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Advancement and Optimization of Solar Water Pump

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ABSTRACT

Diesel-powered irrigation pumps are widely used. However, due to the global increase in the price of oil, the hazardous pollutants released during combustion, the high cost of maintenance,and the short lifespan of conventional vehicles, innovators have been compelled to find an alternative. Scientists are now developing a solar-powered irrigation water pumping device. Solar is a good alternative because it can be used anywhere, even in remote areas. Studying what affects a solar photovoltaic water pump's efficiency is the primary objective of this effort. It was shown to be more economical, less harmful to the environment, and dependable than diesel-powered water pumps, requiring less maintenance and having a longer service life. This paper focuses on the design and implementation of water pump control in the field using solar energy. This works on the principle of photovoltaics. The solar panel converts the solar energy into electrical energy, which is stored in the lead-acid battery. The embedded board PIC18F4520 is used for programming, which controls the switching of the motors. The solar water pump operates as a soft real-time system, where the response time of the system is not crucial. The DC motors turn on or off at different time intervals.

KEYWORDS: Solar Energy, Photovoltaic, Solar Water Pump, Advancement in Farming, Energy Saving, Solar Invertor

1. INTRODUCTION

Solar power is a natural and symbiotic choice for water pumping. It is one of the most economically attractive solar energy applications, with direct-drive PV systems often providing decades of reliable service. There is a good match between seasonal solar resources and seasonal water needs. Photovoltaic water pumping (PVWP) systems can meet a wide range of needs and are relatively simple, reliable, cost-competitive, and low-maintenance. A typical system configuration includes a PV array, pump, controller, inverter (for AC), and overcurrent protection. Until recently, PVWP was competitive for only relatively small pumping loads. Over the past decade, the competitiveness of PVWP has increased dramatically, significantly expanding the range of pumping loads and requirements where PVWP is competitive. Energy is seen as one of the most important inputs for every country's economic and social growth. India's energy consumption is steadily increasing, putting a huge strain on the country's finite resources. With a land area of 3.288 million square kilometers, it is the world's sixth-biggest country. However, India continues to face many developing issues. 1) . Therefore, it is not a wise option to rely solely on rainfall for crops. With the aid of a water pump, irrigation may be done from wells, canals, rivers, and other sources. The bulk of farms in developing nations are between 0.5 and 2 hectares in size, with irrigation water demands ranging from 20 to 120 m3 per day. Irrigation of the summer crop requires water pumping, which is done with traditional lifts, diesel, or electric motor pumps. 2). As a result, agricultural water pumping demand is highest in the summer, when solar energy availability is also highest, making solar water pumping a viable choice. The traditional pumping system (diesel or electric pump) has the benefit of being simple to install, but it has some drawbacks, including regular equipment repair, refueling, and the lack of diesel. 3-5) Due to factors such as rising fossil fuel costs and the extension of new power lines Energy from the sun is possibly more appropriate for irrigation than other renewable resources since crop water requirements are heavily dependent on incoming solar irradiation. 6). India has a large solar energy potential for powering water pumps due to its weather conditions. 7). One such use is solar photovoltaic water pumping systems, which can help meet drinking and irrigation water demands in rural and isolated places where grid energy is not readily accessible. Also, fuel costs have increased by approximately 250%. 8). To boost SPVWPS, the Indian government is taking a variety of actions, including providing subsidies. These incentives and initiative programs are assisting in encouraging farmers to use SPVWPS with minimal investment. 9). Also, due to air circumstances and the earth's rotation, solar radiation reaches the earth's surface in sporadic bursts. Intermittence and variability restrict the practical conversion of solar radiation by necessitating either intermediate energy storage or application to a job that tolerates intermittency. Irrigation water pumping is an operation.

Our project focuses on making the most efficient use of solar water pumps through automation and sparing energy. At the moment, there are approximately 3.5 lakh solar panels installed by the PM-KumumYojna and 1 lakh under the Maharashtra State Government. Most often, solar pumps are only used to pump water for agricultural purposes, and when pumps are not in use, the solar panel's potential energy is lost. Our goal is to improve the present situation, so we are building a model with the following parts: 1) Solar panels and pumps 2) An inverter 3) Grid and home output points 4) Battery set For isolated locations, we may utilise the aforementioned system with batteries as a standalone system and for EV charging; otherwise, we can use it as needed. The IoT will monitor and control all parameters. The above technique may be applied to government scheme initiatives as well as private customers.

