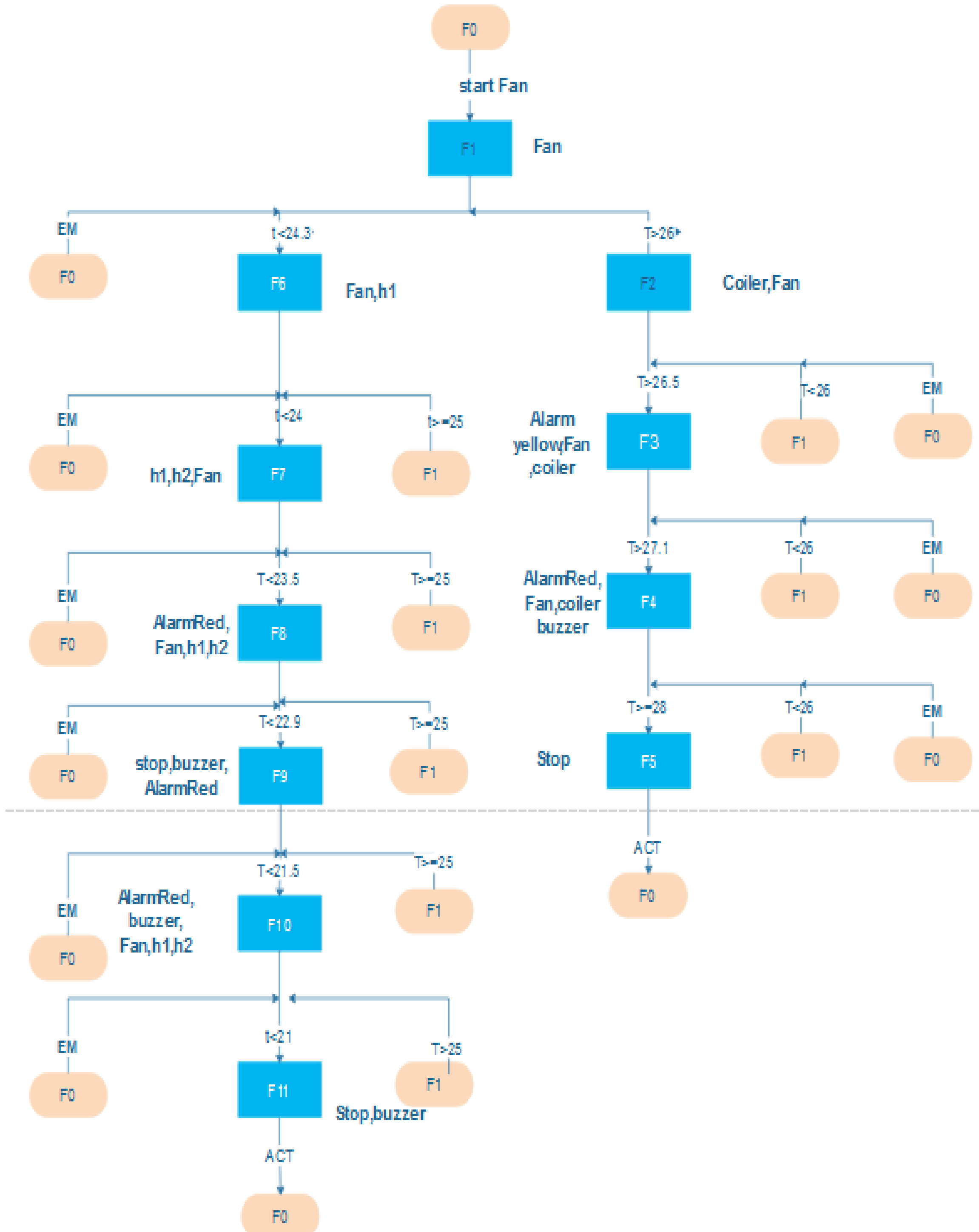

Figure (3.2) State graph temperature

3.4 Duct and Diffuser Design

***Duct:** Duct is mechanical tunnel which used in heating, ventilation, and air conditioning to blow or pull air. The needed airflow includes air supplying and air deflation. Figure (3.3) shows the overall view of the chamber with air inlet and outlet.

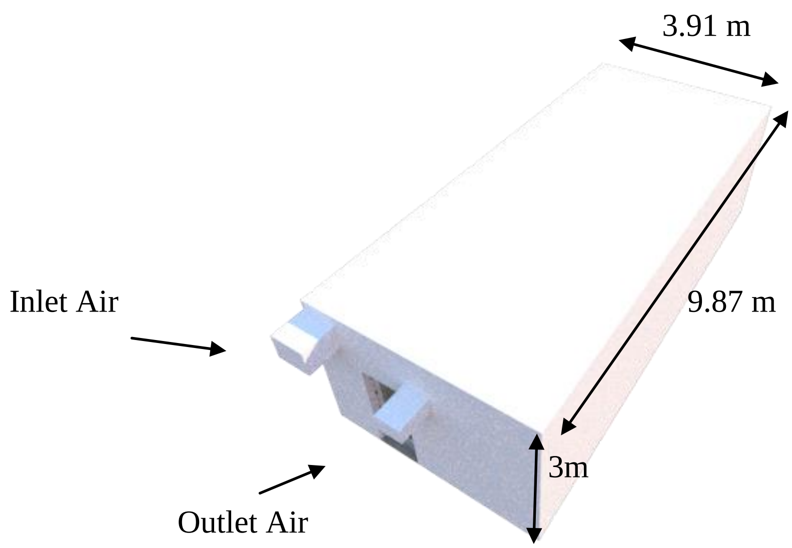

Figure (3.3) Overall view of the chamber

*****Diffuser:** is a device for reducing the velocity and increasing the static pressure of a fluid passing through a system. Air is controlled by blowing out into the chamber throughout four exits distributed along the chamber as shown in figure (3.4).[6]

Figure (3.4) Diffuser inlet air location in the chamber

As shown in figure (3.5) these two outlet diffusers are used to pull out the air from the chamber.

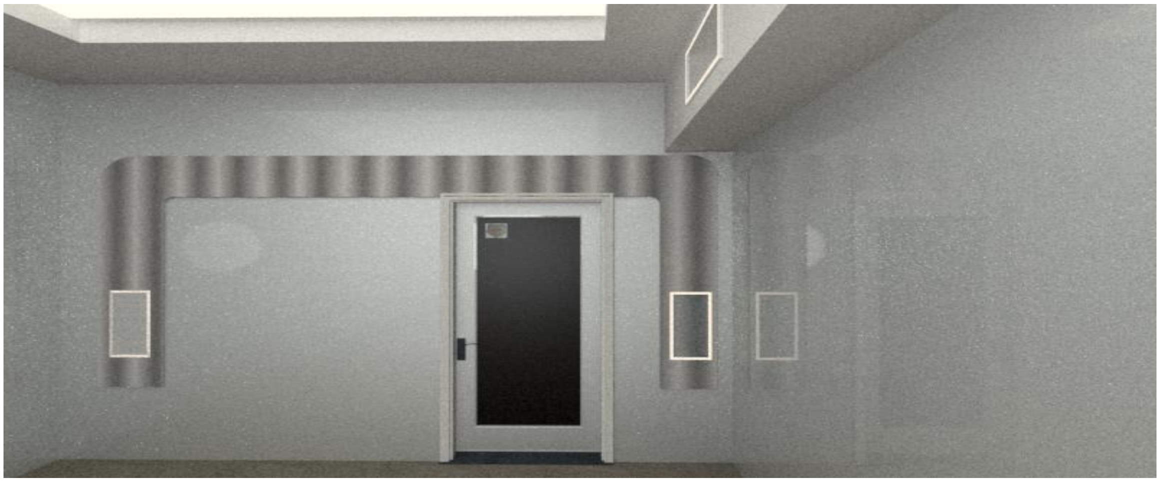

Figure (3.5) Diffuser outlet air location in the chamber

Figure (3.6) Shows the internal design of the chamber with the six diffusers and its locations.

Figure (3.6) The internal design of the chamber

3.5 Mechanical Calculations

Air flow rate is calculated using the following equation:

- The unit is cubic feet per minute (CFM).

$$Af = Ac \times (V / 60) \tag{3.1}$$

Where

- *Af* refers to air flow rate
- *Ac* refers to air change
- *V* refers to the space volume

The air flow rate depends mainly on the heating load that can be calculated using the following equation:

$$L = Q / (c_p \rho (t_h - t_r)) \tag{3.2}$$

Where

- *L* refers to the flow volume, m^3/s
- *Q* refers to heat loss from the building, which equal 8 kW
- c_p refers to specific heat capacity air, which equal 1.005 kj /kg^{o}C
- ρ refers to density of air, which equal 1.2 kg/m^3
- t_h refers to heating air temperature ^{o}C, which equal 27 ^{o}C
- t_r refers to chamber temperature ^{o}C, which equal 23 ^{o}C

Numerically, eq. (3.2) can be rewrite as follow:

$$L = 8 / (1.005 * 1.2 * (27-23)$$

$$L = 1.6\ m^3 / s$$

The chamber volume equals:

$$Space\ volume = width\ x\ length\ x\ height \qquad (3.3)$$

$$= 3.91 * 9.87 * 3$$

$$= 115.77\ m^3$$

Converted into imperial unit, where

$$1\ m^3 = 35.314\ ft^3 \qquad (3.4)$$

So:

$$115.77\ m^3 = 4088.3\ ft^3$$

To find the air flow in CFM:

$$1\ m^3/s = 2118.4\ ft^3/s \qquad (3.5)$$

So:

$$1.6\ m^3/s = 3390\ ft^3/s$$

Practically, the air flow is adjusted to 3500 CFM, to cover unexpected increase in heating load.[7]

The air change per hour (ACH) can be determines as follow:

$$ACH = \frac{air\ flow\ x\ 60}{\text{volume of space}}$$

$$= \frac{3500 * 60}{4088.3}$$

$$= 51\ Air\ change\ per\ hour$$

Summary:

Flow volume = 1.6 m3 / s

Volume = 115.77 m3

ACH = 51 Air change per hour[8]

The equations that were shown earlier used constant parameters based upon factory own values that ensures a constant air change per hour in all the BJP stability rooms. In other hand, in fact the mentioned parameters changes accordingly with temperature and humidity changes. Thus, these changes should be taken into consideration in our calculations to avoid rapid change in temperature and humidity.

As result, this previous mechanism will reduce factory power consumption based upon the relation between temperature and humidity versus air change per hour as shown in the below figure(3.7).

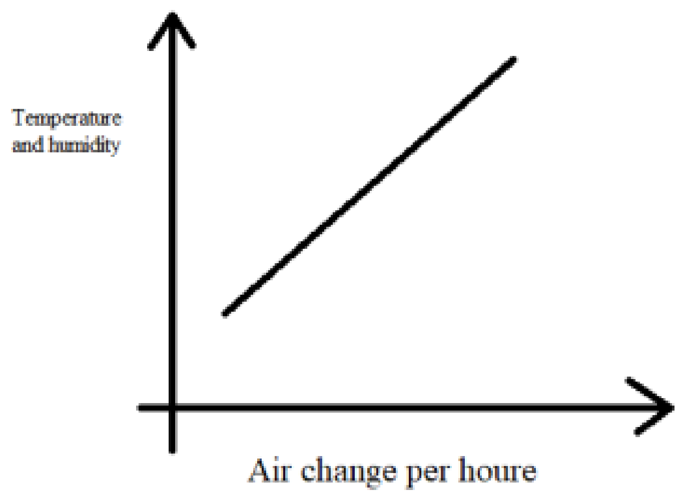

Figure (3.7) The relation between temperature and humidity versus air change per hour

This mechanism was refused by the factory management as all the stability room should have a constant air change per hour.

Chapter Four

Electrical Design

4.1 Overview

4.2 Controller

4.3 Sensors

4.4 The Control Unit Design

4.5 Application

4.6 Devices configuration

4.7 Program Structure

4.8 HMI Panels

4.1 Overview

This chapter talks about electrical circuits and control techniques, as explained in previous chapters about what parameters control and maintain components in the system. Temperature and humidity are regulated using electrical modules. Also, we cover what application used to implement PLC and HMI using three programming languages.

4.2 Controller

SIMATIC S7-300, CPU 313C, compact with MPI are used in this project, as shown in figure (4.1). An analog module is added to the input/output for controlling physical values of temperature and humidity. The system obtains values by sensors, and monitored by (SIMATIC HMI, KTP700 BASIC).

- SIMATIC HMI, KTP700 BASIC will use basic panel key and touch operation 7" TFT display.

Table (4.1) shows complete specifications of the assembled device.

Figure (4.1) SIMATIC S7-300 CPU 313C

Table (4.1) Device specifications:

Description	Module number
SIMATIC S7-300, CPU 313C , COMPACT CPU WITH MPI,24 DI/16DO,4Al,2AO 1 PT100,3 FAST COUNTERS (30 KHZ), INTEGRATED 24V DC POWER SUPPLY, 128 KBYTE WORKING MEMORY, FRONT CONNECTOR (2 X 40PIN) AND MICRO MEMORY CARD REQUIRED	6ES7313-5BG04-0AB0
SIMATIC S7-300, FRONT CONNECTOR WITH SCREW CONTACTS,40-PIN	6ES7392-1AM00-0AA0
SIMATIC S7, MICRO MEMORY CARD FOR S7-300/C7/E 200,3.3 V NFLASH, 128 KBYTES	6ES7953-8LG30-0AA0
SIMATIC S7-300, ANALOG OUTPUT SM 332, OPTICALLY ISOLATED, 4 A0,U/I; DIAGNOSTICS; RESOLUTION 11/12 BITS, 20 PIN, REMOVE/INSERT W. ACTIVE, BACKPLANE BUS	6ES7332-5HD01-0AB0
SIMATIC S7-300, FRONT CONNECTOR FOR SIGNAL MODULES WITH SCREW CONTACTS, 20-PIN	6ES7392-1AJ00-0AA0
SIMATIC S7-300, ANALOG INPUT SM 331, OPTICALLY ISOLATED, 8 AI,13 BIT RESOLUTION U/IRESISTANCE/PT 100, NI 100, NI1000, PTC/ KTY, 66MS MODULE UPDATE, 1X 40 PIN	6ES7331-1KF02-0AB0
SIMATIC S7-300, FRONT CONNECTOR WITH SCREW CONTACTS, 40-PIN	6ES7392-1AM00-0AA0
SIMATIC HMI, KTP700 BASIC, BASIC PANEL, KEY AND TOUCH OPERATION, 7'' TFT DISPLAY, 65536 COLORS, PROFINET INTERFACE, CONFIGURATION FROM WINCC BASIC V13/ STEP7 BASIC V13, CONTAINS OPEN SOURCE SW WHICH IS PROVIDED FREE OF CHARGE	6AV2123-2GB03-0AX0

4.3 Sensors

Sensors are used to measure actual values of the parameters (Temperature and humidity) during the process, these values are sending for processing and proceeding. This project uses a set of sensors and each sensor at the chamber measures temperature and humidity in its location.

4.3.1 Temperature and Humidity Sensors

These sensors are used to observe values of temperature and humidity, the output data is sending to controller to process them to have actual values, and compare these values with the set points of temperature and humidity.

Here we cover how sensor measures values and its components. It contains a humidity sensing component, NTC temperature sensor and an IC on the back side of the sensor.

For measuring humidity, the sensor uses the humidity sensing component which has two electrodes with moisture holding substrate between them. So, when the humidity changes, the conductivity of the substrate changes or the resistance between these electrodes change. This change in resistance is measured and processed by the IC which makes it ready to be monitored by the controller.

On the other hand, for measuring temperature, sensor uses NTC temperature sensor. The term (NTC) stands for (Negative Temperature Coefficient), which means the resistance decreases or increases depending on the change in temperature.

