Lifting Water from Well Using Solar Energy Generator

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Abstract

Water-lifting systems are used especially in rural areas to lift water from a well. The common device used in these rural areas is electrical pump. The electrical pump has taken a high cost due to the implementation of the transmission and also people need to pay for the monthly electric bills. Therefore, there is a need for improving water lifting using cheap solar energy generator. The main focus of this project is to construct a solar energy water lifting system that is clean, provide no pollution, simple and convenient. Step by step approach is applied in this engineering project so that the solutions are based on every single criterion that has been studied. The solar water pump consists of photovoltaic (PV) panel, power storage, charge controller, water level detector and DC submersible water pump. Studies in these fields are needed in order to make sure that the project is successful. The major part focused in this project is to design the overall system and make sure that the prototype of the system is working. Results of the simulation and experiments are included in the Result & Discussion chapter. The report contains five main chapters, namely Introduction, Literature Review, Methodology, Result and Discussion and Conclusion.

Introduction

Water is in liquid form contains hydrogen and oxygen (H2O). Pure water is an odorless, tasteless and clear liquid. It is one of nature's most important gifts to mankind. It is important for the daily life usage such as drinking, bathing, washing and etc. One of the sources of getting the water is from water well.

Water well is structure created in the ground by digging, driving, boring or drilling in order to access underground water. Lifting devices using electrical pump or mechanical pump can be used to raise the water from the well. It can also be drawn up using containers, such as buckets that are raised mechanically or by hand. Well water typically contains more minerals in solution than surface water. There are three types of the water wells which are Dug wells, Driven wells and Drilled well [1].

Dug wells are holes in the ground dug by shovel. In the developing countries, dug well uses hand pumped to lift water. But historically, a dug well was digging out below the groundwater table until incoming water exceeded the digger's bailing rate. Driven wells usually located in areas with thick sand and gravel deposits where the ground water table is within 15 feet of the ground's surface and typically 30 to 50 feet deep. Lastly, the Drilled wells can get water from a much deeper level (range from 20 to 600 feet) by mechanical drilling. Drilled wells with electrical pumps are currently used throughout the world [2].

Solar and wind energy is also used nowadays to generate electricity which supply energy to an electric pump to lift water. Solar generator is a device that generates the electrical power when the sunlight strikes the PV panel. PV cell is

made up of two thin layers of a semi-conductor material appropriately doped with impurity atoms. When sunlight strikes the PV panel, the voltage will be producing. Most of the PV panel is made up from the silicon [3]. Details of the PV cell will be discussing later in Literature Review.

Methodology

At the early stage of this project, a step-by-step approach has been planned in order to complete the task. The project flow is shown in Figure 1 below:-

