SOLAR POWERED WATER PUMP

Mahadir Bin Mohd Tazrin

Bachelor of Electrical Engineering (Industrial Power)

May 2010

" I hereby declared that I have read through this report entitle " *Solar Powered Water Pump*" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power) "

Signature	:
Supervisor's Name	: PN. NUR HAKIMAH BINTI AB AZIZ
Date	: 12 MAY 2010

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MAHADIR BIN MOHD TAZRIN

This Report Is Submitted In Partial Fulfilment of Requirements For The Degree of Bachelor in Electrical Engineering (Industrial Power)

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"I declared that this report entitle "*Solar Powered Water Pum*p" is the result of my own research except as cited in the references. This report has not been accepted for any degree and is not concurrently submitted in candidature of any degree

Signature :
Name : MAHADIR BIN MOHD TAZRIN
IC.No : 850806-12-6181
Date : 22 APRIL 2010

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ABSTRACT

This *Solar Powered Water Pump* project is created to replace the traditional way of using human energy in feeding the farm animal and besides, it can solve the problems faced at the animal farms that are located in the rural area and far away from the electric grid system. In addition, it can also unravel the environmental damage caused by the use of diesel in the electric generator as an energy source. With the existence of this project, the indicated problems and difficulties can be overcome and it can also provide better salary to these farmers because the output or productivity from the farms can be increased. In producing this project, several factors that influence the effect of PV output power is also taken into account and analyzed. The factors that are taken into account such as the effect of tilt angle on the PV output power, the effect of shadows on the PV output power, the effect of solar illumination on the PV output power and the connection of PV either series or parallel to the PV output voltage. All this effects are taken into account to ensure that the solar powered water pump project working more efficiently.

ABSTRAK

Projek Motor Pam Berkuasa Solar ini dicipta untuk menggantikan cara tradisional iaitu cara manual yang menggunakan tenaga manusia dalam memberi minuman kepada haiwan ternakan dan selain daripada itu ianya dapat mengatasi masalah ladang-ladang ternakan terutamanya yang terletak di kawasan pedalaman dan terletak jauh dari sistem grid elektrik sekaligus ianya juga dapat mengatasi pencemaran yang diakibatkan oleh penggunaan penjana elektrik yang menggunakan minyak diesel sebagai sumber tenaga , dengan adanya projek ini segala masalah ini dapat diselesaikan sekaligus dapat menjana pendapatan lebih kepada petani-petani ini kerana hasil pengeluaran dapat ditingkatkan dengan adanya projek ini. Dalam meghasilkan projek ini, beberapa faktor – faktor yang mempengaruhi kesan terhadap kuasa keluaran PV juga diambil kira dan dianalisis. Antara faktor - faktor yang diambil kira seperti kesan sudut PV terhadap kuasa keluaran, kesan bayangan terhadap kuasa keluara , kesan sinaran matahari terhadap kuasa keluaran dan kesan sambungan sel PV sama ada siri atau selari terhadap voltan keluaran sel PV. Kesan-kesan ini diambil kira untuk memastikan projek motor pam berkuasa solar yang dihasilkan dapat berfungsi lebih cekap.

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LIST OF SYMBOLS AND ABBREVATION

PV	-	Photovoltaic
%	-	Percentage
VDC	-	Direct Current Voltage
AC	-	Alternate Current
DC	-	Direct Current
PSH	-	*peak solar hours* (kW/m^2.hari)
°C	-	Degree Celsius
P	-	Power
Tr	-	Reference Temperature
Tc	-	Environment Temperature
S	-	Solar Panel Surface Area
W	-	Watt
H	-	Solar Intensity
ηR	-	PV Panels Efficiency At The Reference Temperature
η	-	PV Panels Efficiency
βp	-	Temperature Coefficient for Efficiency Module
Pe	-	Energy that Generate by a PV Panel
Ah	-	ampere-hour

CHAPTER 1

INTRODUCTION

1.1 Background

Currently, solar water pumps are used in many countries or regions with abundant sunlight. Solar pumps have proven to be a cost-effective and dependable method for providing water in situations where water resources are spread over long distances, power lines are few or non-existent, and fuel and maintenance costs are considerable. Historically, solar water pumps have not been widely used in many countries, in part due to the perception that solar does not work in cold country. However, demonstration units that have been operating over the past few years have proven that solar pumps work at capacity when needed most: during warm, sunny days.

