DESIGN A WATER TANK SWITCHING SYSTEM

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A project report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor (Hons.) of Electrical & Electronics Engineering

Faculty of Engineering and Science
Universiti Tunku Abdul Rahman

September 2011

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

Signature : _________________________

Name : _________________________

ID No. : _________________________

Date : _________________________

APPROVAL FOR SUBMISSION

I certify that this project report entitled **"DESIGN A WATER TANK SWITCHING SYSTEM"** was prepared by **VIMALSHWAREN A/L MAHALINGAM** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor (Hons.) of Electrical & Electronics Engineering at Universiti Tunku Abdul Rahman.

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Date : _________________________

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DESIGN A WATER TANK SWITCHING SYSTEM

ABSTRACT

In the chapter one of this report which is the introduction part, the author has discussed about how he got the idea to do this project which is the water tank switching system and the main focus of this project. This project is titled "Design a Water Tank Switching System", so the main area of focus in this project is the controlling unit of the system which is the electronic unit. Besides that the author has also discussed about the aims and the objective of this project in the chapter one of this report. In the second chapter of this report which is the literature review part, the author has discussed about the mechanism and the main elements of a water tank switching system. This includes the characteristic and nature of the main elements of a water tank switching system. The third chapter is all about the methodology involved in designing this water tank switching system. In this part the author has discussed about the steps involved and things required in designing a water tank switching system. The fourth chapter is all about the results obtained after designing the water tank switching system and the discussion about the results. This includes the experiment conducted to test the success of this water tank switching system. The main objective of this project is to design a water tank switching system with improved safety features and a system which can save power consumption, so these objectives will be experimented and discussed in this chapter. The final chapter is about the future recommendation that can be implemented to this water tank switching system to improve its efficiency even further.

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LIST OF SYMBOLS / ABBREVIATIONS

c_p	specific heat capacity, J/(kg·K)
h	height, m
K_d	discharge coefficient
M	mass flow rate, kg/s
P	pressure, kPa
P_b	back pressure, kPa
R	mass flow rate ratio
T	temperature, K
v	specific volume, m^3
α	homogeneous void fraction
η	pressure ratio
ρ	density, kg/m^3
ω	compressible flow parameter
ID	inner diameter, m
MAP	maximum allowable pressure, kPa
MAWP	maximum allowable working pressure, kPa
OD	outer diameter, m
RV	relief valve

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CHAPTER 1

INTRODUCTION

1.1 Background

The tank system which is available in industries now has a drawback. The drawback is, each time the tank becomes empty, the user have to fill up the tank so that the process which depends on the liquid in the tank doesn't not get interrupted. So if the liquid finishes during midnight or during public holidays, then the any industrial processes which depend on the liquid will be interrupted. To rectify this drawback, the author has designed this tank switching system. If the liquid in a tank finishes, there will be a backup tank whereby the electrical and electronic controlling unit will switch over the dosing of the liquid from the first tank to the second tank automatically. Therefore, any crucial process doesn't get interrupted. Again after the liquid in the second tank finishes, the system will switch the dosing of liquid back to the first tank if the liquid in the first tank is topped up by the user.

1.2 Aims and Objectives

The main aim of the author to do this final year project is to design a water tank switching system by using electrical and electronic components such as DC power supply, relays and ELCB. Therefore the main area focused by the author in this project is the electrical and electronic controlling unit which is build to run the whole system. Besides that the author will also focus on the magnetic level switch sensor and the pump which is attached to the sensor. In this project the pump is like the indicator, whereby when the low level is detected it will stop and switch over to the other pump.

The objective of this final year project is:

a. To enhance the safety features in tank switching systems by using 24V DC power supply to power the sensors.

CHAPTER 2

LITERATURE REVIEW

2.1 Electrical and Electronic Controlling Unit

Electrical and electronic controlling unit is basically used for every control process and there are many types of electrical and electronic controlling unit in use at industries. Electrical and electronic controlling unit can only be designed based on the particular process that we desire to control. To design an electrical and electronic controlling unit, first we need to the process flow of the particular system that we wish to control. After that we have to put the flow and description into electrical drawing. After coming up with electrical drawing, then we have to start building the electrical panel. There are few basic electronic components which are used in the electrical panel such as listed below.

2.1.1 Earth Leakage Circuit Breaker (ELCB) (Mitchel, E.S.2006)

This is used as a protective measure to shut the system down in case of any draw backs. It has a very high earth impedance to prevent shock. The ELCB detects fault currents from live (hot) to the earth (ground) wire within the installation it protects. If sufficient voltage appears across the ELCB's sense coil, it will switch off the power, and remain off until manually reset. An ELCB however, does not sense fault currents from live to any other earthed body.

Figure 2.1: ELCB (ELCB, 2011)

2.1.2 Miniature Circuit Breaker (MCB)

(Mitchel, E.S.2006) revealed a MCB is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and, by interrupting continuity, to immediately discontinue electrical flow. A MCB can be reset (either manually or automatically) to resume normal operation.

Figure 2.2: MCB (ELCB, 2011)

2.1.3 Relays (Mitchel, E.S.2006)

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

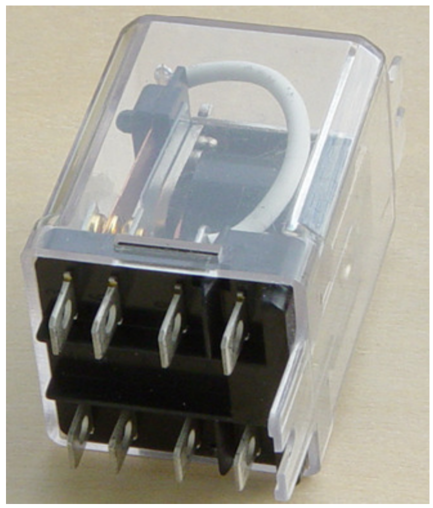

Figure 2.3: Relay (John Hewes, 2011)

2.1.4 Invertors/ Converters

According to Ned, M. et al. (2006), Invertors and convertors are used to convert either AC to DC, DC to AC, AC to AC or DC to DC. This are used to either boost up the current, reduce the current, convert from either DC to AC form or otherwise.

a) AC to DC Converters (Ned, M. Et al. (2006))

A single phase converter with two natural commutated thyristor is shown. The average value of the output voltage v_o can be controlled by varying the conduction time of thyristor or firing delay angle α . The input may be single or three phase source. These converters are also known as controlled rectifier.

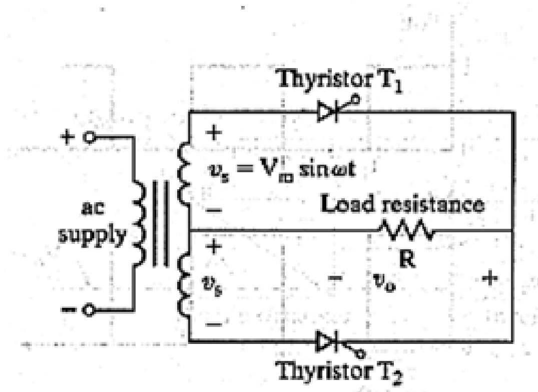

Figure 2.4: Circuit Diagram of an AC to DC Converter (Ned, M. et al.(2006)

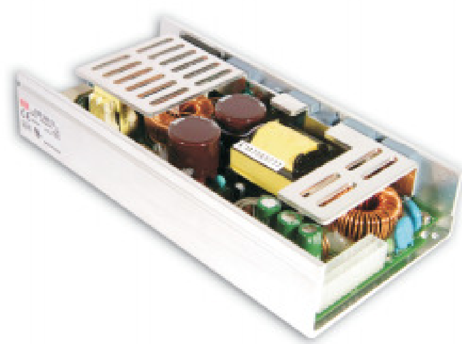

Figure 2.5: AC-DC Converter

b) DC to AC Inverter (Ned, M. et al.(2006))

A single phase transistor inverter is shown below. If transistors M_1 and M_2 conduct one half of a period and M_3 and M_4 conduct for the other half, the output voltage is of the alternating form. The output voltage can be controlled by varying the conduction time of transistors.

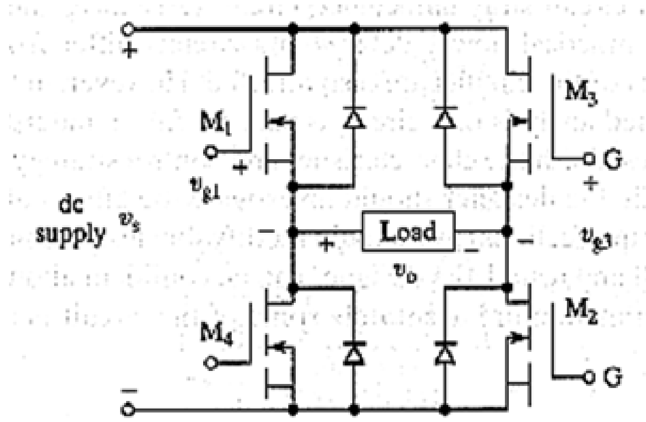

Figure 2.6: circuit Diagram of a DC to AC Inverter (Ned, M. et al. (2006))


Figure 2.7: DC-AC Converter

c) AC to AC Converter (Ned, M. et al.(2006))

These converters are used to obtain a variable ac output voltage v_o from a fixed ac source and a single phase converter with TRIAC is shown. The output voltage is controlled by varying the conduction time of a TRIAC or firing delay angle α. These types of converter are also known as ac voltage controllers.

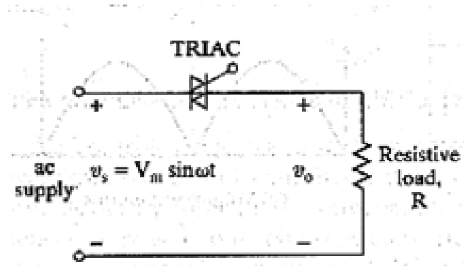

Figure 2.8: Circuit Diagram of an AC to AC Converter

Figure 2.9: AC-AC Converter

d) DC to DC Converter (Ned, M. et al. (2006))

A dc-dc converter is also known as chopper, or switching regulator and a transistor chopper is shown below. The average output voltage v_o is controlled by varying the conduction time *t*, of transistor Q_1. If T is the chopping period, then t_1 = DT , D is called as the duty cycle of the chopper.

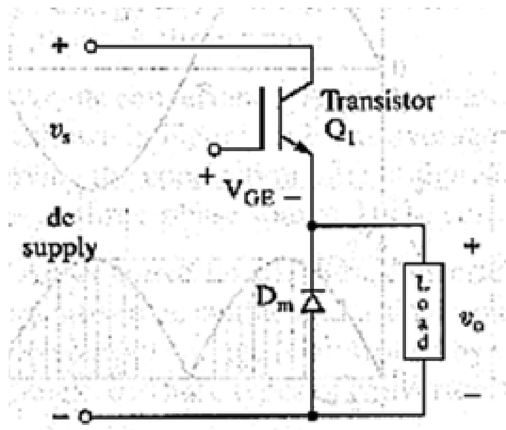

Figure 2.10: Circuit Diagram of a DC to DC Converter (Ned, M. et al. (2006))

Figure 2.11: DC-DC Converter

2.1.5 **Programmable Logic Control (PLC)** (Mitchel, E.S.(2006))

In some high end electrical panels and systems which require precise calculation and measurements, PLC is used. PLC is very handy when it comes to system which gives importance for precision.

Figure 2.12: PLC (Mitchel, E.S.(2006))

2.1.6 24 V DC Power Supply (Mitchel, E.S.(2006))

This component reduces a 230V AC voltage to a 24V DC voltage and with earthing features. This device also gives us a possibility to push up the current in case the reduced current is not sufficient enough for certain functions.

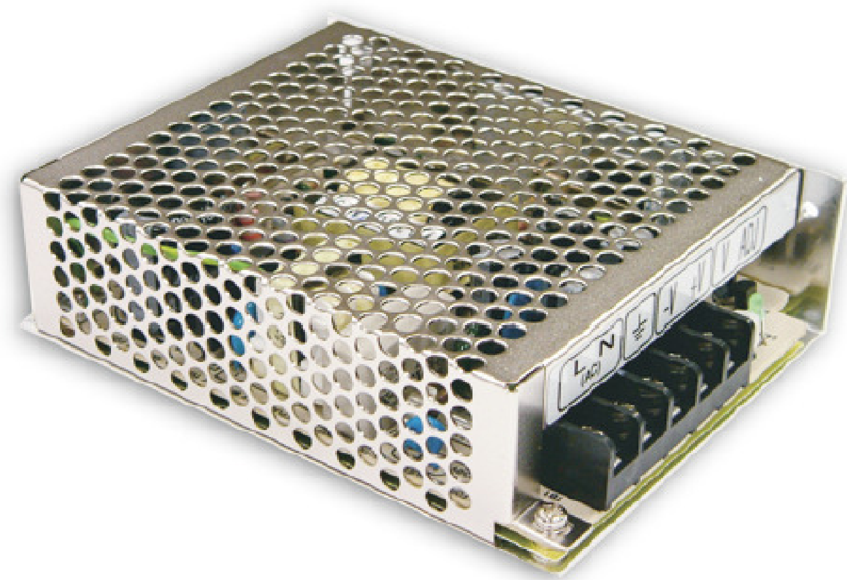

Figure 2.13: 230V AC to 24V DC Power Supply

2.2 Level Measurement Sensors

Level measurement sensors are typically used for the following application: (Endress &Hauser,2005)

a) Cleaning and filtering systems
b) Coolant and lubricant tanks
c) Overspill protection tanks
d) Tanks with pump application
e) Liquid level limit detection in tanks
f) Liquid level detections in pipes

There are many types of level measuring sensors such as below: (Endress &Hauser,2005)

2.2.1 Float switch

This type of level sensors can be used for level switch from drinking water to sewage water. It has fail-safe indication and pump control. The main advantage of this type of level sensors is it has low specific weight of the floating body; therefore it can be used in any environment or condition. It is also low cost polypropylene level switch. These types of sensors are also mercury free operated micro switch.

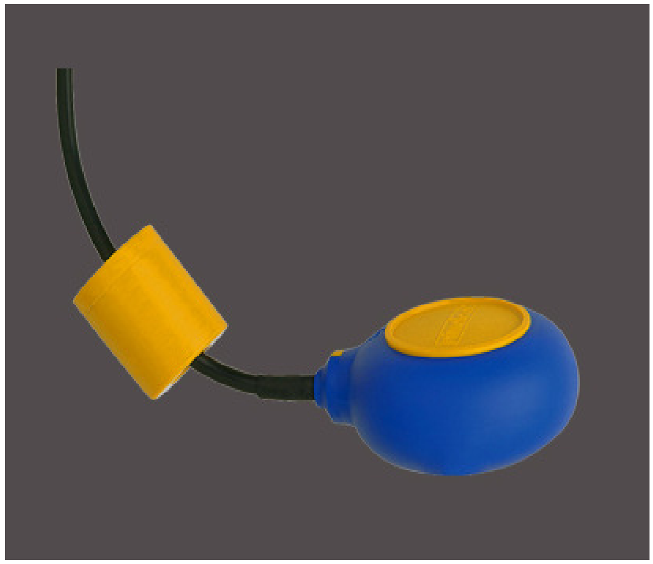

Figure 2.14: Float Switch (Float Switch and Liquid Level Sensor Products, (2002))

2.2.2 Conductivity Level Sensor

Conductive level sensors can be used in conductive liquids. There will be a voltage flowing in the sensor and it is exposed to the liquid. Therefore it has to be carefully used as it is dangerous. If let us say there is a flammable gas around the sensor, it may cause explosion due to exposure to the sensor. It has types in it, one which is limit switch and another one which is the differential switch. It also comes with high or low fail-safe mode.

Figure 2.15: Conductivity Level Sensor (Level Switches, (2011))

2.2.3 Magnetic Coupling Level Sensor

This type of sensor is widely used in power stations, chemical, pharmaceutical and petrochemical industries. This sensor is also used in balance tanks on ships. This can be operated without power supply as well and it has a separated micro-switch. This model of sensor is explosion proof models. It works in a pair, when the first sensor is triggered, a pulse will be send and when the second sensor is sensed then the liquid flow out will be stopped and liquid flow in will start.

Figure 2.16: Magnetic Coupling Level Sensor (Level Switches, (2011))

2.2.4 Magnetic Tracking Level Sensor

This type of sensor is used for liquids which have dense vapour or gas layer above the surface. It is a multi-point level switch which is placed in closed tanks. This sensor can also be operated without power supply and it is an explosion proof model.

Figure 2.18: Magnetic Tracking Level Sensor (Level Switches, (2011))

2.2.5 Vibrating Level Sensors

This type of sensor is used for corrosive, thick, turbulent and flowing liquids. This sensor can also be used for powders and light granules. It has high immunity against vibration and it has no moving parts. It has option to choose various density level and it is an explosion proof model too.

Figure 2.19: Vibrating Level Sensor (Level Switches, (2011))

2.2.6 Guided Radar Level Sensor

It is a proximity switch or transmitter for positioning equipment, packaging equipment and filling equipment. It comes with a switch and also a transmitter and it is a fully temperature compensated unit.