2. LITERATURE REVIEW

With the limitless potential available from solar energy and the continuous decrease in PV module and system prices due to the improvement in their operation and manufacturing efficiencies (as will be discussed later). Research into building and improving PV systems for different applications has blossomed over the last decade, especially in countries that have high solar potential, such as Indonesia, Kuwait, Algeria, and so on. Ghoneim [6] mentioned that one of the best applications of photovoltaic systems is their use as a power source for pumping water. The advantages of utilising water pumps powered by PV systems are low maintenance, ease of installation, reliability, and the matching between the power generated and the water usage. Also, the system can use water tanks instead of batteries. The researcher used TRNSYS (Transient System Simulation Tool) to simulate the performance of the PV pumping system with a maximum power point tracker. The model confirmed its success after it was compared with the manufacturer’s PVCAD programme. The costs of PV equipment and water pumps are expected to decrease more and more over the years. Also, the PV array's life cycle materials are 20–25 years old, whereas those of the engine and pump are eight years old. Prasetyaningsari [7] designed an optimal solar-powered aeration system for fish ponds in Sleman Regency, Yogyakarta. HOMER (Hybrid Optimisation Model for Multiple Energy Resources) proposes a 1 kW photovoltaic system, eight batteries of 200 Ah, a 0.2 kW inverter, and a COE of about US$0.769/kWh for the given requirements of these ponds. Ajao [8] explained the cost analysis of a wind turbine-solar hybrid system in comparison with utility power supply costs. The results indicated that the hybrid system is not economically cheap. Also, the system payback time was 33 years. If the investment cost per kilowatt reduced due to the installation of many instances of this hybrid system on a farm, a wind-solar cell hybrid energy system would be cost-effective. Its availability, sustainability, and environmental friendliness make it a desirable source of energy supply. Salam [9] designed and analysed a PV system that provides lighting to a renewable energy lab. Using

HOMER, the optimal results of the system were found using 12 V, 140 W PV modules, which are connected in series to get 24 V, as well as four batteries of 6 V, 360 Ah capacities. The results obtained from the optimisation give the initial capital cost as US$ 13,500, while the operating cost is US$817/year. The total NPC of the system is US$23,939, and the COE is 1.354 US$/kWh.

Elhassan [10] discussed the use of HOMER for designing an efficient and economically viable hybrid PV/wind electrical power supply system for residential areas in Khartoum, Sudan. This plan was to take advantage of the vast expanses of desert in Sudan, as well as their extremely prevalent sunshine, and design an economically viable way of building large-scale solar power plants. The researchers relied on the NASA global average radiation data and the monthly averaged measure data for wind factors from SEI. HOMER was utilised in the design process and simulation. HOMER's optimisations and simulations demonstrated that the NPC of the grid/renewable energy source (RES) hybrid configuration is comparable to that of a grid-only supply. The resulted payback time was 14 years (at 2004 prices), and a 65% reduction in greenhouse gas emissions can be achieved.

Kazem [11] designed a stand-alone PV system to be used for the electrification of Omani rural areas at optimal efficiency. It specifically dealt with critical aspects such as the PV array's orientation and cell temperatures. The requisite simulations were performed by HOMER software, resulting in a system that satisfies a 33 kWh/day load at a COE of US$0.044/kWh.

3. PROPOSE SYSTEM

For converting solar energy into electrical energy, we used a solar panel. We can convert solar energy through the solar panel by using the solar cells, and we can store the supply in the battery by connecting one diode between the solar panel and battery.

We have provided the facility of automatic switching on and off through mobile. This is archived or carried out using the controller. An LCD is connected to the controller to display the status of the pump. The controller gives command to the corresponding relay to turn on the pump. We have done our programming in C using MPLAB software. A solar panel absorbs sunlight as a source of energy to generate electricity. The solar panel gives electrical energy to the battery for storage purposes. A battery is a device that collects the electrical energy from the solar panel and stores it in chemical form. A solar-powered pump is a pump running on electricity generated by photovoltaic panels or the radiated thermal energy available from collected sunlight, as opposed to grid electricity or diesel-run water pumps.