Table (4.2) describes the sensor specifications, and figure (4.2) shows the locations of sensors inside the chamber.[9]

Table (4.2) Sensor specifications:

Supply	**24Vac/dc**
Relative Humidity	**Range (0.....100)%RH ,Accuracy(25 c^o) ±2RH**
Temperature measurement	**Range (0.....50)c^o , Accuracy(25 c^o) ±0.5 c^o**
Temperature set point	**Range (0.....60) c^o**
Humidity set point	**Range (15.....90)%**

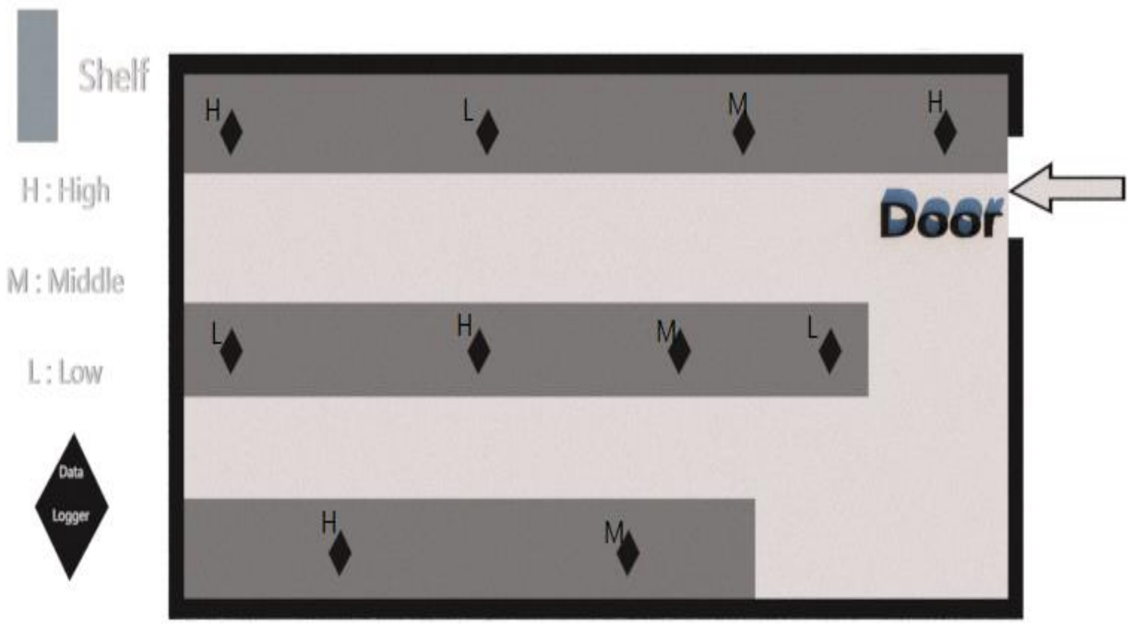

Figure (4.2) Locations of sensors

4.4 The Control Unit Design

Figure (4.3) shows the data-flow between the system modules (HMI, PLC) and the sensors.

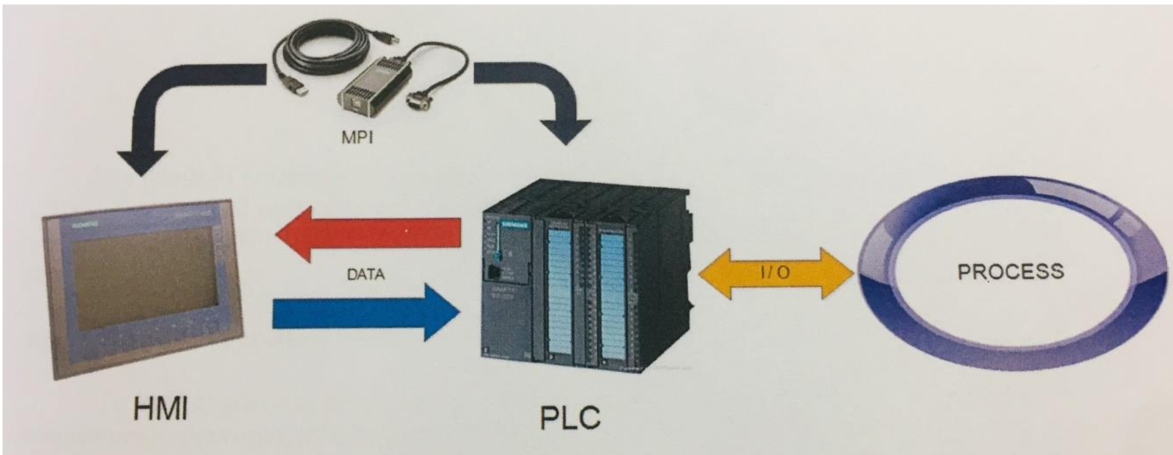

Figure (4.3) HMI, PLC and how they assembled

As shows in figure (4.4) the PLC executes the process, the HMI monitor the process, and display the values given by sensors. The data is transferred to the compact unit using USP & MPI.[10]

4.5 Application

The main step here is to find an application is easy to use in implementing PLC and HMI and to make them work based on our needs. So, because we have both Siemens PLC and HMI, we used a Siemens Software to implement our program.

In this project we used (TIA PORTAL V14) software, which is the last version in Siemens software, see Figure (4.4). This software link PLC with HMI, which gives us ability to implement PLC and HMI at same environment, which makes it easier to link their tags of both PLC and HMI together.

Figure (4.4) TIA PORTAL V14 program

4.6 Devices configuration

As any PLC programming software, we must configure hardware devices, from section 4.1. As a result of knowing PLC type, we know what modules and power supply needed. The figure (4.5) shows the device configurations in the program.

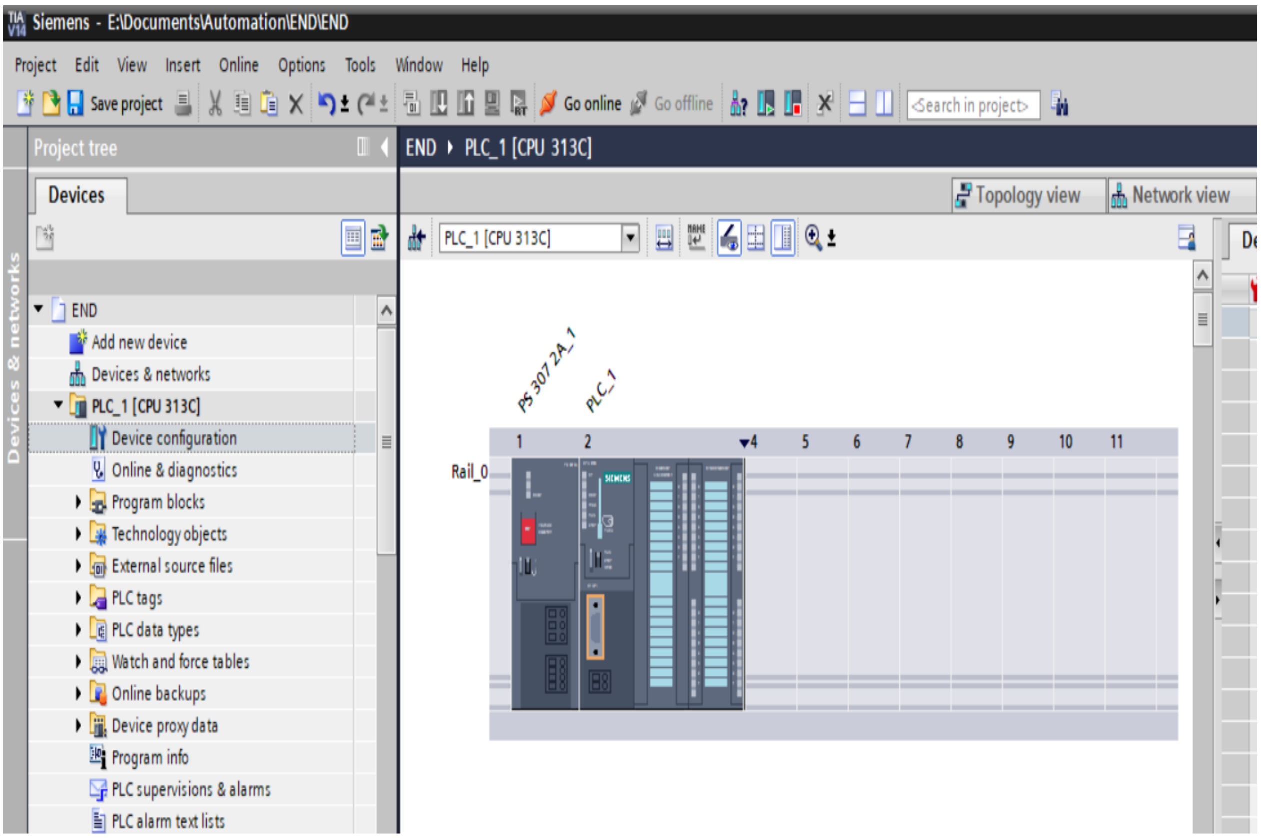

Figure (4.5) PLC configurations

Based on figure above you can note that we insert PLC S7-300 CPU 313C with DI240/DO16 and AI5/AO2 modules, and power supply 5V/2A. After configuring PLC, we insert HMI touch screen as shown in figure (4.6).

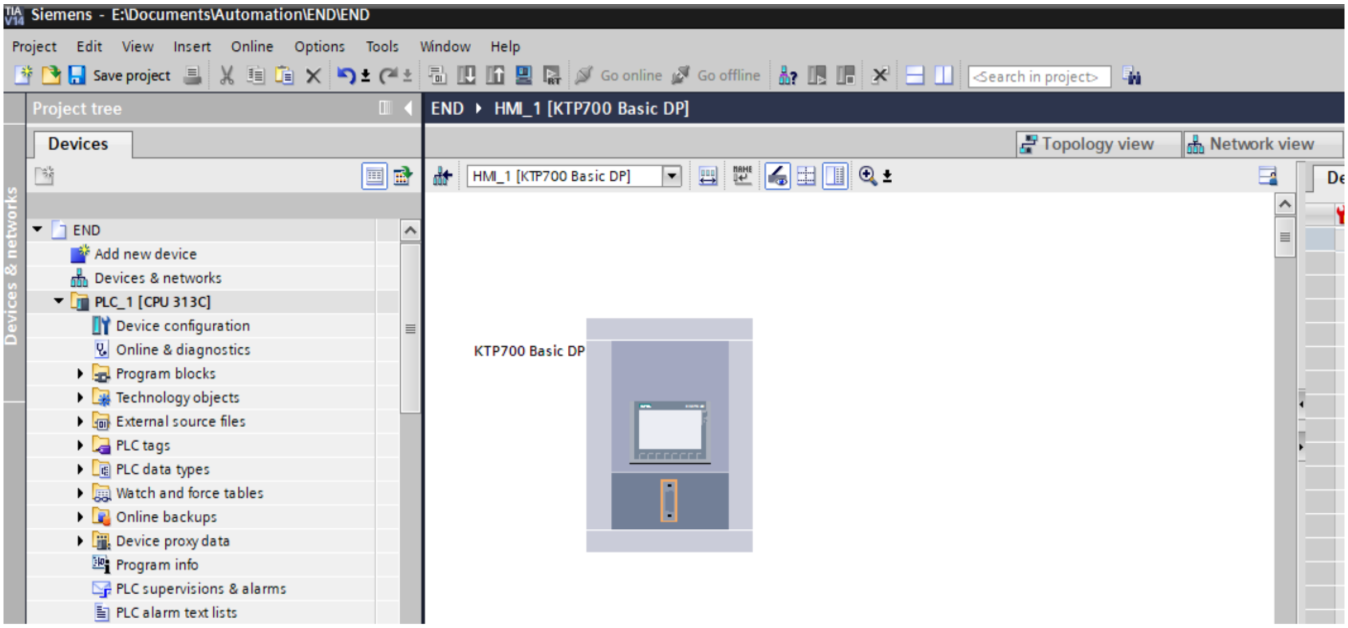

Figure (4.6) HMI configuration

After PLC and HMI are configured, we need to connect them. Using TIA PORTAL, we can connect them and choose the suitable device that is used to connect between them, as shown in figure (4.7).

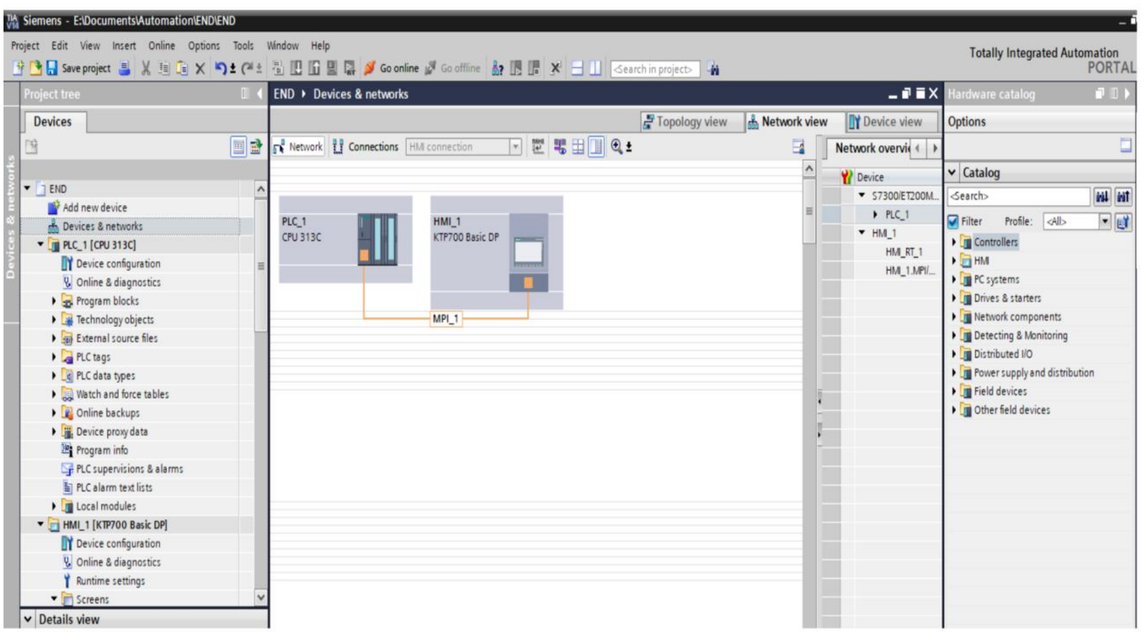

Figure (4.7) Network configuration

From the figure above, want to use Multi-Point Interface (MPI) to connect between HMI and PLC, as shown in figure (4.8).

Figure (4.8) MPI interface

4.7 Program structure

In any controlling system that uses PLC, it must have three modes. These modes are summarized in:

1. Normal mode: this mode is explained in figure (3.1) and (3.2). So, we had to use Function Block Diagram Language instead of State Graph Language, because TIA PORTAL doesn't support State Graph.
2. Float/Emergency/Alarm mode: which is activated automatically if any device in the system has a failure such as a failure in fan or overheat in heater or if anyone turn off the fan, and we used Ladder and Structured Text languages based on requirements.
3. Maintenance mode: this mode provides the ability to maintain devices independently and the ability to test all devices independently without the need to turn off the system.

4.8 HMI Panels

After discussing the related part of PLC, here we are going to talk the four HMI panels we used in our project in the following points:

- **Home panel**

This panel purposes are summarized in displaying the connected parts in our system and its status, and displaying the temperature and humidity values. Also, it implemented to give the worker the ability to turn on/off the connected fan, and to switch between all other panels. Figure (4.9) shows the home panel

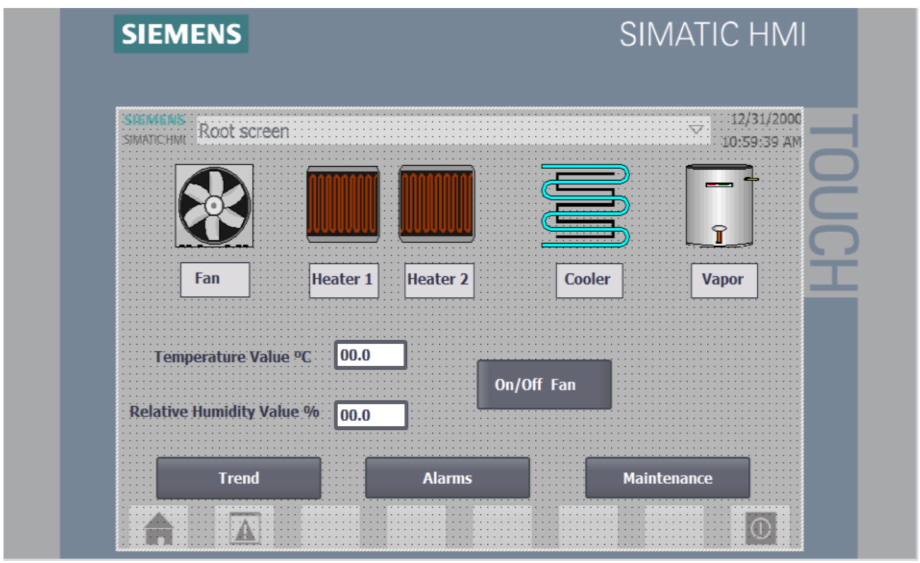

Figure (4.9) Home Panel

If anyone needs to change the status of the Fan, he/she needs a password because the system will not work if the fan was off. On the other hand, the maintenance mode also needs a password, because it switches the mode from automatic mode to manual mode.

