# DEVELOPMENT OF WATER PRESSURE AND DISTRIBUTION MONITORING SYSTEM USING PLC AND SCADA

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# ABSTRACT

Sustainability of clean water resource has been a big issue being discuss lately. From the reason of lack of resources to the attitude of end user that frequently waste clean water, the problem seems not having any improvement on finding ways to at least contain it from increasing. The problem is related to poor water allocation and monitoring, inefficient use, wastage and also lack of adequate integrated water management. There are some reason that this cannot be controllable such as raw resources and the attitude of end user. But there is an area that we can at least control it to the lowest level possible by applying better technology and management. The area that can be improved is the monitoring and management of water storage and distribution. Usually we see water pipe leaks, which results in a fountain of burst water. As a result, there will be a water shortage problem because of the pressure lost, which prevents the water from being supplied to the storage tank. By applying the automation system such as SCADA with the integration of Fuzzy control to control water storage, the management of water distribution and monitoring can be improved thus resulting in reducing the level of water wastage and maintaining the supply of clean water.

# ABSTRAK

Satu perkara yang kerap dibincangkan sejak kebelakangan ini adalah bagaimana untuk memastikan bekalan air bersih boleh dikekalkan. Dari aspek kekurangan kawasan tadahan dan bekalan yang berkurangan hinggalah kepada sikap pengguna itu sendiri, masalah tersebut tidak menampakkan sebarang perubahan yang memberangsangkan dalam mencari penyelesaian terhadap permasalahan tersebut setkurang-kurangnya mengawal dari terus merebak. Permasalahannya adalah berkait rapat dengan kelemahan dari segi pengagihan bekalan air, kelemahan pengawasan yang berterusan, penggunaan yang tidak cekap, pembaziran dan juga kelemahan pengurusan bersepadu bekalan air. Ada juga sebab-sebab yang tidak dapat dikawal yang menyumbang kepada keadaan ini seperti bekalan air tidak dirawat dan juga sikap penggunaa. Namun terdapat juga aspek yang mana mampu dikawal setidak-tidaknya mengurangkan aspek tersebut ke tahap yang rendah dengan mengaplikasikan penggunaan teknologi yang lebih canggih dan pengurusan yang lebih cekap. Aspek yang mampu ditingkatkan antaranya adalah pengawasan dan pengurusan simpanan bekalan air dan pengagihan air. Acapkali kita lihat pancutan air yang terjadi akibat daripada kebocoran paip penghantaran. Kesannya akan terjadilah kekurangan bekalan air disebabkan kehilangan tekanan air didalam paip penghantaran yang mana akan menggangu proses penghantaran air ke tangki simpanan. Dengan penggunaan sistem automasi yang menggabungkan penggunaan SCADA dan juga kawalan Fuzzy Logic untuk mengawal proses penyimpanan air, pegurusan penghantaran dan penyeliaan bekalan air dapat ditambah baik dan kesannya dapat mengurangkan pembaziran air dan mengekalkan bekalan air bersih untuk kegunaan keperluan harian

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# CHAPTER 1

# INTRODUCTION

## 1.1 Project Background

The water supply systems are an important part of the infrastructure ~~in~~ which must be assured the continuity of the water storage, the water quality and also the distribution of the water supply to the end user. Monitoring and control of the quality, distribution and storage of water supply is essential and very important that the management of this resource must be well organized because of the restrictions imposed by the water availability, hydrological conditions, the storage capacity of the tanks and water towers and the increasing diversity of water use.[1]

Sustainability of clean water resource has been a big issue being discuss lately. From the reason of lack of resources to the attitude of end user that frequently waste clean water, the problem seems not having any improvement on finding ways to at least contain it from increasing. The problem is quietly related to poor water allocation and monitoring, inefficient use, wastage and also lack of adequate integrated water management . There are some reason that is not controllable such as raw resources and the attitude of end user. But there is an area that we can at least control it to the lowest level possible by applying better technology and management. The area that can be improved is the monitoring and management of water storage and distribution. Usually we see water pipe leak that resulting a fountain of burst water. As a result of this, there will be a water shortage problem because of the pressure lost in which prevent the water from being supply to the storage tank. By applying the automation system, the management of water distribution and monitoring can be improved thus resulting in reducing the level of water wastage.

Distribution Control System or known as DCS is widely used in many industrial fields where monitoring and data collection process is required. DCS is a system that generally refers to the particular functional distributed control system design that exists in industrial process plants. The DCS concept exists because of the need to gather data and control the systems on a large scale. Range from a simple task process to a more complicated process integrating networking, communication, monitoring, data collecting, data logging and also real time data display. It is common for a DCS that the control system is expanding and including variety of controlling device from different station that communicate with each other to become a complete controlling system, as everything works in real time. These systems evolved from a need to extend pneumatic control systems beyond just a small cell area of a refinery.

Using this concept, it will increase the ability in monitoring ~~to monitor~~ the usage of treated water and their usage efficiency. It is important that the water supply level at the storage tank being monitored and measured continuously. Measuring water level is an essential task for government and resident (Reza, 2010). In the last few years, there are many monitoring system that have been integrated with water level detection system to enable user to monitor and get more information about water supply storage. Common method of level detection is simply to start the pump at low level and allow the pump to continue to pump in water until certain level is reached in the water storage tank. This method is not adequate to ensure the constant water supply especially during peak consumption by user plus there is no data or information sent to the control person.

The system that provides adequate controlling and monitoring aspect usually includes visual information as well as continuous data indication. Audio and visual alarm also being set at a desired level and the control of the pumping system is included as well and the setting is based on the user requirement. Proper monitoring is essential to ensure water sustainability being reached, with disbursement being linked to sensing and automation process. Such an automation system entails water monitoring system using Programmable Logic Controller (PLC) and SCADA.

In order to automate the control of the water level storage tank and the pump station, there is a need to develop a controlling and monitoring system using Programmable Logic Controller (PLC) and SCADA (Supervisory Control and Data Acquisition). The PLC will communicate through its input and output to send the data to the monitoring system using SCADA. SCADA system will then process the data and display it to the user using visual and numerical display. All the setting and parameter adjustment, water level monitoring, data acquisition and data logging will be done through SCADA system. This system will always communicate with PLC to retrieve information, turn On/Off the system and manage the whole process. This system will help reduce error and downtime caused by human negligence. For this project, a controller for controlling the water level of the tank will be designed using Fuzzy Logic Controller and this controller will then be integrated together with PLC as switching device and SCADA as the monitoring and data acquisition device. The system also will consider the water pressure at the incoming pipe to regulate the pump operation.