Figure 2.20: Guided Radar Level Sensor (Sensors, (2009))

2.2.7 Magnetic float level switch

This type of liquid level sensor is the most compact level sensor used in single level detection. This sensor has to be mounted vertically for best results in the top or bottom of a tank or reservoir. This sensor comes standard with a PVC cable with a cross section of 0.14 mm^2 and a length of 500 mm. This sensor is widely used for level control, level detection and monitoring, test and measurement and since it is made of plastic it can be used for any type of liquid expect petrol based liquids. This type of sensor is also the safe type of sensor because it is fully insulated and there will not be any electrical leakage into the tank.

Figure 2.21: Magnetic Float Level Switch

2.3 Pumps

2.3.1 Air Operated Diaphragm Pumps (Babbit et al. 1962)

Air operated Diaphragm (AOD) pumps are a popular choice in wide range of applications for reasons as below:

a) Simple installation
b) Exceptional tolerance to variation in operating conditions
c) Ability to handle problem media
d) Low initial cost

AODs pump virtually anything that flows from water, viscous, corrosive and even abrasive sludge and even some dry powders. This type of pump is seal less, self priming and inherently variable speed. This type of pump has been very reliable to plant engineers.

AOD pumps work by using compressed air to displace liquids. As the diaphragm reciprocates the volume of the vessel alternately expands and contracts, filling with fluids and then expelling the fluids. The valves control the flow to ensure that the cavity fills from the pump inlet and the fluid is expelled. The air control mechanism functions alternately to pressurize and exhaust the air side of the diaphragm.

Figure 2.22: AOD Pumps (Karassik et al. 2001)

2.3.2 Peristaltic Pumps

According to Karassik et al. (2001), the most important advantage of peristaltic pump is their use of tubing as the pump chamber. The fluid is inside the tubing and does not contaminate the pump, nor does the tubing contaminate the fluid. Cleaning up requires only the change of tubing. This saves cost and maintenance time. Peristaltic pump transfers fluid successfully in industries such as food processing, pharmaceutical manufacturing, chemical processing, laboratory research, and agriculture and water treatment.

Peristaltic pump works on simple principle, the alternating pattern of squeezing and releasing the tubing moves the fluid through the pump. As the roller passes over the tubing, it is first occluded then released. The progression of this squeezed area forces the fluid to move in front of the roller. The tubing behind the rollers recovers its shape, creating vacuum which draws fluid in behind it. As the roller moves faster, vacuum pockets are created more quickly and the fluid moving through the system picks up speed. The rollers act as check valves to prevent siphoning or loss of prime.

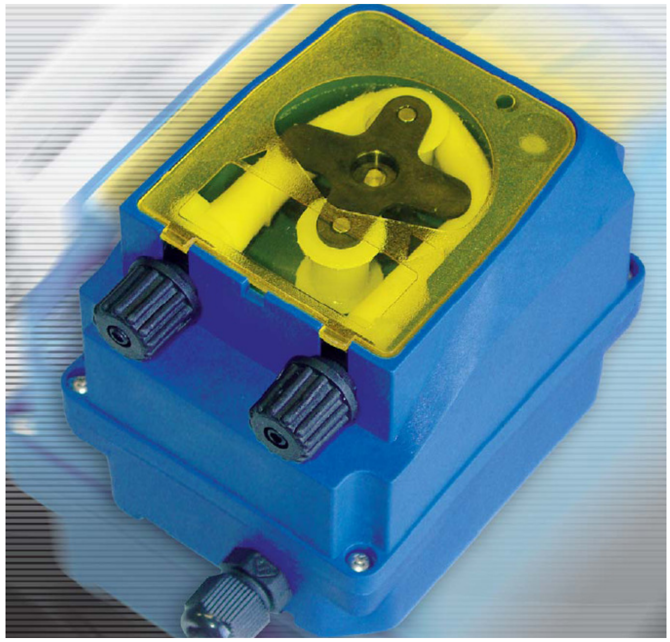

Figure 2.23: Peristaltic Dosing Pump

2.3.3 Metering Pumps

(Karassik et al. 2001) revealed that metering pumps are used whenever it is necessary to pump accurate quantities of liquid. Metering pumps can handle a wide range of fluids, ranging from acids, caustics and corrosive, polymers and in both continuous and batch control process.

Metering pumps has the following advantages:

a) High accuracy
b) High pressure
c) Low flow
d) Pump flow independent of system pressure
e) Leakage free
f) Extended dry run capability
g) Handling of toxic, hazardous or high temperature fluids

Metering pump operating depends on the reciprocating motion of the plunger which displaces process fluid directly or actuates a diaphragm that displaces the fluid. The reciprocating motion creates a sinusoidal flow pattern. Knowledge of this sinusoidal flow pattern is important in view of the peak flows created and the acceleration head created. Metering pump has stroke length adjustment capability that allows capacity adjustments. Metering pump has the capacity that remains relatively steady regardless of the pressure differential. Metering pump has basic four components, which are pump head, stroke adjustment, drive mechanism and powered drive.

Figure 2.24: Metering Dosing Pump

2.3.4 Rotary Gear Pumps

According to Karassik et al. (2001), Rotary gear pumps play very important roles in moving many of today's more difficult to handle fluids.

Rotating gear pumps are rotary, positive displacement pumps in which the pumping action is caused by relative motion between the pumps rotating elements (gears) and stationary elements (the case and end plates). The meshing of two or more gears provides the pumping action. The ability of gear pumps to hold a constant flow, not depending on the system pressure curve is the main advantage of this pump. The flow rate of gear pumps is directly proportional to speed and is marginally affected by differential pressure.

Gear pumps are widely used in the following industries:

a) Chemical and petrochemical processing
b) Lube oil system for circulating lubricating oil in compressor and gasoline engines
c) Food and beverage
d) Fuel delivery in power generation site

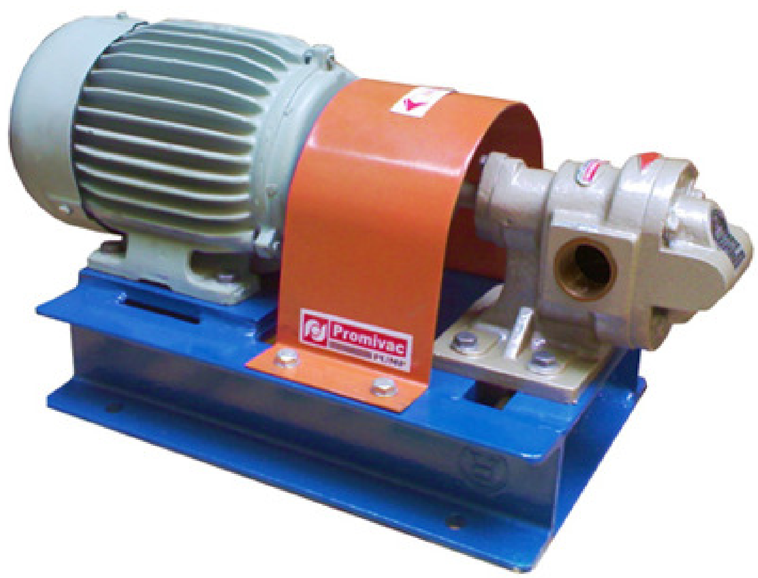

Figure 2.25: Rotary Gear Pump

2.3.5 Submersible Pump

Karassik et al. (2001) reported a submersible pump is a device which has a sealed motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped. The main advantage of this type of pump is that it prevents pump cavitations, a problem associated with a high elevation difference between pump and the fluid surface. Submersible pumps push fluid to the surface.

The main operational mechanism is by the centrifugal force created by rotational speed of the impeller. The fluid will slowly lose their kinetic energy in the diffuser where a conversion of kinetic to pressure energy takes place. The pump shaft is connected to the gas separator or the protector by a mechanical coupling at the bottom of the pump. Fluids enter the pump through an intake screen and are lifted by the pump stages. Other parts include the radial bearings (bushings) distributed along the length of the shaft providing radial support to the pump shaft turning at high rotational speeds. An optional thrust bearing takes up part of the axial forces arising in the pump but most of those forces are absorbed by the protector's thrust bearing.

This type of pump is widely used in water wells, oil wells and also in sewage tanks to pump up the sludge.

Figure 2.26: Submersible Pump

2.4 Tank Systems

There are few general functions of tank systems. They are: (Babbit et al, 1962)

a. To provide a reserve of water in order to minimize interruption of supply due to breakdown.
b. To provide a reserve to meet a fluctuating demand.
c. To act as a break pressure tank where the range of elevation of an area served makes it necessary to sub-divide the distribution system into zones.
d. To provide a reserve of water for fire fighting. The amount of contingency storage to be provided determines the size of the tank.

A sump in tank systems is a low space that collects any often-undesirable liquids such as water or chemicals. Usually a sump can be also used to collect water or used as a reservoir below ground which is in the underground level. A sump can also be an infiltration basin used to manage surface runoff water and recharge underground aquifers.

2.1.1 Water Distribution Tank System

In water distribution system, tanks systems functions can be divided into two main categories: (Babbit et al, 1962)

A. Balancing tanks
B. Service tanks

Generally the main function of balancing tanks is to receive treated water and to distribute it substantially to service tanks.

Balancing tanks are normally built near treatment plants. When there is a draw-off from any of the service tanks, water will flow from the balancing tanks to the service tanks to balance up the draw-off. With the provision of the balancing tank in the distribution system, the required flow rate into the service tank can be maintained.

The total minimum capacity of any tank system should preferably equivalent to one day's storage. The one day storage will normally meet the fire fighting requirement.

There are many types of tanks available in the market. For instance:-

1. Galvanised Pressed Steel Tank (Babbit et al ,1962)

This type of tank is readily available in the market and relatively cheaper compared to any other tanks. In order to minimize corrosion that may occur over the years, the pressed steel tank should be hot-dip galvanised and the bolts and nuts within the tank should be made of stainless steel.

Figure 2.27: Hot-Dip Galvanised Pressed Tank

2. Fiberglass Reinforced Polyester (FRP) Tank

According to (Babbit et al ,1962), although this type of tank is expensive compared to other type of tanks, but it offer the following advantages:

a. Minimum maintenance needed because the tank panels are non-corrodable.
b. The tank can be easily and quickly erected. It can be assembled precisely according to the requirements owing to the available range of the panels with varying strength and sizes.
c. Due to the light weight of the tank, it is possible to provide economical supporting structures.

Figure 2.28: FRP Tank

3. Steel Fused With Glass Tanks (Babbit et al ,1962)

The tank plate material is basically steel fused with glass resulting in a smooth, low friction, hard impervious surface which requires low maintenance. This type of tank can be used at ground level or elevated on steel or reinforced concrete structures.

Figure 2.29: Steel Fused With Glass Tank

2.1.2 Sedimentation Tank System

The objective of sedimentation is to reduce the velocity of flow so as to permit the suspended solids to settle out of the water by gravity. Its efficiency is related to various factors such as loading rate, water quality, temperature, floc size, and floc weight and tank currents. Sludge collection and removal should also be incorporated in the design of the sedimentation tank.

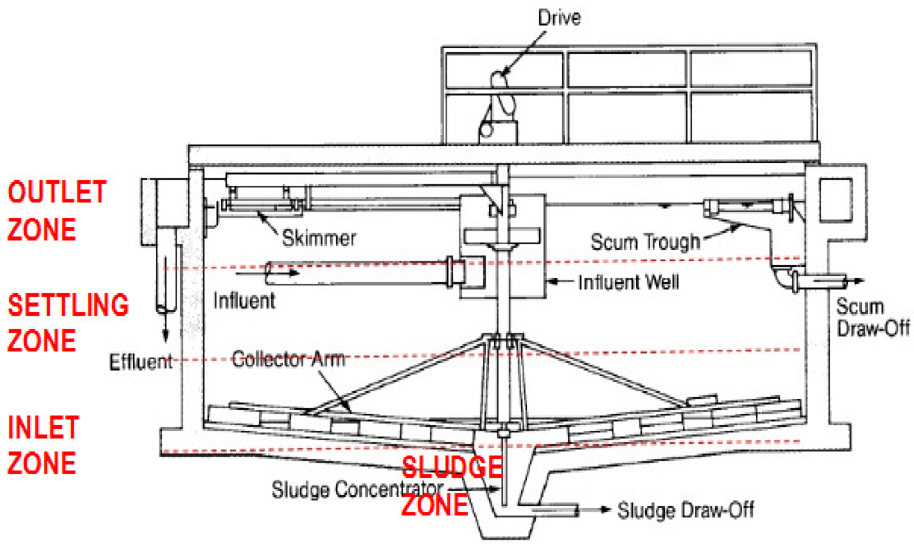

Figure 2.30: Sedimentation Tank

There are 3 types of sedimentation tanks. They are:

i. Horizontal Type Sedimentation Tank
ii. Lovo Sedimentation Tank
iii. Vertical Sedimentation Tank

2.1.3 Hydro-pneumatic Tank System

According to (Babbit et al ,1962), there are several different functions that a hydro-pneumatic tank can perform. In a booster pump application, it can provide water to the system during periods of a no flow shutdown of the booster pump or it can provide water to replace leak loads. In a well water application, it can provide the desired volume of water required between the pump shut down pressure and the pump turn on pressure. In a sprinkler or irrigation pump application, the tank may provide a cushion to maintain necessary pressure so the jockey pump will not short cycle. In any case, the amount of water that the tank will be required to supply to the system during any given cycle is called the drawdown. Drawdown must first be determined to properly size the hydro-pneumatic tank. Water is pumped from the domestic supply system into a pressure tank for storage. Air in the tank is compressed by the water entering the tank. As the pressure in the tank increases, the pressure in the water distribution system also increases, since it is fed from the tank.

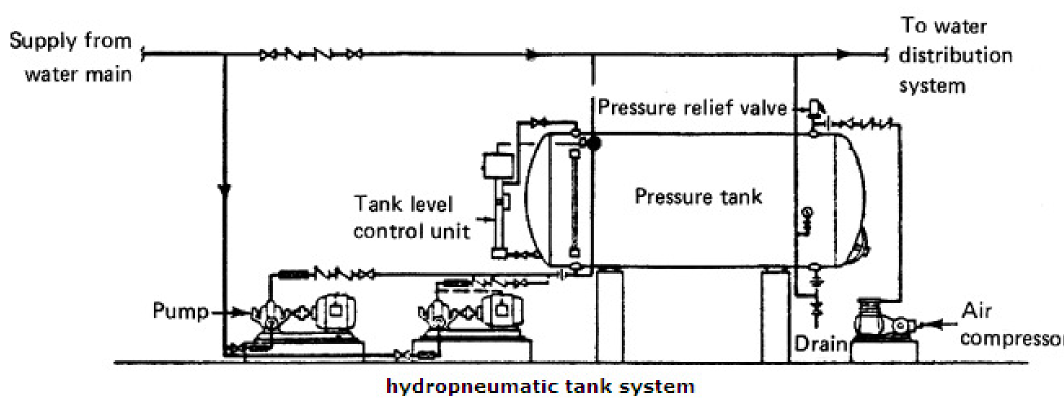

Figure 2.31: Hydropneumatic Tank System (Babbit et al ,1962)

CHAPTER 3

METHODOLOGY

3.1 Functions of the Water Tank Switching System

The water tank switching system which the author has designed has many versatile functions and offers a wide range of applications such as:

1. Back up supply system in crucial places like hospitals. If at all, there is a water supply interruption in hospitals, when the main supply water finishes in the main supply tank, then this system can be used to switch the water supply to the reserve tank.
2. This system can also be used in high rise residential areas. When there is a water interruption in high rise buildings, it will take a while for the water to fill up the main tank. Therefore this system comes in handy, where when the water level drops below the low level in the main tank during the water interruption, the water supply will be switched to the backup tank. Then while the water is being filled back in the main tank, supply will be going from the back up tank till the water in the back up tank drops below the low level and then it will switch back to main tank automatically.
3. This system can be used in restaurants as well. In restaurant the supply of soap water is very crucial when it comes to cleaning and washing the utensils. So this system can be used to have constant soap water supply for the whole day. This means the restaurant workers just need to mix the soap water once in the day which is in the morning only. So when the soap water in the primary tank finishes, then the relay will trigger to switch the pump to dose

the soap water from the back up tank. This saves a lot of time and hassle in the restaurant management.

4. This system can also be used for industry applications whereby this system can be used to supply a constant chemical dosing for a certain process in industrial. This means the dosing of chemical will not be interrupted for the whole process. Workers just need to top up the chemical or liquid once a day either in the morning or in the evening. This means when the chemical or liquid supply finishes from the main tank, the dosing of chemical or liquid will be switched to the back up tank. Once the chemical or liquid in main tank is filled up, the system will switch over to the main tank back provided the chemical or liquid in the back up tank has dropped below the low level of the sensor.

One of the many big advantages that this system offers is, the duration of the whole system can be varied by adjusting the speed of the pump. In addition to this, the capacity of the backup tanks can also be varied. The bigger the capacity of the backup tank, the system can run for longer time in the backup system.

3.2 Operational Principle of the Water Tank Switching System

The main characteristic of the water tank switching system which the author has designed is a system which used relays as its main control element. When the liquid in the main tank drops below the low level and it's detected by the magnetic level float switch in it, the relay will be triggered. This relay in return will trigger the set/reset relay which will switch the dosing of the liquid to the backup tank.