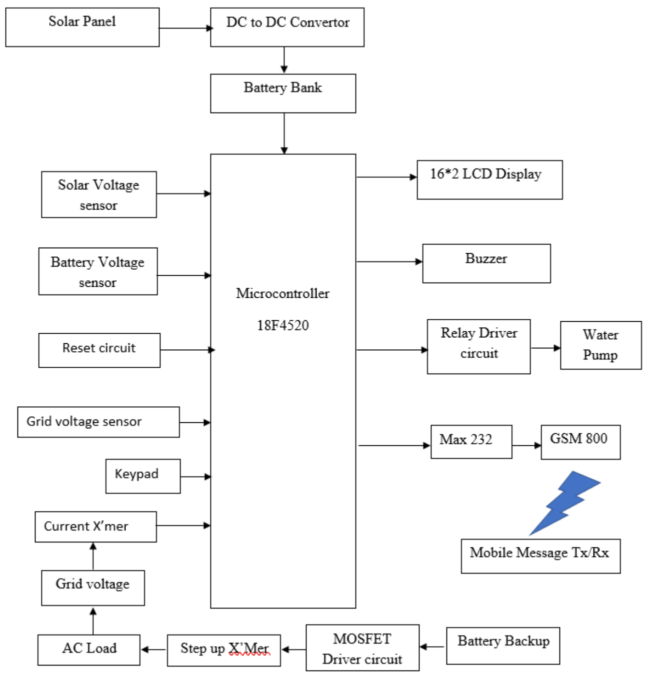


Figure1. Block Diagram

This system is mainly designed for charging an 18-watt inverter using solar energy. Due to the many benefits of using solar energy, many institutions are opting to make use of it. This system uses a solar panel, which helps charge the inverter. The inverter is an electronic device that converts DC to AC. In the presence of electricity, the inverter gets charged. These types of solar panels ensure that the maximum amount of solar energy is captured into the panel by continuously keeping the panel surface perpendicular to the rays of the sun, in other words, by facing towards the sun. This system is powered by a PIC microcontroller and includes a transformer, MOSFET switch, DC inverter, 12 V battery, 50 W solar panel, and charger. Solar energy helps charge the battery because it is a natural source of energy. As we switch on the loads, the battery charger charges the inverter, and it gets converted from DC to AC. The setup transformer then increases the voltage required to run the device. A MOSFET is a transistor that regulates the voltage and then provides power to the load. Our system successfully powers the AC load using solar panels [24].

A. PIC18F4520 MICROCONTROLLER

It is an 8-bit enhanced flash PIC microcontroller that comes with nanowatt technology and is based on RISC architecture. Many electronic applications house this controller and cover wide areas ranging from home appliances to industrial automation, security systems, and end-user products [22]. This microcontroller has made a renowned place in the market and becomes a major concern for university students when designing their projects, setting them free from the use of a plethora of components for a specific purpose as this controller comes with an inbuilt peripheral with the ability to perform multiple functions on a single chip[18].

Figure2. PIC18F4520 Microcontroller

*B. 16*2 LCD Display*

An LCD (liquid crystal display) screen is an electronic display module with a wide range of applications. A 16x2 LCD display is a very basic module and is very commonly used in various devices and circuits. A 16x2 LCD means it can display 16 characters per line, and there are two such lines. On this LCD, each character is displayed in a 5x7 pixel matrix. This LCD has two registers, namely, command and data. The command register stores the command instructions given to the LCD. A command is an instruction given to the LCD to do a predefined task like initialising it, clearing its screen, setting the cursor position, controlling the display, etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