## 1.2 Problem Statement

Water level and distribution management and monitoring will help in reducing the water wastage as well as overflow. Furthermore it can indicate the amount of water in the storage tank, give information about the distribution process, display data about the process and also transmit alarm and warning remotely using communication device. Whereby using the conventional system, all process is done manually and need human assistance. In this research, it has been decided to select water distribution system in Politeknik Tuanku Syed Sirajuddin as a model. Currently, the water distribution and management system in Polytechnic uses a manual system, in which the pump at the pump station needs to be operated manually by a technician. The technician needs to attend the pump throughout the pumping time and turn off manually when the pumping process is finished. Also there are no feedback system to inform about the water level and the distribution condition from the main tank to all the areas. This results in lacking of controlling and monitoring water distribution and it is difficult to troubleshoot if leakage happens at the distribution line.

Frequently happen is the shortage of water supply to the 10 blocks of hostel causes the students are not be able to do their daily routine such as taking bath, bladder and also washing their cloth. Not to mention the water supply shortage also affects their diet as well because the lack of clean water to be consumed. Sometimes this problem happens up to 3 days before the water supply resumes supplying nearly 3600 students and 400 staffs. The main cause of this problem is the main water supply tank located on top of the hill has dried out because of no incoming supply. The incoming supply to the main tank comes from a pump house located below the hill. So the pump house needed to be operated in order to pump water supply from main distribution pipe to the main storage tank. This pump operated manually with no automatic system being applied. Whenever the water level at the main storage tank is low, the technician will attend to the pump house and turn on the pump. If the person in charge overlooked this matter, the water will not be able to be supplied to the main tank in time that results in water shortage at the main tank thus affecting the water pressure within the distribution pipe. When this happen, the water cannot reach the water tank on top each hostel block and this will cause the shortage of water supply.

To prevent the problem from recurring and affecting the life of all the students and staff inside PTSS community, a monitoring system is needed in order to manage and maintain the availability of water supply throughout PTSS area. Constant monitoring will provide constant alert regarding plant condition information supplied by the system, which results in a better preventive maintenance method.

## 1.3 Objectives

The objectives of this project are:

i. To design a simulation model of a water level and distribution monitoring system using PLC/SCADA.

ii. To design controller system that is able to maintain the water level at the main tank within the desired level.

iii. To verify that the system is able to monitor the water level at main storage tank and turn on/off the water pump autonomously.

## 1.4 Scope of Work

The scopes of study are as follows:

i. The project is limited in designing a simulation model of a water level controller system.
ii. This project will focus mainly in designing the Fuzzy controller.
iii. The SCADA systems function is to only monitor and control the operation of the PLC.

## 1.5 Organization of Report

As an overview, the structure of this report is organized as follows. This chapter describes a general introduction of the project, problem statement project aims and project scope. Chapter 2 provides details literature review that includes an introduction to some basic concepts and a survey of existing work in the areas of water level controller. Chapter 3 illustrated the method of the project where the controller design is the main part of this project. This chapter explain the method that has been used for this project and the process of designing the controller. Chapter 4 displays some results from the system and these results are analysed and discussed. In Chapter 5 justification of this project will be explained together with research efforts done and also future recommendation for this project.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This project focuses on the distributed control system (DCS) method that is widely used in industries nowadays ranging from oil and gas, production, refinery and also water management and distribution. The area that being focused is the water distribution monitoring system that consist of the usage of Programmable Logic Controller (PLC) as the controller device and Supervisory Control and Data Acquisition (SCADA) as the monitoring device.

## 2.2 Supervisory Control and Data acquisition (SCADA)

**SCADA** (**supervisory control and data acquisition**) is a type of industrial control system . Industrial control systems are computer controlled systems that monitor and control industrial processes that exist in the real world. SCADA systems has the ability to connect multiple type of industrial automation and control system and able to control large scale processes that can include multiple sites and also system that are large distances. These processes include industrial, infrastructure, and facility-based processes, as described below:

i. Industrial processes include those of manufacturing, production, power generation, fabrication, and refining, and may run in continuous, batch, repetitive, or discrete modes.
ii. Infrastructure processes may be public or private, and include water treatment and distribution, wastewater collection and treatment, oil and gas pipelines, electrical power transmission and distribution, wind farms, civil defence siren systems, and large communication systems.
iii. Facility processes occur both in public facilities and private ones, including buildings, airports, ships, and space stations. They monitor and control heating, ventilation, and air conditioning systems (HVAC), access, and energy consumption.

The term SCADA usually refers to centralized systems which monitor and control entire sites, or complexes of systems spread out over large areas (anything from an industrial plant to a nation). Most control actions are performed automatically by RTUs or by PLCs. Host control functions are usually restricted to basic overriding or *supervisory* level intervention. For example, a PLC may control the flow of cooling water through part of an industrial process, but the SCADA system may allow operators to change the set points for the flow, and enable alarm conditions, such as loss of flow and high temperature, to be displayed and recorded. More often, a SCADA system will monitor and make optimal changes to function; SCADA systems are considered as a closed loop system and run with relatively little human intervention. The feedback control loop passes through the RTU or PLC, while the SCADA system monitors the overall performance of the loop.