When the liquid in the back up tank drops below the low level and detected this low level detected by the magnetic level float switch in the tank, the set/reset relay will be triggered again. This in return will switch the whole process again to the primary tank provided liquid have been topped up in the main primary tank again, or else the whole process will be stalled till the liquid is topped up again. The whole process can be summarized in flow chart below.

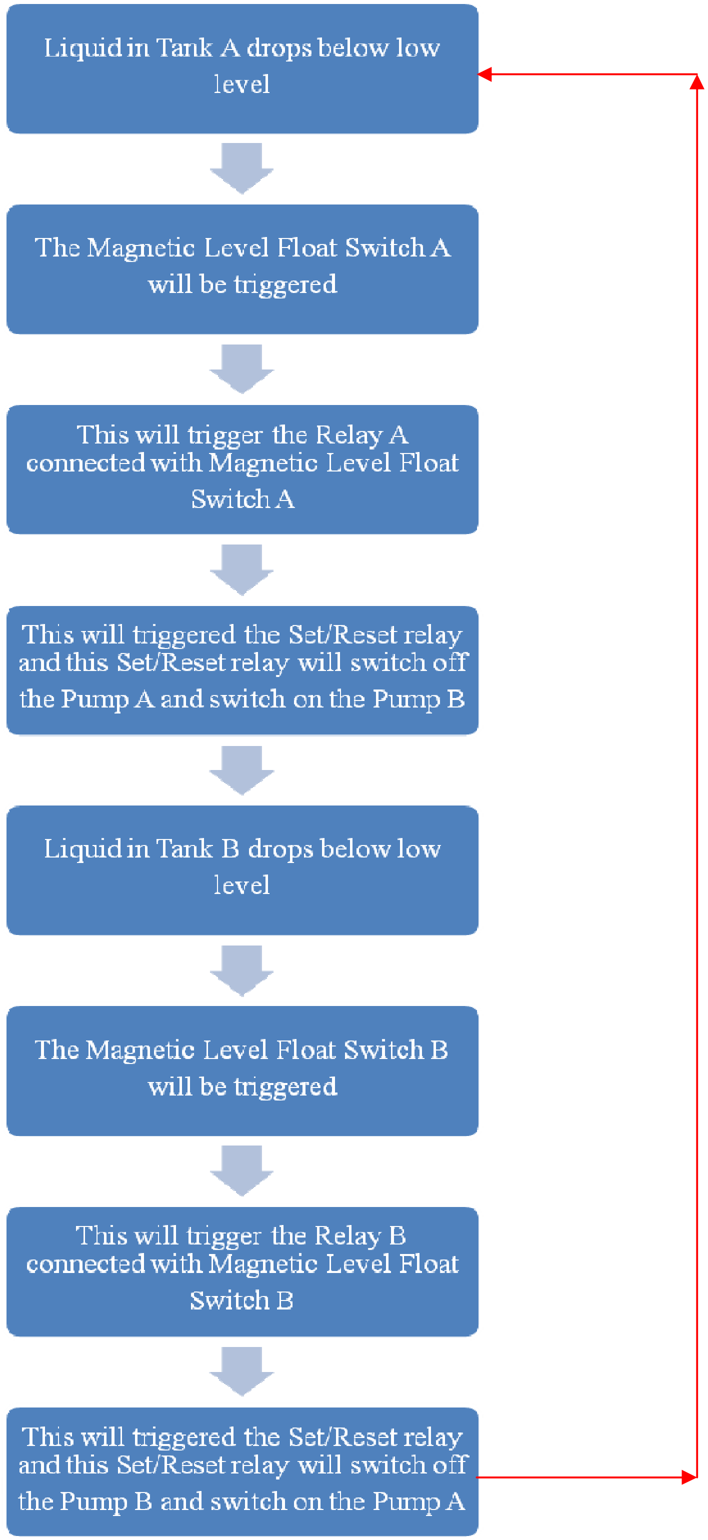

Figure 3.1: The flow chart summarizing the whole system operation

3.3 Steps to Build the Entire System

The entire step needed to build the water tank switching system is summarized in the flow chart below:

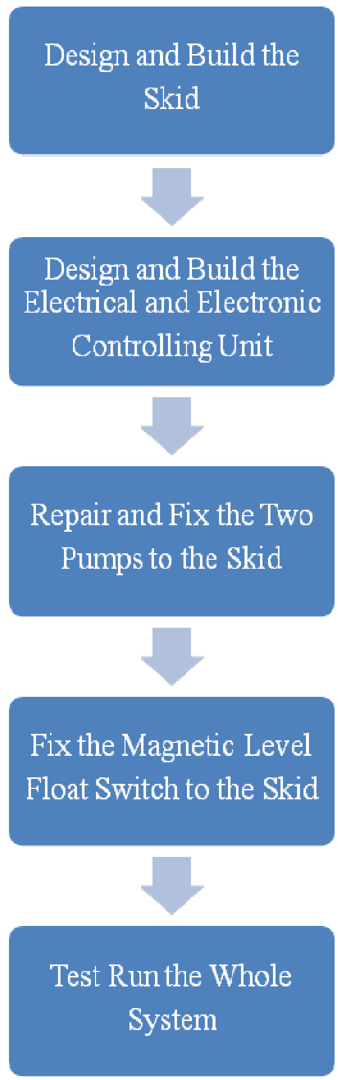

Figure 3.2: The flow chart summarizing the overall work load

3.3.1 Design and Build the Skid

To begin with everything, we need to design the overall skid. Therefore the author used the software AutoCAD to draw the whole skid. The author drew the entire skid with measurement using this software. By looking at the drawing we readers will know how the entire system will look like. Below is the drawing.

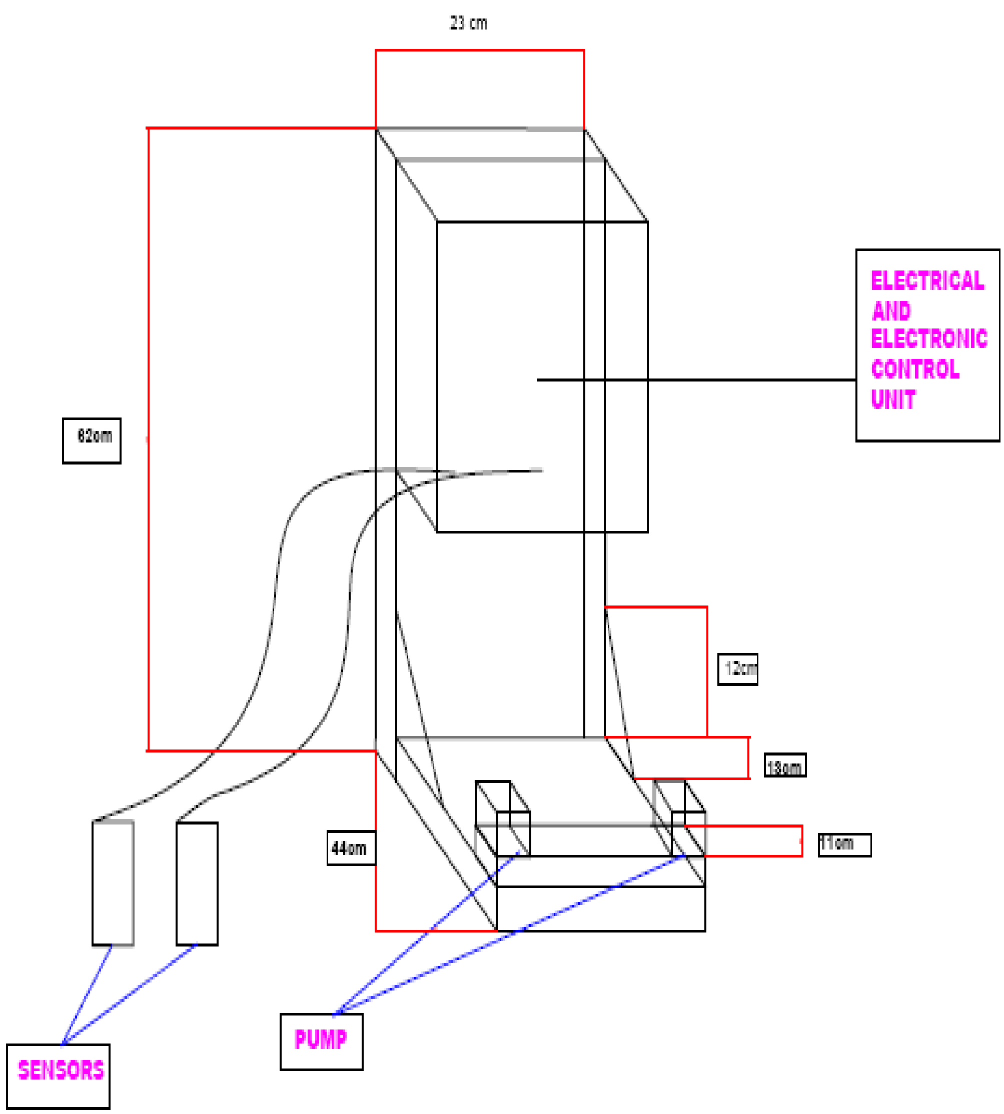

Figure 3.3: AutoCAD drawing of the overall skid

After coming up with drawing, then the author builds the skid. To build the skid, the author bought a big piece of 1 inch PVC board. Then the author drew the measurements on the PVC board. After drawing the measurements, the author cut the PVC board using a machine saw.

After cutting the PVC board, the author filled the sharp edges of the PVC board. Finally the parts of PVC board which was cut according to the measurement were joined together using a PVC welding machine to come up with the final desired skid. The author has attached below one of the photo taken while he was doing all the steps involved in designing and building the skid.

Figure 3.4: The author is welding the PVC boards together

3.3.2 Design and Build the Electrical and Electronic Controlling Unit

To begin designing the electrical and electronic controlling unit, the author drew a flow chart that will resemble the whole operation function of the system. Next the author drew the electrical diagram of the system based on the flow chart he had drawn earlier.

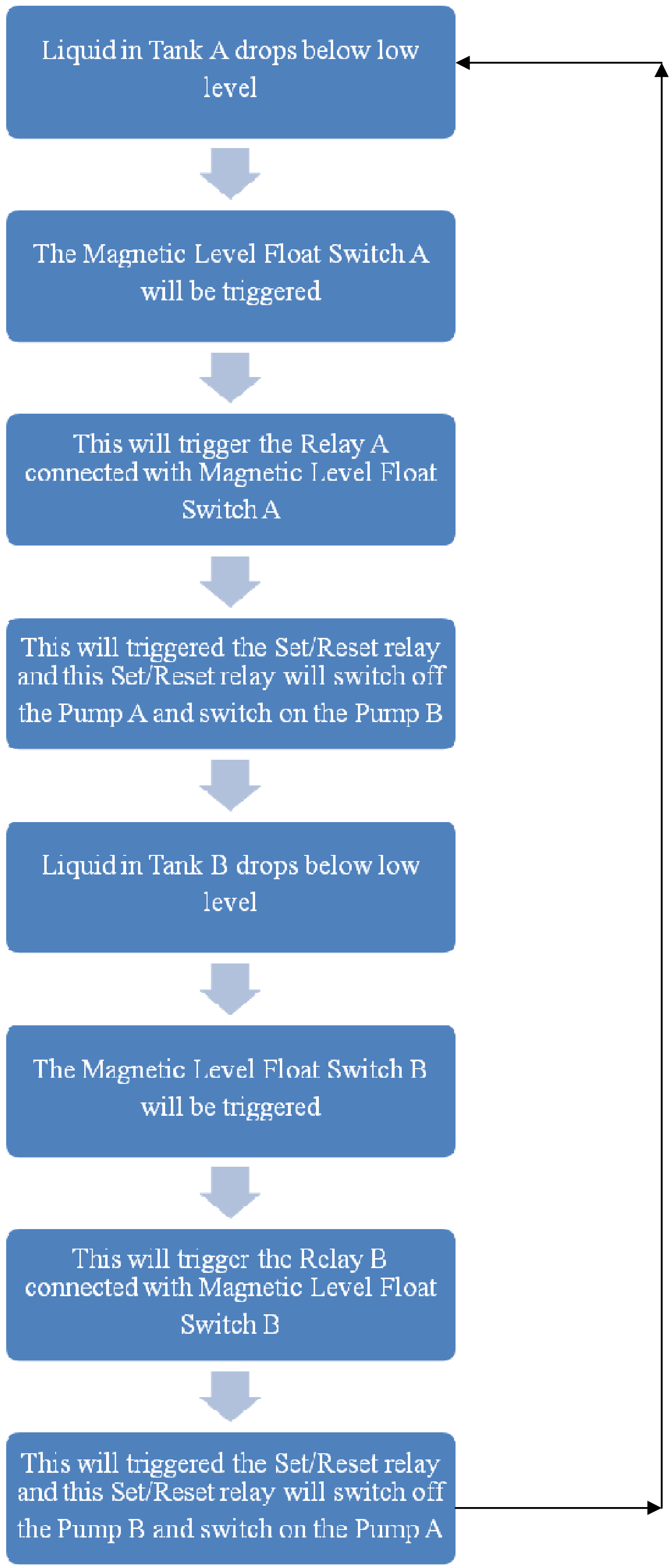

Figure 3.5: The flow chart summarizing the whole system operation

The overall electrical diagram the author has designed based on the words description that was summarized in the flow chart above looks like below:

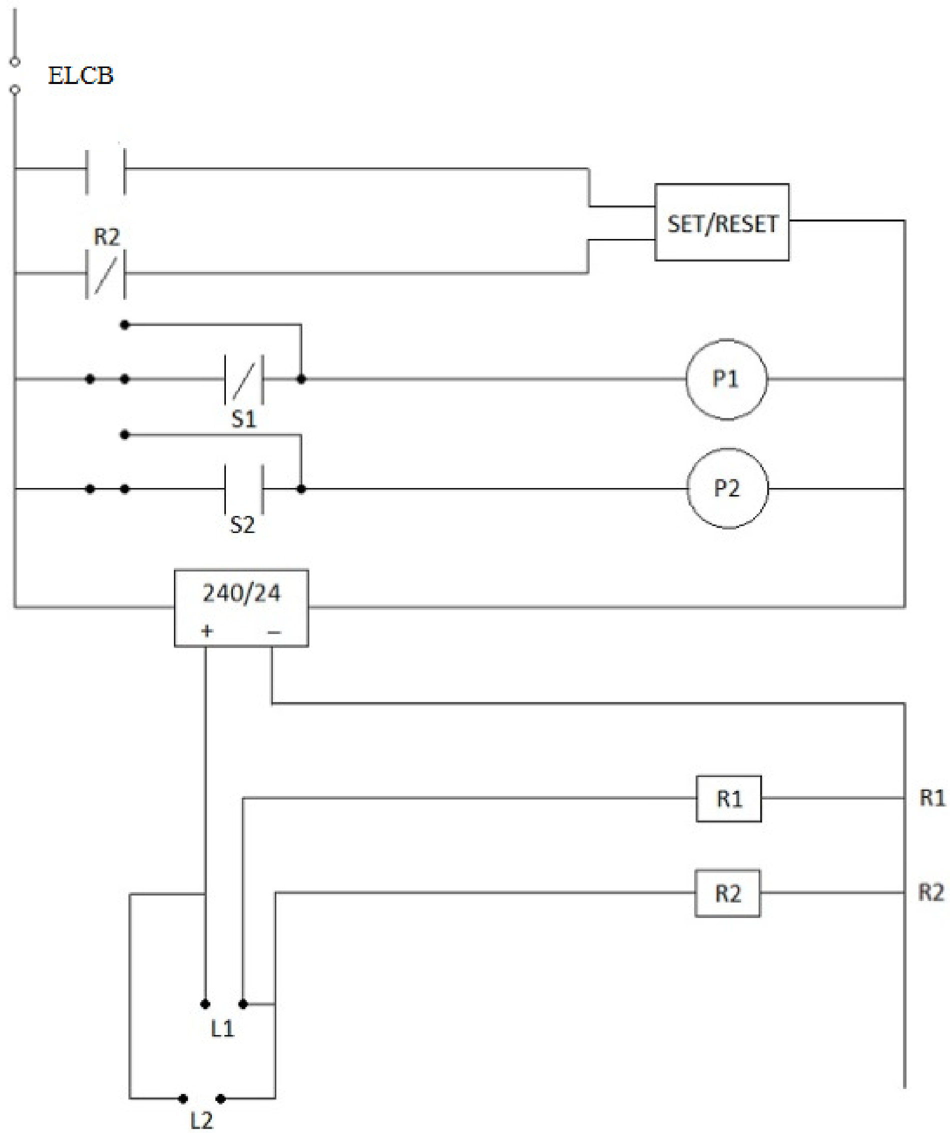

Figure 3.6: The Electrical Diagram of the Tank Switching System

After coming up with the electrical diagram, the author tested the logic of the electrical diagram drawn by using the Programmable Logic Control (PLC) software. From the software, the author knew whether the electrical diagram drawn was working according to his desired objective. There was a little error in the electrical diagram drawn by the author, the author managed to rectify the error by using this PLC software and finally come up with the final desired electrical diagram which looks like below:

