SCADA SYSTEM FOR REVERSE OSMOSIS DESALINATION PLANT WITH ENHANCED FEATURES

STELLA ANAK JAGAH@SUBENG

ELECTRICAL & ELECTRONICS ENGINEERING
UNIVERSITI TEKNOLOGI PETRONAS

JUNE 2010

SCADA SYSTEM FOR REVERSE OSMOSIS DESALINATION PLANT WITH ENHANCED FEATURES

By

STELLA ANAK. JAGAH@SUBENG

FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

SCADA SYSTEM FOR REVERSE OSMOSIS DESALINATION PLANT WITH ENHANCED FEATURES

by

Stella Anak. Jagah@Subeng

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Approved:

(Dr. Irraivan Elamvazuthi)
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

JUNE 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(Stella Anak Jagah@Subeng)

ABSTRACT

Water is essential for all living creatures as well as a crucial resource of the economy, especially in the agriculture industry. However, the access of clean consumable water is deteriorating as the demand for it rises in following the rapid increase in the world's population. Many now turn to reverse osmosis desalination which is one of most widely used application in water treatment engineering, as an easier solution to obtain usable water especially in countries where source of water is scarce. Research has been done to further enhance the available system of this particular process plant. An important attribute when designing ways to monitor the plant is the safety of both the plant and the workers. These plants may also be built at remote and hard to reach area that could contribute to time wastage when immediate process data is needed. Hence, coming up with an online monitoring system running at real-time that allows user to monitor and control the plant from any location would be a fitting solution. The plant can be monitored and controlled by a system designed with the help of PC-based software like LabVIEW™. A lab-scaled water treatment plant is hooked up onto the PC with a system designed for it. This PC will act as a server, while client could access the plant remotely by accessing the website designed to capture the data sent by the server.

ACKNOWLEDGEMENTS

First and foremost, I would like thank God for constantly being my light, and source of strength throughout the one year period of this project.

I would like to express the deepest appreciation to my supervisor, Dr Irraivan, who has the attitude and the substance of a genius: he continually and convincingly conveyed a spirit of adventure, pouring out various ideas to further enhance the project at hand. Without his guidance and persistent help this dissertation would not have been possible.

I would also like to thank the fellow lecturers and technicians, especially in the Electrical and Electronics Department, for contributing their time in this work. Many thanks for allowing the usage of certain labs to be accessesed throughout the semester to do the necessary research.

I thank Universiti Teknologi PETRONAS for preparing great facilities in the campus especially the amazingly resourceful Information Resource Center that has an extensive amount of important journals and reference articles.

The appreciation is also extended to fellow friends and coursemates. It has been a wonderful experience exchange various ideas, views and perspectives towards the project.

Lastly, my sincerest appreciation goes to my beloved family, for all their supports, patience and undivided attentions towards me throughout my ups and downs.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

DAQ	Data Acquisition
DCS	Distributed Control System
IC	Integrated Circuit
IP	Internet Protocol
LabVIEW	Laboratory Virtual Instrument Engineering Workbench
MAX	Measurement and Automation Explorer
PC	Personal Computer
RO	Reverse Osmosis
RPCM	Remote Panel Connection Manager
SCADA	Supervisory Control and Data Acquisition
VB	Visual Basic
VWD	Visual Web Developer
WWW	World Wide Web

CHAPTER 1
INTRODUCTION

1.1 Background of Study

The earth is made up of large area of water. However, the major part of the water crisis is closely related to the scarcity of usable/consumable water and water pollution. One main reason is due to population growth, and is estimated that there will be an increase of up to 3 billion more people by middle of the 21st century [1]. This number has improved since then. This rapid rise in human population demands for more consumable water at a time. In the absence of clean water, waterborne diseases can easily be spread. According to the World Health Organization, it is said that more than 3.4 million people died due to waterborne diseases such as typhoid, cholera and hepatitis A [2]. The shortage of water resources in many areas have forced more communities to find alternative water sources.

A method of treating and using water taken by source like the sea is through reverse osmosis desalination. The development of reverse osmosis water treatment ever since it started in the year 1970 has brought hope to people around the world where water is considered scarce such as in a remote and disaster prone areas. After the recent earthquake disaster in 2006 that hit Indonesia, many people in the country have lost their source of power and water [3]. The geographical condition of certain areas makes it hard for development. Available non-exhaustible water source have also been tarnished and worsen during the dry season. Desalination has allowed this water source to be treated and supplied to the people all year round.

A critical factor in any decision for the use of new water resources is the cost involved throughout the production. In order to save cost, these water treatment facilities are built close to the source and are normally at hard to reach location and are also prone to nature attack like heavy downpour.

In order to cater for the safety of fellow workers and the plant especially for plants built on remote area, save cost and valuable time an easier way to monitor and control the process plant is needed to be developed.

The existence of modern control has made it easier to monitor and keep track of the plant's health from a certain distance from the plant. The latest control system currently being utilized in most process plants around the world is the *SCADA* system. This system is known for its ability to deliver a flexible and a high performance control and monitoring system. It also has an architecture that can easily be modified to meet the requirement for the plant to help maximize its usage. The latest of its kind is the web-based *SCADA* which allows for continuous monitoring and information gathering from anywhere outside the plant and in a safe area.

1.2 Problem Statement

Many water treatment facilities are constantly being built to solve the water cirsis world wide. In order to run the plants efficiently, the developement of an easier way to control and monitor the plant is very crucial to reduce wastage while maintaining the condition of the plant continuously in order to save cost and time without neglecting the safety of the workers and users.

1.3 Objective of Project

The objective of this project is to develop a web-based *SCADA* system that allows user or client to continuously monitor and control the reverse osmosis desalination water treatment plants from anywhere within a certain distance.

1.4 Scope of Study

The system focuses on the small scale working model of a reverse osmosis desalination plant as an analogy of a real desalination plant. The SCADA System would be used for the purpose of data acquisition, logging and control of the plant variables.The system created should be able to be used and run on normal PCs.

A comparison was made to compare between the manual and automatic monitoring and controlling of the plant and which method would prove to be better in the terms of safety and risks assessment and time management. The project aimed to create a system that is able to:

a. Save time and efforts looking for information about the plant's current health. As an example, the total runtime of the plant since startup/shutdown.
b. Online monitoring of the process's temperature and the level of the water in the tank. This reduces the need of an operator to go to the field repetitively to obtain readings.
c. Remote monitoring that allows for monitoring of the plant from anywhere. This allows the operator to monitor the plant's status from a safer distance as well as to check its condition it whenever he or she is not in the plant area.

CHAPTER 2
LITERATURE REVIEW AND THEORY

2.1 Reverse Osmosis

Reverse osmosis (RO) desalination plant is created to produce drinking water and also industrial water from seawater or wastewater more economically. It can also be used to improve the quality of drinking water in order to remove the harmful substance in it [4]. There are 4 levels involved in the process. The levels are:

a. Pre-treatment
b. Pressurization
c. Membrane Separation
d. Post-treatment stabilization

In an RO desalination plant, the pre-treatment level is the most important level. This reverse osmosis method utilizes an ultra-fine filtration method in order to allow only water to go through and in one way. It means that this membrane does not allow for any back pulsing of the water. The reverse osmosis occurs when a pressure higher than osmotic pressure is applied to the raw water and then it is fed to the membrane in order to get back the drinking water and the solute component. Due to this, there is a tendency for waste from the filter to be accumulated on the membrane surface and is most likely clog. This will cause a loss of the production capacity.

Desalination on the other hand refers to the few processes that help to remove excess salt and other minerals from water. Water is desalinated to convert the salt water to fresh water so that is will be suitable for human consumption. A typical large-scaled desalination process uses large amount of energy that makes it slightly costlier than the usage of fresh water from rivers. Middle Eastern is an example of where desalination has grown rapidly throughout the year. This is due to their relative water scarcity as well as huge energy reserve.

2.2 System

In order to maintain the performance of the plant, its health should be monitored constantly. There are two ways to do so, either manually o automatically. Manual monitoring means that there would be operators working around from time to time to obtain data from instruments in the field. The data is then tabulated and compared to conclude on the plant's health at the end of the day.

Automatic monitoring system involves the installation of monitoring units that will automatically collect values from the field and transmits it into a centralized unit in the control room. Automatic monitoring can be programmed to monitor various items regarding the plant.

The SCADA system and DCS are two different systems that can be used for constant monitoring. In fact, the SCADA system may be a subset of the DCS. It is possible for a single system to be capable of performing both DSC and SCADA functions.

2.2.1 DCS

DCS stands for distributed control systems. A DCS system is continuous or very process oriented. The definition of DCS has changed over its history. The information processing role of a DCS has expanded, adding advanced process control, information analysis tools and intelligent system capabilities. The DCS has basically three essential qualities.

The first quality is that it distributes its functions into smaller sets of semi-autonomous subsystems that covers specific process or geographic areas of the plant complex (hierarchical automation system). A DCS's functions generally are process analysis and supervision, data collection, process control, storage and retrieval of information as well as presentation of information and reports. The operators console in the control room is connected through a shared communication facility o several distributed local units.

The second quality is that a DCS is used to automate the manufacturing process by means of integrating advanced regulatory control logic and also procedural languages with the advanced in the application packages, expert systems that includes production scheduling, preventive and predictive maintenance scheduling. Finally, the third essential characteristic is the system aspect of the DCS in which it organizes information flow between each constituent part in order to have a single automation system unifying the semi-autonomous subsystems.

Therefore, the complexity of a DCS can vary depending on its purpose. It can simply be made up of a CRT display and keyboard in the control room and a local control unit in the process area in which it is connected by cables. Figure 1 shows a general architecture of a DCS.