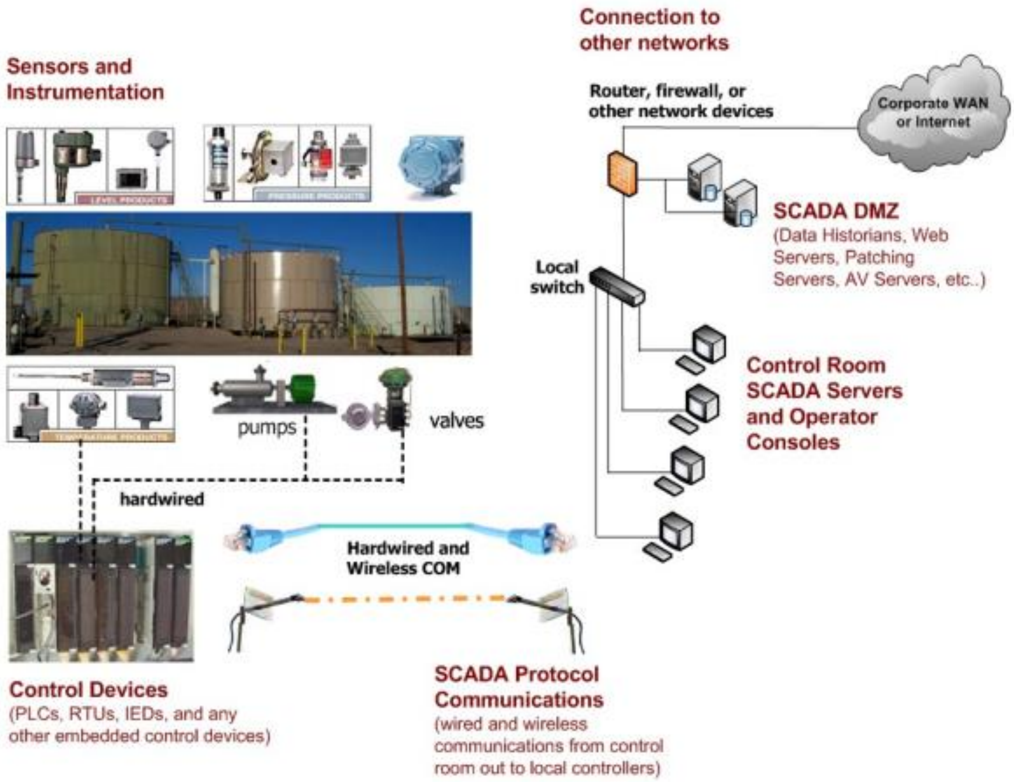


Figure 2.1: Major Component of a SCADA System [18]

There are many parts of a working SCADA system. A SCADA system usually includes input and output device signal, controllers, networks, user interface, communications equipment and software. The term SCADA actually refers to the entire central system that combines and interconnected between those subsystem that need to be controlled. The central system usually monitors data from various sensors that are either in close proximity or off site.

The brains of a SCADA system are performed by the controller and mostly the controllers are located inside the RTU. These RTU is connected between each other using some kind of communication method or protocol. The RTUs are usually set to specific requirements according to the function and nature of the system it want to control. Although the system is set to match the environment and function of the system, most RTUs allow human intervention. In addition, any changes or errors are usually automatically logged for and/or displayed.

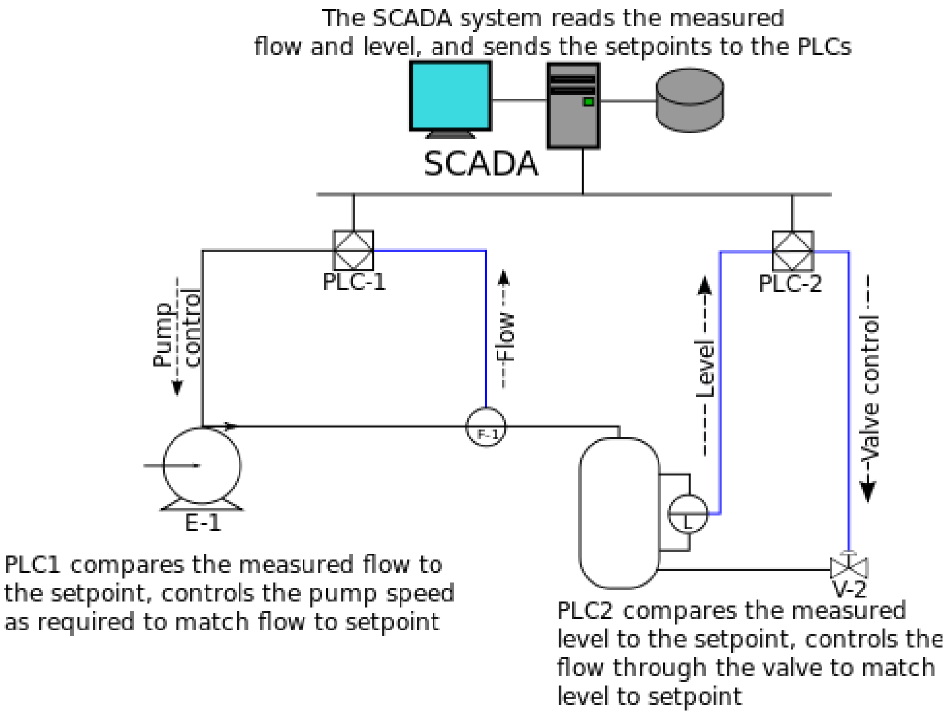


Figure 2.2: Basic concept for SCADA water distribution system [2]

One key processes of SCADA system is the ability to monitor an entire system in real time. This is facilitated by data acquisitions function including meter reading, checking statuses of sensors and actuators and communicating at regular intervals depending on the system. Besides the data being used by the controller system and also the RTU, it is also displayed it for a human that is able to interface with the system to override settings or make changes when necessary.

SCADA also can be seen as a system with many data elements called points. Usually each point is a monitor or sensor. A point represents a single input or output value monitored or controlled by the system. Points can be either "hard" or "soft". A hard point represents an actual input or output within the system, while a soft point results from logic and math operations applied to other points such as calculation application software. (Most implementations conceptually remove the distinction by making every property a "soft" point expression, which may, in the simplest case, equal a single hard point.) Points are normally stored as value-timestamp pairs: a value and the timestamp when it was recorded or calculated. A series of value-timestamp pairs gives the history of that point. It is also common to store additional data with tags, such as the path to a field device or PLC register, design time comments, and alarm information.

An important part of most SCADA implementations is alarm handling. The system monitors whether certain alarm conditions are satisfied, to determine when an alarm event has occurred. Once an alarm event has been detected, one or more actions are taken (such as the activation of one or more alarm indicators, and perhaps the generation of email or text messages so that management or remote SCADA operators are informed). In many cases, a SCADA operator may have to acknowledge the alarm event; this may deactivate some alarm indicators, whereas other indicators remain active until the alarm conditions are cleared. Alarm conditions can be explicit—for example, an alarm point is a digital status point that has either the value NORMAL or ALARM that is calculated by a formula based on the values in other analogue and digital points—or implicit: the SCADA system might automatically monitor whether the value in an analogue point lies outside high and low limit values associated with that point.

Examples of alarm indicators include a siren, a pop-up box on a screen, or a coloured or flashing area on a screen with the role of the alarm indicator is to draw the operator's attention to the part of the system 'in alarm' so that appropriate action can be taken. In designing SCADA systems, care must be taken when a cascade of alarm events occurs in a short time, otherwise the underlying cause (which might not be the earliest event detected) may get lost in the noise.

## 2.3 Human Machine Interface (HMI)

A human–machine interface also known as HMI is a device in which the main purposes are to display and present process data to a human operator through which the human operator can controls the process. HMI is usually linked to the SCADA system's databases and software programs in order to provide trending, diagnostic data, and management information such as scheduled maintenance procedures, logistic information, detailed schematics for a particular sensor or machine, and system troubleshooting guides.

