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Solar Powered Smart Irrigation System

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Abstract

Cost effective solar power can be the answer for all our energy needs. Solar powered smart irrigation systems are the answer to the Indian farmer. This system consists of solar powered water pump along with an automatic water flow control using a moisture sensor. It is the proposed solution for the present energy crisis for the Indian farmers. This system conserves electricity by reducing the usage of grid power and conserves water by reducing water losses.

Keywords: Smart irrigation; solar power; solar pump; moisture sensor;energy crisis.

1. Introduction

Solar energy is the most abundant source of energy in the world. Solar power is not onlyan answer to today's energy crisis but also an environmental friendly form of energy. Photovoltaic generation is an efficient approach for using the solar energy. Solar panels (an array of photovoltaic cells) are nowadays extensively used for running street lights, for powering water heaters and to meet domestic loads. The cost of solar panels has been constantly decreasing which encouragesits usage in various sectors. One of the application of this technology is used in irrigation systems for farming. Solar powered irrigation system can be a suitable alternative for farmers in the present state of energy crisis in India. This a green way for energy production which provides free energy once an initial investment is made.

In this paper we propose an automatic irrigation system using solar power which drives water pumps to pump water from bore well to a tank and the outlet valve of tank is automatically regulated using controller and moisture sensor to control the flow rate of water from the tank to the irrigation field which optimizes the use of water. The

paper is divided into 6 sections discussing the literature survey, proposed solution, implementation, cost analysis and results and conclusion, references.

2. Literature Survey and Background Study

According to the survey conducted by the Bureau of Electrical Energy in India in 2011 there are around 18 million agricultural pump sets and around 0.5 million new connections per year is installed with average capacity 5HP. Total annual consumption in agriculture sector is 131.96 billion KWh (19% of total electricity consumption).As cited in paper [1] solar powered smart irrigation technique is the future for the farmers and a solution for energy crisis. So for the proposed solar powered system we are using techniques analyzed in paper [2] and [4] and modified. Sine PWM technique has been used for inverter operation for minimum harmonics as given in paper [3] which further increases the efficiency of the system.The rating of the system was calculated corresponding to the pump specifications referring to paper [5].

3. The Proposed Solution

In this proposed system we utilize the solar energy from solar panels to automatically pump water from bore well directly into a ground level storage tank depending on the intensity of sunlight. While conventional methods include pumping of water from bore well into a well and from this well onto field using another pump, our system uses only a single stage energy consumption wherein the water is pumped into a ground level tank from which a simple valve mechanism controls the flow of water into the field. This saves substantial amount of energy and efficient use of renewable energy. A valve is controlled using intelligent algorithm in which it regulates the flow of water into the field depending upon the moisture requirement of the land. In this system we use a soil moisture sensor that detects the amount of moisturepresent in the soil and depending upon the requirement of level of moisture content required for the crop the water flow is regulated thus, conserving the water by avoiding over flooding of crops.

3.1 System description

Proposed irrigation system mainly consists of two modules- Solar pumping module and automatic irrigation module. In solar pumping module a solar panel of required specification is mounted near the pump set.

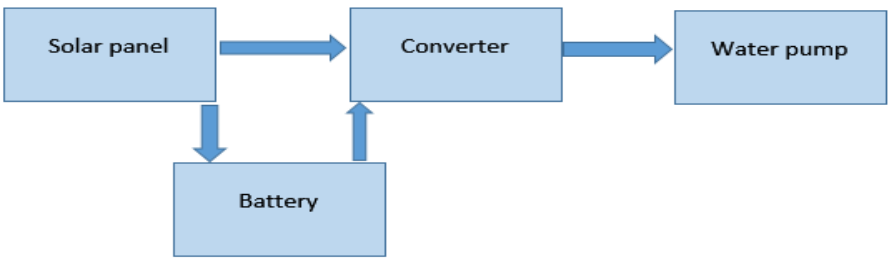

Fig. 1: Block diagram of solar pumping module.