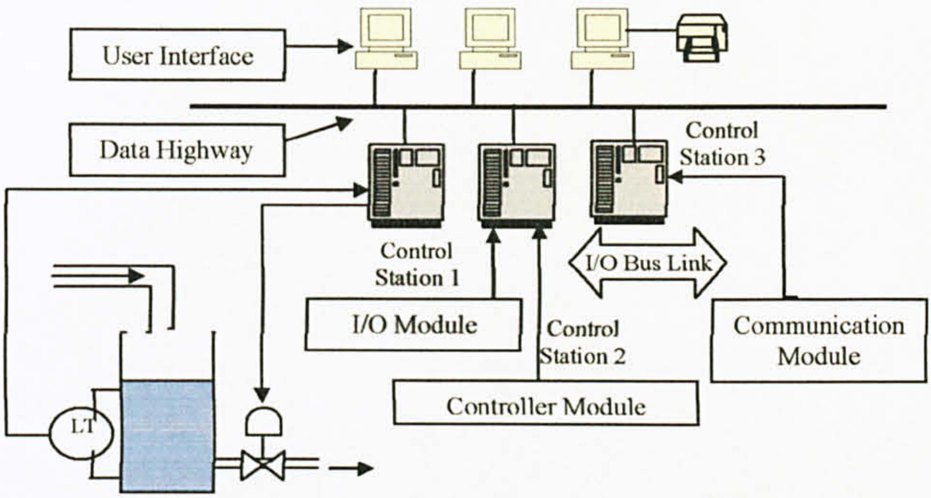


Figure 1 :DCS General Architecture

It looks at the controlled process such as the reverse osmosis plant as its heart and it presents the data to operators as part of its job. The controller elements are not centralized, but are distributed throughout the system and each component of the sub-system is being controlled by one of more controllers. DCSs are connected to sensors and actuators and it uses control to control the flow of material through the plant. A simple DCS operator station is connected with its I/O through local wiring or Field Bus. In order to obtain information the DCS has to make a request which runs directly to the field I/O. The system can be directly interrupted by the field events.

2.2.2 SCADA System

The *SCADA* is also known as the Supervisory Control and Data Acquisition system. It is a computer system designed especially for monitoring and also controlling of the process. It is normally referred to a centralized system that monitors and controls an entire site or a system that is spread out in a larger area. This means, this system is the one that supervises and manages the information submitted to it. The SCADA is used mainly for direct control. It can only be used for monitoring and indirect control based on certain set-points. Any changes to a process would have to go through few levels before being implemented. Figure 2 is a basic SCADA system architecture.

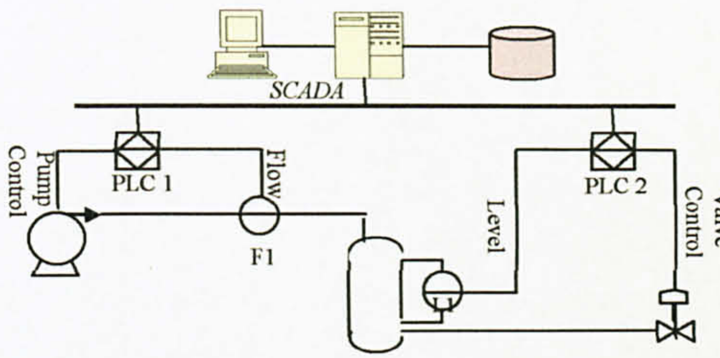


Figure 2 : *SCADA* System General Architecture

The *SCADA* system can come in open and non proprietary protocols. The Smaller systems are extremely affordable and can either be purchased as a complete system or can be mixed and matched with specific components [5]. A major problem one will face in running various size of reverse osmosis desalination plants are the high production cost, difficulty in finding experienced personnel and the variable demand of water. Hence, these factors resulted in deterioration of performance of the plant and may lead to complete. This system generates data from various components and makes it easier to handle. This is because the information is kept at a central location and tends to be a much better and efficient choice.

The differences between a centralized control system structure and a distributed control structure are the functions. In a centralized control system structure, the main functions of control and process monitoring, data acquisition, alarm and logging and also data processing are concentrated in a central computer. While in a DCS system architecture, only the data needed for other programs within the automation system will be distributed. DCS distributes its function into smaller sets of semi-autonomous subsystems covering specific process or geographic area of the plant complex.

2.3 DAQ Card and LabVIEW

Traditionally, most measurements are done based on stand-alone instruments such as multi meter and oscilloscopes. However, there is a need for recording measurements and to process the data for visual purposes has then increased tremendously. There are many way to exchange data between instruments and computer as there are ports available to transfer data to and from these devices. One way to measure signals and also transfer the data into a computer is by using a Data Acquisition board. The DAQ Card is a low-cost, low-power analog input, digital, and timing I/O card for computers equipped with a Type II PCMCIA slot. The small size and weight of the DAQ Card coupled with its low-power consumption make this card ideal for use in portable computers, making remote data acquisition practical.

A DAQ hardware is however of little use if there is no proper control and can be very hard to be programmed. A good software can be used to acquire data as a specified sampling rate, stream data to and from disk and also integrate different type of DAQ boards in a computer as well as make use of various functions available on the DAQ board from a single user interface.

LabVIEW is an innovative program development software package for data acquisition and control applications and it is one of the best software to be used with a DAQ board. LabVIEW utilizes graphical programming; which includes extensive libraries for data acquisition, instrument control, data analysis, and graphical data presentation. LabVIEW has the ability to identify each board by its device number and so one can have as many devices as allowed by their computer.

2.4 Remote Monitoring

Remote *SCADA* is an alternate way for users or operators to access their plant and security information from their *SCADA* network from their own laptop or PDA regardless of where they are. This technology has rapidly been used in most plants that utilizes *SCADA* network. It is a stepping stone in achieving factories managed from home

The main reason for selecting remote against local is due to the ability to cover a wide area of connectivity and also pervasiveness. Remote *SCADA* has a larger addressing range, and it can reduce redundancy and Hot Standby. Remotely monitoring the plant is a way of ensuring the safety of the workers working on a certain plant as they are able to see the condition of the plant before entering the plant area to do their routine task. Sometimes, a SCADA site is located at hard to reach locations or isolated areas.

This technology is one way towards the integration of IT to the Automation and Monitoring Networks. The concept of the Web-SCADA as designed by White Hart Automation Ltd.[6] is that data from the factory is send to an online database, where it will be further viewed by the user. User then can take appropriate actions based on available options available on the designed web. The diagram in Figure 3 shows the design architecture of the Web-based SCADA.

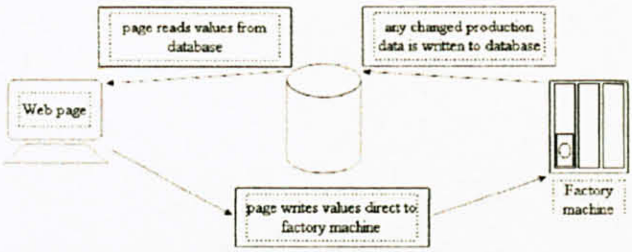


Figure 3 :Design Architecture of the Web Based SCADA [6]

A simple plant's SCADA can be running locally on its platform, but has the capability to be monitored and controlled over the internet from within a Web browser, with the help of the host computer is then connected to the Internet.

If the client is set with the same setting, the client could see the same front panel as the local host and could also have the same program functionality. This is further illustrated in Figure 4.

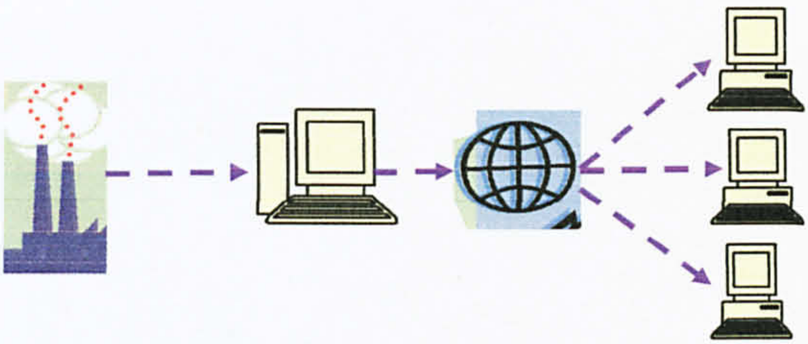


Figure 4 : Internet Control of a Remote Plant

There are differences between web-based and web-enabled SCADA system. Web-enabled system only has limited functions which is made available through a certain web portal. However, this is not the case for a web-based system. A web-based *SCADA* system has the capability to be built and run wholly in a web environment. This means that it has access to all the functions that the *SCADA* design should have. Any change in data or information is connected with the client in their own specified area of interest [7]. There are currently several types of web-based architectures used for the internet based *SCADA* system.

Different architecture gives different advantages and disadvantages and is used depending on the plant's need. Figure 5 shows the connection between the clients and the platform independent SCADA Server.

Figure 5 : Web-Based SCADA Clients Accessing Platform Independent [7]

One such company specializing in remote *Scada* is the Citect. According Citect global director-*SCADA*, Stephen Flannigan, a continuous connection to the plant data can lead to a better decision making regarding the plant and in turn would also be able to increase the productivity [8]. Based on CitectSCADA, their system works on a web-based client that allows the remote factory, operators as well as plant technicians to see data that is stored in their *SCADA* network through a web browser like the Windows Internet Explorer. In terms of security, it is said that any data obtained is not stored on the PDA or any mobile devices but will remain on the central server. This is important to ensure the security of the plant is not jeopardized in the event that these mobile devices were stolen or went missing.

There are many kinds of systems available to enable a web-based *SCADA* system. The first system is the PLC with a Web Server embedded directly in the device. This device is generally used for a small stand-alone system which does not need large controller and requires the remote access through the internet.

The second system is a hosted *SCADA* system. This is also known as the Bentek System [9]. As an example of a *SCADA* Service Provider is the e-scada. They provide servers to company that would want to utilize a web-based server. The main purpose of this SCADA Service Provider is to provide the needed data transfer through and from the client and the internet. Figure 6 below shows the Remote and Local Access via a SCADA Service Provider.