The HMI system presents the information to the operating personnel graphically, in the form of a mimic diagram. This means that the operator can see a schematic representation of the plant being controlled. For example, a picture of a pump connected to a pipe can show the operator that the pump is running and how much fluid it is pumping through the pipe at the moment. The operator can then switch the pump off. The HMI software will show the flow rate of the fluid in the pipe decrease in real time. Mimic diagrams may consist of line graphics and schematic symbols to represent process elements, or may consist of digital photographs of the process equipment overlain with animated symbols.

The HMI package for the SCADA system typically includes a drawing program that the operators or system maintenance personnel use to change the way these points are represented in the interface. These representations can be as simple as an on-screen traffic light, which represents the state of an actual traffic light in the field, or as complex as a multi-projector display representing the position of all of the elevators in a skyscraper or all of the trains on a railway.

Nearly all major PLC manufacturers have offered integrated HMI/SCADA systems with many of them using open and non-proprietary communications protocols. Numerous specialized third-party HMI/SCADA packages, offering built-in compatibility with most major PLCs, have also entered the market, allowing mechanical engineers, electrical engineers and technicians to configure HMIs themselves, without the need for a custom-made program written by a software developer.

## 2.4 Programmable Logic Controller (PLC)

A Programmable Logic Controller or famously known as PLC is a digital computer that is widely used normally in industrial sector for automation in wide range of process such as electromechanical processes, to control various types of equipment, devices and machinery in factory assembly lines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, can stand higher temperature, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a real time system controller since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.

The functionality of the PLC has evolved over the years to include sequential relay control, motion control, process control, distributed control systems and networking. The main difference from other computers is that PLCs are armoured for severe conditions (such as dust, moisture, heat, cold) and have the facility for extensive input/output (I/O) arrangements. These connect the PLC to sensors and actuators. PLCs read limit switches, analogue process variables (such as temperature and pressure), and the positions of complex positioning systems. Some use machine vision. On the actuator side, PLCs operate electric motors, pneumatic or hydraulic cylinders, magnetic relays, solenoids, or analogue outputs. The input/output arrangements may be built into a simple PLC, or the PLC may have external I/O modules attached to a computer network that plugs into the PLC.

PLCs have built in communications ports, usually 9-pin RS-232, but optionally EIA-485 or Ethernet. Modbus, BACnet or DF1 is usually included as one of the communications protocols. Other options include various field buses such as DeviceNet or Profibus. Other communications protocols that may be used are listed in the List of automation protocols. Most modern PLCs can communicate over a network to some other system, such as a computer running a SCADA (Supervisory Control And Data Acquisition) system or web browser. This is why PLC has been choose in this project to integrate with SCADA system and controlled the process.

**2.5 Related Works**

There are many researches that have been conducted to address the problem of water shortage due to lack of pressure. For example, water level sensing and controlling by using Microcontroller has been done by [1], in which microcontroller was used to detect water level condition and to control the water pump. The authors also proposed the usage of water level monitoring network using a wireless automated controlling system that include the application of web monitoring services to monitor large area of distribution network.

In terms of performance of SCADA system, [6] shows that SCADA system with enhanced features not only used for wide area system operation, but also covers

Distribution Management System (DMS), Energy Management System (EMS), various Network Applications and Metering Management systems. The disadvantage of this system is about the usage of the microcontroller for the purpose of the application. For a system that operates in the hash condition, the controller must be proven to be rugged and can withstand the rough condition of the working environment. PLC has been proved to be more rugged, easy accessibility and also more reliable than microcontroller. Plus the system required to design interface software should it required to be monitored and controlled remotely.

Fuzzy control systems have been successfully applied in many application cases where conventional control algorithms are difficult or even impossible to be applied. Jiri Kocian et. Al [23] presented the implementation of universal fuzzy PS/PD function block to the PLC Simatic S7 300/400. A control system with implemented PS/PD regulator and visualization was designed. For testing and analysis purpose, Fuzzy PS and PD regulator was designed also in Matlab. The weaknesses of this system are there are lack of controlling and monitoring system that will constantly monitor and adjust the system condition. Moreover in this research the author focus more on the fundamental and the concept of controlling the system using fuzzy logic and not concerning on the system as a whole complete system

S. Bogdan et. Al [28], discussed and explained the implementation of a self-learning fuzzy logic controller (SLFLC) in a form of PLC super block [28]. The SLFLC contains a learning algorithm that utilizes a second-order reference model and sensitivity model related to the fuzzy controller parameters. They also had tested the effectiveness of the PLC super block with experiment in the position control loop of an electronically commutated servo system in the presence of a gravity-dependent shaft load. The experimental resulted in proving that that the SLFLC implemented in PLC provided desired closed-loop control behaviour.

To solve the problem of poor quality and waste of electric energy coursed by water supply mode of a high water tower and direct water pump, [29] introduced a constant pressure supply water system, which adopts embedded fuzzy control technology using PLC and frequency converter as its core. Water pressure value of the pipe is inputted into the PLC from input terminal using pressure transmitter. The rotation speed of the water pump was controlled and the water pressure was measured and adjusted. The measured water pressure value and its set value were compared and the PLC controlled the operation frequency of the frequency converter depending on the output signal provided by fuzzy calculation.

L. Körösi and D. Turcsek [30], explain some existing fuzzy toolboxes for PLCs and present a universal fuzzy system for PLC with a methodology to convert Matlab fuzzy system into PLCs fuzzy structure [30]. This paper discussed the usage of two different PLC brands to implement the concept of fuzzy controller in the PLC programming. Although the research cover the fuzzy logic and also the PLC function, the research did not mention anything about water control management and also monitoring aspect of water level and water condition which were the important part in clean water management system.

V.rajeswari et. Al [31] explained in their research about the management of water storage and distribution in the pharmaceutical industry. This stage is of vital importance to minimize possible contamination of the water and the proliferation of micro-organisms. Systems must be sealed with continuous recirculation and must have a sanitization system. The first stage was to automate the water storage & distribution for various requirements and control the level in the storage tank and monitoring the pH, conductivity, temperature before being distributed. This is very important as any small change in these parameters may hinder the performance of the whole pharmaceutical plant. The flow rate of the water in the distribution line also needed to be controlled and then the water is given to the U-V Treatment to minimize contamination and micro-organisms. The water is then distributed for continuous recirculation.

