Sudan University of Science and Technology

College of Graduate Studies

Use of SCADA system for remote monitoring of Khartoum state water corporation

استخدام نظام اسكادا للمراقبة عن بعد لهيئة مياه ولاية الخرطوم

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of M.Sc. in Mechatronics Engineering

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الآية

الرَّحْمَنُ ﴿1﴾ عَلَّم الْقُرْآنَ ﴿2﴾

خَلَقَ الْإِنسَانَ ﴿3﴾ عَلَّمَهُ الْبَيَانَ ﴿4﴾

صدق الله العظيم

(سورة الرحمن)

DEDICATION

This work is dedicated to
My parents

ACKNOWLEDGEMENT

I would like to thank all my parents, my brother, my sisters and my friends. Special thanks are due to my Supervisor, Dr.ALAAELDEEN AWOUDA, zeta automation systems training center and all persons who supported me in preparing this research.

ABSTRACT

The Supervisory Control and Data Acquisition (SCADA) system monitors and controls many applications such as:

(Water distribution network including water reticulation,pump stations ,Public utilities, including electrical power generation, oil and gas pipelines, and water and sewage treatment plants).

The SCADA system provide reliable and efficient water supply services across (enabling us to monitor and control the entire network from one location, saving time and resources and Minimizing risk of human error).

The main objective of this research to design SCADA system for remote monitoring of Khartoum state water corporation and collecting data from soba station.

الملخص

تستخدم انظمة مراقبة التحكم ونظام اكتساب البيانات في العديد من التطبيقات على سبيل المثال

(شبكة مضخات المياه متضمنة مد شبكات المياه ومجطات الضخ وفي المرافق العامة مثلا في محطات توليد الكهرباء وحقول النفط والغاز و محطات معالجة المياه والصرف الصحي).

وتعمل انظمة مراقبة التحكم ونظام اكتساب البيانات بموثوقية وفعالية عالية في امداد المياه والصرف الصحي اذ تقوم ب(تمكننا من رصد ومراقبة الشبكة بالكامل من مكان واحد و توفير الوقت والموارد وتقليل احتمالات الخطأ البشري).

الهدف الرئيس من هذا البحث هو تصميم انظمة مراقبة التحكم ونظام اكتساب البيانات لرئاسة هيئة مياه ولاية الخرطوم للحصول على البيانات من محطة سوبا.

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List of Abbreviation

SCADA	Supervisory Control and Data Acquisition	1
KSWC	Khartoum State Water Corporation	1
PLC	Programmable logic Controllers	2
DSL	Digital Subscriber Line	2
WINCC	Windows Control Center	2
SINAUT	Siemens Network Automation	2
CPU	Central Processing Unit	6
LAD	Ladder Diagrams	8
IL	Instruction List	8
FBD	Function Block Diagram	8
ST	Structured Text	8
SFC	Sequential Function Charts	8
SQL	Structured Query Language	10
MTU	Master Terminal Unit	11
HMI	Human-Machine Interface	11
MTU	Master Terminal Unit	11
I/O	INPUT/OUTPUT	12
ST7cc	Step 7 Control Center	13
GPRS	General Packet Radio Service	13
MSC	Micro Switching Centre	15
TIM	Telecontrol Interface Module	16
WAN	Wide Area Network	16
PC	Personal Computer	16

S7-300	STEP 7 300	16
S7-400	STEP 7 400	16
LAN	Local Wide Area Network	18

CHAPTER ONE
INTRODUCTION

1.1 Overview:

The Supervisory Control and Data Acquisition (SCADA)system monitors and controls many industrial applications such as:

1. water distribution network including water reticulation and pump stations
2. sewage collection and treatment network
3. Gathering real-time data, monitoring equipment and controlling processes in industrial facilities.
4. Public utilities, including chemical plants, electrical power generation, oil and gas pipelines, and water and sewage treatment plants.

The SCADA system is critical to provide reliable and efficient water supply and sewage treatment services across an area of more than 5700 square kilo meters, by:

- enabling us to monitor and control the entire network from one location
- saving time and resources
- Minimizing risk of human error.

The control center had been configured for authorized users at Khartoum state water corporation (KSWC) center, for remote monitoring of water plant, communications, and system diagnostics. The WINCC software also provides real-time information on reservoirs water level, flow values, water pressure and other mission-critical data, as well as reporting. The main station is Soba water treatment pumps station.The customer wanted a user-friendly system, with advanced and reliable communication. They also needed a system that could issue targeted urgent alerts, as well as on-demand summary reports of system activity the solution, with total system monitor, can be expanded and modified to meet changing of Khartoum state water corporation needs.

1.2 Problem Statement:

Problem of this research no data exchange between the center of Khartoum state water corporation (KSWC)and soba station. The Khartoum state water corporationfinds problems in obtaining information from the Soba station it is difficult to check daily reports,status and know theimportant data in soba station (output flow rate, PH, output pressure, TUR and……….. etc.).

1.3Proposed Solution:

Design and implement a remote monitoring center for Khartoum state Water Corporation with SOBA water treatment pumps stationto Logging of all data and statuses and to know all data in soba station (output flow rate, PH, output pressure and ……. etc.). This research will depend on software program (WINCC and SINAUT ST7cc) to solve the main problem.

1.4Research Objectives:

The main objective of this research design SCADA systemWINCC and SINAUT ST7cc for remote monitoring of Khartoum state Water Corporationto achieve of this objective:

- Proposed control system using PLC.
- Proposed monitoring system using SCADA WINCC.
- Proposed communication media DSL.
- Simulation practices and implementation.

1.5 Scope

Collecting data from soba station to Khartoum state Water Corporation (KSWC)usingSINAUT ST7cc and WINCC.

1.6Methodology

The methodology is: -

- ✓ Configuration of SIMATIC ST7.
- ✓ Setting up WINCC then configuration.
- ✓ Installing the system hardware DSL router in the center.
- ✓ Setting up SINAUT ST7cc then configuration.

1.7Thesis Layout

This thesis consists of five chapters:

Chapter Onegives an introduction,and problem statement. It also presents the objectives and methodology of this study.

Chapter Two Theoretical backgroundofPLC, SCADA system, DSL and SINAUT ST7cc

Chapter three deals with the design and Implementation system. It gives the simulation of collecting data from soba station to the center of Khartoum state Water Corporation using PLC, SCADA WINCC and SINAUT ST7cc.

Chapter fourthe resultsand discussion

Chapter fiveconclusions and recommendations.

CHAPTER TWO

THEORETICAL BACKGROUND

2.1 previous studiesof SCADA systems: -

- In 2010 Mr.binqin and mr.dongyan were designed remote SCADA system of secondary pressurization pump station uses a PLC controller, through the friendly human machine interface to control and monitor. The designed system shows that the control system has high degree of automation, and stable and reliable performance, largely reducing the acquisition time and meeting the control requirements [1], [2].
- In 2012 mr.xin ma was designed the SCADA system for longnan water corporation it is include (master terminal unit (MTU)-communication system (CS)-two class dispatch center and RTU and the SCADA designed based on Ethernet. [3], [4].
- In 2014 mr. Adrian Korodi, and mr.IoanSilea were designed Specifying and Tendering of Automation and SCADA Systems: Case Study for Waste Water Treatment Plants providing a set of information that has to be contained by an adequate technical documentation for automation and SCADA works. [5], [6]
- in 2010 mr. Amir Firoozshahi was designed Intelligent and Innovative Monitoring of Water Treatment Plant in Large Gas Refinery the Monitoring System has been successfully designed, installed, commissioned and started up. All features accessed. Operators are working by this system easily and satisfied. [7], [8]

2.2 Programmable Logic Controllers (PLC)

Programmable logic controllers, also called programmable controllers orPLCs, are solid-state members of the computer family, using integratedcircuits instead of electromechanical devices to implement control functions.They are capable of storing instructions, such as sequencing, timing,counting, arithmetic, data manipulation, and communication, to controlindustrial machines and processes.

Programmable controllers have many definitions. However, PLCs can be thought of in simple terms as industrial computers with specially designed architecture in both their central units (the PLC itself) and their interfacing circuitry to field devices (input/output connections to the real world).

PLCs have the great advantage that the same basic controller can be used with a wide range of control systems. To modify a control system and the rules that are to be used, all that is necessary is for an operator to key in a different set of instructions. There is no need to rewire. The result is a flexible, cost effective, system which can be used with control systems which vary quite widely in their nature and complexity.[9]

2.2.1 PLCInternal Architecture

Thebasic internal architecture of a PLC consists of acentral processing unit (CPU) containing the system microprocessor, memory, and input/output circuitry, as shown in Figure (2.1). The CPU controls and processes all the operations within the PLC. It is supplied with a clock with a frequency of typically between 1 and 8 MHz This frequency determines the operating speed of the PLC and provides the timing and synchronization for all elements in the system.

The information within the PLC is carried by means of digital signals. The CPU uses the data bus for sending data between the constituent elements, the address bus to send the addresses of locations for accessing stored data and the control bus for signals relating to internal control actions. The system bus is used for communications between the input/output ports and the input/output unit. [10]

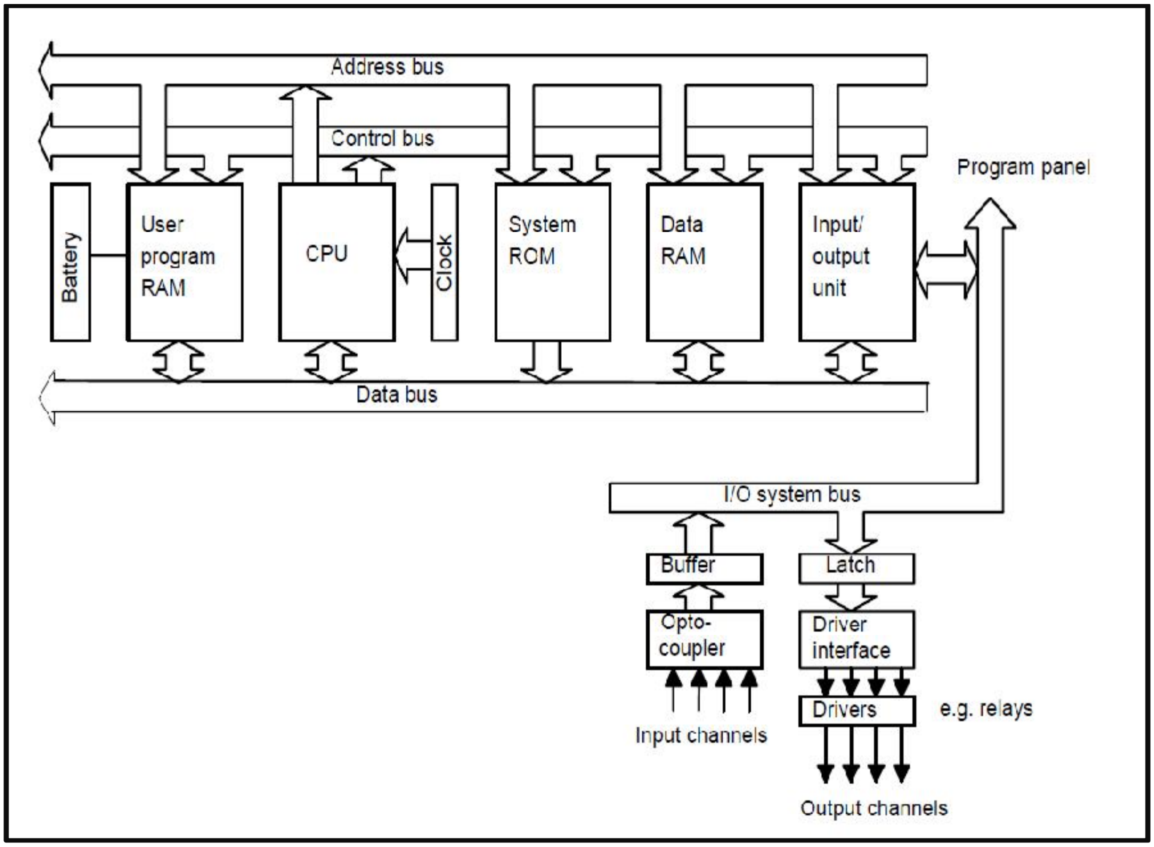

Figure (2.1): PLCInternalArchitecture

2.2.2Operation Principles

The input/ output (I/O) system is physically connected to the field devices that are encountered in the machine or that are used in the control of a process. These field devices may be discrete or analog input/output devices, such as limit switches, pressure transducers, push buttons, motor starters, solenoids, etc. The I/O interfaces provide the connection between the CPU and the information providers (inputs) and controllable devices (outputs). During its operation, the CPU completes three processes:

- **Reads**or accepts the input data from the field devices via the input interfaces.
- **Executes**or performs, the control program stored in the memory system.
- **Writes**or updates the output devices via the output interfaces. This process of sequentially reading the inputs, executing the program in memory, and updating the outputs is known as scanning as shown as figure (2.2) illustrates a graphic representation of a scan. [1]

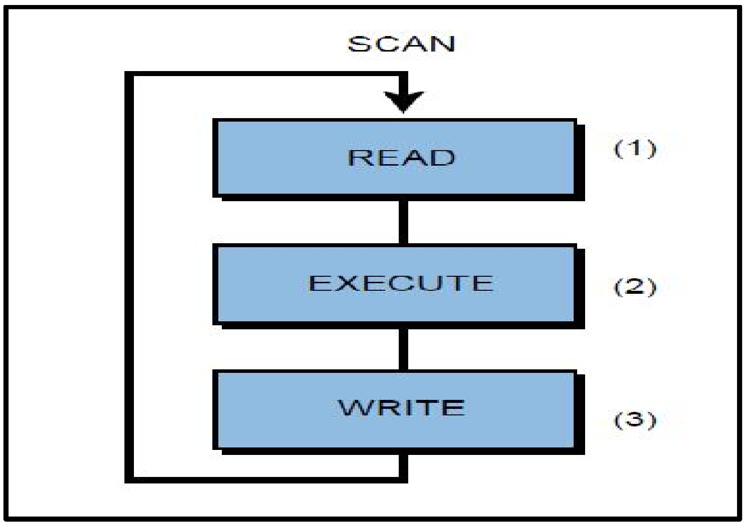

Figure (2.2):PLC Scanning

The input/output system forms the interface by which field devices are connected to the controller as shown as figure (2.3). The main purpose of the interface is to condition the various signals received from or sent to external field devices. Incoming signals from sensors (e.g., push buttons, limit switches, analog sensors, selector switches, and thumbwheel switches) are wired to terminals on the input interfaces.

Devices that will be controlled, like motor starters, solenoid valves, pilot lights, and position valves, are connected to the terminals of the output interfaces. The system power supply provides all the voltages required for the proper operation of the various central processing unit sections. [1]

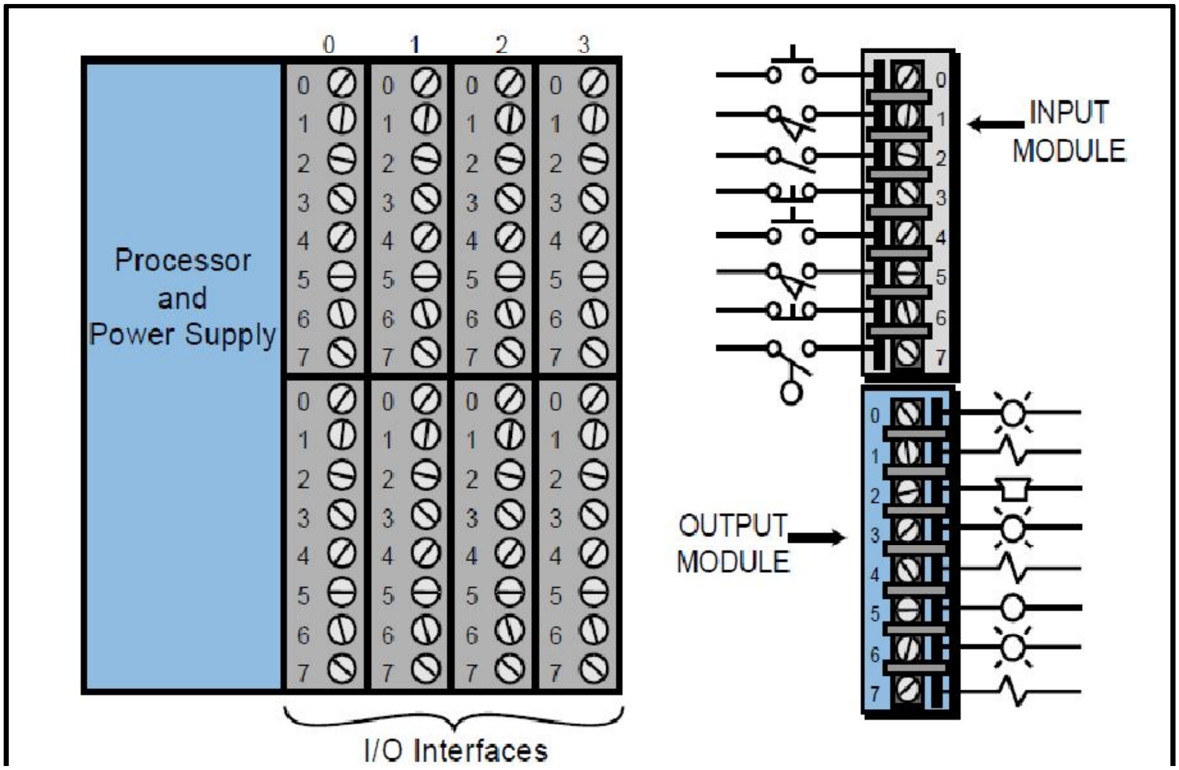

Figure (2.3): PLC Input/outputInterface

2.2.3 PLCProgramming

Programs for microprocessor-based systems have to be loaded into themin machine code, this being a sequence of binary code numbers to represent the program instructions. PLCs are intended to be used by engineers without any great knowledge of programming, this is a means of writing programs which can then be converted into machine code by some software for use by the PLC microprocessor, and this method of writing programs became adopted by most PLCmanufacturers.

The standard, published in 1993, is IEC 1131-3 (International ElectroTechnical Commission), the IEC 1131-3 programming languages are ladder diagrams (LAD), instruction list (IL), sequential function charts (SFC), structured text (ST), and function block diagram (FBD), as shown in Figure (2.4).Ladder diagrams a very commonly used method of programming PLCs is based on the use of ladder diagrams. Writing a program is then equivalent to drawing a switching circuit. The ladder diagram consists of two vertical lines representing the power rails. Circuits are connected as horizontal lines, i.e. the rungs of the ladder, between these two verticals. [12]

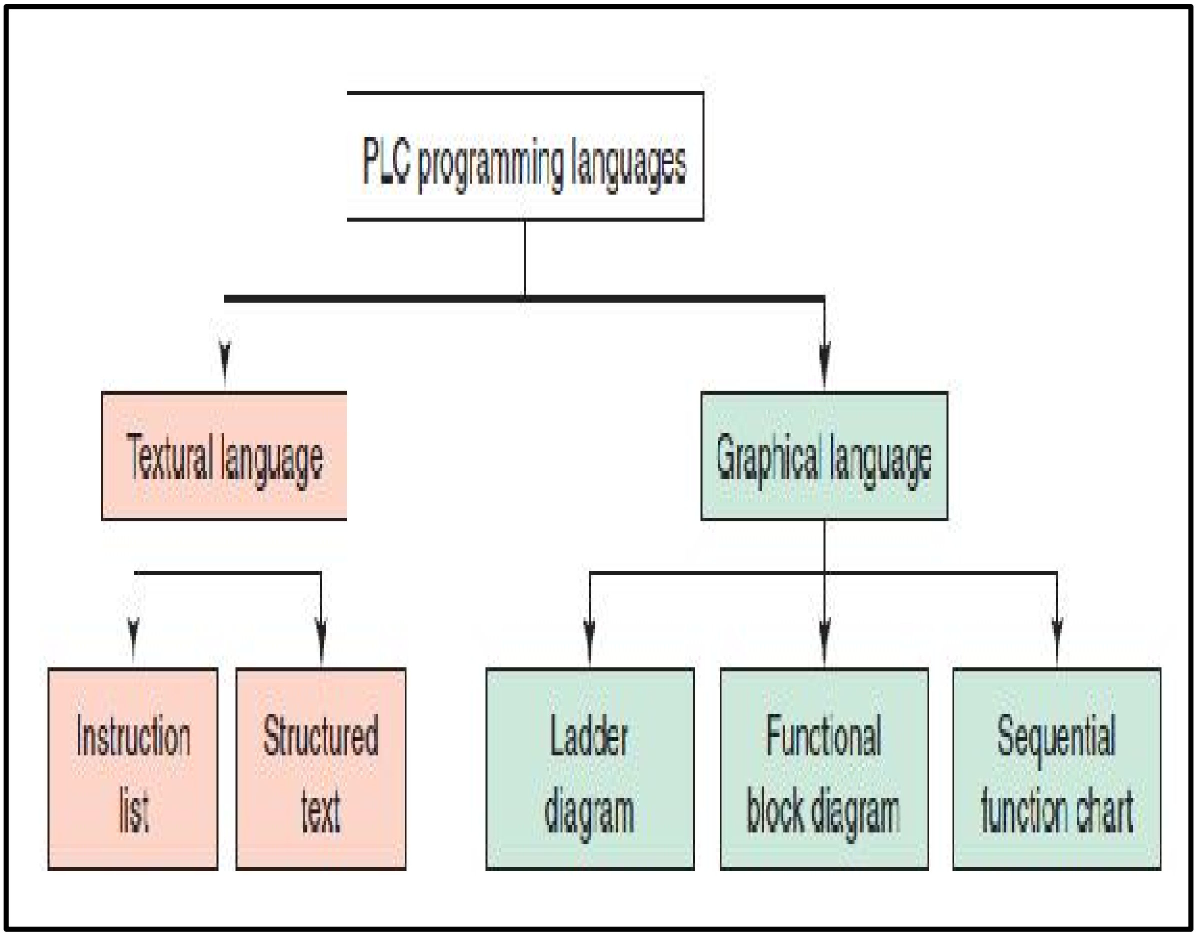

Figure (2.4): PLC ProgrammingLanguages

2.2.4 PLC Advantages

- **Flexibility:** One single Programmable Logic Controller can easily run many machines.
- **Correcting Errors:** In old days, with wired relay-type panels, any program alterations required time for rewiring of panels and devices. With PLC control, any change in circuit design or sequence is as simple

as retyping the logic. Correcting errors in PLC is extremely short and cost effective.

