

# Sensor based Solar Tracker System using Electronic Circuits for Moisture Detection and Auto-Irrigation

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**Abstract**— In this study, we propose a simple but efficient, low-cost power efficient embedded system for solar based Off-Grid irrigation by orientation of the solar panel in the direction of the sun for providing the necessary power source in remote areas or in the field for irrigation where it is not possible to provide charge through a stable current supply. The solar panel is used for charging 5V supply. We have used Soil moisture sensor to sense the moisture conditions of the soil. Based on moisture sensor values, a water pump is connected to switched on and off automatically. When moisture level of the soil reaches to low, the soil moisture sensor is sending the signal to microcontroller to start the pump by using stored solar energy. At the same time, using GSM, microcontroller sends message on farmers mobile about pump status. The microcontroller receives the pump status, moisture condition of the soil and moisture and temperature in air or enclosed region and provides this information over a data acquisition device. The system can be utilized in varied domains by regulating the voltage necessary including mobile phone charging, access drip irrigation and also weather data monitoring and irrigation facilities.

**Keywords**— Solar Panel, soil moisture sensor, Arduino Uno, GSM

## I. INTRODUCTION

Solar power panel installation and use has become a modern day revolution with most of the scientific community using the immensely potential inexhaustible and non-polluting solar energy source to suffice our ever-increasing energy requirements for agro based applications and building scientifically clean and environment friendly applications. In India, agriculture assumes an imperative part to advancement of nation as our economy for the most part in light of it. India positions second worldwide in cultivate yield. However, with increase of population in urban and semi-urban townships, most of the ground water resources have depleted due to

mismanagement water conservation and planning. As most of the fresh water supply is to be provided to households, the critical factor for the farming is facing difficulties to manage sufficient supply of water. As the rural households require water, carrying sufficient water from rivers and water shortage, the Government has to apply fast track agro-based automation for water supply for irrigation that will suffice the need to make legitimate utilization of rural water supply use and coordination that will stop squandering of water reservoir to huge extent. With the expansion of Social schemes on rain water preservation focused on water conservation and drainage, it has turned out to be vital to manage on the utilization of water using electronic equipments and instrumentation in places where it is not possible to manage water using electric power resources. In order to address this issue Solar based irrigation factors can be utilized to a great extent in irrigation to optimize use of water by adopting sensor base irrigation system. Soil moisture sensor base irrigation system ensures proper moisture level in the soil for growing plants in all season. In this system, sensor is sensing the moisture content of soil and accordingly switches the pump motor on or off. Soil moisture sensor is used to detect the soil condition whether the soil is wet or dry. If soil is dry, the pump motor will pump the water till the field is wet which is continuously monitored by the microcontroller. The main advantage of soil moisture sensor is to ensure accurate measurements and farmer doesn't have to visit his farm to operate the pump. It is necessary to identify impediment work items for tasking the devices to automatically orient the solar panels in the direction of the sun's position and the direction of the solar panel to get the maximum output from the solar cell. The practical inefficiency of solar-energy conversion for solar panel components fixed at a certain angle is that we cannot track the sunlight direction with diurnal and seasonal changes. As a result, power output for the system cannot be

improved as the area of exposure of sunlight on solar panels and efficiency of the solar tracking system involving solar panels cannot be improved. Our effort is to develop solar panel tracking system. We also develop sensor base irrigation system based on soil moisture. This work is an application development done in college project. In the proposed work, done we had first collected all the necessary components and then used a solar panel to drive a battery for charging. The light dependant resistors were not connected although in the proposed study, we proved using electrical output. After this work, we connected the DHT11 sensor for moisture and humidity analysis and the soil moisture sensor interfaced with the GSM relay to calculate the output. The Raspberi pi device had been also attached with the Arduino to collect serial port data information for moisture and humidity mapping of the soil and ground.

In order to address the issue first, we include in our design the solar cell which looks as shown in Figure 1.