This research uses PLC as the main controller and the SCADA application as the monitoring and management system application. They integrated various types of input and output to the PLC and communicate through the communication method to the SCADA software for easy monitoring and data acquisition. They also developed alarm triggering system within the SCADA application to warn and inform the user about the abnormality in the operation. Although it seems that the system is quite sophisticated, there is some weakness in this project such as they did not mention on how they controlled the water level inside the storage tank. They did not use any type of self tuning controller such as PID or FUZZY in their research and just opted to use the basic controller of HIGH and LOW water level method only. This maybe because the behaviour of their system that did not require constant level of water inside the storage tank to ensure continuous availability of the resources.

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

Every system that runs autonomously will need a very reliable controller to control and regulate all the inputs and outputs related the environment of the system. Usually a controller is considered reliable when the controller itself can detect the inaccuracy in its reading and adjust accordingly to the inputs and output so that the desired results can be achieved. Closed loop controlling system is the terms given to this controller with ability and capability to detect and adjust its input or output condition based on the error detected in its reading. This is called feedback and the feedback is important in closed loop controlling system to ensure the controller is reliable.

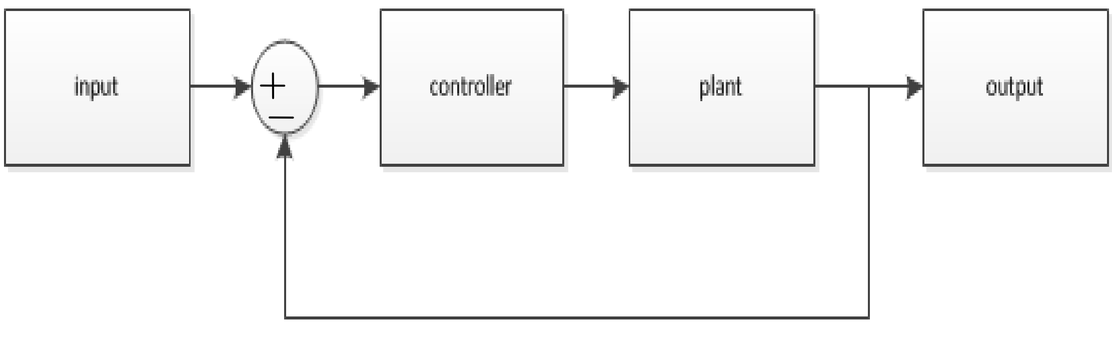


Figure 3.1: Closed Loop Control System

For this particular project, the plant is the water storage system currently available at Politeknik Tuanku Syed Sirajuddin and the system currently run as manual system. All the input and output are stand alone and not communicate between one another. So this project will focus on creating a system that will integrate all the inputs and outputs using one controller. In order to do that the controlling method needs to be decided and the overall layout of the proposed system need to be finalised.

After doing some research on the cases similar to this project and also other relevant documents and method used to design a controller that can behave similar to this project [21] [25], Fuzzy Logic Controller has been chosen to control and monitor the system thus making the system autonomous. Although there are many other methods that can be used to control the system, this method was chosen because of the requirement of the system that do not need a very precise or high level of accuracy to achieve the desired target and easy to design and implement. The overall layout of this project has been decided and the controller will be the main brain of this system while the PLC will act as the switching device and the SCADA will act as the data logger and data acquisition system for this project. Most of the efforts in this project are focused on designing the Fuzzy Logic Controller for water level controlling system. The overall layout of the main system is shown in Figure 3.2.

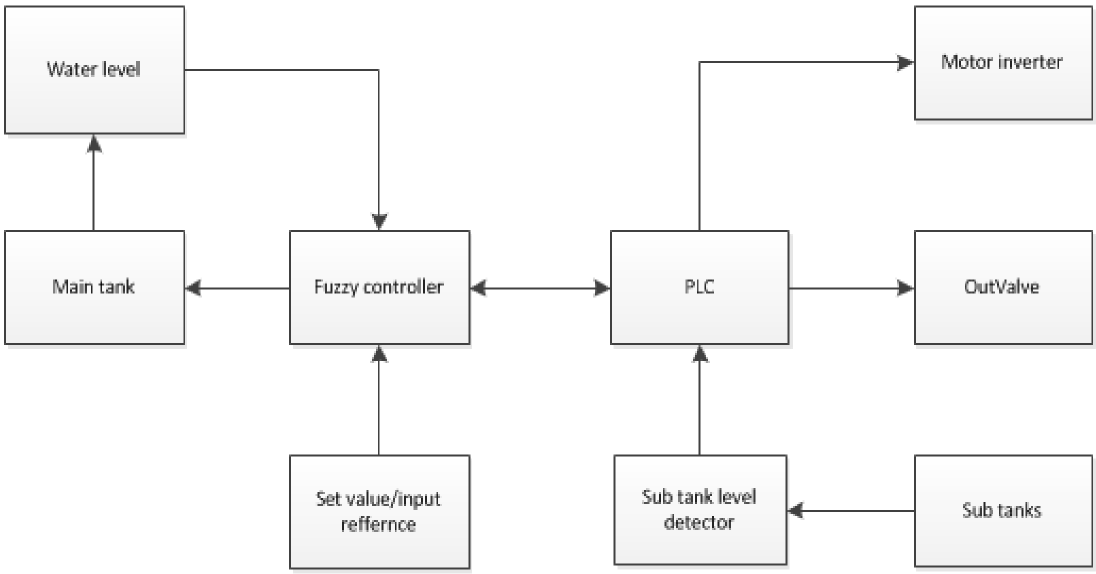


Figure 3.2: Overall layout of the system

Although the main focus of this project is the controller part of the system, the integration of inputs and outputs, controller and also the data acquisition device are also taken into account. The selection of communication method and also the input and output device will greatly depend on the functionality and also the main purpose of the system. All the selected method and the most suitable device and technologies used in the project will be explained in details in this chapter. The main technologies used in this project are Supervisory Control and Data Acquisition (SCADA), Programmable Logic Controller (PLC) and Matlab Fuzzy Logic.

The computer software system integrates a SCADA application program specifically developed for water distribution management and monitoring. The program emulates the operator console HMI and the technological user interfaces in order to monitor the pressure measurements points, the water level indication and supervise the correct functioning of the distributed system and controlling the remote control of the pumping stations equipment. The data acquired from the remote terminal units (RTU) from the pumping stations PLCs and the water reservoirs tank are transmitted to the dispatching unit computer installed in the water distribution central controller.