This is particularly important for animal grazing operations. While there are several possible methods for supplying water to remote pastures, such as wind, gas/diesel pumps, and ram pumps, solar-powered water pumps may offer the best option in terms of long-term cost and reduced labor. In the relatively rare instances with favorable topography and spring or pond location, ram pumps or gravity feed may be better options. In flat areas where the water is supplied by a remote well and where there is limited access to the power grid, solar pumps appear to be the best option.

Solar pumps are used globally where there is no power and water sources are scattered, such as cattle ranches or village water systems. In temperate regions, the water pumps can be used year-round. Because Malaysia is subject to tropical weather, the use of solar pumps for providing water for grazing livestock in this country is more easy and efficient. In grazing operations, a solar pump can be used to fill a central tank that is located at a high point of the property. The water can then be distributed by gravity feed to a network of pipes to individual stock tanks. Solar pumping can also be used for smallscale irrigation, though this has not yet been implemented. It is possible that water systems set up for watering grazing livestock could be oversized to provide emergency pasture irrigation during drought. During the winter or cloudy day, the solar pump still can operate by using supply from the battery [1].

1.2 Problem Statement

The farms that are located in the rural area that further away from the area that can be reached by the electrical grid from electricity provider such as Tenaga Nasional Berhad (TNB) in Malaysia peninsular or Sabah Electricity Sdn Bhd (SESB) in Sabah and this rural area sometimes have problem due to the earth's structure factor, for example, in the rural area of Sabah and Sarawak contributes to the using of diesel generator as a main source of energy to get electricity. The using of this diesel generator needs a lot of diesel fuel and this is not efficient from aspect of cost especially to the farmers because the cost of the diesel is increasing nowadays. Other than that, it also needs a high maintenance and gives negative effects to the environment that can cause air and environmental pollution. The use of diesel generator is also not efficient to the aspect of lifetime because the lifespan of generator is shorter than the use of the PV cell.

1.3 Project Objectives

The aim of this project is to provide the solar powered water pump. This project will focus on water pump that operate by using PV cell as power supply that:

1. More cheaper than the water pump that using generator diesel as power supply.

2. Could operate in any weather condition such as cloudy or rainy day and PV cell that have suitable tilt angle to increase the output power,

3. Using hybrid system with PV cell as main power supply and battery as backup supply.

4. Controlled automatically using charger controller and water level sensor circuit

1.4 Project Scope

The scope of this project is to design prototype project application for water grazing livestock system. This project can operate during day and night depending on the sunlight and battery capacity. The project using the rechargeable battery 1.7Ah as storage to operate the DC water pump during night or cloudy day with the battery charger controller will produce current range within 1mA–10A with battery charge current range value within 500mAH – 400AH. The water pump specification using voltage 12Vdc, 24W input power and 1.98A input current and for the PV Cell, using 75W PV panel with tilt angel 30 degree as the PV angle orientation.

1.4 Outline of Report

Chapter 1 represents the Introduction part, project background, problem statement, project objectives, project scopes, and report outline. Chapter 2 represents the literature review part. This part including review on related project based on solar powered water pump. Chapter 3 represents the project methodology that will be applied in this project. Chapter 4 represents discussion, result and analysis for this project. Finally in Chapter 5 represents the Conclusion and future recommendation of this project.

CHAPTER 2

LITERATURE REVIEW

The research must be done in their scope of project, which means the research must be related to the projects that have been suggested. From the topic that have been suggested "Solar Powered Water Pump". In fact, solar energy is one of the renewable energy, so project that based on Photovoltaic system will be taken in order to do the literature review.

J.S Ramos and Helena M.Ramos paper [2] describes the study about the possible application of solar energy to deep well water pumps for water supply in rural or isolated zones. Developing countries are composed of numerous small villages and farmers, making it economically unviable to extend the electrical national grid to every location where it is needed. Also the difficulty in collecting dues makes this solution even less viable. These countries still struggle with the lack of water in many villages and farms. These factors, along with the increase in the price of conventional energy sources and concerns regarding sustainable growth, have led to the development of solar powered water pumps. Most African, South Asian and Latin-American countries have good sun exposure almost all year and many of its villages still have lack of water. For this study , they considered a small village composed of 10 families with a daily consumption of 100 l each, a well with a depth of 100 m, a reservoir 10 m above ground level, an autonomy of 6 days and a permitted loss of load of 2%. In this work a PV advanced model was used. For the conditions mentioned, a water cost of 1.07 €/m3 and an investment cost of 3019 € were obtained. A pump power of 154 Wand a solar array of 195 Watt peak (Wp) are necessary. The water cost obtained is believed to be a competitive value proving these types of solutions as good alternatives to extending the electric grid or having a diesel generator connected to the pump