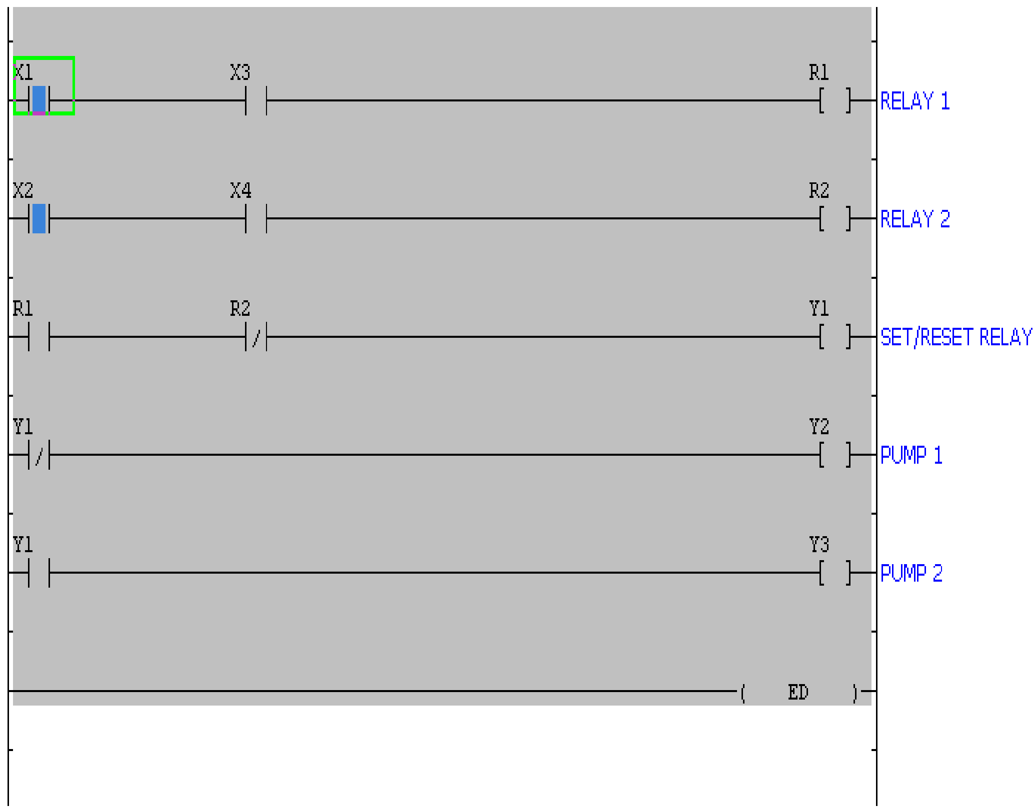

Figure 3.7: Ladder Diagram when Initial State

The above ladder diagram is when the system is at initial state. The X1 and X2 is the on/off button for the pump A (pump 1 in the above diagram,) and pump B (pump 2 in the above diagram). X3 is the magnetic level float switch A and X4 is the magnetic level float switch B. R1 is relay A (relay 1 in above diagram) which is attached to the magnetic level float switch A. R2 is relay B (relay 1 on the above diagram) is the relay attached to the magnetic level float switch B. Y1 is the Set/Reset relay. Y2 is the pump A (pump 1 in above diagram) and Y3 is pump B (pump 2 in above diagram).

From the above diagram, the X1 and X2 is light up because both the ON/OFF switches are in the ON state. Both the magnetic level float switches X3 and X4 are not light up, which means both the tank is filled up with water. The sensors are not being triggered. So at this moment, the pump A will be working.

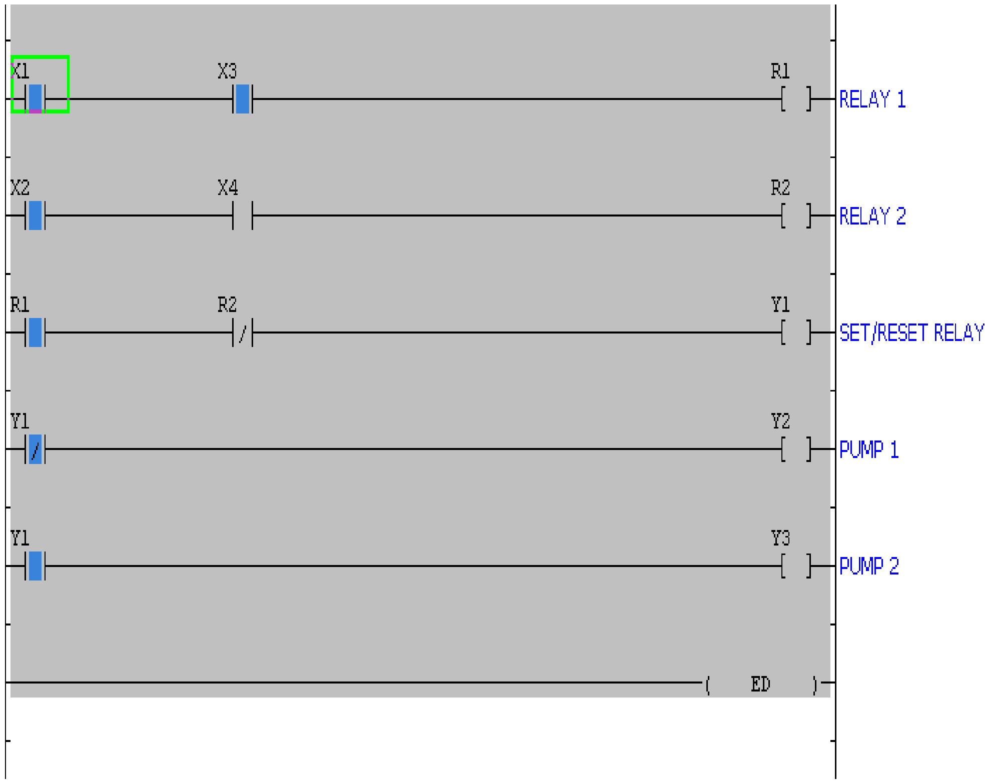

Figure 3.8: Ladder Diagram when Sensor A Triggered

The above diagram refers to when the magnetic level float switch sensor A is triggered which means the water in tank A drops below the low level. When this happens, the relay A (relay 1) will be triggered. Relay A will eventually trigger the Set/Reset relay as the relay B is in the normally close state. When the Set/Reset relay is being triggered, the pump A (pump 1) will stop functioning because it is in the normally close state and when Set/Reset relay is being triggered, it will change state to normally open. Then the pump B (pump 2) will start functioning as it is connected to the Set/Reset relay as normally open. Therefore when the Set/Reset relay is triggered, it will change state to be normally close and pump B will start functioning.

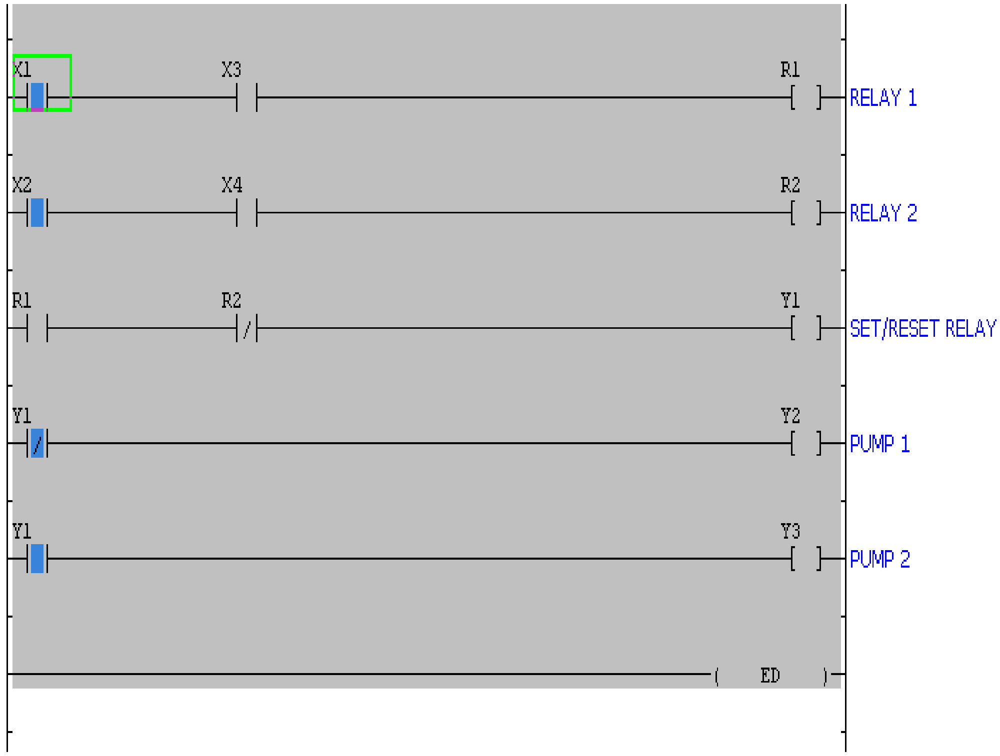

Figure 3.9: Ladder Diagram when the Tank A is Filled Up

The above diagram is seen when the pump B (pump 2) is still functioning but when this pump is functioning, the tank A is filled up with water again. Therefore the X3 light goes off which means the tank A is full. When this happens, the relay A (relay 1) is triggered again but the Set/Reset relay is not triggered because relay B (relay 2) is still in the normally close state. Therefore the Set/Reset relay is not triggered.

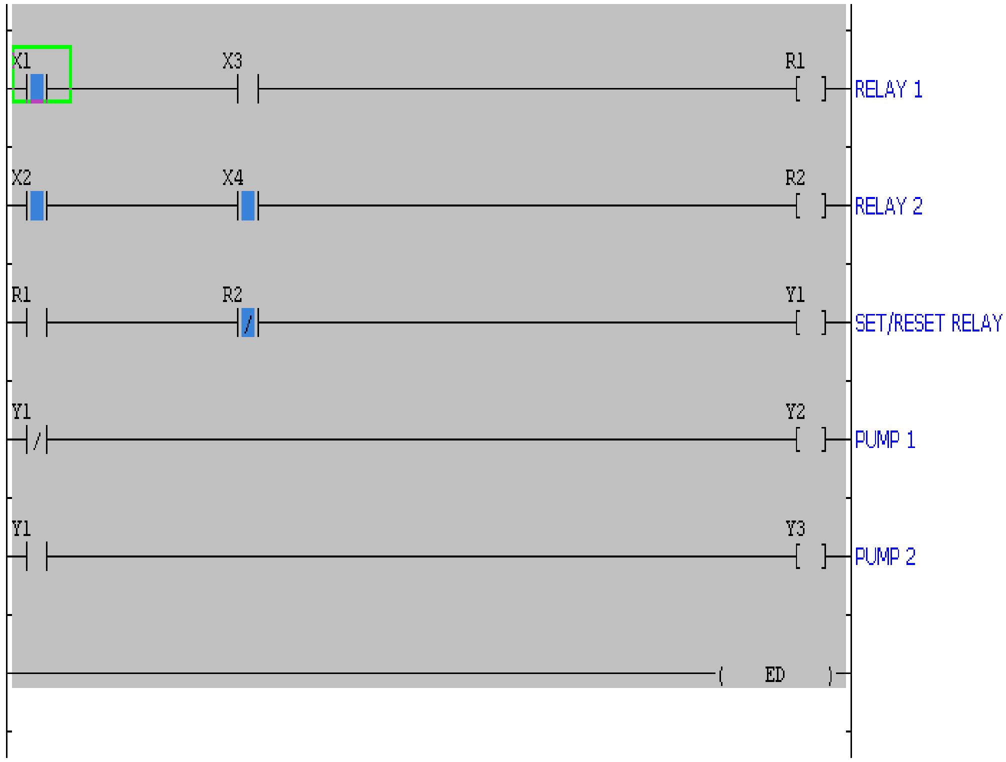

Figure 3.10: The Ladder Diagram when Sensor B Triggered

When the magnetic level float switch sensor B is triggered (X4 in the above diagram), the set Set/Reset relay is triggered because the relay B (relay 2) which is connected to the sensor B is triggered. When relay B is triggered, it changes state from normally close state to normally open state. This will trigger Set/Reset relay which will eventually make pump A (pump 1) to function and stop pump B (pump 2).

When the tank B is filled up with water again, the magnetic float switch will be in off state which means the tank is full. The X4 light will go off which means the relay B (relay 2) will be triggered. This in return will not trigger the Set/Reset relay because the relay A (relay 1) is in normally open state. The ladder diagram for this state look like below. After this, the entire process repeats itself.

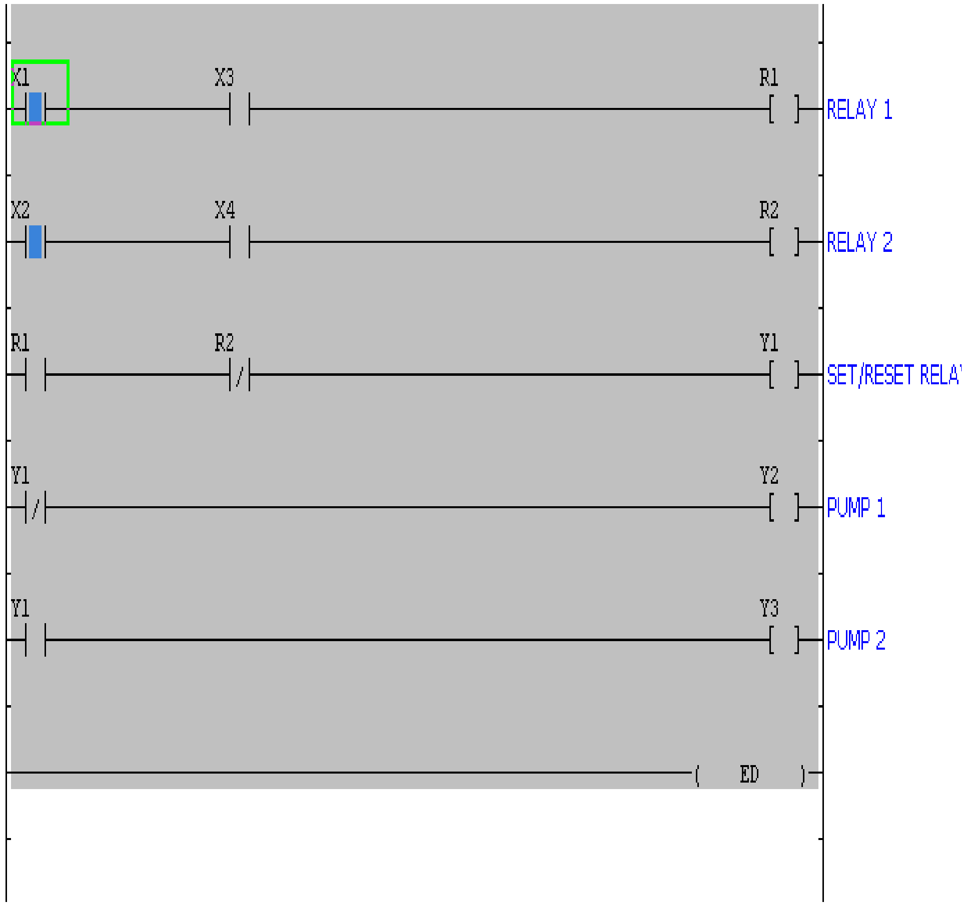

Figure 3.11: Ladder Diagram when the Tank B is Filled Up

After testing the workability of the electrical diagram drawn, then the author summarized all the components needed to build the electrical and electronic controlling unit. The components needed are as follow:

1. Omron Set/Reset Relay

The purpose this relay was chosen by the author was to set and reset the system after every cycle. For example, at initial point, it will be at the set point and when the magnetic level sensor A detects a low level of liquid, then the relay A which is attached to the sensor A will trigger this Set/ Reset relay to go from Set state to Reset state.

When this transition takes place, this relay’s contact positions will change. This means if a contact is connected as normally close (NC), and then it will change to normally open (NO) and vice versa. Therefore initially the pump A will be connected as NC and therefore it will be working when it is at Set state and Pump B will not be working as it will be connected as NO. When the transition of state takes place from Set to Reset, Pump A will stop working as the contact will change from NC to NO and Pump B will be working as the contact will change from NO to NC.

When the Sensor B has detected a low level, then the Relay B which is attached to sensor B will trigger this Set/Reset relay to change state from Reset to Set. Therefore the Pump B will stop working and Pump A will start working due to the change of state from NC to NO for Pump B and NO to NC for Pump A. This process repeats every time a low level is detected by the sensors.

This relay offers few advantages such as high vibration and shock resistance. In addition to that, this relay assures a long service life as it is unaffected by aging. The magnetic material in this relay allows a long and continuous holding time and there is a built in indicator for easy relay operation monitoring. The data sheet of this Omron Set/Reset relay is attached in the appendices part.

Figure 3.12: The Omron Set/Reset Relay

2. Relpol 24V DC Relay

This relays are attached to the sensor A and sensor B. The relay A will be connected to sensor A and relay B will connect to sensor B. Initially both the tanks will be full (high level), therefore the author made the relay A as NO and relay B as NC. Pump A will be working. When the liquid in tank A reaches low level, the sensor A will be triggered, therefore relay A will change state from NO to NC, this will trigger Set/Reset relay as it is directly connected to Set/Reset relay. Therefore the Set/Reset relay will change state from Set to Reset. Therefore Pump B will start functioning and Pump A will stop.

While Pump B is functioning, the liquid in tank A will be filled up again, therefore the sensor A will be in high level again. Therefore relay A will change state from NC to NO again.