- **Space Efficient:** Today's Programmable Logic Control memory is getting bigger and bigger this means that we can generate more and more contacts, coils, timers, sequencers, counters and so on. We can have thousands of contact timers and counters in a single PLC.
- **Low Cost:** Prices of Programmable Logic Controllers vary from few hundreds to few thousand dollars.
- **Testing:** A Programmable Logic Control program can be tested and evaluated in a lab.
- **Visual Observation:** When running a PLC program a visual operation can be seen on the screen. Hence troubleshooting a circuit is really quick, easy and simple.[8]

2. 3 SCADASystem

SCADA IS (Supervisory Control and Data Acquisition). SCADA is a system that collects information from sensors and from the components of the Control System, and sends the data to the main Computer for the purpose of: Management, supervision, Control and MonitoringSCADA System is invented in order to allow the Operator to control this net or even more complicated networks through his computer. And informs the Operatorwhether the circuits are normal or not.

The system will warn/alert of any problem in any circuit. In fact, SCADA System. Is more developed than that: It allows the computer to review and display the received data, draw graphs (curves) to explain the data values within a certain period of time. Also, it compiles the information and outline it the form of Report. [13]

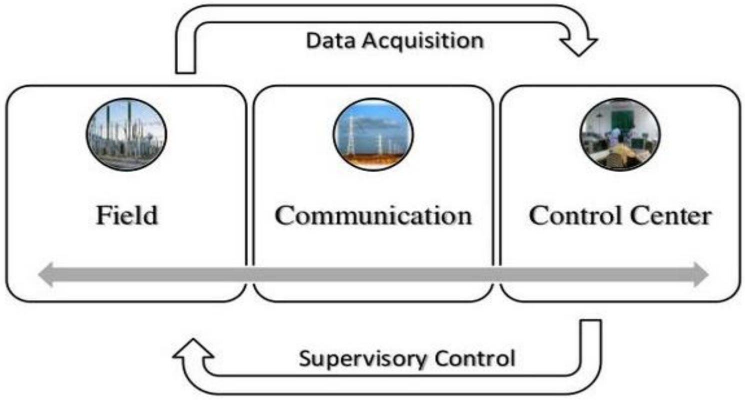

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Figure (2.5):SCADA Systems

2.3.1 SCADA System Capacities

1. Adding more control buttons for the pages to do one or more jobs.
2. Design of indicators to show the working situation and the current condition at the station.
3. Display of text messages or drawing to show the state of the workflow or the warning.
4. Send orders from the keyboard to deal with all pages or with one single page.
5. Monitoring & Control to display all alerts in different forms.
6. To exchange information available at the station with another site of work.
7. Control of the Quality of Production.[14]

2.4 Siemens network Automation Step7 Control Center (SINAUT ST7cc).

SINAUT ST7cc is the tele-control system based on SIMATIC ST7, consists Oftwo independent systems:

•SINAUT MICRO

Tele-control system for monitoring and controlling distributedplants using DSL on the basis ofSIMATIC S7-200 and WinCC flexible or WinCC explorer as a result ofits bidirectional communications capability, SINAUT micro can handle simple tele-control tasks.

•**SINAUT ST7cc**

Versatile tele-control system based on SIMATIC S7-300,S7-400 and for fully automatic monitoring andcontrol of process terminals which exchange data with oneor more control centers or with each other via a WAN or overEthernet. Configuration is carried out using STEP 7.SINAUT ST7 is a tele-control system based on SIMATIC S7(S7-300 and S7-400)for fully-automatic monitoring and control of process terminalswhich exchange data with one or more control centers or witheach other via a wide range of WAN media.

The modular design and the support of a huge variety of networkforms and operating modes including IP-based networks permitthe design of flexible network structures that can also contain redundantlinks.By using all forms of transmission media, the networks canbe optimally adapted to the respective local conditions.The SINAUT ST7cc system is based on SIMATIC S7 systemsS7-300, S7-400. It supplements these systems with the specific SINAUT hardwareand software components listed below.

- **Hardware Components**

1. TIM communications modules.
2. DSL

- **Software Components**

SINAUT ST7cc Engineering Software. [16]

- **TIM Communications Modules**

The central component of the SINAUT ST7cc hardware is the Tele-control Interface Module (TIM). It is used by the S7 CPU or control center PC for data exchange via the relevant SINAUT network, optionally with the SINAUT ST7.

The TIM is housed in an S7-300 enclosure and is available in two basic versions:

1. TIM 3V-IE/TIM 3V-IE Advanced Module

The TIM 3V-IE is a SINAUT communication module for the SIMATIC S7-300. It has anRS232 port, to which an appropriate external modem can beConnected for data transmission via a conventional WAN. In the case of the TIM 3V-IE,SINAUT communication can be processed alternately via one of the two interfaces, while in the TIM 3V-IE advanced both interfacescan be operated simultaneously.

When used in a node station, TIM 3V-IE Advanced can, for example,Exchange data over its RS232 interface over a radio network with the lower-level stations. It is then connected to the control center over a fiber-optic cable. In this configuration, data can be exchanged between each of the SINAUT stations regardless of which network they are situated in order to disconnect the networks, the connection in the control center can be made via a TIM 4R-IE or, as in the example, directly to the Ethernet interface of the PC as shown figure (2.7).[16]

- **Benefits Of TIM 3V-IE/TIM 3V-IE Advanced**

1. Flexible option for connection to any IP-based WAN.
2. For universal use with S7-300, S7-400, C7 compact controlSystem and control center PC
3. Simplified maintenance through replacement of modules without PG.
4. Reliable storage of important data.
5. Remote programming and remote diagnostics (PC routing) in
   Parallel with data transmission via the WAN or IP-connection
   Saves time and money.

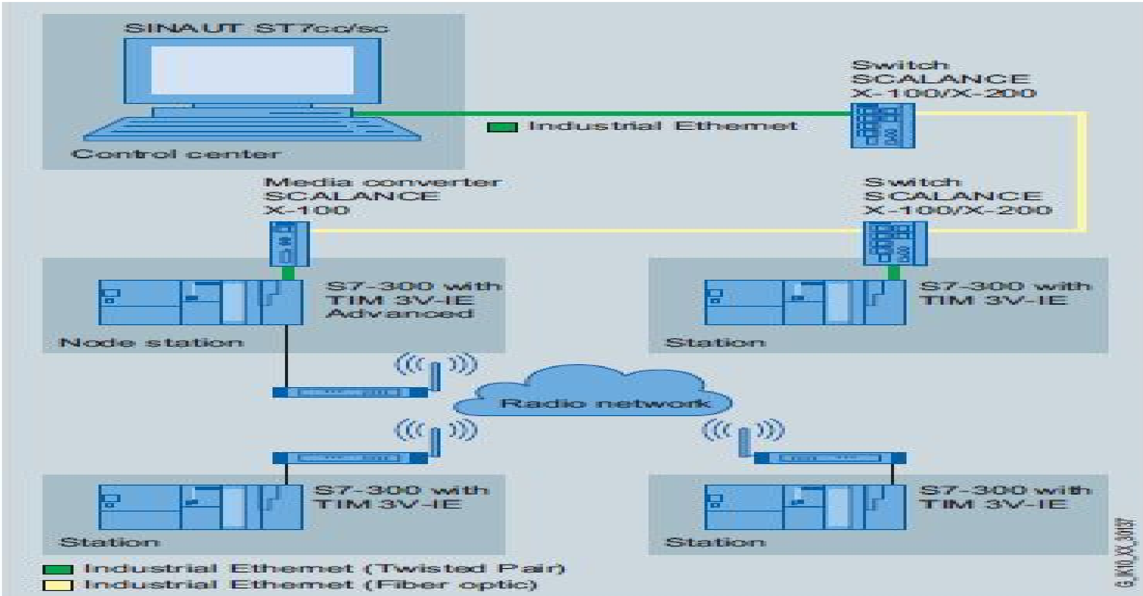

Figure (2.6): Node StationofTIM 3V-IE Advanced Module

2. TIM 4R-IE Module

The TIM 4R-IE has two RS232/RS485 interfaces for SINAUT data transmission via conventional WANs and additionally two RJ45 interfaces for connection to IP-based networks (WAN or LAN). This TIM can be used as a communications processor ina SIMATIC S7-300.but is particularly suitable as a SINAUT communications processor for a SIMATIC S7 400 or the control console PC (SINAUT ST7cc or ST7sc). It is then connected without S7-300 CPU a standalone device via one of the two Ethernet interfaces to the S7-400 or the PC.

In a node station with a SIMATIC S7-400 the TIM 4R-IE is connected to the S7-400 via one of its two Ethernet interfaces and can, for example, exchange data by radio with the subordinate stations via an RS232/RS485 interface. It is then connected to the control center via the second Ethernet interface. In this configuration, data can be exchanged between all of the SINAUT stations regardless of which network they are situated as shown figure (2.9). [16]

- **Benefits of TIM 4R-IE**

1. Flexible connection capability to up to four SINAUT networks
2. For universal use with S7-400 and control center PC as well as with S7-300.
3. Compact module with 4 WAN interfaces saves installation Space in the rack and cabinet
4. Reliable storage of important data.

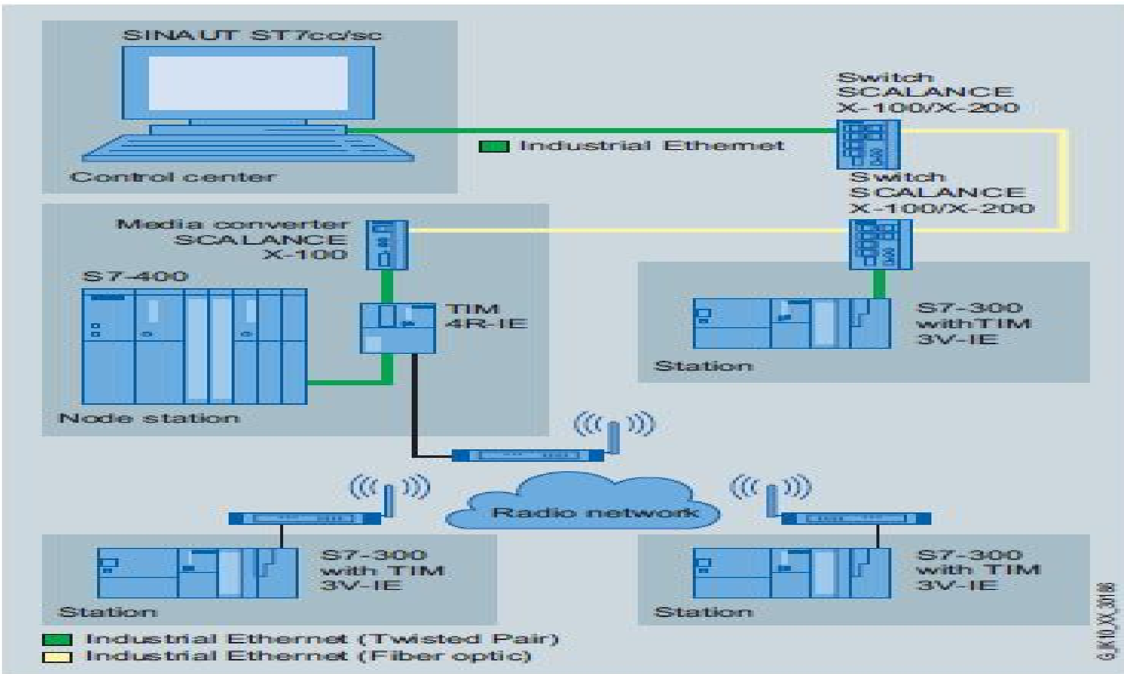

Figure (2.7):Node Station of TIM 4R-IE Module

2.5 DSL Router

The DSL router must be able to handle the Port Forwarding property. With Port Forwarding the router waits for data packages at a configured port and forwards them to a certain port in the internal network. For the MSC protocol any port (starting from port 1025) can be used which will be forwarded to the MSC Server via Port Forwarding.

MSC (Micro Switching Centre) is Ethernet based proprietary protocol which has been developed for cost-effective VPN networks in Telecontrol Systems. Theauthenticationof the MSC client at the MSC server takesplace with the username and password and the net data are encoded via a pre-shared key.The connection is initiated by the MSC client.[17]

CHAPTER THREE

DESIGN AND IMPLEMENTATION SYSTEM

3.1Background of Soba Station's Operation

Soba station has included five processes:

1. Intake process.
2. Sedimentation process.
3. Clari-floracator process.
4. Filters process.
5. Lifting pump process

Three pumps are used in the intake process before the operation electrical valve (V127-V128) must be close after pumps are working we open the electrical valve (V127-V128) and the water go through flow meter and pressure meter to check the outlet of flow and pressure also we use level sensor to check the sea level as shown figure (3.1).

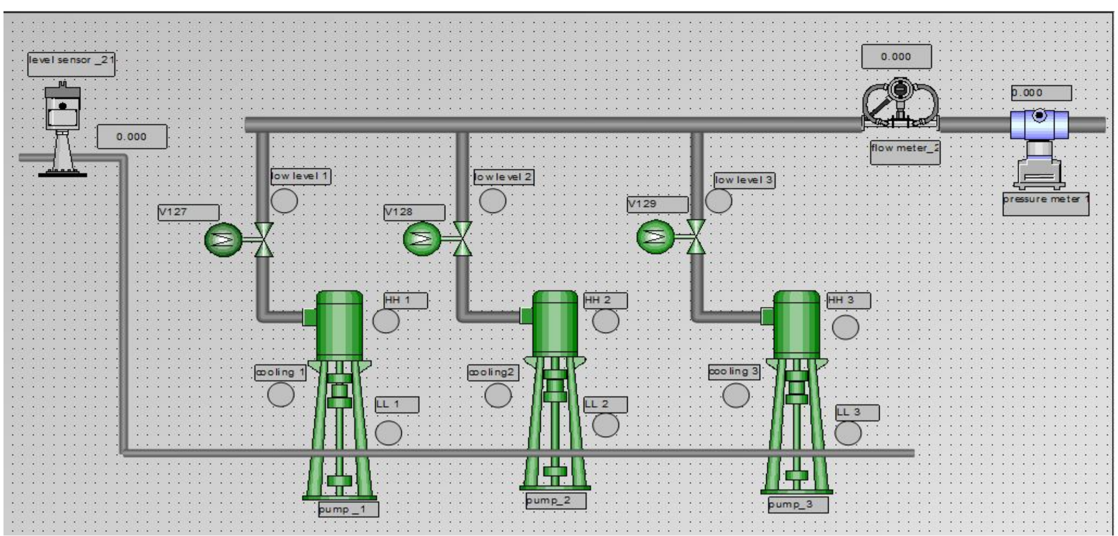

Figure (3.1): Intake Process of Soba Station

In the sedimentation process all water come to tank then distributing to two tanks through electrical valve(V138 and V140) and add chemical material and mixing together by mixer using electrical motor (other motor is standby). There are two outlets in two tanks one for mud go through electrical valve (V139 and V141) interval (min) and duration (sec). We use also flow meter (flow meter 24 and flow meter 25) other for water goes to clari-flocarator as shown figure (3.2).

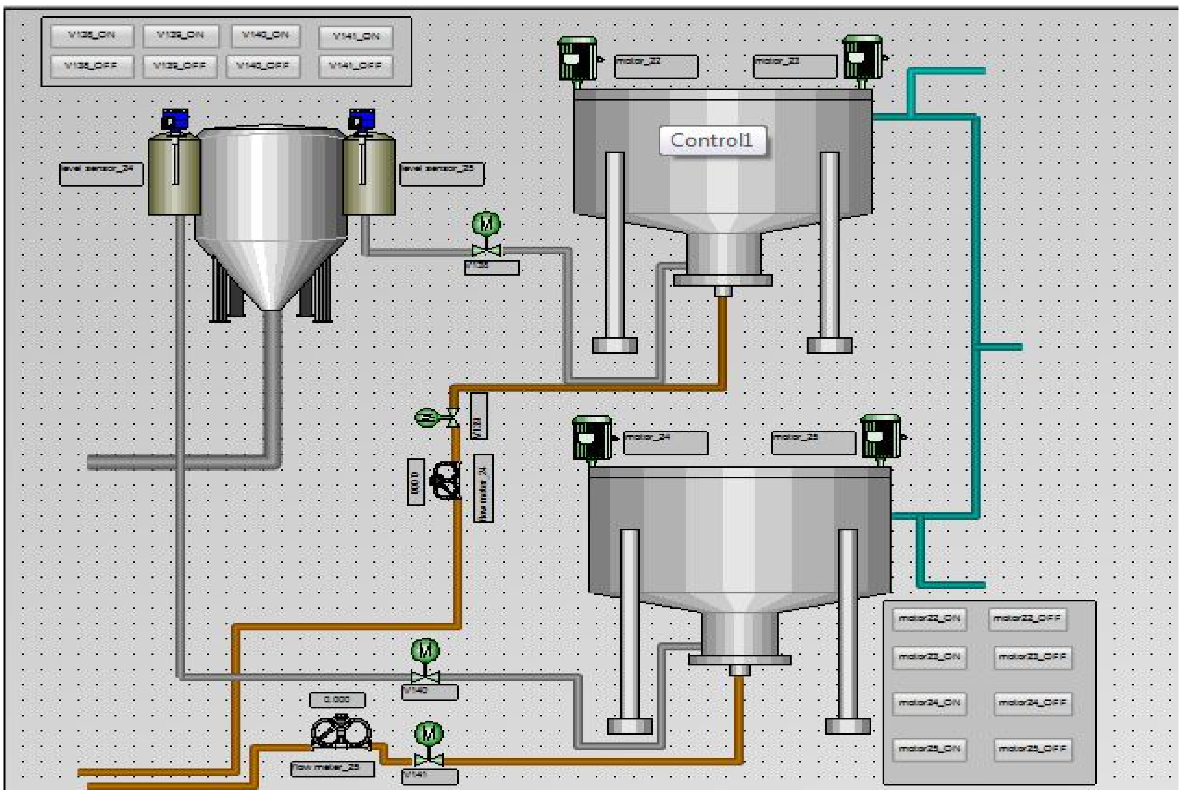

Figure (3.2): Sedimentation Process of Soba Station

In the clari-flocarator process collecting the water then distributing to three tanks and add chemical material and mixing together using electrical motor (motor 4, motor 10 and motor 16) and mixers (mixer 5, mixer6,mixer11,mixer12, mixer17 and mixer18). After that there are two outlets in three tanks one for mud go through electrical valve (V122, V124 and V126) and other for water goes to Filters process as shown figure (3.3).