A.Braijnstein and A.Kornfeld paper [3] describes about the development of solar powered electric water pumps (SPEWP). The SPEWP consists of a solar cell array, storage of electrical energy or water, controls, an electric motor and a pump. This paper deals with the characteristics of each element in a SPEWP and its mathematical model. The mathematical model of the whole system is studied and analyzed. The solutions of the non-linear equations yield a method for determination of the rate of volume flow, the head of water and the efficiency of the system as a function of the radiation levels. The pump motor is studied and so is its operation point and the torque under varying conditions of the load and the solar energy available. A numerical solution of the mathematical equation is presented describing the torque of the series d.c. motor as a function of its characteristics and the non-linear nature of the solar cell array (SCA). The centrifugal pump operation is analyzed by the torque equation and its variations as a function of the pumped rate of flow and the rotation velocity is studied. A method for determination of the pump parameters is given. Finally, they discuss the principles and method for obtaining the rate of volume flow and the head of water as a function of the radiation levels. The theoretical results are compared to measured ones allowing us to examine the validity of correction factors. The authors of this paper also believe that this paper contributes to better design of SPEWPs, which, in many cases, even without improvements are being chosen today over conventional water pumping systems.

A.A Ghoneim paper [4] describes the results of performance optimization of a photovoltaic powered water pumping system in the Kuwait climate. The direct coupled photovoltaic water pumping system studied consists of the PV array, DC motor, centrifugal pump, a storage tank that serves a similar purpose to battery storage and a maximum power point tracker to improve the efficiency of the system. The pumped water is desired to satisfy the domestic needs of 300 persons in a remote area in Kuwait. Assuming a figure of 40 l/person/day for water consumption, a volume of 12 m3 should be pumped daily from a deep well throughout the year. A computer simulation program is developed to determine the performance of the proposed system in the Kuwait climate. The simulation program consists of a component model for the PV array with maximum power point tracker and component models for both the DC motor and the centrifugal pump. The five parameter model is adapted to simulate the performance of amorphous silicon solar cell modules. The size of the PV array, PV array orientation and the pump– motor–hydraulic system characteristics are varied to achieve the optimum performance for the proposed system.

The life cycle cost method is implemented to evaluate the economic feasibility of the optimized photovoltaic powered water pumping system. At the current prices of PV modules, the cost of the proposed photovoltaic powered water pumping system is found to be less expensive than the cost of the conventional fuel system. In addition, the expected reduction in the prices of photovoltaic modules in the near future will make photovoltaic powered water pumping systems more feasible.

Conclusion

Based on three reviews that have been done from the related journals, there are certain relations between the literature review and this project. Solar powered water pump project is based on all of these reviews but is not exactly the same. There are certain improvements that will be done later. There are also some of the applications are not been use in this project and has been change into the other methods and applications. This project is part of all the reviews and has been combined to create and support this project itself.

2.1 Types of PV cell

Cells are manufactured from a range of different types of materials. The most significant is crystalline silicon. There is a broad range of different PV cells produced by over 100 manufacturers. There are three main types of commercially available cells:

1. Monocrystalline silicon PV;
2. Polycrystalline silicon PV;
3. Thin film- amorphous silicon PV;

From the three main types of PV cell that available in the market, for this project, the type used here is a monocrystalline panel. Its features include a lightweight anodized aluminum frame, time-tested monocrystalline silicon solar cells , and a polycarbonate junction box. With nominal maximum power of 75 watts, this PV cell is well-suited for this project. Its 36 series-connected cells charge 12V batteries efficiently in virtually any climate. To produce monocrystalline silicon a crystal of silicon is grown from highly pure molten silicon. This single crystal cylindrical ingot is cut into thin slices between 0.2 and 0.3mm thick- this is the basis of a solar PV cell. The edges are cut off to give a hexagonal shape so more can be fitted onto the module. Figure 2.1 show the monocrystalline silicon PV. These PV cells have efficiencies of 12-15% and are the most efficient type of the three types of silicon PV cell. However, they require more time and energy to produce than polycrystalline silicon PV cells, and are therefore slightly more expensive [1]. Table 2.1 shows the efficiency and cost comparison for various types of PV panel.