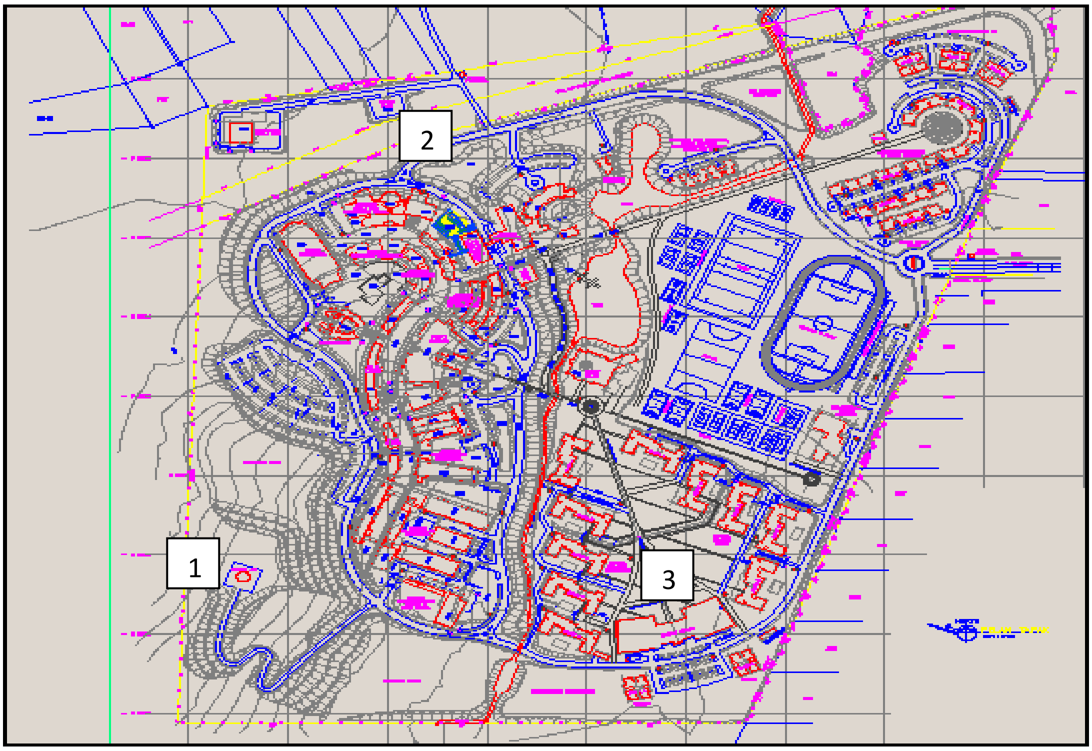


Figure 3.3: Geographically plan layout of the campus area (scale 1:1250)

The RTU's for this SCADA system is located separately from the Main Control Unit (MCU). There are a minimum of 3 RTU's that will communicate with the MCU located at a fixed location (shown in maps below). The RTU's are Main Storage Tank RTU (1), Pumping station RTU (2), and Hostel Blocks Storage RTU (3). All these RTU's will actuate and receive all the output and input devices available. Data from all these RTU's will then is monitor real time by a SCADA system in the MCU and the process is automated by using the program created.

The storage tank RTU will observe and monitor the condition of water level inside the main tank.

Using the SCADA system, the process of distributing the water throughout the campus area will be monitored, the water pressure will be regulated, the pumping process of water from main distribution line to the storage tank will be automated and the alarm system will be executed if there is any malfunction or error occur at any part of the system. All these process are integrated, automated and monitored by the SCADA/PLC system.

## 3.2 SCADA Implementation

The SCADA system also will record all the alarm event occur during the operation and will store the data according to date occur. The system stores the acquired data in a specific database for later use analysis and retrieving. The access of the operator to the SCADA system is managed through three levels of restricted access by means of identification codes or password.

i. Low Level - Offer the access to proceed the alarm/events acknowledgement, to elaborate the on/off command for the pumping units, open/close for the electric operated valves, selection of functional regime automatic/manual, remote set up of controller set-points and PID parameters and modification of the technological parameters limits,
ii. High Level - Global authorizations including the access to configure templates, user interfaces, create or change specific reports, technological P&I equipment process pictures, data base definition and to include more digital/analogue input/output parameters.

The SCADA system process the information regarding the operation status of all pumps, electric actuators such as valves, the actual position of all remote operated water level sensors and equipment, the operation time and number of starts for all electrical drives. Actual operation status report is online updated in a graphical process user interface on the dispatching console including operation status. Analogue measurements and calculations are displayed as digital values in field areas coordinated with the process symbol images and their associated graphical icon.

Process events and alarms are displayed in the graphical process image by their colour change and status update by text message or numerical data while an alarm identification attachment as a text message. The alarm list for display or print follows the sorting criteria imposed by the operator. The operator may change alarm settings for parameter limits under normal operation. The actual operation is carried out through Windows pop-up pictures, by mouse, keyboard, input fields using the menu driven selection of the operation. In each process graphical user interface it is possible to call out a menu picture which allows displaying technological process images, events, alarms and status lists. The operator is inform about the process parameters measured values, status signals and actual alarms change currently in real time on all the actual user interface in use.

## 3.3 Alarms, Reports, Real Time Data Display and Trend Displays

Alarms and reports are main parts of the SCADA system functions [3]. The control system will generate several alarms that are used to alarm the controller if the system entered danger state or there is malfunction at any part of the system. All these alarms are archived in the SCADA system. Suggested alarms to be extracted are:

i. Pump failure
ii. Very High and Very Low water pressure level,
iii. Low water level condition,
iv. Valve failure

Other data as the pressure meter, water level and pump condition are also display and archived in the SCADA system and used for monitoring, analyzing and developing the systems. Monitoring process and reports are among the main functions and benefits of the SCADA system, recommended monitoring process and reports that may be displayed and generated for the system are:

i. Time of pumps operation.

ii. Current state of the motor pump.

iii. Pressure level of the distribution line.

iv. The flow rate of the water from the pump station.