Then using a control circuit it is used to charge a battery. From the battery using a converter circuit it gives power to the water pump which is submerged inside the well. Then the water is pumped into an overhead tank for storing water temporarily before releasing the water into the field.

In automatic irrigation module the water outlet valve of the tank is electronically controlled by a soil moisture sensing circuit. The sensor is placed in the field where the crop is being cultivated. The sensor converts the moisture content in the soil into equivalent voltage. This is given to a sensing circuit which has a reference voltage that can be adjusted by the farmer for setting different moisture levels for different crops. The amount of water needed for soil is proportional to the difference of these two voltages. A control signal was given to a stepper motor whose rotational angle is proportional to the difference in voltage. The stepper motor in turns controls the cross-sectional area of the valve to be opened controlling flow of water. Therefore the amount of water flowing is proportional to the moisture difference.

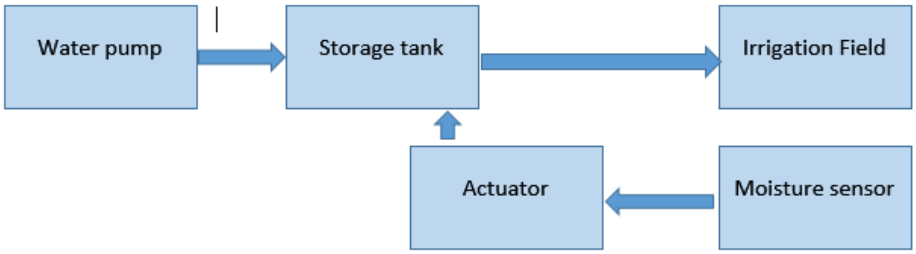

Fig. 2: Block diagram of automatic irrigation module.

4. Implementation

For the implementation of the proposed system we are using a 2 HP water pump and various modules which are designed and fabricated separately and then finally they are assembled together to implement the proposed system. Solar energy is harnessed using solar panel PVL-68 that generates 53W at Nominal Operating Cell Temperature. It is 24V, amorphous silicon type solar cell.

Specification of the solar panel selected:

Array capacity --240Wp

Irradiance – 580 W/m^2

Open circuit voltage – 18.1 V

Short circuit current – 3.98 A

Load test on a solar panel have been conducted and its maximum and minimum values is tabulated.

Table 1: Load test characteristics of solar panel.

S. No	Voltage (in Volts)	Current (in Ampere)	Irradiance (W/m^2)
1	5.2	1.45	300
2	17.5	2.95	710

4.1 Design of converter and battery specification

An inverter is designed with a DC input of 230V D.C which is generated from 12V D.C using a boost converter. Sine PWM technique is applied to generate 230V A.C. The inverter circuit fabricated is shown in Fig. 4. As far as battery is concerned we are using a battery with 12V, 100Ah capacity for a 2HP pump.

4.2 Moisture sensor module

A moisture sensor is used to sense the level of moisture content present in the irrigation field. It has a level detection module in which we can set a reference value. This circuit can be used with analog probes that produce a voltage proportional to soil moisture such as VG400 probe shown in Fig. 3. The moisture content of the soil is found by using the soil moisture sensor such as VG400 which produces an equivalent output voltage proportional to the conductivity between the two probes.

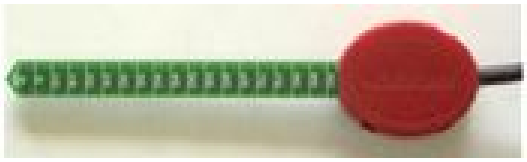

Fig. 3: Soil Moisture Sensor probe.

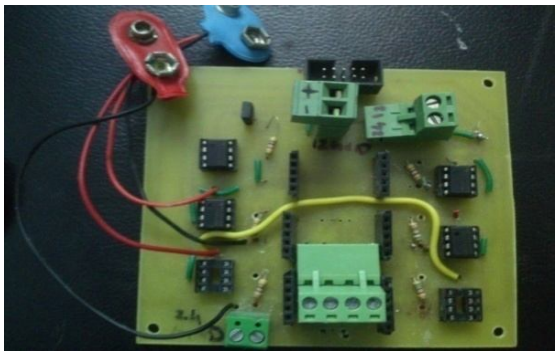

Fig. 4: Inverter circuit.