When the liquid in tank B reaches low level, the sensor B will be triggered. This will eventually change the state of the relay B from NC to NO. When this changes take place, this will trigger the Set/Reset relay to change state from Reset to Set as the relay B is directly connected to the Set/Reset relay. Therefore Pump B stops and Pump A switches on.

While Pump A is functioning, the liquid in tank B will be filled up, therefore, the sensor B will be triggered high and this eventually changes the state of relay B from NO to NC.

The author decided to use a 24V DC relay because to connect the 24V DC magnetic level float switch to the relay for protection and power saving purpose. The sensors are placed in the water tank, and eventually if the author uses a 240V AC relay connects the sensor to a 240V AC supply and if there is a leakage from the sensor, then it will be harmful for anyone operating the system or anyone filling up the liquid in the tank because the sensor and the relay are directly connected. This also can cause explosion if there is a flammable gas in the surrounding. So to avoid all this problems, the author decided to use a 24V DC relay and connect the magnetic level float switch to the 24V DC power supply. The datasheet of this relay is attached in the appendices part.

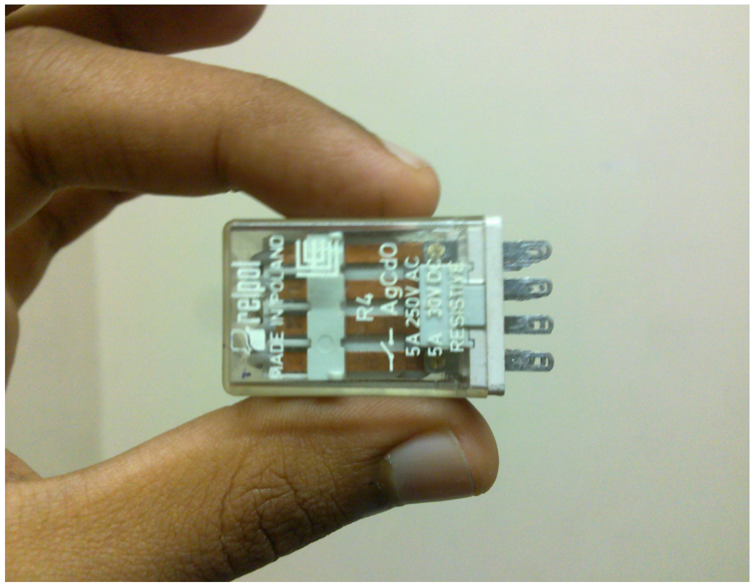

Figure 3.13: Relpol 24V DC relay

3. 24V DC Power Supply

This 24V DC power supply is used by the author to achieve the main objective of this project which is to improve the safety features of this system and to reduce the power consumption of this whole system.

Firstly to improve the safety features of this system, the author used this 24 V DC to reduce the incoming 240V AC supply to 24 V DC. By doing so, the author can connect the two 24V DC relays directly to this power supply to energize its coils. In addition to this, the author has also connected the two magnetic level float switches to this 24V DC power supply.

The author decided to use 24V DC power supply to power up the relay and the sensor because the sensor is placed inside the liquid tank. If there is any leakage from the sensor, then there will be voltage flowing in the liquid. The liquid will be conductive and this is very dangerous as it can be very harmful to anyone mending with the tank. The point here is, if the sensor is connected to 240V AC and happen to be there is leakage from the sensor, if anyone touches the liquid, he/she will electrocuted and may cause death. If at all the same situation happens when a 24V DC power supply is used, then chances of survival are very high. The 24 V DC power supply also comes with grounding protection and therefore it gives extra protection to the system as the sensors and relays are connected to the 24V DC power supply.

In some cases, the electrical and electronic control unit may be placed in quite some distance from the sensor. Therefore there will be loses due the higher resistance. When the tank is far from the controlling unit, the sensor has also been placed far from the controlling unit together with the tank. Therefore the sensor wire is longer, therefore the resistance is higher and the current will fall. This can be proved from the fundamental formula V=IR. To overcome this situation, this 24V DC power supply allows us to adjust the current to higher value. When the current can be adjusted, the efficiency of the system can be maintained although the sensor is placed far from the controlling unit. The datasheet of this power supply is attached in the appendices part.

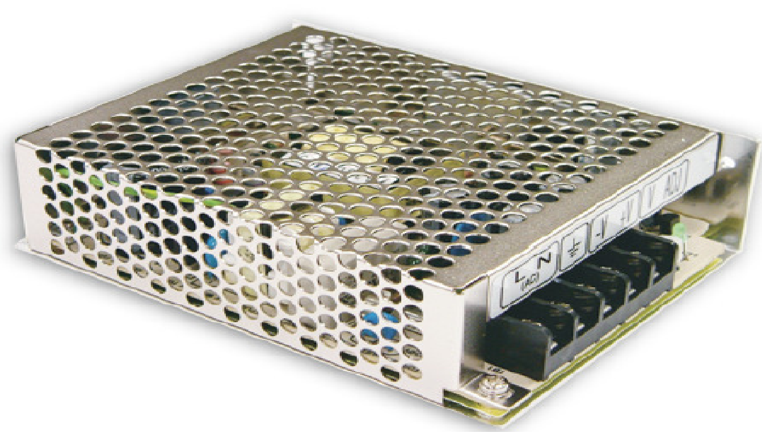

Figure 3.14: 24V DC Power Supply

4. Relay Socket for Omron Set/Reset Relay

This relay socket is to connect the relay at one side and the wires at the other side. This socket with connectors around it numbered according to the reference of the datasheet of this relay. So users have to refer to the datasheet of this relay and do the wiring on the socket.

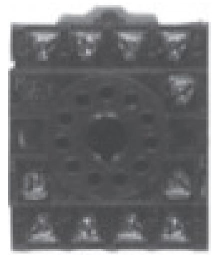

Figure 3.15: Omron Set/Reset Relay Socket

5. Relay Socket for Relpol 24V DC Relay

This socket as the same functions as the socket above. We refer to the datasheet of this relpol relay and do the necessary wiring on the socket.

Figure 3.16: Relpol 24V DC Relay Socket

6. Earth Leakage Circuit Breaker (ELCB)

This ELCB was used by the author to protect the circuit in case of any fault. If there's any short circuit or voltage surge, this ELCB will trip and power supply to this entire system will be interrupted. Therefore all the essential components in this system like the sensor, 24V DC power supply, the relays and the pumps can be protected.

Figure 3.17: ELCB

7. Isolator Switch

This isolator switch was used by the author in this system to switch on and off the entire system. When the button is in OFF state, the entire system is switched off. When the button is turned to manual mode, the entire system will be controlled manually and where else when the button is set to the auto state, the entire system will run automatically. This device will help users to detect any errors in the system.

Figure 3.18: Isolator Switch

8. Wire Terminal Block

This terminal block is like connectors. The author used this terminal block to connect the two pumps and the two sensors.

Figure 3.19: Wire Terminal Block

9. PVC 310x230x145 Junction Box

This PVC 310x230x145 junction box was used by the author as casing to contain all the electrical and electronic controlling unit components. This junction box was screwed to the skid and the components were fixed inside the junction box.

Figure 3.20: PVC 310x230x145 Junction Box

Upon determining all the components needed, the author the connected all the components according to the electrical diagram drawn. He wired up all the components according to electrical diagram. The author also added marker to every wire when doing the connection so that the author can trace back the wires in case there is any errors or faults. The author used 1.5mm core red cables to wire all the life points and 1.5mm core black wires to connect all the neutral points. The author also used 1.5mm core green wire to connect all the earth points.

3.3.3 Repair and Fix the Two Pumps to the Skid

After completing the electrical and electronic controlling unit, the author then bought two second hand pumps. The author then reconditioned the two pumps to be used in this system.

One of the pumps was still working when it was bought. Therefore the author just cleaned the electronic card of the pump and bought suction and discharge valves to replace the worn out ones in the pump. The other pump needed some repair in its electronic card. Its transformer, power switching IC and two power diodes were spoiled, therefore the author replaced all the faulty components and then the pump was working. The author also replaced its suction and discharge valves of the pump as it was worn out as well.

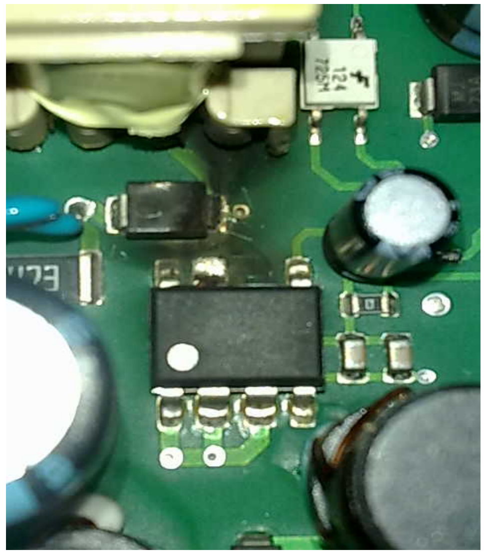

Figure 3.21: The faulty electronic card of one of the pumps

After conducting the entire repair job, the author tested both the pumps. He switched on both the pumps for two hours to test its efficiency. After testing, when all was fine, the author screwed both the pumps onto the skid.

3.3.4 Connect the Magnetic Level Float Switch

After getting the pumps ready, then the author bought two magnetic level float switches. Then he made a holder for the magnetic level float switch using a PVC pipe. The author decided to use this type of level sensor because it is dry contact and does not have any conducting parts. Therefore when the sensor is placed in the liquid, it will not be dangerous to people who is handling with the liquid.

This type of sensor is very safe and can be used for any type of liquids. The author did not use the conductivity type of sensor although the conductivity type has higher precision because the conductivity type of sensor is very dangerous as it will have voltage running in the liquid and eventually onto the tank as well if the tank is made out of metal. The conductivity type of sensor can also cause explosion if there is any flammable gas around the sensor.

After going thru all this carefully, the author decided to use the dry type of level sensor which is magnetic level float switch. The datasheet of the magnetic level float switch used is attached in the appendices part.

Figure 3.22: Magnetic Level Float Switch with Holder

After fixing the sensor to the holder, the author wired the sensor to the electrical and electronic controlling unit.

3.3.5 Test Run the Whole System

After completing all the above steps, the author then designed a power cable for the system. One end of the wire was fixed with 3-pin plug and at the other end of the wire; the life and neutral wires were connected to the incoming supply of the ELCB. The earth wire was connected to the terminal block which has all the earth wires and later the terminal block was grounded.

Later the author connected the 3-pin plug to the power supply and powered the entire system. The system was working according to what was expected. The author switched the system on for 2 hours to test the workability of the system and to test if there is any error.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 General Discussion

The author has mentioned earlier that the main objectives of this project are to enhance the protection of this tank switching system.

To achieve this objective, the author used a 24V DC power supply to power the sensors and the relays attached to the sensors. By using the 24V DC power supply, the sensor will only running in 24V DC instead of 240V AC. So if let say, there is explosive gas around the tank and the sensor is worn out due to corrosion and durability, there will be voltage leakage. This voltage leakage may cause arching with the explosive gas. If the voltage is higher, the arching might be more dangerous and may cause explosion. This can be prevented if the voltage used to power the sensor is low.

If the voltage is higher and there is a leakage in the sensor, the voltage will be flowing in the liquid of the tank and eventually on the tank. So if anyone touches the tank, he/she will be electrocuted with a voltage of magnitude 240V AC, which is extremely dangerous. Therefore, by using 24 V DC, the author can cultivate all this undesirable events from occurring.

Although by using the 24V DC power supply the author can achieve this objective, the author has to prove that the system's efficiency is higher or the same as using 240V AC to power the sensor. If the efficiency is the same or higher, then the author have achieved the main objective of this project. Efficiency is the time taken for the pump to switch over from one tank to the other tank and speed of the transition upon sensor detection and relay switching.

Therefore to test the efficiency of this system, the author conducted two experiments. In the first experiment, the author connected the two magnetic level float switches and the two relays corresponding to the sensors to 240 V AC. Therefore the author have to use 240V AC relay instead 24V DC relay. The sensor is the same. The author then measured the time taken for the pump A to pump 0.2 liters water and switch to pump B upon sensor A detecting a low level at different pump speeds. He repeated the experiment for pump B to pump 1 liter water and switch to pump A again upon sensor B detecting a low level.

The author then conducted the second experiment with the two magnetic level float switches and the two relays connected to the 24 V DC power supply. In this experiment for sure, the author used the 24V DC relay and the same sensor. He then repeated the same steps in first experiment which is to measure the time taken for pump A to pump 0.2 liters of water and switch to pump B upon sensor A detects a low level. The experiment was repeated to measure the time taken for pump B to pump 1 liter of water and switch over to pump A upon sensor B detects a low level.

4.2 Experiment 1 (Using 240V AC)

In experiment 1, the author connected the two magnetic level float switches and the relay corresponding to the sensors to 240V AC power. The relay used is 240V AC relay which has the same specification with the 24V DC relay. Both relays must have the same specification as it will be very vital in producing the end result. The sensor used is the same which is the magnetic level float switch.

In this experiment, for the first section, the author measured the time taken for pump A to pump 0.2 liters of water and then switch over to pump B. The author conducted this experiment for four different stroke length of the pump which is 25%, 50%, 75% and 100%. Stroke length of pump is defined as the distance marked by the farthest ends of reciprocating vertical movement of the diaphragm.

For each stroke length, the author conducted five experiments with each of the experiment with different frequencies. There are total five frequencies which are 60 Hz, 70 Hz, 80 Hz, 90 Hz and 100 Hz. Frequency here means is how fast the pump diaphragm moves. For each experiment, five readings of time were measured and the average is calculated and tabulated. The results obtained from these experiments were tabulated in table below.

Table 4.1: Time taken by pump A to pump 0.2 liters of water and switch over to pump B at stroke length of 25 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	1049.0	1053.0	1055.0	1051.0	1050.0	1051.6
70	1020.0	1019.0	1025.0	1028.0	1027.0	1023.8
80	986.0	989.0	991.0	988.0	992.0	989.2
90	953.0	952.0	956.0	958.0	955.0	954.8
100	920.0	923.0	918.0	921.0	922.0	920.8

Table 4.2: Time taken by pump A to pump 0.2 liters of water and switch over to pump B at stroke length of 50 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	905.0	908.0	910.0	907.0	906.0	907.2
70	878.0	875.0	877.0	879.0	878.0	877.4
80	849.0	847.0	850.0	846.0	847.0	847.8
90	825.0	823.0	826.0	824.0	826.0	824.8
100	795.0	799.0	800.0	797.0	796.0	797.4

Table 4.3: Time taken by pump A to pump 0.2 liters of water and switch over to pump B at stroke length of 75 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	825.0	826.0	828.0	824.0	827.0	826.0
70	796.0	799.0	800.0	802.0	797.0	798.8
80	785.0	784.0	782.0	786.0	784.0	784.2
90	759.0	763.0	765.0	760.0	758.0	761.0
100	749.0	751.0	750.0	747.0	753.0	750.0

Table 4.4: Time taken by pump A to pump 0.2 liters of water and switch over to pump B at stroke length of 100%

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	758.0	755.0	759.0	762.0	760.0	758.8
70	743.0	748.0	745.0	744.0	745.0	745.0
80	728.0	733.0	729.0	730.0	735.0	731.0
90	679.0	683.0	689.0	687.0	691.0	685.8
100	664.0	670.0	661.0	665.0	668.0	665.6

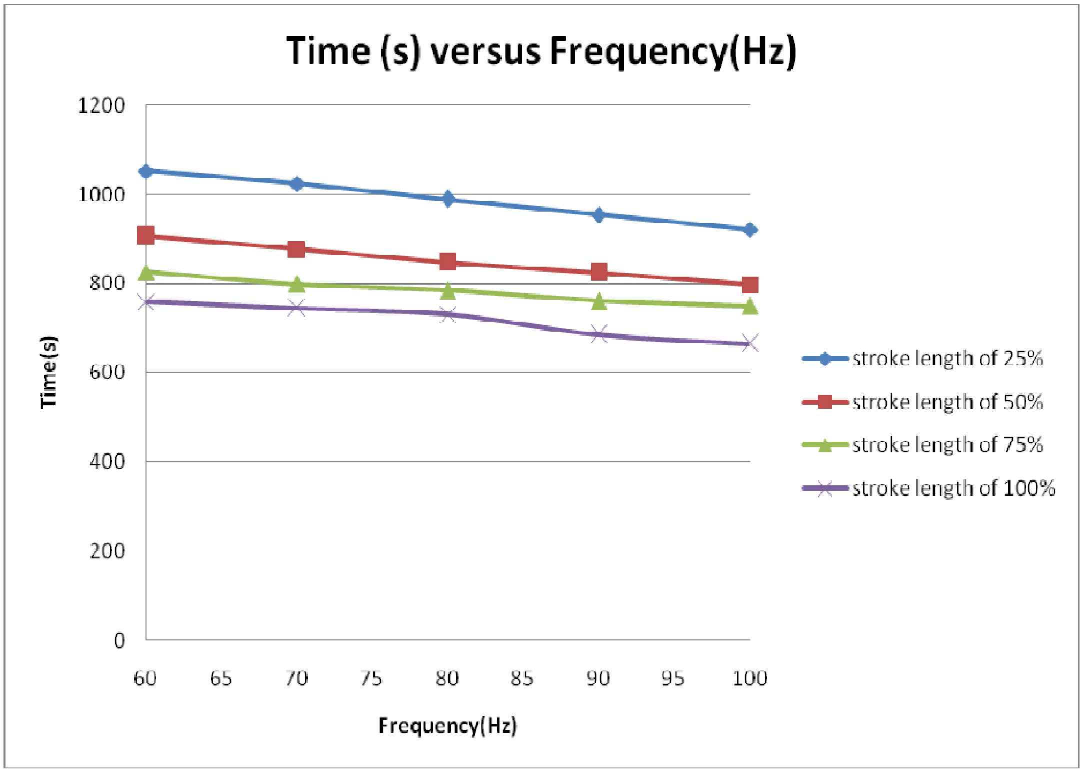

Figure 4.1: Performance of the Tank Switching System Powered by 240V AC measured in terms of Time taken by pump A to pump 0.2 liters of water and switch over to pump B at four different stroke lengths

The data tabulated in the above tables were plotted into the graph above whereby, the average of the five readings for the time was plotted against the frequency for four different stroke lengths.