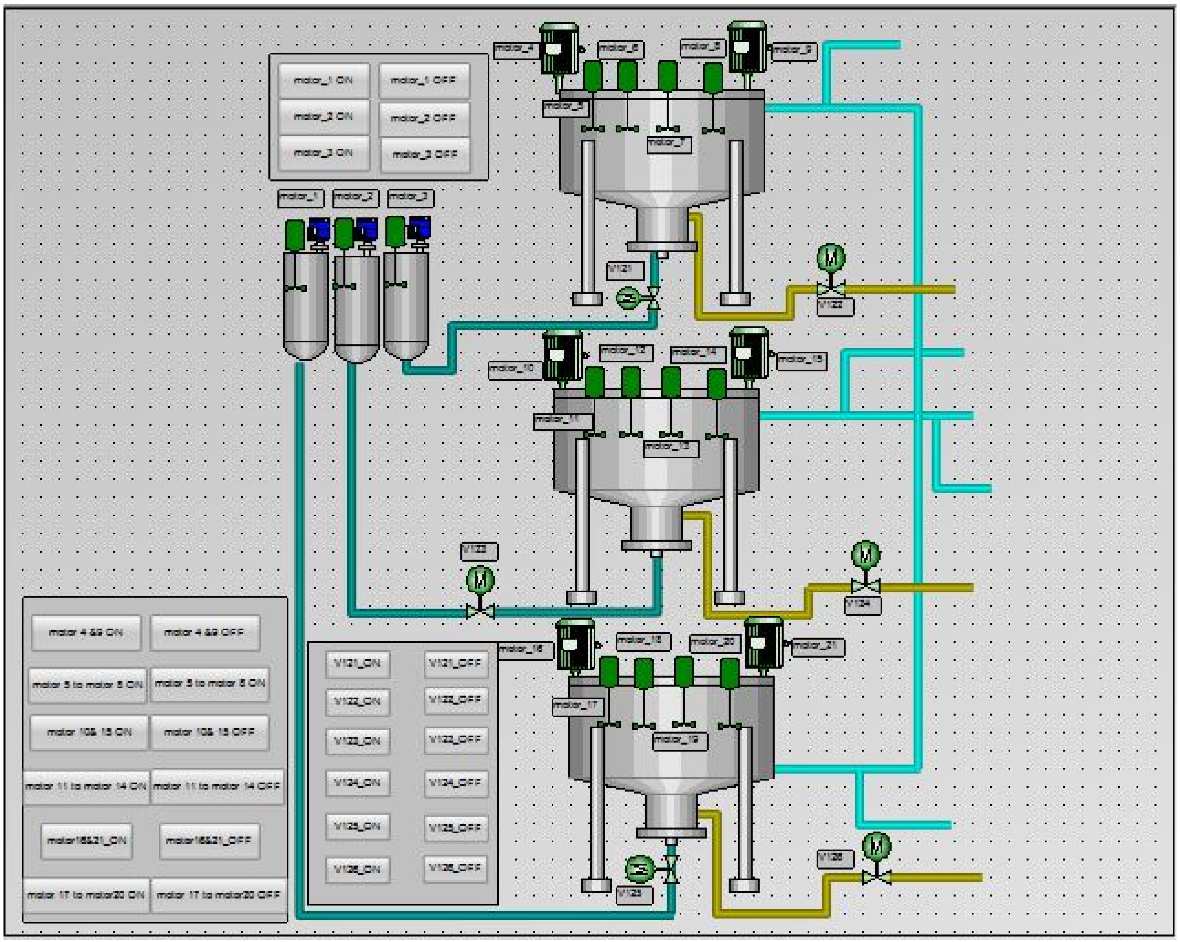

Figure (3.3):Clari-FlocaratorProcessof Soba Station

In filters process, there are five filters using level sensor to check the level in the filter and six electrical valves (inlet, outlet, air, water, mud and mixing)after that the water goes to last process lifting pump as shown figure (3.4).

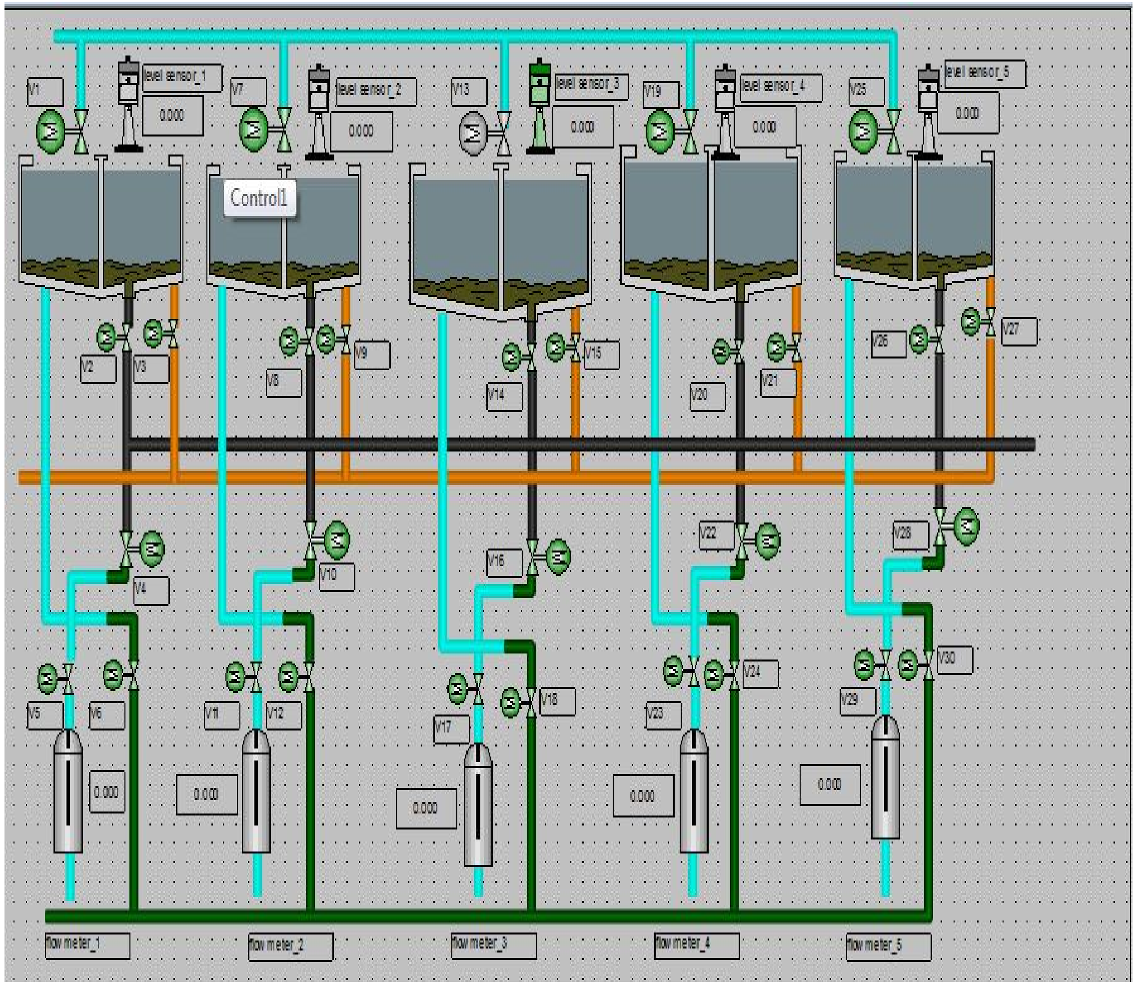

Figure (3.4): Filters Process of Soba Station

In the lifting pumps process the water goes to four small tanks then collecting in one tank using level sensor to check the tank level.After that lifting water by (pump4&pump5) another pump is standby. The water goes through flow meter 23 and pressure meter 2 to check the final outlet of flow and pressure as shown figure (3.5).

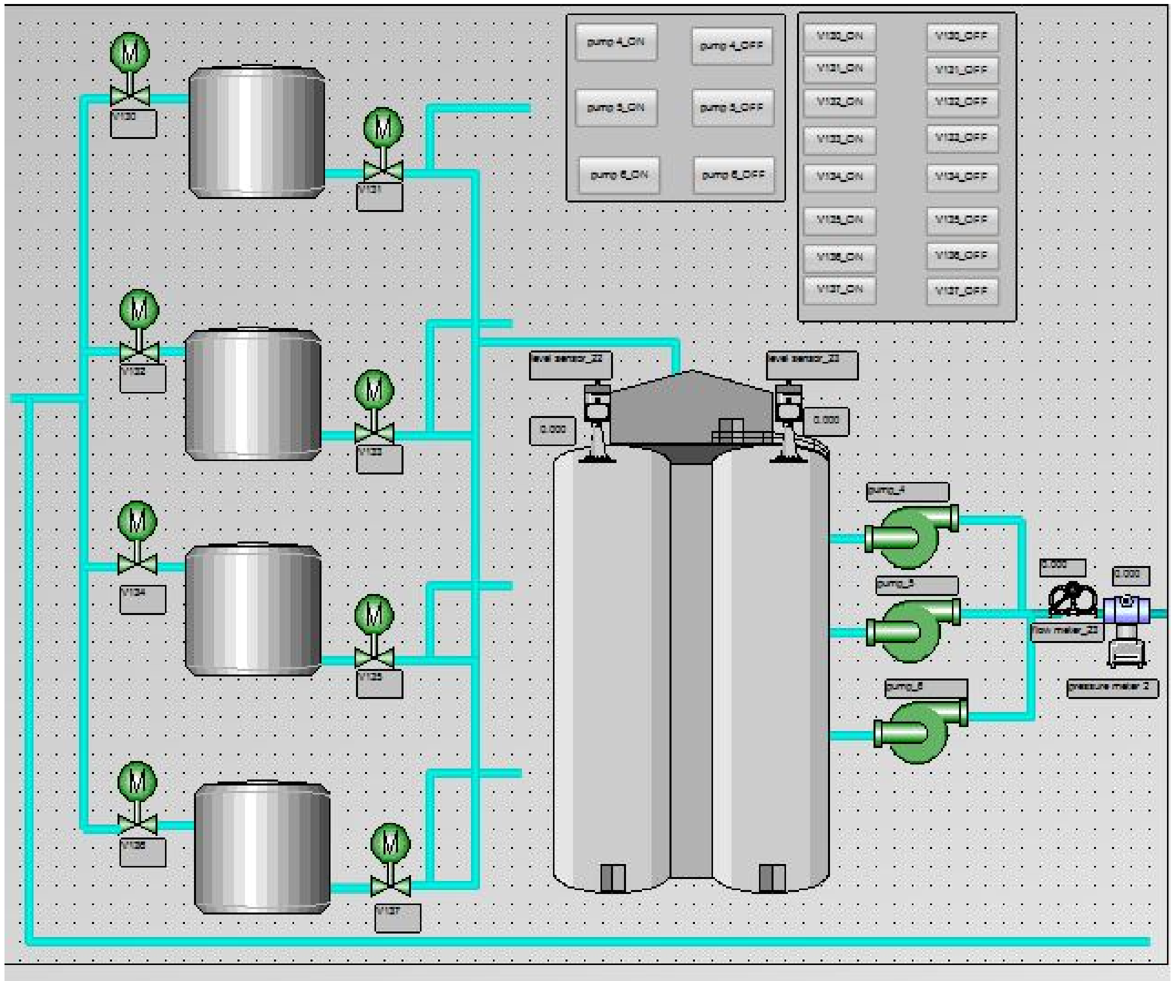

Figure (3.5): Lifting Pump Process of Soba Station

Table (3.1):The Components ofSoba StationProcess

NO	Process	components	Code
1	Intake	Valves	V127-V129
		Level sensor	Level sensor 21
		Flow meter	Flow meter 22
		Pump	Pump 1- pump 3
		Pressure meter	Pressure meter 1
2	Sedimentation	Motor	Motor 22– motor 25
		Valves	V138-V141
		Flow meter	Flow meter 24- flow meter 25
		Level sensor	Level sensor 24- level sensor 25
3	Clari-flocarator	Motor	Motor 1 – motor 21
		Valves	V121-V126
		Flow meter	Flow meter 21
4	Filter	Valves	V1-V120
		Level sensor	Level sensor 1- level sensor 20
		Flow meter	Flow meter 1- flow meter 20
5	Lifting pump	Valves	V130-V137
		Level sensor	Level sensor 22- level sensor 23
		Flow meter	Flow meter 23
		Pump	Pump 4- pump 6
		Pressure meter	Pressure meter 2

3.2Configuration of Siemens Network Automation Step 7Control Center:

- Steps of configuration:

1. SIMATIC ST7 hardware Configuration.
2. Network Configuration.
3. ST7cc configuration.
4. ST7ccconfig.
5. SCADA configuration.

1. SIMATIC ST7 Hardware Configuration:

The hardware is going to be configured with the tool hardwareconfiguration. The stations are inserting first subsequently the configuration of each station takes place.as shown below steps of configuration:

First Step: insert three stations (01_ST7cc station, MasterTIM station And 03_ station (DSL)) as shown figure (3.6)

Second Step: configuration of 01_ST7cc station and download it to PLC as shown figure (3.7).

Third Step: configuration of MASTER TIM station and download it to PLC as shown figure (3.8).

FourthStep: configuration of DSL 03_station and download it to PLC as shown figure (3.9).