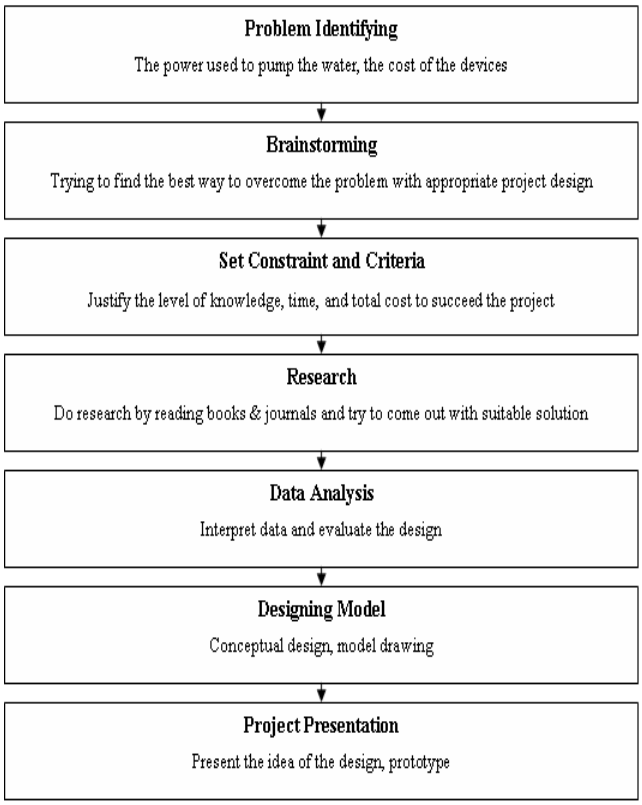

Figure 1: Design Approach

Figure 2 shows the process flow of the system:-

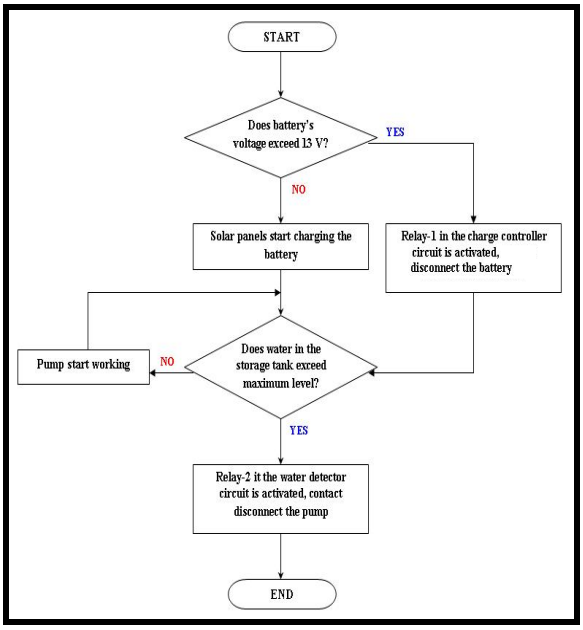

Figure 2: Process flow

The overall system is shown in Figure 3. The solar water pump consists of PV panel, charge controller, battery, water level detector and the DC water pump.

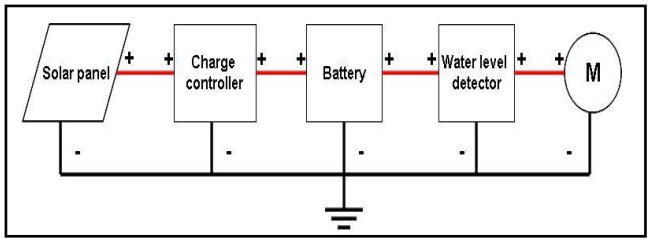

Figure 3: Block diagram of the overall system

In this system, voltage indicator circuit is used as a charge controller. The main component in the voltage indicator circuit is the LM3914 IC. The LM3914 IC is a small integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. Each LED indicates voltage level of the battery range from 10V to 14.5V.

Modification of the voltage indicator circuit is made with the additions of relay and diodes. The solar panel in the system is connected with the blocking diode. It is because

the system includes a battery storage system where a reverse flow of current from the batteries through the PV array can occur. This flow will drain power from the batteries. Diodes used to stop this reverse current flow. On the other hand, relay contacts disconnect the circuit when battery's voltage reached 13V in order to avoid overcharging voltage to the battery.

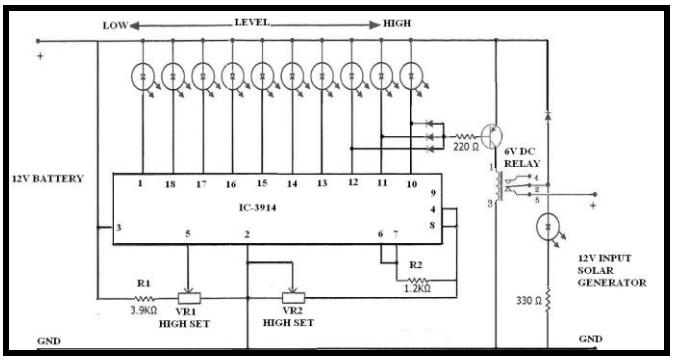

Figure 4: Schematic diagram of charge controller

Water level detector used to detect the presence of water at the maximum level in the water storage tank. The importance of having water detector is to prevent the overflow of the water and to optimize the use of DC water pump (pump only running when no water in the storage tank until water reaches the maximum level).

