ALTERNATIVE SOLAR HOT WATER SYSTEM WITH MULTISTORAGE TANK

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DECLARATION

We hereby declare that this thesis report has been written based only on the works and results found by ourselves. Material of the works or research or thesis by other researchers are mentioned by their references. This thesis, neither in whole nor in part, has been previously submitted for any degree.

Signature of Supervisor Signature of Author

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ABSTRACT

The use of renewable energy has been spread all over the globe very rapidly. Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). Along with the major developments in the alternative sources of energy, a major breakthrough is the solar energy. More energy from sunlight strikes Earth in one hour than all of the energy consumed by humans in an entire year. So it is very convenient to utilize this energy in our daily life. In many other countries solar energy is being used within vast area. Researches are going on to make the solar system more efficient and affordable.

So it has been necessary to bring the idea of using solar energy in our country in wide range including domestic purpose. It will be in fact a great achievement if we can minimize electricity consumption by substituting it with solar energy. This thought leads us to work on our project which is on the topic “Alternative Solar Water Heater with Automated Control System”.

Using solar energy to supply hot water for both industrial and domestic purpose can be a very good application of utilizing solar power and that is the target that we will be trying to achieve. Our task is to implement a solar water heater along with a backup water heater controlled by a controller to ensure the constant hot water supply in the cheapest possible way. Our thesis work also provides a solution to increase the efficiency of solar water heater by implementing high capacitive multiple hot water storage tanks.

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MOTIVATION

There is an immense potential for the use of solar PV technology in Bangladesh. Solar is a very good option for harnessing energy without affecting any environmental damage. Due to the lack of natural energy resources like fossil fuel and natural gas we are nearly running out of sufficient power generation. As our country always struggling to produce the power generation it's needed to produce and day by day power crisis becoming a very big problem we can draw our attention towards solar energy and by using solar energy we can find a greater solution.

Even though solar water heater is used today mainly for providing hot water to households and pools nevertheless we have to consider it for industrial sectors, where solar thermal heat could be fruitfully used. The key sectors are food (including wine and beverage), textile, pharmaceuticals, hotels, hospitals, tannery industries, metal and plastic treatment, and chemical. The areas of application with the most suitable industrial processes, include cleaning, drying, evaporation and distillation, blanching, pasteurization, sterilization, cooking, melting, painting, and surface treatment

However energy costs for heating water is increasing at considerable rate by increasing operating costs and reducing profitability due to continuous escalating of fuel price. Hence, this thesis is going to explore solar energy as sustainable alternative for large scale water heating system and thus shall contribute a great role on saving our energy storage.

OBJECTIVE

The recent failure of electricity supply reminds us the lack of energy and energy sources in this country. Energy is presently a crisis not only in terms of our country but in terms of world. Due to the vast population and their necessity the natural resource of energy that is currently being used will soon be vanquished. At this present moment there are no other alternative rather then to look for a new source of energy.

Our country is exposed to the sun mostly throughout the year. During the summer time the heat of sun is at its peak. During the year we need a lot of hot water in hospitals and industries as well as in households. Due to the power failure supply of hot water is hampered. Besides, a lot of power is consumed by the electric hot water system used in hospitals and industries. Considering this facts we can implement an alternative way which not only provides continuous supply of hot water but also save a huge amount of power and money. This invokes the necessity of "Alternative Solar Hot Water System with Multiple storage Tanks" to come into action.

Thus the objective of our project is-

- To implement the solar water heater with backup electric water heater to ensure the supply of hot water in both domestic and industrial purpose
- To lower the consumption of electricity by increasing the efficiency of solar water heater by the help of high capacitive hot water storage tanks.
- To establish a hot water supply system in the most cost efficient way
- To develop a controller system to control the water supply with a human interface so that general people can easily interact with the system.
- To handle all the risk management those are related with the whole system.

CHAPTER I

INTRODUCTION

1.1 Dependency on Natural Resources – A Brief History of Killing Ourselves

In November 2007, Bangladesh faced a devastating natural calamity. The calamity came in the form of a great cyclone. It was the strongest cyclonic wave of last century built in this global region. The cyclone was named ”Sidr”. Sidr attacked Bangladesh on November 15, 2007. The storm a large scale of evacuation and about 4000 death were blamed on the storm. The economic and environmental loss was unthinkable.

In the month of January of the running year, an earthquake occurred with catastrophic magnitude of 7.0 in Richter scale in the epicenter of Haiti. The earthquake caused a major damage in the capital Port-au-Prince, Jacmal and other settlements in the region. An estimated 230,000 people had died, 300,000 had been injured and 1,000,000 made homeless. Many residences, commercial and notable buildings have destroyed or severely damaged. In the next month, even a larger earthquake happened at the centre of Chile. The magnitude was 8.8 in Richter scale. This also caused a great misery to the country and the death roll was of millions.

For the last few years, we have been observing that Natural incidents like these are occurring very frequently and the affect is getting higher and higher. These are the indicators of the global climatic changes for which we, the humans are responsible only. The current rate of consumption of resources and the resulting burden on the environment are not sustainable: in spite of technical improvements, growth in resource consumption has often outstripped progress on the environment or productivity increases. There is likely to be an even greater tendency in this direction as certain countries such as China or India become more industrially advanced. The risk of resources running out and the pollution caused by their use thus pose an ever-greater threat to our environment. Natural resources are under increasing pressure, threatening public health and development. Water shortages, soil exhaustion, loss of forests, air and water pollution, and degradation of coastlines afflict many areas. As the world's population grows, improving living standards without destroying the environment is a global challenge.

Most developed economies currently consume resources much faster than they can regenerate. Most developing countries with rapid population growth face the urgent need to improve living standards. As we humans exploit nature to meet present needs, we are destroying resources needed for the future. This also takes us to the time rapidly when we shall be seeing our non existence.

1.2 Need of Solar Energy Application

In this time we are in great need of renewable energy. Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which is renewable (naturally replenished) .The radiated energy from the sun, is the largest source of renewable energy available from earth. If we can make the proper utilization of this radiated energy then we can not only keep our environment cleaner but also preserve our limited natural resources for longer period. In recent time the developed and the developing world have concentrated much on the utilization of solar energy. Solar PV electricity, solar thermal electricity, solar powered vehicle, solar water heater and many more applications of solar energy in the field of agriculture have been developed.

1.3 A Focus on Bangladesh

Bangladesh is a small country with a huge population of more than 150 million. The large population creates a lot of problem in our country. The failure to meet the demand of electricity is such a major problem in this country. We may focus on some recent facts related to this criterion.

- According to the annual report of PDB, tin year 2009 the peak demand was 6000 MW in summer
- The generation was 4500 MW
- There was a shortage of 1500 MW of electricity
- 80 million people do not have access to electricity
- Remaining 70 million people of course having unreliable power
- Maximum generation in the last month was 4268 MW
- Maximum generation in this year has been 4606 MW in April
- The demand was always higher than 5000 MW

From these facts we can conclude that we are lacking a lot of electricity. That's why we need a very quick alternative solution which can be of course solar energy.

1.4 Why We Need Alternative Solar Hot Water System?

The need of hot water in our country is increasing in our country day by day as we are becoming more dependent on our industrial sector. About 500 gallons of hot water is needed daily in the tanneries and in pharmaceuticals. Glass, Ceramic and other factories also need hot water for their production. Beside it has been now a great necessity of hot water supply in the hospitals as well as in hotels. Today all these hot waters are coming from either electric or gas based water heating system. This leads to a lot of consumption of our limited resources. It also creates pressure on the power generation. To reduce the pressure on the power sector where we already have a lot of crisis, we need an alternative water heating system that provides continuous hot water supply without consumption of electricity. The Alternative Solar Hot Water System is just the solution we are looking for.

CHAPTER II

SYSTEM OVERVIEW

2.1 Description of the System

According to achieve the objective of our project be successful, our system should be able to supply hot water to the user by using the radiated energy from the sun. So the main appliance of the system is a Solar Water Heater which transforms energy of sunrays to heat and produce hot water. But this Solar Water Heater can provide hot water only if there is sufficient energy available. And sufficient energy is only available when there is the sun available. If the sun is not available then the hot water can not be supplied. We may not get sun for continuous days in the time of winter or the rainy season. So to improve the efficiency of the system we added a series of Hot Water Storage Tanks of high capacity. This storage tanks can store the hot water produced by the Solar Water Heater for three days (72 hours) so that we shall be able to supply hot water for some time in spite of having the sun available. The user will be having the supply from these Storage tanks. This surely improves the system's performance on a high scale in a tropical country like Bangladesh where consecutive unavailability of the sun is not naturally expected. We still have an Electric Water Heater as the backup water supplier. If the solar system fails to supply hot water then the supply would be getting from the Electric Heater so that there would be no interruption in the supply. All the water transportation and supplying would be controlled by the controller circuit with the help of Electromagnetic Valves, Temperature Sensors, Water Level Detectors etc. There comes the collaboration between a solar system and an embedded system.

2.2 System Components

The Alternative Solar Hot water System that we implemented on the roof top of BRAC University for our thesis is comprised with these appliances –

1. Solar Water Heater (1 unit of 150 Liters Capacity)
2. Hot Water Storage Tank (1 unit of 300 Liters Capacity)
3. Electromagnetic Valve (5 units)
4. Temperature Sensor (2 units)
5. Water Level Detector (2 units)
6. Electric Water Heater (1 unit of 40 Liters Capacity)
7. LCD display (1 unit)
8. Power Supply 24 volts (1 unit)
9. 24 volts Relay (5 units)
10. Microcontroller At mega 32 (2 units)

We also needed the plumbing materials for the setup of the system and the electronic and circuitry materials for the controller setup and testing.

2.3 The Solar Water Heater

The Solar Water Heater is the main equipment of the Alternative Solar Hot Water System. This Heater has the ability to absorb energy from the abundant rays of the sun and turn this energy into heat. By this transformed heat the water gets heated. For our thesis purpose we have used one Solar Water Heater having the capacity of 150 Liters. The Solar Water Heater has two parts. One is the solar collector and the other is the water tank.

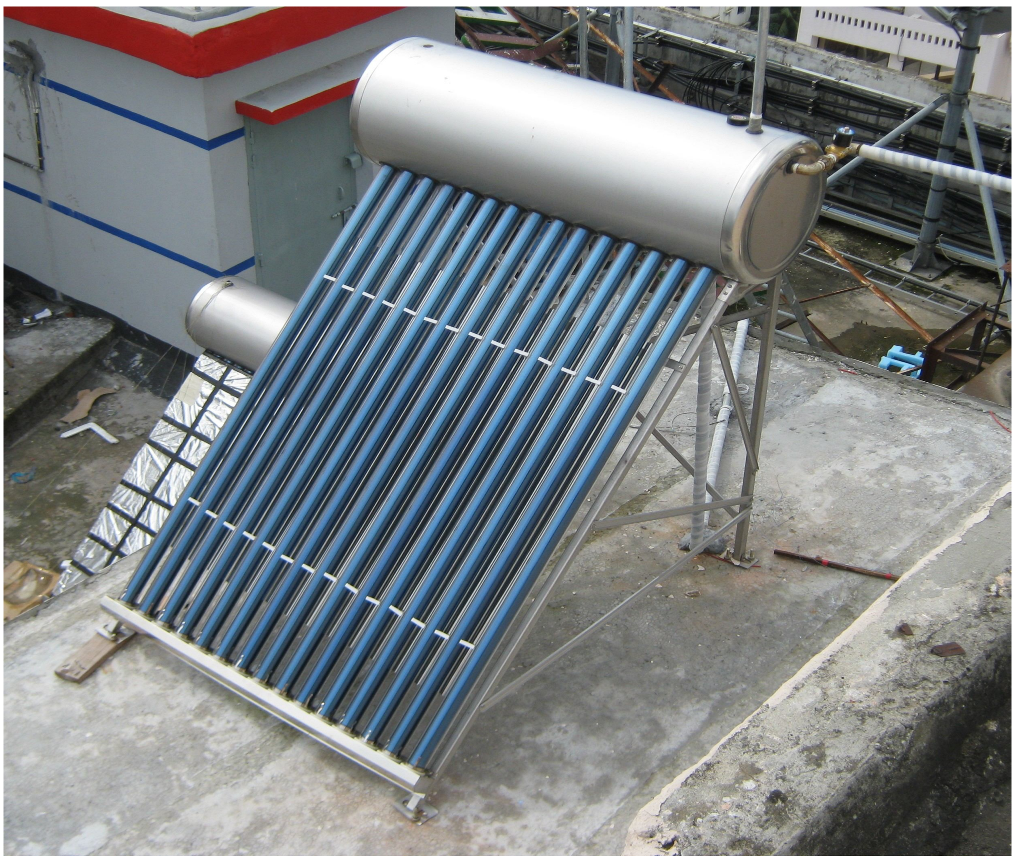


Figure 2.1 : Solar Water Heater installed on the roof of BRAC University

2.3.1 The Collector

The collector is the most important part of the Solar Water Heater which kept facing towards the sun. The collector absorbs the energy of the sunrays. The collectors are actually some evacuated tubes placed parallelly with each other inclined at 45^{o} angle with the ground. These evacuated tubes are the absorber of the solar energy. There are several types of evacuated tubes in use in the solar industries. The type which is used in our Solar Heater is called “Twin-glass tube”. This type of tubes is used for its reliability, performance and low manufacturing cost

Each evacuated tube consists of two glass tubes made from extremely strong borosilicate glass. The outer tube is transparent allowing light rays to pass through with minimal reflection. The inner tube is coated with a special selective coating (Al-N/Al) which features excellent solar radiation absorption and minimal reflection properties. The top of the two tubes are fused together and the air contained in the space between the two layers of glass is pumped out while exposing the tube to high temperatures. This "evacuation" of the gasses forms a vacuum, which is an important factor in the performance of the evacuated tubes.