The above experiment then was repeated by the author again with now to measure the time taken by pump B to pump 0.2 liters of water and then switch over to pump A at four different stroke lengths and for each stroke length at five different frequencies.

Table 4.5: Time taken by pump B to pump 0.2 liters of water and switch over to pump A at stroke length of 25 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	1047.0	1054.0	1050.0	1049.0	1054.0	1050.8
70	1018.0	1021.0	1026.0	1024.0	1025.0	1022.8
80	988.0	985.0	993.0	989.0	995.0	990.0
90	954.0	950.0	955.0	953.0	959.0	954.2
100	923.0	919.0	921.0	924.0	920.0	921.4

Table 4.6: Time taken by pump B to pump 0.2 liters of water and switch over to pump A at stroke length of 50 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	902.0	906.0	912.0	907.0	909.0	907.2
70	874.0	879.0	880.0	882.0	877.0	878.4
80	852.0	849.0	854.0	848.0	850.0	850.6
90	829.0	825.0	828.0	824.0	823.0	825.8
100	793.0	798.0	801.0	799.0	797.0	797.4

Table 4.7: Time taken by pump B to pump 0.2 liters of water and switch over to pump A at stroke length of 75 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	825.0	826.0	828.0	824.0	827.0	826.0
70	794.0	797.0	798.0	801.0	800.0	798.0
80	783.0	780.0	777.0	782.0	785.0	781.4
90	755.0	762.0	764.0	763.0	760.0	760.8
100	744.0	752.0	748.0	747.0	753.0	748.8

Table 4.8: Time taken by pump B to pump 0.2 liters of water and switch over to pump A at stroke length of 100 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	755.0	759.0	763.0	758.0	756.0	758.2
70	741.0	746.0	743.0	747.0	742.0	743.8
80	727.0	731.0	728.0	734.0	733.0	730.6
90	680.0	685.0	690.0	687.0	686.0	685.6
100	659.0	665.0	660.0	668.0	669.0	664.2

The data tabulated from the tables were put together in to the graph below to see the performance of the tank switching system.

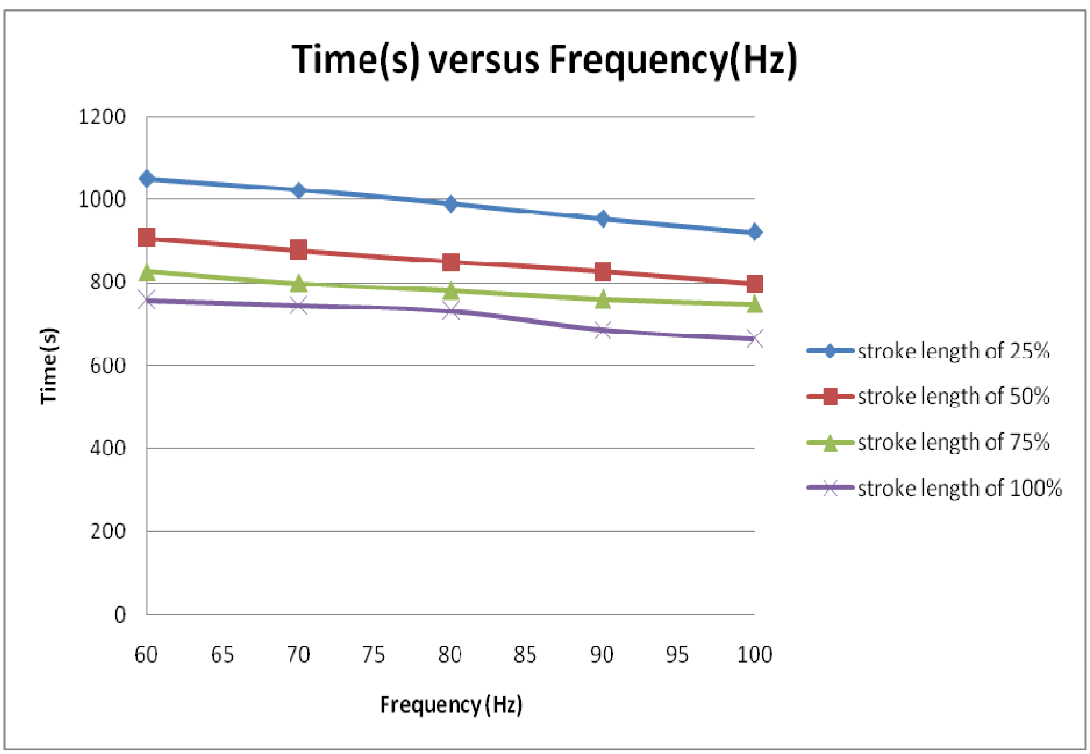

Figure 4.2: Performance of the Tank Switching System Powered by 240V AC measured in terms of Time taken by pump B to pump 0.2 liters of water and switch over to pump A at four different stroke lengths

4.3 Experiment 2 (Using 24V DC)

In experiment 2, the author connected the two magnetic level float switches and the relay corresponding to the sensors to 24V DC power. The relay used is 24V DC relay which has the same specification with the 240V AC relay used in the experiment 1. Both relays must have the same specification as it will be very vital in producing the end result. The sensor used is the same which is the magnetic level float switch.

In this experiment, for the first section, the author measured the time taken for pump A to pump 0.2 liters of water and then switch over to pump B. The author conducted this experiment for four different stroke length of the pump which is 25%, 50%, 75% and 100%. Stroke length of pump is defined as the distance marked by the farthest ends of reciprocating vertical movement of the diaphragm.

For each stroke length, the author conducted five experiments with each of the experiment with different frequencies. There are total five frequencies which are 60 Hz, 70 Hz, 80 Hz, 90 Hz and 100 Hz. Frequency here means is how fast the pump diaphragm moves. For each experiment, five readings of time were measured and the average is calculated and tabulated. The results obtained from these experiments were tabulated in table below.

Table 4.9: Time taken by pump A to pump 0.2 liters of water and switch over to pump B at stroke length of 25 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	1048.0	1055.0	1047.0	1049.0	1052.0	1050.2
70	1022.0	1016.0	1023.0	1027.0	1030.0	1023.6
80	985.0	990.0	993.0	989.0	987.0	988.8
90	957.0	955.0	954.0	959.0	960.0	957.0
100	922.0	923.0	921.0	918.0	920.0	920.8

Table 4.10: Time taken by pump A to pump 0.2 liters of water and switch over to pump B at stroke length of 50 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	907.0	905.0	909.0	911.0	908.0	908.0
70	875.0	874.0	876.0	880.0	874.0	875.8
80	848.0	851.0	855.0	849.0	846.0	849.8
90	823.0	821.0	825.0	827.0	825.0	824.2
100	794.0	795.0	799.0	802.0	793.0	796.6

Table 4.11: Time taken by pump A to pump 0.2 liters of water and switch over to pump B at stroke length of 75 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	823.0	827.0	826.0	830.0	822.0	825.6
70	797.0	795.0	799.0	801.0	803.0	799.0
80	787.0	785.0	784.0	783.0	782.0	784.2
90	763.0	759.0	760.0	759.0	766.0	761.4
100	744.0	749.0	741.0	745.0	748.0	745.4

Table 4.12: Time taken by pump A to pump 0.2 liters of water and switch over to pump B at stroke length of 100 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	752.0	759.0	763.0	757.0	765.0	759.2
70	740.0	745.0	749.0	744.0	742.0	744.0
80	729.0	725.0	720.0	722.0	723.0	723.8
90	679.0	680.0	686.0	692.0	694.0	686.2
100	665.0	660.0	664.0	669.0	672.0	666.0

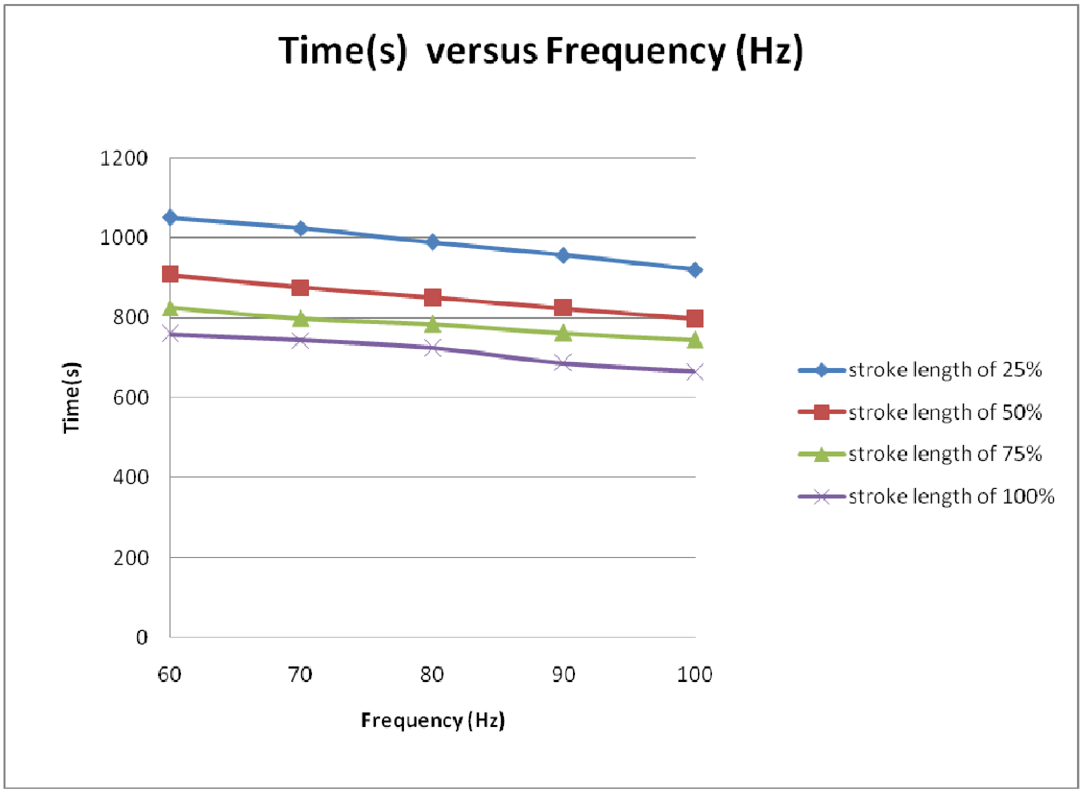

Figure 4.3: Performance of the Tank Switching System with 24 V DC Power Supply measured in terms of Time taken by pump A to pump 0.2 liters of water and switch over to pump B at four different stroke lengths

For this experiment 2, again the data tabulated for this part experiments were plotted in a graph. The graph plotted was the time taken to pump 0.2 liters of water in seconds against the frequency in Hertz.

The above experiments were done again by the author with now measuring the time for pump B to pump 0.2 liters of water and switch over to pump A. All the result collected from the experiment was tabulated in the tables below and the graph to verify the performance of the tank switching system were plotted based on the tabulated data.

Table 4.13: Time taken by pump B to pump 0.2 liters of water and switch over to pump A at stroke length of 25 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	1056.0	1052.0	1051.0	1051.0	1049.0	1051.8
70	1019.0	1023.0	1018.0	1026.0	1030.0	1023.2
80	985.0	993.0	989.0	991.0	990.0	989.6
90	949.0	955.0	959.0	954.0	950.0	953.4
100	925.0	921.0	923.0	917.0	919.0	921.0

Table 4.14: Time taken by pump B to pump 0.2 liters of water and switch over to pump A at stroke length of 50 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	906.0	913.0	911.0	910.0	908.0	909.6
70	877.0	881.0	878.0	883.0	876.0	879.0
80	847.0	846.0	848.0	851.0	849.0	848.2
90	823.0	822.0	826.0	829.0	825.0	825.0
100	796.0	795.0	798.0	801.0	797.0	797.4

Table 4.15: Time taken by pump B to pump 0.2 liters of water and switch over to pump A at stroke length of 75 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	823.0	827.0	824.0	828.0	826.0	825.6
70	798.0	803.0	797.0	801.0	800.0	799.8
80	785.0	784.0	782.0	786.0	784.0	784.2
90	758.0	763.0	764.0	763.0	756.0	760.8
100	749.0	750.0	749.0	751.0	747.0	749.2

Table 4.16: Time taken by pump B to pump 0.2 liters of water and switch over to pump A at stroke length of 100 %

Frequency (Hz)	Time (Seconds)					
	1	2	3	4	5	Average
60	755.0	760.0	757.0	759.0	765.0	759.2
70	741.0	743.0	743.0	746.0	749.0	744.2
80	728.0	729.0	735.0	729.0	733.0	730.8
90	695.0	685.0	683.0	691.0	689.0	688.6
100	669.0	663.0	668.0	665.0	670.0	667.0

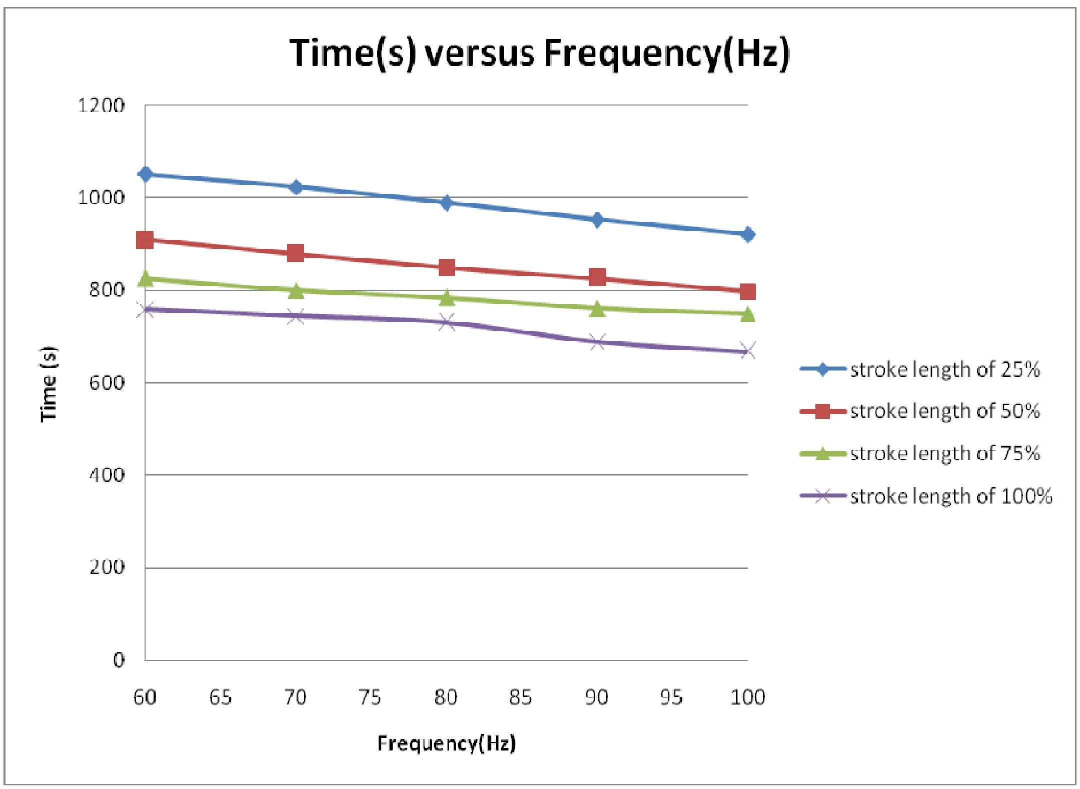

Figure 4.4: Performance of the Tank Switching System with 24 V DC Power Supply measured in terms of Time taken by pump B to pump 0.2 liters of water and switch over to pump A at four different stroke lengths

4.4 Overall Discussion

From the results tabulated above, the author without any doubt can conclude that the usage of 24V DC power supply to power the magnetic level float switch sensor and relays corresponding to the sensors have got the same efficiency as using 240V AC to power the sensors and relays.

The reason why the author can say this because from the results tabulated from the above experiments, can be seen that the average time taken for pump to pump 0.2 liters of water is generally the same for both using 24V DC power supply and 240 V AC power supply. From the graph plotted above, the trend for all four conditions of the of the experiments is the same which is when stroke length is smaller, the time taken is lower and when the frequency is lower, the time taken is longer as well. This condition is satisfied for both 240 V AC and 24 V DC power supplies.