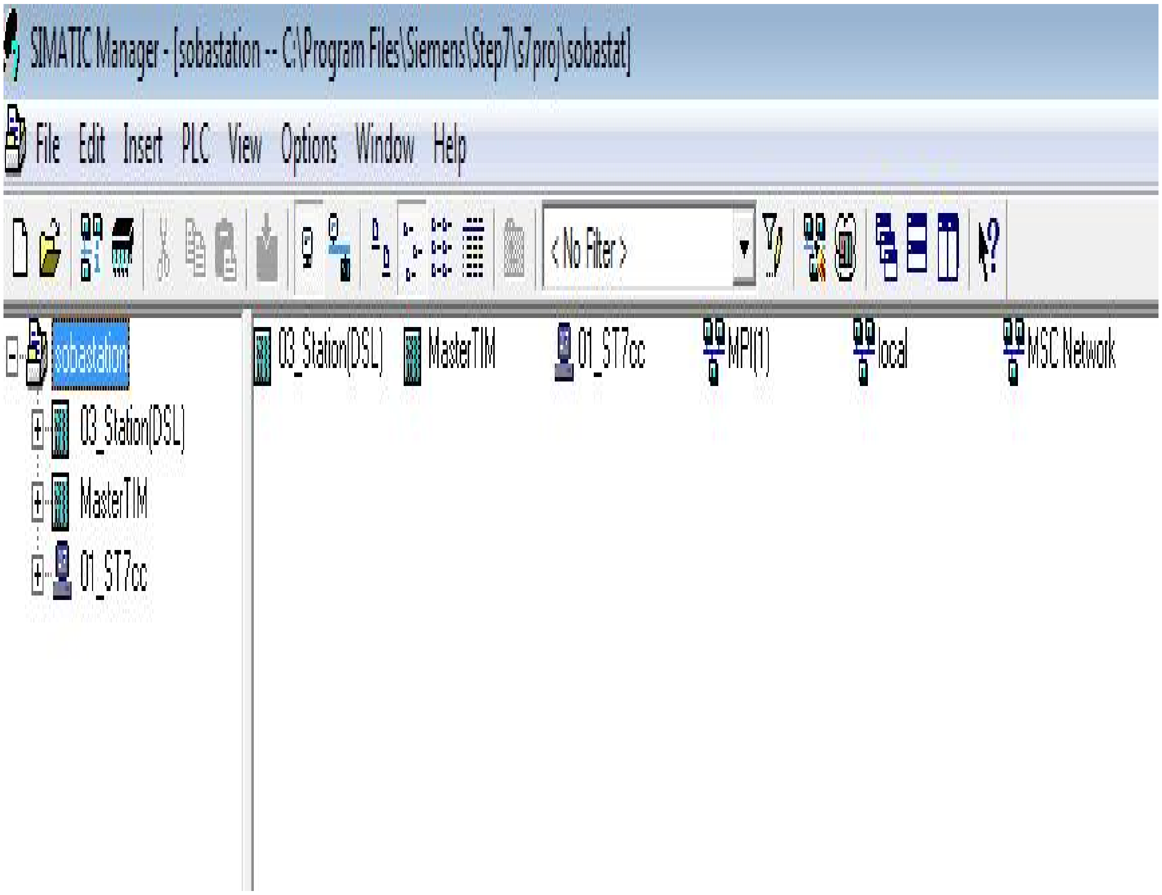

Figure (3.6):Three Stations of HardwareConfiguration

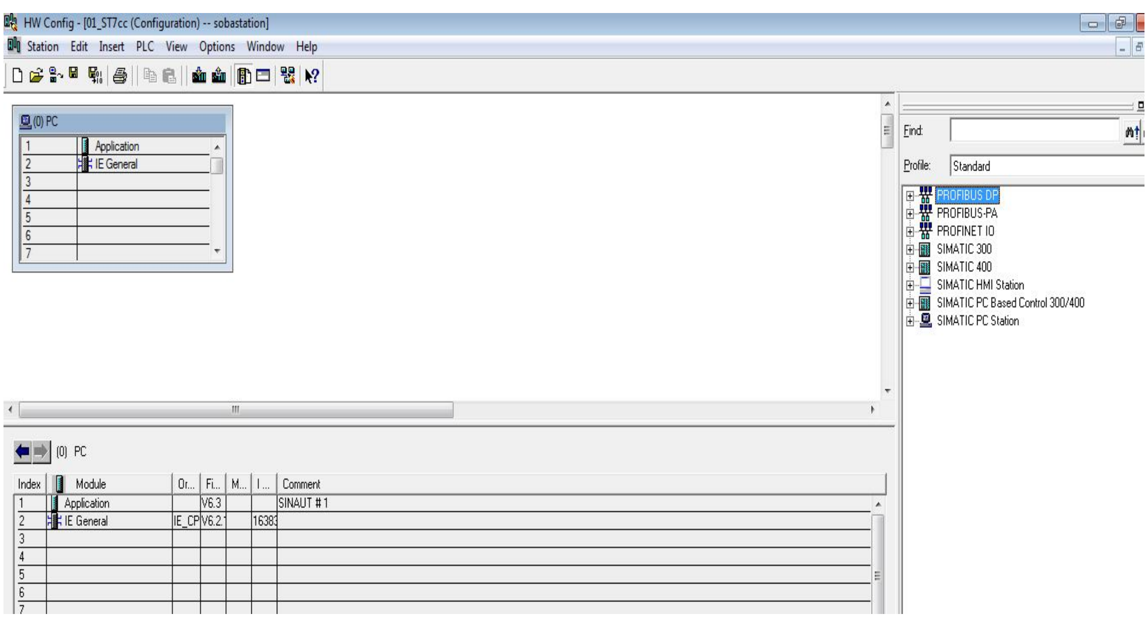

Figure (3.7):PcStationConfiguration

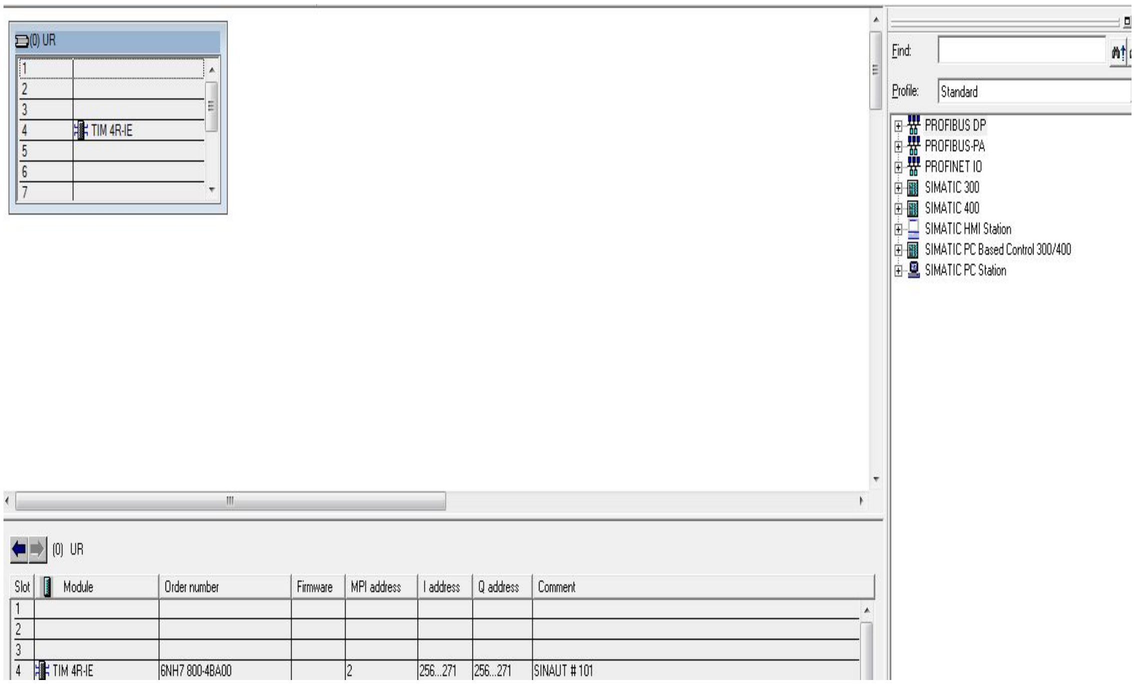

Figure (3.8): Master TIM Station Configuration

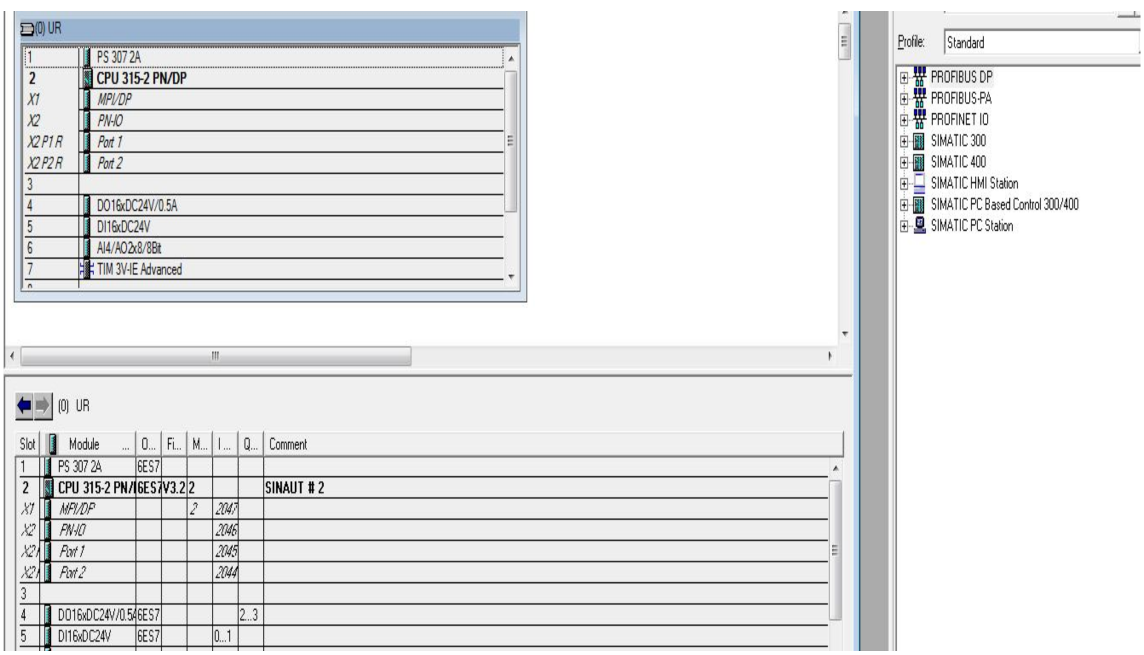

Figure (3.9): DSL Station configuration

2. Network Configuration:

The networks are going to be configured then MSC master and clients are going to be defined it uses for check the connection between two devicesas shown below steps of configuration:

First Step: insert two industrial Ethernet (local and MSC network). Local network is use to connect between 01_ST7cc and MasterTIM other one MSC network is use to connect between 03_station (DSL) and MasterTIM as shown figure (3.10)

Second Step: setting of IE general of 01_ST7cc station as shown figure (3.11)

ThirdStep: setting of keepalives of 01_ST7ccstation as shown figure (3.12)

Four Step: setting of Ethernet interface 2 of TIM4-IE connect with PC as shown figure (3.13)

FifthStep: setting of Ethernets interface 1 of TIM4-IE connect with DSL station as shown figure (3.14)

SixthStep: setting of keepalives of Master TIM as shown figure (3.15)

SeventhStep: setting of time service of Ethernet2 of Master TIM as shown figure (3.16)

EighthStep: setting of time service of Ethernet 1 of Master TIM as shown figure (3.17)

NinthStep: setting of Ethernet interface of TIM3-IE advanced of 03_Station (DSL) as shown figure (3.18)

TenthStep: setting of keepalives of 03_Station (DSL)as shown figure (3.19)

EleventhStep: setting of time service of Ethernet 1of 03_Station (DSL) as shown figure (3.20)

TwelfthStep: save and compile.

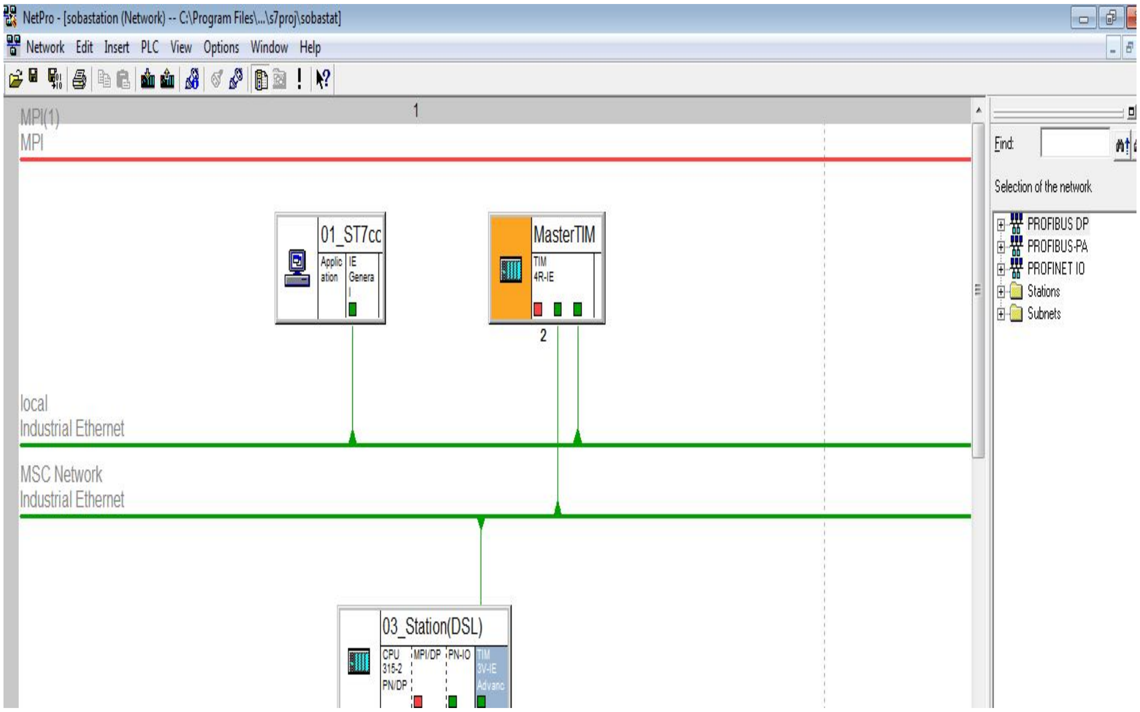

Figure (3.10):Industrial Ethernet Configuration

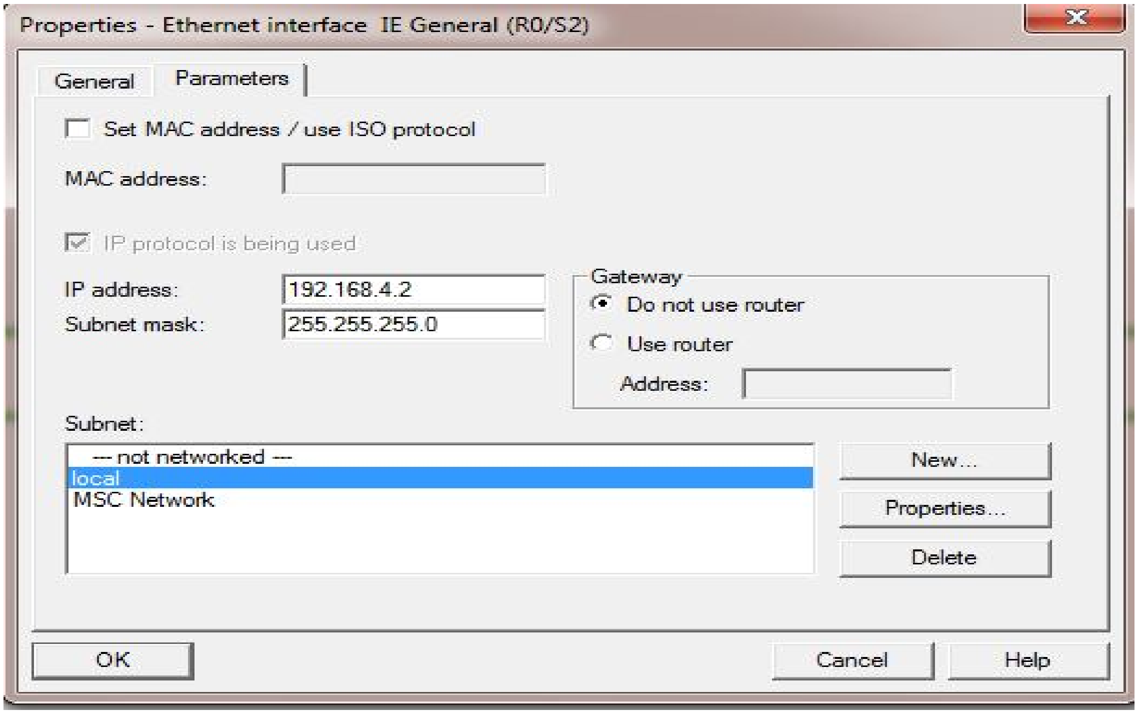

Figure (3.11):Setting of IE General (PcStation)

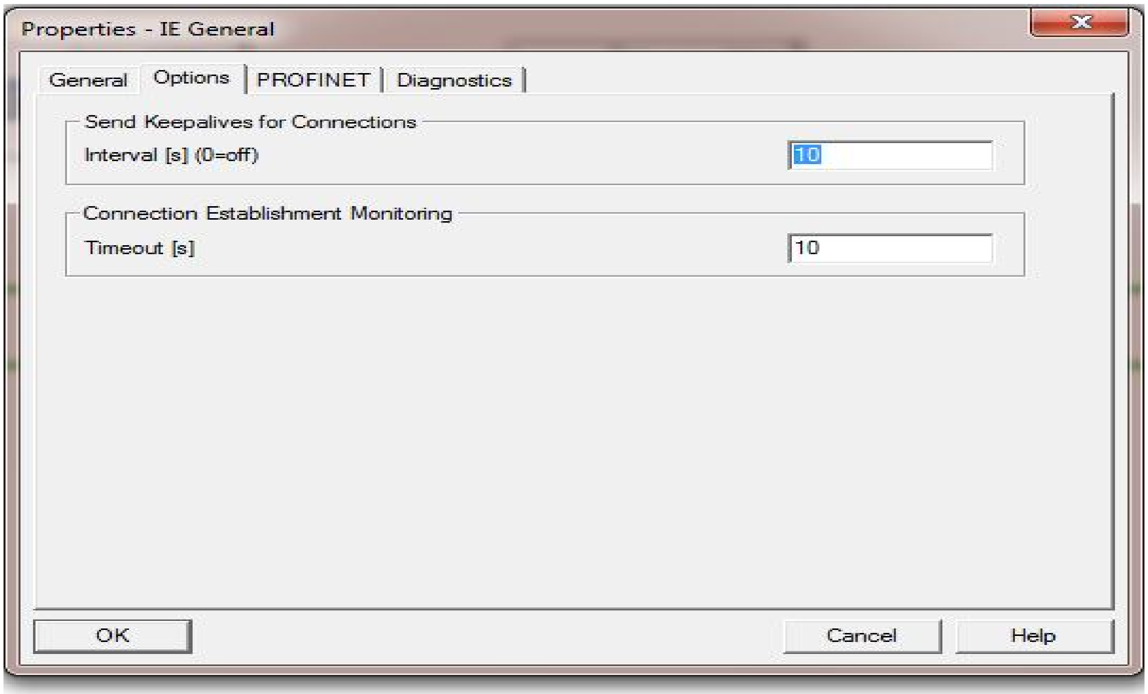

Figure (3.12):Setting ofKeepalives (PcStation)

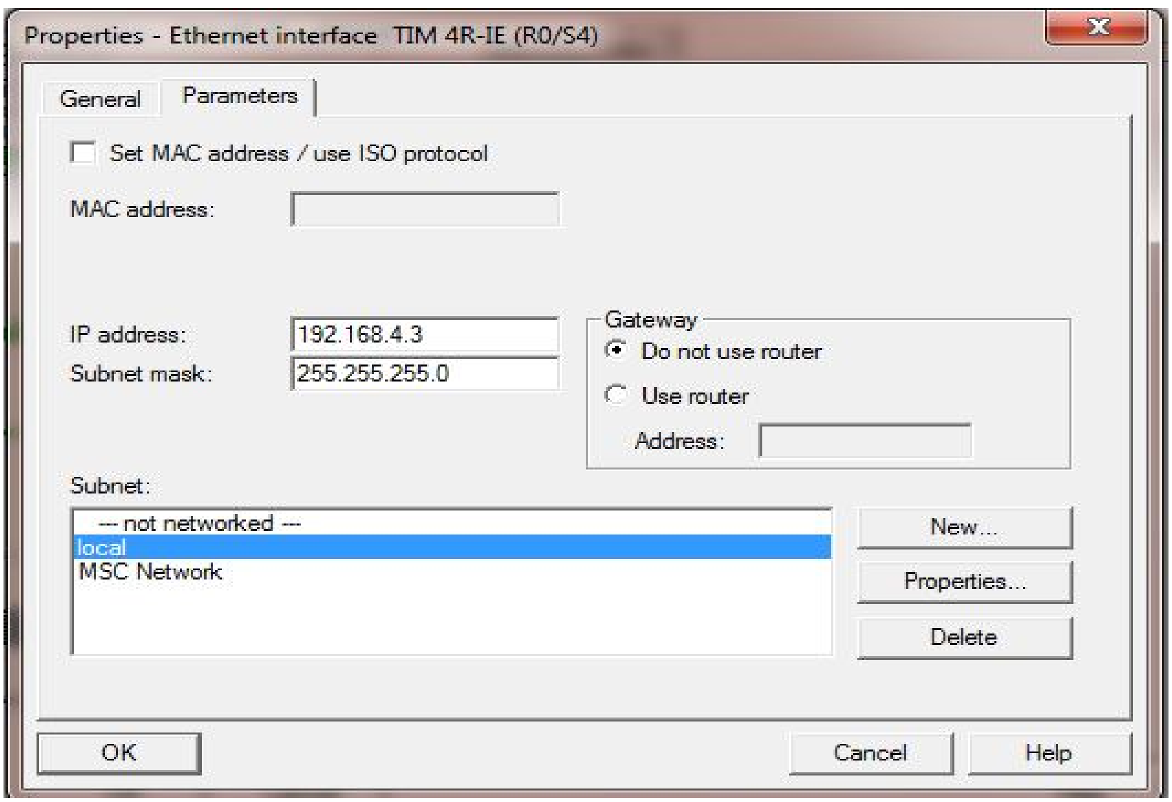

Figure (3.13): Setting of Ethernet Interface 2 (TIM4-IE)Connect with PC

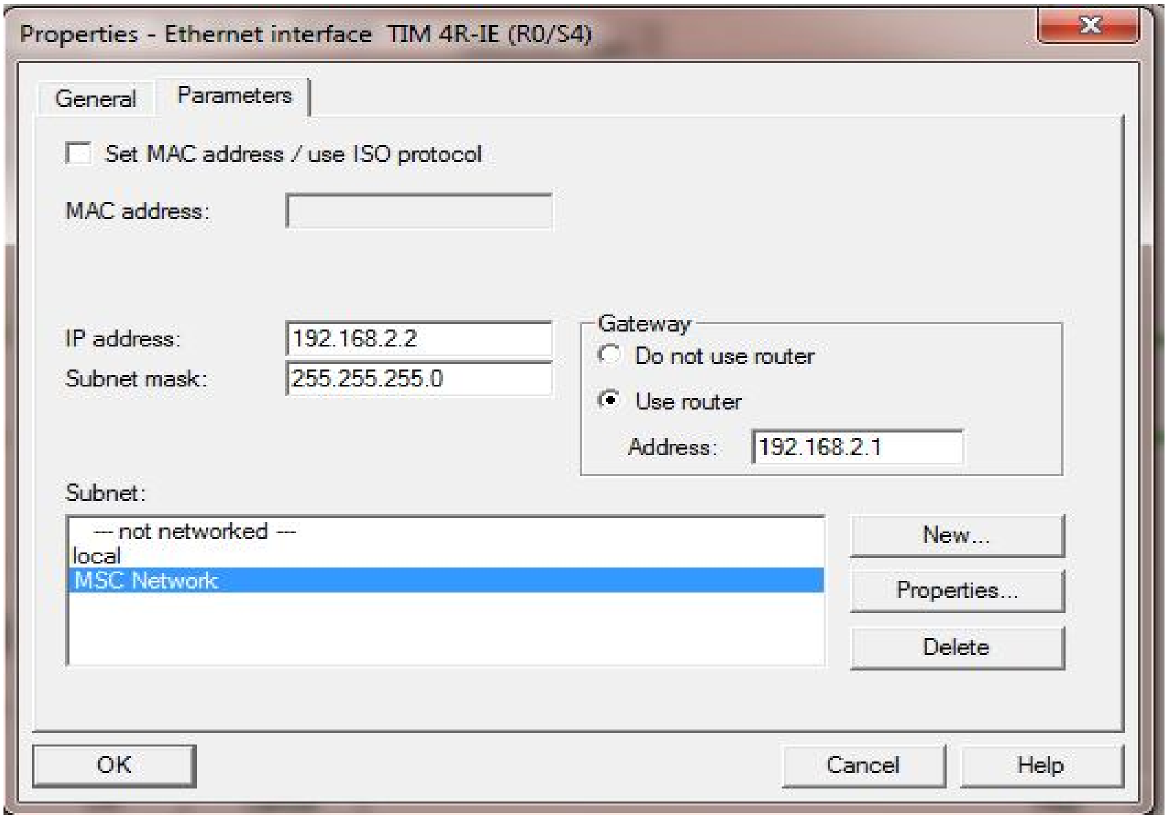

Figure (3.14): Setting of Ethernet Interface 1(TIM4-IE)Connect with DSL

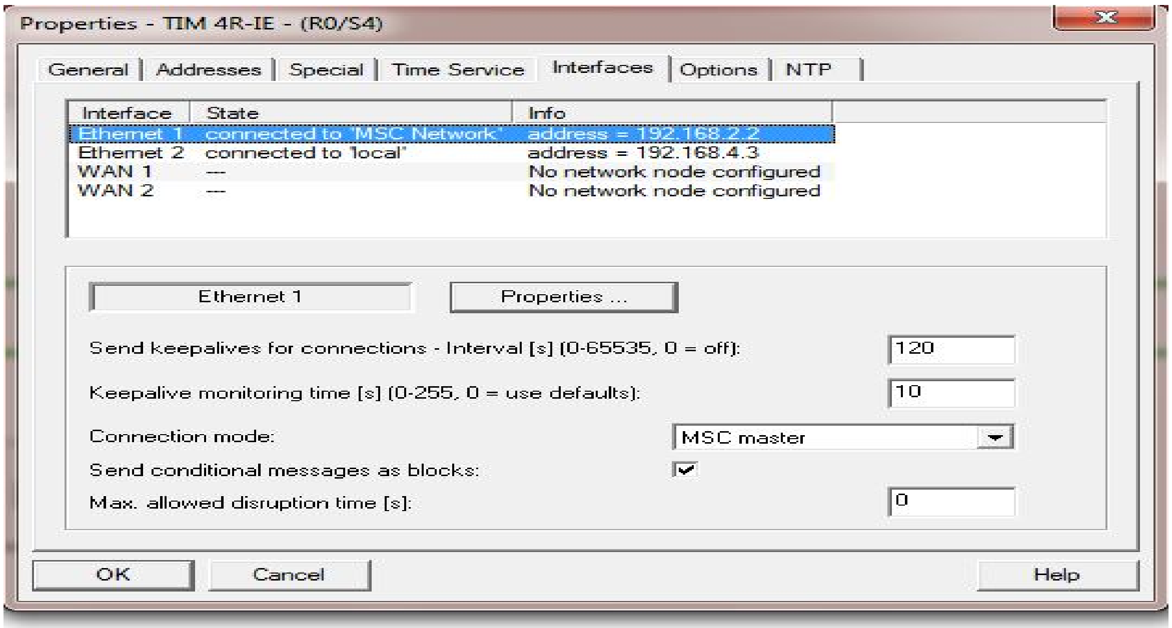

Figure (3.15):Setting ofKeepalives (MasterTIM)