- **Alarms Panel**

Alarms panel or Alarms screen as shown in figure (4.10). This panel displays all the implemented alarms, it also shows the time of any failure occurred in the system, and for more security it shows an alert on screen.

If the system reached the stop mode, we put the acknowledgement button in the Alarms Panel to force the operator to read all the details related to occurred alarm before pressing acknowledgement.

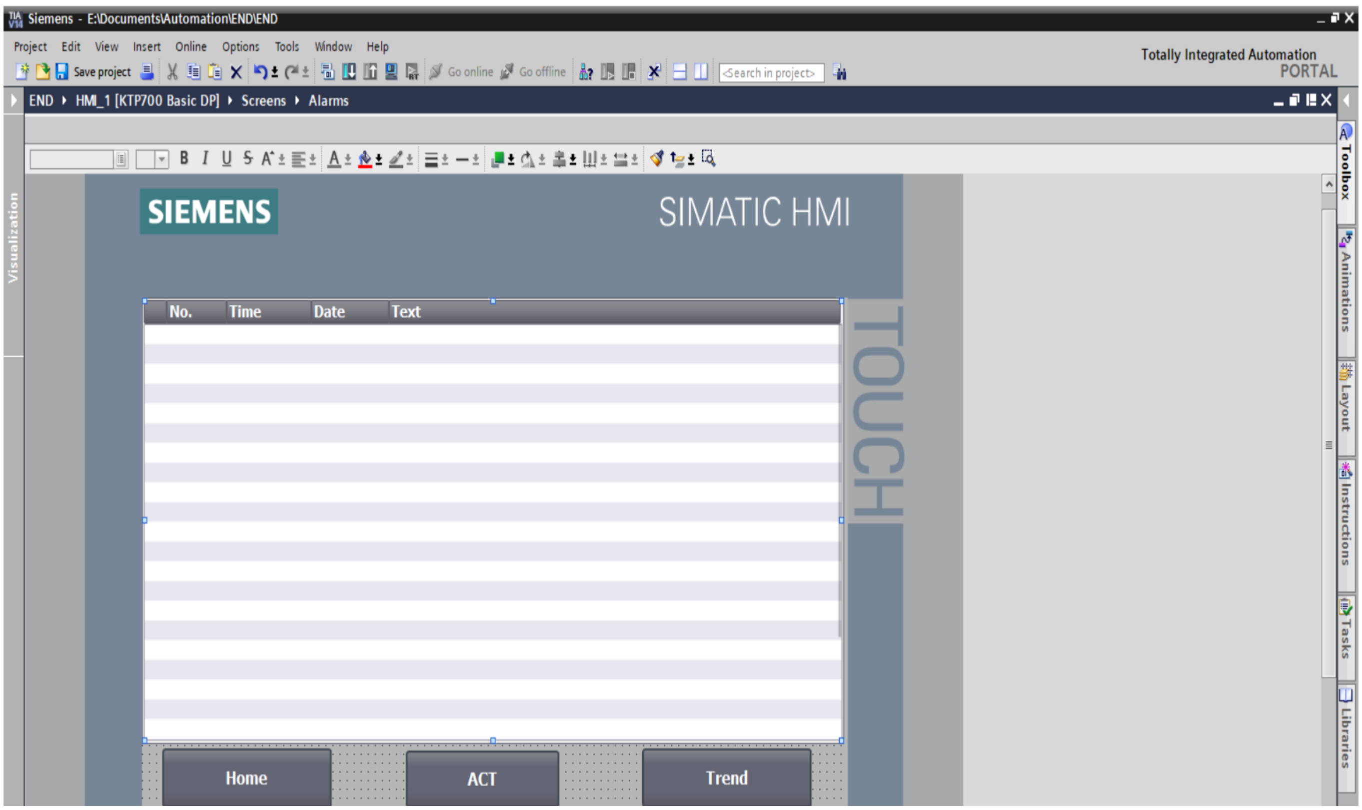

Figure (4.10) Alarms panel

- **Maintenance panel**

In this screen as shown in figure (4.11), the automatic system is switched to manual by entering to this panel, and to make it easier to maintain the system if any failure happens. This mode gives the operator the ability to check each connected device independently.

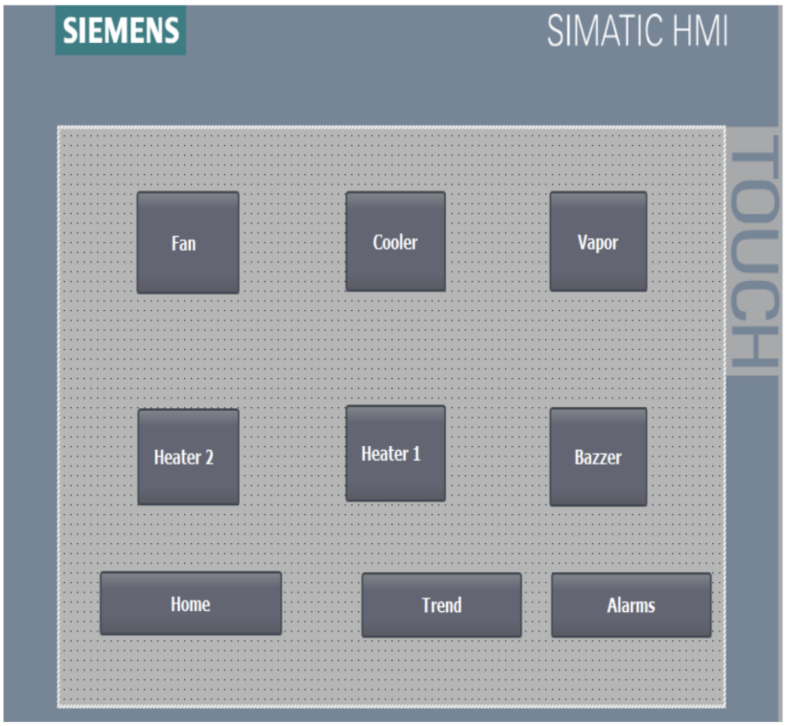

Figure (4.11) Maintenance panel

After finishing the maintaining process, the operator needs to press on the Home button to switch the system from manual to automatic.

- **Trend panel**

  In trend panel as shown in figure (4.12). This panel purpose is to show a graph of temperature and humidity values in 48 hours. So, by Trend panel we can monitor the parameters in the system. Moreover, we added Home/Alarms buttons to make it easier for the operator to switch to other panels.

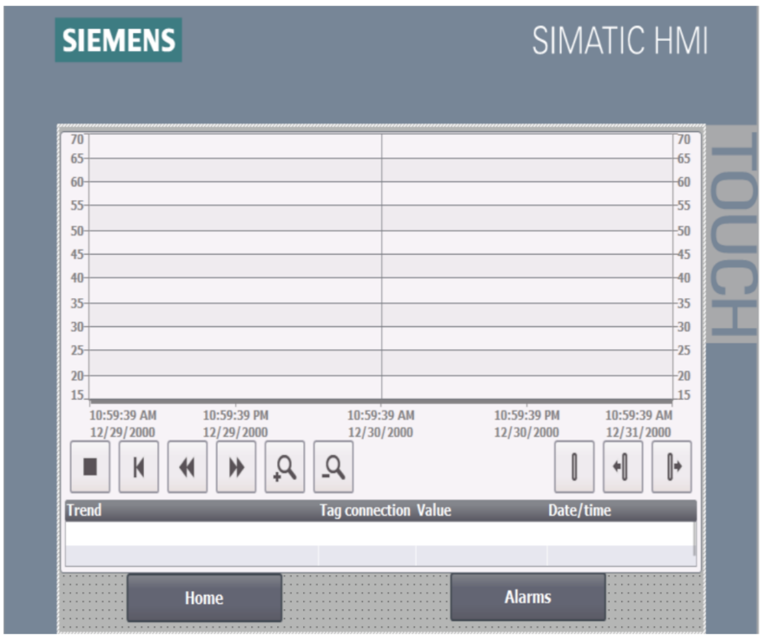

Figure (4.12) Trend panel

To be noted:

- The electrical heater
- The cooler polar
- The Humidifier
- The fan
- The duct and diffuser

Are already installed, and our purpose is to implement more effective and reliable control of the temperature and humidity values, according to BJP requirements.

Chapter Five

Summary and Recommendation

5.1 Summary

5.2 Challenges

5.3 Recommendation

5.1 Summary

1. The system has been successfully implemented, and it works correctly, and it achieves the goal to keep the temperature and humidity values stable in stability room.
2. Monitoring any system failure using Alarms Panel.
3. Add more safety procedures to protect all devices.
4. Maintenance mode is added to give the ability to test each connected device independently.
5. Show a graph for changing in temperature and humidity values in 48 hours in Trend Panel.

5.2 Challenges

1. Lack of resources, we had to contact Siemens Company to give a license to use their program for educational purposes, they just allow us to use TIA application for just 20 days.
2. We faced a time challenge because we used TIA Portal application, and it was our first time using it. The challenge was to learn how to use TIA Portal and implementing system and downloading it on PLC and HMI in such time.
3. We had to learn everything about the previous connected panel in BJP, because they didn't allow us to use or change anything in their panel. So, we had to implement new panel that has the ability to control their panel.
4. Difference in electrical resources, the old system is using 24VAC, and the new controller needs 24VDC.
5. We had to buy new memory for the PLC online, because BJP has PLC with no memory, so we had to wait more than two weeks for memory arrival.

5.3 Recommendations

5.3.1 for the companies and factories

The system we built more suitable and compatible for all companies/factories use stability room. Therefore, we highly recommend to use our system because easy to use and it has less power consumption.

5.3.2 for the Hospitals

This system is also suitable for hospitals, specially medicine inventories, because our system has the ability to control and monitor more than one stability room using one PLC and one HMI. So, it can be configured easily upon hospital needs in any place, by changing its parameters (set points).

5.3.3 for future development and expansion

In this project we used HMI touch screen. If we want to develop the project and connect to it remotely, we can use Supervisory Control and Data Acquisition (SCADA) system.

SCADA system provides the ability to monitor and control the system using any connected device to the internet (online). Basically, it saves time and efforts. As result there is no need to control the system from its chamber. In addition, SCADA provides more reliability and security to the system.

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PLC Technology," *Convergence Information Technology(JCIT*, vol. 8, p. 10, Feb 2013.

