Photo-Voltaic based Smart Irrigation Cart

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Abstract. The need of energy is increasing dramatically in all sectors of life. The cost-effective solution be the answer for all our energy requirements. Renewable energy is the best possible solution to replace conventional energy sources, both in terms of cost and environmental issues. While considering Indian farming system, electricity is a source of problem behind fruitful irrigation of the field. PV based smart irrigation cart can the solution for electricity problems faced by Indian farming where there is no electricity. The proposed approach consists of PV powered water pump system installed on a mobile cart for irrigating the field. The present work is based on the concept of “pay for power” where an independent source of power will be developed and utilized by the farmers for their irrigation purpose. It will also reduce the dependency of the farmers on conventional electrical companies and further reduces the cost of farming.

1. Introduction
The main hurdle towards the development of Indian agriculture sector is intermittent supply of electricity in rural areas. India’s rural system is still in developing phase, with major sections of its populace are still waiting for un-interrupted electric supply for their irrigation work. In an isolated sector such as the rural zones, the use of the RES mainly Photo-Voltaic (PV) provides better solution to obtain required electric energy for their applications to both the domestic and agriculture sectors [1,2]. Hence, in this scenario stand-alone PV systems are obtaining an increasing interest and becoming very competitive solution in India, because excess sunny days are available throughout the year.
Now-a-days PV based farming irrigation systems are generally employed for farming, livestock and water supplies at low scale level [3]. The main applications of PV stand-alone systems in remote or rural areas are for water pumping where considerable amount of solar radiations are available and have no access to electricity [4]. An effective option must ensure that the PV systems to operate on the Maximum Power Point Tracking (MPPT) concept [5]. Once an initial investment has been made, this green approach for electricity application provides free energy.
In this paper, based on novel concept of pay-for-power, solar powered mobile smart irrigation cart has been proposed. This system can provide options to the farmers located in isolated or rural places where reach to electricity is still a concern. If farmers don't want to pay a large upfront cost (initial cost), farmer can still irrigate their land by taking advantage of proposed solar irrigation cart service. They just have to pay for the amount of power they have used. On this mobile cart, complete irrigation system has been installed which drives water pumps to pump water from bore well to crop field using solar irradiations. The objective of this paper is to develop a hardware-based model that will help the farmers to irrigate their land without taking energy from the main grid. SCADA software has been used in order to simulate the performance of the proposed approach and the results obtained are quite satisfactory. The paper has been divided into six sections comprising the introduction and problem formulation, the proposed solution, system description, hardware implementation, and finally conclusions are made in the final stage.

2. Proposed Solution
As discussed earlier, the concept of pay-for-power has been implemented on hardware model in which farmer have to only pay for the amount of unit used during irrigation process. They don't have to install the whole system. It mean the initial cost of the whole system will be saved. They will be also free from the maintenance charge. This project can also be used in the place where the grid connection has not reached till now such as Nagaland, many mountain regions of India. Talking about the worldwide it can be mainly used in African country. The block diagram of the PV based irrigation system is shown in ‘Figure 1’.

![Block diagram of the PV based irrigation system](image)

3. Hardware Model Description
The complete hardware implementation comprises of mainly four modules—(i) Solar pumping module, (ii) automatic traction of sun intensity, (iii) moisture sensor, and (iv) installation of whole system on cart.

3.1 PV based pumping module
In this module (as shown in ‘Figure 2’), a solar panel and a pump set of required specification is mounted on cart. A control circuit has been used to charge a battery that provides supply to the converter circuit that energizes the water pump. This pump pumps the water in to an overhead tank for storing water temporarily before releasing into the field or directly release to the ground. A 12V DC pump has been employed in the hardware for pumping the water from about 15 feet. The sump of about 10 feet has been considered.
This pumping module tracks the micro level of the water in the field with the help of the drip irrigation system which will further save the water.

3.2 Solar tracking system

Solar tracking system (as shown in ‘Figure 3’) can be considered as a main part or heart of the complete project. Using tracking system, the PV panel oriented towards the solar irradiations. This system uses microcontroller to determine the location of the Sun relative to the object being aligned. The microprocessor processes complicated algorithms that enable the system to track the Sun, and sensors. Tracking system also provides information to microcontroller about the location of Sun and accordingly the direction of the panel is set.

The sunlight intensity varies from dusk-down so it is required to track it. Light Dependent Resistor (LDR) based sensor receives the sunlight intensity and generates command to the microcontroller. Microcontroller converts these signals to ramp signal and further gives commands to the motor driver and accordingly the direction of a panel changes.

While considering a complete day, following possibilities can be found:

a) If the voltage of LDR1= voltage of LDR2 then the motor is stable and if the voltage of LDR1 is not equal to LDR2 then compare the voltages.
b) If LDR1> LDR2 then rotate the motor in clock wise direction.
c) If LDR1< LDR2 then rotate the motor in anti-clockwise direction.
d) At time T = 17.00 hr. bring the motor to the initial position.