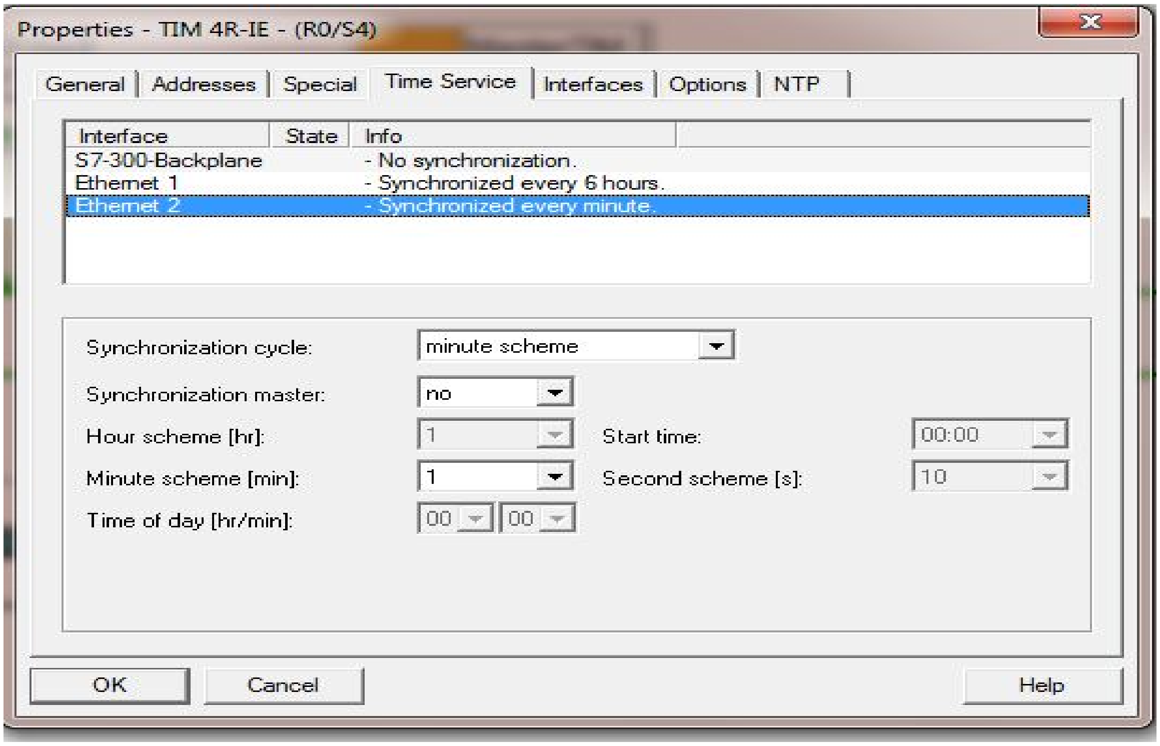

Figure (3.16):Setting Time of Ethernet2 (MasterTIM)

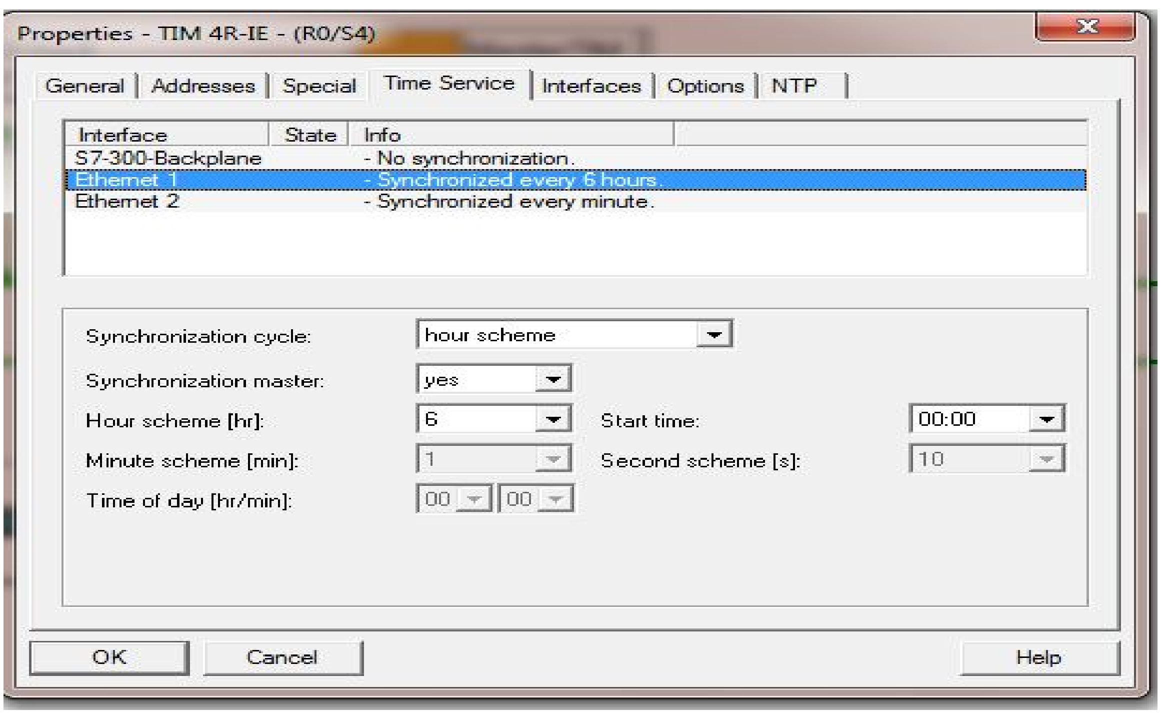

Figure (3.17):Setting Timeof Ethernet 1(MasterTIM)

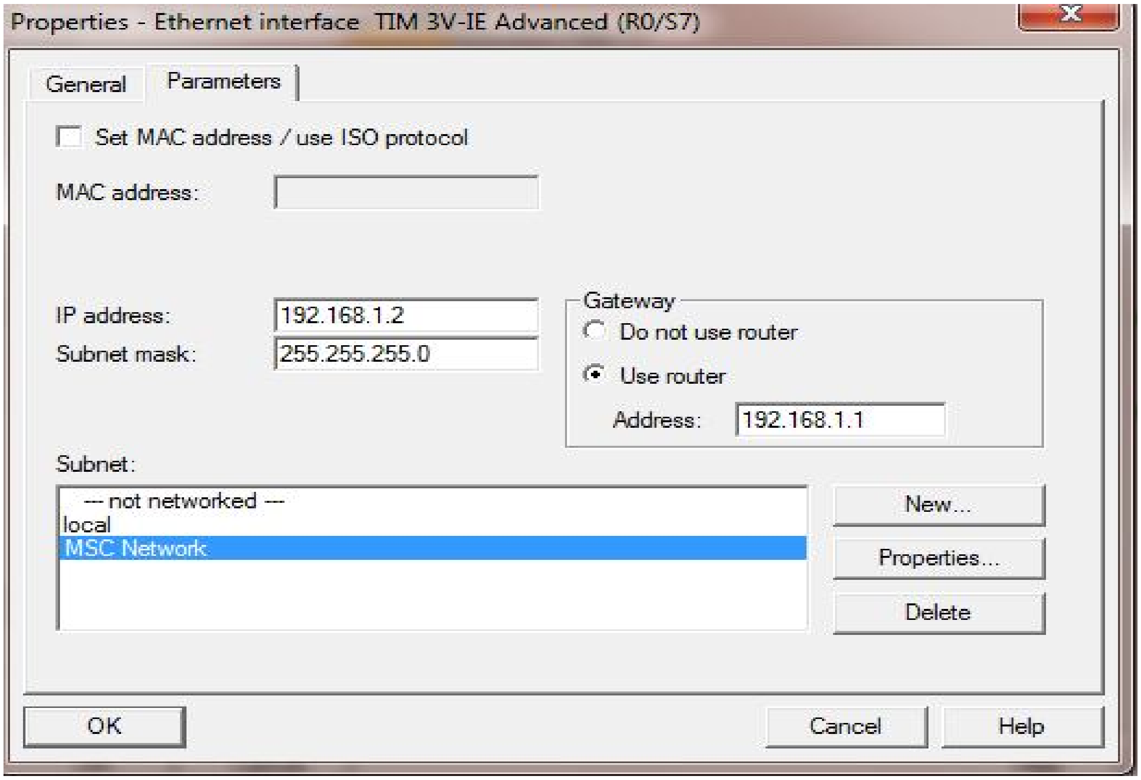

Figure (3.18): Setting ofEthernet Interface DSL Station

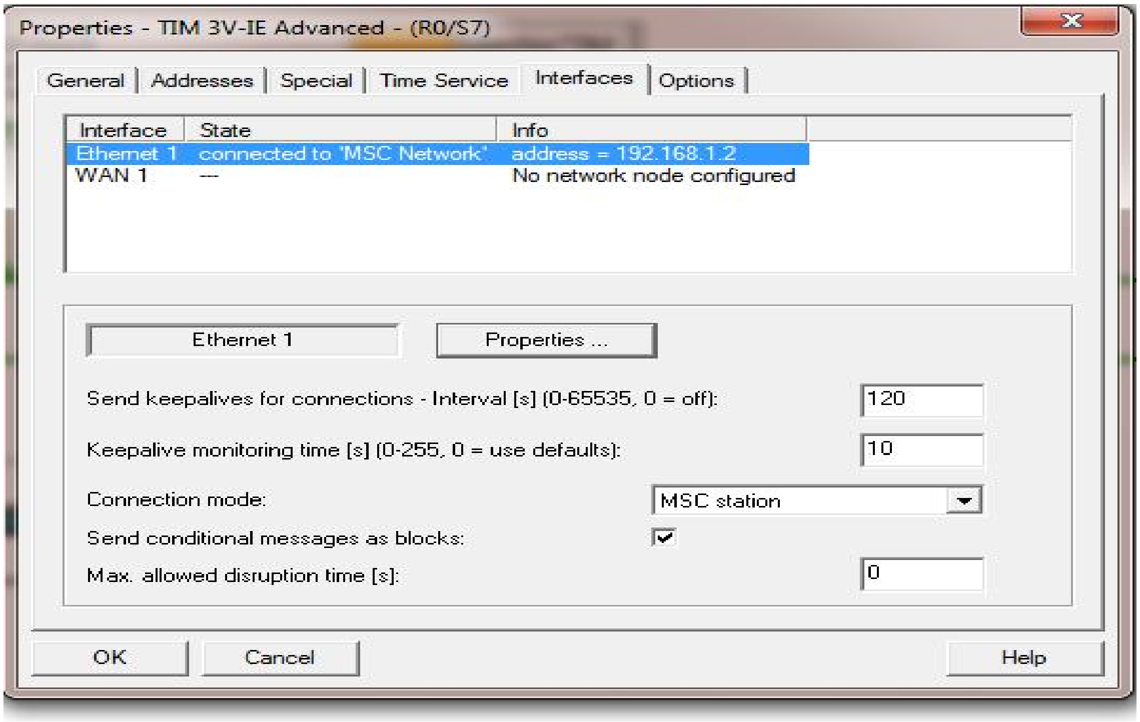

Figure (3.19): Setting of KeepalivesDSL Station

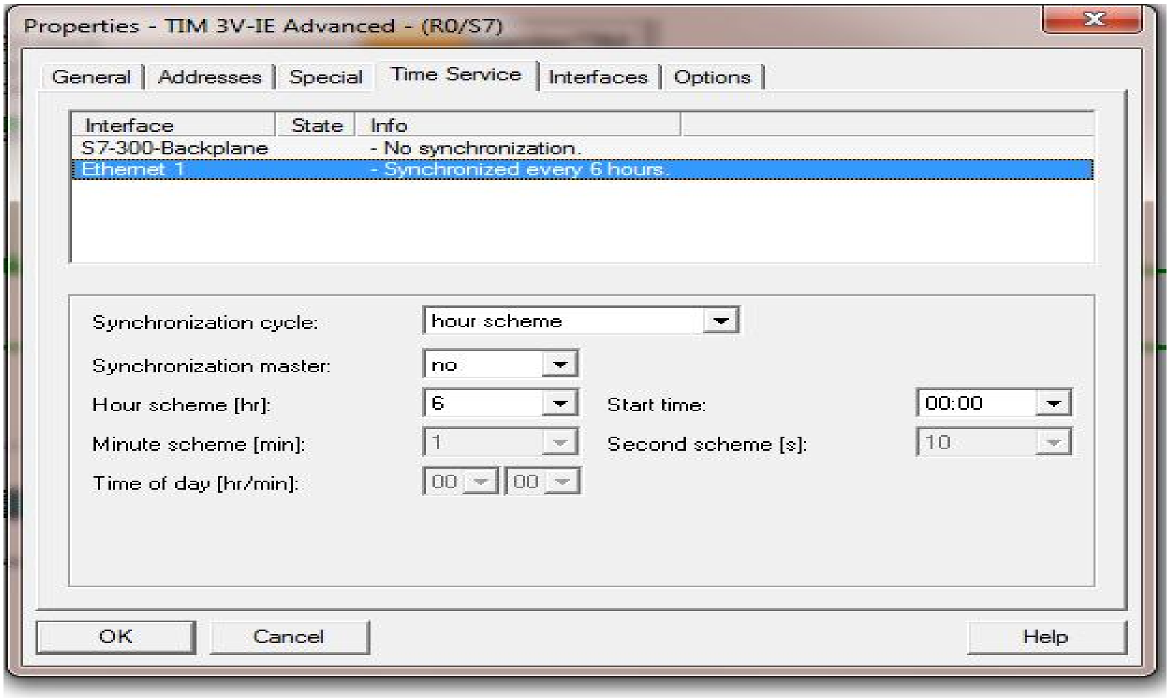

Figure (3.20):Setting Time of Ethernet 1 DSL Station

3. **SINAUT ST7cc Configuration: (Preparation of Transmit Data)**

The connections are going to be configured, the subscriber numbers are going to be changed and MSC parameters are going to be set as shown below steps of configuration:

First Step: setting of connection configuration as shown figure (3.21)

Second Step: save it then select subscriber administration as shown figure (3.22)

Third Step: fixed IP from provider for (router TIM4) and select MSC port (port 1025) the select ok after that save for the setting Preparations of all transmit data from 03_station (DSL) to Master TIM (Digital or analog data) as shown figure (3.23)

Four Step: select the digital and analog data as shown figure (3.24)

FifthStep: preparation digital transmit data as shown figure (3.25)

SixthStep: preparationanalog transmit data as shown figure (3.26)

SeventhStep: setting of station configuration Then select import station for (PC is PC station) then ok as shown figure (3.27)

Eighth Step: commutation setting (for check IP of IE general) as shown figure (3.28)

