Syria Arabic Republic

Syrian Private University

Faculty of Computer & Informatics Engineering

ON-OFF Control of Two Water Tank System

(Phase I)

A Senior Project Phase I Presented to the Faculty of Computer and Informatics Engineering in the Partial Fulfillment of the Requirements for the Degree of Bachelor of Engineering in the Computer and Control Engineering Department

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Dedication

To the source of love and care ..

To the person who fears over me …

To the person who prays for me day and night

Mom

To the teacher of morality ..

To the persons who give me power …

To the person who sacrificed everything to be where I am ..

Dad

To the special people who brings out the best of me..

To the people who stood by me all my life..

To the people who pushed me to be better..

Sisters & Brothers

To all my family, the symbol of love and giving..

Family

To the people I am proud to have in my life ..

Best friends

Along with all hard working and respected..

Teachers

Acknowledgments

Praise be to ALLAH, the beneficent the merciful

Praise to ALLAH for the blessing of mind …

Praise to ALLAH for the blessing of Love …

Praise to ALLAH for his uncountable blessing and guidance.

We dedicate this work to our teachers at the Syrian Private University, Particularly to Prof. Dr. Ali Skaf, the Dean of the Faculty of Informatics & Computer engineering and to all members of the faculty for their help and encouragements.

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Finally, special thanks to Dr. Raghad Samir Al Najim for her countless hours of reflecting, reading, encouragement and her patience throughout the entire work.

Abstract

Among several problems in an Industrial control system, it is a fact that water control management system is a challenging problem. Theoretical study as well as practical implementation is considered for this work.

Two interactive tank system are considered and three point control is carried out using a proposed algorithm. The idea and the steps of this algorithm was proposed by some costumer who would like to implement such a problem in their company.

In this work two special control tools will be used, SCADA system and software will be implemented to simulate the two tanks and three point control approach depending on the types of sensors that will be used , also to manage the water level control system in the control room in a supervisory manger.

Finally the proposed algorithm as well as the simulated SCADA system will be carried out using the programming logic control PLC in a practical manger. Taking into consideration that the theoretical study and analysis of such interactive level control system has been done in an junior project and the stability considerations was satisfied.

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Chapter One

Introduction

1.1 Introduction

Certain industrial processes cover areas that may be measured in the thousands of square miles and have dimensions that may be hundreds, occasionally thousands, of miles long. Over the past thirty-five years, a method Knows as SCADA, for supervisory control and data acquisitions, has evolved for monittoring and controlling processes that cover such large areas. As with most evolving tcchnologies, SCADA has borrowed something from one applied science and something else from others. It is now a mature technology. That is not to say that SCADA will stop evolving but rather that most of its current techniqes have cleared the hurdles that the real world places in the path of new ideas.

This is a practical Implementation of some real time applications of two water tank level system management and control in a building such as hotels and hospitals.

The design requirements were done in earlier project of two level interactive tank system theoretically. And in this project the control design will be implemented using SCADA system and PLC based on a proposed algorithm that was suggested by some user in order to be applied in a hospital in Damascus- Syria.

This work will be portioned in two parts the first part will consider the constructed of the proposed algorithm and applied it to SCADA system and software; the second part will include the design implementation of the SCADA models practically based on PLC system in a hardware manner.

1.2 Scope of the Project

The scope of this work can be organized as follow:

Chapter One: Introduction

We will give an introduction about project and what we used in project.

Chapter Two: An introduction to supervisory control and data acquisition SCADA System

This chapter will include some definitions of SCADA, its application area as well as some functions that could be useful and related to our work.

Chapter Three: Programming Logic Controllers (PLC)

We will define PLC and why we use it and define PLC components.

Chapter Four: Proposed Algorithm of project

In this chapter, the proposed algorithm will be introduced and discussed also the type of the control strategy will be specified.

Chapter Five: Implementation using SCADA

The proposed algorithm discussed in previous chapter will be implemented using SCADA system and to manage the water level and flow throughout the entire system.

Chapter Six: The suggested future work

The final chapter will handle with future work that will be suggested to complete the entire work using SCADA and PLC systems.

1.3 Aim of The Project

The theoretical study of the system has been done in a previous research, and after confirming the results of the stability system, a choice has been made to choose a suitable controller which is called three point controllers.

This type of control system depending on the measurements of the sensors and measurements of water levels based on it.

Thus the aim of such work is to do the following::

1- Defining an algorithm that will depend on water management and control the level in two interactive tanks of water tank system.
2- Build a SCADA system: Build a water level control system of two interactive tanks using SCADA.
3- Practically and real time system will also be constructed via PLCs of the entire system to manage and control the water in the system
4- A verification of the entire SCADA as well as PLC system will supervised by the user using the CONTROL room in the SCADA model.

Chapter Two

An introduction to supervisory control and data acquisition [SCADA] System

SUPERVISORY CONTROL AND DATA ACQUISITION

(SCADA)

2.1 Introduction

SCADA is the technology that enables a user to collect data from one or more distant facilities and to send limited control instructions to those facilities. SCADA makes it unnececssary for an operator to be assigned to stay at or freqyently visit remote locations when those remote facilities are operating normally. SCADA includes the operator interface and the manipulation on application-related data, but it is not limited to that. Some manufacturers are building software packages that they call SCADA, and while these are often well suited to act as parts of SCADA system, because they lack communications links and other nececssary equipment they are not complete SCADA systems.

SCADA stands for Supervisory Control and Data Acquisition. SCADA systems are an important part of most nations' infrastructures.

They control a wide variety of operations such as pipelines, chemical plants, power plants, water management systems, etc. Because a SCADA system provides remote monitoring and control, it is perfect for industrial operations that could be hazardous to an operator.

SCADA has come a long way since it was developed in 1960. Low-cost microcomputers made computer control of process and manufacturing operations feasible.

Programmable logic controllers also known as PLCs introduced relay ladder logic to the control industrial process. They allowed engineers to program in relay logic instead of using programming languages and operating systems. Initially, control systems were only accessed locally.

With the evolution of the microcomputers, PLCs, standard computers, operating systems, and networks, SCADA has expanded into distributed systems. SCADA now allows real-time remote monitoring and control distant operations.

2.2 Definition of SCADA

SCADA is the technology that enables a user to collect data from one or more distant facilities and / or send control instructions to those facilities. SCADA makes it unnecessary for an operator to be assigned to stay at, or to visit, remote locations in the normal operation of that remote facility.

SCADA is an acronym that is formed from the first letters of Supervisory Control and Data Acquisition. A SCADA system allows an operator, in a location central to a widely distributed process such as an oil or gas field, pipeline system, or hydroelectric generating complex, to make set point changes on distant process controllers, to open or close valves or switches, to monitor alarms, and to gather measurement information.

When the dimensions of the process become very large – hundreds or even thousands of kilometers from one end to the other – the benefits in terms of reduced cost of routine visits can be appreciated.

Typical signals gathered from remote locations include alarms, status indication, analog values, and totaled meter values. However, with this apparently limited menu of available signal types, a vast range of information can be gathered.

Similarly, signals sent from the central location to the remote site are usually limited to discrete binary bit changes or analog values addressed to a device at the process. An example of a binary bit change would be an instruction ordering a motor to stop. An analog value example would be an instruction to change a valve controller set point to 70 percent. Given simple signal types like these and some imagination, many control changes can be effected (Boyer, 1993).