The IC 555 is a highly stable controller capable of producing accurate time delays, or oscillation. Probe is used as a water sensor. Relay will act like a switch and is operated in normal close (NC) mode. When no water detected by probe, relay is inactive (relay contact connect the circuit) which result the pump to operate. On the other hand, when water is detected, relay is activated (relay contacts disconnect the circuit) result the pump to stop operate. Schematic diagram of the water detector is shown in the Figure 5.

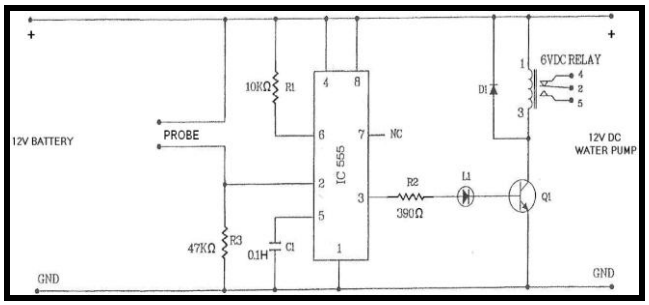

Figure 5: Schematic diagram of water detector

Battery and circuit need to have a proper storage in order to prevent them from damages. Figure 6 below shows the storage box for the battery and circuit.

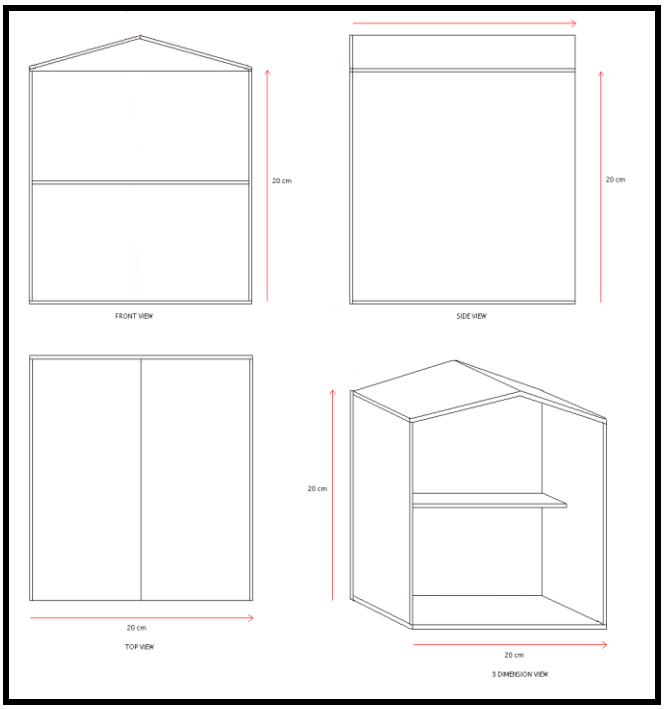

Figure 6: Storage box schematic view

Results

Individual PV panel can be wired in series or parallel to obtain the required voltage or current needed to charge the battery. Experimental value of the output of PV panel has been recorded for 5 days and results has been recorded in a graph as shown in Figure 7 and Figure 8 below:-