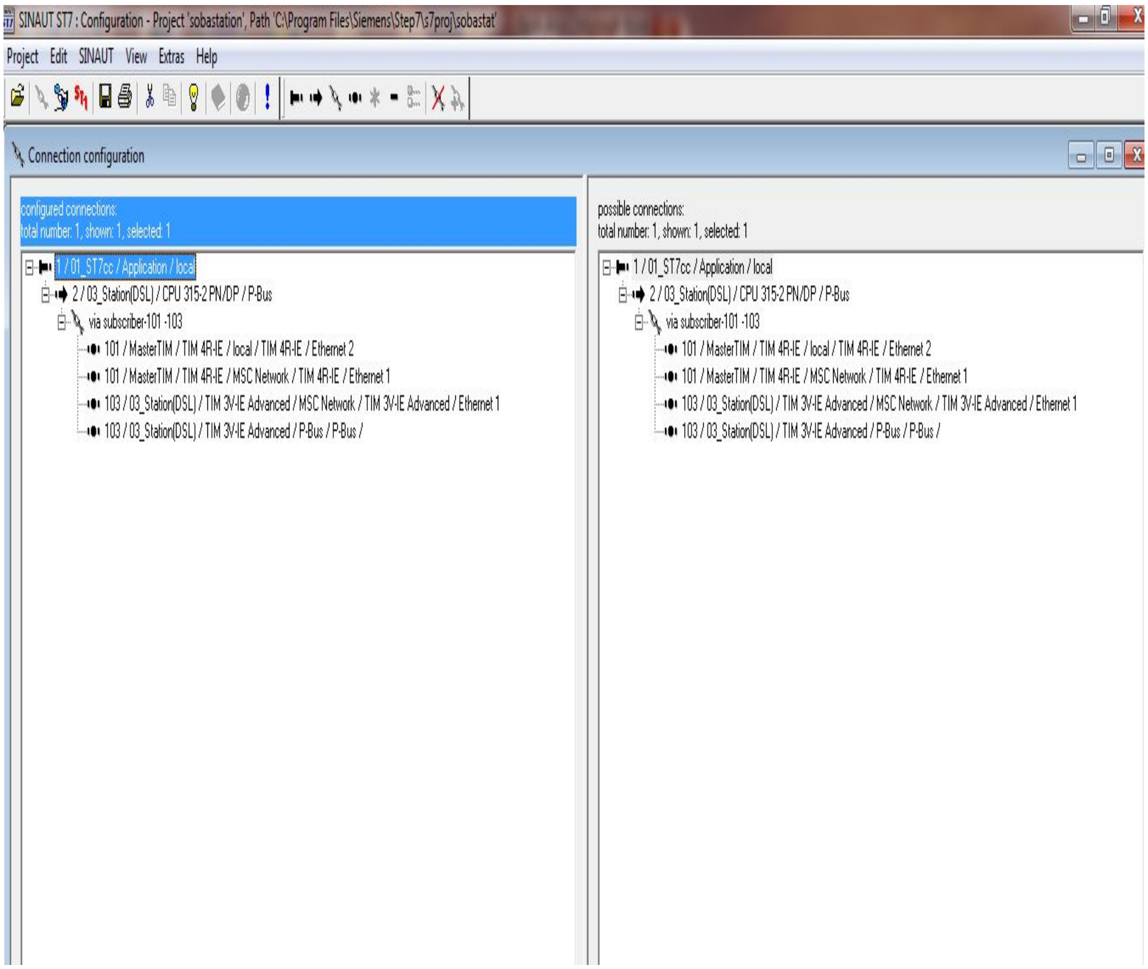

Figure (3.21) Connection Configuration

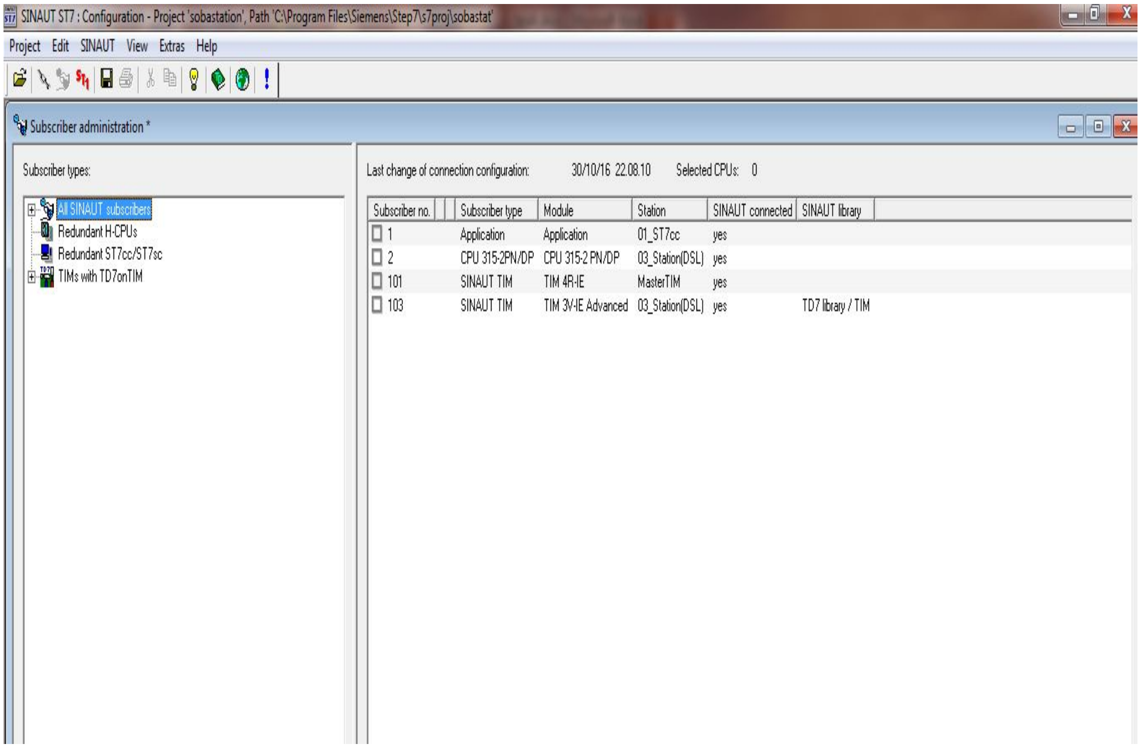

Figure (3.22) Subscriber Administration

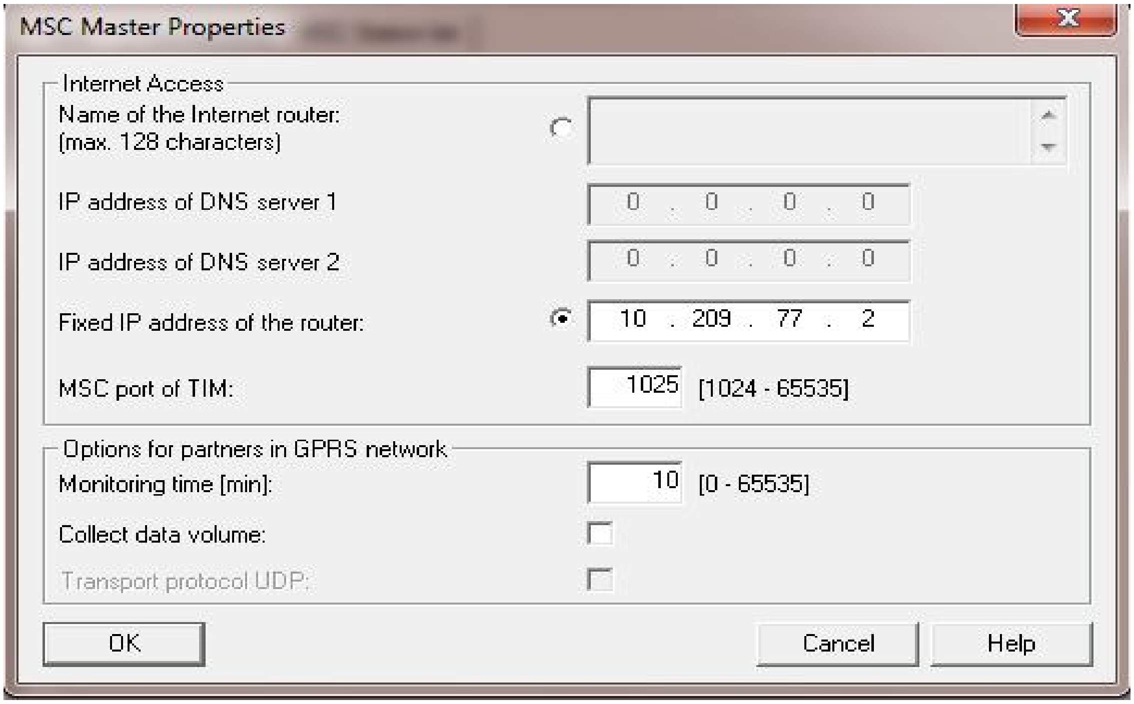

Figure (3.23) MSCMaster Properties

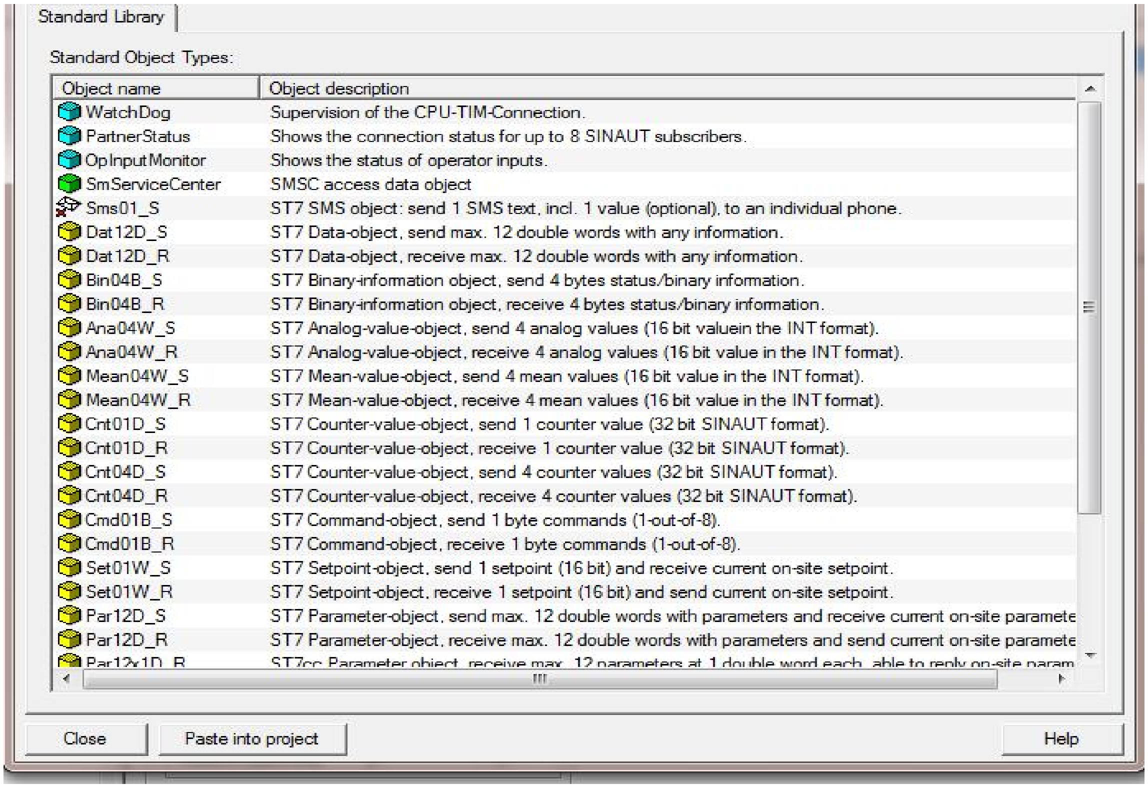

Figure (3.24) Binary and AnalogData

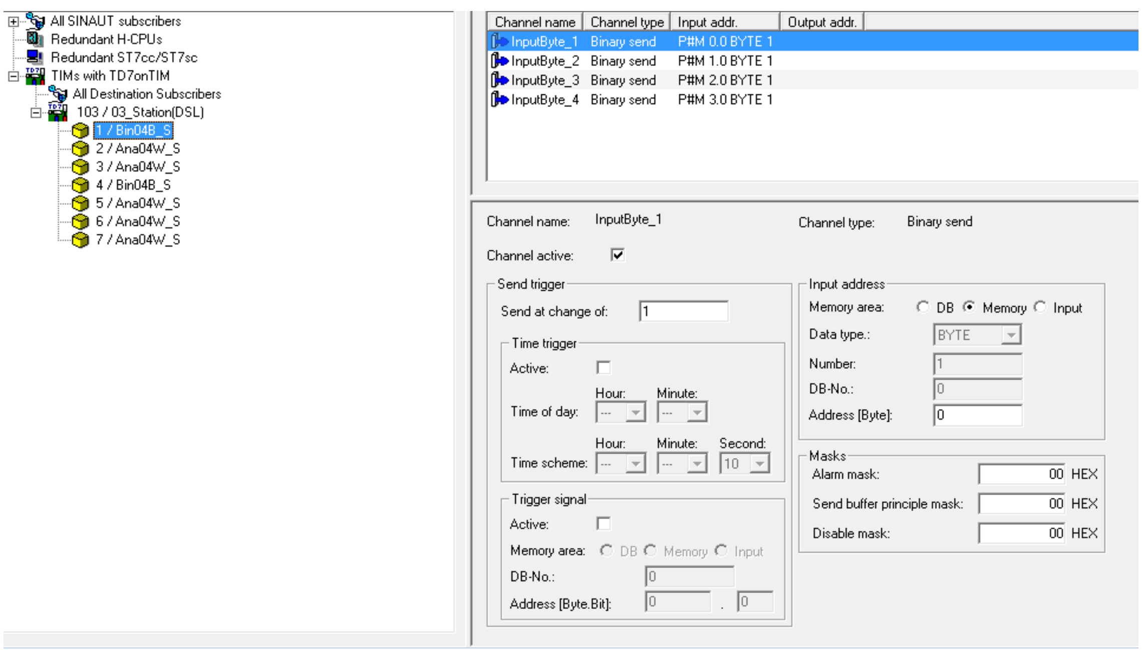

Figure (3.25) Preparation of Digital Transmit Data

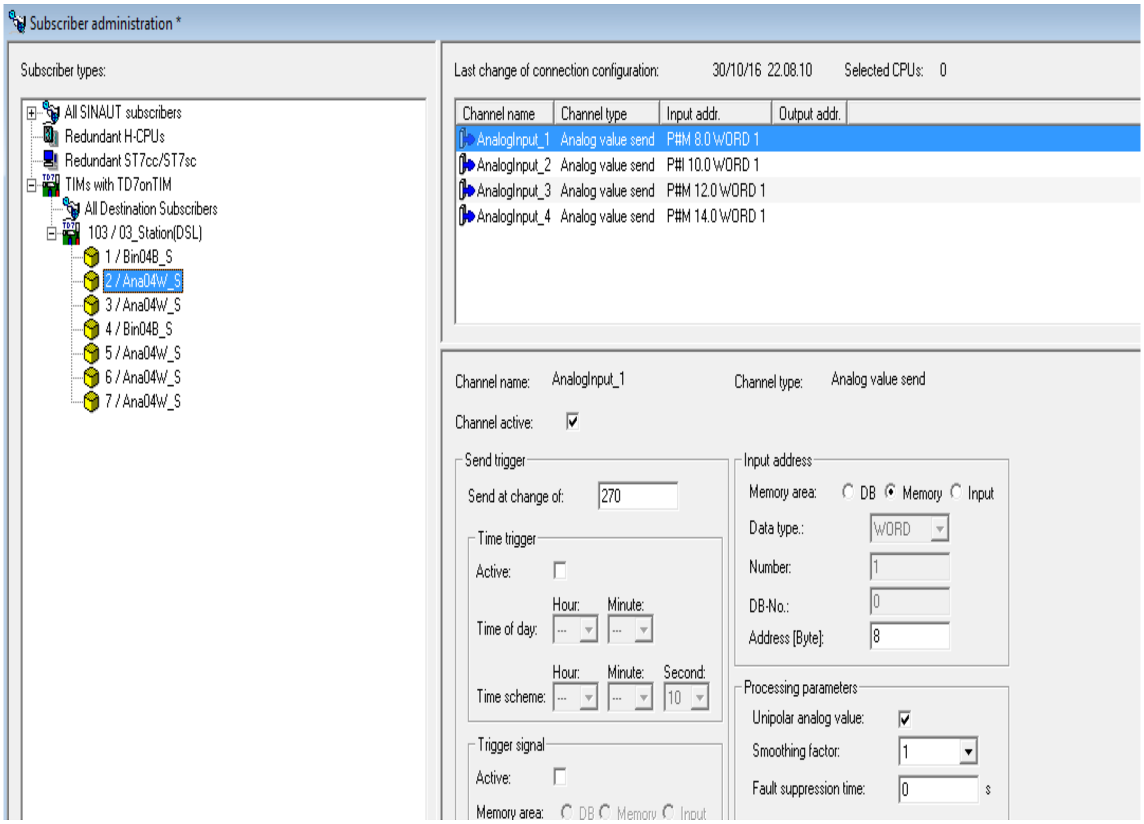

Figure (3.26) Preparation of Analog Transmit Data

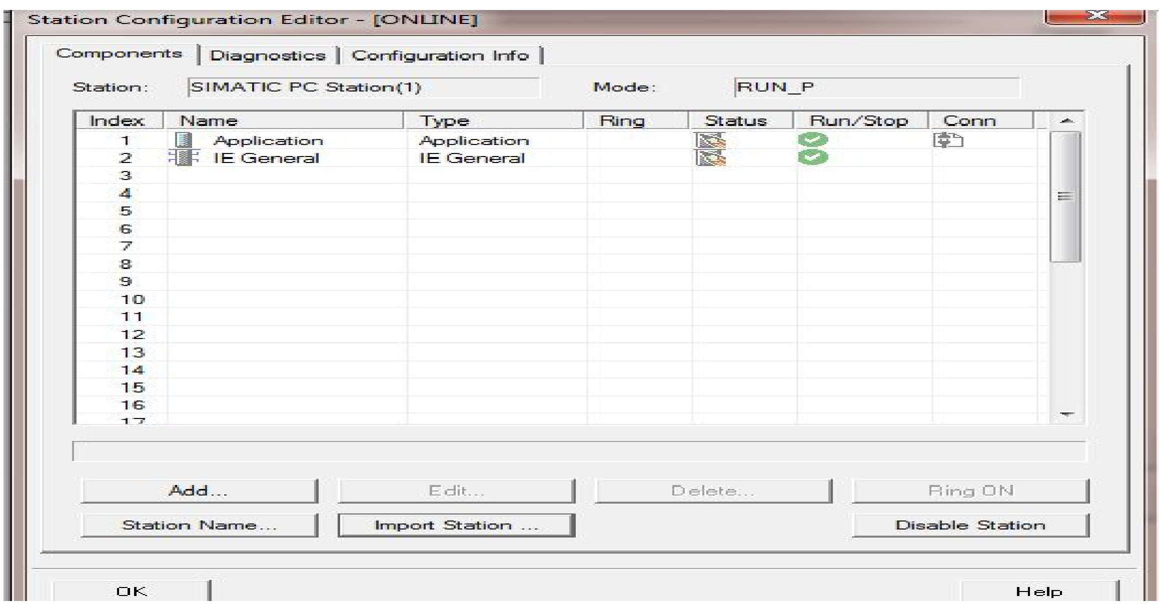

Figure (3.27) Pc Station Configuration

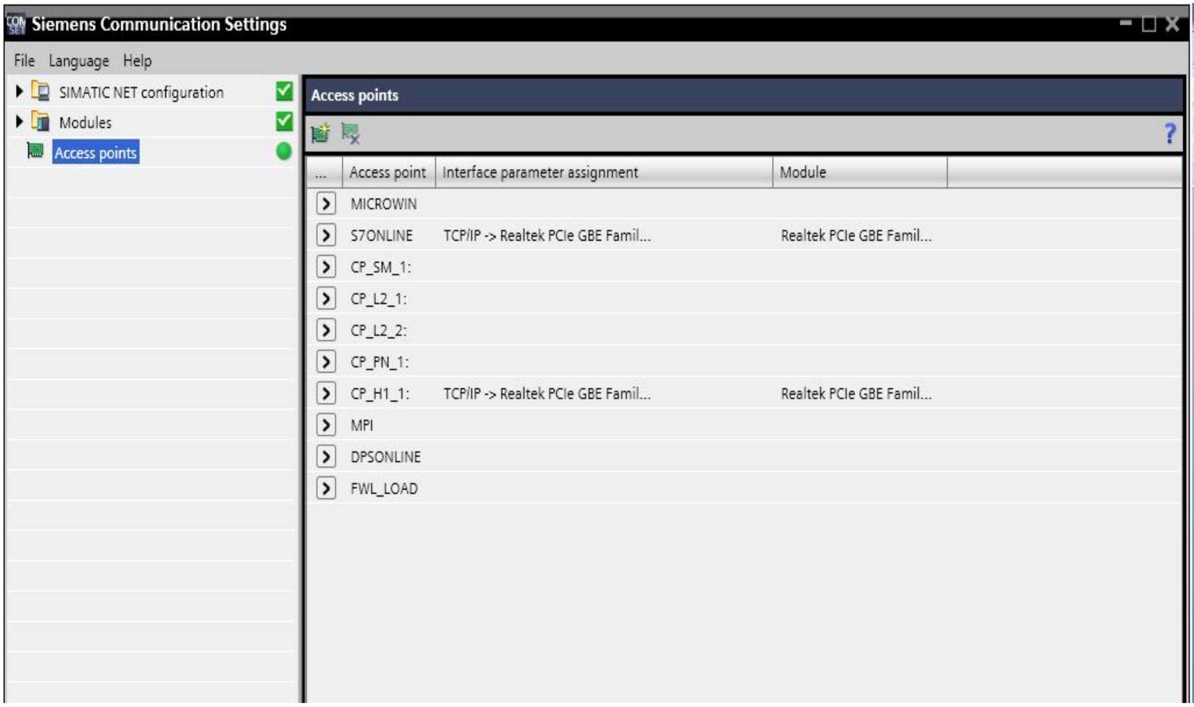

Figure (3.28) Commutation Setting

4. **ST7cc Config (Preparation Received Data)**

First Step: global setting to check the name and IP address as shown figure (3.29)

Second Step: project setting for activate parameter as shown figure (3.30)

ThirdStep: setting local IP, access point and subscriber number as shown figure (3.31)

FourthStep: preparation of all received digital data as shown figure (3.32)

Fifth Step: preparation of all received analog data as shown figure (3.33)

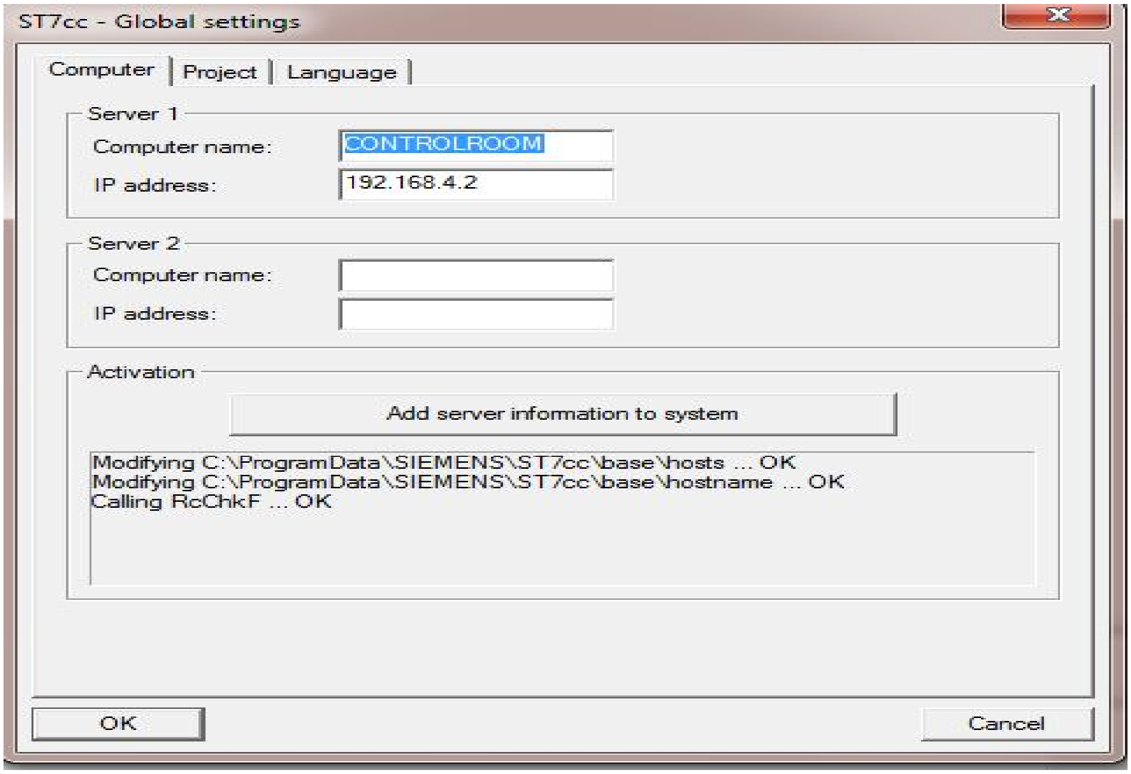

Figure (3.29):Global Setting (Computer)