THE SCADA SYSTEM FROM THE UNIVERSITY OF ORADEA

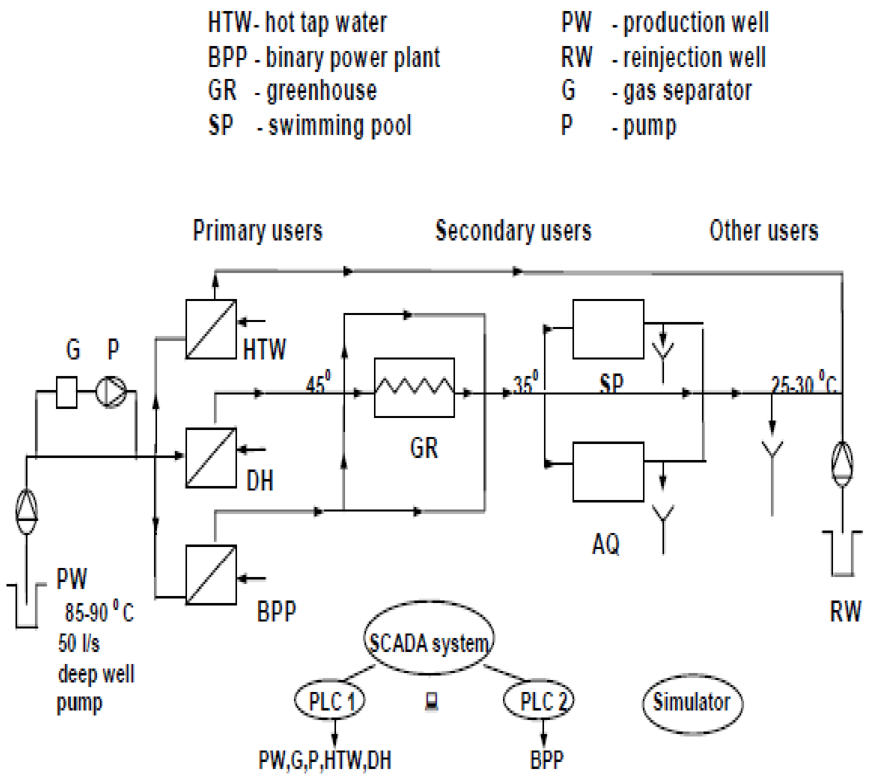


Figure (2.1) **The SCADA System from the University of ORADEA**

2.3 Components of SCADA System

SCADA systems are composed of the following:

a. Field Instrumentation

b. Remote Stations

c. Communications Network

d. Central Monitoring Station

A SCADA system consists of a computer placed at a central location, communications equipment, programmable logic controllers, sensors, and other devices that when put together, will monitor and control equipment and processes in a utility, such as a water system.

Remote sites, equipped with remote telemetry units (RTUs), can be located as close as within the same building or as far away as across the country.

RTUs measure a variety of conditions and parameters, including tank levels, temperature, voltage, current, volumes, and flow rates, and report back to a central processing unit (CPU).

This technology is widely accepted in the water and wastewater industries as a reliable and efficient control system.

2.4 SCADA Equipment Enhances Water Operations

Functions that the SCADA system can perform include: remote monitoring of well levels and control of their pumps, and monitoring flows, tank levels, or pressures in storage tanks.

A SCADA system can also monitor water quality characteristics, such as pH, turbidity, and chlorine residual, and control the addition of chemicals.

In the distribution system, SCADA can supervise and control the water pressure of networks, assure water pressure is uniformly distributed, lower the leakage rate, and store data for future analysis.

SCADA is not a new technology by any means, but significant innovations and improvements have been achieved since its introduction. By automating many routine tasks, a SCADA system frees the viable option.

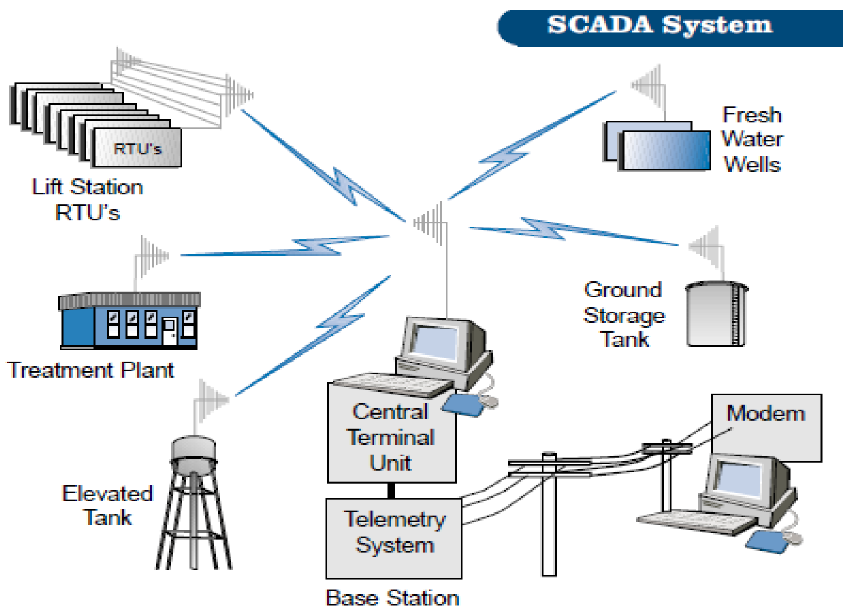


Figure (2.2) SCADA System

Initial installation costs, which are often high, typically pay for themselves in a short time through direct labor and vehicle cost savings, as well as increased efficiency.

Due to a low tax base, many small communities have limited financial resources for drinking water system management and operation.

Thus, it is difficult for operators to maintain extensive manual monitoring to ensure the system complies with complex regulations.

These small systems, therefore, frequently violate (monitoring/reporting violations).