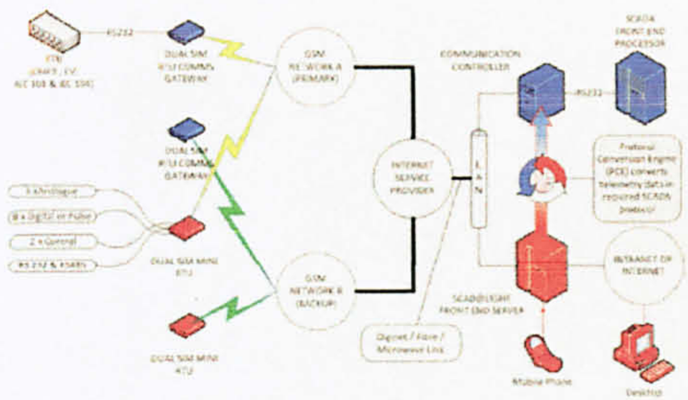


Figure 6 : Remote and Local Access Via a SCADA Service Provider [9]

2.5 Client/Server Architecture

The client/Server Architecture refers to a two-tier architecture where the user interface runs on the client and the database is stored on the server. The available application logic can run on either the client or their server based on administrative settings. This architecture has become an important model that will take enterprise-wide computing into the 21st century [10]. It is designed to take advantage of cooperative processing and distributive computing utilizing the Internet as the network infrastructure. The client/server system encompasses a client that requests the information, a server that supplies information and finally the network that transfers the information.

The client component can be either hardware of software. The client workstation is an example of a hardware component that is capable of stand-alone information processing. A Web browser on the other hand is an example of a software client.

The server component can also be either hardware or software. In hardware context, the personal computer that functions as a server is enhanced with extra storage capacity and normally fits in the same location as the business activity.

In software context, a computer running Windows NT server or engineering software with Internet capabilities like LabVIEW would act as a secure server.

2.6 Remote SCADA System in Oia Plant, Greece

The Oia plant in Santorini Island, Greece is an example of a unique reverse osmosis desalination plant that is built on a hard to reach area, exactly on the top of the caldera. Santorini Island has an interesting volcanic structure. Due to this, the only access to the Oia Seawater Pumping Station from the mainland is via boat. Oia has two individual units; each has the capacity to produce 380m3/d and 160m3/d. The plant is located 160 meters above sea level and is not exactly built next to its water source (the sea), where there is a pumping station at the sea level having two pipelines where the sea water is fed in a leveling tank of 200m3 [10,11].

The main issue of running this plant is the maintenance. This is due to the distance between two pipelines and the seawater pumping stations. Apart from that, the plant itself lacks constant monitoring of its performance which is constantly suffering from hazardous conditions such as collapsing of the ground around it. Oia plant's two unit have classic automation with relay. These relays are used as low pressure switch, high pressure switch and conductivity meter controlling a product disposal valve.

Unfortunately, the system has suffered failure twice and consumers were delivered with salt water. Based on research, the cause was due to the burst of one of the O-ring that in turn allowed the seawater to pass through to the permeate side. The conductivity meter at that moment was faulty and could not detect the increase in conductivity.

Due to this, a PC based SCADA system was installed. The choice was taken because the system itself is flexible and device supervision in long distance is achievable. The advantage of the particular SCADA system is the ability to be supervised by any computer, with minimal requirement of telephone line connecting two PC's with installed modem to transfer digital signals to analogs between them. Oia Plant is now operating around the clock with no direct supervision. It significantly reduces labor cost and increase labor productivity.

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

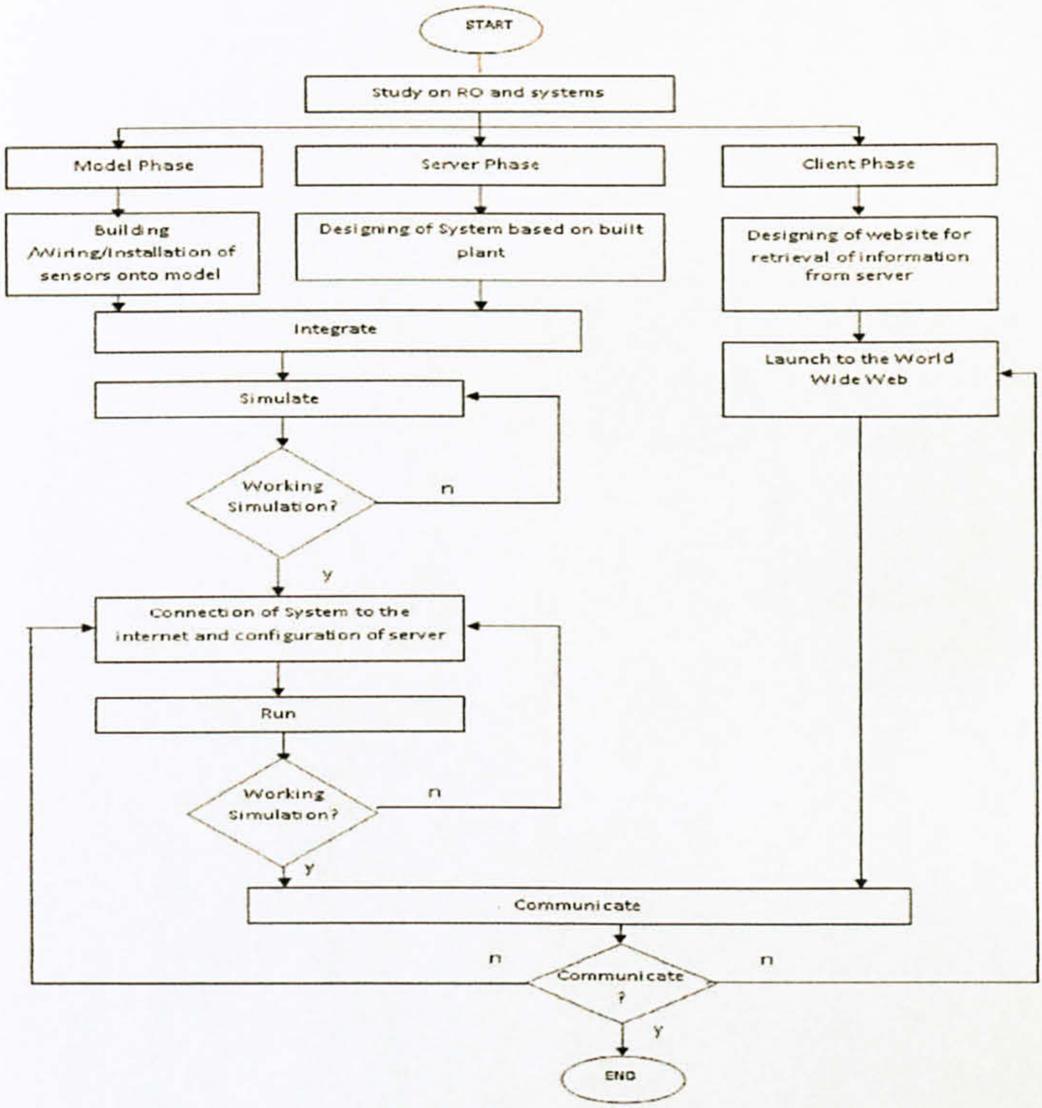


Figure 7 : Flow of Project

The project"s target was to develop a remote monitoring system (web-based *SCADA* system) that allowed client to continuously monitor the plant from any location. The system was able to save time, reduce repetitive work, and maintain the safety of operators.

It involved research and development of the SCADA system"s Internet connection and graphical user interface on the PC that would act as the server, and the development of a website deployed by FTP as the client software [6]. The project utilized LabVIEW to create the SCADA system and act as a link for the system to the Internet. In order to run a real-time system a lab-sized model of an RO desalination plant was hooked up to it via a DAQ card. The plant contained few variables that were able to be measured continuously and a few units that could be controlled to direct these variables. Once deployed online, this system was monitored through accessing a website where all the data was docked. The website was built using Microsoft Visual Studio 2008, which was then transferred online through an FTP server. After achieving the necessary connections, various data obtained from the system were analyzed to check the reliability of the system.

As a summation for the entire system, the process flow chart as in Figure 7 is formulated. Each step of the project is able to be tracked based on the flow chart. The Gantt chart for the project can be found in Appendix A.

3.2 Research Methodology

The main part of this project is to design and build a web-based *SCADA* system for a laboratory scaled model of the full-sized RO desalination water treatment plant designed by a former student.

A thorough research was done through the internet and also from the information resource centers (IRCs) on the safest water concentration that can be digested by human and also the right condition (temperature, flow, composition etc) of the water to improve the drinking water quality.

3.2.1 Conceptual Design

The project is divided into 3 parts which is the model and the system. The interaction between the the parts is shown in figure 8 below.

Figure 8 : Interaction Between Parts of Project

3.2.2 RO Model

In a desalination plant, the untreated water taken from the source, in this case the sea water would have to undergo several level of treatment before it can be safe to be consumed. 1a. The Scaled Model of the RO Desalination Plant is built to follow the design shown in Figure 9.