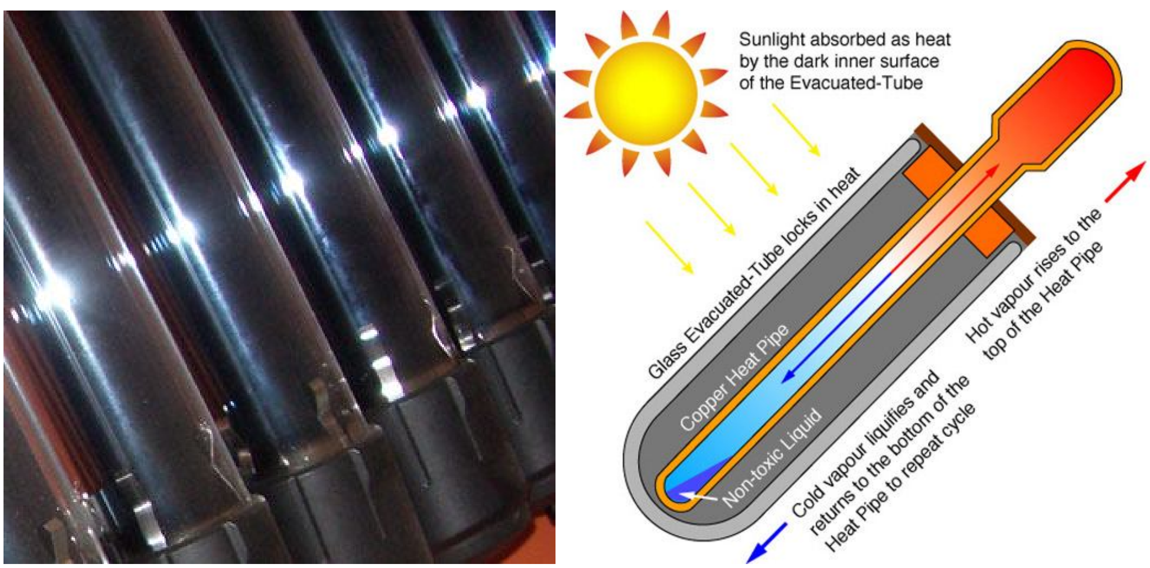


Figure 2.2 : Solar collector evacuated tubes and its working function

The glass tubes are vacuum because a vacuum is an excellent insulator. This is important because once the evacuated tube absorbs the radiation from the sun and converts it to heat, we don't want to lose it. The vacuum helps to achieve this. The insulation properties are so good that while the inside of the tube may be $150^{o}C$ / $304^{o}F$, the outer tube is cold to touch. This means that evacuated tube water heaters can perform well even in cold weather when flat plate collectors perform poorly due to heat loss (during high Delta-T conditions). In order to maintain the vacuum between the two glass layers, a barium getter is used (the same as in television tubes). During manufacture of the evacuated tube this getter is exposed to high temperatures which cause the bottom of the evacuated tube to be coated with a pure layer of barium. This barium layer actively absorbs any CO, CO_2, N_2, O_2, H_2O and H_2 out-gassed from the evacuated tube during storage and operation, thus helping to maintaining the vacuum. The barium layer also provides a clear visual indicator of the vacuum status. The silver colored barium layer will turn white if the vacuum is ever lost. This makes it easy to determine whether or not a tube is in good condition.

(a) (b)

Figure 2.3 : a) The Barium Getter used inside the evacuated tubes
b) Correct and faulty tubes

Evacuated tubes are aligned in parallel, the angle of mounting depends upon the latitude of your location. In a North South orientation the tubes can passively track heat from the sun all day. In an East West orientation they can track the sun all year round.

Evacuated Tube Basic Specifications

Length (nominal)	1500mm /1800mm
Outer tube diameter	58mm

Inner tube diameter	47mm
Glass thickness	1.6mm
Thermal expansion	3.3x10^{-6} ^{o}C
Material	Borosilicate Glass 3.3
Absorptive Coating	Graded Al-N/Al
Absorptance	>92% (AM1.5)
Emittance	<8% (80^{o}C)
Vacuum	P<5x10^{-3} Pa
Stagnation Temperature	>200^{o}C
Heat Loss	<0.8W/ (m2^{o}C)
Maximum Strength	0.8MPa
Wind resistance	30m/s
Freezing resistance	-35 ^{o}C
Net weight	1.5-2.7Kg

2.3.2 The Water Tank

The water tank is placed on the top of the Heater. The main inlet is in the side of the tank. The cold water comes into the tank through this inlet. There are two more inlet points at the top of the tank. One of these inlets is to be used as the pressure outlet. The other can be used for any other purpose like inserting temperature sensor or water level detector probes etc. The main water outlet is in the lower surface of the tank.

2.3.3 Working Principle

The working principle of the Solar Water Heater is based on the rules of closed loop Thermosyphone system. Thermosyphon refers to a method of passive heat exchange based on natural convection which circulates liquid without the necessity of a mechanical pump. In this case, the cold water comes and stored in the water tank. This water is circulated through the solar collector tubes. When these tubes are exposed to sun rays then they absorb heat and get heated internally. The water flowing through the tubes gets hot also. As the hot water has less density than the cold water, the hot water goes up to the water tank and cold water from the water tank comes down flowing through the evacuated tubes and this process goes on until all the water gets hot enough.

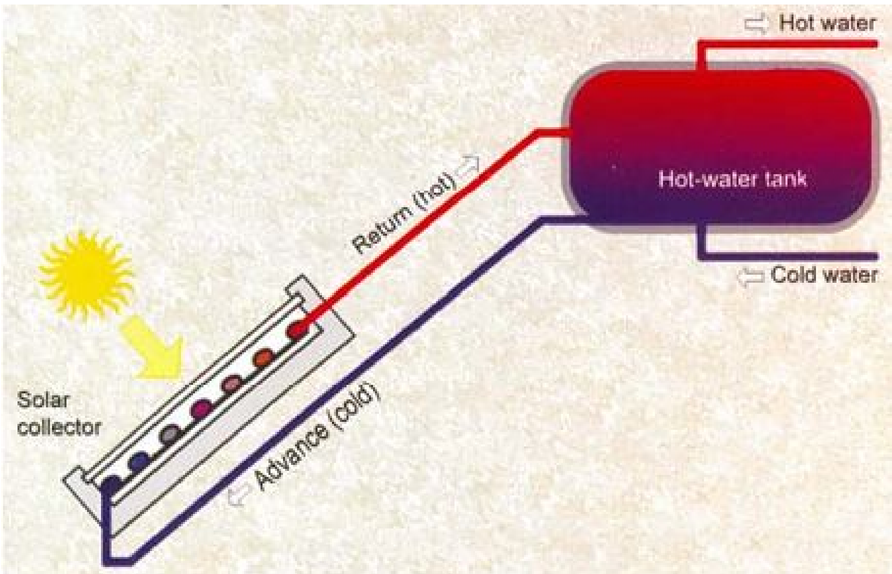


Figure 2.4 : working proncíple of Solar Water Heater

2.4 Hot Water Storage Tank

The Hot Water Storage Tank is the second most important and expensive material of the Solar Hot Water System. It's a special integrated water tank which is capable of keeping water without changing the temperature for maximum three days or 72 hours. This heat preservation is done mechanically without any power consumption. There would be multiple layers of heat insulation in the tank. There are many types of hot water storage tanks. But unfortunately we could manage none for its unavailability in Bangladesh. So we had to come up with another idea.

The water tank that comes with an evacuated tube solar water heater is actually an integrated thermal storage tank which has the capacity of preserving the water temperature for almost 72 hours. This naturally gives us the advantage to use the tank separately as the thermal storage tank. But the tank could not be separated from the collector tubes for its remaining holes. So we bought a 300 Liter capacitive evacuated tube solar water heater and thermally insulated the collector tubes with a layer of Asbestos wrapped up by Aluminum foil. That is how we got a Hot Water Storage Tank.

Figure 2.5 : 300 liter solar water heater with insulated collector on the roof top of BRAC University

2.4.1 Inner structure of the water tank

The water tank has a several layers of thermal insulation inside the tank.

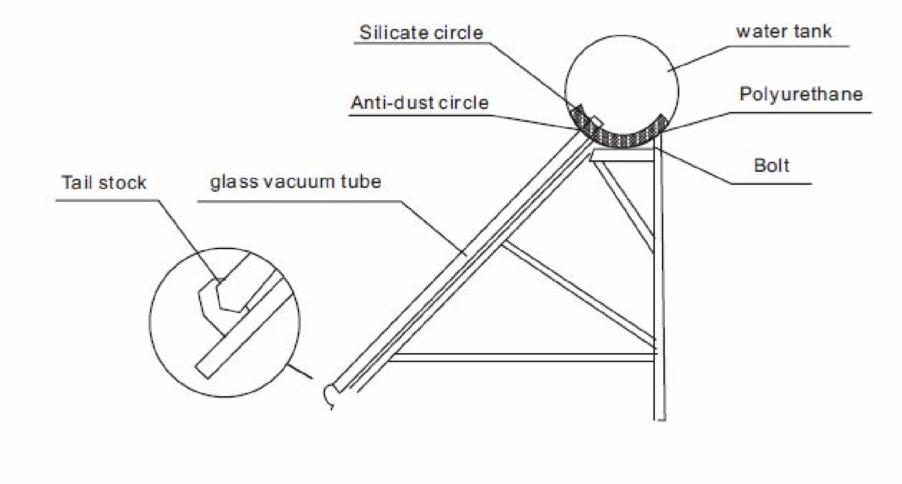


Figure 2.6 : Inner structure of the hot water tank

Silicate circle: It is used to improve the performance of cathodic protection systems used in water heater tanks, this silicate coatings also prevent complete deactivation of the anode by oxides, and bacterial interactions which generate objectionable odors and silicate coatings also reduce anode usage by increasing its electrochemical efficiency which then allows less metal or lower cost alloys to be used for tank protection.

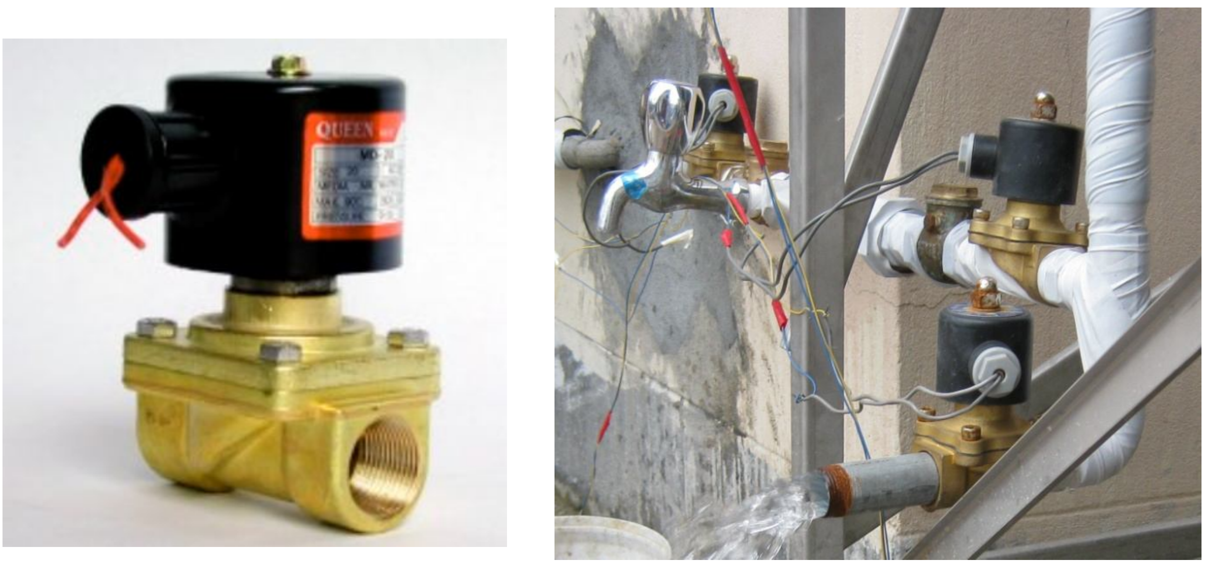
Polyurethane: Polyurethane is a unique material that offers the elasticity of rubber combined with the toughness and durability of metal. Polyurethanes have better abrasion and tear resistance than rubbers, while offering higher load bearing capacity. Compared to plastics, urethanes offer superior impact resistance, while offering excellent wear properties and elastic memory. Tear-strength ranges between 500-100 Ibs./linear inch, which is far superior to rubbers. Polyurethane has outstanding resistance to oxygen, ozone, sunlight and general weather conditions.

Anti-dust circle:

We use The anti-dust circles into the manifold holes so that after the vacuum tubes are inserted, they have a good sealing effect.

2.5 Electromagnetic Valve

An Electromagnetic Valve is an electromechanical device which allows for an electrical device to control the flow of a gas or liquid. The valve is also called Solenoid Valve. The valve is controlled by an electric current through a solenoid coil. This current flow in turn results in a magnetic field which causes the displacement of a metal actuator. This actuator is mechanically linked to a valve inside the solenoid valve. The valve then changes state, either opening or closing to allow a liquid or gas to either flow through it. A spring is used to return the actuator and valve back to their resting state when the current flow is removed.



(a) (b)

Figure 2.7 : a) 1.5 inches Electromagnetic Valve, b) Electromagnetic Valves installed in the system at the rooftop of BRAC University

2.5.1 Specification

Operating Mode	Normally Closed
Orifice Size	1.5 Inches
Body	Stainless Steel
Operating Voltage	24 volt DC

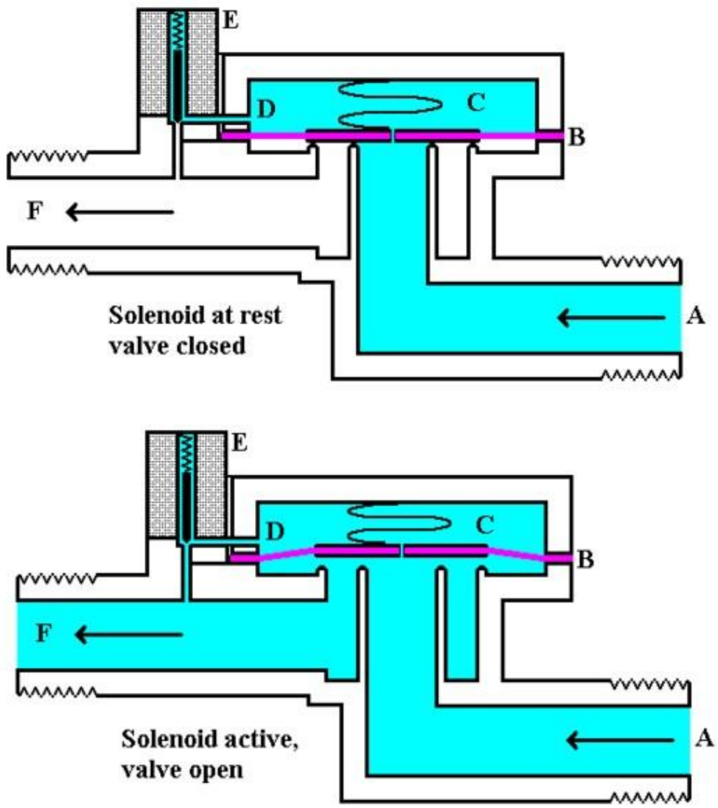
Voltage Tolerance	+10% to -15% of applicable voltage
Temperature Rating	Fluid Temperature : -50^o C to 150^o C
Maximum Operating Pressure	150 PSI (for water)
Power Consumption	9 Watt

2.5.2 Working Principle

A solenoid valve has two main parts: the solenoid and the valve. The solenoid converts electrical energy into mechanical energy which, in turn, opens or closes the valve mechanically. A *direct acting* valve has only a small flow circuit, shown within section E of this diagram (this section is mentioned below as a pilot valve). This *diaphragm piloted valve* multiplies this small flow by using it to control the flow through a much larger orifice.