v. Storage tank water level (Main and Substation)

vi. Valve opening and closing condition

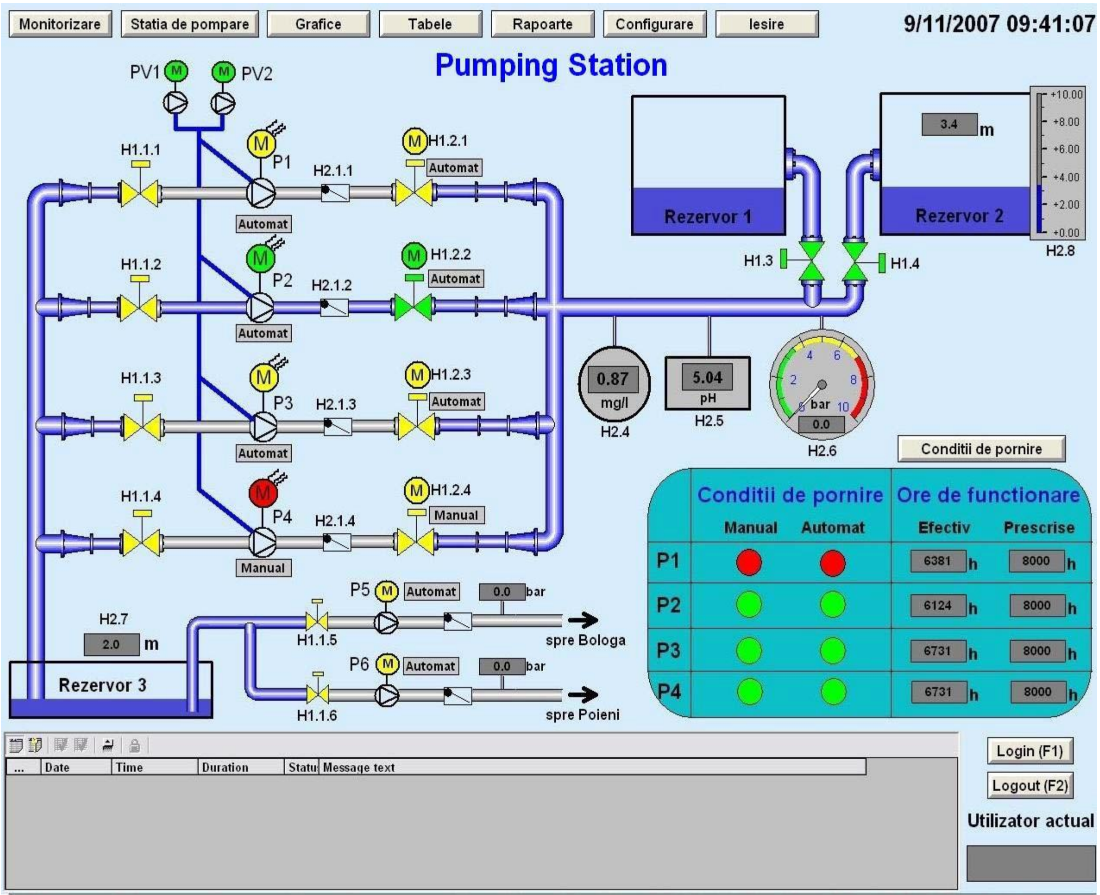


Figure 3.4: Example of SCADA interface for water Distribution [17]

## 3.4 Communication methods

Because of the readily available Local Area Network (LAN) connection throughout the campus plus with the availability of wireless LAN or WLAN, this communication method is selected in order to make this project more cost effective, economical and practical. The reason why wireless LAN is included in the method is that the geographical condition of the location where each RTU will be assembled.

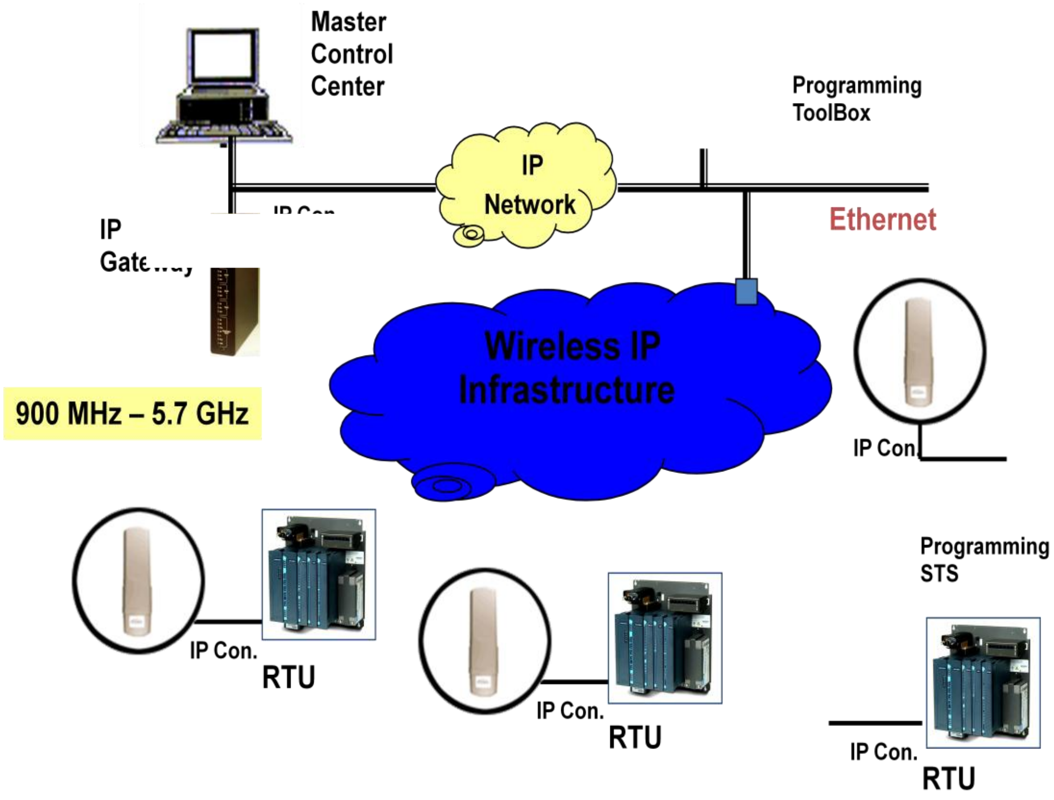


Figure 3.5: Wireless IP connection with SCADA [6]

Each RTU is connected to the wireless LAN frequency using Internet Protocol structure as shown in Figure 3.3. Most wireless networks are based on the IEEE® 802.11 standards. A basic wireless network consists of multiple stations communicating with radios that broadcast in either the 2.4GHz or 5GHz band (though this varies according to the locale and is also changing to enable communication in the 2.3GHz and 4.9GHz ranges). Most recent technology has expanded the broadcasting range to 5.8GHz (Based on Basics of Industrial Wireless LAN, SIEMENS 05/2004). 802.11 networks are organized in two ways: in *infrastructure mode* and also *ad-hoc mode*.