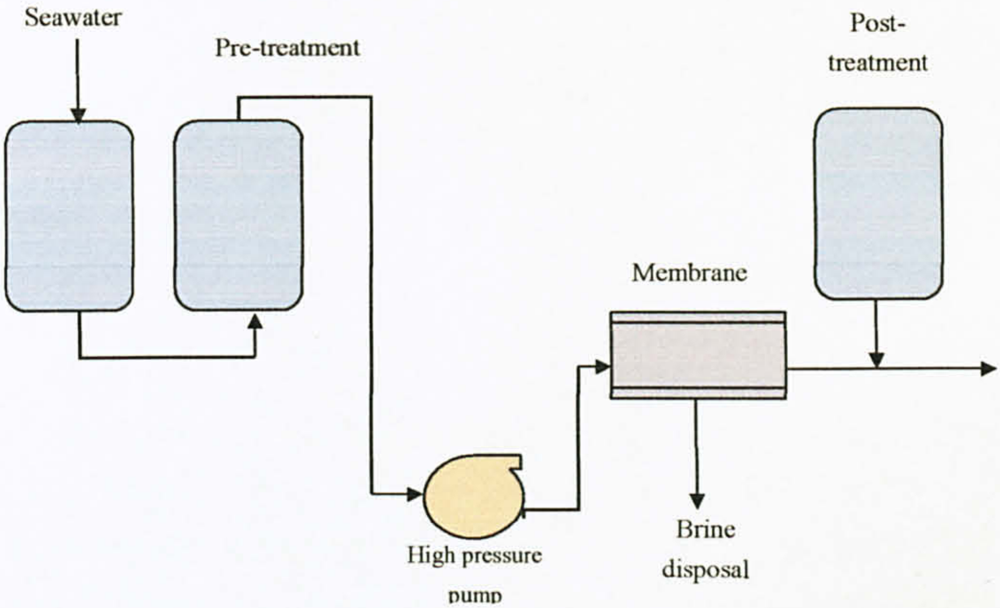


Figure 9 : Simple Reverse Osmosis Desalination Plant Design

The water source is taken from the sea. The plant should at least be able to filter the input to get cleaner water. In the proposed designed, several connectors would be used to connect the various parts of the plant to the computer. These connectors will be connected onto the transmitters in the field. These variables would be measured:

a. Level of the water in all tanks and pump
b. Temperature of the water

3.2.3 *System*

A system is built to monitor and control the RO plant. The SCADA system is built using LabVIEW and a DAQ card is used to create an interaction between the model and the system. The system is built using G programming. G programming is much like the C or BASIC language. However, there is one distinct feature of the G programming. While other programming languages use texts or line of codes, G is a graphical programming language that utilizes block diagram to create its program. G programming is also known as Virtual Instruments (VI). This is because their appearances imitate the actual instruments. However, they are analogue to the functions in conventional programming languages.

3.2.4 *Web-Based SCADA System*

There are a few issues that need to be looked into when designing a Web-based *SCADA* System. The first point to consider is if the installed software to create the program is compatible with the operating system. The current project is created on Windows Vista 32-bit OS. The second issue is to choose a website type. The table in Appendix B shows the summarized types if websites that can can be created using Visual Web Developer, a web developing tools under Visual Studio. The third issue is the types of programming language and data communication methods available to be used. There are many programming languages available to be used and is compatible on the web. The most common language would be C, C++, html, javascript and Visual Basic .Net. Another point to take into consideration is the lack of programming experience with any language beyond Matlab and basic C programming.

a. Programming in C++

C is considered to be a procedural language. It is a flexible and powerful language. C++ on the other hand is superset of the C language. It is a higher-level object-oriented programming language. C++ is considered unique as it treats both data and also the code as a single entity called a class. The advantages of C++ are similar with C with an addition of the object-oriented programming.

b. Programming in Visual Basic

Visual Basic can be classified as a Graphic User Interface (GUI). This is because, while the user draws, the program is automatically written in the back panel. Visual Basic is also a complete graphical development environment. The environment allows users to develop Microsoft Windows applications that have the ability to use Object Linking Embedding (OLE) objects like Excel.

c. .NET Framework

The .NET framework is a development framework that provides a programming interface to Windows services. It is a common language runtime and is located on top of the Windows operating system. It provides an abstraction layer over the operating system, where the most important feature of the framework is the Common Language Runtime (CLR). This framework contains Base Class Libraries where the pre-built codes for the common low-level programming tasks are kept. The .NET Framework also allows the user to apply common skills across a variety of devices and integrates with other tools and technologies to build the right solution.

The main advantage of the .NET framework is that it allows for easy implementation of Web Services. It was designed from the ground up with networking in mind, with XML Web Services and Distributed Applications development being a couple of its main selling points.

3.3 Tools and Equipment

Based on the explanation in the design methodology section, the tools and equipments used in the project are listed in Table 1.

Table 1 : Tools And Equipment

Phase	Hardware	Software
Model	1. Temperature Sensor (Thermocouple) 2. Temperature Sensor (IC) 3. Pumps 4. Membranes 5. Vessels 6. Piping & Skid 7. Auto Valve on/off 8. Manual Valves	
Server	1. DAQ Card (PCI-6024E) 2. Connector Block (CB-68LP)	LabVIEW 6i Student Edition
Client		Visual Web Developer 2008 (Visual Basic.NET)

The information transferring speed between server and client depends on the internet network or connection speed of the Internet at the point of use. An example of a wireless connection would be to install a secured high-speed wireless network using telecommunication provider such as Celcom broadband that has the speed capability of 3.6Mbps. Else, the usage of LAN connection provided by the university would suffice. These two connections are used interchangeably.

3.4 Project Cost

The cost of the project is divided into 2 parts mainly the small scale model and its control devices, and the system and Web-based part. These costs are divided into two parts which are the direct and indirect cost. Direct costs are materials purchased personally while indirect costs are materials obtained from the University or from other sources. By doing cost segregation, the overall cost for this project would not be so overwhelming.

The Table 2 shows a breakdown of the estimated cost for building the RO Mode and its control and Table 3 is a breakdown of cost for the system and the web-based.

Table 2 : Estimated Cost for Building the Small-Scaled RO Model

	Item	Quantity needed	Est. cost per unit	Sum
Direct Cost	Temperature Sensor (Thermocouple)	2	RM19.90	RM39.80
	Pumps	1	RM 150	RM 150.00
	Membranes	1	RM 60	RM 60.00
	Vessels	2	RM 40	RM 80.00
	Piping & Skid	1	RM 150	RM 150.00
	Auto Valve on/off	1	RM 60	RM 60.00
	Manual Valves	3	RM 10	RM 30.00
	Total Cost			**RM 569.80**
Indirect Cost	Pressure & Flow Sensors	3	RM 400	RM 1200.00
	DAQ Card & Connections	1	USD 800	RM 2,698.00
	Temperature Sensor (IC)	1	RM30.00	RM30.00
	Total Cost			**RM 3928.00**

Table 3 : Estimated Cost for Building the SCADA System and Website

	Item	Quantity needed	Est. cost per unit	Sum
Direct Cost	Personal Computer	1	RM3500.00	RM3500.00
	Web Hosting (myrosc.com)	1 year	RM199.00	RM199.00
	Total Cost			**RM 3699.00**
Indirect Cost	LabVIEW ® Software (6i)	1	RM269.631	RM269.63
	Visual Basic. NET	1	-	-
	Total Cost			**RM 269.63**

CHAPTER 4
RESULT AND DISCUSSION

4.1 Result

The system design is based on the design proposed in chapter 3. A client/server architecture is adopted with Windows application running Visual Web Developer.NET (VB.NET) as the client of the system. VB.NET provides user with a web view of the system. LabVIEW on the other hand provides a graphical user interface (GUI) of the plant with few options to control it. By connecting the GUI to VB.NET. the safety of the plant could be monitored when a security login is created to ensure that only authorized personnel is allowed to view and control the plant.

The server part of the project is mainly using another PC where it loads the plant's GUI to the internet. The client then polls the internet for required data from the control system.

4.1.1 RO Plant Model

The plant constructed is a simple plant and used as an analogy of the real water treatment facility. It is consisted of two vessels each $0.0257m^3$. These vessels are stacked on top of each other on a metal skid. The upper vessel is labeled as inlet tank and is where the untreated water is stored. While the lower vessel is labeled as outlet tank and is used to store the treated water.

Level sensors and are installed onto the inlet tank. There are two probes for the level sensors, each for the upper and lower indicator. The level sensor is a point type sensor. It works like a relay, where the indicator would be turned on where the upper probe is fully submerge in water and will turn off only when the lower probe has no contact with the liquid. The level sensor is important to inform operator on the level of the liquid in the tank. It helps to ensure that the tank is not overflowed with water or that the tanks is nearly empty. The pump may get spoiled if there is no liquid fed into it. The level sensor plays the role of the controlled variable. The high level probe is installed 0.14m from the base and the low level probe is about 0.08m from base.

Another important sensor installed are the thermocouples (type K) and the IC temperature sensor. A type K thermocouple can sense temperature reading from -200°C to about 1250°C. This sensor has shielded end with a wide sensitivity range. These thermocouples are installed on both inlet and outlet tanks. The IC temperature sensor on the other hand is installed outside of the tank. It serves as a reference temperature. The reference temperature is used to compare the reading between the inlet and outlet tank and the surrounding temperature.

The pump installed uses a 24Vac to power it up. In order to use it, first the source from the main supply is stepped down. The pump will be the manipulated variable in the system. The hardware wiring of the units installed onto the plant can be found in Appendix C. Figure 10 is the completed RO model that is hooked up to the computer and ready for the next phase.