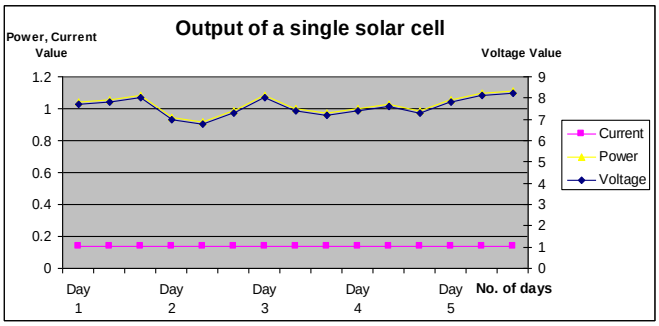

Figure 7: Output of a single solar cell

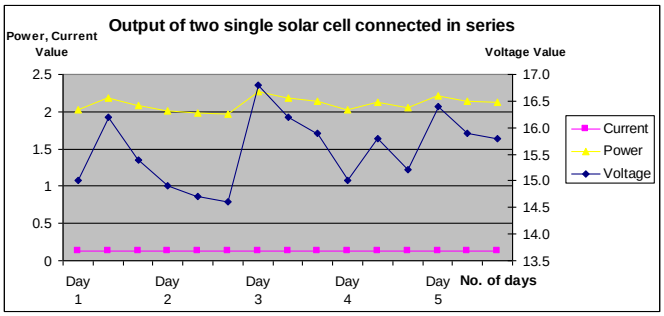

Figure 8: Output of two single solar cells connected in series

The first design of connecting the water pump, water detector level and the batteries is shown in the Figure 9 below. All the three components are connected in series. The problem occurred that the water pump was not working due to low current flowing through the pump.

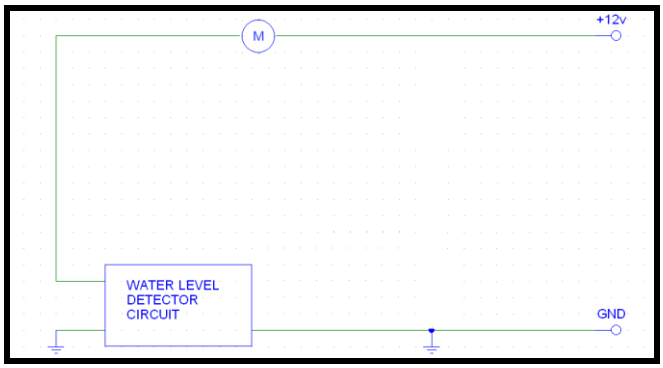

Figure 9: First design of the output system

Since the problem of the first design was due to low current flowing through the pump, NPN transistor has been added to the original design. The main purpose of this transistor is to amplify or switch electronic signal. A voltage or current applied to one pair of the transistor's terminals changes the current flowing through another pair of terminals. Because the controlled (output) power can be much more than the controlling (input) power, the transistor provides amplification of a signal.

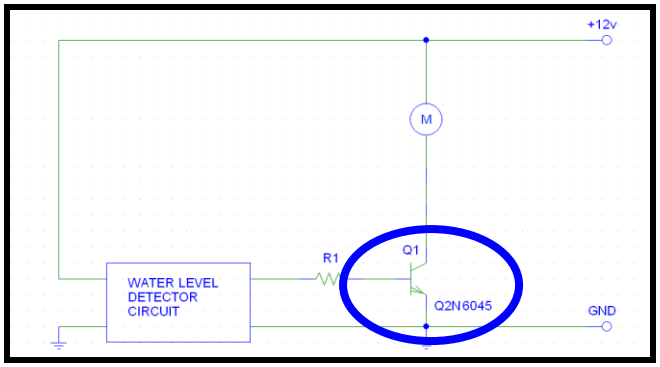

Figure 10: Second design of the output system

Pump in the second design was working but only for a few seconds. A further analysis has been carried out and the problem has been determined; there is a reverse flow of current from the motor (everytime the battery is disconnected). As a countermeasure, diodes used to stop this reverse current flow.