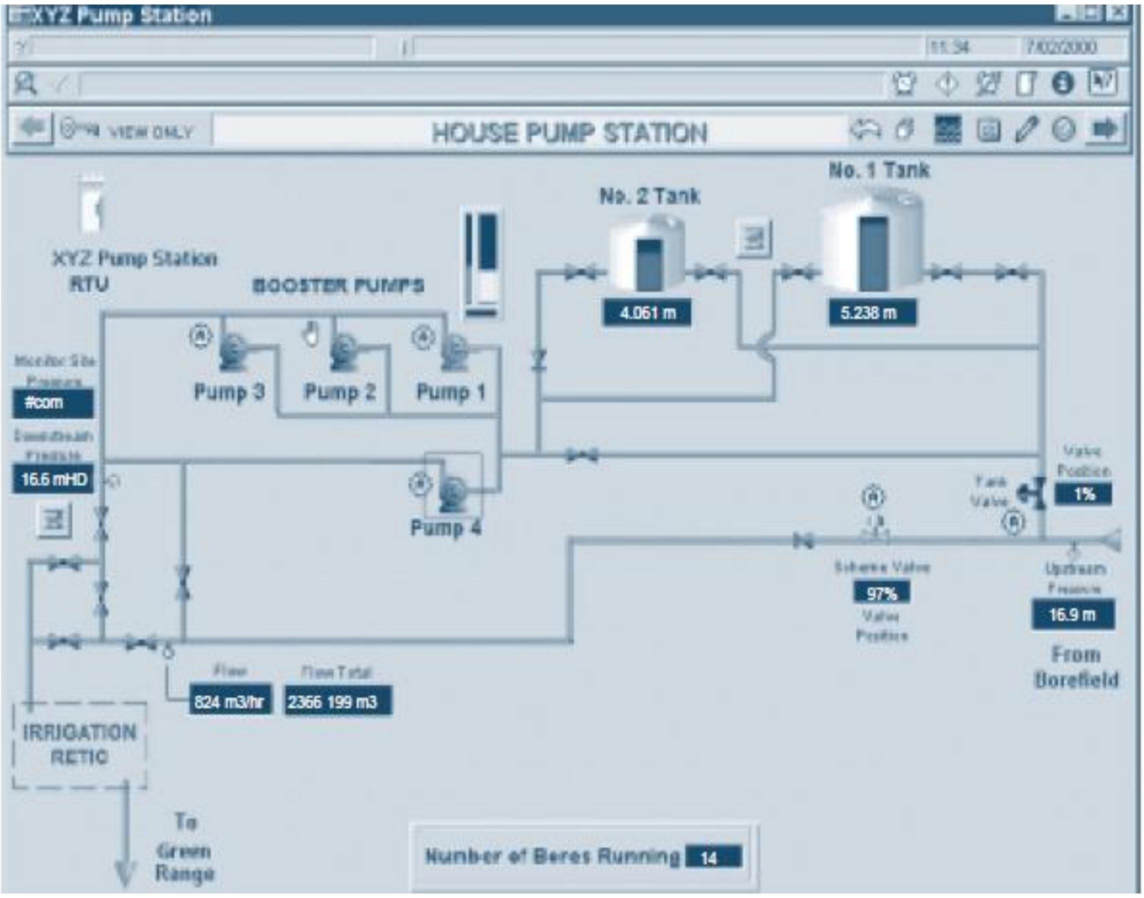


Figure (2.3) **SCADA Interface**

Plant operator to perform other duties, such as addressing state and federal reporting requirements.

In fact, SCADA can assist in mandated reporting because it can store various activities and information on the computer.

Graphs and reports can be generated automatically using the data collected remotely from the field.

These reports are important in inferring production and consumption patterns, data that help manage the water resources more efficiently.

Stored information also proven invaluable when producing the annual Consumer Confidence Reports required under the 1996 Safe Drinking Water Act (SDWA) Amendments.

SCADA is useful in an emergency situation. Immediately following an incident, an operator can be notified via personal pager and increase response capability dramatically.

SCADA provides multipurpose utility management, operating flexibility and more complex system control. SCADA keeps an eye on the entire system from one place.

2.5 SCADA Provides Cost-Effective Control and Monitoring for Small Water Systems

Because of its cost, smaller systems often viewed SCADA as a luxury item. But water system management has become complex and SCADA has become more advanced yet, paradoxically less expensive, making SCADA the SDWA and its amendments, according to the National Research Council.

One solution to keeping up with ever more stringent requirements is for several small communities to pool their resources.

The U.S. Environmental Protection Agency is evaluating the option of using remote telemetry, called an "electronic circuit-rider," that allows one qualified operator to monitor and control the operation of several small treatment systems from a centrally located computer.

Using such a system can optimize the time spent taking daily readings out in the field. For onsite inspection and maintenance efforts, the RTS allows the operator to visit only the problematic systems.

The results expected from an appropriately designed and successfully deployed remote monitoring and control system include enhanced water quality, compliance with existing water quality regulations, and reduced operating and maintenance costs for small communities.

2.6 SCADA system software

Selecting the appropriate SCADA system software is all-important. The software program should be capable of performing every task needed to operate and maintain water treatment and the distribution system.

Its use in many similar applications should prove its reliability.Make sure the hardware supplier and the software developer can guarantee prompt, efficient, and cost effective support.

The manufacturer should have experience in the water and wastewater industry and be able to provide service, replacement parts, and support for the system when needed.

To expedite the selection of specific devices/ components for an RTS that monitors and controls a small drinking water facility, prepare a list of features associated with the particular water treatment facility.

Identify the water quality parameters and types of monitoring that are key to the specific operation. For example, monitor residual chlorine to verify disinfection operations.

Next, review the regulatory compliance requirements and consider them when reviewing manufacturers' specifications and discussing the applicability of their device or system. Finally, select the monitoring device.

It is important to document the pump characteristics, operational functions, and the physical dimensions of the treatment system before selecting components to monitor flow John Barker, plant operator for Martin's Ferry, Ohio, inspects the water levels of the system's storage tanks from his desk.

2.7 Using simulators

Some commercial simulators, such as Opal Software's slim SCADA, provide a virtual environment for studying SCADA systems.

They are mostly used to imitate the network traffic between field devices and MTUs and are effective at reducing hardware purchase and installation costs.

2.8 Building small-scale SCADA systems

Government and academic researchers use commercial hardware and software to build laboratory-scale test beds of some SCADA systems such as industrial blowers, gas pipelines, power grids, and petroleum storage tanks.

For example, Mississippi State University has a test bed for studying and learning about multiple industrial control systems.

The Idaho National Laboratory has a test bed of a full-scale electrical grid that is dedicated to control system cyber security assessment, standards improvements, and training.

2.9 Industry collaboration

When applying for project funding, researchers try to engage SCADA owners and operators as industrial partners. The terms of agreement for a project usually involve technical assistance, facility access (at least to the test bed the operators use for testing application patches from vendors), and financial support.

Industrial collaboration provides close access to real-world SCADA systems and the technical personnel who actually experience the problems and understand the limitations of their particular system.

However, industry collaboration is often difficult to achieve due to the critical nature of SCADA systems, which discourages owners and operators from cooperating with the research community to prevent information leakage.