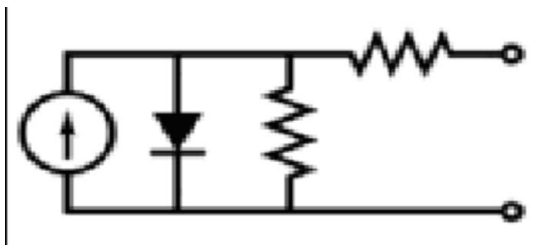


Figure.1: Equivalent Circuit of Solar Cell

In order to model and analyze the electronic behavior of a solar cell, it is useful to create a model which is electrically equivalent, and is based on discrete electrical components. An ideal solar cell may be modeled by a current source in parallel with a diode. In practice no solar cell is ideal, so a shunt resistance and a series resistance component are added to the model. The result is the "equivalent circuit of a solar cell". Dynamic trackers measure the light force from the sun to figure out where the sun based modules ought to be pointing. Sensors situated on the tracker at different areas and if the sun is not incidental on the tracker specifically there will be a change in light force on one light sensor contrasted with another and this distinction can be utilized to decide in which bearing the tracker needs to tilt to be facing in the direction of the solar rays.

## II. TYPES OF SOLAR TRACKERS

First, There are many different types of solar tracker which can be grouped into single axis and double axis models.

### A. SINGLE AXIS SOLAR TRACKERS

Single pivot sun powered trackers can either have an even or a vertical application. The flat part of the system is utilized as a part of tropical day where the sun gets high at twelve, yet the days are short. The vertical sort is utilized as a part of high scopes where the sun does not get high, but rather summer days can be long. These have a physically customizable tilt point of 0 - 45 °and programmed following of the sun from East to West. They utilize the PV modules themselves as light

sensor to maintain a strategic distance from superfluous following development and for dependability. During the evening the trackers take up a level position as appeared in figure 2.

### B. DUAL AXIS TRACKERS

Double axis solar trackers have both a horizontal and a vertical axle and so can track the Sun's apparent motion exactly anywhere in the world. This type of system is used to control astronomical telescopes, and also in hydro plants to send water at fixed points in the using solar power predict and track the motion of the sun across the sky. Dual axis trackers track the sun both East to West and North to South for added power output (approx 40% gain)and convenience. In our structure and prototype design, a servo motor has been added for the two degree of freedom of the solar panel.

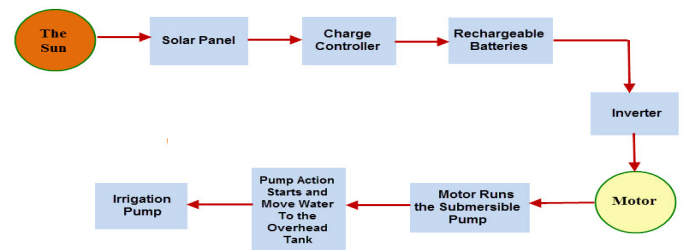


Figure 2: Pump Action and Irrigation Monitor Control

These stationary as well as expensive solar panels are unable to extract the maximum solar energy as there is no stability of weather conditions [3]. The power output of solar panels is maximum when it is oriented perpendicularly to the direction of sun rays as both the area of illumination of sunlight on solar panels and intensity of sun-rays is maximum in this case. It has been found out that the efficiency of solar panels improve by 30-60 percent for mobile solar tracking system instead of a stationary array of solar panels [4]. The design and implementation of a power efficient solar tracker is challenge owing to the immobility of the solar panels. The angle of inclination of sun-rays with the solar panels continuously changes due to the movement of the sun from east to west because of earth's rotation independent of the weather conditions [5]. The essential thought behind this work is that the power of light will be detected by the LDR's, the comparators will contrast the episode light force and the force of opposite occurrence. The small scale controller will turn the stepper engine by the coveted point upon the yield of the comparators by means of a stepper motor driver circuit to expand the productivity. For the adjustment in the area where the instrument is set and climate conditions, the power of daylight changes, for which we have influenced an arrangement of changing the limit to an incentive by utilizing variable resistances.