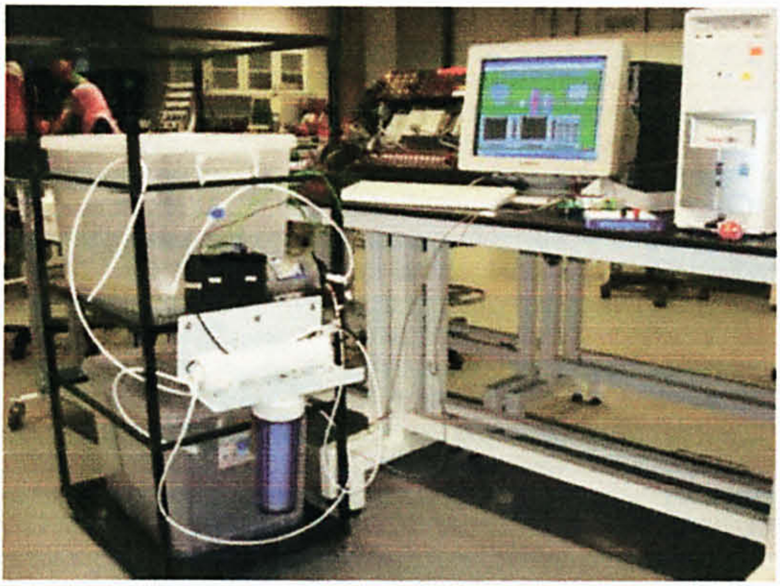


Figure 10 : Completed RO Model

4.1.2 Server Program Function

The purpose of a web service is to provide access to the software components of another machine across a network using a protocol. The web service allows an application to view or access any object on another machine. This function is invisible to the client. The web service on the server side has two functions, which are to accept request from clients on HTTP port and to connect to the control system and retrieve the request.

The server phase of the project mainly comprises of the plant's GUI designed using LabVIEW. Figure 11 shows a screenshot of the system's front panel while Figure 12 is the system's back panel. A complete view on the back panel wiring can be found in Appendix D.

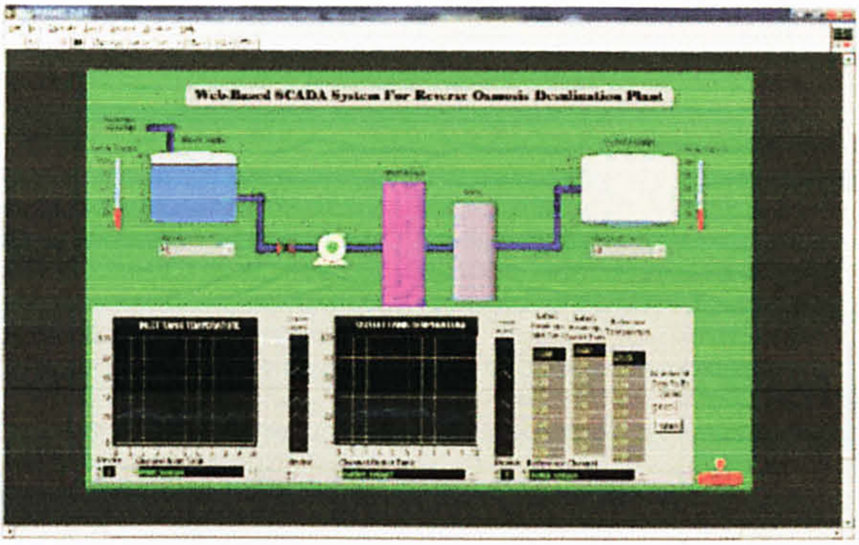


Figure 11 :RO System Front Panel

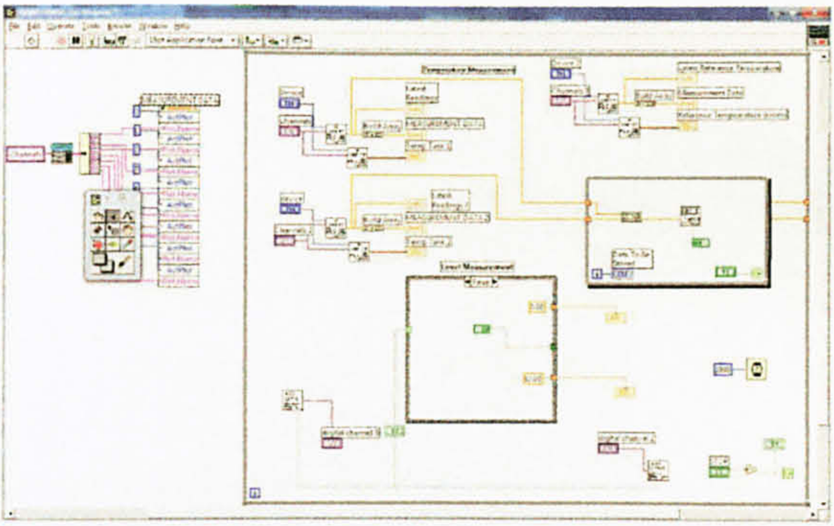


Figure 12 : RO System Back Panel

The system is designed using graphical programming. The graphical user interface above has a section to measure the level for the tank and the temperature of the water moving in the plant. The entire system is built using combinations of mulitiple subVIs. A remote SCADA is like a remote laboratory, which is defined as a computer-controlled laboratory that is accessed and controlled over some communication medium.

This software has been upgraded with internet features to its data acquisition environment, located in its Internet Toolkit 6. In order to change the application into a remote laboratory, the VI to be published is saved into the LabVIEW memory. The Web Publishing Tool, available in the LabVIEW control panel is used to create and publish the remote SCADA. Upon saving, another message box will pop-up with the URL address of the enabled application. Figure 13 is a screenshot of the setting.

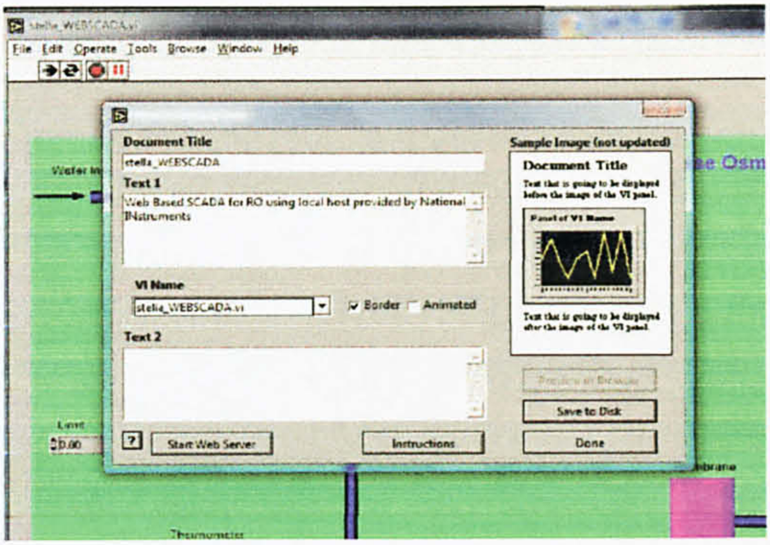


Figure 13 : Enabled Remote Panel

When the Web server is activated, the HTML of this system is saved in the LabVIEW file folder WWW by default. If the application is needed to be viewed remotely, the codes should be uploaded onto the hosting server. Upon deploying the system online, user can also specify how many people are allowed to access the system at a time. This is to avoid congestion and can keep track on anyone who logged in.

4.1.3 Client Program Function

The client program is written in the Windows form in the Visual Web Developer, utilizing both HTML and VB programming language. Information transfered from the server would need an area to be docked. Its main function is to provide a base for the information to be stored and as main page for the user to retrieve information and also a security login to protect the online SCADA. Figure 14 is a screenshot of the website designed in the program.

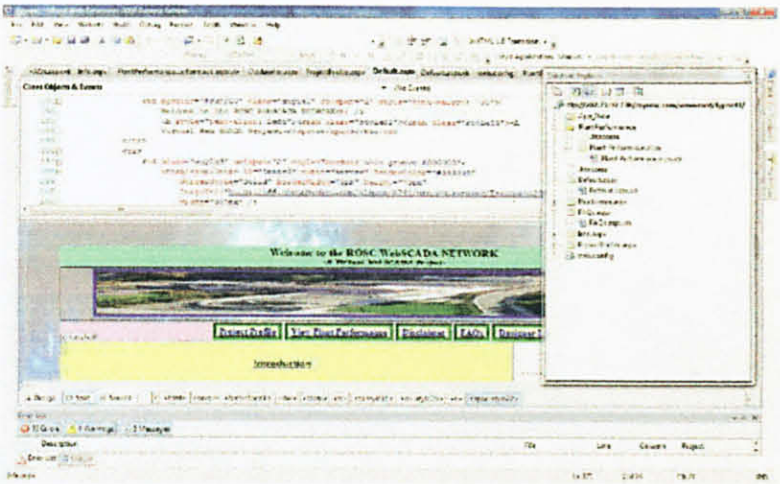


Figure 14 : Website Designed in Visual Web Developer

Web application are normally designed, created and tested in a development environment where it is only accessible to the programmer working on it. However, since the web application is created to be viewed by many user, the application should be deployed to any web server that has the .NET Framework and Internet Information Services (IIS). The File Transfer Protocol (FTP) is used for copying files from one machine to another over a network. An FTP client is designed to copy files from the computer to another computer that runs an FTP server.

Most web host provider supports file transfers through FTP. After purchasing a web domain, the provider would provide user with their own online storage with personal login verification. Figure 15 is a screenshot of myrosc.com control panel purchased from a web hosting provider that supports FTP and ASP.NET.

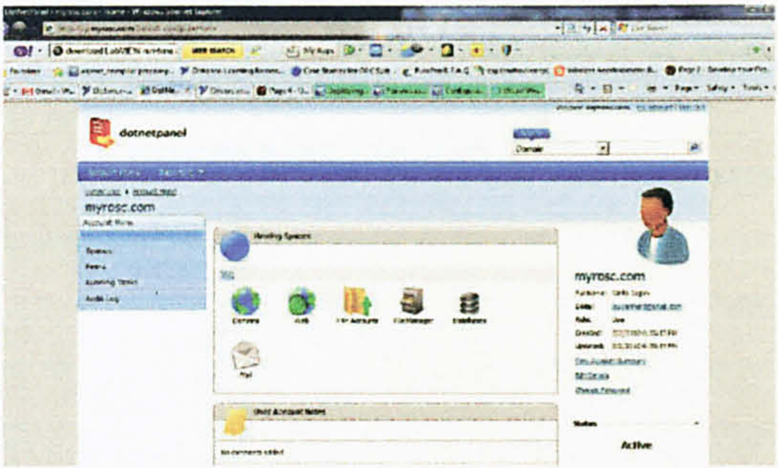


Figure 15 : myrosc.com Control Panel with FTP Enabled

Transferred file for viewing on the web is stored in the wwwroot directory in the online server. Once deployed, the files can be arranged and viewed according to the user's need. The SCADA system that was deployed online is docked to the same server, and is fetched by the website via its online address. The website is available for public viewing at www.myrosc.com/fypnet1. User can specify who is allowed to view the page by putting restriction or simply acquiring login username and password to avoid anonymous viewer.