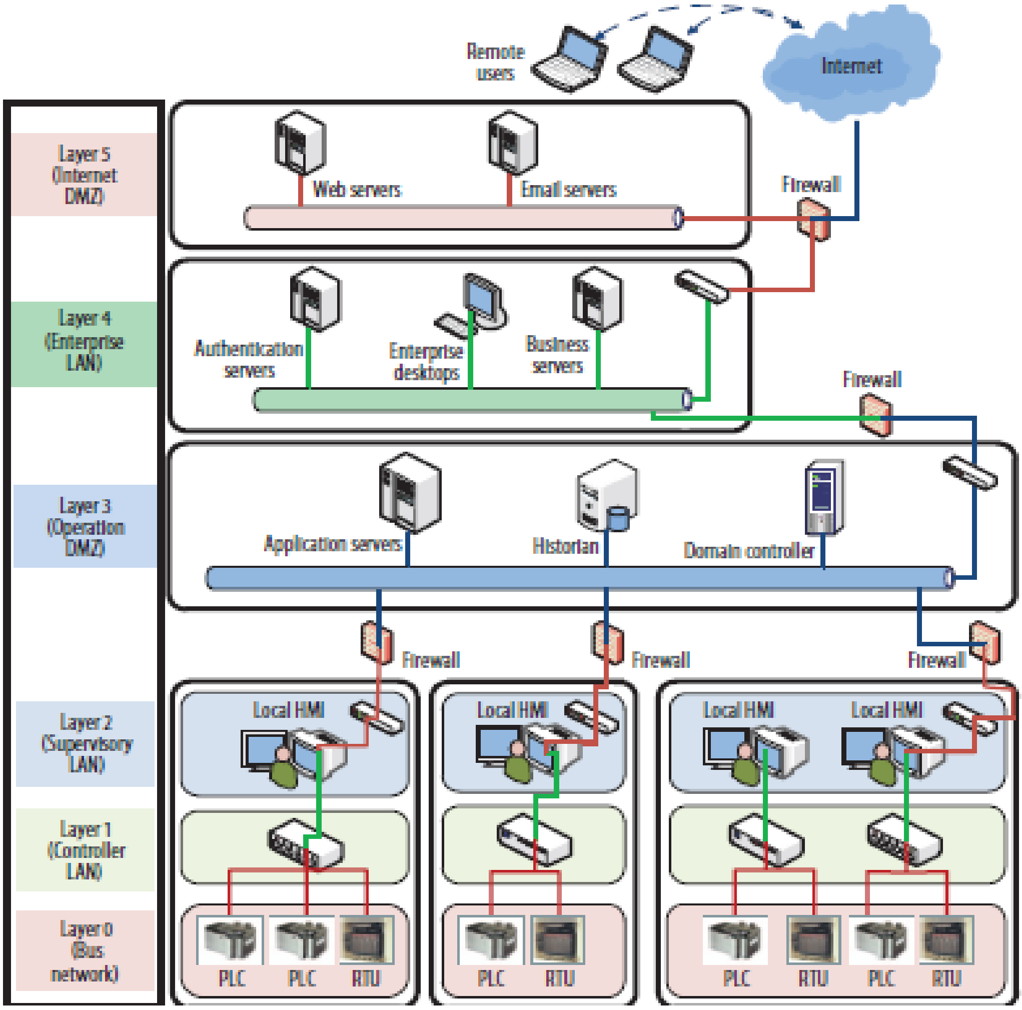


Figure (2.4) **SCADA Layers**

Chapter Three

Programming Logic Controllers (PLC)

3.1 PLC is

Also called a PLC or programmable controller, is a computer-type device used to control equipment in an industrial facility.

The kinds of equipment that PLCs can control are as varied as industrial facilities themselves. Conveyor systems,

food processing machinery, auto assembly lines…you name it and there's probably a PLC out there controlling it.

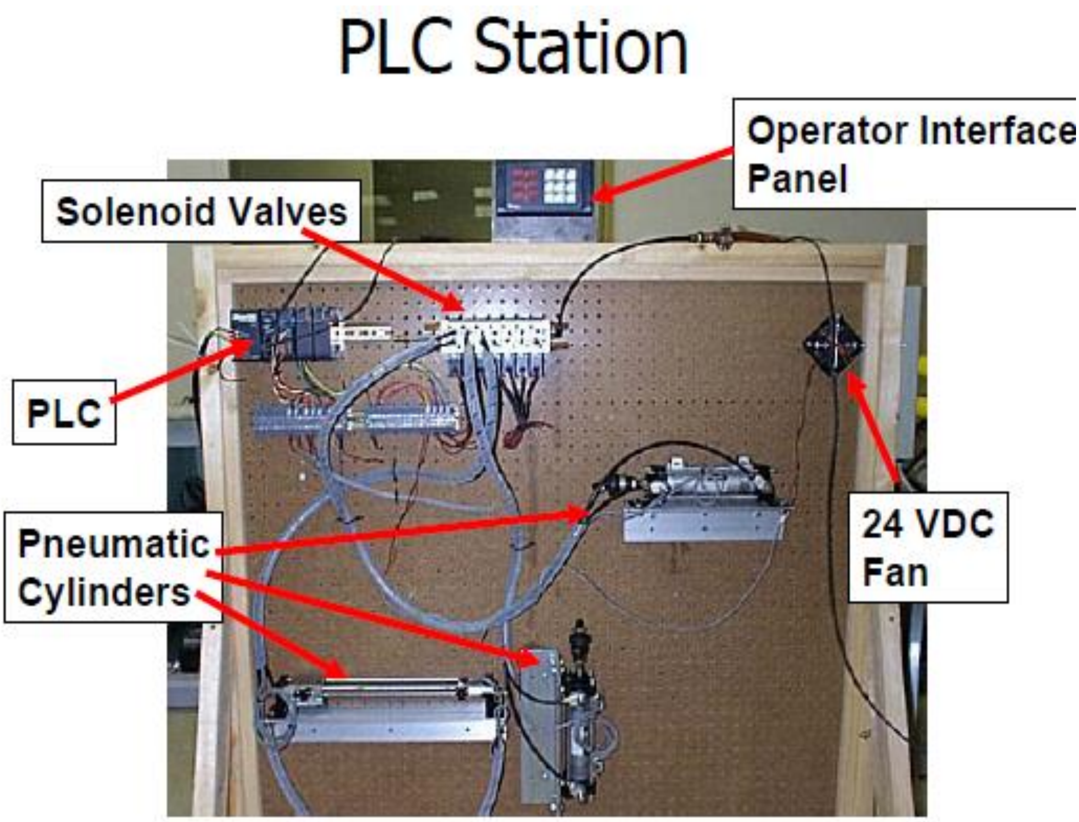


Figure (3.1) **PLC station**

Figure (3.2) PLC Hardware

In a traditional industrial control system, all control devices are wired directly to each other according to how the system is supposed to operate. In a PLC system, however, the PLC replaces the wiring between the devices. Thus, instead of being wired directly to each other, all equipment is wired to the PLC. Then, the control program inside the PLC provides the “wiring” connection between the devices.

The **control program** is the computer program stored in the PLC’s memory that tells the PLC what’s supposed to be going on in the system.

The use of a PLC to provide the wiring connections between

system devices is called soft wiring.

3.2 Why use PLC ?

The soft wiring advantage provided by programmable controllers is tremendous. In fact, it is one of the most important features of PLCs. Soft wiring makes changes in the control system easy and cheap.
If you want a device in a PLC system to behave differently or to control a different process element, all you have to do is change the control program.
In a traditional system, making this type of change would involve physically changing the wiring between the devices, a costly and time-consuming endeavor.

Let's say that two push buttons, PB1 and PB2, are connected to a PLC. Two pilot lights, PL1 and PL2, are also connected to the PLC.

The way these devices are connected now pressing push button PB1 turns on pilot light PL1 and pressing push button PB2 turns on pilot light PL2.

Let's say that you want to change this around so that PB1 controls PL2 and PB2 controls PL1
In a traditional system, you would have to rewire the circuit so that the wiring from the first push button goes to the second pilot light and vice versa. However, because these devices are connected to a PLC, making this change is as simple as making a small change in the control program.

In addition to the programming flexibility we just mentioned, PLCs offer other advantages over traditional control systems.

a- high reliability- small space requirements - computing capabilities
d- reduced costs- ability to withstand harsh environments- expandability

A PLC basically consists of two elements:

- The central processing unit
- The input/output system

3.3 But what exactly is a PLC ?

The central processing unit (CPU) is the part of a programmable controller that retrieves, decodes, stores, and processes information. It also executes the control program stored in the PLC's memory.

In essence, the CPU is the "brains" of a programmable controller. It functions much the same way the CPU of a regular computer does, except that it uses special instructions and coding to perform its functions.

The CPU has three parts:

- The processor
- The memory system
- The power supply

The processor is the section of the CPU that codes, decodes, and computes data.

The memory system is the section of the CPU that stores both the control program and data from the equipment connected to the PLC.

The power supply is the section that provides the PLC with the voltage and current that needs to operate.

3.4 PLC – is an "Industrial" Computer

Hardware & Software adapted to Industrial Environment and Electrical Technician.