On the basis of above possibilities, the proposed flowchart of solar tracking system is given in ‘Figure 4’.
Figure 4. Proposed flowchart of solar tracking system

When the sun light falls on LDR sensor, the analog signals are generated and this digital form of these signals are obtained with the help of Analog-to-Digital Convertor (ADC) and these voltage signals are compared. In this project two LDRs are used. With the help of microcontroller, these LDRs measure irradiation intensity. Microcontroller reads and compares values of both LDRs and rotates the solar panel system using 12V DC gear motor. If the intensity of light at both the LDRs are same then solar panels don’t rotate and stepper motor remain in off condition. Circuit diagram of microcontroller based solar tracking system is shown in ‘Figure5’.
When there will be no light on PV panel, that is, during night condition, it will remain in stable condition. During Morning time, left light sensor has been turned ON and starts rotating the PV panel in linear mode with the help of stepper motor. Rotation of motor depends on the intensity of light. PV panel keep rotating until light intensity on both sensor remainssame. When both sensors have same intensity of light, solar panel become stable. This process repeat in reverse direction after 12:00 noon.

In evening time, when the light intensity of both the light sensors become equal, the solar panel again becomes stable. This process remains continue during day timing. At 17.00 hr. the motor brings the panel to its initial position.

3.3 Moisture sensor

A moisture sensor (as shown in ‘Figure 6’) senses the moisture level present in the irrigation field. It has a level detection module where a reference value can be set. This moisture circuit can be used with probes that produce a voltage proportional to soil moisture. YL38 comparator module, a single channel OPAMP comparator based on L393 IC, has been employed in the present work. This module compares the output voltage of the sensing probe with a reference voltage and switches its voltage appropriately for the microcontroller to read.

‘Figure 7’ shows the circuit diagram of moisture sensor based automatic control of irrigation pump.
3.4 Cart module
By using cart module, extra feature of the mobility has been added to the hardware. The complete hardware has been mounted on the movable cart so that the system can be move to any place as per the requirement of the farmer. So that it can be used in the place where the transmission line has not reached till now such as various hilly regions and various part of villages where reach of electricity is still not possible. This type of mobile cart system has been extensively required especially in rural areas of states like Rajasthan, UP, Gujarat, and Punjab because sunlight has been in abundance. ‘Figure 8’ shows the Cart design on which electrical hardware has been mounted.

![Figure 8. Cart design](image-url)
4. Hardware Implementation

The details of components used in the proposed work are given in Table 1.

| S. No. | Component     | Rating      | Quantity |
|--------|---------------|-------------|----------|
| 1      | PV panel      | 12V, 50W    | 1        |
| 2      | DC Pump       | 12V         | 1        |
| 3      | LDR           | -           | 2        |
| 4      | Battery       |             | 1        |
| 5      | DC gear motor | 12V         | 1        |
| 6      | Microprocessor| AT89S52     | 1        |
| 7      | Moisture sensor| YL69      | 1        |
| 8      | Cart          | -           | 1        |

The complete hardware development has been divided in four modules, as –

4.1 Module 1
This circuit (shown in ‘Figure 9’) has been developed to amplify the signal obtained from the LDR sensor and give command to the microcontroller AT89s52 in the form of 0 and 1.

![Figure 9. Circuit of solar tracker](image)

After that the microcontroller gives command to the DC gear and the motor rotate the solar panel according to the sunlight.

4.2 Module 2
In this module, the amplifier circuit connects to the microcontroller (as shown in ‘Figure 10’). By doing so the device can able to detect and follow the movement of observable indoor as well as outdoor lights.
Figure 10. Developed circuit of microcontroller and solar tracker

The microcontroller based solar tracker employ DC gear motors for enabling a wide range of rotation for the PV panel.

4.3 Module 3
In this module, the moisture sensor circuit has been developed and shown in ‘Figure 11’. As the water level increases in the field the moister sensor resistance decreases and gives command to the microcontroller and further to the relay.

Figure 11. Developed moisture sensor circuit

As the relay get command it trip and the pump stop pumping water to the field. In this way the moister sensor adds additional advantage to our project.

4.4 Module 4
At the end, the proposed approach has been implemented on a small hardware as shown in the ‘Figure 12’. The final product, that is, the solar tracker assembled on the movable cart which will move the panel on a single axis in the direction of sunlight.
When the sun light falls on the panel the LDR sense the intensity of the sunlight and make the rotation of panel according to the sun intensity this increase the efficiency of the solar panel and the battery store the charge. Now the store charge is used the run the pump or it can directly be run from the panel if it is DC pump and with the help of controller (buck & boost convertor). The flow of water is control by moisture sensor. Moisture sensor gives command to the microcontroller and microcontroller give command to the relay to cut the supply to the pump. In this way the whole system works. This complete system has been installed on the cart which provides mobility to the project as shown in ‘Figure 13’.

5. Conclusion
The goal of the project was to design and implement a small-scale PV based smart irrigation cart. The present work provides a smart solution to Indian farmer to deal with energy crisis and economy crisis. In this system they can use the power without installing the whole system with the help of pay-for-power concept. This project can also be used as a mobile micro grid. By connecting several carts makes it a small micro system which can be used in the isolated regions such as near flood regions, hilly area etc. and
the place where the electricity has not reached till now. It can also use as secondary source in the village where the electricity is not present throughout the day. The use of PV based smart irrigation cart system can reduce the economical load on the farmer and also reduces the peak load demand on the power stations.

6. References

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