Figure 16 is the online directory where the files can be viewed. In order to view, user needs to log in first.

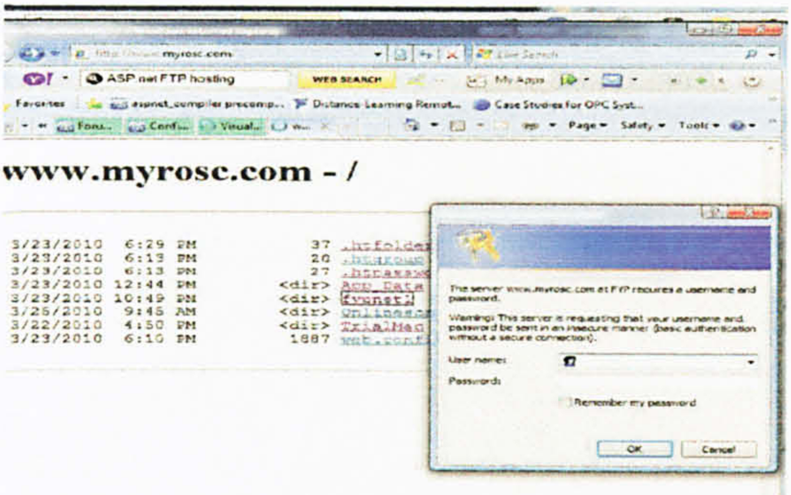


Figure 16 : Online Directory with Login Request

Once logged in, user will be greeted with a welcome page. Then, a tab on the upper part of the webpage would direct user to the plant performance page. Client would remain in monitor state until they are granted access to control the process plant.

Figure 17 is a screenshot of the website with the RO SCADA System embedded in the page. Other related codes used to build the website are listed in Appendix E.

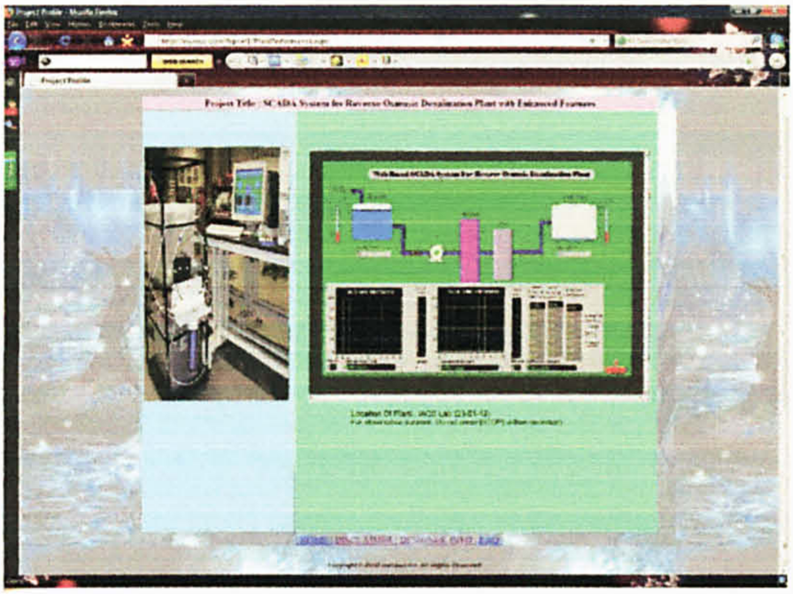


Figure 17 : Online Directory with Login Request

Upon connected to the page itself, user will be automatically in monitor state. In order to start controlling, user needs to request permission from the server. If the server is busy, client has to continue on waiting until control access is granted to it. The number of users allowed to hold the control access can be specified in the Remote Panel Connection Manager (RPCM)on the server part of the entire system. Normally, only one user is granted access at a time for a particular duration of time. The flow of the user access is shown in figure 18.

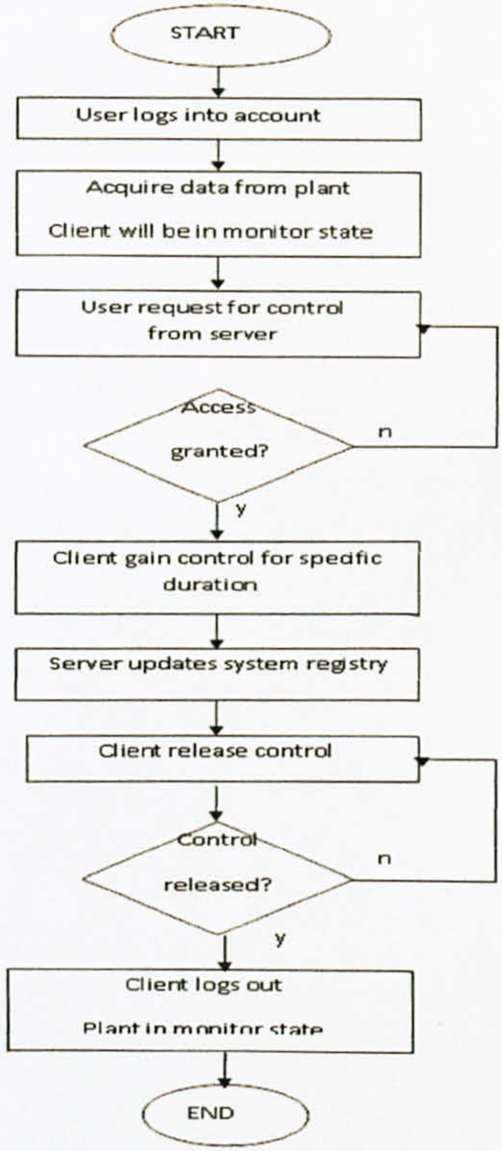


Figure 18 : Flow of Control

4.1.4 Safety of Online Monitoring and Control

Safety is always the main concern especially when it involves networking in a huge environment, example the internet where it is accessed by millions of people every seconds. In this project, there are two safety measures taken to minimize the ability to intrude into the system network.

The first layer of protection is by setting up the server client. In order to prevent intrusion, the server plays the part in controlling who can access the control of the plant. The detection can be done through IP address recognition, encrypted passwords and unique username or identification. These safety measures are available on the LabVIEW software, basically through the RPCM, and the web publishing tools and server access configuration under the option tools.

The second layer lies in the capability of the web hosting used or by programming a personal database to store in information of users. It is always advisable to have a password of an access code that contains both alpha-numerical values. This helps strengthens the account. When accessing the website to retrieve information, before going into the authentication from the server, user has to go through authentication from the website itself. This was earlier explained in section 4.1.3.

4.2 Discussion

This system developed is based around Windows console application at first before deploying to the internet through a host provider. The initial stage of the project is to test the server by accessing it through a web browser. However the connectivity is limited as the only main connection to the web is through the local machine or a remote website which is embedded inside most Windows operating system. When testing the ASP.NET application locally, the ASP.NET development web server is used. This service only allows local deployment. However, the production website is powered by the Internet Information Services (IIS), which are suite of services that provides common internet-based functionality. In order for the application to run correctly, the IIS must be configured properly.

Second issue is pertaining the version of the LabVIEW software used. LabVIEW 6i is a student version software. It does have the internet properties, however does not allow for remote controlling and only can monitor. It lacks the license to use the RPCM. This RPCM is an important tool for remote controlling, as it helps specify which tools are available to be controlled by user online, who and how long each user can use it. The later version, version 6.1 and above addresses the issue and the remote panel is accessable.

Another issue to overcome would be to connect the plant to the computer using the DAQ card. Based on few trial, there seemed to be time lag or sometimes read error occur when taking the signal from the plant. Lag time must be overcome as it is still dangerous if exist in real application. Lag time will cause slow reaction by the operator or the system itself, and before action could be taken, the plant has already tripped.

Lastly, there was also an issue on fluctuating readings given out by the thermocouples. A thermocouple sensor has a very huge sensitivity range. Hence, the reading will fluctuate when it is not fully submerged underwater. However, this can also be an added advantage in knowing if the water level in the tank is sufficient. The thermocouple is installed at the same level as the low level probe. Therefore, in the event that the level sensors fail, user can also view the reading given from the thermocouple. If the reading fluctuates, this means that either it is not fully submerge and the water is low or the thermocouple is faulty. IC The temperature sensor is used as a reference temperature to compare the reading obtained from the thermocouples.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

A good monitoring system would ensure the health of the plant as well as to be able to check the water quality before it is distributed to homes. Web-based *SCADA* system would further enhance the normal *SCADA* system as it does not only allow users to view the plant from the plant area, but also remotely. It also promotes safety as the plant is monitored away from the source of hazard and provides backup if one monitor happens to malfunction. The continuous monitoring would lead to better decision making apart from ensuring up to date data management. A web-based SCADA System allows for constant communication between one another from faraway distance.

5.2 Recommendations

This project is focused towards a web-based SCADA system. There are still some improvement that could be done to further enhance the capability of the web-based SCADA system. Some recommendations for future work:

a. Improvement on Time-Lag. There are two types of time lag encountered, mainly time lag during data acquisition and time lag during transferring and updating information over the network. This could be overcome by upgrading the future PC that would be used as a server to a better processor. A faster network connection would also suffice to fix the network issue.

b. Selection of better measurement instruments which are less susceptible to noise with appropriate sensitivity range.