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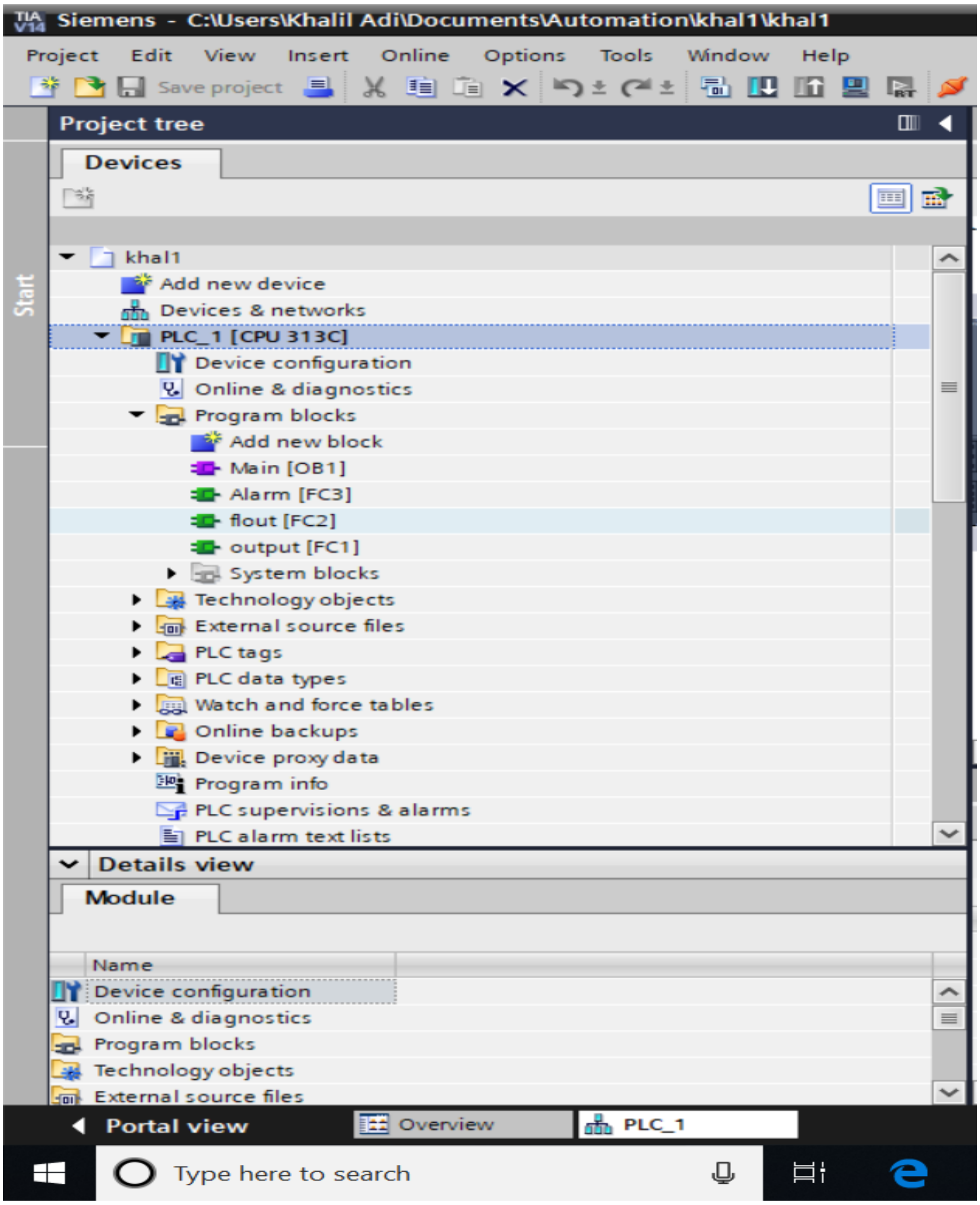
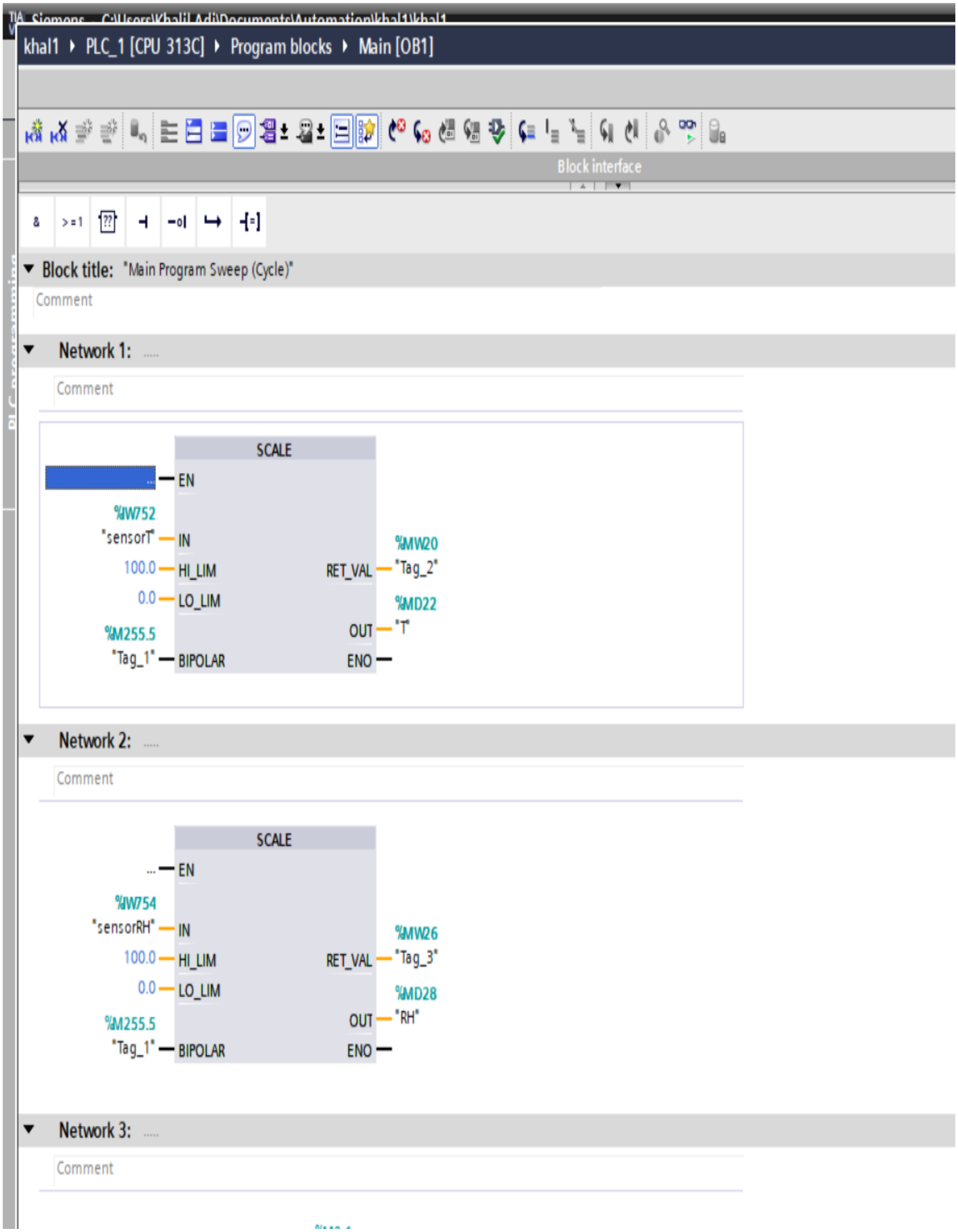
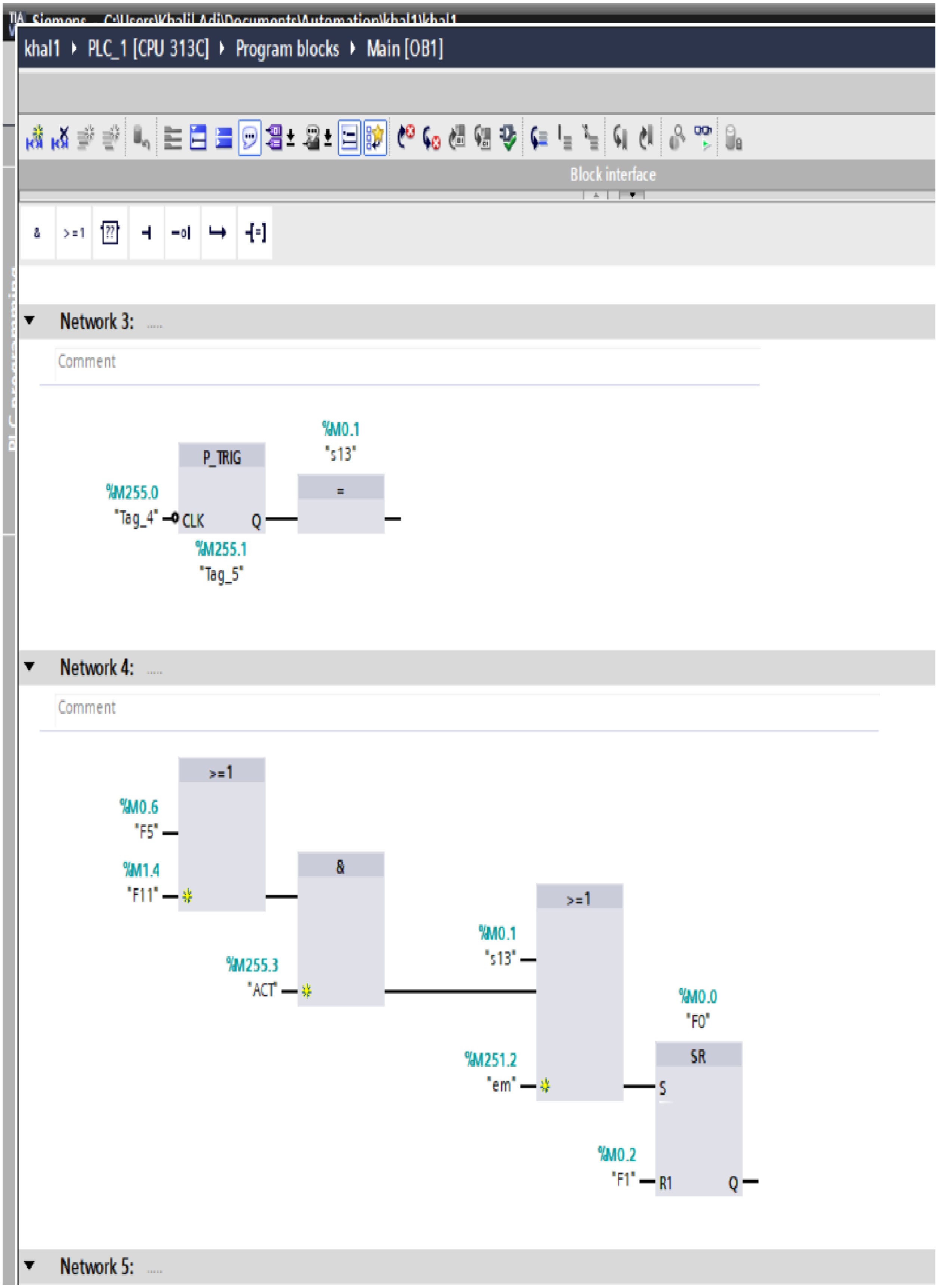
APPENDIXES