Solenoid valves may use metal seals or rubber seals, and may also have electrical interfaces to allow for easy control. A spring may be used to hold the valve opened or closed while the valve is not activated.

The diagram to the right shows the design of a basic valve. At the top figure is the valve in its closed state. The water under pressure enters at **A**. **B** is an elastic diaphragm and above it is a weak spring pushing it down. The function of this spring is irrelevant for now as the valve would stay closed even without it. The diaphragm has a pinhole through its center which allows a very small amount of water to flow through it. This water fills the cavity **C** on the other side of the diaphragm so that pressure is equal on both sides of the diaphragm. While the pressure is the same on both sides of the diaphragm, the force is greater on the upper side which forces the valve shut against the incoming pressure. In the figure, the surface being acted upon is greater on the upper side which results in greater force. On the upper side the pressure is acting on the entire surface of the diaphragm while on the lower side it is only acting on the incoming pipe. These results in the valve being securely shut to any flow and, the greater the input pressure, the greater the shutting force will be.



A- Input side
B- Diaphragm
C- Pressure chamber
D- Pressure relief conduit
E- Solenoid
F- Output side

Figure 2.8 : Internal Mechanism of an Electromagnetic/Solenoid Valve

In the previous configuration the small conduit **D** was blocked by a pin which is the armature of the solenoid **E** and which is pushed down by a spring. If the solenoid is activated by drawing the pin upwards via magnetic force from the solenoid current, the water in chamber **C** will flow through this conduit **D** to the output side of the valve. The pressure in chamber **C** will drop and the incoming pressure will lift the diaphragm thus opening the main valve. Water now flows directly from **A** to **F**.

When the solenoid is again deactivated and the conduit **D** is closed again, the spring needs very little force to push the diaphragm down again and the main valve closes. In practice there is often no separate spring, the elastomer diaphragm is moulded so that it functions as its own spring, preferring to be in the closed shape.

From this explanation it can be seen that this type of valve relies on a differential of pressure between input and output as the pressure at the input must always be greater than the pressure at the output for it to work. Should the pressure at the output, for any reason, rise above that of the input then the valve would open regardless of the state of the solenoid and pilot valve.

2.6 Electric Water Heater

The electric water heater acts as the backup hot water supplier of our system. When the solar hot water system fails to provide the supply of hot water then the user will get his/her required hot water from this electric heater. The heater comes along with a stainless steel water tank which can preserve 45 Liters of water. The heater operates at 220/240 volts AC voltage supply. The power consumption is 1200 watt. There is a thermostat from which we can set the temperature of water from 30^{o} Celsius to 80^{o} Celsius.

Figure 2.9 : The Electric Water Heater installed on the roof top of BRAC University

2.6.1 Working Principle

An electric water heater has many parts that make it function. It contains a dip tube that allows cold water to enter the tank. A pipe allows hot water to flow out of the tank. A thermostat controls the water's temperature inside the tank. Heating elements heat up the water.

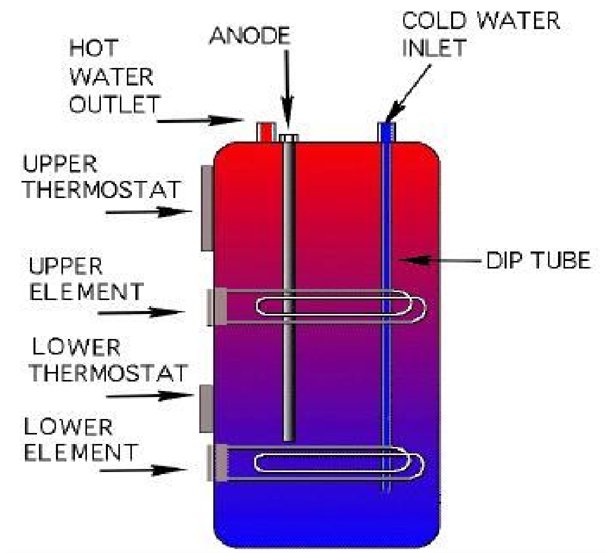


Figure 2.10 : Internal structure of an Electric Water Heater

Cold water enters the water heater's tank via a pipe connected to the house's water system. The water gets heated by the heating coil inside the tank. The thermostat controls the water temperature once it is inside the tank. When the water temperature rises up to the certain level then power gets off automatically so that the heating coil stops heating the water. The water heater is able to separate cold water from hot water. This happens when the cold water enters the tank. It automatically goes to the bottom of the tank, whereas the hot water rises because of its density.

2.7 Power Supply

For the purpose of our thesis we have used one power supply. The operating voltage is 115 volts or 220 volts AC. The device converts 220 volt AC to 24 DC. There are 3 pairs of output line

.

Figure 2.11 : 24 volt DC power supply used in our thesis

CHAPTER III
THE CONTROLLER

To automatically control the Alternative Hot Water System a embedded control system had to be developed. This control system detects several parameters like the water temperatures and the water levels of the Solar Water Heater and the Hot Water Storage Tank and takes decision whether the user will get water supply from the Solar Hot Water system or from the backup Electric Water Heater by turning on/off the Electromagnetic valves. Below the components and the design of the control system are described.

3.1 Microcontroller

The whole control system is operated by a microcontroller. This is the main part of the control system. A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers usually contain from several to dozens of general purpose input/output pins (GPIO). These pins are software configurable to either an input or an output state. When GPIO pins are configured to an input state, they are often used to read sensors or external signals. Configured to the output state, GPIO pins can drive external devices such as LED's or motors. There is an analog to digital converter (ADC) is installed with the microcontroller convert the incoming data into a form that the processor can recognize. The feature of digital-to-analog converter (DAC) is also available which allows the processor to output analog signals or voltage levels. The microcontroller also contains a timer device called Programmable Interval Timer (PIT). This timer is much useful to test or detect temperature periodically. A dedicated Pulse Width Modulation (PWM) block makes it possible for the microcontroller to control power converters, resistive loads, motors etc.

For the control system of our thesis we used AVR AT mega 32 Microcontroller.

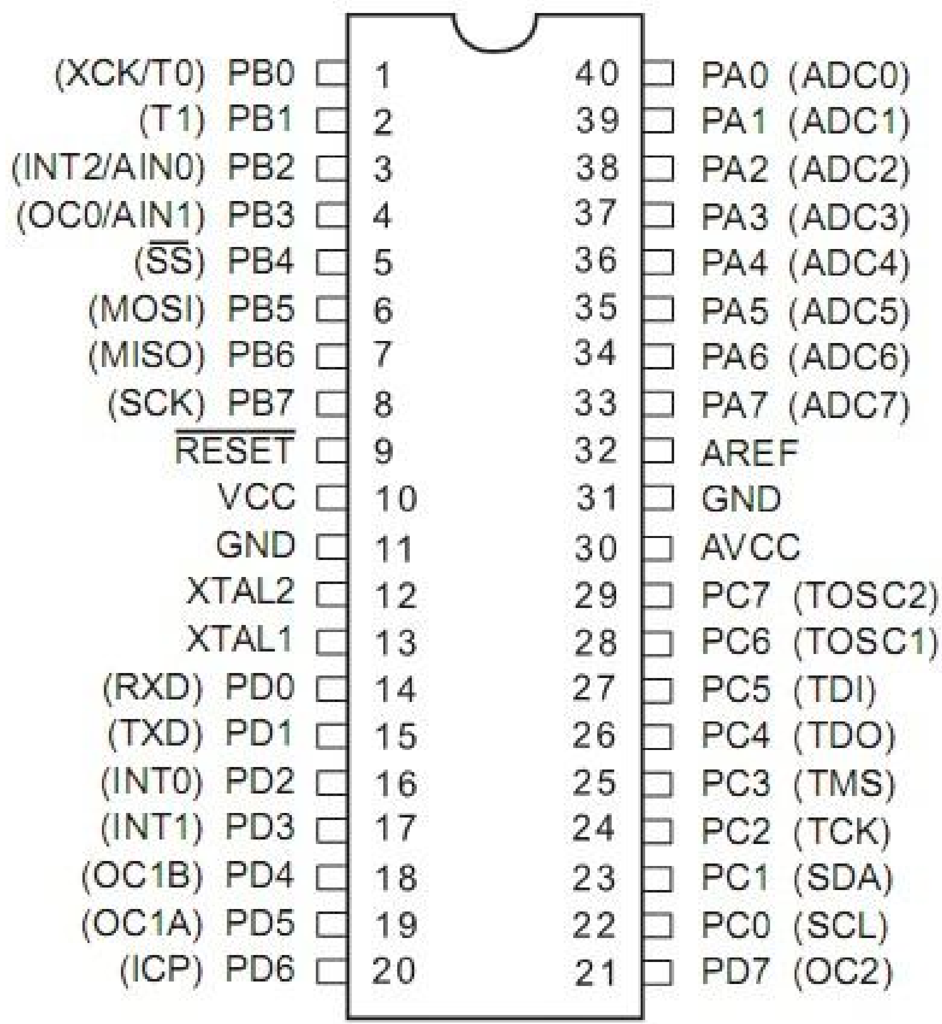


Figure 3.1 : Pin (input/output) configuration of AT mega 32

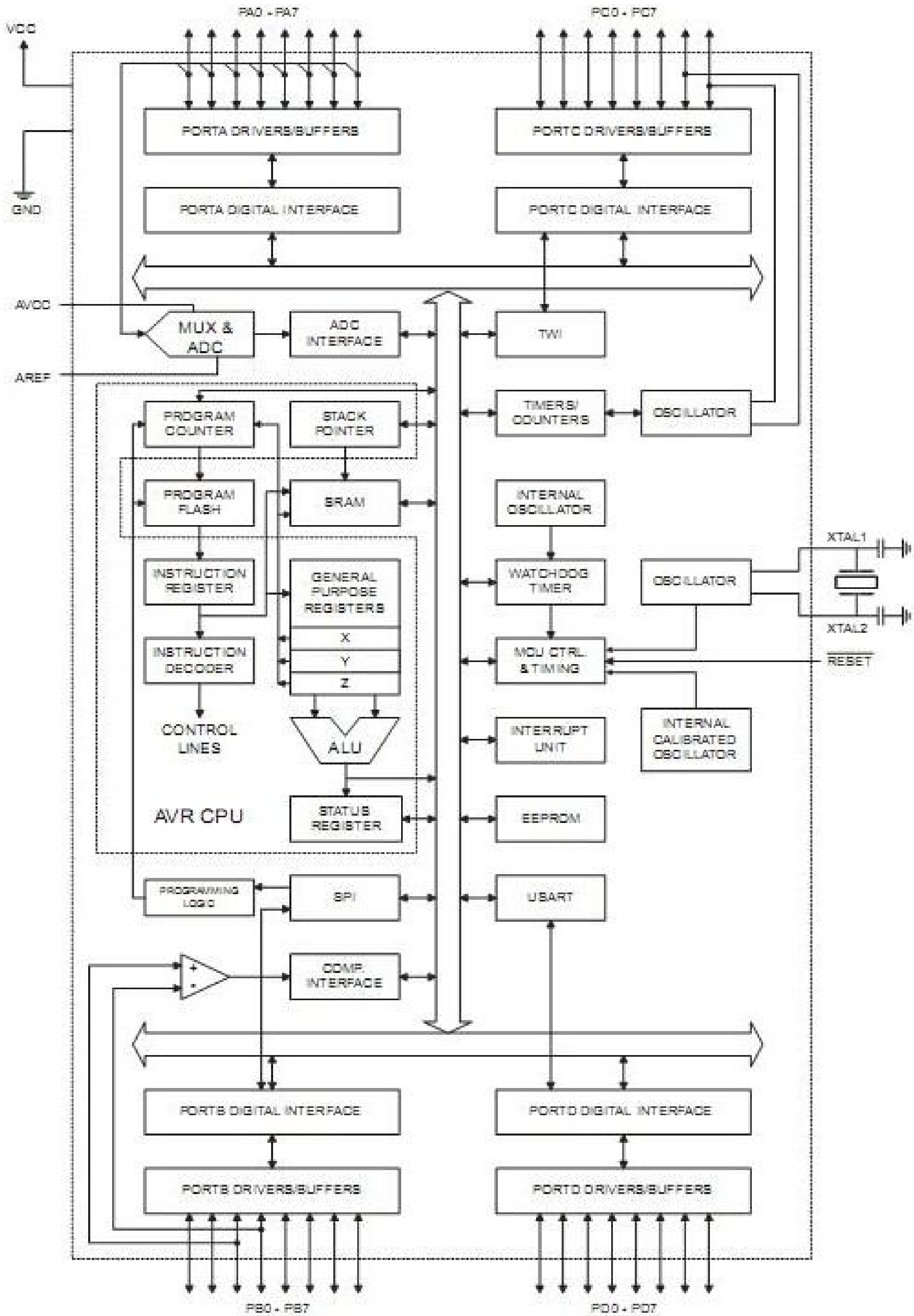


Figure 3.2 : Block diagram of an AVR AT mega 32 Microcontroller

3.2 Temperature Sensor

3.2.1 What is a Temperature Sensor?

A temperature sensor is a device that converts any temperature to a corresponding electric voltage signal. There are many types of temperature sensors available like Thermistor, Thermocouple, Silicon Bandgap Temperature Sensor, Resistance Temperature detector, Integrated Circuit Temperature Sensor etc. For our system we used LM35 which is an Integrated Circuit Temperature Sensor.