REFERENCES

[1] William A. Jury and Henry J. Vaux Jr, 2007 "*The Emerging Global Water Crisis: Managing Scarcity and Conflict Between Water Users*" , Department of Environmental Science, University of California and Riverside and Department of Agriculture and Natural Resources, University of California, Berkeley

[2] VOA.com, 2009, "*WHO: Waterborne Disease is World's Leading Killer*", http://www.voanews.com/

[3] BBC News, 2009, "*World Water Crisis*", http://news.bbc.co.uk/hi/english/static/in_depth/world/2000/world_water_crisis/default.stm

[4] Nicholas P. Cheremiscinoff, 2002 "*Handbook of Water and Wastewater Treatment Technologies*", Butterworth Heinemann

[5] Jim Fererro, 2009 "*Linking SCADA development with operational needs Feature Articles*", Digital Energy Journal, Apr 2009 Edition

[6] White Hart Automation Ltd, 2010, "*Web-Based SCADA*", http://www.whitehartautomation.com/howitworks.html

[7] New HMI technology in SCADA, 2009, http://instrumentation.co.za/article.aspx?pklArticleId=5679

[8] Remote scada for mobile user, 2009, http://www.pacetoday.com.au/Article/Remote-SCADA-for-mobile-users/432504.aspx

[9] Bentek System, 2009, http://www.scadalink.com/support/wireless_scada.html

[10] F.Soesianto and Ismail K. Ibrahim, 2010, "*The Feasibility of Web-Based Client/Server Information System: A Case Study*", Department of Electrical Engineering Gadjah Mada University, Indonesia

[11] S.A Avlonitis, 2001, "*Operational water cost and productivity improvements for small-size RO desalination*", Laboratory of Quality Control and Operations Management, Depart of Mechanical Engineering, Technological Educational Institution (T.E.I) of Halkidas

[12] Micheal Romanos et al., 2004 "*Santorini: Sustainable Regional Development 2004; regional planning of the islands of Thera and Therasia Phase A: Analysis*", University of Cincinnati School of Planing

APPENDICES

APPENDIX A

GANTT CHART

Milestones for the First Semester of the Final Year Project

No.	Detail/ Week	1	2	3	4	5	6	7	8	9		10	11	12	13	14
1	Selection of Project Topic			H							M					
											I					
2	Preliminary Research Work			I							D					
3	Submission of Preliminary Report			N							S					
											E					
5	Project Work - Equipment Listing, Cost Estimation, LabView Practice			I							M					
6	Submission of Progress Report			B							B					
7	Seminar (Compulsory)			R							R					
8	Project work continues - Debugging, Model Testing			E							E					
9	Submission of Interim Report Final Draft			A							A					
10	Oral Presentation			K							K					

Suggested milestone by coordinator

Process

Milestones for the Second Semester of the Final Year Project

No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Project Work Continue - Server Searching								M							
									I							
2	Submission of Progress Report 1								D							
3	Project Work Continue - Testing of Prototype								S							
									E							
4	Submission of Progress Report 2								M							
5	Seminar (Compulsory)								.							
5	Project work continue - Finalized project								B							
6	Poster Exhibition								R							
7	Submission of Dissertation (Soft Bound)								E							
8	Oral Presentation								A							
9	Submission of Project Dissertation (Hard Bound)								K							

Suggested milestone

Process

APPENDIX B

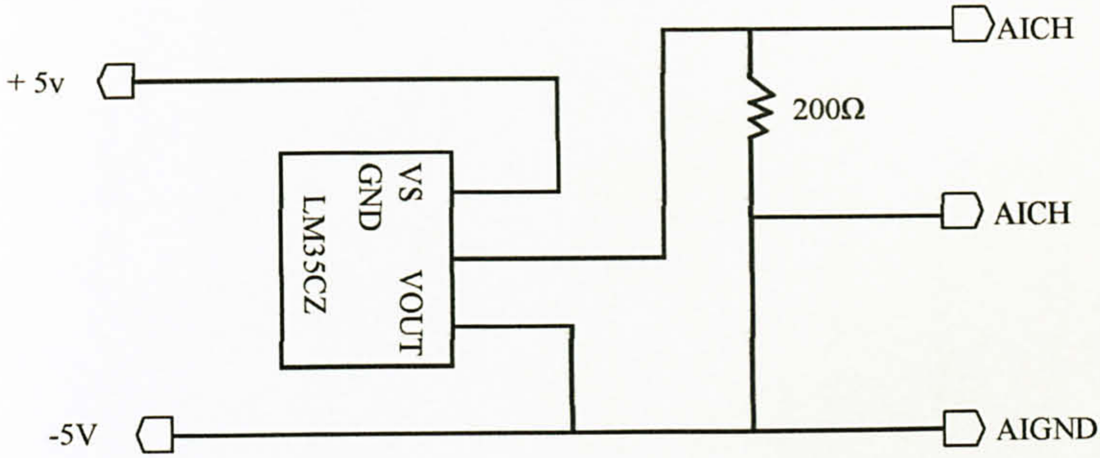
SUMMARY OF WEBSITES PROVIDED

Web site type	Summary
Local IIS Web site	Use a local IIS Web site when you want to create Web pages on your local computer and you have IIS installed. **Advantages:** • The site is accessible from other computers. • You can test with IIS features, such as HTTP-based authentication, application pooling, and ISAPI filters. **Disadvantages:** • You must have administrative rights to create or debug an IIS Web site. • Only one user on the computer can debug an IIS Web site at one time. • By default, remote access is enabled for a local IIS Web site.
File-system Web site	Use a file-system Web site when you want to create Web pages on your local computer or on a shared drive and you do not have IIS installed. **Note:** You can create a file-system Web site and later create an IIS virtual directory that points to the folder containing your pages. **Advantages:** • The site can be accessed only from the local computer, reducing security vulnerabilities. • You do not need to have IIS installed on your computer. • You do not need administrative rights to create or debug a local file-system Web site. • If the computer is configured to allow remote desktop connections, multiple users can create and debug local file-system Web sites at the same time. **Disadvantages:** • You cannot test a file-system Web site with IIS features, such as HTTP-based authentication, application pooling, and ISAPI filters.
FTP-deployed Web site	Use an FTP-deployed Web site when your site already exists on a remote computer that has been configured as an FTP server. (For example, your Internet service provider (ISP) has provided space on a server.) **Advantages:** • You can test the FTP-deployed Web site on the server where it will be deployed. **Disadvantages:** • You do not have local copies of the FTP-deployed Web site files unless you copy them yourself. • You cannot create an FTP-deployed Web site — you can only open one.
Remote Web	Use a remote Web site when you want to create a Web site by using IIS

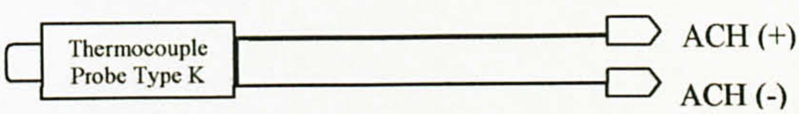
site	running on a remote computer. The remote computer must be configured with FrontPage Server Extensions. **Advantages:** • You can test the Web site on the server where it will be deployed. • Multiple developers can work with the same remote Web site at the same time. **Disadvantages:** • Configuration for debugging a remote Web site can be complex. • Only one developer can debug the remote Web site at one time. All other requests are suspended while the developer is stepping through code.

APPENDIX C
HARDWARE WIRING

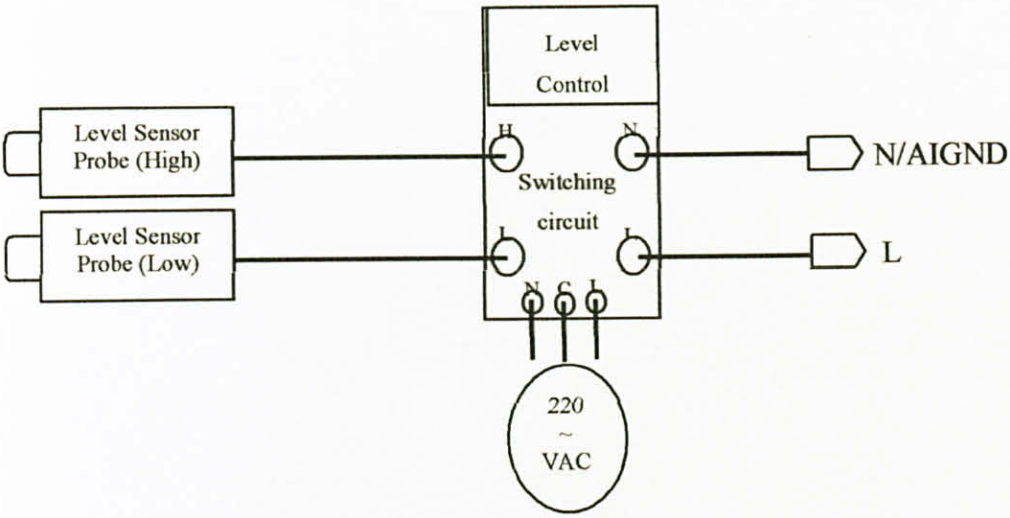
All these units will be connected to the computer through a connector block and DAQ Card. Each pins stated are the connections on their respective ports on the connector block.