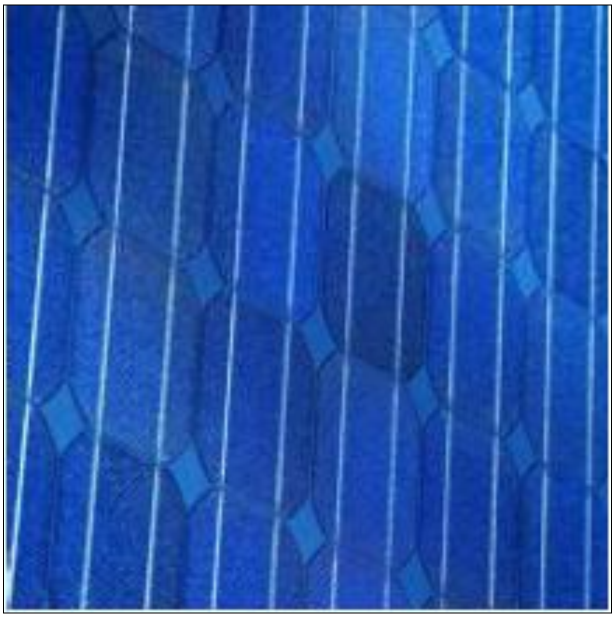

Figure 2.1: Monocrystalline silicon PV

Table 2.1: PV Cell Efficiency and Cost Comparison [4, 6]

PV cell Type	**PV Module Efficiency**	**Max. Efficiency that has been recorded in the lab (%)**	**Cost (USD / W)**
Monocrystalline	12-15%	24%	5.5-6
Polycrystalline	11-14%	18.6%	4.5
Amorphous	6-8%	12.7%	3
Copper Indium Diselenide	8-12%	18.8%	3.8
Cadmium Telluride	7-10%	16%	3.8

2.2 Charger Controller

The charger controller is for use in PV-system with battery storage in the field of leisure as well as in the living area, in smaller industrial systems. The charger controller surveys the state of the battery, controls the charging process as well as the switching on and off of the users. Thus the battery can be used optimally and its service life is prolonged considerably. The controllers are for use with lead accumulators with liquid electrolyte and can be adapted for use with others electrolytes. The controller can be used with all solar modules up to the maximum connection value of the module [5].

In other words, solar charge controller function is to regulate the power flowing from a photovoltaic panel into a rechargeable battery. It features easy setup with one potentiometer for the float voltage adjustment, an equalize function for periodic overcharging, and automatic temperature compensation for better charging over a range of temperatures [6].