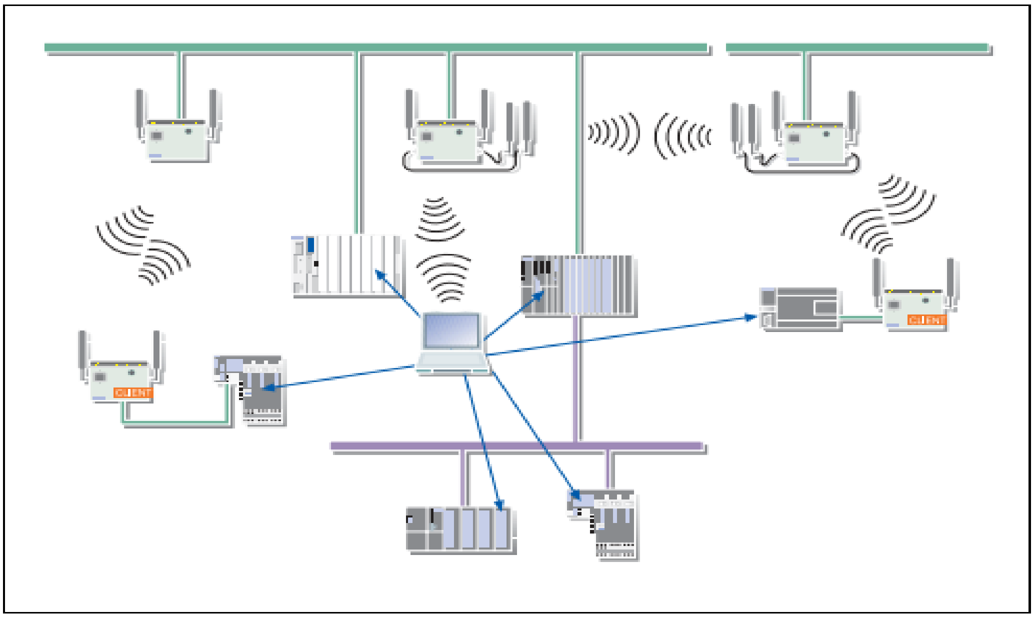

Figure 3.6: Infrastructure mode [6]

In infrastructure mode, communication takes place over an access point. In the simplest case, there is a group of IEEE 802.11 stations in the wireless range of this access point. In this mode, one station acts as a master with all the other stations associating to it. This type of network the master station is termed an access point (AP). In infrastructure mode all communication passes through the AP; even when one station wants to communicate with another wireless station messages must go through the AP. The backbone network meanwhile uses cables with one or more wireless AP connecting the wireless RTU's to the wired network.

## 3.5 Measuring Equipment

### 3.5.1 Water Pressure Measurement

The SCADA system will monitor water pressure level at desired points set by the administrator based on the system requirement. In this project, the water pressure value at main supply pipe, after pumping station and distribution network is taken. It is important to monitor the water pressure at the main distribution line to determine the suitable pumping period in order not to disrupt water supply to the villagers. It is also important to continuously monitor the water pressure along the distribution pipe within campus area to reduce burst pipe because of high pressure in the distribution pipe. All this measurement will be monitored using SCADA and any perimeter adjustment will be made according to these reading.

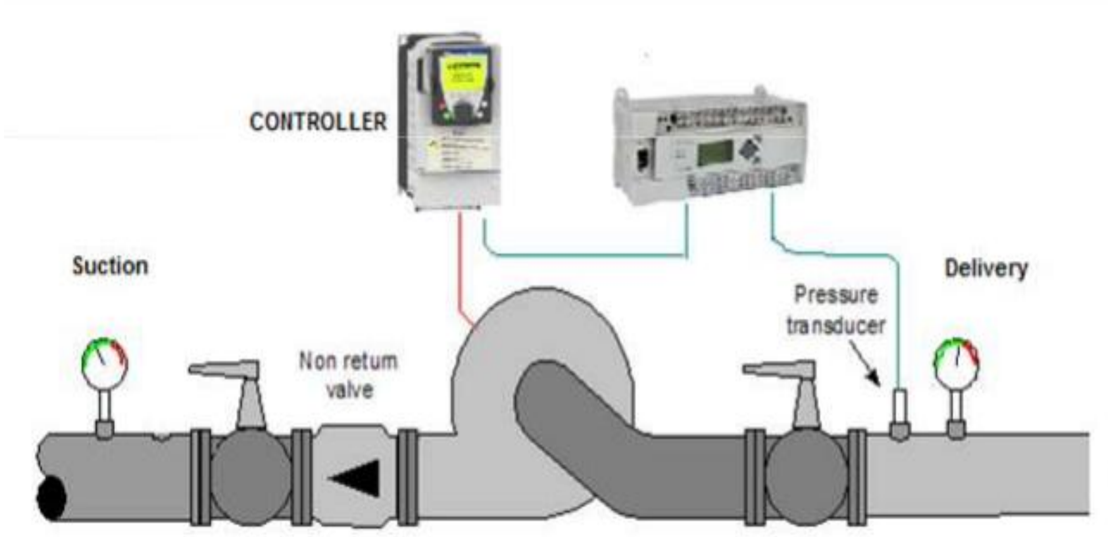


Figure 3.7: Example of pressure level monitoring and measurement method []

### 3.5.2 Water Level Measurement

Utilizing water's ability to conduct electricity, a circuit path can be established between one probe tip and the other. Current conducts through the water across probes of dissimilar length. One common or reference probe is present in all systems and is shared by all functions of the system. This probe can be identified by its length. It is the longest probe in the system and extends the deepest into the basin. The current path is routed between all other probe tips and this one "common". When the water level reaches the shorter probe, the circuit is completed and the relay responds, opening or closing relay contacts corresponding to a fixed level.

High and low water alarms can be utilized to give warnings associated with abnormal operating water levels. To provide indication of these types of alerts, the control system provides dry contacts to interface with various digital control systems or can be connected to user supplied alarm indicators to signal when corrective action is required. Meanwhile Low-water cut-offs are used to protect pumps from operating without sufficient water. When used in unattended operating environments, the low-water cut-off is configured to shut the pump off, thus preventing costly repairs. Dry contacts can be wired directly in series with pilot duty controls or to digital control systems to initiate the shutdown of protected equipment during low-water situations.

The number of probes is determined by the system requirement. As an example, in a main water storage system there are five probes. The five probes are common or reference probe, high water level, low water level, very high water level and very low water level. The tip of the reference probe is normally positioned slightly above the water tank floor with the additional probe tips positioned at different heights dictated by their specific function. The system would have one probe at a height to send signal to start filling the tank and another positioned higher to complete or stop filling. A probe for a High Alarm or High Cut-off would be positioned at a level to activate when the water inside the tank exceeds its normal operating level and a Low Alarm or Low Cut-off would be positioned to detect a low water level nearer the bottom of the tank.

Figure 3.8: Water level detector device [14]

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