## III. LITERATURE REVIEW

Several research and hardware based analysis shows that we can apply auto-tracking techniques for the analysis of solar tracking methodology. The autotracking of a 8051 microcontroller based solar tracker using a combinations of LDRs, opto-couplers, stepper motor,

relays, analog to digital converter, etc and manual tracking done by a “Sun Tracking Software” is reported in [1]. Anuraj et al reported the implementation of a solar tracking system using ATMEGA 16 which improved the power efficiency by as much as 20% [2]. Tudorache *et al.* explained the design and execution of solar tracker system for Photovoltaic (PV) power plants. The operation of the tracker is based on a DC motor controlled by an intelligent driver circuit which moves a mini PV panel sensing the difference signal from two efficient light sensors [6]. The tracking implementation of a solar tracker prototype using a PIC 16F84A microcontroller with the design of two degrees of freedom- azimuth and vertical is reported in [7]. Many recent studies involve the use of a dual-axis solar tracking PV system utilizing a feedback control theory, a four-quadrant light dependent resistor (LDR) sensor and simple electronic circuits. Tracking is accomplished with the help of a unique dual-axis AC motor and a stand-alone PV inverter [8].

#### IV. APPLICATION OF THE ALGORITHM

The Arduino microcontroller receives analog input from panel. The maximum voltage which can be obtained from solar cell is set as reference voltage in micro controller. The Panel output voltage and current is compared with the reference voltage and current accordingly controller gives signal to the stepper motor. If the output of ADC is equal to the reference voltage then stepper motor keeps the solar panel in same direction. And if output is less than reference voltage then stepper motor keeps rotating the solar panel till we get the voltage equal to the reference voltage. The Solar panel will be controlled by a stepper / servo motor to rotate to adjust the light on fixed time basis (LDR is not used to get the time benefit). From Solar Panel, a rechargeable battery will be charged. The battery will be used to operate the pump. There will be moisture sensor, and when the value goes below a predefined value it will start the pump. Also the user gets an SMS notification at his / her mobile about the moisture status when it goes below the predefined value. The entire project will be controlled using Arduino. The Arduino Moisture sensor is used which controls the data using serial pin and transfers the output to Raspberri pi to data log from the sensors.

#### A. Hardware Development and Implementation

In this section, we will elaborate the block diagram, circuit diagram, working principle and different components required for the implementation of our solar tracking system. Figure 3 shows the block diagram of the designed solar tracker system.

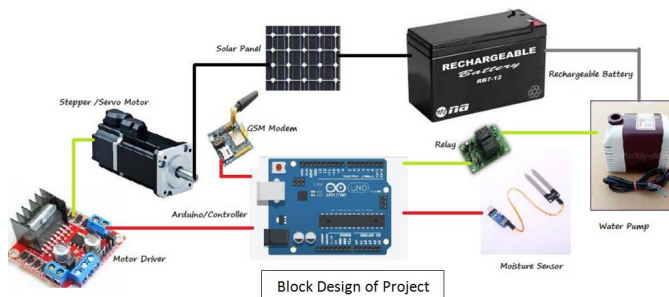


Figure 3: Module Diagram for the Stepper Motor

For condition 1,  $V_{out}$  will be close to 5V and under normal light condition  $V_{out}$  will be close to 2.5V. So, to differentiate between normal light condition and perpendicular light condition, we set a threshold of approximately 4V. Stepper motor is a digital actuator whose input is in the form of programmed energization of the stator windings and whose output is in the form of discrete angular rotation. The stepper motor is used to rotate the solar panel accordingly where we obtain maximum voltage. The cylindrical covering is used to prevent the stray light from being detected by the LDRs [9]. We had earlier calculated the resistance of the LDR under three different situations using multimeter. The steps involved in the selection of stepper motor are as follows,

1. Initialize a servo object for the connected servo
2. Initialize the relay pin and other variables for sensor information
3. Attach the signal pin of servo to pin9 of Arduino
4. Sets the GSM Module in Text Mode
5. Set Mobile Phone Values
6. Send SMS on pump status on pump on and off
7. Servo command to set value for rotation of the servo motor
8. Rotate at the specified angle for specifying the acceleration
9. Call the functions
10. Set the value of the moisture sensor using loop to be put in Raspberri pi to calculate every minute.
11. Read data using the dht11 sensor to calculate the temperature and humidity using data pin.
12. Put the delay to calculate using serial pin port.
13. Raspberri pi measures the change of soil moisture using values for the soil moisture sensor
14. Calculate humidity and temperature using DHT11 sensor gives the condition of the environment.
15. Apply machine learning algorithms to identify the nature of the soil conditions.