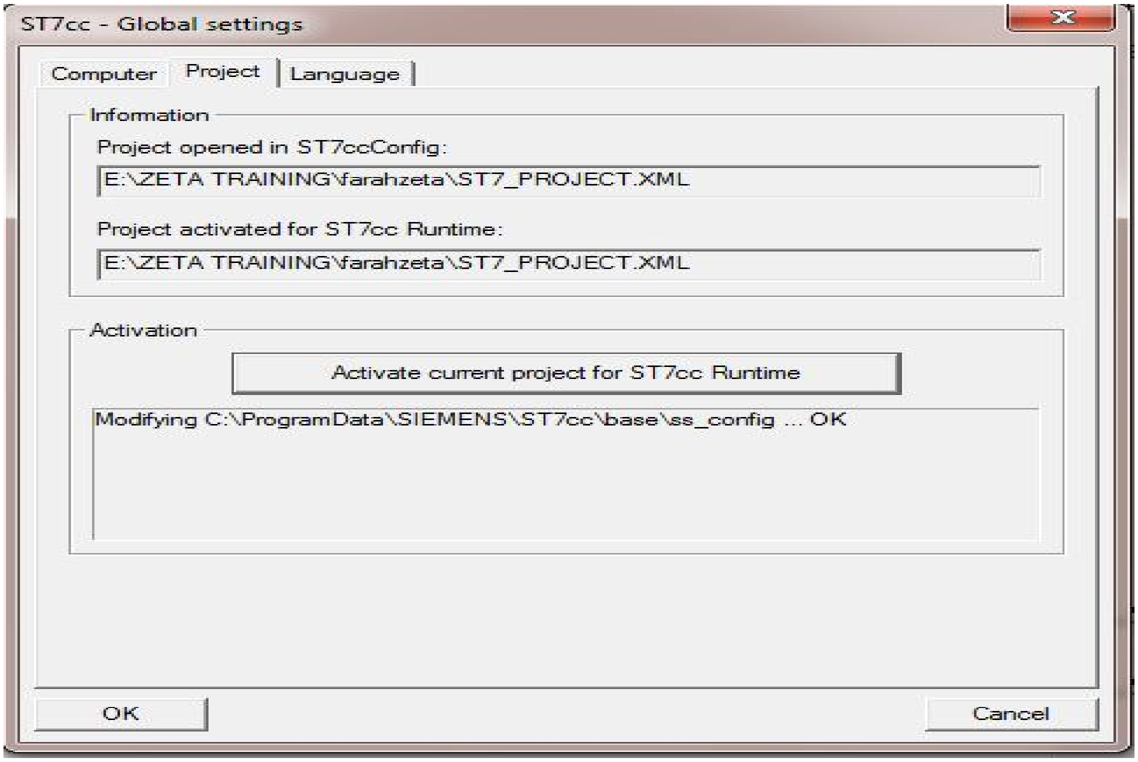

Figure (3.30):Global Setting (Activate Parameter)

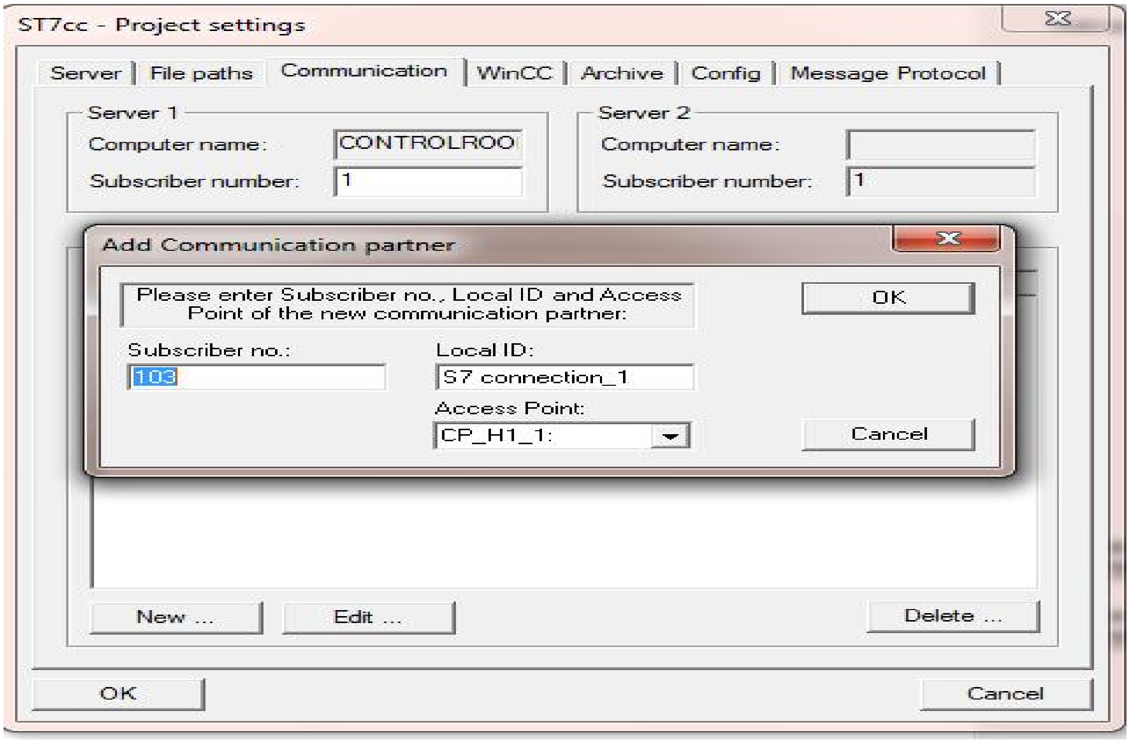

Figure (3.31):Setting of local IPs, Access Point and Subscriber Number

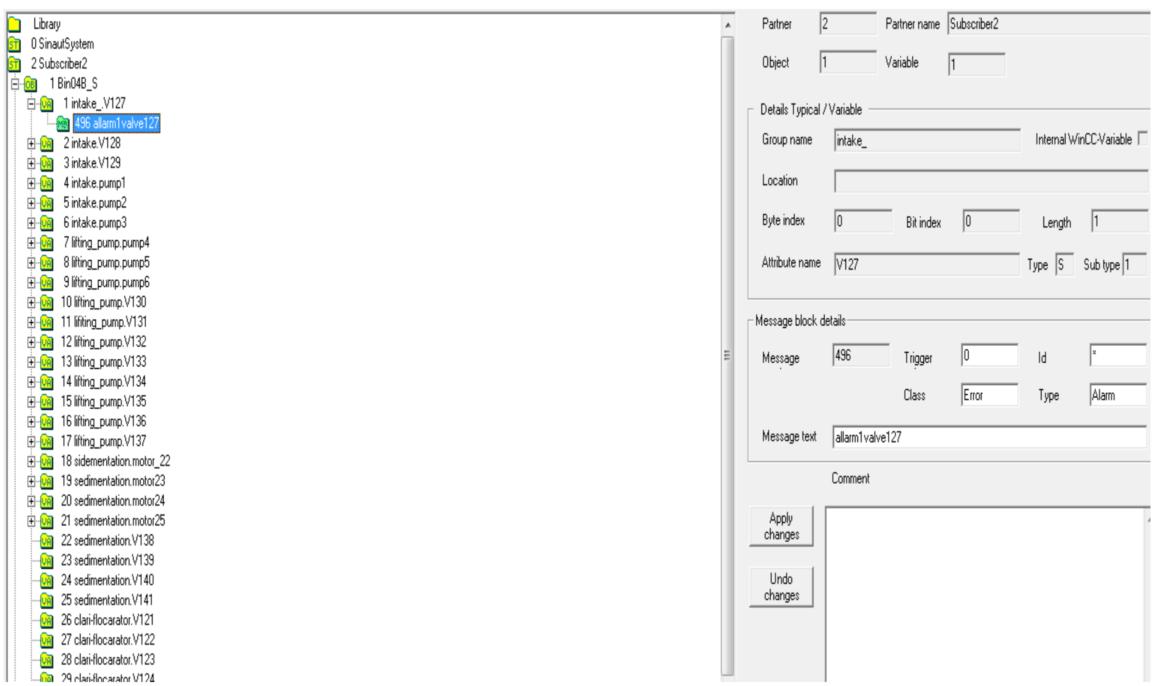

Figure (3.32):Received Digital Data

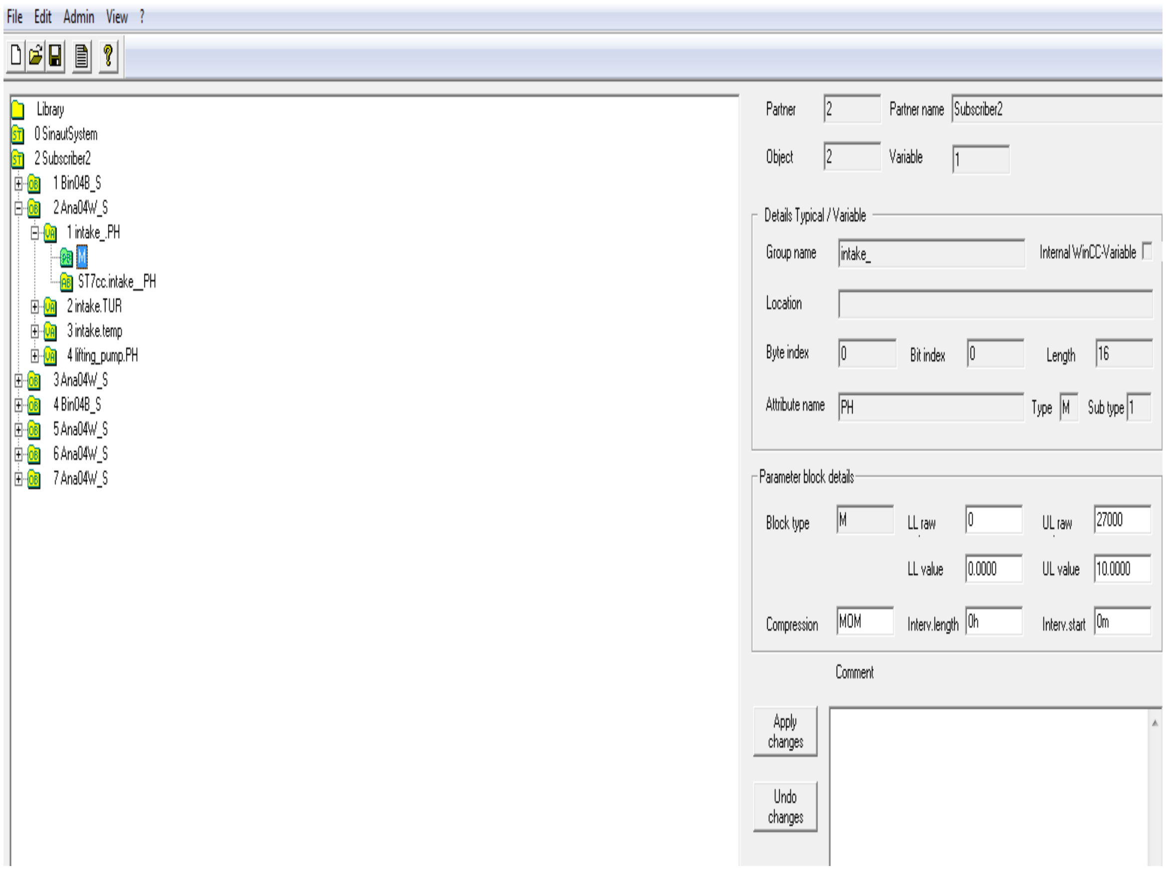

Figure (3.33):Received Analog Data

5. **SCADA Configuration:**

First Step: setting of startups of computer properties (alarm logging, tag logging and graphic runtime) as shown figure (3.34)

Second Step: ST7 server from tag management as shown figure (3.35)

Third Step: generation of all tags from WINCC (edit then select complete WINCC generation) as shown figure (3.36)

Fourth Step: generation tags to WINCCas shown figure (3.37)

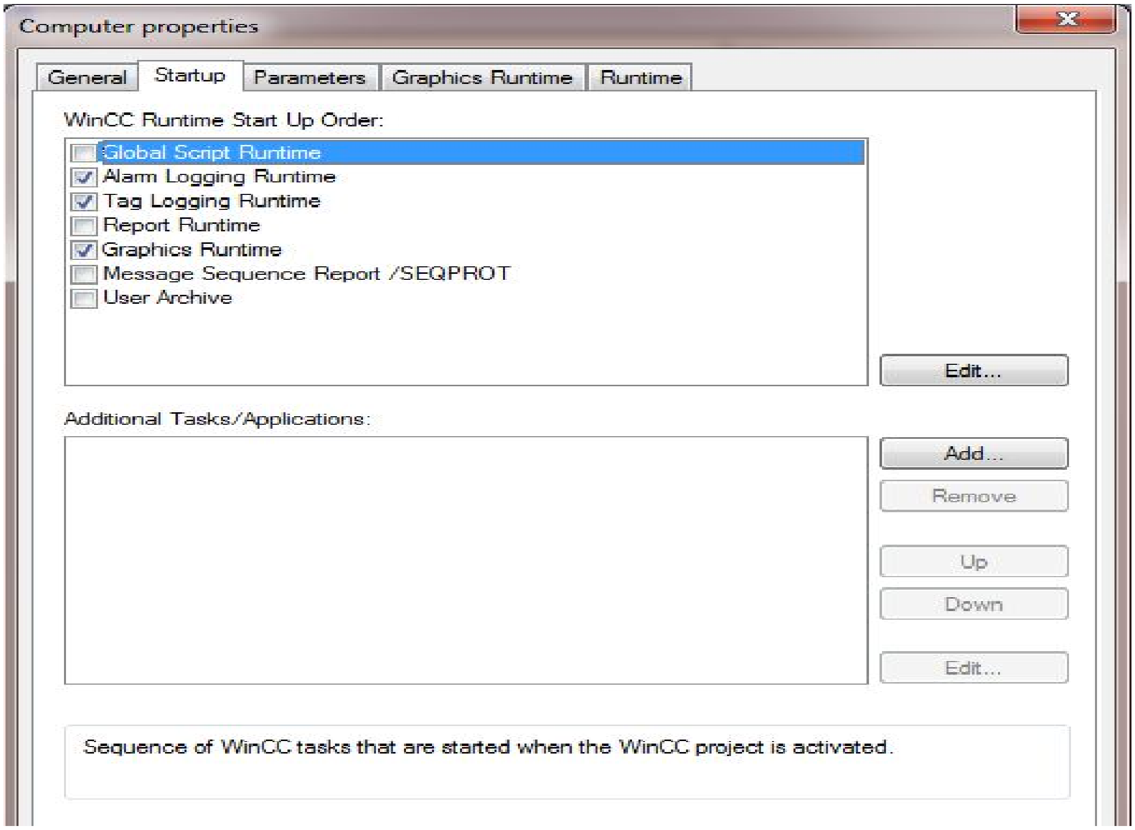

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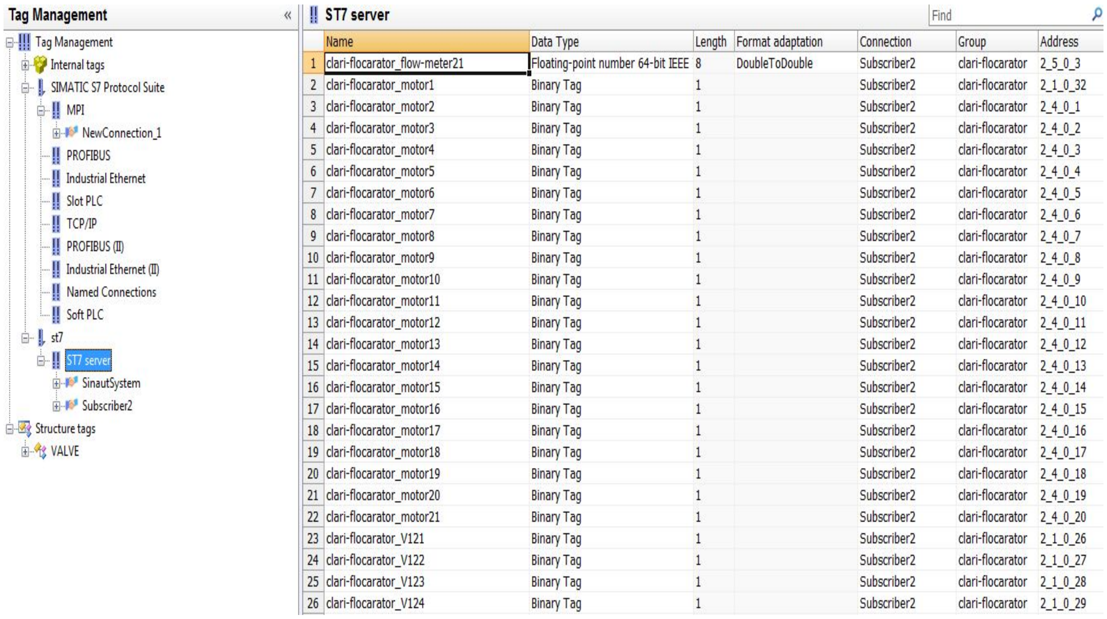
Figure (3.34):Computer Properties



	Name	Data Type	Length	Format adaptation	Connection	Group	Address
1	clari-flocarator_flow-meter21	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2	clari-flocarator	2_5_0_3
2	clari-flocarator_motor1	Binary Tag	1		Subscriber2	clari-flocarator	2_1_0_32
3	clari-flocarator_motor2	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_1
4	clari-flocarator_motor3	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_2
5	clari-flocarator_motor4	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_3
6	clari-flocarator_motor5	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_4
7	clari-flocarator_motor6	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_5
8	clari-flocarator_motor7	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_6
9	clari-flocarator_motor8	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_7
10	clari-flocarator_motor9	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_8
11	clari-flocarator_motor10	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_9
12	clari-flocarator_motor11	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_10
13	clari-flocarator_motor12	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_11
14	clari-flocarator_motor13	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_12
15	clari-flocarator_motor14	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_13
16	clari-flocarator_motor15	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_14
17	clari-flocarator_motor16	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_15
18	clari-flocarator_motor17	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_16
19	clari-flocarator_motor18	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_17
20	clari-flocarator_motor19	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_18
21	clari-flocarator_motor20	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_19
22	clari-flocarator_motor21	Binary Tag	1		Subscriber2	clari-flocarator	2_4_0_20
23	clari-flocarator_V121	Binary Tag	1		Subscriber2	clari-flocarator	2_1_0_26
24	clari-flocarator_V122	Binary Tag	1		Subscriber2	clari-flocarator	2_1_0_27
25	clari-flocarator_V123	Binary Tag	1		Subscriber2	clari-flocarator	2_1_0_28
26	clari-flocarator_V124	Binary Tag	1		Subscriber2	clari-flocarator	2_1_0_29