From the results above, it can be seen that, for 240V AC, some of the average time is longer compared to 24V DC for a given condition. For some of the condition, it can be seen that the average time is lower for 240V AC compared to 24V DC. This clearly indicates that, the use of 24 V DC power supply does not influence the efficiency or the performance of the overall system.

The reason why both have got the same efficiency is because, the sensor is using magnetic switch to operate, which means if 24V DC or 240V AC is supplied to the sensor, it will still operate as usual, coz power is used by this sensor to energize its coil in the sensor. When the float outside the insulated coil which has a magnet in it is moved up and down, a pulse is sent to the relay. When the tank has water in it, then the float will be up which indicates tank have got water. When the low level is detected, which is when water in the tank finishes, the float will come down, which will trigger the relay. Therefore the power is used for the sensor to energise its coil only. So it doesn’t matter if 24V DC or 240V AC is used to energise its coil. This is the reason why the efficiency is the same for both power supplies.

Another key thing to be noted is, when 24V DC is supplied to the sensor to energise the coils, so automatically enhanced protection method have been achieved. So if there is a leakage from the sensor due to corrosion or worn out, the leakage voltage will only be 24V DC instead 240V AC if the sensor were to be powered with 240V AC. 24V DC has smaller impact on humans compared to 240V AC if at all anyone to be electrocuted due to leakage.

The relays used also have no impact on the efficiency of this system because both the relays, 24V DC and 240 V AC has got the same specification. Furthermore power is used by this relay to energise it's coil only, so if a 240V AC relay is used, 240 V AC is used to energise the coil of the relay and if 24V DC relay is used, then 24 V DC is used to energise the coil of the relay.

So after conducting all the experiments, the author can prove that the main objective of this project which is to enhance the protection level of this water tank switching system by using 24V DC power supply were achieved without affecting the efficiency of the tank switching system.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As for the conclusion, the author can confidently conclude that the main objective of this project has been achieved. The author has successfully found a method to enhance the safety features of the tank switching system. This main objective of this project was achieved by the author by using a 24 V DC power supply to power the magnetic level float switch sensor and relay corresponding to the sensor.

The author has also mastered the working principle of relays and how to utilise relays to do design a tank switching system. The author has also understood thoroughly the working principle and main elements of pumps and sensors. There are many types of pumps and sensors to be used in different types of environment and surroundings. The author has mastered the usage of each type of pumps and sensors and in which type of surroundings these pumps and sensors are used.

The author has also mastered the knowledge of repairing electronic cards by repairing the electronic card of the pump and made the pump to be in a workable condition again. This also shows that the author knows how electronics components work and what the usage of the each electronic component is.

5.2 Future Recommendations

5.2.1 Have large capacity of storage tank

To have large capacity of storage tank, the system only requires a small alteration which to design a larger version of storage tank. Other than storage tank, all other equipments in this system would be still a same.

The users of this system can customize the type of storage tank that they would like to have for their usage. Some customers may require to a very large storing capacity of few hundred gallons of water and so on. So to have a large storing capacity, the storage tank is customized in this system.

5.2.2 Have capability to pump more liquid

This enhancement can be achieved by changing the pump capacity. Other than customizing the pump, the control elements of this system still remains the same. The pump capacity is customized by choosing a pump which a have larger pumping capacity like 50 liters per hour or 80 liters per house or pumps which even have larger pumping capacity than this.

So when a large pump is used, then a large place may be required to fix this system. A large area here means a wide area to have the bigger storage tank and bigger capacity pump attached to it while the controlling unit is placed a little further from the pump and storage tank so that the system is fixed neatly.

When the controlling unit is fixed in quite a distance from the pump and storage tank, then wires connecting the sensor to the controlling unit will be longer. From Ohms Law, V=IR, the loses will be higher due to the longer wire connection which means longer wire connection have got higher resistance and therefore losses would be high as well. Since the voltage is fixed at 24 V DC, the current got to be increased. The 24V DC power supply the author has used in the electrical and electronic controlling unit of this system provides the option to increase the current level. Therefore by using a bigger capacity pump or large storage tank, the efficiency of this tank switching system can still be maintained.

5.2.3 Have more precision of level measurement

This feature can be achieved in this system by replacing the magnetic level float switch sensor with guided radar level sensor. Guided radar level sensor is widely used in industries in this modern era due to its high precision.

This type of sensor has to be just attached to the top of the storage tank or the cover of the storage tank. It sends waves to the bottom of the tank and when the tank is empty, the sensor is triggered.

This type of sensor has higher efficiency compared to magnetic level float switch because, when magnetic level float switch detects a low level, there will be still a small amount of liquid in the tank. This is due to the structure of the magnetic level float switch. Where else, for the guided radar level sensor, it will only be triggered when the tank is totally empty. Besides that, the user can also actually set at what level he wants the guided radar level sensor to be triggered rather than waiting for the water to finish completely. The efficiency of this guided radar level sensor is way higher compared to magnetic level float switch and yet the author did not use in this project because due to budget constrain.

5.2.4 Have alarm to alert in tank is not filled up

This is another key feature that can be amended to this system. When first sensor is detected to be low level, the pumping of liquid will switch from tank A to tank B. So liquid will be pumped from tank B and someone has to fill up the liquid in tank A so that when liquid in tank B drops below low level, and when sensor detects this, the water can be pumped from tank A instead of tank B.

For an example, when the users of this tank forget to fill up the liquid in tank A, and sensor in tank B also detects to be a low level, then the pump B will be working but there will be no liquid to be pumped. So to alert users when this scenario happens, the author recommends implementing an alarm system. When this specified situation takes place, then the alarm will ring to alert the users to fill up both the tanks.

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APPENDICES

APPENDIX A: Data Sheet of the 24 V DC power supply

MEAN WELL

40W Single Output Switching Power Supply — S-40 series

■ Features :

- Universal AC input / Full range
- Protections: Short circuit / Overload / Over voltage
- Cooling by free air convection
- 100% full load burn-in test
- Fixed switching frequency at 75KHz
- 2 years warranty

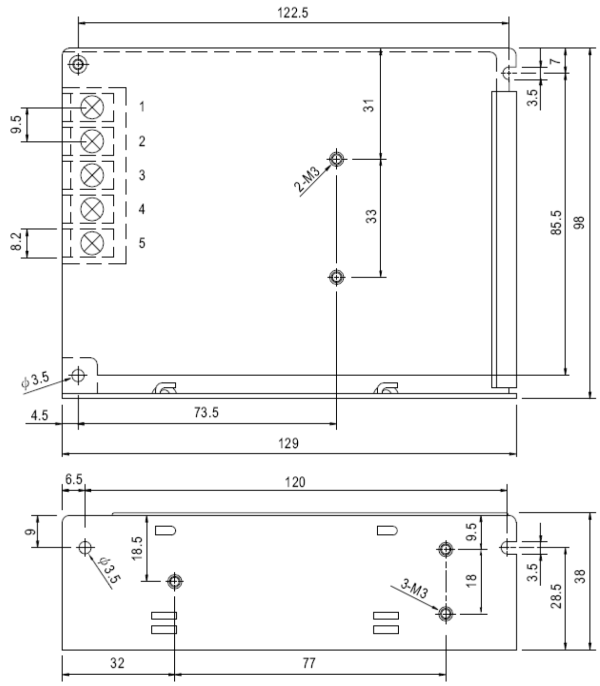
SPECIFICATION

MODEL		S-40-5	S-40-12	S-40-15	S-40-24
OUTPUT	DC VOLTAGE	5V	12V	15V	24V
	RATED CURRENT	8A	3.5A	2.8A	1.8A
	CURRENT RANGE	0 ~ 8A	0 ~ 3.5A	0 ~ 2.8A	0 ~ 1.8A
	RATED POWER	40W	42W	42W	43W
	RIPPLE & NOISE (max.) Note.2	75mVp-p	100mVp-p	100mVp-p	100mVp-p
	VOLTAGE ADJ. RANGE	4.75 ~ 5.5V	10.8 ~ 13.2V	13.5 ~ 16.5V	21.6 ~ 26.4V
	VOLTAGE TOLERANCE Note.3	±2.0%	±1.0%	±1.0%	±1.0%
	LINE REGULATION	±0.5%	±0.5%	±0.5%	±0.5%
	LOAD REGULATION	±1.0%	±0.5%	±0.5%	±0.5%
	SETUP, RISE TIME	300ms, 50ms/230VAC 800ms, 50ms/115VAC at full load			
	HOLD UP TIME (Typ.)	70ms/230VAC 15ms/115VAC at full load			
INPUT	VOLTAGE RANGE	85 ~ 264VAC 120 ~ 370VDC			
	FREQUENCY RANGE	47 ~ 63Hz			
	EFFICIENCY (Typ.)	72%/115VAC	76%/115VAC	76%/115VAC	78%/115VAC
	AC CURRENT (Typ.)	1.2A/115VAC 0.6A/230VAC			
	INRUSH CURRENT (Typ.)	COLD START 25A/115VAC 50A/230VAC			
	LEAKAGE CURRENT	<1mA / 240VAC			
PROTECTION	OVERLOAD	105 ~ 150% rated output power			
		Protection type : Hiccup mode, recovers automatically after fault condition is removed			
	OVER VOLTAGE	5.75 ~ 6.75V	13.8 ~ 16.2V	17.25 ~ 20.25	27.6 ~ 32.4V
		Protection type : Hiccup mode, recovers automatically after fault condition is removed			
ENVIRONMENT	WORKING TEMP.	-10 ~ +60℃ (Refer to output load derating curve)			
	WORKING HUMIDITY	20 ~ 90% RH non-condensing			
	STORAGE TEMP., HUMIDITY	-20 ~ +85℃, 10 ~ 95% RH			
	TEMP. COEFFICIENT	±0.03%/℃ (0 ~ 50℃)			
	VIBRATION	10 ~ 500Hz, 2G 10min./1cycle, period for 60min. each along X, Y, Z axes			
SAFETY & EMC (Note 4)	SAFETY STANDARDS	UL1012, UL60950-1, TUV EN60950-1 approved			
	WITHSTAND VOLTAGE	I/P-O/P:3KVAC I/P-FG:1.5KVAC O/P-FG:0.5KVAC			
	ISOLATION RESISTANCE	I/P-O/P, I/P-FG, O/P-FG:100M Ohms / 500VDC / 25℃/ 70% RH			
	EMI CONDUCTION & RADIATION	Compliance to EN55022 (CISPR22) Class B			
	HARMONIC CURRENT	Compliance to EN61000-3-2,-3			
	EMS IMMUNITY	Compliance to EN61000-4-2,3,4,5; ENV50204, EN55024, light industry level, criteria A			
OTHERS	MTBF	314.1K hrs min. MIL-HDBK-217F (25℃)			
	DIMENSION	129*98*38mm (L*W*H)			
	PACKING	0.44Kg; 30pcs/13.9Kg/0.86CUFT			
NOTE		1. All parameters NOT specially mentioned are measured at 230VAC input, rated load and 25℃ of ambient temperature. 2. Ripple & noise are measured at 20MHz of bandwidth by using a 12" twisted pair-wire terminated with a 0.1uf & 47uf parallel capacitor. 3. Tolerance : includes set up tolerance, line regulation and load regulation. 4. The power supply is considered a component which will be installed into a final equipment. The final equipment must be re-confirmed that it still meets EMC directives. For guidance on how to perform these EMC tests, please refer to "EMI testing of component power supplies." (as available on http://www.meanwell.com)			

MEAN WELL 40W Single Output Switching Power Supply **S-40 series**

Mechanical Specification

Case No. 903 Unit:mm

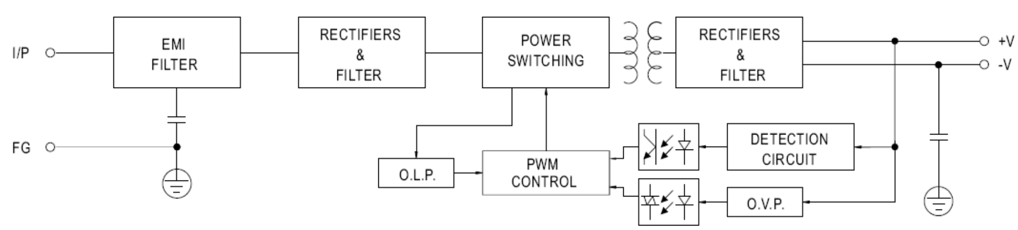


Terminal Pin No. Assignment

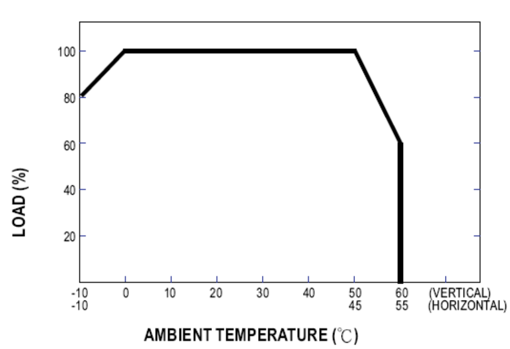
Pin No.	Assignment	Pin No.	Assignment
1	AC/L	4	DC OUTPUT -V
2	AC/N	5	DC OUTPUT +V
3	FG ⏚		

Block Diagram

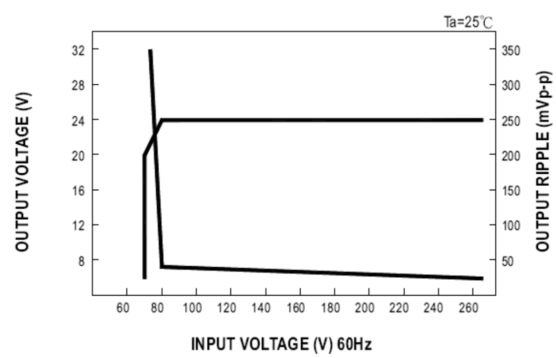
fosc : 75KHz



Derating Curve



Static Characteristics (24V)



APPENDIX B: Data Sheet of the 24 V DC Relpol relay

6 A / 250 V AC

- WT - standard plug-in version with indicating flag and manual testing/latching lever
- Miniature size, cadmium - free contacts available, coil AC and DC
- Plug-in version - 35 mm DIN rail mount, EN 50022 or on panel mounting
- For PCB and soldering connections - option
- General purpose relays
- **Have obtained The Lloyd's Certificate „Register of shipping" - R4...WT**
- Relays may be provided with the P type test buttons as well as plugs instead for T type buttons - page 167

Contacts

Contact number & arrangement		4C/O
Contact material		**AgNi**, AgNi/Au 0,2 μm, AgNi/Au 5 μm
Max. switching voltage	AC/DC	250 V / 250 V
Min. switching voltage		5 V
Rated load	AC1	6 A / 250 V AC
	DC1	6 A / 24 V DC
Min. switching current		5 mA AgNi, 5 mA AgNi/Au 0,2 μm, 2 mA AgNi/Au 5 μm
Max. inrush current		12 A
Rated current		6 A
Max. breaking capacity	AC1	1 500 VA
Min. breaking capacity		0,3 W AgNi, 0,3 W AgNi/Au 0,2 μm, 0,1 W AgNi/Au 5 μm
Resistance		≤ 100 mΩ
Max. operating frequency		
• at rated load	AC1	1 200 cycles/hour
• no load		18 000 cycles/hour

Coil

Rated voltage	50/60 Hz AC	6...240 V
	DC	5...220 V
Must release voltage		AC: ≥ 0,2 U_n DC: ≥ 0,1 U_n
Operating range of supply voltage		see Table 1, 2
Rated power consumption	AC	1,6 VA
	DC	0,9 W

Insulation

Insulation category		B250
Insulation rated voltage		250 V AC
Dielectric strength		
• coil - contact		2 500 V AC
• contact - contact		1 500 V AC
• pole - pole		2 000 V AC
Contact - coil distance		
• clearance		≥ 1,6 mm
• creepage		≥ 3,2 mm

General data

Operating time (typical value)		AC: 10 ms DC: 13 ms
Release time (typical value)		AC: 8 ms DC: 3 ms
Electrical life		
• resistive AC1		≥ 10^5 6 A, 250 V AC
• cosϕ		see Fig. 2
Mechanical life (cycles)		≥ 2 x 10^7
Dimensions (L x W x H)		27,5 x 21,2 x 35,6 mm ❶ 27,5 x 21,1 x 33,5 mm ❷
		27,5 x 21,2 x 33 mm ❸
Weight		35 g
Ambient temperature		
• storing		-40...+85 °C
• operating		AC: -40...+55 °C DC: -40...+70 °C
Cover protection category		IP 40
Shock resistance	(NO/NC)	10 g / 5 g
Vibration resistance		5 g 10...150 Hz
Solder bath temperature		max. 270 °C
Soldering time		max. 5 s

Standard contact material marked with bolt type.
❶ WT - standard plug-in version ❷ PCB version ❸ Version with threaded bolt

Coil data - DC voltage version Table 1

Coil code	Rated voltage V DC	Coil resistance (±10%) at 20 °C Ω	Coil operating range V DC	
			min. (at 20 °C)	max. (at 55 °C)
1005	5	28	4,0	5,5
1006	6	40	4,8	6,6
1012	**12**	**160**	**9,6**	**13,2**
1024	**24**	**640**	**19,2**	**26,4**
1048	48	2 600	38,4	52,8
1060	60	4 000	48,0	66,0
1080	80	7 100	64,0	88,0
1110	110	13 600	88,0	121,0
1125	125	16 000	100,0	137,5
1220	220	54 000	176,0	242,0

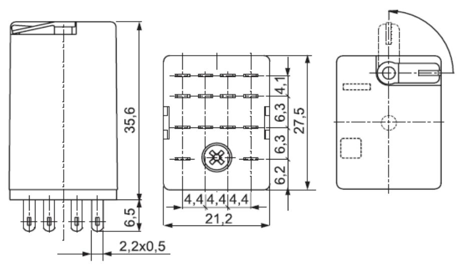
Standard coil rated voltages marked with bold type.