3.2.2 LM35 – General Description

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full -55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a -55° to +150°C temperature range.

Features

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy
- Rated for full -55° to +150°C range
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08°C in still air

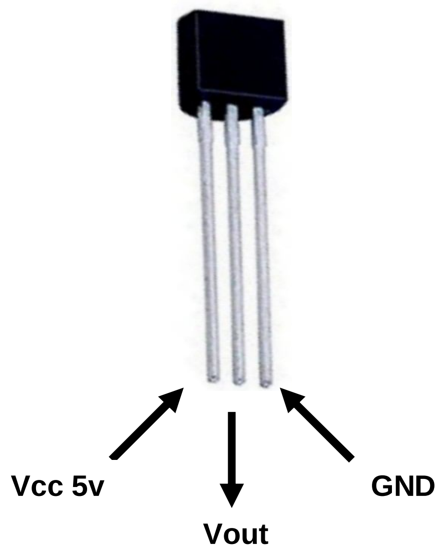


Figure 3.3 : LM35 temperature sensor

3.2.3 How to Measure Temperature by using LM35?

The method to measure temperature using LM35 is quite easy. The circuit should be designed like this –

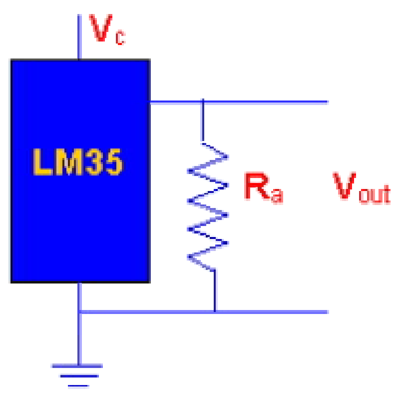


Figure 3.4 : Circuit design of LM35

In this circuit, V_c = 5 volt

$$R_a = V_c / 10^{-6}$$

Now the sensor has a sensitivity of 10 mV / ^oC.

So taking the conversion factor which is reciprocal is 100^o C / V.

So Temperature (in ^oC) = V_{out} * 100^o C / V.

So if the V_{out} is 1 volt then the temperature is 100^o C.

3.2.4 Insertion into the Water tank

To get the temperatures of the water of Solar Water Heater or the Hot Water Storage Tank we have to insert the sensor inside the tank so that the black head touches the water. So the sensor has to be inserted through one of the inlets on the tank all the way to the ground of the tank. The LM35 can be worked with water but the pins have to be insulated. Moreover it is risky to insert the electric probes into hot water and to keep them there for long time. So we have used a heat conductor metal tube whose one head is open and the other head is sealed. The tube's closed head is inserted into the tank through the inlet so that the tube head touches the ground of the tank. The tube is suchly positioned so that the other open head is out of the tank. Then the inlet is sealed so that no water can be come out due to overflow. The LM35 sensor is inserted into the metal tube through the open head so that the sensor head touches the tube's closed head from the inside. Whenever the water gets hot, the metal tube also gets hot according to same temperature and that temperature is detected by the sensor. Thus the sensor insertion problem is solved.

3.3 Water Level Detector

Water Level Detector is the device that let us know the level or height of the water inside the water tank. For the automated controlling purpose of the system, like the temperatures we have to know the filled and empty levels of water inside the Solar Water Heater Tank and the Hot Water Storage Tank. So we built a very simple circuit of water level detector. This circuit is useful to measure the water height unless it is corrosion free. The circuit is based on five transistor switches. Each transistor outputs a 5V voltage when its base is supplied with current through the water through the electric probes.

3.3.1 Design and Implementation

One electrode probe is (F) with 5V DC is placed at the bottom of tank. Next probes are placed step by step above the bottom probe. When water is rising the base of each transistor gets electrical connection to 5V DC through water and the corresponding probe. That in turn makes the transistors to conduct to give a 5 volt output that indicates the level of water. The ends of probes are connected to corresponding points in the circuit as shown in circuit diagram. Insulated Aluminum wires with end insulation removed will do for the probe. Arrange the probes in order on a PVC pipe according to the depth and immerse it in the tank.

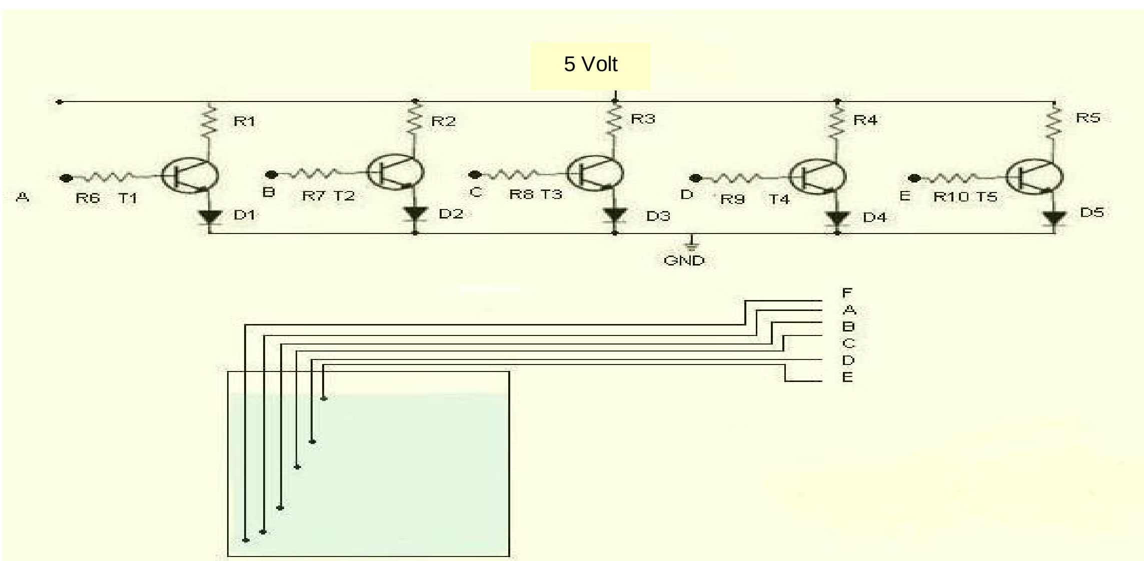


Figure 3.5 : Circuit Diagram of the Water Level Detector

3.4 The Design of the Control System

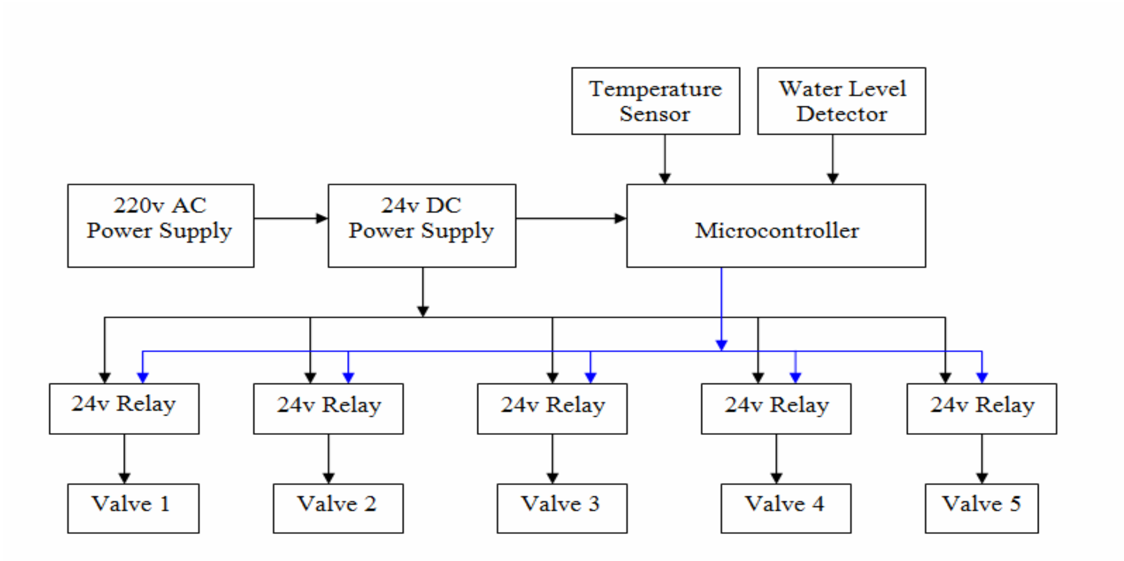


Figure 3.6 : Block Diagram of the Control System

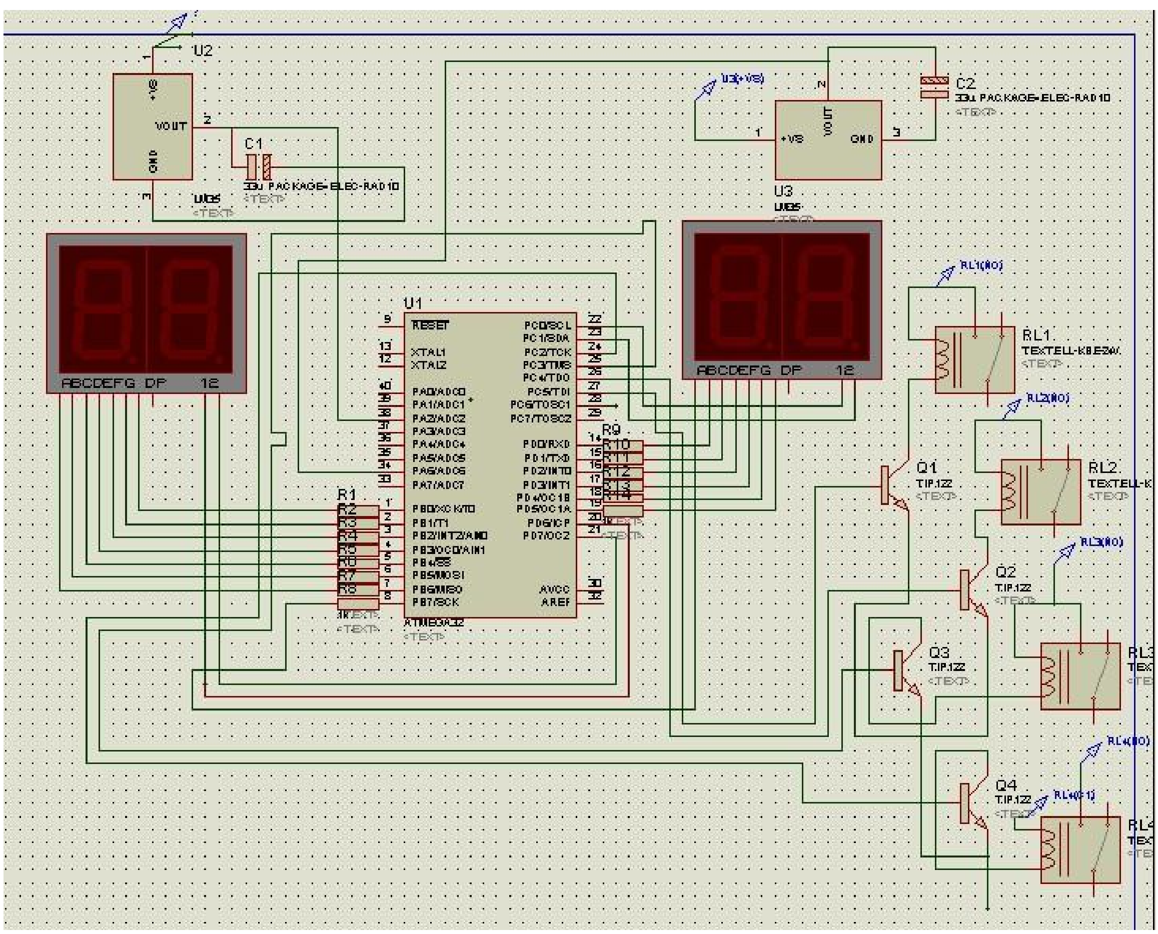


Figure 3.7 : the controller circuit diagram

CHAPTER IV

How the Alternative Solar Hot Water System Works

4.1 Preview of the Whole System

From the previous two chapters we came to know about the instrumentation of the Alternative Solar Water System. In this chapter we are going to know how the whole system works under automated controlling system and how it provides the supply of water of required temperature to the user.

From the flowchart of the system we can see that the Solar Water Heater and the Electric Water Heater is getting cold water from the main supply water tank. This water is kept in the tank of Solar Water Heater and gets hot with the help of it's collector. When the water is enough hot that means the temperature is equal to or above the required temperature then it is transferred to the Hot Water Storage Tank. The water transmission is controlled by a valve between the Solar Heater and the Storage Tank. The user gets hot water supply from the storage tank through another valve. If the water preserved in the Storage Tank gets cooler than the required temperature then this supply valve gets closed. This time the user gets hot water supply from the backup electric heater through another valve. Simultaneously another valve attached with the Storage Tank gets opened and the relatively cold water of the Storage Tank flows back to the main supply tank so that no water is wasted. All these valves are automatically operated by the controller system.