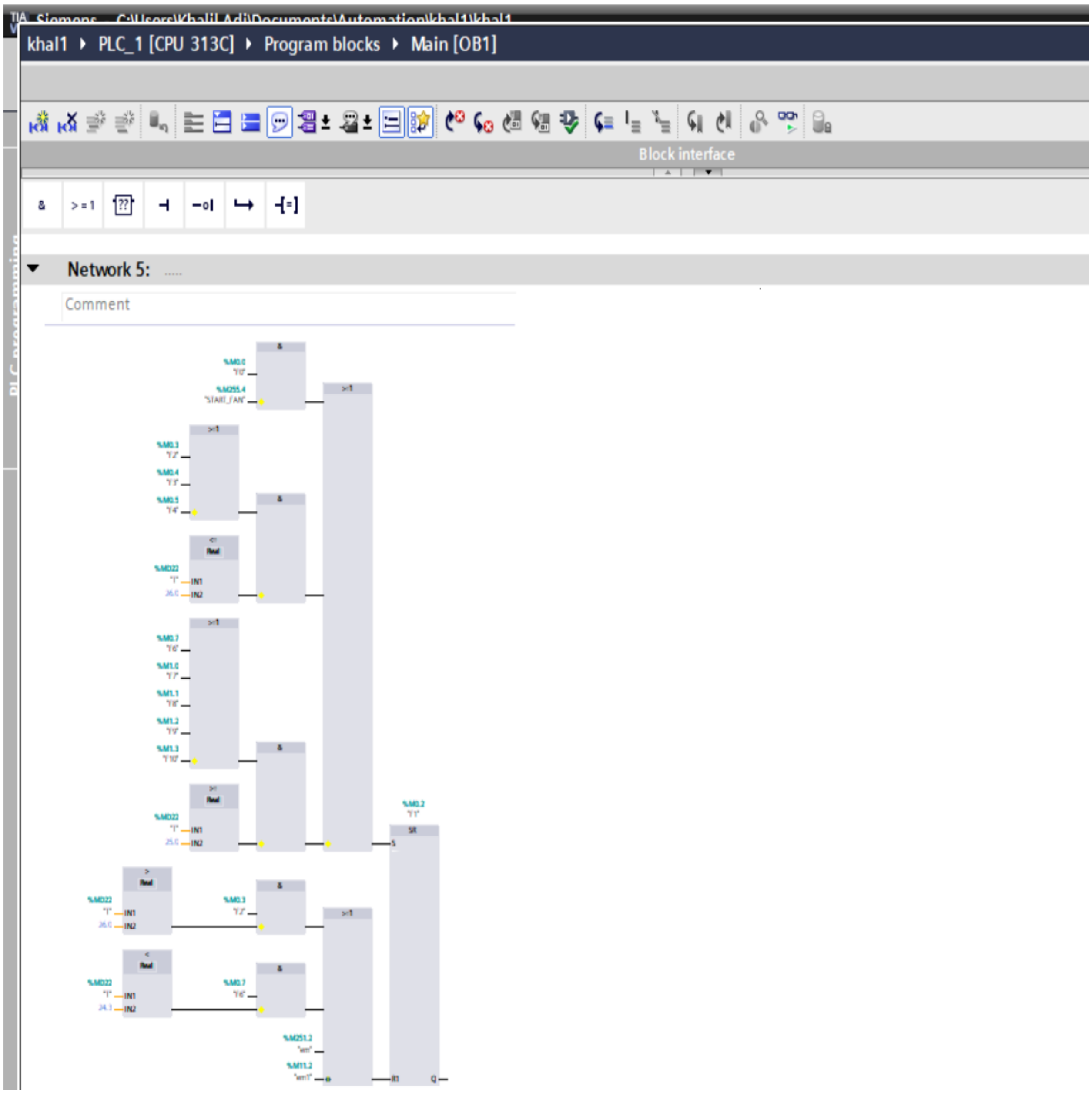
APPENDIX A

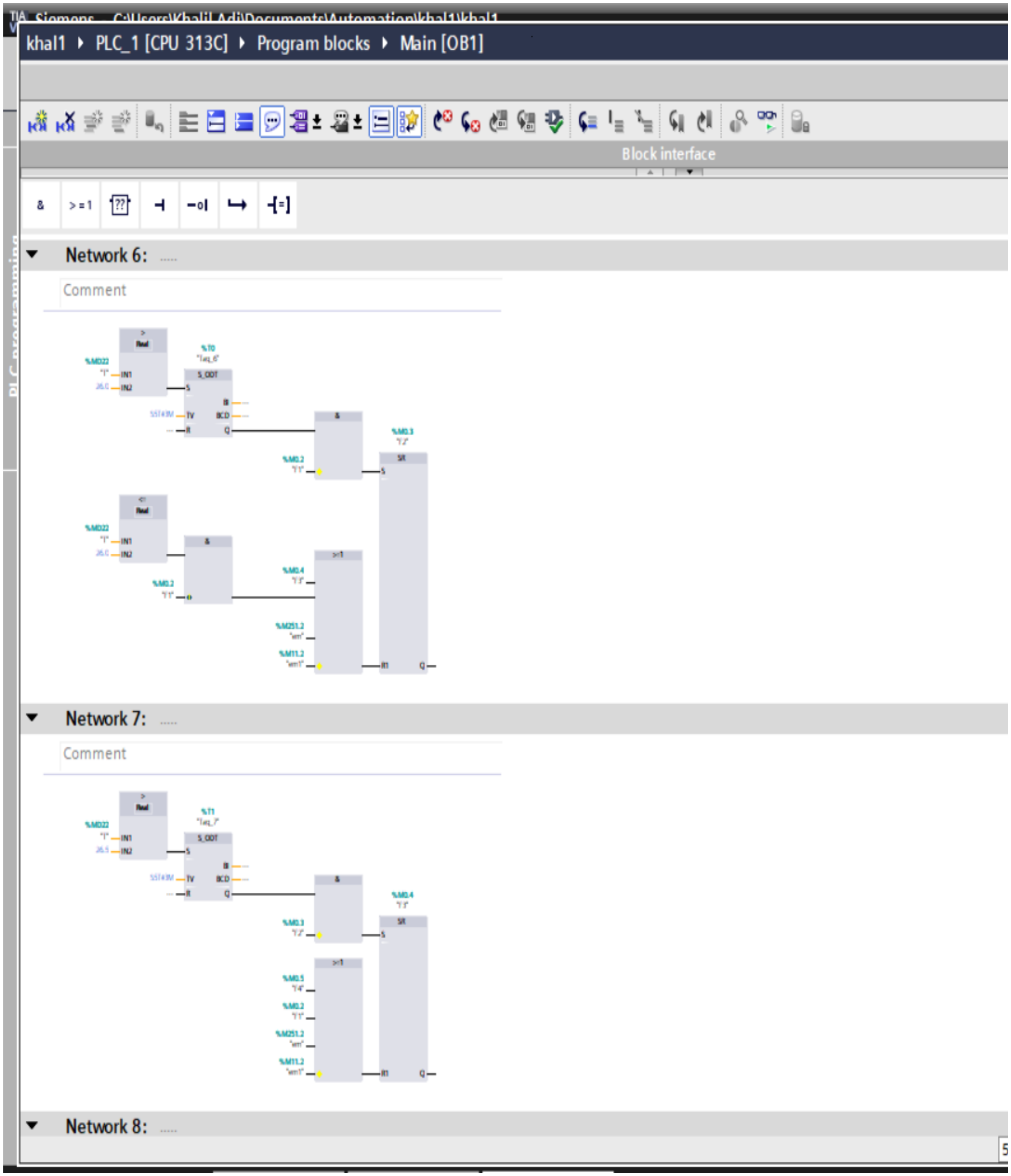
Programing structure



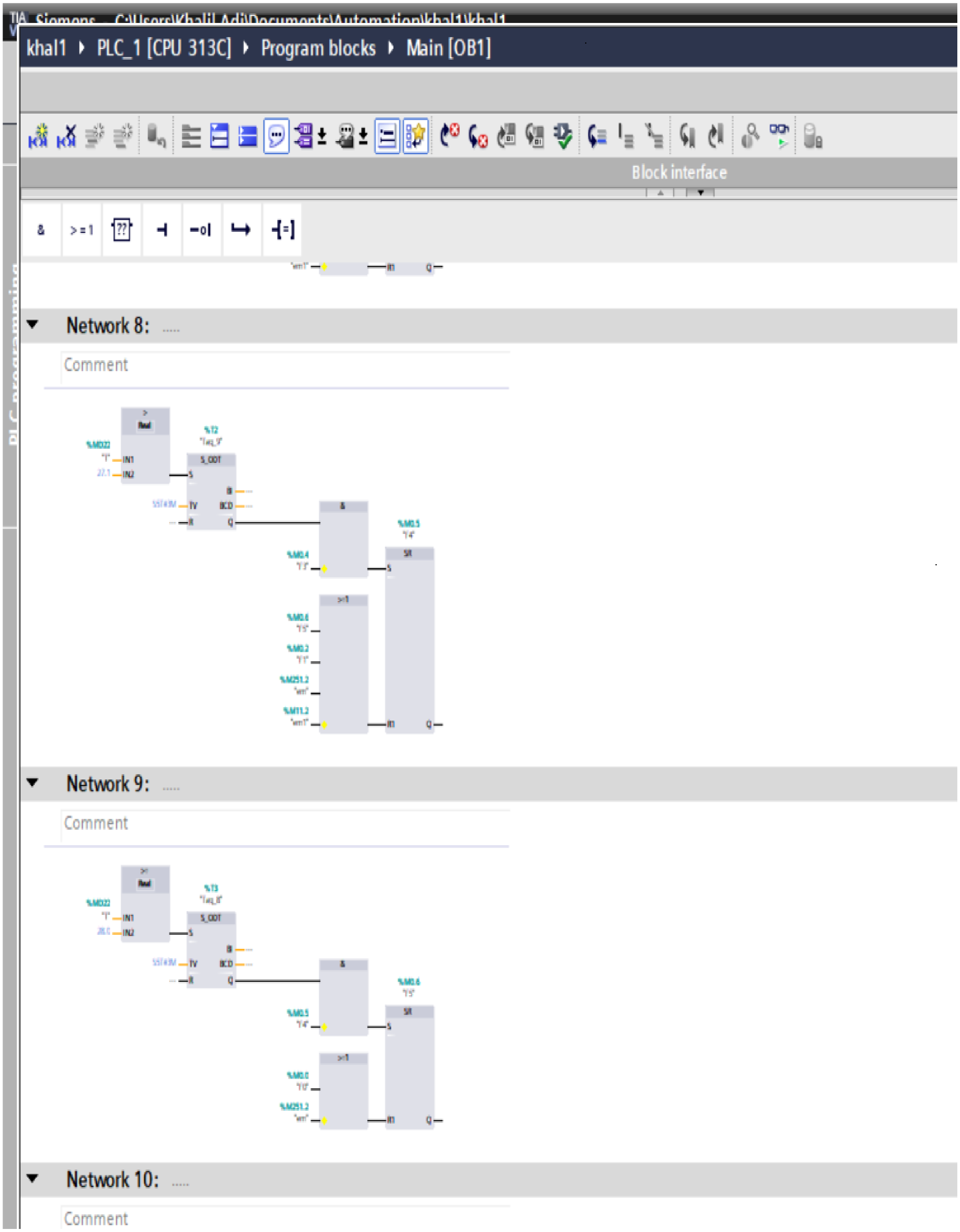

khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Block title: "Main Program Sweep (Cycle)"
Comment
Network 1: .....
Comment
SCALE
EN
%IW752
"sensorT"
IN
100.0
HI_LIM
0.0
LO_LIM
%M255.5
"Tag_1"
BIPOLAR
RET_VAL
%MW20
"Tag_2"
OUT
%MD22
"T"
ENO
Network 2: .....
Comment
SCALE
EN
%IW754
"sensorRH"
IN
100.0
HI_LIM
0.0
LO_LIM
%M255.5
"Tag_1"
BIPOLAR
RET_VAL
%MW26
"Tag_3"
OUT
%MD28
"RH"
ENO
Network 3: .....
Comment

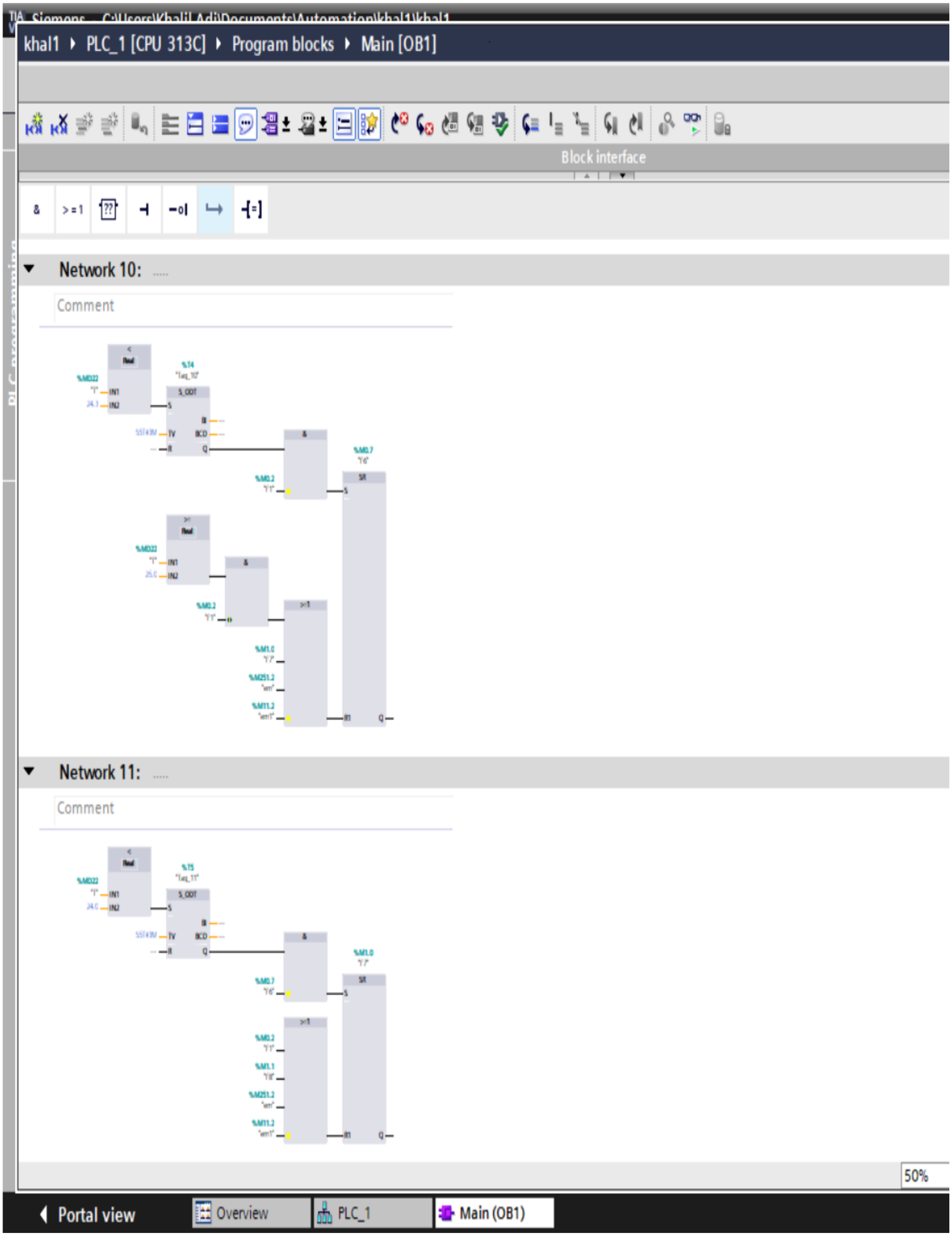

khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 3:
Comment
P_TRIG
%M255.0
"Tag_4"
CLK
Q
%M255.1
"Tag_5"
%M0.1
"s13"
=
Network 4:
Comment
>=1
%M0.6
"F5"
%M1.4
"F11"
&
%M255.3
"ACT"
>=1
%M0.1
"s13"
%M251.2
"em"
%M0.0
"F0"
SR
S
%M0.2
"F1"
R1
Q
Network 5:


khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 5:
Comment

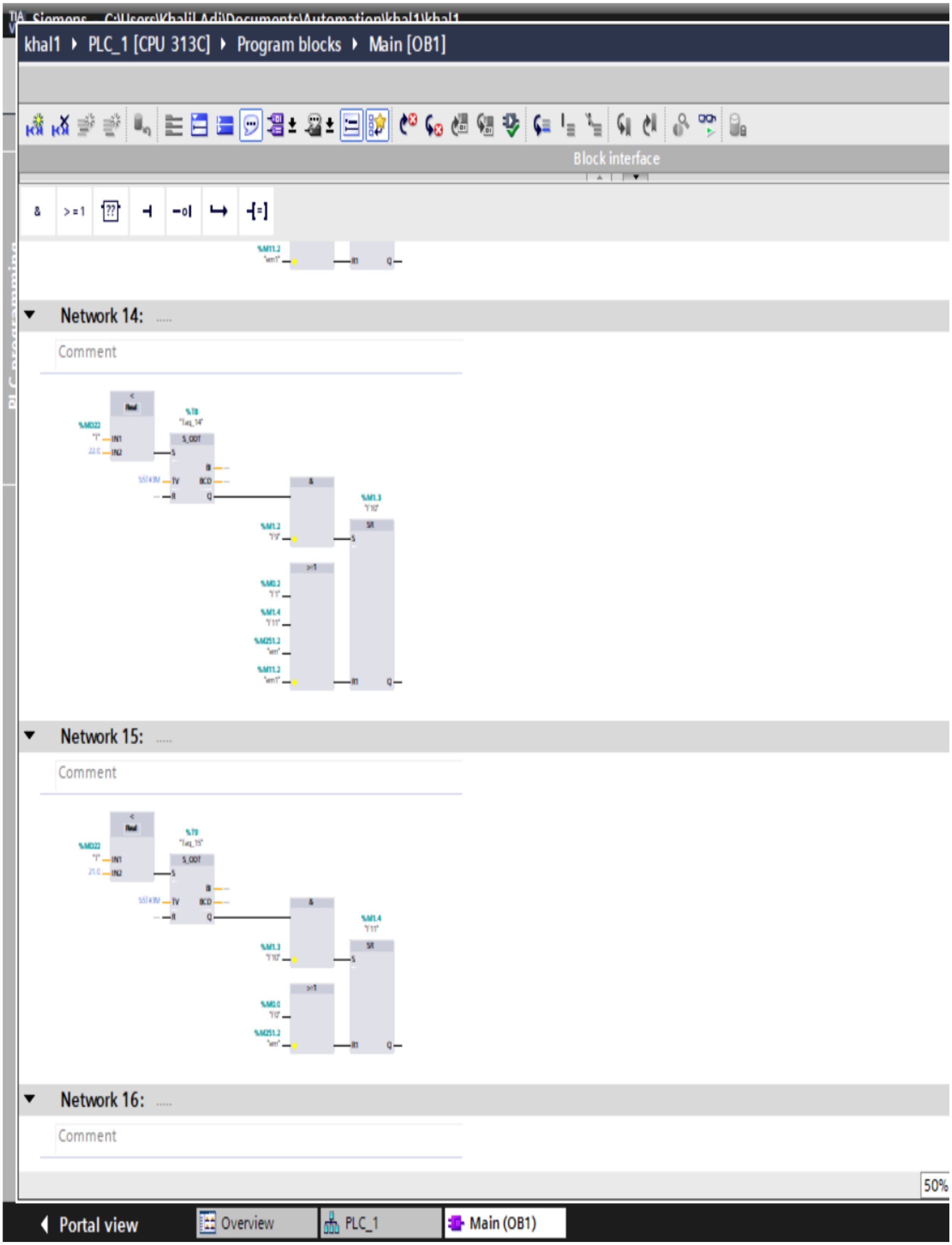


khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 6: .....
Comment
Network 7: .....
Comment
Network 8: .....

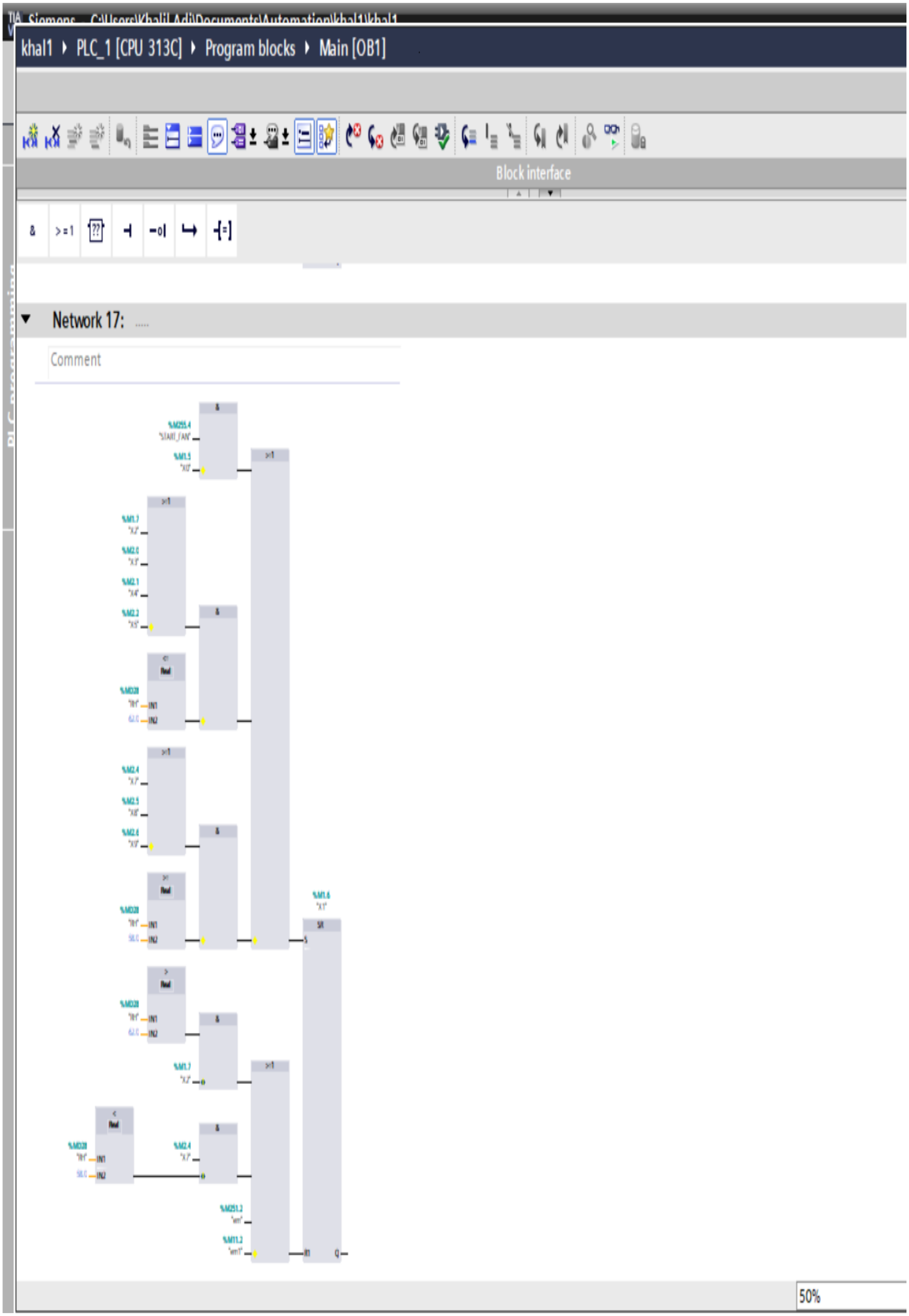

khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 8: .....
Comment
S_ODT
SR
Network 9: .....
Comment
S_ODT
SR
Network 10: .....
Comment


khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 10:
Comment
Network 11:
Comment
50%
Portal view
Overview
PLC_1
Main (OB1)