3.5 Why Programmable Logic Control?

a- PLC is the work horse of industrial automation.

b- Production processes go through a fixed repetitive sequence of operation with logical steps.

c- Electronic Relays were used prior to PLC s.

d- Control systems were hard-wired using relays, timers and logical units.

e- Control system had to be re-wired for new applications.

f- Inflexible and time consuming.

g- Resulted in product delays, high production costs.

3.6 PLC Overview

A PLC consists of 4 main parts:

1- Program Memory: Stores instructions for logical control sequence.

2- Data Memory: Stores status of switches, interlocks, past and current

Values of data items.

3- Output Devices: Hardware/software drivers for industrial process actuators

Solenoid switches, motors, valves.

4- Input Devices: Hardware/software drivers for industrial process sensors.

Switch status sensors, proximity detectors, interlock settings …

Central Processing Unit: Brain of the PLC.

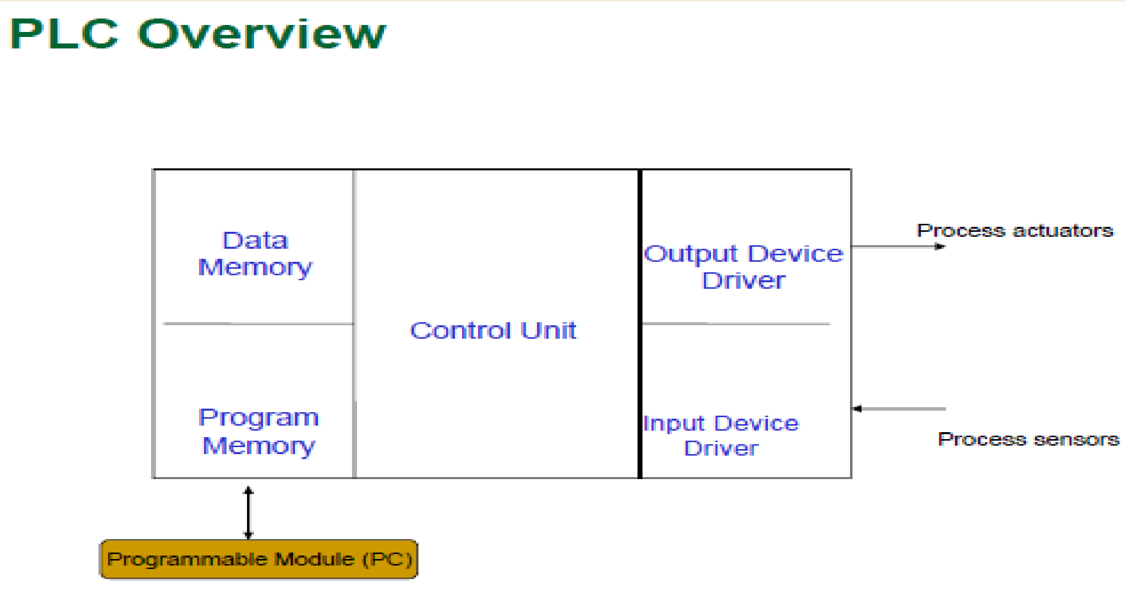


Figure (3.3) PLC Overview

3.7 Central Processing Unit (CPU)

- contains one or more processors to control the PLC.
- Handles communication with other components.
- Handles computations: executes OS, manages memory, monitors inputs, evaluates the user logic(“ladder logic”).
- Programming language: ladder logic.
- Lab PLC CPU (Rockwell).
- Key switch is used to switch between different CPU modes.
- Program Mode.
- Run Mode.
- Remote Mode.

3.8 CPU Modes

- Program Mode: All outputs are forced to off condition regardless of their .
- State in logic.
- Develop and download your program in memory.
- Run Mode: PLC continuously scans and executes your ladder logic.
- Remote Mode: Allows you to remotely control the CPU mode from you.

  Computer: Switch between Program and Run modes from your Computer.

3.9 Memory

- PLC Memory stores OS memory and application memory
- OS Memory: The OS is burned into ROM by Manufacturer and controls
- System software used to program PLC ROM is non-volatile
- Application Memory:
- Stores status of inputs and outputs, i.e. I/O Image tables as patterns

  Of 0 and 1 (binary digits)
- Stores contents of variables in user programs: “timers” ,“counters”
- Random Access Memory:
- Your programs run/execute in the RAM.
- RAM is volatile – All data items in the RAM are lost if power is turned off Mode.

3.10 Input/output Modules

- Input Module:
- Takes inputs from the outside world from any device (protects the CPU).
- Converts real-world logic to CPU logic.
- (**250 VAC Input Module**)
- low-level DC Signal.
- Output Module:
- Provides connection to the real-world output devices.
- Output modules can handle DC or AC voltages to output digital or analog .