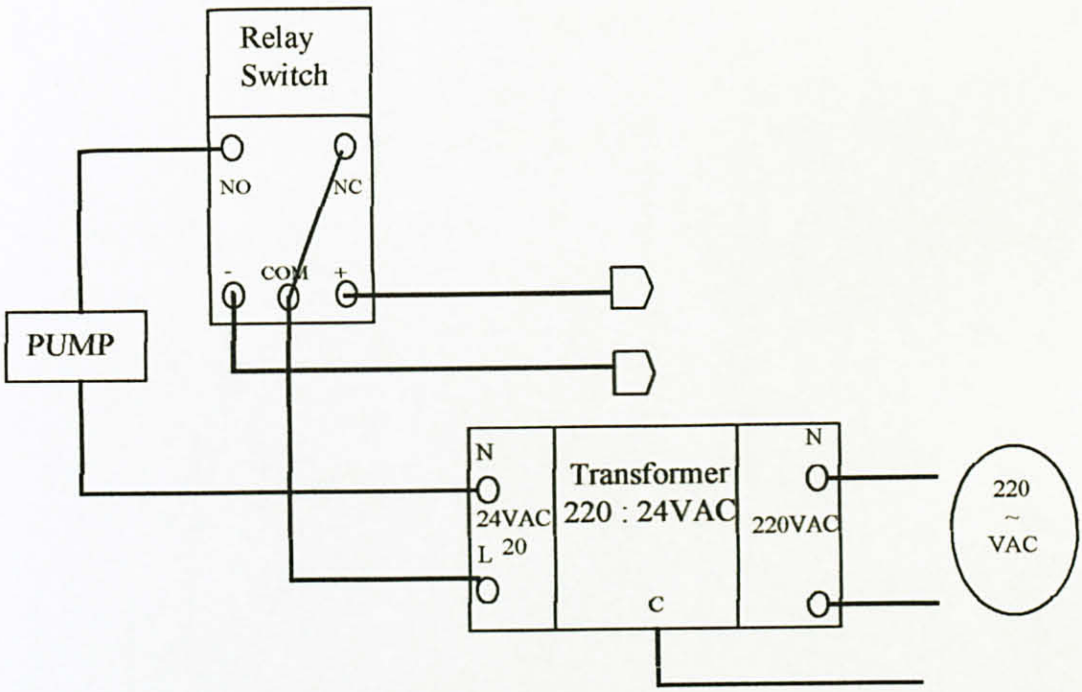
IC Temperature Sensor



Thermocouple Temperature
Sensor



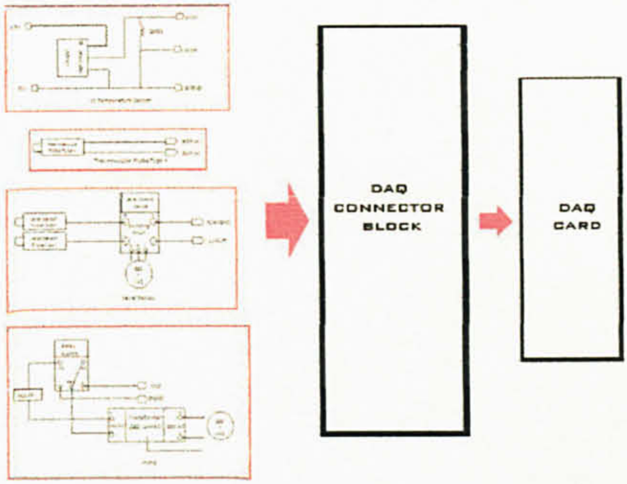
Level Sensor



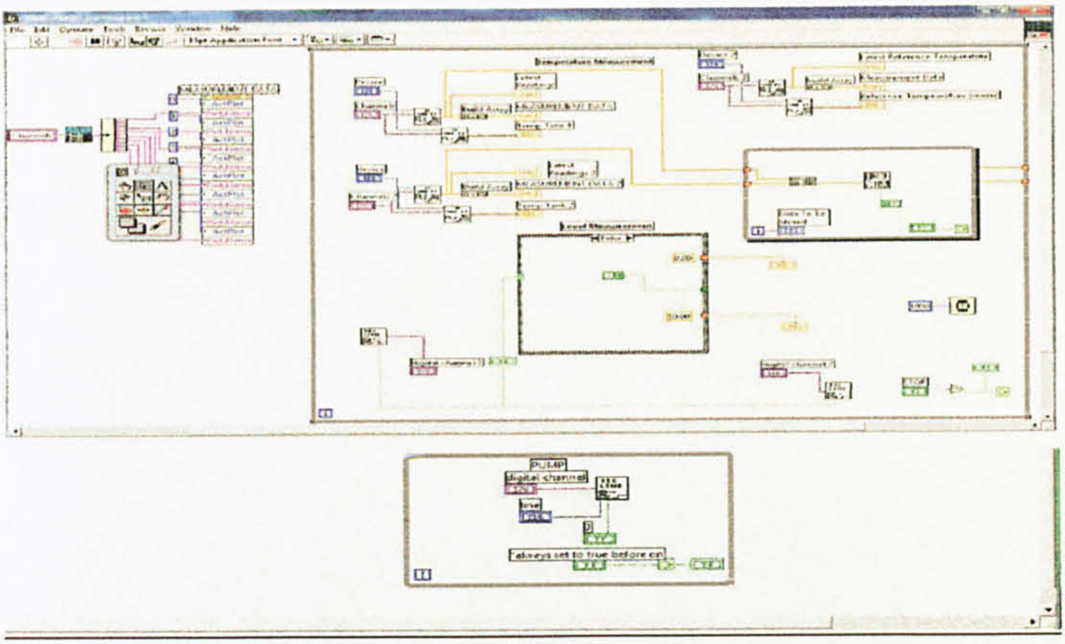
Pump

APPENDIX D
BACK PANEL WIRING

Below are some screenshots of the back panel wiring done on LabVIEW.



Overview of connection



Back Panel Wiring

APPENDIX E

CODES

Below is a string of codes for the Plant Performance page to tell user that complete logout occurs after browser is close and the page refreshes every 10 seconds.

```
<%@ Page Language="VB" AutoEventWireup="false"
CodeFile="PlantPerformance.aspx.vb" Inherits="_Default" %>

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">

<html xmlns="http://www.w3.org/1999/xhtml">
<head runat="server">
<META
     http-equiv="Refresh"
     content ="10;
URL=http://www.myrosc.com/plantperformance/PlantPerformance.aspx">
    <title>PlantPerformance</title>
    <style type="text/css">
        .style1
        {
            text-align: center;
        }
        .style3
        {
            width: 843px;
        }
        .style7
        {
            width: 562px;
            height: 69px;
            font-weight: bold;
            text-align: justify;
        }
        .style8
        {
            width: 231px;
            height: 69px;
            text-align: center;
        }
        .style10
        {
            font-weight: normal;
            text-align: justify;
        }
        .style11
        {
            text-align: justify;
        }
        .style12
```

```
        {
            font-weight: normal;
        }
        .style21
        {
            font-family: "Lucida Calligraphy";
            font-size: large;
            font-weight: bold;
        }
        .style22
        {
            font-size: x-small;
            font-style: italic;
        }
    </style>
</head>
<body
background="http://i66.photobucket.com/albums/h244/projectkuroame/
introPage.jpg">
    <form id="form1" runat="server">
    <div>

        <br />
        <br />
        <table align="center" class="style3">
            <tr>
                <td bgcolor="#FFCCFF" class="style1" colspan="2">
                    <b style="text-align: center">Plant
Performance</b> <i><a href =
"http://www.myrosc.com/fypnet1/">[Logout]</a></i></td>
            </tr>
            <tr>
                <td class="style8" bgcolor="#CCFFFF">
                    <asp:Image ID="Image2" runat="server"
Height="400px" ImageAlign="Middle"

ImageUrl="http://i66.photobucket.com/albums/h244/projectkuroame/fo
r_site.jpg"
                        Width="192px" style="text-align: center"
/>
                    <br />
                    <span class="style22">Screenshot on plant at
lab</span></td>
                <td class="style7" bgcolor="#99FFCC">
                    <br />
                    <br />
                    <asp:ImageButton ID="ImageButton1"
runat="server" Height="391px"

ImageUrl="http://i66.photobucket.com/albums/h244/projectkuroame/fr
ont_panel_for_site.jpg"
                        Width="634px" />
                    <span class="style11">
                    <i>
                    <br />
                    (for viewing only)</i></span><span
class="style10"><br />
                    </span>
```

```
                    <br />
                    <span class="style11">Observation Lab
Location: 23-01-11 (UTP) <br />
                    <br />
                    <span class="style12">
                    <br />
                    </span></span>
                </td>
            </tr>
            <tr>
                <td class="style1" colspan="2">
                    <asp:HyperLink ID="HyperLink1" runat="server"

NavigateUrl="http://www.myrosc.com/fypnet1/">| HOME
|</asp:HyperLink>
                    <asp:HyperLink ID="HyperLink2" runat="server"

NavigateUrl="http://www.myrosc.com/fypnet1/Disclaimer.aspx">DISCLA
IMER |</asp:HyperLink>
                    <asp:HyperLink ID="HyperLink3" runat="server"

NavigateUrl="http://www.myrosc.com/fypnet1/Info.aspx">DESIGNER
INFO |</asp:HyperLink>
                    <asp:HyperLink ID="HyperLink4" runat="server"

NavigateUrl="http://www.myrosc.com/fypnet1/FAQs.aspx">FAQ
|</asp:HyperLink>
                    <asp:HyperLink ID="HyperLink5" runat="server"

NavigateUrl="http://www.myrosc.com/fypnet1/Miscellaneous.aspx">MIS
C. |</asp:HyperLink>
                    <asp:HyperLink ID="HyperLink6" runat="server"

NavigateUrl="http://www.myrosc.com/fypnet1/ProjectProfile.aspx">PR
OJECT PROFILE |</asp:HyperLink>
                    <br />
                    <br />
                        <span
class="style21"><asp:Label ID="Label1" runat="server"
                        style="font-size: x-small; font-family:
Arial, Helvetica, sans-serif"
                        Text="Copyright © 2010 stellaworks- All
Rights Reserved "></asp:Label>
                    </span></td>
            </tr>
        </table>

    </div>
    </form>
<body onunload="alert('You will be directed away. Complete logout
when browser is closed.')">
</body>
</html>
```