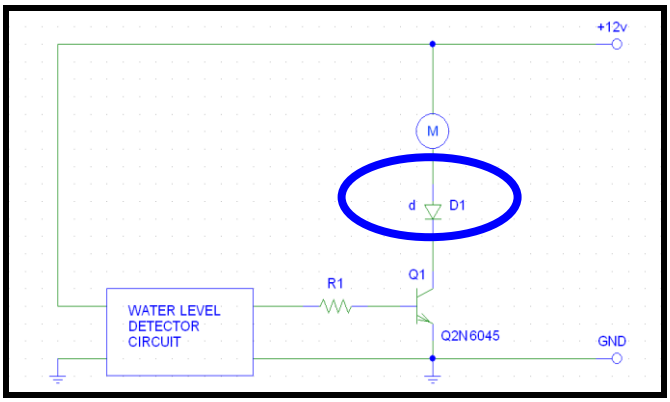

Figure11: Third design of the output system

Discussion

As known from the theory, the voltage output from cells wired in series is the sum of all the voltages from the cells. After doing the simulation with PSpice and running the experiment, it is proven that the voltages of the output came from the summation of the two solar cells while the amount of current maintain the same (equal to single solar cell).

In case solar cells connected in parallel, the voltage output from cells wired in parallel is the same value of the voltage from the single solar cell. Meanwhile, the current (amps) output is the sum of all the currents (amps) from the panels. Simulation and experimentation results proved the theory.

For the system part, since the pump does not need to operate for 24-hours per day, therefore, water level detector is used to disconnect the circuit whenever the water in the storage tank is full. Charge controller used in between PV panel and battery to monitor the charging voltage plus to prevent battery from overcharging. Final focus was made to complete prototype by the end of the semester.

Several difficulties have been faced throughout the semester. At the beginning of the semester, AC water pump has been considered to use as a load (output) in the system. Since the PV panel (input) produced DC output voltage, inverter is used to convert from DC to AC. Unfortunately; the output power from the inverter is too small (did not support the pump). As an alternative, DC pump has been used instead of AC pump.

Another difficulty was when connecting the battery, DC water pump and water detector level. Several experiment needed to be carried out in order to find the successful way to connect all the things together. As a countermeasure, NPN transistor with blocking diode at the transistor has been used.

Conclusion

Most of the work carried out was follow the time frame. The concept of each part (PV panel, power supply, charge controller, water detector and DC water pump) used in this project has been studied. The studies are done continuously throughout this two semesters. The prototype of the project is implemented this semester. Project is completed in two semester courses.

The first three objectives of the project have been achieved, which were to design the solar water lifting system, to construct charge controller for the power storage and to construct water level detector for the pump. Studies the operations of the charge controller and the water detector circuit have been done. Circuits also have been designed and implemented. The final objective of the project was to construct the prototype of solar energy water lifting system which will be completed soon.

Step by step approach is applied in this engineering project so that the solutions are based on every single criterion that has been studied. As a conclusion, the project is found to be successful although there are some difficulties in order to complete this project. Hopefully, this project will help the communities from the rural areas to solve their problems regarding water lifting someday.

Recommendation

Due to limited resources and time constraints, the study in this project is not fully completed. Several points should be included to improve the performance of this project. Therefore, the following suggestions are recommended for further study:

Currently, there is only one probe in the water storage tank. Pump will keep running starting from empty water until the water level reach maximum (where probe has been placed). In order to increase the life span of the pump, another probe should be added in the water storage tank. This probe will be placed at a certain minimum level so that pump only start to operate whenever the water level exceed the minimum level of the probe, and will stop operate whenever the water lever exceed the maximum level of the probe.

For this project, the charge controller functions as the voltage indicator and at the same time, also to prevent the overcharging voltage by limiting the amount of voltage charge to the battery. The improved charge controller must be able to choose the operation whether to charge the battery or to directly supply the power to the pump whenever the battery voltage exceeded cutoff value. Hopefully, the improvement of the circuit can make this project is become much better.

Solar panel only produces voltage when there is sunlight. In order to improve the input power to the source, adding another source such as wind turbine which will boost up the input power.

Acknowledgment

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