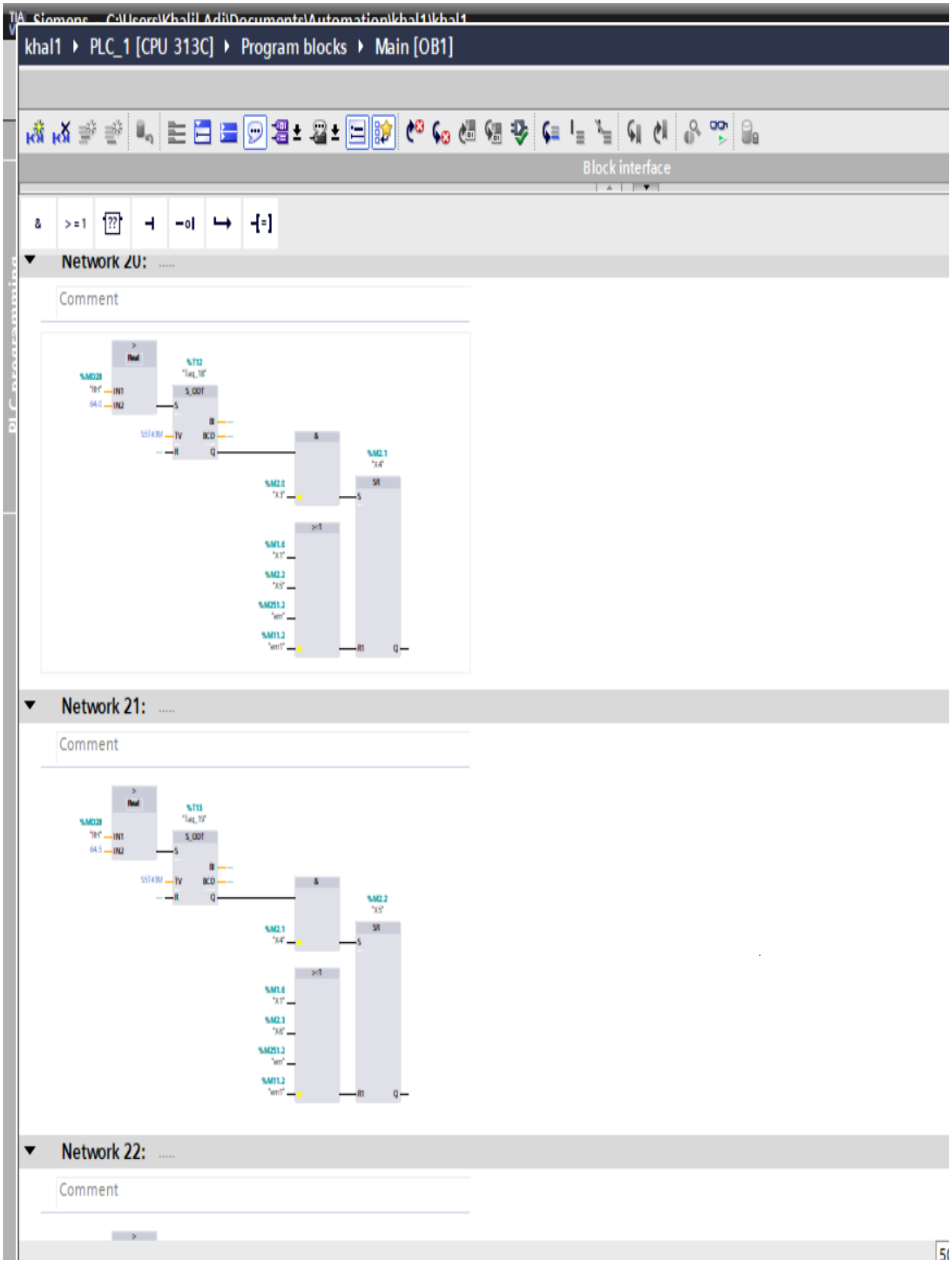

khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 12:
Comment
Network 13:
Comment
Network 14:
Comment
50%
Portal view
Overview
PLC_1
Main (OB1)

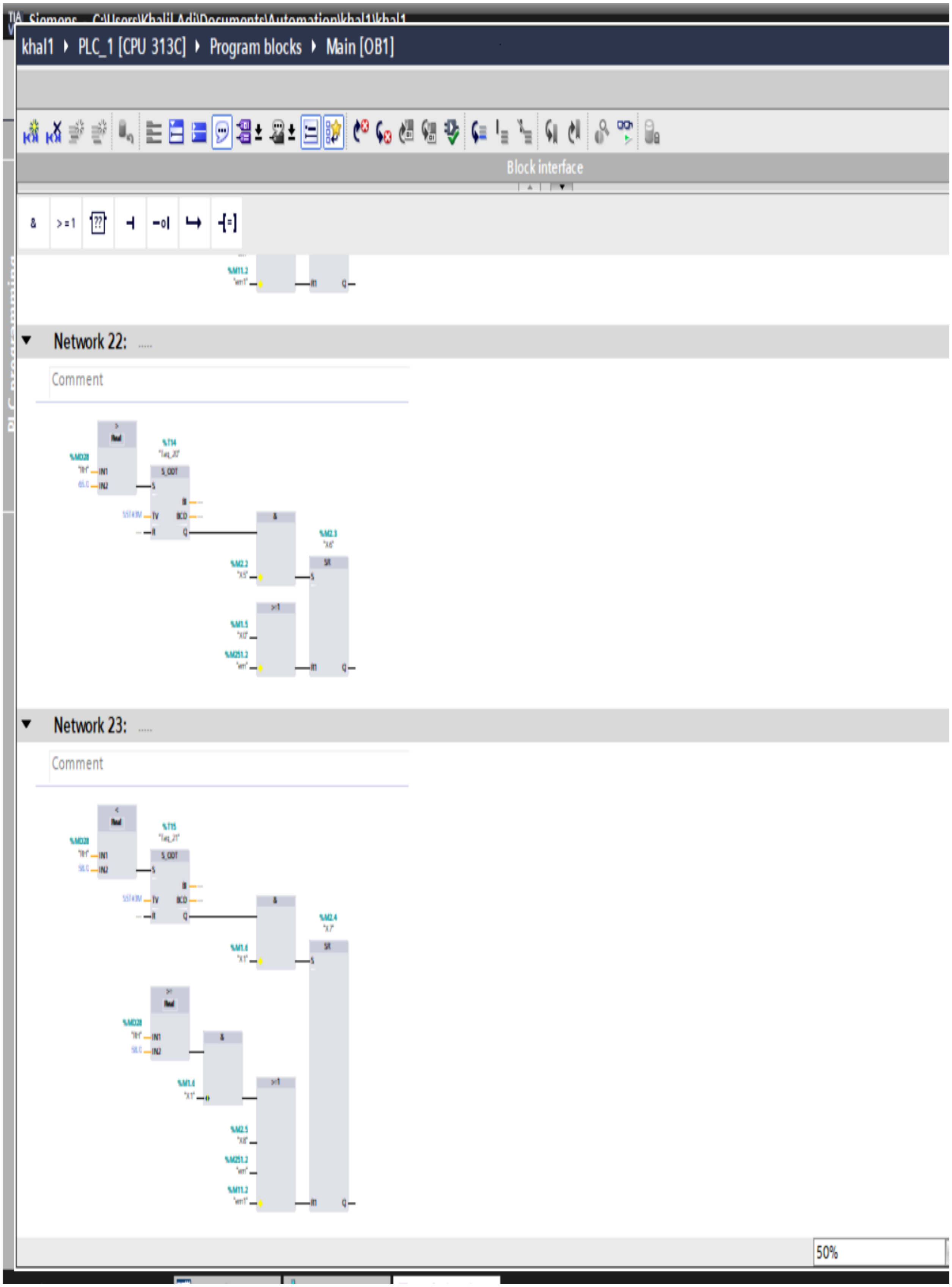

khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 14:
Comment
Network 15:
Comment
Network 16:
Comment
50%
Portal view
Overview
PLC_1
Main (OB1)

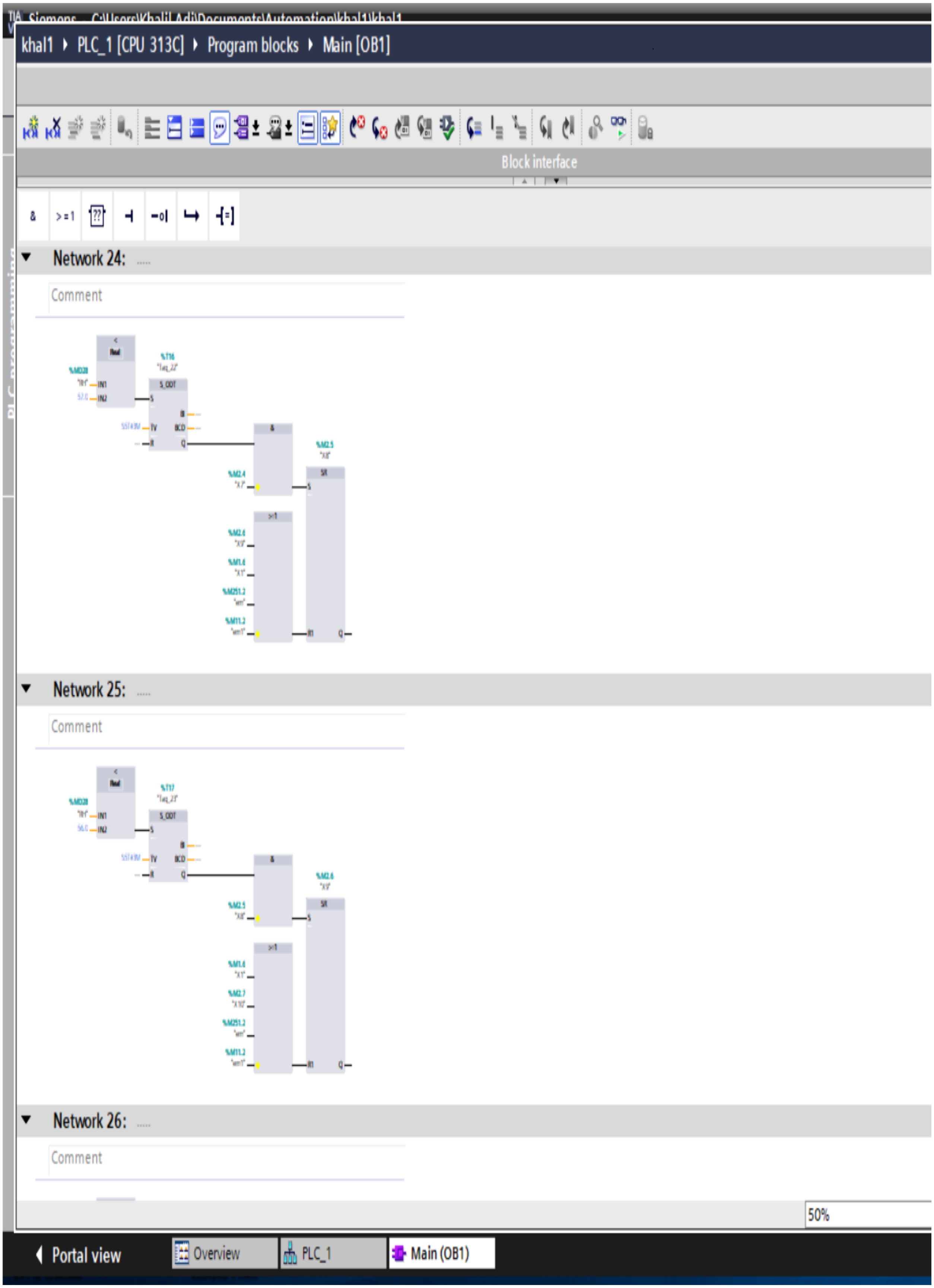
khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
"em"
R1
Q
Network 16:
Comment
%M2.3
"X6"
%M2.7
"X10"
%M255.3
"ACT"
%M0.1
"s13"
%M251.2
"em"
%M1.5
"X0"
SR
S
%M1.6
"X1"
R1
Q
Network 17:
Comment
%M255.4
"START_FAN"
%M1.5
"X0"
%M1.7
"X2"
%M2.0
"X3"
%M2.1
"X4"
80%
Portal view
Overview
PLC_1
Main (OB1)


khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 17:
Comment
50%

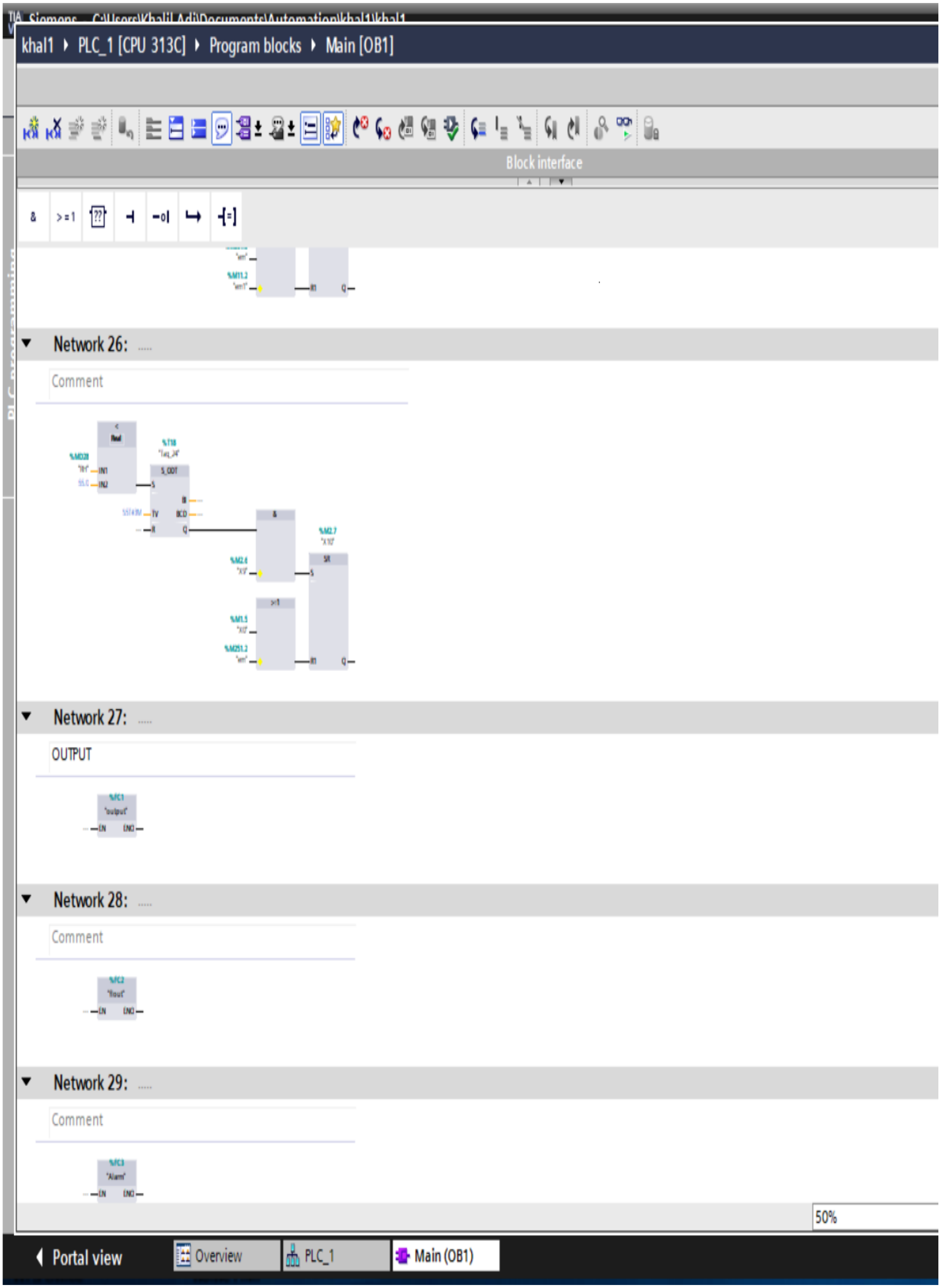

khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 18:
Comment
Network 19:
Comment
Portal view
Overview
PLC_1
Main (OB1)