4.3 Automatic valve regulation

For an automatic valve control we are using a stepper motor as an actuator control of the valve whichis connected to theoutlet valve of the tank. With the help of moisture sensor signaland a controller, a control pulses is given to the driver circuit that excites the stepper motor. So this way the outlet valve is slowly opened or closed depending upon the amount of moisture present in the soil of the field. When the soil moisture content reaches the required value, the valve is fully closed and power to driver circuit is killed and controller is put into sleep mode for low power consumption. When the moisture in soil is dried and reach a minimum cut-off value, the controller comes out of sleep mode and flow of water is regulated. This way the whole system works automatically.

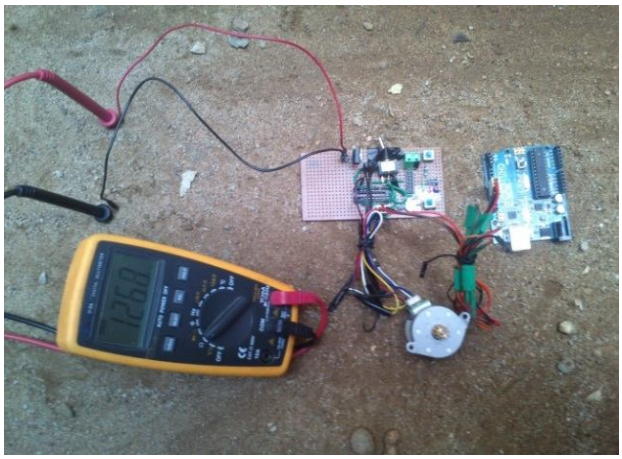

Fig. 5: Automatic valve regulation circuit.

5. Cost Analysis

With over nine hundred thousand tube wells being used in every state of India, around Rs.18 Million of energy is used for pumping water for irrigation. This amount of money used for electricity can be saved with the help of solar water pump. Annually the cost of nearly five million kilo watt hour of energy can be spared. That is around Rs.27 Million per annum can be redeemed which comes around 40% of the total amount of investment.

Even though the initial investment is high, it can be earned back in 2 and a half years' time. If we assume the cost of power is Rs. 1.5 Million per kilo watt hour, Rs.18 Million is used for pumping water alone in a year. By using the solar water pump, we can save up to 4.8 million KWh of energy annually which saves a lot of energy. The excess energy can also be given to the grid with small modifications and investments in the circuit, which can add to the revenue of the farmer.

Table2: Cost analysis.

Component	Unit Cost	Quantity	Total Cost
Solar Panel (1.4m^2)	24000	4	Rs.96000
Converter Circuit	400	1	Rs.400
Battery 24V,100Ah	8250	1	Rs.8250
		Overall cost	Rs.104650

6. Conclusion

By implementing the proposed system there are various benefits for the government and the farmers. For the government a solution for energy crisis is proposed. By using the automatic irrigation system it optimizes the usage of water by reducing wastage and reduce the human intervention for farmers.The excess energy produced using solar

panels can also be given to the grid with small modifications in the system circuit, which can be a source of the revenue of the farmer, thus encouraging farming in India and same time giving a solution for energy crisis. Proposed system is easy to implement and environment friendly solution for irrigating fields. The system was found to be successful when implemented for bore holes as they pump over the whole day.Solar pumps also offer clean solutions with no danger of borehole contamination. The system requires minimal maintenance and attention as they are self starting. To further enhance the daily pumping rates tracking arrays can be implemented. This system demonstrates the feasibility and application of using solar PV to provide energy for the pumping requirements for sprinkler irrigation. Even though there is a high capital investment required for this system to be implemented, the overall benefits are high and in long run this system is economical.

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