Coil data - AC 50/60 Hz voltage version Table 2

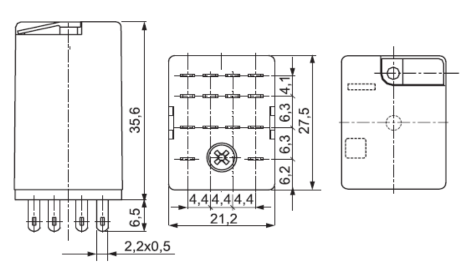
Coil code	Rated voltage V AC	Coil resistance (±10%) at 20 °C Ω	Coil operating range V AC	
			min. (at 20 °C)	max. (at 55 °C)
5006	6	9,8	4,8	6,6
5012	12	39,5	9,6	13,2
5024	**24**	**158,0**	**19,2**	**26,4**
5042	42	470,0	33,6	46,2
5048	48	640,0	38,4	52,8
5060	60	930,0	48,0	66,0
5080	80	1 720,0	64,0	88,0
5110	110	3 450,0	88,0	121,0
5120	120	3 770,0	96,0	132,0
5127	127	4 000,0	101,6	139,0
5220	220	15 400,0	176,0	242,0
5230	**230**	**16 100,0**	**184,0**	**253,0**
5240	240	16 800,0	192,0	264,0

Standard coil rated voltages marked with bold type.

Dimensions - plug-in version (WT), with manual testing/latching lever type T

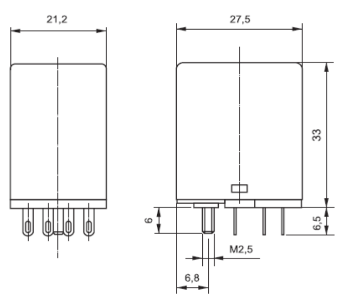


Dimensions - plug-in version (WT), with P type buttons and plugs or plugs

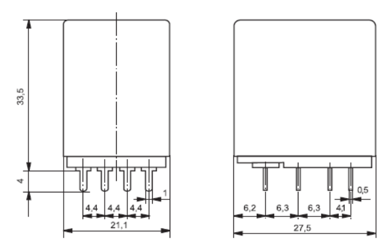


P type buttons and plugs and plugs need to ordered saparately.
Exchange of the buttons is done by Customer.
Information on P type buttons and plugs and plugs on page 167.

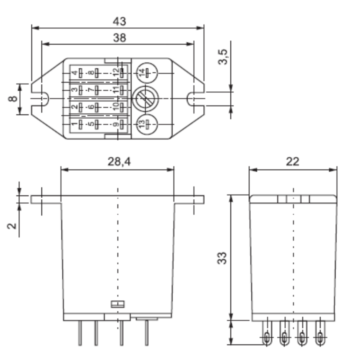
Dimensions - version with threaded bolt



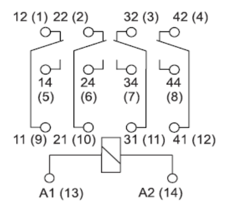
Dimensions - PCB version (without WT)



Dimensions - version with mounting flange (without WT)

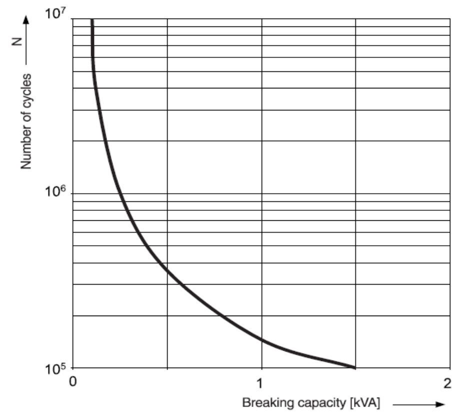


Connections diagram (pin side view)

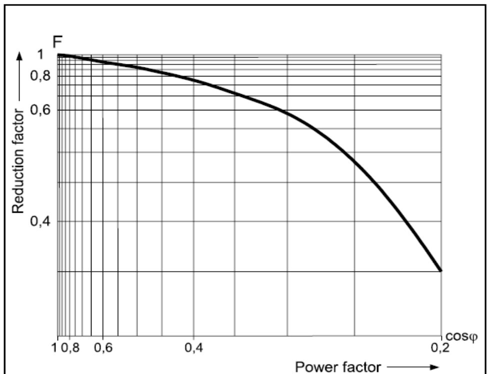


Relay terminals for PCB 0,5 x 1 mm
Drilling hole: • for relays Ø 1,3 + 0,1 mm • for sockets Ø 1,5 + 0,1 mm

Electrical life at AC resistive load Fig. 1

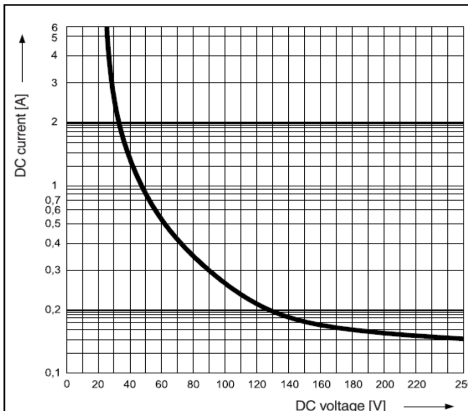


Electrical life reduction factor at AC inductive load Fig. 2



$N_{cos\varphi} = N \times F$

Maximum DC resistive load breaking capacity Fig. 3



Mounting

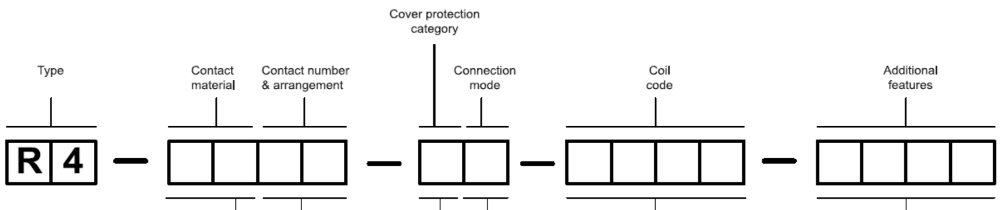
R4 relays are offered in versions: • standard, plug-in version with flag indicator and machanical latching (WT). **Customer may exchange T type button with P type button (no latching) or with plug (no mechanical operation). P type buttons and plugs and plugs need to ordered saparately** • for PCB (without WT) • with threaded bolt • with mounting flange (without WT).

Relays **R4** are designed for: • screw terminals sockets **GZT4** and **GZM4** with clip **GZT4-0040** or **G4 1052**; screw terminals sockets **GZR4** with clip **G4 1052**, 35 mm DIN rail mount, EN 50022 or on panel mounting. **M...** type signalling and protection plug-in modules are available with sockets **GZT4** and **GZM4** (see page 170) • terminals sockets for PCB mounting **SU4D** with clip **G4 1053** (WT) or **G4 1050** (without WT) • solder terminals sockets **SU4L** with clip **G4 1053** (WT) or **G4 1050** (without WT) and spring clamp **G4 1040** • solder terminals sockets **G4** with clip **G4 1053** (WT) or **G4 1050** (without WT) • direct PCB mounting.

Contact material selection for different load types

- **AgNi** - for resistive or inductive loads,
- **AgNi/Au 0,2 µm** - contact surface protection against oxidation during storage,
- **AgNi/Au 5 µm** - for small resistive loads in control circuits.

Ordering codes



Contact material

20 - AgNi
21 - AgNi/Au 0,2 µm
23 - AgNi/Au 5 µm

Coil code: see Table 1, 2 page 99

Contact number & arrangement

14 - 4C/O

Cover protection category

2 - in housing, IP 40 version
4 - in housing with mounting flange, IP 40 version

Connection mode

3 - plug-in
5 - PCB
7 - PCB with threaded bolt
9 - plug-in with threaded bolt

Additional features *

-----	no additional features
L -	LED indicator
D -	arc suppressing diode
LD -	LED indicator +arc suppressing diode
WT -	indicating flag + manual testing/latching lever (standard)
WTL -	indicating flag + manual testing/latching lever + LED indicator
WTD -	indicating flag + manual testing/latching lever + arc suppressing diode
WTLD -	indicating flag + manual testing/latching lever + LED indicator + arc suppressing diode

* **WT** - **standard features plug-in power relays**
D, LD, WTD, WTLD - only for DC coils
P type buttons and plugs and plugs ordered separately for substition of T type button by Customers themselves:
- Button P R4 AC - orange (coils AC)
- Button P R4 DC - green (coils DC)
- Plug R4 AC - orange (coils AC)
- Plug R4 DC - green (coils DC)

Information on P type buttons and plugs and plugs on page 167.

Note:
DC coil polarity for versions equipped with D (arc suppression diode) and L (LED) is fixed.
Terminal A1 (13) "+"; terminal A2 (14) "-".
Supply polarity is marked on relay housing.
Button color represents type of supply: orange for AC coil, green for DC coil.

APPENDIX C: Data Sheet of the 240 V AC Omron relay

OMRON

Latching Relay

MKK-P

Magnetic Latching Relay Ideal for Memory Circuits

- Magnetic materials allow long, continuous holding times.
- Key characteristics unaffected by aging assure long service life.
- High vibration and shock resistance.
- Built--in operation indicator for easy relay operation monitoring.

Ordering Information

Contact form	Plug-in type
DPDT	MK2KP

Note: When ordering, add the rated coil voltage (listed in "Specifications") to the model number as shown below:
Example: MK2KP AC 240
Rate of coil voltage

Specifications

■ Time Ranges

Rates voltage (v)		Item										
		Set coil			Reset coil			Must set voltage	Must reset voltage	Maxium voltage	Power consumption (VA, W)	
		Rated current (mA)	Coil resistance (W)	Coil inductance (ref. value) (H) Armature ON	Rated current (mA)	Coil resistance (W)	Coil inductance (ref. value) (H) Armature OFF	% of rated voltage			Set coil	Reset coil
AC	6	286	4.9	0.05	29	78	0.16	80 max.	80 max.	110	Approx. 1.5 to 2	Approx. 0.1 to 0.7
	12	128	25	0.22	14.4	325	0.59					
	24	66	105	0.88	10.8	965	1.09					
	50	31	410	3.93	3.2	8,450	5.03					
	100	17.8	1,670	13.4	3.6	13,350	13.8					
	110	19.6	1,670	13.5	4	13,350	15.1					
	120	19	1,900	15.1	4.2	12,400	16.7					
	200	9.8	6,200	48.9	3.2	27,350	29.2					
	220	10.6	6,200	49.8	3.5	27,350	35.3					
	240	10.4	7,400	54.9	3.4	29,100	53.2					
DC	6	390	13	0.056	92.5	64	0.013				Approx. 2.3 to 2.7	Approx. 0.5 to 1.2
	12	205	52	0.23	50	240	0.05					
	24	110	210	0.90	22.8	1,050	0.20					
	48	48.5	990	4.13	23.4	2,050	0.20					
	100	24	4,160	16.5	10.3	9,740	1.25					
	110	26.4	4,160	16.5	11.3	9,740	1.25					

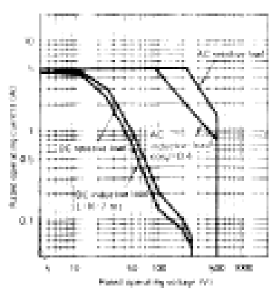
Note:
1. The rated current and coil resistance are measured at a coil temperature of 23%C with tolerances of +15%, −20% for rated current, and +15% for rated coil resistance.
2. The rated current and performance characteristics are measured at a coil temperature of 5 to 35%C.
3. Peak reverse voltage of the built-in diode is 1,000 V.

Contact ratings

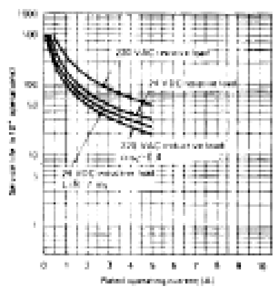
Item \ Load	Resistive load (cosm=1)	Inductive load (cosm=0.4; L/R = 7 ms)
Rated load	220 VAC 5 A 24 VDC 3 A	220 VAC 2 A 24 VDC 2.5 A
Carry current	5 A	
Max. operating voltage	500 VAC 250 VDC	
Max. operating current	5 A	AC 5 A DC 4.6 A
Max. switching capacity	1,100 VA, 72 W	440 VA, 60 W
Minimum permissible load	1 VDC 1 mA (reference value)	

Engineering Data

Maximum switching capacity



Electrical service life

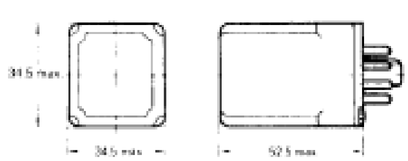


Characteristics

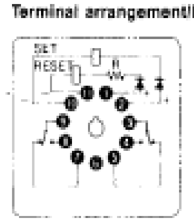
Contact resistance	50 mg max.
Operate time	30 ms max.
Release time	30 ms max.
Operating frequency	Mechanical: 1,800 operations/hour Under rated load: 1,800 operations/hour
Insulation resistance	100 Mg min. (at 500 VDC)
Dielectric strength	2,000 VAC, 50/60 Hz for 1 minute (1,000 VAC between contacts of the same polarity and between set and reset coils)
Vibration	Mechanical durability: 10 to 55 Hz; 1.5 mm double amplitude Malfunction durability: 10 to 55 Hz; 1.0 mm double amplitude
Shock	Mechanical durability: 500 m/s^2 (approx. 50 G) Malfunction durability: 100 m/s^2 (approx. 10 G)
Ambient temperature	Operating: –10 to 40%C
Humidity	35 to 85% RH
Service life	Mechanical: 5,000,000 operations min. (at operating frequency of 1,800 operations/hour) Electrical: See "CHARACTERISTIC DATA".
Weight	Approx. 85 g

Note: The data shown above are initial values.

Dimensions



Terminal arrangement/internal connections (bottom view)



NOTE:

1. R is a resistor for ampere-turn compensation, and is incorporated in the relays rated at 50 VAC or above and 48 VDC or above.
2. Pay attention to the polarity of the set and reset coils, as incorrect connection of positive and negative terminals will result in malfunctioning of the relay.

■ Sockets (Order Separately)

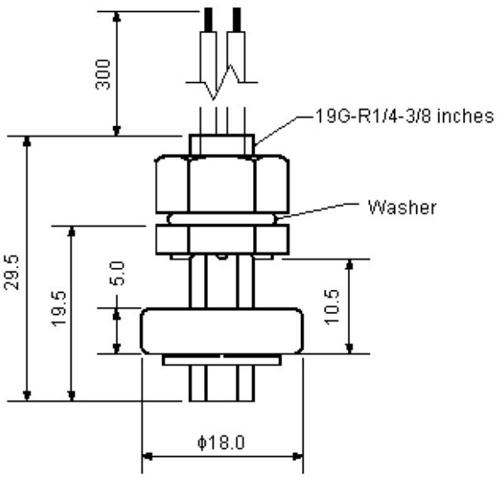
DIN Rail (track) mounted Socket

PF083A-E

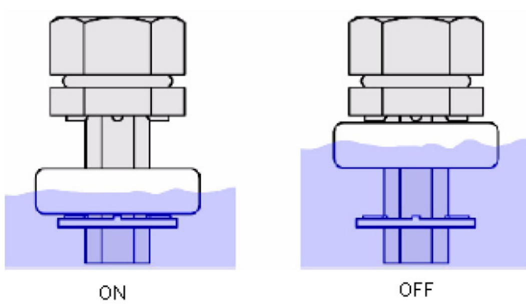
PF113A-E

APPENDIX D: Data Sheet of the magnetic level float switch sensor

Magnetic Level Sensor
Vertical Float



Operating Diagram



Magnetic Level Sensor
Vertical Float

SPC multicomp

Specifications:

Electrical Characteristics

Contact form (ASA)	: A.
Contact material	: Ru.
Maximum contact rating	: 10W/VA.
Maximum switching current	: 0.7A.
Maximum carry current	: 1.0A.
Maximum switching voltage	: 180V DC.
	: 130V AC.
Minimum breakdown voltage	: 200V DC.

Temperature Range

Operating temperature	: -20 to +80°C.
Storage temperature	: -30 to +80°C.

Material

Case/Nut	: PP.
Float	: PP.
Washer	: TEP.
Potting compound	: Epoxy.
Cable	: UL 1007, AWG 24.

Testing

Sensors tested 100% for electrical function and operating distance.

Remarks

When mounted near ferromagnetic parts switching points may vary.

Part Number Table

Description	Part Number
Float Switch, NC, Vertical	MCPLS-020-B-3