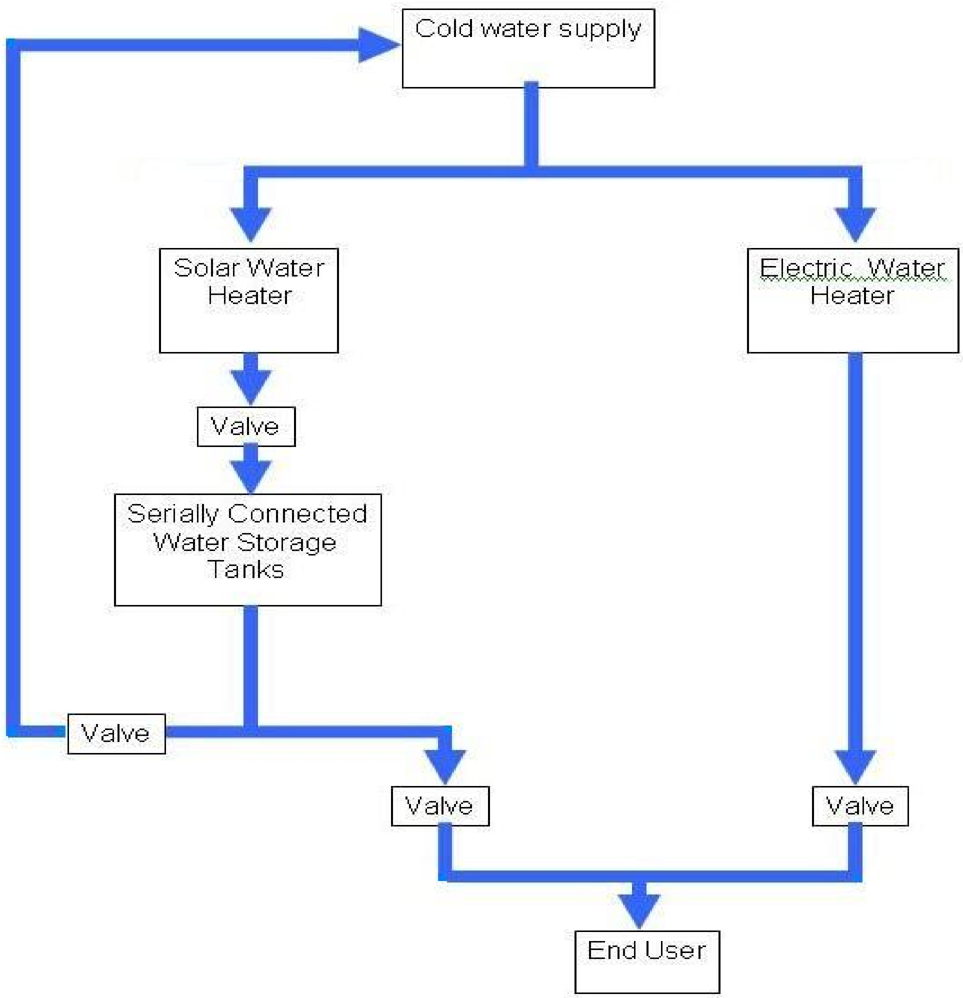


Figure 4.1 : Flowchart of the Alternative Hot Water System

From the flowchart of the system we can see that the Solar Water Heater and the Electric Water Heater is getting cold water from the main supply water tank. This water is kept in the tank of Solar Water Heater and gets hot with the help of it's collector. When the water is enough hot that means the temperature is equal to or above the required temperature then it is transferred to the Hot Water Storage Tank. The water transmission is controlled by a valve between the Solar Heater and the Storage Tank. The user gets hot water supply from the storage tank through another valve. If the water preserved in the Storage Tank gets cooler than the required temperature then this supply valve gets closed. This time the user gets hot water supply from the backup electric heater through another valve. Simultaneously another valve attached with the Storage Tank gets opened and the relatively cold water of the Storage Tank flows back to the main supply tank so that no water is wasted. All these valves are automatically operated by the controller system.

4.2 Controlling of the System

The controlling of the whole system is based on several conditions. These conditions are derived from some parameters. For this case the most important parameters are the water temperature of the Solar Water Heater (T1) and the water temperature of the Hot Water Storage Tank (T2). Lets assume for the system the user's required water temperature should be To Celsius.

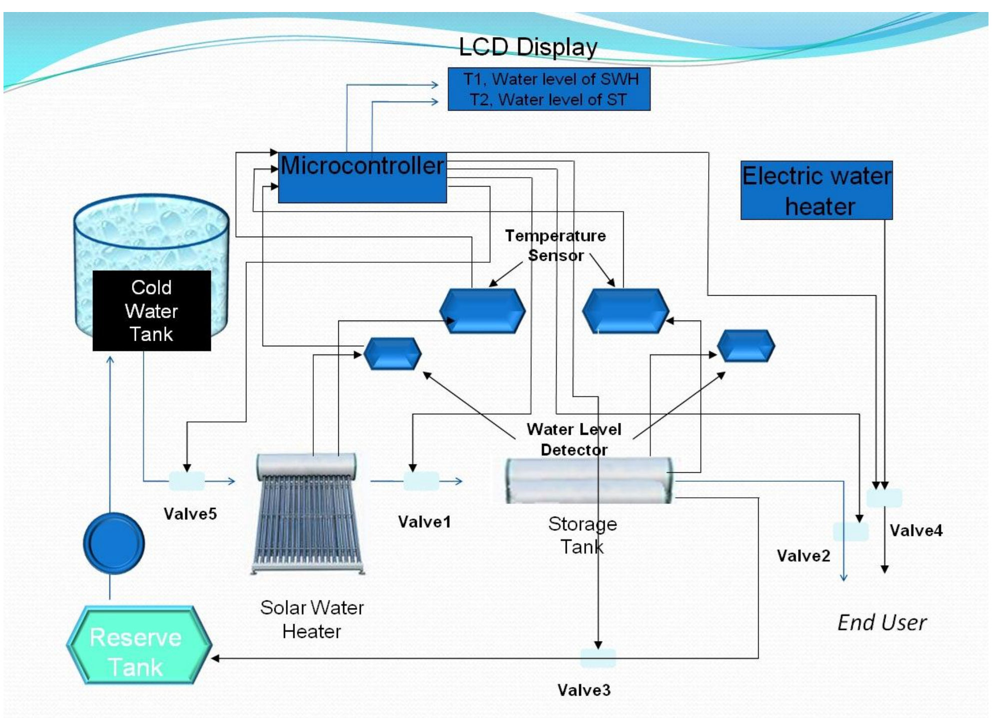


Figure 4.2 : Block diagram of the whole system

Condition 1 : If T1 and T2 both are less than T, then the Valve1 and Valve 2 both are closed and the Valve 3 and Valve 4 are open. For this configuration no water is transferred from Solar Water Heater to the Storage tank and the user gets hot water supply from the Electric Heater. If there is any cold water inside the storage tank then it will be drained out.

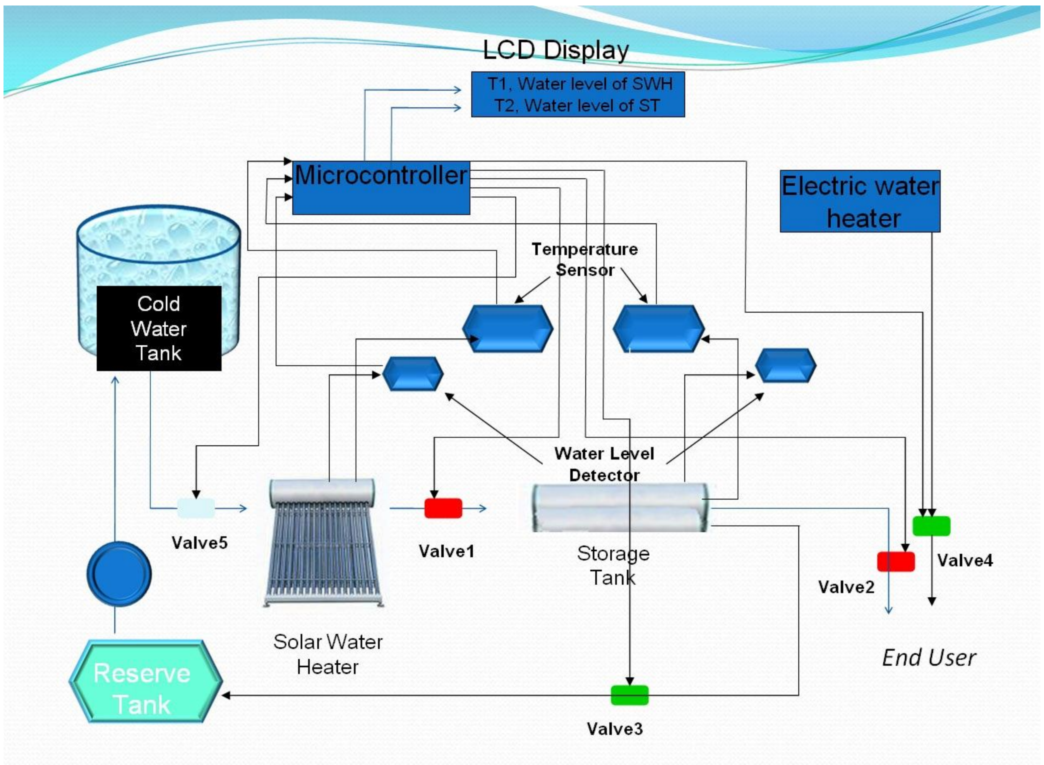


Figure 4.3 : Block diagram of condition 1 (T1<T, T2< T)

Condition 2 : If T1 is greater than T and T2 is less than T, then the Valve1 gets open while the Valve 2 remains closed. The Valve 3 and Valve 4 are also remain open. For this configuration hot water is transferred from Solar Water Heater to the Storage tank but the user gets hot water supply from the Electric Heater. If there is any cold water inside the storage tank then it will be drained out.

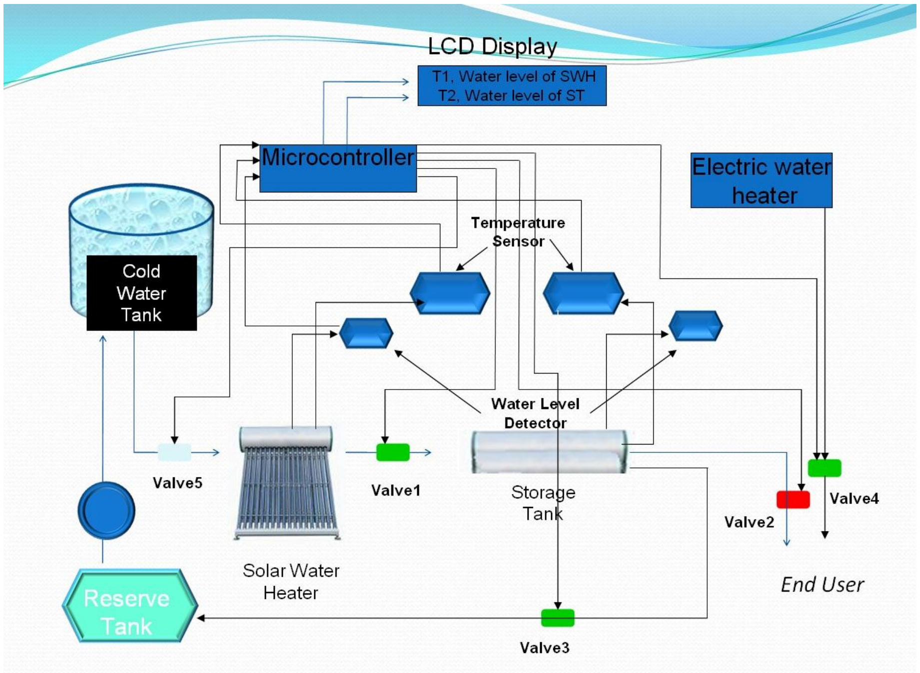


Figure 4.4 : Block diagram of condition 2 (T1>=T, T2< T)

Condition 3 : If T1 and T2 both are greater than T, then the Valve1 and Valve 2 both are open. This time the Valve 3 and Valve 4 get closed. In this case hot water is transferred from Solar Water Heater to the Storage tank and the user gets hot water supply from the Storage tank instead of Electric Heater. The drain path is also cold so that no water from the storage tank can be drained out.

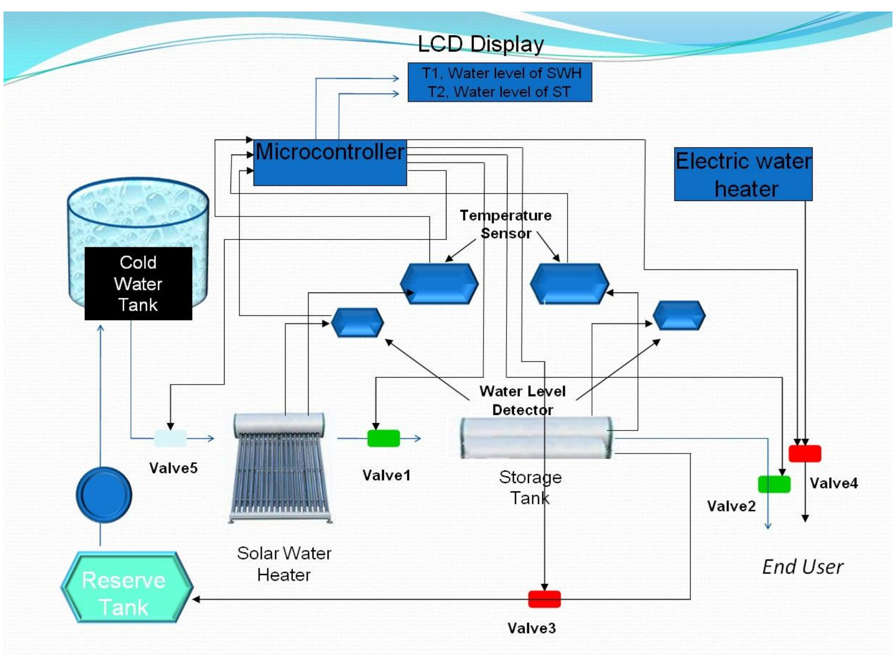


Figure 4.5 : Block diagram of condition 3 (T1>=T, T2>= T)

Condition 4 : If T1 is less than T but T2 is greater than T, then the Valve1 gets closed again while the Valve 2 remains open. This time the cold water from the Solar Heater can not be transferred to the Storage Tank. The user gets the supply from the Storage Tank as the Valve 3 and Valve 4 are closed. No water is drained out from the storage tank.