Basic PLC Architecture

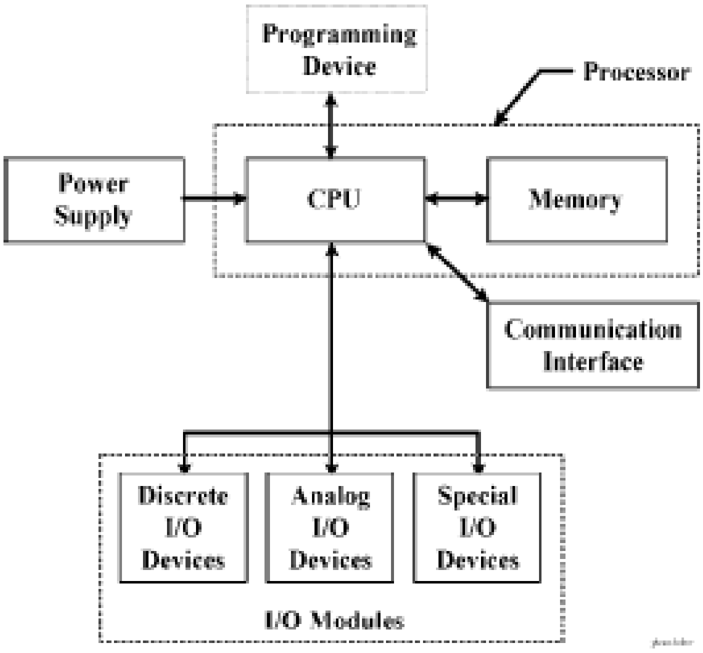


Figure (3.4) PLC Architecture

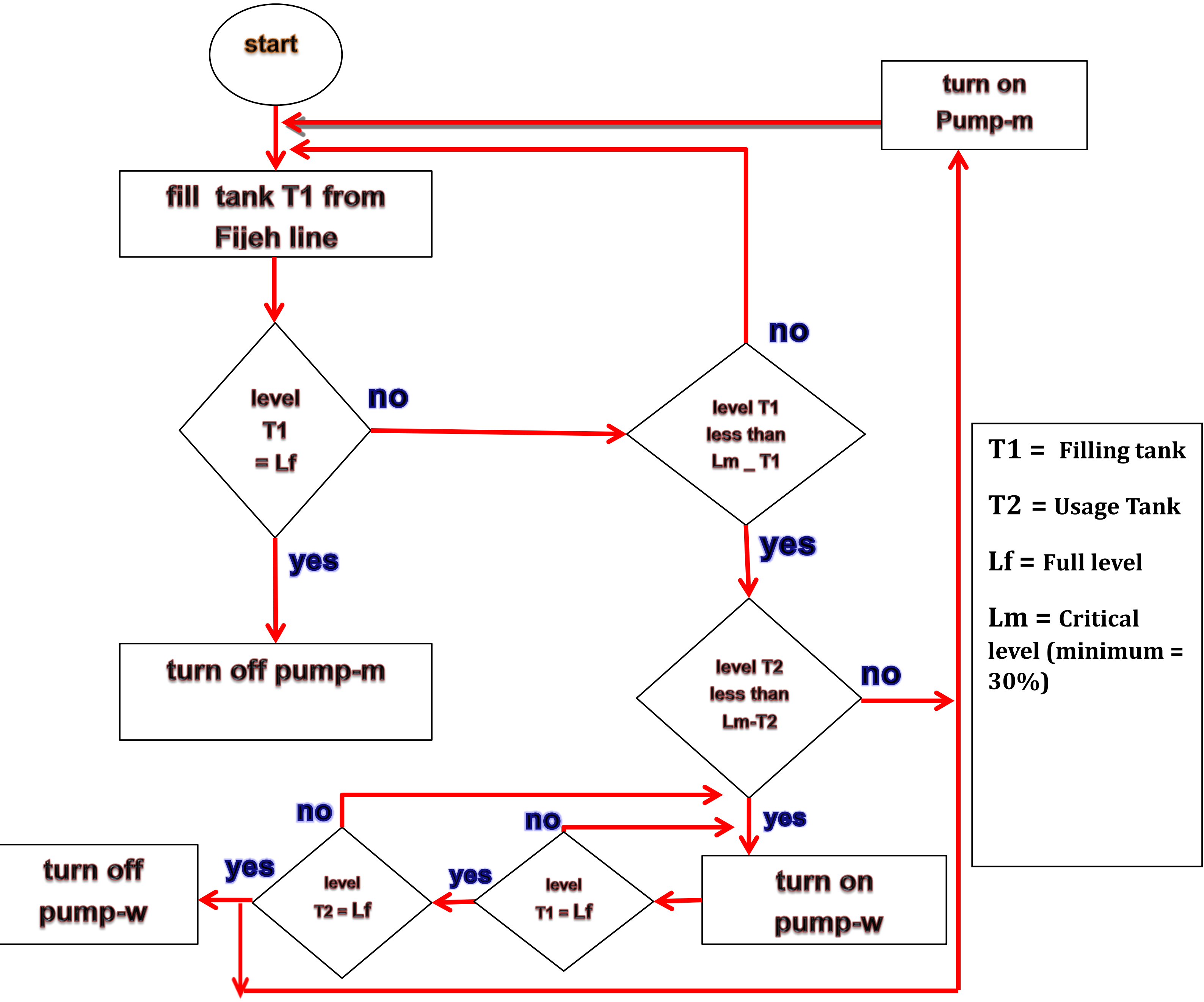
Chapter Four

Proposed Algorithm of project

The proposed algorithm

This chapter demonstrates the proposed algorithm to control the water level in an interactive two tanks of a hospital which was proposed by a customer.

4.1 The proposed algorithm to control and manage water level in a building



4.2 Steps of Algorithm

The proposed algorithm can be summarized in the following steps

1- Fill water tank T1 and water tank T2 using by Fijeh line and close Fijeh line by mechanical float when filling each tank.

2- When the level in tank T1 decreases to 50%, an alarm signal will remind the supervisor to be ready to take a new action.

3- Due to daily consumption, the water level in T2 reached to Lm (minimum or critical value = 30%), the water pump-m must be turned on.

4- When T1 level reached to 30% as well level T2 reaches 30% pump-w will turned on until level of T1=Tf and close pump-w.

4.3 Level Control system: ON-OFF control

This algorithm summarized the managed water in the tanks; also examine the level control in each one as well as in an interactive manner.

Since that there are three critical point in the first tank that is defined by the sensors and two other critical points in the second tank, there is a need to apply three or two point level control system design based on sensors measurements.

In this type of control which can be specified as ON-OFF control system, a response of such action is applied to both pumps, the main source pump (Fieja source of water) and the well pump. This is done base on sensors and used valves as be shown in the SCADA simulated system in the next chapter.

Chapter Five

Water level control system Using SCADA

5.1 Practical Implementation using SCADA

This part will include the implementation of the proposed algorithm using SCADA system and software. The Implementation can be summarized by the following steps

1- Start by adding two tanks as shown in figure (5.1).

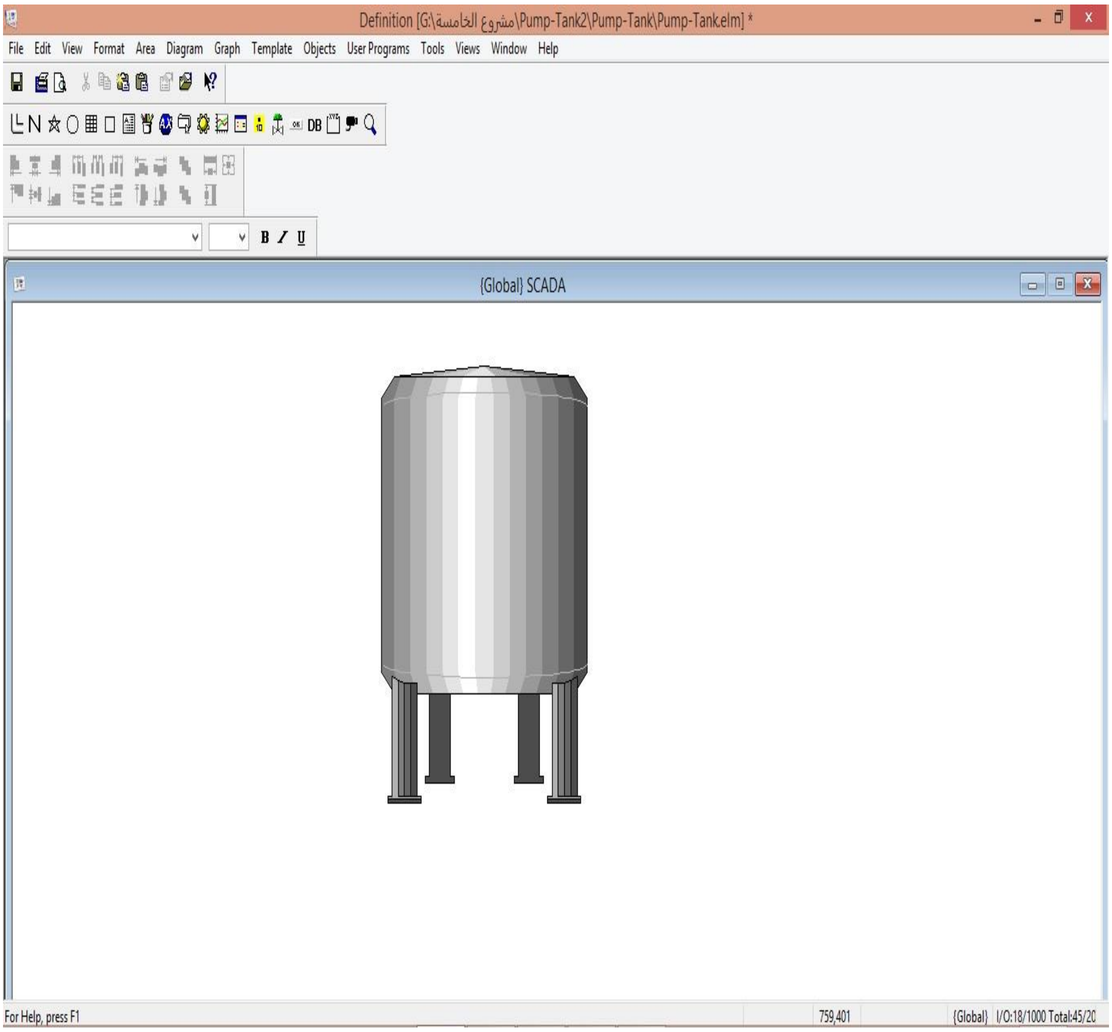


Figure (5.1) Water Tanks

2- We added the level sensors in both Tanks, and defining their specifications as well as their critical points shown in figures (5.2), (5.3).