Figure (3.35):setting of ST7 Server

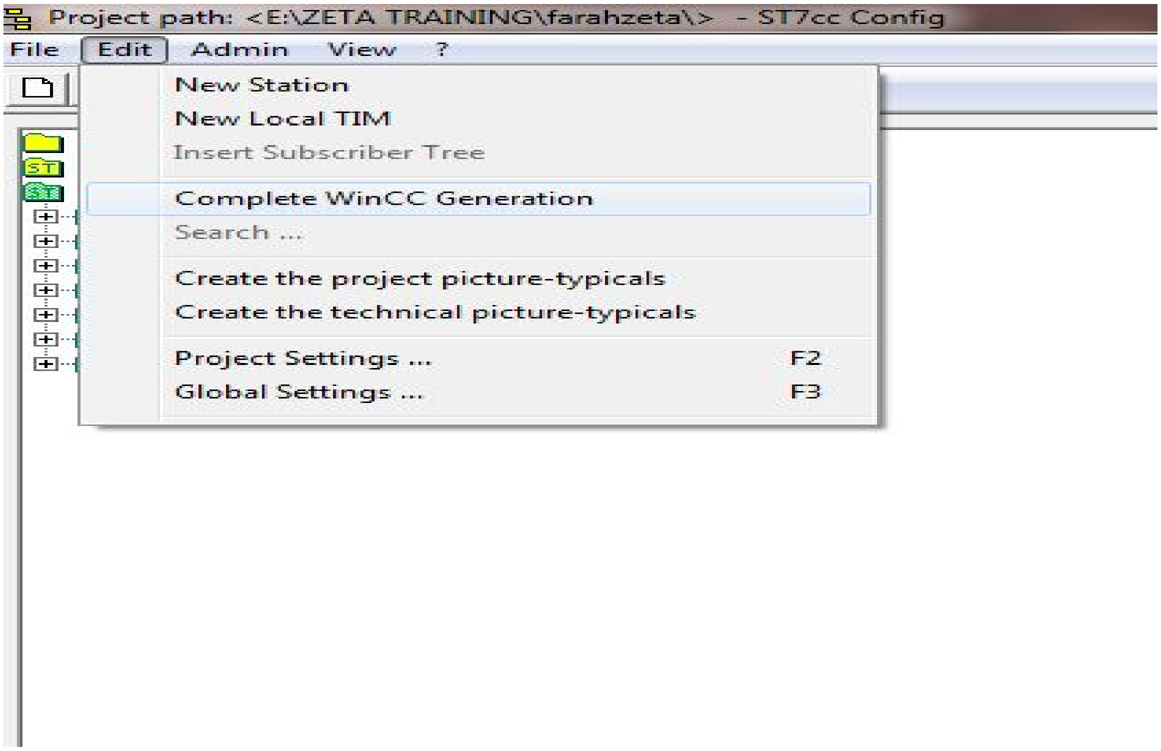
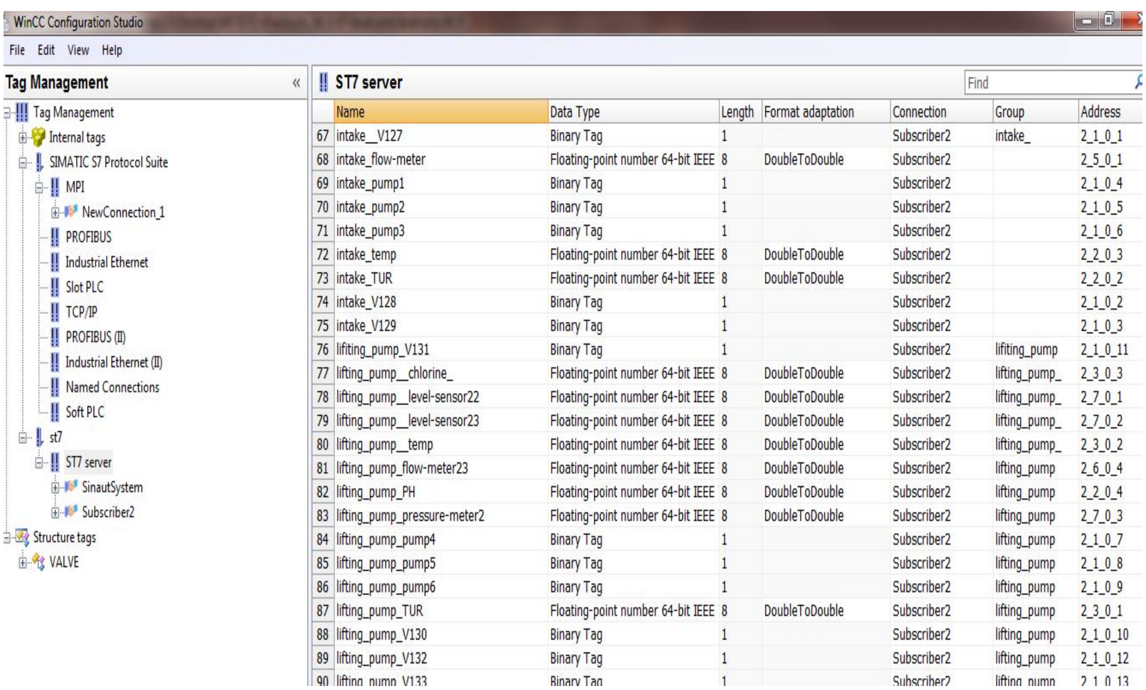


Figure (3.36):Generation Tags to WINCC



	Name	Data Type	Length	Format adaptation	Connection	Group	Address
67	intake__V127	Binary Tag	1		Subscriber2	intake_	2_1_0_1
68	intake_flow-meter	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2		2_5_0_1
69	intake_pump1	Binary Tag	1		Subscriber2		2_1_0_4
70	intake_pump2	Binary Tag	1		Subscriber2		2_1_0_5
71	intake_pump3	Binary Tag	1		Subscriber2		2_1_0_6
72	intake_temp	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2		2_2_0_3
73	intake_TUR	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2		2_2_0_2
74	intake_V128	Binary Tag	1		Subscriber2		2_1_0_2
75	intake_V129	Binary Tag	1		Subscriber2		2_1_0_3
76	lifting_pump_V131	Binary Tag	1		Subscriber2	lifting_pump	2_1_0_11
77	lifting_pump__chlorine_	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2	lifting_pump_	2_3_0_3
78	lifting_pump__level-sensor22	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2	lifting_pump_	2_7_0_1
79	lifting_pump__level-sensor23	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2	lifting_pump_	2_7_0_2
80	lifting_pump__temp	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2	lifting_pump_	2_3_0_2
81	lifting_pump_flow-meter23	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2	lifting_pump	2_6_0_4
82	lifting_pump_PH	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2	lifting_pump	2_2_0_4
83	lifting_pump_pressure-meter2	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2	lifting_pump	2_7_0_3
84	lifting_pump_pump4	Binary Tag	1		Subscriber2	lifting_pump	2_1_0_7
85	lifting_pump_pump5	Binary Tag	1		Subscriber2	lifting_pump	2_1_0_8
86	lifting_pump_pump6	Binary Tag	1		Subscriber2	lifting_pump	2_1_0_9
87	lifting_pump_TUR	Floating-point number 64-bit IEEE	8	DoubleToDouble	Subscriber2	lifting_pump	2_3_0_1
88	lifting_pump_V130	Binary Tag	1		Subscriber2	lifting_pump	2_1_0_10
89	lifting_pump_V132	Binary Tag	1		Subscriber2	lifting_pump	2_1_0_12
90	lifting_pump_V133	Binary Tag	1		Subscriber2	lifting_pump	2_1_0_13

Figure (3.37):GenerationTags in ST7

Table (3.2): Hardware and Software Components Used

No	Item	Code
1	TIM4R-IE	6NH7800-4BA00
2	TIM 3V-IEAdvanced	6NH7800-3CA00
3	PC	
4	Power supplyPS3075A	6ES7307-1EA00-0AA0
5	S7-CPU315PN/DP	6ES7313-5BF03-0AB0
6	MicroMemoryCard	6ES7953-8LF11-0AA0
7	Digital input module	DI16Xdc24V/0.5A
8	Ethernet cable	
9	Digital output module	DO16Xdc24V/0.5A
10	Analogue input	AI4/AO2Xb/8bit
11	SINAUTST7 Engineering Software Edition 09/2009	6NH7997-0CA50-0AA0
12	SINAUTST7cc V2.7	6NH7997-7CA15-0AA1
13	STEP 7 V5.4 SP5	6ES7810-4CC08-0YA5
14	SIMATIC NETPC software Edition 2006	6GK1704-1LW64-3AA0
15	SIMATIC WINCCV7.2 SP2	6AV6381-1BM06-2AX0

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1The Result of Implementation

- **Intake Process**
  - The status of Pump_1

When the soft starter of pump _1 is stopping, the pump cannot be working so the result of pump_1 is default indicated by red color. See the figure (4.1)

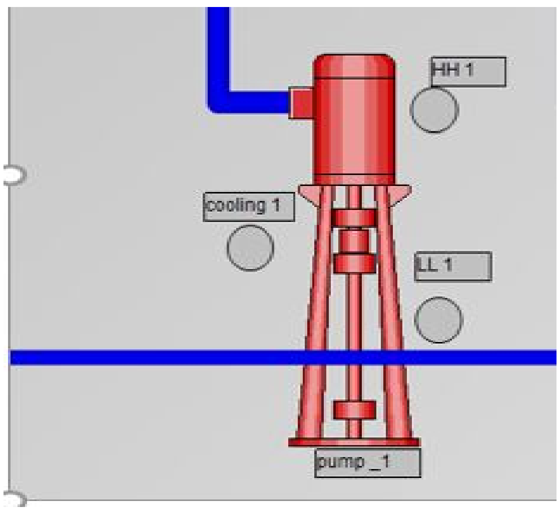


Figure (4.1):Default of Pump_1

If the soft starter of pump _1 is starting, the pump can be working so the result of pump_1 is running indicated by green color. See figure (4.2)

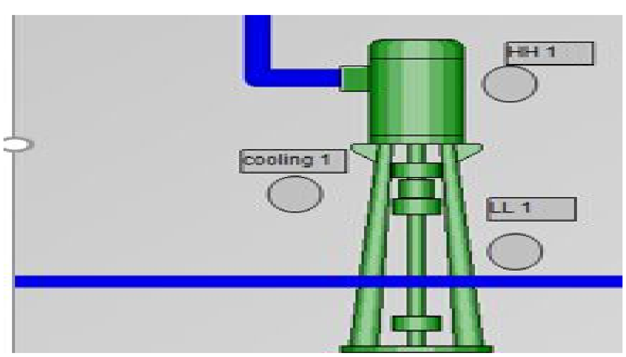


Figure (4.2):Running of Pump_1

➢ The status of electrical motor (V_127)

When the contactor of electrical motor (V_127) in the intake process isde-energize the auxiliary contact usually is normal open so the result of (V_127) is default indicated by red color. See figure (4.3)

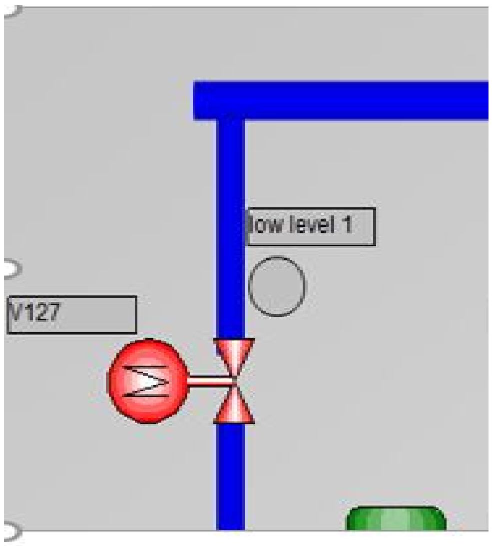


Figure (4.3): Default of Electrical Motor_V127

if the contactor of electrical motor (V_127) in the intake processesenergize the auxiliary contact usually is normal open will change to normal close so the result of (V_127) is running indicated by green color. see figure (4.4)

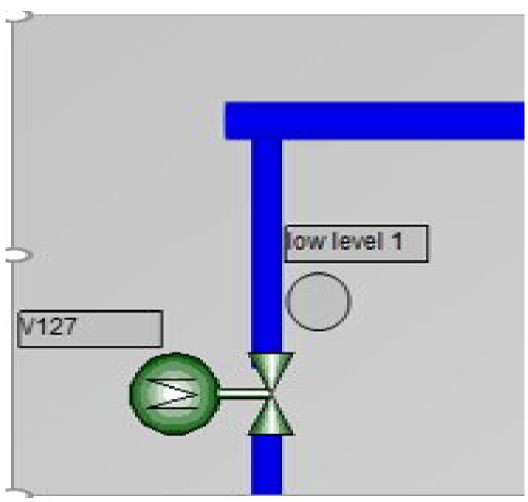


Figure (4.4): Running of Electrical Motor V_127

- The status of level sensor_21

The minimum value oflevel sensor_21 = 3.5 and the maximum value of level sensor_21 =11When the value of level sensor_21 isless than or equal 3.5 or more than or equal 11indicated alarm. Nowthe value of level sensor_21 is = 3 so the result is default indicated by red color. See figure (4.5)

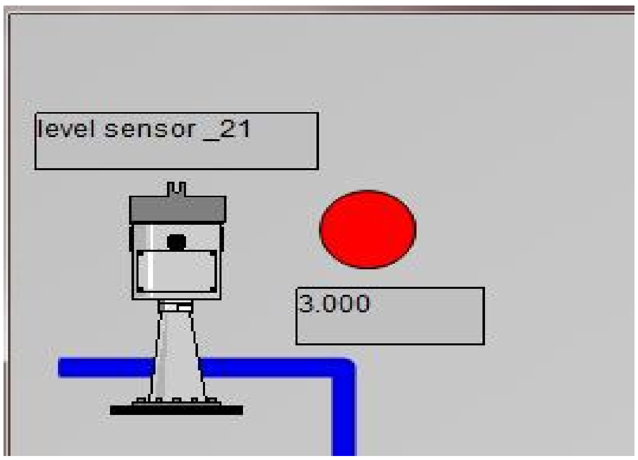


Figure (4.5):Default of Level Sensor _21

Ifthe minimum value oflevel sensor_21 = 3.5 and the maximum value of level sensor_21 =11 When the value of level sensor_21 is less than or equal 3.5 or more than or equal =11indicated alarm. Now the value of level sensor_21 is = 8 so the result is running indicated by green color. See figure (4.5)

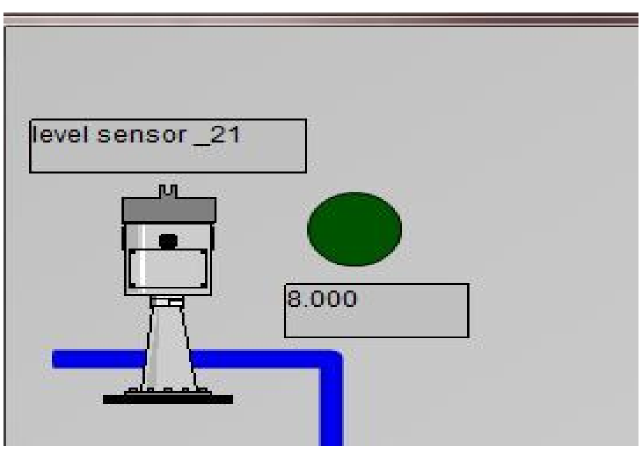


Figure (4.6):Running of Level Sensor _21

➢ The status of pressure meter_1

The minimum value ofpressure meter_1= 1 and the maximum value of pressure meter_1=3.5 When the value of pressure meter_1is less than or equal 1 or more than or equal = 3.5 indicated alarm. Now the value of pressure meter_1 is = 1 so the result is default indicated by red color. See figure (4.7)

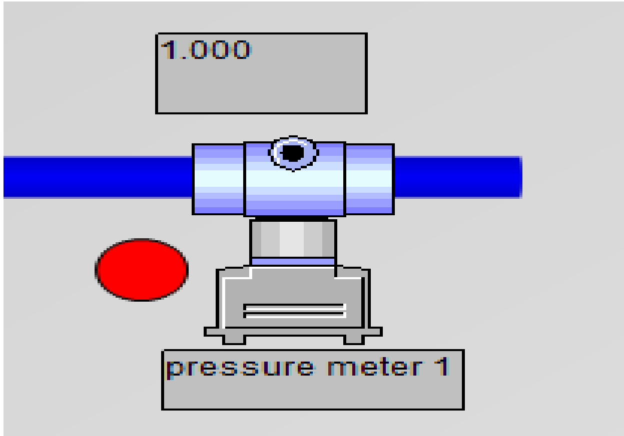


Figure (4.7):Default of Pressure Meter 1

Ifthe minimum value ofpressure meter_1= 1 and the maximum value of pressure meter_1=3.5 When the value of pressure meter_1is less than or equal 1 or more than or equal 3.5indicated alarm. Now the value of pressure meter_1 is = 2 so the result is running indicated by green color. See figure (4.8)

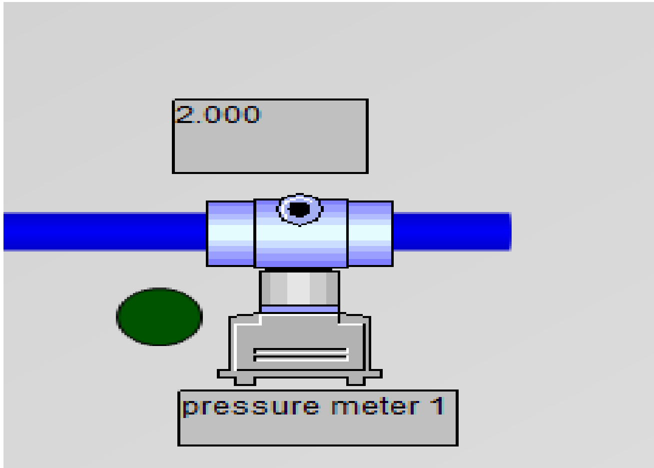


Figure (4.8):Running of Pressure Meter 1

Table (4.1): Actual Value of Device Using In theProcessfromSoba Station

NO	Device	Name of process	High value	Low value
1	Level sensor 21	Intake	11 m	3.5 m
2	Flow meter_ 22	Intake	10000 m^3/hour	0 m^3/ hour
3	Pressure meter_ 1	Intake	3.5 bar	1 bar
4	PH	Intake	8.5 moles/liter	7 moles/liter
5	TUR	Intake	5 NTU	1 NTU
6	Level sensor_ 24	Sedimentation	90%	30%
7	Level sensor_ 25	Sedimentation	90%	30%
8	Flow meter_ 24	Sedimentation	2500 m^3/ hour	0 m^3/ hour
9	Flow meter _25	Sedimentation	2500 m^3/ hour	0 m^3/ hour
10	Flow meter_ 23	Lifting pump	8500 m^3/ hour	0 m^3/ hour
11	Level sensor _22	Lifting pump	98m	45m
12	Level sensor _23	Lifting pump	98m	45m
13	Pressure meter _2	Lifting pump	6 bar	5 bar
14	PH	Lifting pump	8.7 moles/liter	7.5moles/liter
15	TUR	Lifting pump	12000 NTU	500 NTU
16	Chlorine	Lifting pump	4 mg/L	0 mg/L

Table (4.2):Some of Input Module Using In Implementation

NO	Input address	Description
1	I0.0	Electrical valve V_127 intake process (digital input)
2	I0.1	Pump 1 intake process (digital input)
3	PIW100	level sensor 21 intake process (analog input)
4	PIW102	pressure sensor 1 intake process (analog input)
5	PIW104	PH intake process (analog input)
6	PIW106	level sensor 24 sedimentation process (analog input)
7	PIW108	flow sensor 23 lifting process (analog input)
8	PIW110	level sensor 23 lifting process (analog input)
9	PIW112	pressure meter2 lifting process (analog input)
10	PIW114	PH lifting process (analog input)
11	PIW116	TUR lifting process (analog input)
12	PIW118	Chlorine lifting process (analog input)

CHAPTER FIVE

CONCLUSIONSAND RECOMMENDATIONS

5.1 Conclusions

The control center had been configured for authorized users at Khartoum state water corporation center, for remote monitoring of water plant, communications, and system diagnostics. The WINCC software also provides real-time information on reservoirs water level, flow values, water pressure and other mission-critical data, as well as reporting.

SCADA WINCC in each station and DSL router in the center and SINAUT ST7cc for communication use for data exchange between two stations.

5.2 Recommendations

The SINAUT ST7cc. Would is useful to further for communication between Khartoum state water corporation and more than sub-station using DSL or GPRS.

1.7 References:

[1] S.AbdallahA.Adbulkarim . (2004).Methodology to desigy an automatedpump plants with PLC control system. *Proceedings of the International engineering conference. Mutah-Jordan*. 373-398.

[2] OMRON. (2009). How Safe is Allowing Remote Access to Omron PLCsVia the Internet and How is it Accomplished.

[3] L. Harte B. Strange. (2004). Introduction to GPRS and EDGE Technology Operation and Services. *Althos Publishing*. ISBN 1-93-281306-3 NC USA.

[4] Siemens. (2009). SIMATIC S7-1200–Micro Controller for TotallyIntegrated Automation.

[5] M. Duran-Ros. (2008). Definition of a SCADA system for a micro irrigation network with effluents. *computers and electronics in agriculture*. vol.64, pp. 338-342.

[6] ZafarAydogmus. (2009). Implementation of a fuzzy-based level control using SCAD A.*Expert Systems with Applications*. vol. 36, pp.6593-6597.

[7] Adamo, F. Attivissimo, F.Cavone G. Giaquinto.N . (2007). SCADAIHMIsystems in advanced educational courses. *IEEE Transactions onInstrumentation and Measurement*.vo1.56, pp. l09-121.

[8] A. Hossain, M. H. Rashid, The Hardware and Softwar Interface of aProgrammable Logic Grade Process Controller to an Industrial Control System, IEEE Conferance, 1990, USA, pp. 1862-1868.

[9] Nebojsa Matic, Introduction to PLC controllers.

[10] Festo Didactic - Learning system for automation and technology – programmable Logic Controller - Basic Level TP301 – Text Book.

[11] L.A. Bryan, E.A. Bryan, Programmable Controllers - Theory and Implementation, Second Edition.

[12] Siemens Technical Education Program, Basics of PLCs

[13] Modern SCADA protocols, Elsevier, newness publication

[14] Engineering the Architecture of Distributed Control Systems, Eric.

[15] Practical SCADA for Industrial.

[16] Siemens KI PI 2009.

[17] DSL network communication.