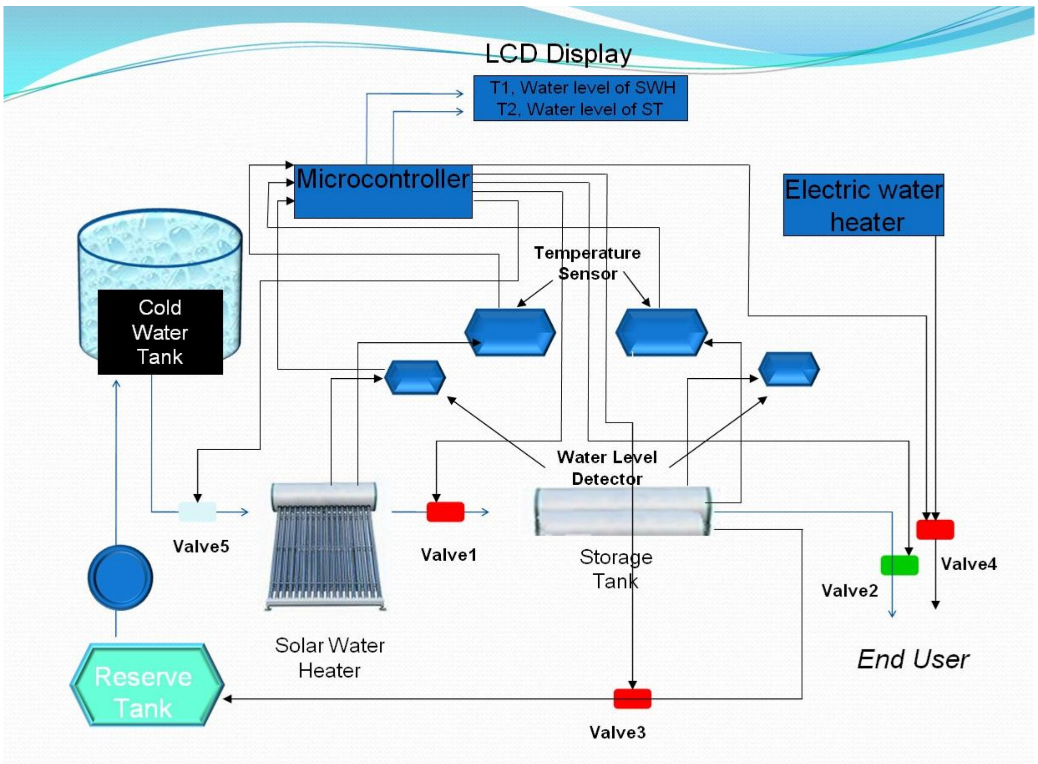


Figure 4.6 : Block diagram of condition 4 (T1<T, T2>= T)

Another condition is also applied here on the basis of the output of Water level Detector. There is another valve is attached between main cold water supply and the Solar Water Heater. When the Solar Heater Tank is empty only then this valve gets open and cold water fills up the Solar Heater tank. When the tank is full then the valve automatically gets off because we don't need to mix up cold water with the hot water inside.

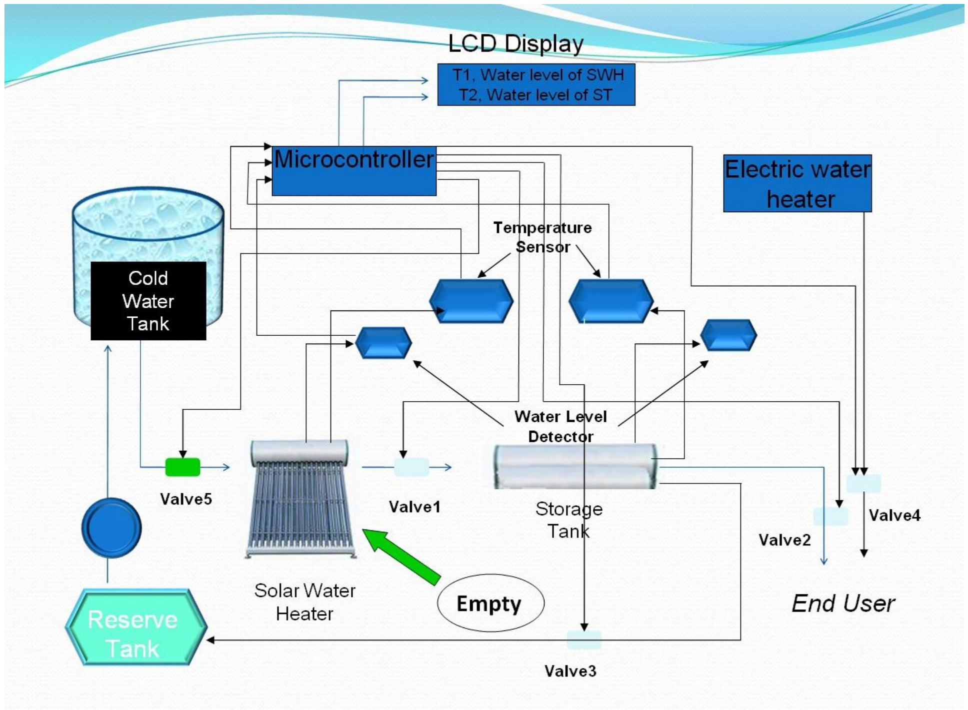


Figure 4.7 : Block diagram of condition 5 (when the Solar Water Heater tank is empty)

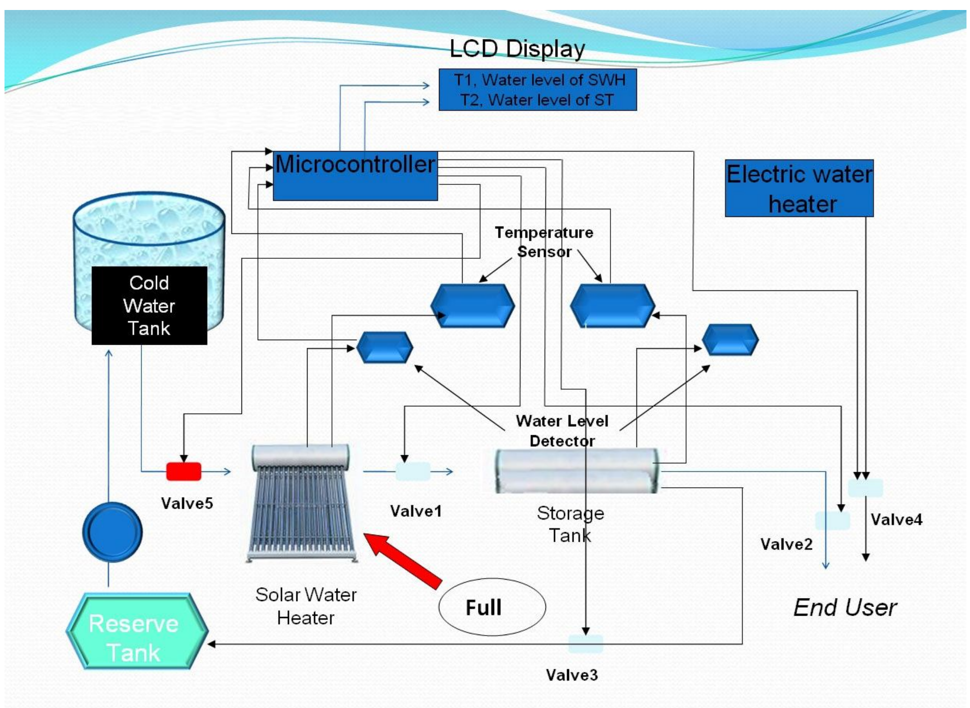


Figure 4.8 : Block diagram of condition 5 (when the Solar Water Heater tank is full)

The Programming Code of the total control system done in AVR studio is given below.

```
#include <avr/io.h>

#include<util/delay.h>


void Display(unsigned int in);

void Display1(unsigned int in1);


#define SEGMENT_DATA_DDR DDRB

#define SEGMENT_DATA_PORT PORTB


#define SEGMENT_CONTROL_DDR DDRD

#define SEGMENT_CONTROL_PORT PORTD


#define sbi(address,bit) (address |= (1<<bit));

#define cbi(address,bit) (address &=~ (1<<bit));


#define SEG1 cbi(PORTD,PD7) sbi(PORTD,PD6)

#define SEG2 cbi(PORTD,PD6) sbi(PORTD,PD7)


void delay_ms(unsigned int ms){


  while(ms){

   _delay_ms(1.000);

   ms--;

   }

}
```

```
void InitADC()
{
ADMUX =(1<<REFS0) | (1<<REFS1) ;                        // For Aref=AVcc;
ADCSRA=(1<<ADEN)|(1<<ADPS2)|(1<<ADPS1) | (1<<ADPS0); //Rrescalar div factor =128
}

uint16_t ReadADC(uint8_t ch)
{


  //Select ADC Channel ch must be 0-7
  ch=ch&0b00000111;
  ADMUX|=ch;

  //Start Single conversion
  ADCSRA|=(1<<ADSC);

  //Wait for conversion to complete
  while(!(ADCSRA & (1<<ADIF)));

  //Clear ADIF by writing one to it




  ADCSRA|=(1<<ADIF);

  return(ADC);
}
```

```
int main()
{

  SEGMENT_DATA_DDR=0xFF;
  SEGMENT_DATA_PORT=0x00;
  SEGMENT_CONTROL_DDR=0xFF;
  SEGMENT_CONTROL_PORT=0x00;
  DDRC=0xFF;
  PORTC=0x00;
  sbi(DDRD,PD0);
  sbi(DDRD,PD1);
  sbi(DDRD,PD2);
  sbi(DDRC,PC0);



  InitADC();

    unsigned int adc_val,adc_va;
    unsigned int temp1,temp3,temp4;
    unsigned int temp2,i;

    while(1)
    {
      InitADC();

    adc_val=ReadADC(2);
```

```
    adc_val=adc_val/3.5;



adc_va = ReadADC(6);
    adc_va =adc_va/3.5;



    if(adc_val<60 && adc_va<45){
        sbi(PORTC,PC2);
        sbi(PORTC,PC3);
          cbi(PORTC,PC4);
          cbi(PORTC,PC5);
          }

    if(adc_val<60 && adc_va>=45){
        sbi(PORTC,PC2);
        cbi(PORTC,PC3);
          sbi(PORTC,PC4);
          sbi(PORTC,PC5);
          }

    if(adc_val>=60 && adc_va<45){
        cbi(PORTC,PC2);
        sbi(PORTC,PC3);
          cbi(PORTC,PC4);
          cbi(PORTC,PC5);
          }

      if(adc_val>=60 && adc_va>=45){
```

```
   cbi(PORTC,PC2);
   cbi(PORTC,PC3);
    sbi(PORTC,PC4);
    sbi(PORTC,PC5);
    }

 temp3=adc_va%10;
adc_va=adc_va/10;
temp4=adc_va%10;


temp1=adc_val%10;
adc_val=adc_val/10;
temp2=adc_val%10;



for(i=0;i<1500;i++){

cbi(PORTC,PC0);
sbi(PORTC,PC1);
   Display1(temp3);

cbi(PORTD,PD6);
sbi(PORTD,PD7);
Display(temp1);

delay_ms(5);
```

```
      cbi(PORTC,PC1);
      sbi(PORTC,PC0);
      Display1(temp4);

      cbi(PORTD,PD7);
      sbi(PORTD,PD6);
      Display(temp2);
      delay_ms(5);

    }




    }
    return 0;
}


void Display(unsigned int in)
{

  switch(in){

      case 0:
              sbi(SEGMENT_DATA_PORT,0);
              sbi(SEGMENT_DATA_PORT,1);
```

```
        sbi(SEGMENT_DATA_PORT,2);
        sbi(SEGMENT_DATA_PORT,3);
        sbi(SEGMENT_DATA_PORT,4);
        sbi(SEGMENT_DATA_PORT,5);
        cbi(SEGMENT_DATA_PORT,6);
        break;

    case 1:
        cbi(SEGMENT_DATA_PORT,0);
        sbi(SEGMENT_DATA_PORT,1);
        sbi(SEGMENT_DATA_PORT,2);
        cbi(SEGMENT_DATA_PORT,3);
        cbi(SEGMENT_DATA_PORT,4);
        cbi(SEGMENT_DATA_PORT,5);
        cbi(SEGMENT_DATA_PORT,6);
        break;

    case 2:
        sbi(SEGMENT_DATA_PORT,0);
        sbi(SEGMENT_DATA_PORT,1);
        cbi(SEGMENT_DATA_PORT,2);
        sbi(SEGMENT_DATA_PORT,3);
        sbi(SEGMENT_DATA_PORT,4);
        cbi(SEGMENT_DATA_PORT,5);
        sbi(SEGMENT_DATA_PORT,6);
        break;

    case 3:
        sbi(SEGMENT_DATA_PORT,0);
```

```
        sbi(SEGMENT_DATA_PORT,1);
        sbi(SEGMENT_DATA_PORT,2);
        sbi(SEGMENT_DATA_PORT,3);
        cbi(SEGMENT_DATA_PORT,4);
        cbi(SEGMENT_DATA_PORT,5);
        sbi(SEGMENT_DATA_PORT,6);
        break;

case 4:
          cbi(SEGMENT_DATA_PORT,0);
        sbi(SEGMENT_DATA_PORT,1);
        sbi(SEGMENT_DATA_PORT,2);
        cbi(SEGMENT_DATA_PORT,3);
        cbi(SEGMENT_DATA_PORT,4);
        sbi(SEGMENT_DATA_PORT,5);
        sbi(SEGMENT_DATA_PORT,6);
        break;

case 5:

             sbi(SEGMENT_DATA_PORT,0);
        cbi(SEGMENT_DATA_PORT,1);
        sbi(SEGMENT_DATA_PORT,2);
        sbi(SEGMENT_DATA_PORT,3);
        cbi(SEGMENT_DATA_PORT,4);
        sbi(SEGMENT_DATA_PORT,5);
        sbi(SEGMENT_DATA_PORT,6);
        break;
```

```
case 6:

        cbi(SEGMENT_DATA_PORT,0);
    cbi(SEGMENT_DATA_PORT,1);
    sbi(SEGMENT_DATA_PORT,2);
    sbi(SEGMENT_DATA_PORT,3);
    sbi(SEGMENT_DATA_PORT,4);
    sbi(SEGMENT_DATA_PORT,5);
    sbi(SEGMENT_DATA_PORT,6);
    break;

case 7:

        sbi(SEGMENT_DATA_PORT,0);
    sbi(SEGMENT_DATA_PORT,1);
    sbi(SEGMENT_DATA_PORT,2);
    cbi(SEGMENT_DATA_PORT,3);
    cbi(SEGMENT_DATA_PORT,4);
    cbi(SEGMENT_DATA_PORT,5);
    cbi(SEGMENT_DATA_PORT,6);
    break;
case 8:
    sbi(SEGMENT_DATA_PORT,0);
    sbi(SEGMENT_DATA_PORT,1);
    sbi(SEGMENT_DATA_PORT,2);
    sbi(SEGMENT_DATA_PORT,3);
    sbi(SEGMENT_DATA_PORT,4);
    sbi(SEGMENT_DATA_PORT,5);
    sbi(SEGMENT_DATA_PORT,6);
```

```
            break;

    case 9:

          sbi(SEGMENT_DATA_PORT,0);
            sbi(SEGMENT_DATA_PORT,1);
            sbi(SEGMENT_DATA_PORT,2);
            cbi(SEGMENT_DATA_PORT,3);
            cbi(SEGMENT_DATA_PORT,4);
            sbi(SEGMENT_DATA_PORT,5);
            sbi(SEGMENT_DATA_PORT,6);
            break;

    }

}




///////////////////

//////////////////

void Display1(unsigned int in1)
{

  switch(in1){

     case 0:
```

```
        sbi(PORTB,7);
        sbi(PORTD,0);
        sbi(PORTD,1);
        sbi(PORTD,2);
        sbi(PORTD,3);
        sbi(PORTD,4);
        cbi(PORTD,5);
        break;

    case 1:
        cbi(PORTB,7);
        sbi(PORTD,0);
        sbi(PORTD,1);
        cbi(PORTD,2);
        cbi(PORTD,3);
        cbi(PORTD,4);
        cbi(PORTD,5);
        break;

    case 2:
        sbi(PORTB,7);
        sbi(PORTD,0);
        cbi(PORTD,1);
        sbi(PORTD,2);
        sbi(PORTD,3);
        cbi(PORTD,4);
        sbi(PORTD,5);
        break;
```

```
case 3:
    sbi(PORTB,7);
    sbi(PORTD,0);
    sbi(PORTD,1);
    sbi(PORTD,2);
    cbi(PORTD,3);
    cbi(PORTD,4);
    sbi(PORTD,5);
    break;

case 4:
     cbi(PORTB,7);
    sbi(PORTD,0);
    sbi(PORTD,1);
    cbi(PORTD,2);
    cbi(PORTD,3);
    sbi(PORTD,4);
    sbi(PORTD,5);
    break;

case 5:

       sbi(PORTB,7);
    cbi(PORTD,0);
    sbi(PORTD,1);
    sbi(PORTD,2);
    cbi(PORTD,3);
    sbi(PORTD,4);
    sbi(PORTD,5);
```

```
        break;

    case 6:

            cbi(PORTB,7);
        cbi(PORTD,0);
        sbi(PORTD,1);
        sbi(PORTD,2);
        sbi(PORTD,3);
        sbi(PORTD,4);
        sbi(PORTD,5);
        break;

    case 7:
            sbi(PORTB,7);
        sbi(PORTD,0);
        sbi(PORTD,1);
        cbi(PORTD,2);
        cbi(PORTD,3);
        cbi(PORTD,4);
        cbi(PORTD,5);
        break;
case 8:
        sbi(PORTB,7);
        sbi(PORTD,0);
        sbi(PORTD,1);
        sbi(PORTD,2);
        sbi(PORTD,3);
        sbi(PORTD,4);
```

```
        sbi(PORTD,5);
        break;

    case 9:
            sbi(PORTB,7);
        sbi(PORTD,0);
        sbi(PORTD,1);
        cbi(PORTD,2);
        cbi(PORTD,3);
        sbi(PORTD,4);
        sbi(PORTD,5);
        break;
    }
}
```