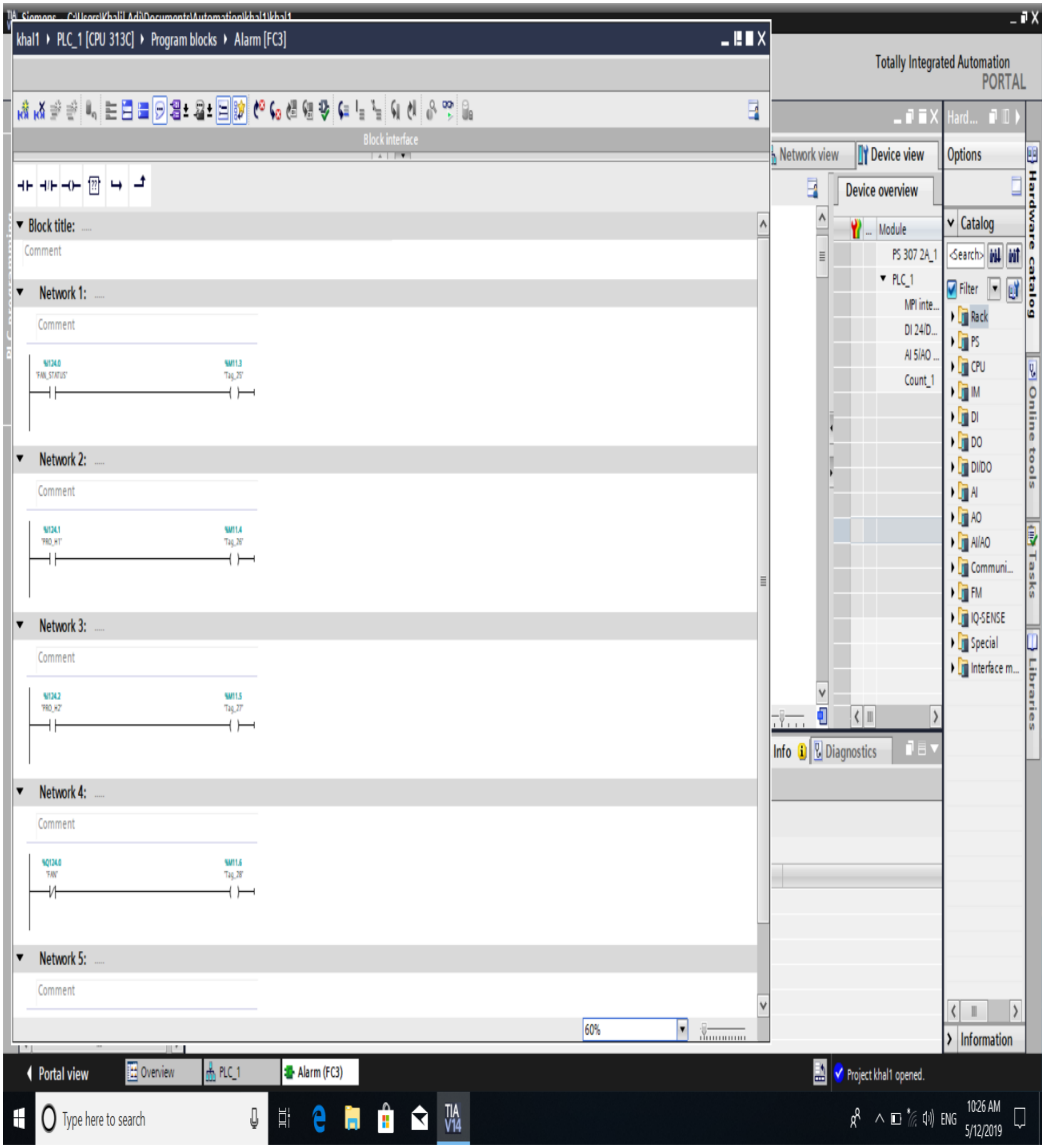

khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 20: .....
Comment
Network 21: .....
Comment
Network 22: .....
Comment

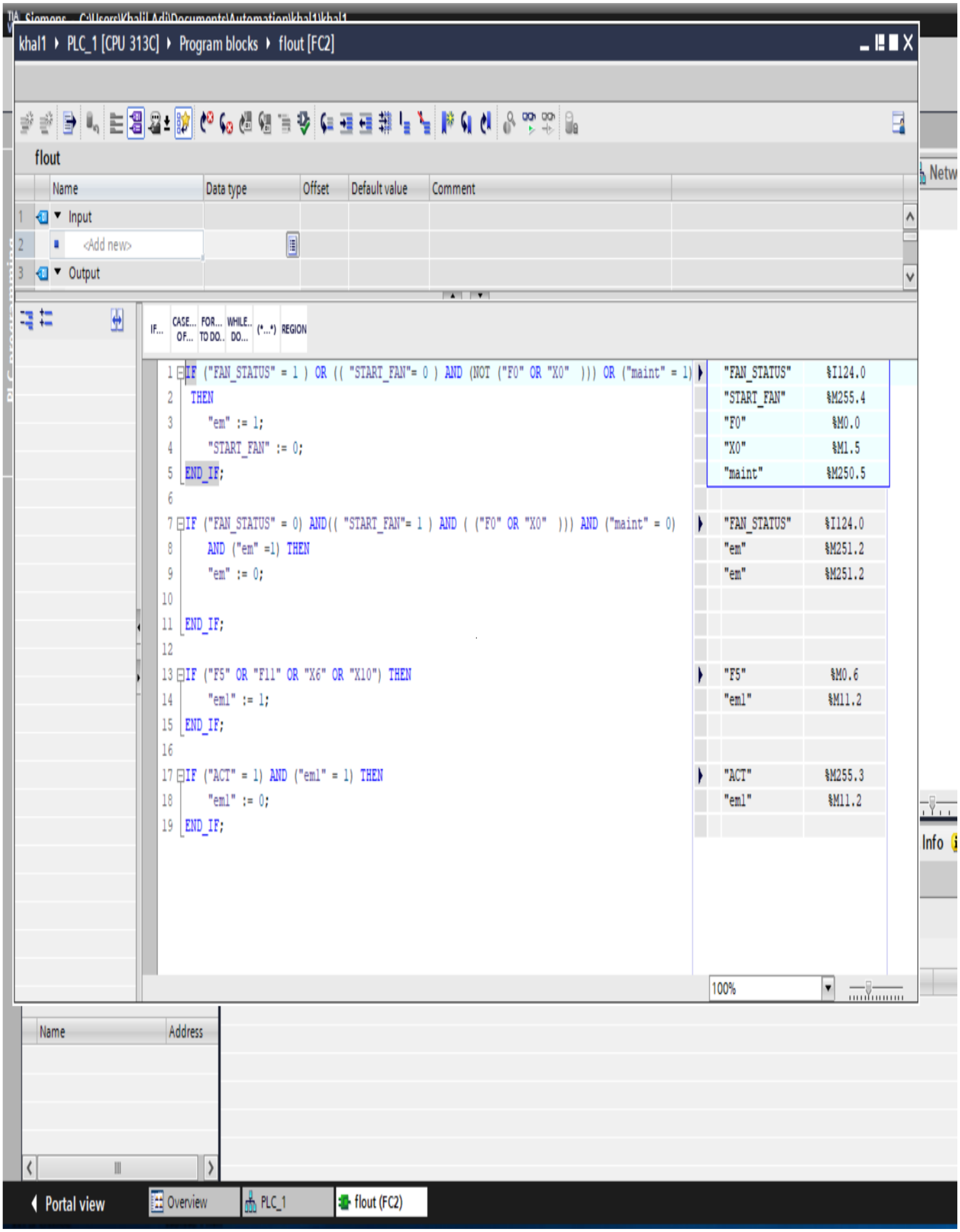

khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 22:
Comment
Network 23:
Comment
50%

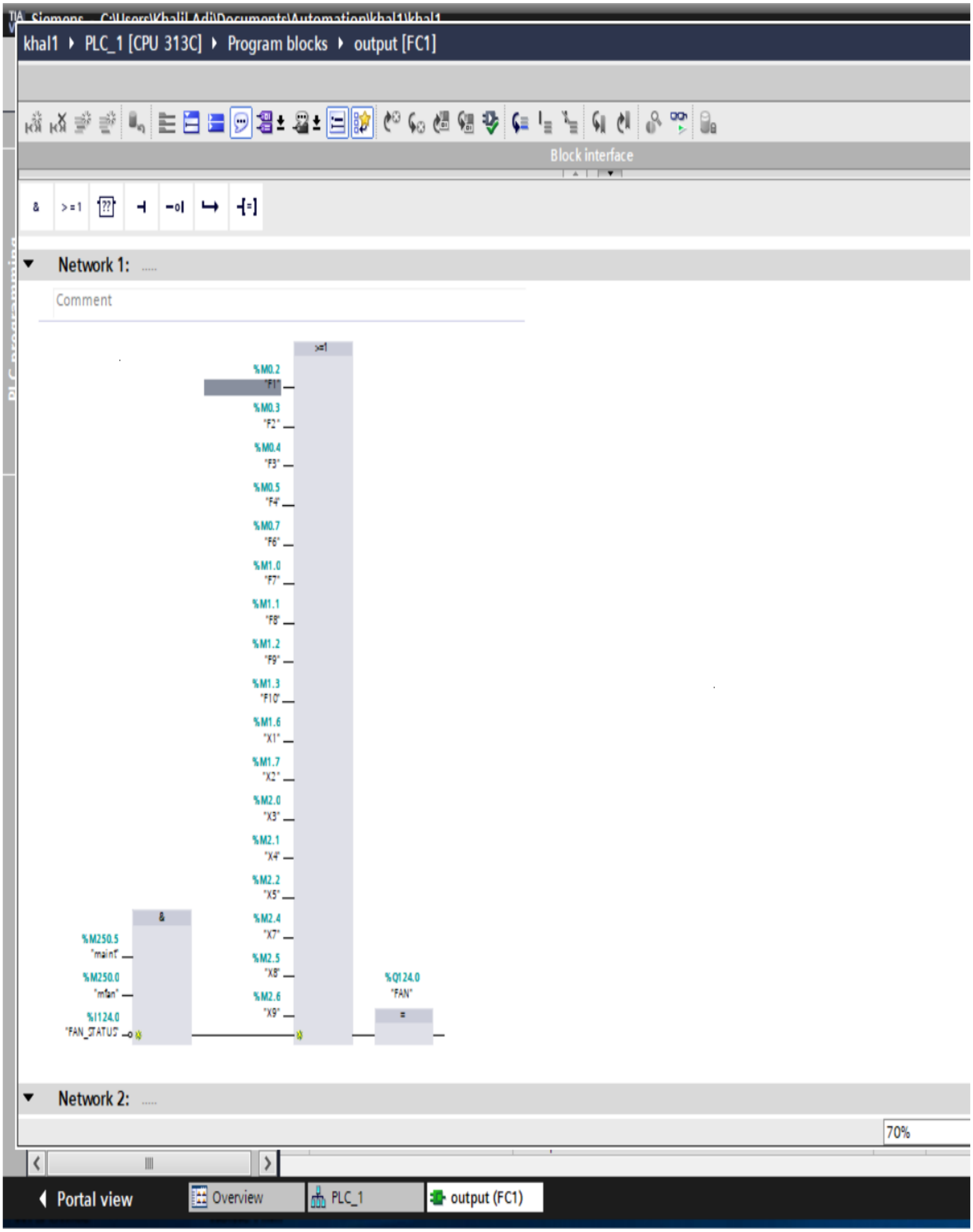


khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 24:
Comment
Network 25:
Comment
Network 26:
Comment
50%
Portal view
Overview
PLC_1
Main (OB1)


khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 26:
Comment
Network 27:
OUTPUT
Network 28:
Comment
Network 29:
Comment
50%
Portal view
Overview
PLC_1
Main (OB1)


khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ Alarm [FC3]
Totally Integrated Automation
PORTAL
Block interface
Block title:
Comment
Network 1:
Comment
Network 2:
Comment
Network 3:
Comment
Network 4:
Comment
Network 5:
Comment
60%
Network view
Device view
Device overview
Module
PS 307 2A_1
PLC_1
Count_1
Options
Catalog
Filter
Rack
PS
CPU
IM
DI
DO
DI/DO
AI
AO
AI/AO
Communi...
FM
IQ-SENSE
Special
Interface m...
Information
Info
Diagnostics
Hardware catalog
Online tools
Tasks
Libraries
Portal view
Overview
PLC_1
Alarm (FC3)
Project khal1 opened.
Type here to search
ENG
10:26 AM
5/12/2019


khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ flout [FC2]
flout
Name
Data type
Offset
Default value
Comment
Input
<Add new>
Output
IF...
CASE... OF...
FOR... TO DO...
WHILE... DO...
(*...*)
REGION
IF ("FAN_STATUS" = 1) OR (("START_FAN"= 0) AND (NOT ("F0" OR "X0"))) OR ("maint" = 1)
THEN
"em" := 1;
"START_FAN" := 0;
END_IF;
IF ("FAN_STATUS" = 0) AND(("START_FAN"= 1) AND (("F0" OR "X0"))) AND ("maint" = 0)
AND ("em" =1) THEN
"em" := 0;
END_IF;
IF ("F5" OR "F11" OR "X6" OR "X10") THEN
"em1" := 1;
END_IF;
IF ("ACT" = 1) AND ("em1" = 1) THEN
"em1" := 0;
END_IF;
"FAN_STATUS" %I124.0
"START_FAN" %M255.4
"F0" %M0.0
"X0" %M1.5
"maint" %M250.5
"FAN_STATUS" %I124.0
"em" %M251.2
"em" %M251.2
"F5" %M0.6
"em1" %M11.2
"ACT" %M255.3
"em1" %M11.2
100%
Name
Address
Portal view
Overview
PLC_1
flout (FC2)


khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ output [FC1]
Block interface
Network 1:
Comment
>=1
%M0.2 "F1"
%M0.3 "F2"
%M0.4 "F3"
%M0.5 "F4"
%M0.7 "F6"
%M1.0 "F7"
%M1.1 "F8"
%M1.2 "F9"
%M1.3 "F10"
%M1.6 "X1"
%M1.7 "X2"
%M2.0 "X3"
%M2.1 "X4"
%M2.2 "X5"
%M2.4 "X7"
%M2.5 "X8"
%M2.6 "X9"
&
%M250.5 "maint"
%M250.0 "mfan"
%I124.0 "FAN_STATUS"
%Q124.0 "FAN"
=
Network 2:
70%
Portal view
Overview
PLC_1
output (FC1)

khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ output [FC1]
Block interface
Comment
%M0.3 "F2"
%M0.4 "F3"
%M0.5 "F4"
%M1.7 "X2"
%M2.0 "X3"
%M2.1 "X4"
%M2.2 "X5"
%M250.5 "maint"
%M250.3
%Q124.1 "COOLER"
Network 3:
Comment
%M0.7 "F6"
%M1.0 "F7"
%M1.1 "F8"
%M1.2 "F9"
%M1.3 "F10"
%M250.5 "maint"
%M250.1
%Q124.2 "HEATER1"
%I124.1 "PRO_H1"
Network 4:
70%
Portal view
Overview
PLC_1
output (FC1)

khal1 ▸ PLC_1 [CPU 313C] ▸ Program blocks ▸ output [FC1]
Block interface
Network 4: .....
Comment
%M250.5 "main"
%M250.2 "mheater2"
%M1.0 "F7"
%M1.1 "F8"
%M1.2 "F9"
%M1.3 "F10"
%I124.2 "PRO_H2"
%Q124.3 "HEATER2"
Network 5: .....
Comment
%M250.5 "main"
%M250.4 "mvapor"
%M2.4 "X7"
%M2.5 "X8"
%M2.6 "X9"
%Q124.4 "VAPOR"
Network 6: .....
Comment
%M0.5
70%
Portal view
Overview
PLC_1
output (FC1)

APPENDIX B

SIMATIC S7-300, CPU 313C

Module #: 6ES7313-5BG04-0AB0

SIEMENS

Product data sheet 6ES7313-5BG04-0AB0

SIMATIC S7-300, CPU 313C,
COMPACT CPU WITH MPI, 24 DI/16 DO, 4AI,
2AO 1 PT100, 3 FAST COUNTERS (30 KHZ),
INTEGRATED 24V DC POWER SUPPLY,
128 KBYTE WORKING MEMORY,
FRONT CONNECTOR (2 X 40PIN) AND MICRO
MEMORY CARD REQUIRED

General information	
Hardware product version	01
Firmware version	V3.3
Engineering with	
Programming package	STEP 7 V5.5 + SP1 or higher or STEP 7 V5.3 + SP2 or higher with HSP 203
Supply voltage	
24 V DC	Yes
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
External protection for supply cables (recommendation)	Miniature circuit breaker, type C; min 2 A; miniature circuit breaker type B, min. 4 A
Mains buffering	
Mains/voltage failure stored energy time	5 ms
Repeat rate, min.	1 s
Digital inputs	