Figure3. LCD Display

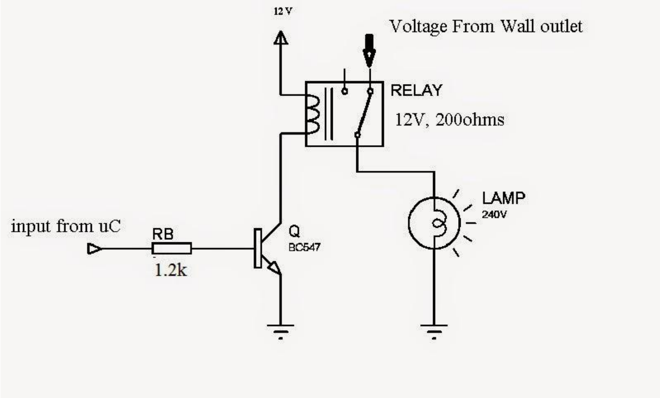
C. GSM Module

The SIM800L GSM/GPRS module is a miniature GSM modem that can be used in a variety of IoT projects. You can use this module to do almost anything a normal cell phone can do, such as sending SMS messages, making phone calls, connecting to the Internet via GPRS, and much more. To top it all off, the module supports quad-band GSM and GPRS networks, which means it will work almost anywhere in the world. This GSM modem has a SIM800A chip and an RS232 interface, which enables easy connection with the computer or laptop using the USB to Serial connector or to the microcontroller using the RS232 to TTL converter [21]. Once you connect the SIM800 modem using the USB to RS232 connector, you need to find the correct COM port in the Device Manager of the USB to Serial Adapter [20].

Figure4. GSM Module

D. Relay Driver Circuit

A relay driver circuit is a circuit that can drive, or operate, a relay so that it can function appropriately in a circuit. The driven relay can then operate as a switch in the circuit, which can open or close according to the needs of the circuit and its operation. In this project, we will build a relay driver for both DC and AC relays. Since DC and AC voltages operate differently, building relay drivers for them requires a slightly different setup. We will also go over a generic relay driver that can operate from either AC or DC voltage and operate both AC and DC relays. Now that we're using a transistor to drive the relay, we can use considerably less power to get the relay driven [23]. Because a transistor is an amplifier, we just have to make sure that the base lead gets enough current to cause a larger current to flow from the emitter of the transistor to the collector. Once the base receives sufficient power, the transistor will conduct from emitter to collector and power the relay.



3. RESULTS AND DISCUSSION

Following Figure shows actual photograph of our project. In this way we successfully implement our concept "Advancement & Optimization of Solar Water Pump".

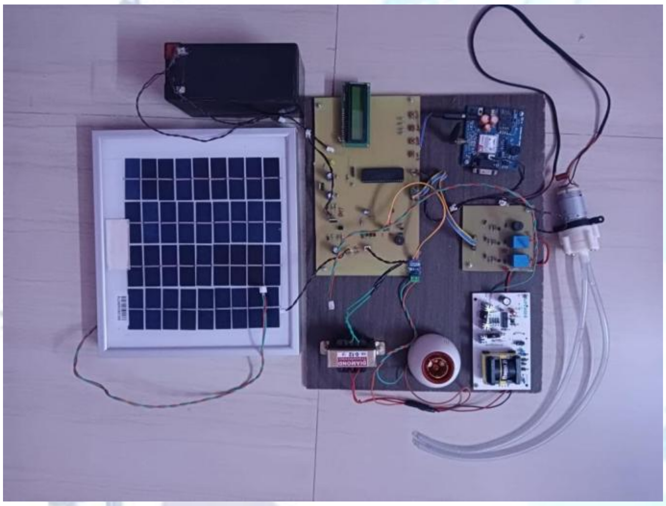


Figure6. Photograph of our System

4. CONCLUSION

In this study, we propose a simple but efficient, low-cost, power-efficient embedded system for solar-based off-grid irrigation by orienting the solar panel towards the sun to provide the necessary power source in remote areas or in the irrigation field where it is not possible to provide change through a stable current supply.

Since the increase in price per unit increase in power output of a photovoltaic system is greater than that for a diesel, gasoline, or electric system, photovoltaic power is more cost-competitive when the irrigation system with which it operates has a low total dynamic head. For this reason, photovoltaic power is more cost-competitive when used to power a microirrigation system as compared to an overhead sprinkler system. Photovoltaic power for irrigation is cost-competitive with traditional energy sources for small, remote applications if the total system design and utilisation timing are carefully considered and organised to use the solar energy as efficiently as possible.

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Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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