CHAPTER V
System Analysis

5.1 Performance of Solar Water Heater

The Alternative Solar Hot Water System is developed on the basis of the Solar Water Heater. So the achievement of the system highly depends on the performance of the Solar Water Heater. The performance of the solar water heater again depends entirely on the condition of the weather. If it is a hot sunny day then of course we would have an expected performance while in gloomy days we have to be waiting for the sun. Through the entire thesis work we have taken the temperature data for a lot of days including hot, average and gloomy or rainy days. Some of them are provided here to see the performance of solar water heater.

Datasheet – Temperature reading of Solar Water Heater

08 July 2010 – Thursday (A sunny day)

Time	Temperature (^{o}C)	Weather Condition
10:00 A.M	37	Fully Sunny
10:30 A.M	40	Fully Sunny
11:00 A.M	44	Fully Sunny
11:30 A.M	47	Fully Sunny
12:00 P.M	50	Fully Sunny
12:30 P.M	55	Fully Sunny
1:00 P.M	61	Fully Sunny
1:30 P.M	67	Fully Sunny
2:00 P.M	71	Fully Sunny
2:30 P.M	74	Fully Sunny
3:00 P.M	77	Fully Sunny
3:30 P.M	81	Fully Sunny
4:00 P.M	82	Sunny

Table 5.1 : Temperature datasheet of solar water heater (08/07/2010)

23 June – Wednesday (An average day)

Time	Temperature (^{o}C)	Weather Condition
10:00 A.M	33	Rainy
10:30 A.M	33	Cloudy
11:00 A.M	33	Cloudy
11:30 A.M	38	Sunny

12:00 P.M	43	Fully Sunny
12:30 P.M	45	cloudy
1:00 P.M	46	cloudy
1:30 P.M	47	cloudy
2:00 P.M	49	Sunny
2:30 P.M	52	Sunny
3:00 P.M	54	Sunny
3:30 P.M	56	Cloudy
4:00 P.M	62	Sunny

Table 5.2 : Temperature datasheet of solar water heater (23/06/2010)

14 July – Wednesday (A gloomy day)

Time	Temperature (^{o}C)	Weather Condition
10:00 A.M	33	Rainy
10:30 A.M	33	Rainy
11:00 A.M	35	Cloudy
11:30 A.M	36	Cloudy
12:00 P.M	40	Sunny
12:30 P.M	42	Sunny
1:00 P.M	43	Cloudy
1:30 P.M	45	Cloudy
2:00 P.M	47	Cloudy
2:30 P.M	49	Cloudy
3:00 P.M	51	Cloudy
3:30 P.M	52	Cloudy
4:00 P.M	54	Sunny

Table 5.3 : Temperature datasheet of solar water heater (14/07/2010)

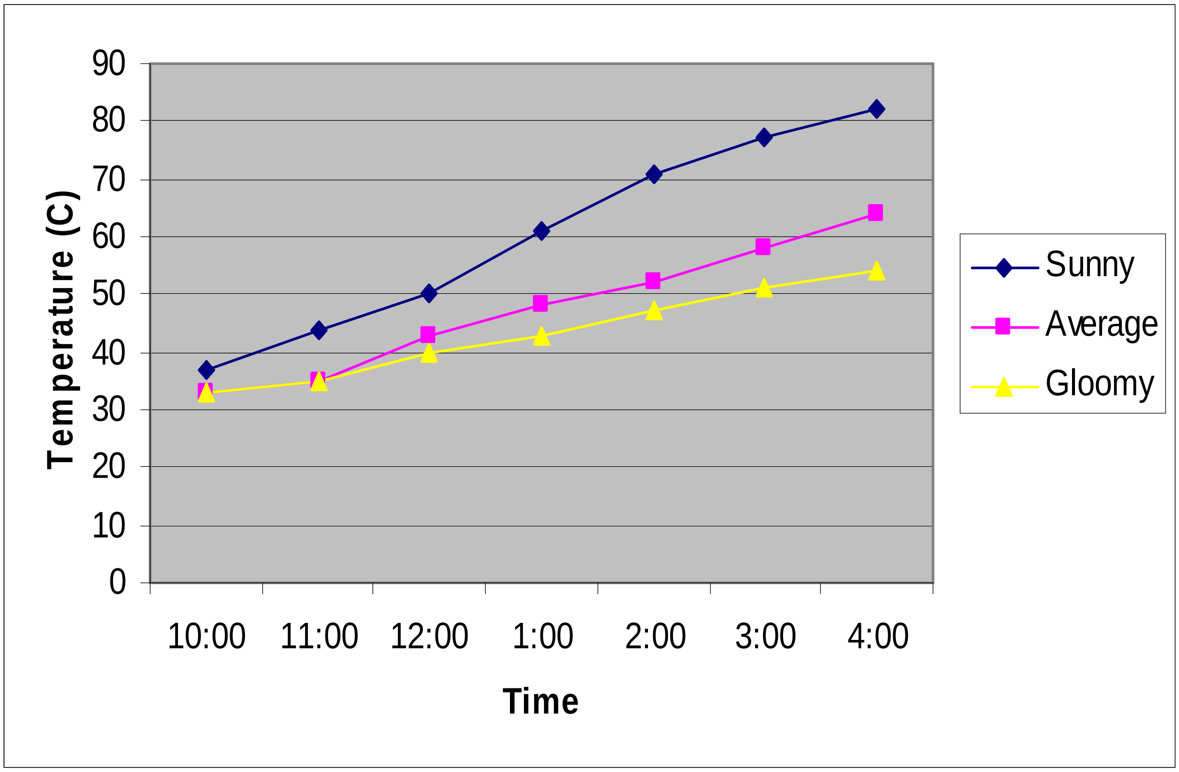


Figure 5.1 : Graph representation of temperature readings of solar water heater for a sunny, an average and a cloudy day

The above datasheets and the graph is showing that –

- The maximum temperature we got up to now is 82^{o} Celsius
- It takes 3 hours to raise the temperature up to 50^{o} Celsius from ambient temperature in average days
- At solar noon it takes only 2 hours
- So at sunny days the 150 Liter solar water heater can produce 300-450 Liters of water of 50^{o} Celsius or above
- If our required temperature is in between 50^{o} and 60^{o} Celsius then the solar water heater may provide at least 150 Liters of water each and everyday

5.2 Performance of the Hot Water Storage Tank

The hot water storage tank preserves the hot water for 72 hours without losing heat. So the efficiency of the alternative system is highly increased if these storage tanks perform well. The Storage tanks performance can be analyzed by the data below.

Datasheet – Temperature reading of Hot Water Storage Tank

Date	Temperature at 5:00 P.M (^oC)	Temperature on next day at 10:00A.M (^oC)	Temperature on 2^{nd} next day at 10:00 A.M (^oC)	Temperature on 3^{rd} next day at 10:00 A.M (^oC)
13.07.10	41	38	34	33
11.07.10	50	45	41	38
15.07.10	55	51	46	42
03.08.10	60	56	52	47
02.08.10	65	61	56	47

Table 5.4 : Temperature datasheet of hot water storage tank

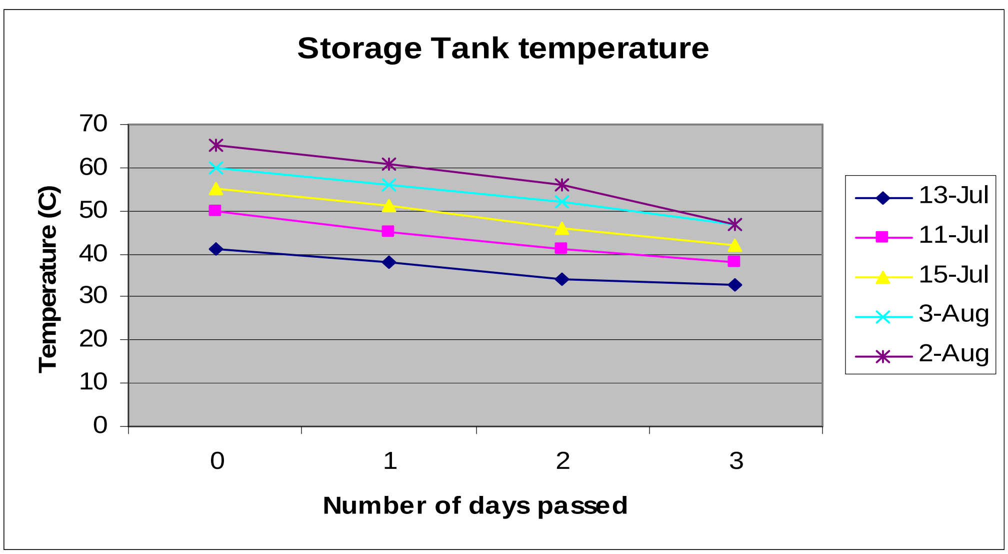


Figure 5.2 : Graph representation of storage tank temperature performance

5.3 Temperature sensor calibration

For the system we have implemented two temperature sensors. One for measuring the water temperature of the solar water heater and another for the hot water storage tank. The temperature sensor readings are calibrated by comparing with a normal thermometer reading.

Datasheet – Temperature sensor calibration

13 July 2010 – Tuesday

Time	Thermometer reading (^oC)		Sensor reading (^oC)		Weather condition
	Solar heater	Storage tank	Solar heater	Storage tank	
10:00	33	41	34	40	Rainy
11:00	35	41	36	40	Cloudy
12:00	40	41	41	40	Sunny
1:00	43	41	44	40	Cloudy
2:00	47	41	48	40	Cloudy
3:00	51	41	52	40	Cloudy
4:00	54	41	56	40	Sunny
5:00	54	41	56	40	Cloudy

Table 5.5 : datasheet for temperature sensor calibration

From the calibration we see that the sensors kept a constant 1 or 2 degree difference with the actual temperature. But there is a lot of fluctuation has been observed which is later corrected by…….