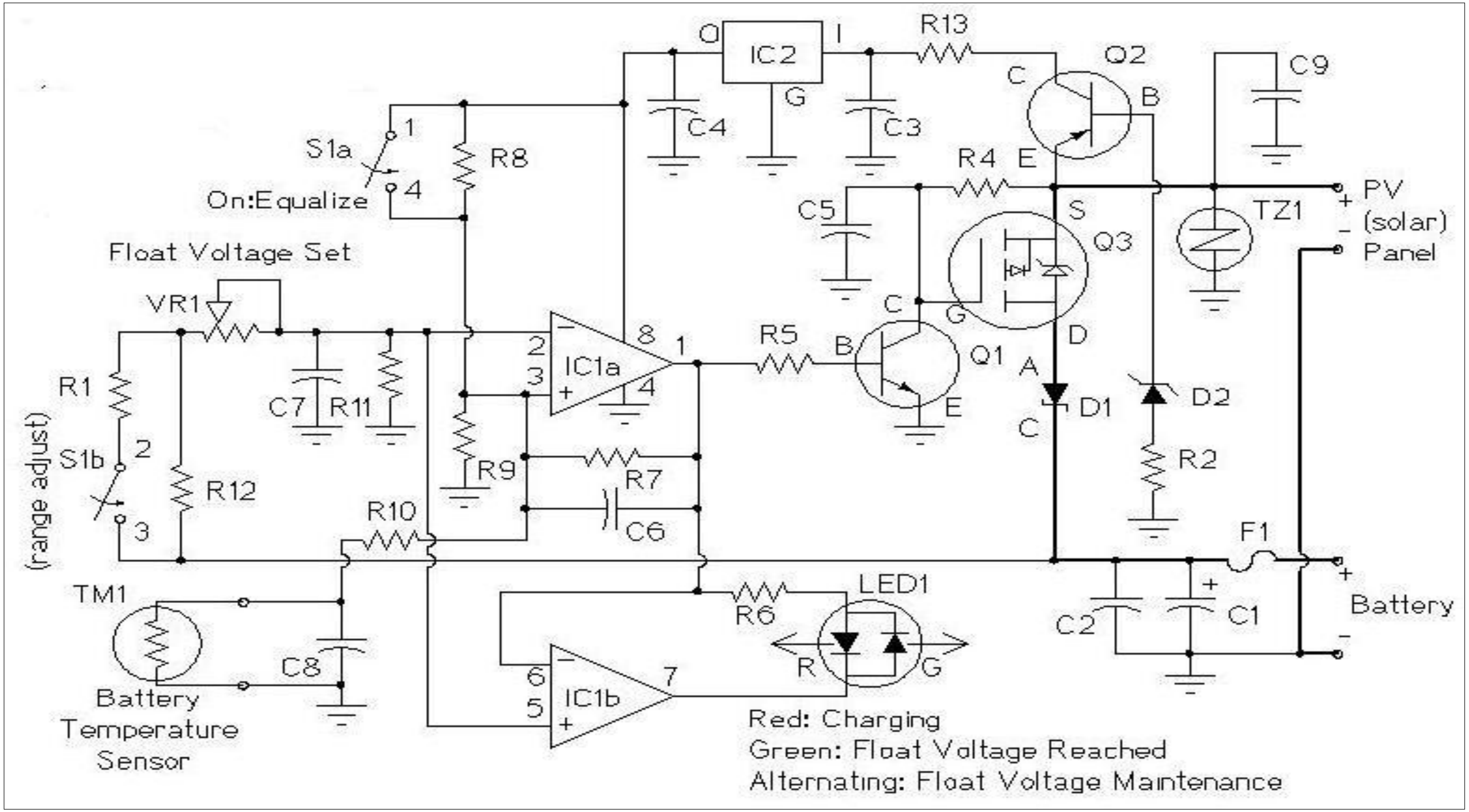

Figure 2.4: Charger Controller Circuit [12]

2.2.1 Charger Controller Circuit Operation

Diode **D1** prevents reverse night time current flow from the battery back to the PV panel. When the PV voltage is high enough to charge the battery, zener diode **D2** conducts and turns on transistor **Q2. Q2** switches the power for the rest of the circuit on. The circuit is switched off at night. **IC2** provides a 5 volt regulated voltage to power the comparator circuits; it also provides a reference voltage for comparator **IC1a**.

When the battery voltage is below the desired full voltage and needs charging, comparator **IC1a** turns on and activates **Q1** and **Q3,** this allows the solar charging current to flow into the battery. Note that **Q3** is a P-channel mosfet, this allows the circuit to be wired with a common ground for the solar panel and battery. The solar current loop is drawn in heavy lines on the schematic.

When the battery reaches the full charge point, **IC1a** operates as a comparator based schmidt trigger oscillator, it switches the solar current off and on. The switching causes the battery voltage to oscillate a few tens of millivolts above and below the desired set point. A rail-to-rail op-amp is required for proper operation, 741 style op-amps will not work in this circuit.

The red/green charging/full LED is driven between the output of **IC1a** and **IC1b**. **IC1b** has an inverted version of the **IC1a** signal. Pin 5 of **IC1b** only needs an approximate center point to work as an on-off comparator, it is connected to the varying **IC1a** pin 2 so that it does not require another reference divider circuit.

The resistors and thermistor on the input side of **IC1a** form a resistive bridge circuit that is used to compare the battery voltage to a reference voltage coming from **IC2/R8/R9.** The potentiometer adjusts the voltage point around which the circuit will oscillate on full charge. Resistor **R7** adds positive feedback to **IC1a** for a schmidt trigger characteristic. The thermistor provides thermal compensation, as the temperature goes down, the full voltage goes up.