Load voltage L+	
Rated value (DC)	24 V
Reverse polarity protection	Yes
Digital outputs	
Load voltage L+	
Rated value (DC)	24 V
Reverse polarity protection	No
Input current	
Current consumption (rated value)	650 mA
Current consumption (in no-load operation), typ.	150 mA
Inrush current, typ.	5 A
I^2t	0.7 $A^2 \cdot s$
Digital inputs	
from load voltage L+ (without load), max.	80 mA
Digital outputs	
from load voltage L+, max.	50 mA
Power losses	
Power loss, typ.	12 W
Memory	
Work memory	
Integrated	128 kbyte
Expandable	No
Size of retentive memory for retentive data blocks	64 kbyte
Load memory	
pluggable (MMC)	Yes
pluggable (MMC), max.	8 Mbyte
Data management on MMC (after last programming), min.	10 a
Backup	
Present	Yes ; Guaranteed by MMC (maintenance-free)
without battery	Yes ; Program and data
CPU processing times	

for bit operations, min.	0.07 µs
for word operations, min.	0.15 µs
for fixed point arithmetic, min.	0.2 µs
for floating point arithmetic, min.	0.72 µs
CPU-blocks	
Number of blocks (total)	1024 ; (DBs, FCs, FBs); the maximum number of loadable blocks can be reduced by the MMC used.
DB	
Number, max.	1024 ; Number range: 1 to 16000
Size, max.	64 kbyte
FB	
Number, max.	1024 ; Number range: 0 to 7999
Size, max.	64 kbyte
FC	
Number, max.	1024 ; Number range: 0 to 7999
Size, max.	64 kbyte
OB	
Description	see instruction list
Size, max.	64 kbyte
Number of free cycle OBs	1 ; OB 1
Number of time alarm OBs	1 ; OB 10
Number of delay alarm OBs	2 ; OB 20, 21
Number of time interrupt OBs	4 ; OB 32, 33, 34, 35
Number of process alarm OBs	1 ; OB 40
Number of startup OBs	1 ; OB 100
Number of asynchronous error OBs	4 ; OB 80, 82, 85, 87
Number of synchronous error OBs	2 ; OB 121, 122
Nesting depth	
per priority class	16
additional within an error OB	4
Counters, timers and their retentivity	

S7 counter	
Number	256
Retentivity	
Adjustable	Yes
lower limit	0
upper limit	255
Preset	Z 0 to Z 7
Counting range	
lower limit	0
upper limit	999
IEC counter	
Present	Yes
Type	SFB
Number	Unlimited (limited only by RAM capacity)
S7 times	
Number	256
Retentivity	
Adjustable	Yes
lower limit	0
upper limit	255
Preset	No retentivity
Time range	
lower limit	10 ms
upper limit	9990 s
IEC timer	
Present	Yes
Type	SFB
Number	Unlimited (limited only by RAM capacity)
Data areas and their retentivity	
retentive data area, total	All, max. 64 KB
Flag	

Number, max.	256 byte
Retentivity available	Yes ; MB 0 to MB 255
Retentivity preset	MB 0 to MB 15
Number of clock memories	8 ; 1 memory byte
Data blocks	
Number, max.	1024 ; Number range: 1 to 16000
Size, max.	64 kbyte
Retentivity adjustable	Yes ; via non-retain property on DB
Retentivity preset	Yes
Local data	
per priority class, max.	32 kbyte ; Max. 2048 bytes per block
Address area	
I/O address area	
Inputs	1024 byte
Outputs	1024 byte
of which, distributed	
Inputs	None
Outputs	None
Process image	
Inputs	1024 byte
Outputs	1024 byte
Inputs, adjustable	1024 byte
Outputs, adjustable	1024 byte
Inputs, default	128 byte
Outputs, default	128 byte
Default addresses of the integrated channels	
Digital inputs	124.0 to 126.7
Digital outputs	124.0 to 125.7
Analog inputs	752 to 761
Analog outputs	752 to 755
Digital channels	

Inputs	1016
Outputs	1008
Inputs, of which central	1016
Outputs, of which central	1008
Analog channels	
Inputs	253
Outputs	250
Inputs, of which central	253
Outputs, of which central	250

APPENDIX C

SIMATIC HMI, KTP700 BASIC, BASIC PANEL

Module #: 6AV2123-2GA03-0AX0

SIEMENS

Data sheet 6AV2123-2GA03-0AX0

SIMATIC HMI, KTP700 Basic DP, Basic Panel, Key/touch operation, 7" TFT display, 65536 colors, PROFIBUS interface, configurable as of WinCC Basic V13/ STEP 7 Basic V13, contains open-source software, which is provided free of charge see enclosed CD

General information	
Product type designation	KTP700 Basic color DP

Display	
Design of display	TFT widescreen display, LED backlighting
Screen diagonal	7 in
Display width	154.1 mm
Display height	85.9 mm
Number of colors	65 536
Resolution (pixels)	
• Horizontal image resolution	800 Pixel
• Vertical image resolution	480 Pixel
Backlighting	
• MTBF backlighting (at 25 °C)	20 000 h
• Backlight dimmable	Yes

Control elements	
Keyboard fonts	
• Function keys	
— Number of function keys	8

• Keys with LED	No
• System keys	No
• Numeric keyboard	Yes; Onscreen keyboard
• alphanumeric keyboard	Yes; Onscreen keyboard
Touch operation	
• Design as touch screen	Yes
Installation type/mounting	
Mounting position	vertical
Mounting in portrait format possible	Yes
Mounting in landscape format possible	Yes
maximum permissible angle of inclination without external ventilation	35°
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Input current	
Current consumption (rated value)	230 mA
Starting current inrush I^2t	0.2 $A^2 \cdot s$
Power	
Active power input, typ.	5.5 W
Processor	
Processor type	ARM
Memory	
Flash	Yes
RAM	Yes
Memory available for user data	10 Mbyte
Type of output	
Acoustics	
• Buzzer	Yes
• Speaker	No
Time of day	
Clock	
• Hardware clock (real-time)	Yes
• Software clock	Yes
• retentive	Yes; Back-up duration typically 6 weeks
• synchronizable	Yes
Interfaces	

Number of industrial Ethernet interfaces	0
Number of RS 485 interfaces	1
Number of RS 422 interfaces	1; together with RS 485
Number of RS 232 interfaces	0; with optional adapter
Number of USB interfaces	1; Up to 16 GB
Number of 20 mA interfaces (TTY)	0
Number of parallel interfaces	0
Number of other interfaces	0
Number of SD card slots	0
With software interfaces	No
Industrial Ethernet	
• Industrial Ethernet status LED	0
Protocols	
PROFINET	No
Supports protocol for PROFINET IO	No
IRT	No
PROFIBUS	Yes
MPI	Yes
Protocols (Ethernet)	
• TCP/IP	No
• DHCP	No
• SNMP	No
• DCP	No
• LLDP	No
WEB characteristics	
• HTTP	No
• HTML	No
Redundancy mode	
• MRP	No
Further protocols	
• CAN	No
• EtherNet/IP	No
• MODBUS	Yes; Modicon (MODBUS RTU)
Interrupts/diagnostics/status information	
Diagnostic messages	
• Diagnostic information readable	No
EMC	
Emission of radio interference acc. to EN 55 011	
• Limit class A, for use in industrial areas	Yes
• Limit class B, for use in residential areas	No
Degree and class of protection	

IP (at the front)	IP65
Enclosure Type 4 at the front	Yes
Enclosure Type 4x at the front	Yes
IP (rear)	IP20

Standards, approvals, certificates	
CE mark	Yes
cULus	Yes
RCM (formerly C-TICK)	Yes
KC approval	Yes
Use in hazardous areas	
• ATEX Zone 2	No
• ATEX Zone 22	No
• IECEx Zone 2	No
• IECEx Zone 22	No
• cULus Class I Zone 1	No
• cULus Class I Zone 2, Division 2	No
• FM Class I Division 2	No
Marine approval	
• Germanischer Lloyd (GL)	Yes
• American Bureau of Shipping (ABS)	Yes
• Bureau Veritas (BV)	Yes
• Det Norske Veritas (DNV)	Yes
• Lloyds Register of Shipping (LRS)	Yes
• Nippon Kaiji Kyokai (Class NK)	Yes
• Polski Rejestr Statkow (PRS)	No
• Chinese Classification Society (CCS)	No

Ambient conditions	
Suited for indoor use	Yes
Suited for outdoor use	No
Ambient temperature during operation	
• Operation (vertical installation)	
— For vertical installation, min.	0 °C
— For vertical installation, max.	50 °C
• Operation (max. tilt angle)	
— At maximum tilt angle, min.	0 °C
— At maximum tilt angle, min.	40 °C
• Operation (vertical installation, portrait format)	
— For vertical installation, min.	0 °C
— For vertical installation, max.	40 °C
• Operation (max. tilt angle, portrait format)	
— At maximum tilt angle, min.	0 °C

— At maximum tilt angle, min.	35 °C
Ambient temperature during storage/transportation	
• min.	-20 °C
• max.	60 °C
Relative humidity	
• Operation, max.	90 %; no condensation

Operating systems

proprietary	Yes
pre-installed operating system	
• Windows CE	No

Configuration

Message indicator	Yes
Alarm system (incl. buffer and acknowledgment)	Yes
Process value display (output)	Yes
Process value default (input) possible	Yes
Recipe management	Yes
Configuration software	
• STEP 7 Basic (TIA Portal)	Yes; via integrated WinCC Basic (TIA Portal)
• STEP 7 Professional (TIA Portal)	Yes; via integrated WinCC Basic (TIA Portal)
• WinCC flexible Compact	No
• WinCC flexible Standard	No
• WinCC flexible Advanced	No
• WinCC Basic (TIA Portal)	Yes
• WinCC Comfort (TIA Portal)	Yes
• WinCC Advanced (TIA Portal)	Yes
• WinCC Professional (TIA Portal)	Yes

Languages

Online languages	
• Number of online/runtime languages	10
Project languages	
• Languages per project	32

Functionality under WinCC (TIA Portal)

Libraries	Yes
Applications/options	
• Web browser	No
• SIMATIC WinCC Sm@rtServer	No
Number of Visual Basic Scripts	No
Task planner	Yes
• time-controlled	No
• task-controlled	Yes
Help system	Yes

• Number of characters per info text	500
Message system	
• Number of alarm classes	32
• Bit messages	
— Number of bit messages	1 000
• Analog messages	
— Number of analog messages	25
• S7 alarm number procedure	No
• System messages HMI	Yes
• System messages, other (SIMATIC S7, Sinumerik, Simotion, etc.)	Yes; System message buffer of the SIMATIC S7-1200 and S7-1500
• Number of characters per message	80
• Number of process values per message	8
• Acknowledgment groups	Yes
• Message indicator	Yes
• Message buffer	
— Number of entries	256
— Circulating buffer	Yes
— retentive	Yes
— maintenance-free	Yes
Recipe management	
• Number of recipes	50
• Data records per recipe	100
• Entries per data record	100
• Size of internal recipe memory	256 kbyte
• Recipe memory expandable	No
Variables	
• Number of variables per device	800
• Number of variables per screen	100
• Limit values	Yes
• Multiplexing	Yes
• Structures	No
• Arrays	Yes
Images	
• Number of configurable images	250
• Permanent window/default	Yes
• Global image	Yes
• Pop-up images	No
• Slide-in images	No
• Image selection by PLC	Yes
• Image number in the PLC	Yes

Image objects	
• Number of objects per image	100
• Text fields	Yes
• I/O fields	Yes
• Graphic I/O fields (graphics list)	Yes
• Symbolic I/O fields (text list)	Yes
• Date/time fields	Yes
• Switches	Yes
• Buttons	Yes
• Graphic display	Yes
• Icons	Yes
• Geometric objects	Yes
Complex image objects	
• Number of complex objects per screen	10
• Alarm view	Yes
• Trend view	Yes
• User view	Yes
• Status/control	No
• Sm@rtClient view	No
• Recipe view	Yes
• f(x) trend view	No
• System diagnostics view	Yes; System message buffer of the SIMATIC S7-1200 and S7-1500
• Media Player	No
• HTML browser	No
• PDF display	No
• IP camera display	No
• Bar graphs	Yes
• Sliders	No
• Pointer instruments	No
• Analog/digital clock	No
Lists	
• Number of text lists per project	300
• Number of entries per text list	100
• Number of graphics lists per project	100
• Number of entries per graphics list	100
Archiving	
• Number of archives per device	2; One message and one process value archive
• Number of entries per archive	10 000
• Message archive	Yes
• Process value archive	Yes

• Archiving methods	
— Sequential archive	Yes
— Short-term archive	Yes
• Memory location	
— Memory card	No
— USB memory	Yes
— Ethernet	No
• Data storage format	
— CSV	No
— TXT	Yes
— RDB	No
Security	
• Number of user groups	50
• Number of user rights	32
• Number of users	50
• Password export/import	Yes
• SIMATIC Logon	No
Character sets	
• Keyboard fonts	
— US English	Yes
Transfer (upload/download)	
• MPI/PROFIBUS DP	Yes
• USB	No
• Ethernet	No
• using external storage medium	Yes
Process coupling	
• S7-1200	Yes
• S7-1500	Yes
• S7-200	Yes
• S7-300/400	Yes
• LOGO!	Yes
• WinAC	Yes
• SINUMERIK	Yes; No access to NCK data
• SIMOTION	Yes
• Allen Bradley (EtherNet/IP)	No
• Allen Bradley (DF1)	Yes
• Mitsubishi (MC TCP/IP)	No
• Mitsubishi (FX)	Yes
• OMRON (FINS TCP)	No
• OMRON (LINK/Multilink)	Yes
• Modicon (Modbus TCP/IP)	No

• Modicon (Modbus)	Yes
Service tools/configuration aids	
• Backup/Restore manually	Yes
• Backup/Restore automatically	No
• Simulation	Yes
• Device switchover	Yes

Peripherals/Options

Peripherals	
• Printer	No
• SIMATIC HMI MM memory card: Multi Media Card	No
• SIMATIC HMI SD memory card: Secure Digital memory card	No
• SIMATIC HMI CF memory card Compact Flash Card	No
• USB memory	Yes
• SIMATIC IPC USB Flashdrive (USB stick)	Yes
• SIMATIC HMI USB stick	Yes

Mechanics/material

Enclosure material (front)	
• Plastic	Yes
• Aluminum	No
• Stainless steel	No

Dimensions

Width of the housing front	214 mm
Height of housing front	158 mm
Mounting cutout, width	197 mm
Mounting cutout, height	141 mm
Overall depth	39 mm

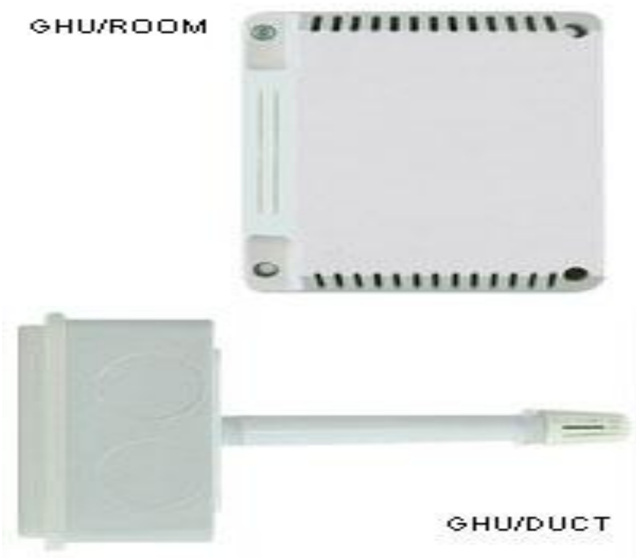
Weights

Weight without packaging	800 g
Weight incl. packaging	1 kg

last modified: 05/04/2019

APPENDIX D

GHU ROOM - DUCT Sensor



GHU Room/Duct Sensor

General purpose stand-alone humidity and temperature sensor for room or duct.

The GHU Room or Duct sensors are general purpose, all-in-one™ sensors for both temperature and humidity.
Humidity measurement is given as a proportional output, 0-10VDC while temperature reading may be given in one of two ways:

1. Normally via a thermistor (for controllers that do not offer 0-10VDC temperature inputs- temperature sensor used must be Meitav-tec type)
2. As a proportional signal (0-10VDC)

With wide temperature and humidity ranges, the GHU Room / Duct sensors are practical and ideal solutions for all room and duct applications.

Features

- Main Supply – 24VAC or 12VDC
- Proportional temperature output- 0-10VDC
- Proportional humidity output- 0-10VDC
- Temperature set point range from 0°C-60°C / 32°F-140°F (0-10VDC)
- Humidity set point range from 15%-90% RH (0-10VDC)

Wiring Diagram