5.4 Electric Water Heater temperature calibration

<u>Datasheet – Electric Water Heater temperature calibration</u>

Set Temperature (^oC)	Actual Temperature (^oC)
30	38
40	44
50	54
60	66
70	72
80	82

Table 5.6 : Temperature calibration of the Electric water heater

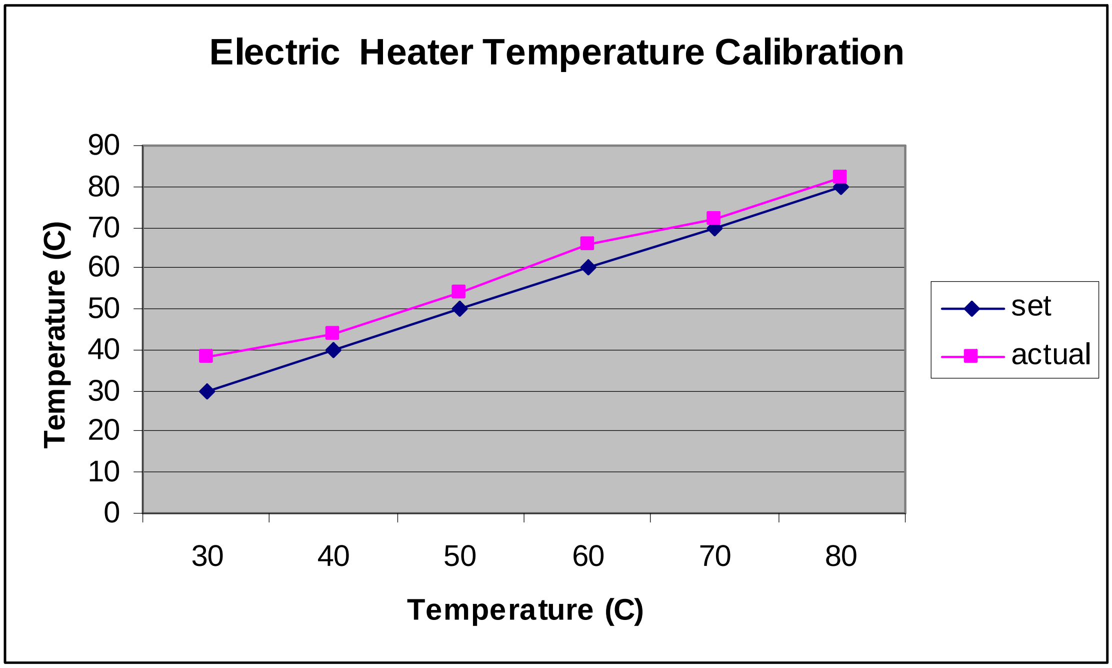


Figure 5.3 : Graph representation of electric water heater temperature calibration

5.5 Cost Analysis

Total cost of the system

1. Solar Water Heater = 30,000 tk.
2. Hot water storage tank = 50,000 tk
3. Elctromagnetic Valves (5 units) = 7,500 tk
4. Electric water heater = 7,000 tk
5. Power Supply = 1,800 tk
6. Miccrocontroller (2 units) = 900 tk
7. Temperature sensor LM35 (2 units) = 200 tk
8. LCD display = 250 tk
9. Plumbing and other circuitry cost = 10,000 tk
10. Storage tank insulation = 500 tk

Total cost = 1, 08,150 tk

Now We assume electric water heater works for 4 hours daily

Electric water heater consumes 4kW

According to PDB per unit electricity charge is Tk5.65

In case of Alternative Water Heater we assume the electric water heater is being used for 1 hour.

Description	EWH (24 hours)	SWH (Day time only)	Alternative WH(24 hours)
Electricity charge per day	Tk90.4	0	Tk22.6
Electricity charge per month	Tk2,712	0	Tk678
Electricity charge per year	Tk32,544	0	Tk8,136
Electricity charge for 15 year	Tk4,88160	0	Tk1,22040
Maintenance cost	Tk1000-2000	0	Tk1000-2000

Table 5.7 : Cost analysis of the system

The implementation cost of Alternative water heater is Tk1, 08,150

Money saving per month = (2,712 – 678) tk = 2,034 tk

Money saving per year = (2,034 * 12) tk = 24,408 tk

Total money saves in 15 years = (24,408* 15) tk = 3, 66,120 Tk.

The user will get the payback within = (1,08,150/24,408) tk = 4.43 years

Now if we compare the amount of money spend for Electric and Alternative water heater we can see within four years and five months the customer can get the payback.

User's Profit got from 15 years = (3,66,120 – 1,08150) tk = 2,57,970 tk

CHAPTER VI

CONCLUSION

6.1 Observation

From our thesis work we can come up with the following observations –

- The solar water heater should not be left with empty water tank exposed in the sun for consecutive 3 days or 72 hours. Because the vacuum tubes gets hot up to 150o Celsius and if the tank is empty then there is a high pressure is produced. For this reason the evacuated tubes can be broken.
- If we increase the capacity of solar water heater to 300 liters then the system could provide more hot water and will increase the efficiency.
- When we switch off and again switch on the power supply during the system working then the system starts malfunctioning as all the sensors give garbage values with fluctuation. This incident happens because of a back EMF flowing. This can be removed by using some zener diodes by reducing the back EMF flow.
- The open head of metal tube where the temperature sensor is inserted should be covered well so that rain water can not get inside.

These observations give us a clear picture of having an efficient and effective power consumption reducing solar hot water system.

6.2 Future Work

In future we have certain things to do with this system to make it more efficient and user friendly. These are –

- We are going to implement the circuitry on a PCB board to make it more sophisticated and effective for practical environment.
- We shall be testing our system by start functioning in the BRAC University.
- To measure the solar irradiance we shall install a pyranometer. This will help us to identify the operating optimum temperature for our system.
- We also may make the system more user friendly by implementing alarm buzzer and LED lamps indicators with the Electromagnetic valves.

And finally, we can hope that, it is not very far away when the Alternative Solar Hot Water System shall be using in large scale in the industrial as well as domestic sector to make sufficient use of solar energy to save our natural resources and to pull up pressure from our power sector and thus make our Bangladesh a more environmental and happier country.

LIST OF REFERENCE

- ✓ Solar Domestic Hot water-Numerical & Thermal Experimental study of the Thermal Stratification. A paper by-Dr. Chakib Kerkeni, Fethi Benjema
- ✓ Design & Application of Solar Water heater intelligent Control System. A paper by-Yu Gui Yan
- ✓ Water heating-http://en.wikipedia.org/wiki/Water_heating
- ✓ A Thesis Paper written by-Samara Sadrin, Mehrin from Brac University
- ✓ Demonstration of Solar Water Heating System in Bangladesh (UNDP supported) -http://www.reein.org/solar/thermal.htm

APPENDIX

Temperature Datasheets

24 June – Thursday

Time	Temperature of Solar Water Heater(150L)	Temperature of Storage Tank(300L)	Weather Condition
9:00 A.M	38^{o} Celsius	40^{o} Celsius	Full Sunny
9:30 A.M	44^{o} Celsius	38^{o} Celsius	Full Sunny
10:00 A.M	44^{o} Celsius	38^{o} Celsius	Full Sunny
10:30 A.M	46^{o} Celsius	39^{o} Celsius	Full Sunny
11:00 A.M	45^{o} Celsius	38^{o} Celsius	Sunny

***** Reading after mixing (150L water to 300L and new supply water to 150L)**

12:30 P.M	43^{o} Celsius	41^{o} Celsius	Full Sunny
1:00 P.M	46^{o} Celsius	42^{o} Celsius	Full Sunny
1:30 P.M	48^{o} Celsius	42^{o} Celsius	Full Sunny
2:00 P.M	56^{o} Celsius	42^{o} Celsius	Full Sunny
2:30 P.M	58^{o} Celsius	42^{o} Celsius	Full Sunny
3:00 P.M	60^{o} Celsius	42^{o} Celsius	Full Sunny
3:30 P.M	62^{o} Celsius	42^{o} Celsius	Full Sunny
4:00 P.M	62^{o} Celsius	42^{o} Celsius	Sunny and Cloudy
4:30 P.M	64^{o} Celsius	40^{o} Celsius	Sunny

23 June – Wednesday

Time	Temperature of Solar Water Heater(150L)	Temperature of Storage Tank(300L)	Weather Condition
9:00 A.M	34^o Celsius	35^o Celsius	Sunny
9:30 A.M	34^o Celsius	35^o Celsius	Rainy
10:00 A.M	33^o Celsius	35^o Celsius	Rainy
10:30 A.M	33^o Celsius	35^o Celsius	Sunny with Cloudy
11:00 A.M	33^o Celsius	35^o Celsius	Sunny with Cloudy
11:30 A.M	38^o Celsius	35^o Celsius	Full Sunny
12:00 P.M	43^o Celsius	35^o Celsius	Full Sunny
12:30 P.M	45^o Celsius	35^o Celsius	Sunny and Cloudy
1:00 P.M	46^o Celsius	35^o Celsius	Sunny and Cloudy
1:30 P.M	47^o Celsius	35^o Celsius	Sunny
2:00 P.M	49^o Celsius	36^o Celsius	Sunny
2:30 P.M	52^o Celsius	36^o Celsius	Sunny
3:00 P.M	54^o Celsius	36^o Celsius	Sunny
3:30 P.M	56^o Celsius	36^o Celsius	Sunny
4:00 P.M	62^o Celsius	42^o Celsius	Sunny and Cloudy

** After Mixing (150L water to 300L and new supply water to 150L)

4:30 A.M	34^o Celsius	41^o Celsius	Sunny

21 June – Monday

** Before insulating Storage tank Collector

Time	Temperature of Solar Water Heater(150L)	Temperature of Storage Tank(300L)	Weather Condition
12:30 P.M	63^o Celsius	61^o Celsius	Sunny
1:30 P.M	66^o Celsius	62^o Celsius	Sunny
2:30 P.M	68^o Celsius	70^o Celsius	Full Sunny
4:30 P.M	66^o Celsius	69^o Celsius	Sunny (with rain)

20 June – Sunday

Time	Temperature of Solar Water Heater(150L)	Temperature of Storage Tank(300L)	Weather Condition
12:30 P.M	52^o Celsius	58^o Celsius	Sunny With Cloud
4:00 P.M	58^o Celsius	60^o Celsius	Sunny With Cloud

16 June – Wednesday

** Before insulating Storage tank Collector

Time	Temperature of Solar Water Heater(150L)	Temperature of Storage Tank(300L)	Weather Condition
10:30 A.M	46^o Celsius	50^o Celsius	Cloudy
11:30 A.M	46^o Celsius	50^o Celsius	cloudy
12:30 P.M	46^o Celsius	50^o Celsius	cloudy
1:30 P.M	46^o Celsius	50^o Celsius	cloudy
2:30 P.M	46^o Celsius	50^o Celsius	Cloudy
3:30 P.M	46^o Celsius	50^o Celsius	Cloudy

11 July – Sunday

Time	Temperature of Solar Water Heater(150L)	Temperature of Storage Tank(300L)	Weather Condition
10:00 A.M	33^o Celsius	31^o Celsius	Sunny
10:30 A.M	35^o Celsius	32^o Celsius	Sunny
11:00 A.M	37^o Celsius	32^o Celsius	Cloudy
11:30 A.M	39^o Celsius	32^o Celsius	Cloudy
12:00 P.M	43^o Celsius	32^o Celsius	Sunny
12:30 P.M	48^o Celsius	32^o Celsius	Sunny
1:00 P.M	53^o Celsius	32^o Celsius	Sunny
1:30 P.M	56^o Celsius	32^o Celsius	Cloudy
2:00 P.M	59^o Celsius	32^o Celsius	Cloudy
2:30 P.M	62^o Celsius	32^o Celsius	Sunny
3:00 P.M	63^o Celsius	32^o Celsius	Sunny
3:30 P.M	64^o Celsius	32^o Celsius	Sunny

13 July – Tuesday

** Temperature reading from thermometer

Time	Temperature of Solar Water Heater(150L)	Temperature of Storage Tank(300L)	Weather Condition
10:00 A.M	45^o Celsius	44^o Celsius	Cloudy
10:30 A.M	45^o Celsius	44^o Celsius	Cloudy
11:00 A.M	46^o Celsius	44^o Celsius	Cloudy
11:30 A.M	46^o Celsius	44^o Celsius	Cloudy
12:00 P.M	46^o Celsius	44^o Celsius	Rainy
12:30 P.M	46^o Celsius	44^o Celsius	Rainy
1:00 P.M	46^o Celsius	44^o Celsius	Cloudy
1:30 P.M	46^o Celsius	44^o Celsius	Cloudy
2:00 P.M	47^o Celsius	44^o Celsius	Cloudy
2:30 P.M	48^o Celsius	44^o Celsius	Cloudy
3:00 P.M	49^o Celsius	44^o Celsius	Sunny

** Temperature reading from sensor

Time	Temperature of Solar Water Heater(150L)	Temperature of Storage Tank(300L)	Weather Condition
10:00 A.M	46^o Celsius	43^o Celsius	Cloudy
10:30 A.M	46^o Celsius	43^o Celsius	Cloudy
11:00 A.M	47^o Celsius	43^o Celsius	Cloudy
11:30 A.M	47^o Celsius	43^o Celsius	Cloudy
12:00 P.M	47^o Celsius	43^o Celsius	Rainy
12:30 P.M	47^o Celsius	43^o Celsius	Rainy
1:00 P.M	47^o Celsius	43^o Celsius	Cloudy
1:30 P.M	47^o Celsius	43^o Celsius	Cloudy
2:00 P.M	47^o Celsius	43^o Celsius	Cloudy
2:30 P.M	48^o Celsius	43^o Celsius	Cloudy
3:00 P.M	49^o Celsius	43^o Celsius	Sunny

14 July – Wednesday

Time	Temperature of Thermometer	Temperature of Sensor	Weather Condition
10:00 A.M	36^o Celsius	37^o Celsius	Sunny
11:00 A.M	41^o Celsius	43^o Celsius	Sunny
12:00 P.M	42^o Celsius	44^o Celsius	Cloudy
1:00 P.M	46^o Celsius	48^o Celsius	Sunny
2:00 P.M	50^o Celsius	52^o Celsius	Sunny
3:00 P.M	52^o Celsius	54^o Celsius	Cloudy
4:00 P.M	54^o Celsius	56^o Celsius	Cloudy
5:00 P.M	55^o Celsius	57^o Celsius	Cloudy

14 July – Wednesday

Time	Temperature of Sensor	Weather Condition
12:35 P.M	34^o Celsius	Fully Sunny
12:45 P.M	36^o Celsius	Fully Sunny
12:55 P.M	38^o Celsius	Fully Sunny
1:05 P.M	40^o Celsius	Fully Sunny
1:15 P.M	41^o Celsius	Fully Sunny
1:25 P.M	42^o Celsius	Sunny
1:35 P.M	44^o Celsius	Fully Sunny
1:45 P.M	44^o Celsius	Cloudy
1:55 A.M	45^o Celsius	Sunny
2:05 P.M	45^o Celsius	Cloudy
2:15 P.M	46^o Celsius	Cloudy
2:40 P.M	48^o Celsius	Cloudy
2:50 P.M	49^o Celsius	Cloudy
3:00 P.M	50^o Celsius	Cloudy
3:10 A.M	50^o Celsius	Cloudy
3:20 P.M	52^o Celsius	Cloudy
3:30 P.M	52^o Celsius	Cloudy
3:50 P.M	53^o Celsius	Cloudy
4:00 P.M	53^o Celsius	Cloudy
4:30 P.M	54^o Celsius	Cloudy