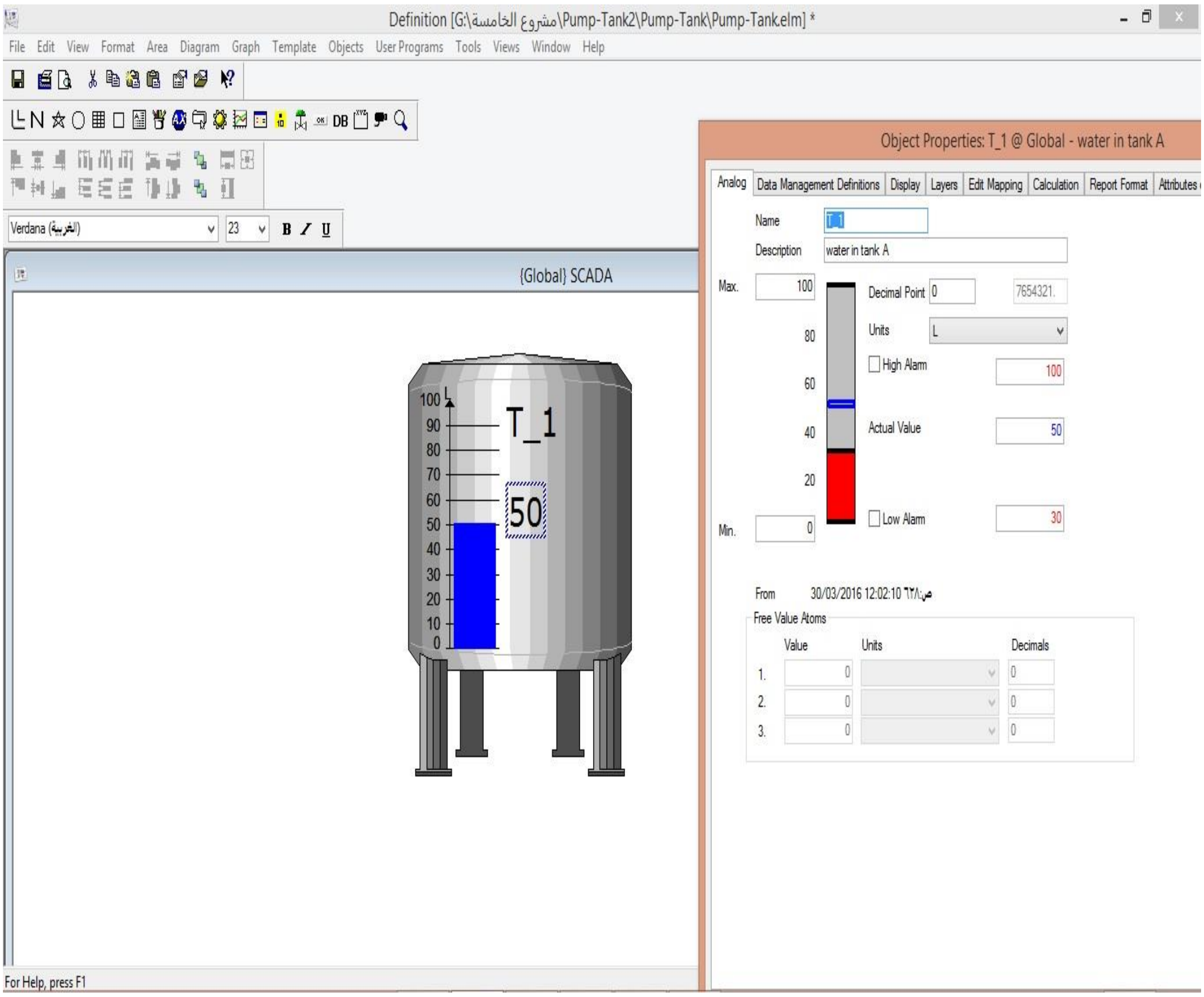


Figure (5.2) **Level sensors of the Tanks**

Figure (5.3) **The used Sensor**

3- We added The main water pump and well water pump shown in figures (5.4), (5.5) and (5.6).

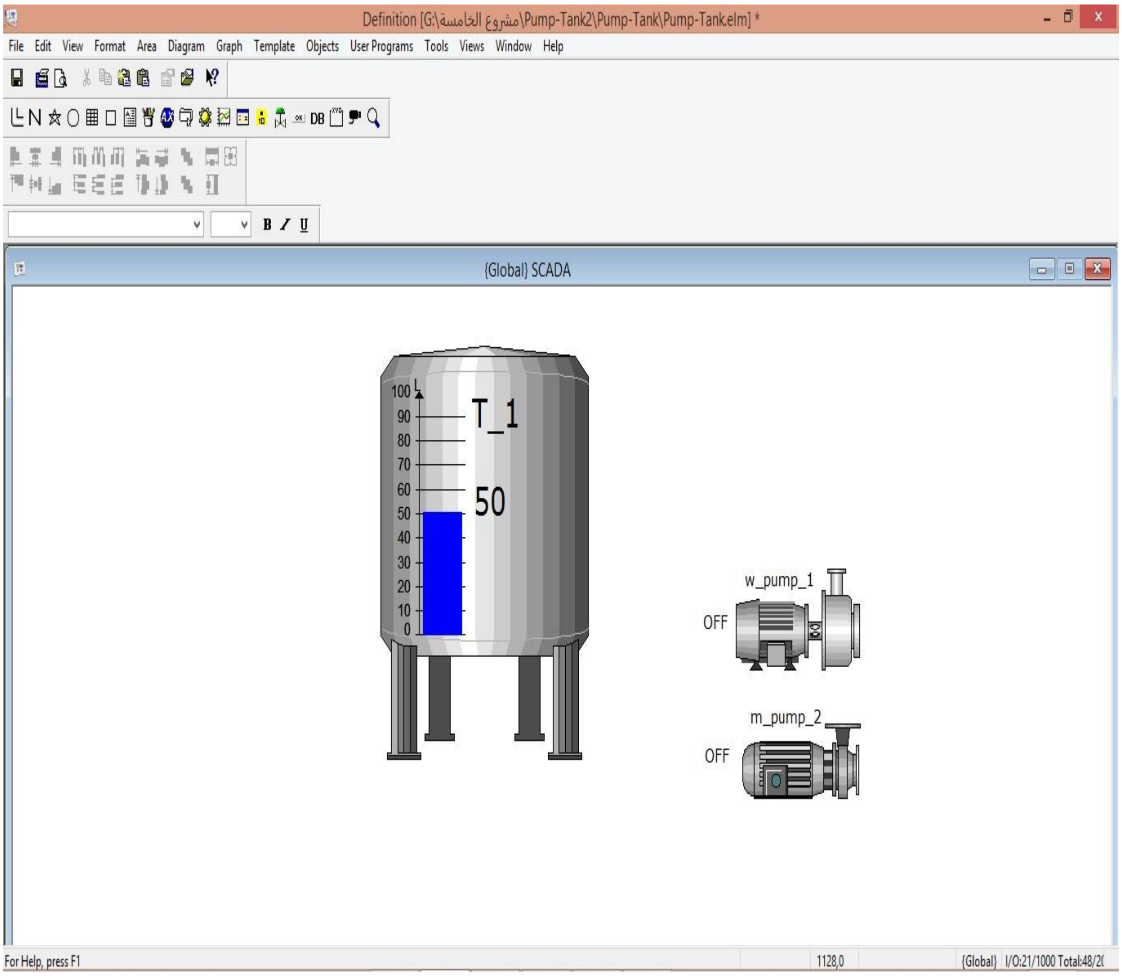


Figure (5.4) The Water Pumps

Figure (5.5) Main Water Pump

Figure (5.6) Well water Pump

4- Final view of the Tank with Valve and all Functions shown in figure (5.7) for one tank only.

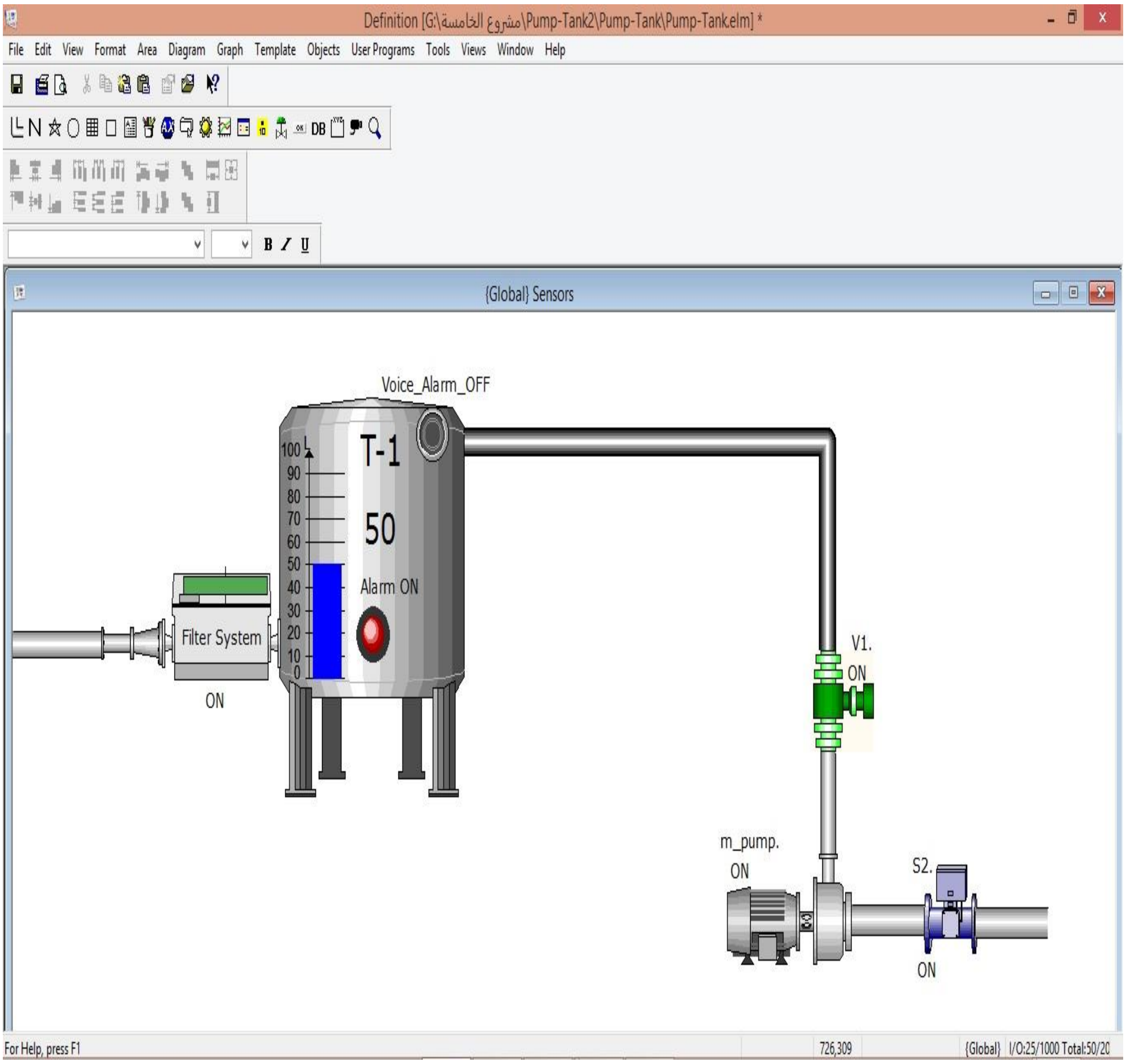


Figure (5.7) **One Tank with all functions**

Chapter Six

The suggested Future work

6.1 Future Work of The Project

This work will be continued for the proposed system and this will include building and implementing the algorithm with SCADA and display the result in control room that can be supervised and managed by a control engineer.

Also a practical implementation will be done to the control system and linked the SCADA simulation in a practical manner using PLC.

Finally, any new suggestions will be considered as well as any suggested future work.

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[8]-PLC Primer

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[14]-Industrial Automation (http://program-plc.blogspot.com)

الخلاصة

من بين العديد من المشاكل في نظام التحكم الصناعي، بل هو حقيقة أن نظام إدارة التحكم في المياه هي مشكلة صعبة. وكذلك تعتبر الدراسة النظرية فضلا عن التطبيق العملي لهذا العمل.

في منظومة التحكم تم اعتماد خزانين ماء ومتحكم بثلاث نقاط تم تنفيذهم باستخدام الخوارزمية المقترحة. عرضت الفكرة والخطوات من هذه الخوارزمية من قبل بعض العملاء الذين يرغبون في تنفيذ مثل هذه المشكلة في شركاتهم.

في هذا العمل أداتين تحكم خاصة سوف تستخدم ، وسيتم تنفيذ نظام سكادا و برامج لمحاكاة نهج السيطرة لخزانين الماء ومتحكم بثلاث نقاط تبعا لأنواع من أجهزة الاستشعار التي سيتم استخدامها، و أيضا لإدارة نظام مراقبة مستوى المياه في غرفة التحكم بطريقة إشرافية.

واخيرا سيتم تنفيذ الخوارزمية المقترحة وبرامج محاكاة نظام سكادا باستخدام PLC بطريقة عملية، مع الاخذ بعين الاعتبار أن الدراسة النظرية والتحليل للخزانين ومستوياتها ولمنظومة التحكم قد تمت دراستها في مشروع سابق و الاستقرارية لمنظومة التحكم كانت محققة.

Syria Arabic Republic

Syrian Private University

Faculty of Computer & Informatics Engineering

التحكم بمنظومة المياه في خزانين باستخدام المتحكم ON-OFF

(الجزء ١)

تم تقديم مشروع التخرج إلى كلية هندسة الحاسوب والمعلوماتية لتلبية متطلبات الحصول على درجة بكالوريوس في هندسة الحاسوب والتحكم

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