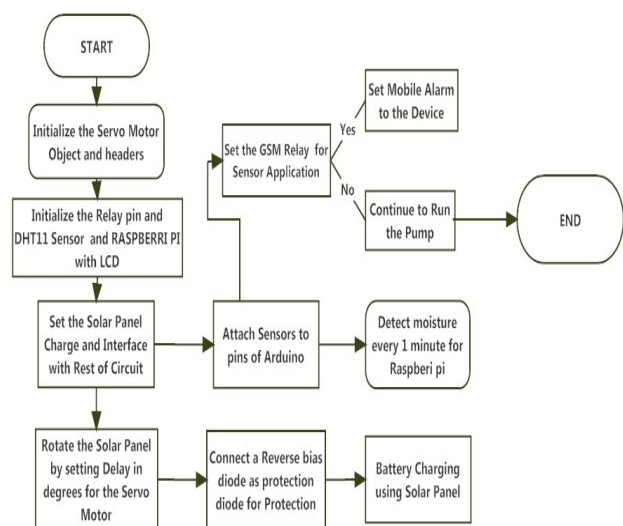


Figure 4: Flow Diagram showing Execution of Hardware and software implementation

The main advantages of this proposed system are as follows. By utilizing soil moisture sensors in the field, this framework gives water to plants. Further, utilization of this sustainable power source is not required due to the use of a solar powered device. This sustainable power source delivers practically zero waste items, for example, carbon dioxide or other substance poisons, so it has least effect on condition. The proposed framework controls measure of water use for water system in the agrarian fields. In this way it lessens inordinate weight on agriculturists to pay extra water levy on water. Notwithstanding this controlled water system likewise spare extra cost for water pumping, decreases the movement and circulation problems in the field level. This framework diminishes keep running off from over watering soaked soils, abstain from inundating at the wrong time, which will enhance sufficient water and supplement adjusting in the field at the time of requirement. Further, it counteracts saltiness of rural grounds which cause for poor profitability and land fertility dinnudation through soil moisture level identification. What's more, this framework helps in efficient, expulsion of human mistake in modifying accessible soil dampness level and to boost their net benefit. By utilizing sunlight based following framework when contrasted with settled boards, vitality yield is expanded. Principle use of the proposed framework is for water system of agribusiness fields. Indeed, even we can apply this framework in agribusiness, especially in nurseries or controlled farming frameworks, high accuracy soil dampness control can be achieved. Utilization of sunlight based vitality in the proposed framework enables us to utilize this framework in remote ranges where power is not accessible.

## V. CONCLUSIONS

Solar power provides sufficient amount of power to drive the system. To overcome the necessity of electricity and ease the irrigation system for our farmers, the propose model can be a suitable alternative. The designed solar tracker system could track the movement of the sun in bi directional movement. The power obtained by solar tracking is almost constant over a period of time when compared with the output obtained by panel without tracking. Figure 5 shows the designed solar tracker system which is actually a working model of the main system. The components used for the tracker are Microcontroller (Arduino Uno), OPAMP as comparator (LM358), Servo Motor (4SHG-050A 5IS 5V, 5 $\Omega$ ), Solar panel (Module type-SS3P) and Stepper Motor Driver and Moisture Sensor and DWT11 Moisture and temperature sensor which gives the necessary output to the arduino for tracking the soil conditions in different places. For making the system more reliable fault indicators can be added.

Hardware will be enhanced further with the use of different sensors. The model developed by us is an integrated system as we have used an arduino as a programmable microcontroller and also using raspberri pi in interface with arduino for control. Thus although the system lacks a bootloader and requires an inbuilt bootloader, efficiency of the system will be dependant on the scale of the farm in use. The solar access energy produced using solar panels can also be given to the grid which small modification in the system, which can be a source of the revenue of the farmers and local community and encouraging profitable farming and techno-innovation in India and same time giving a solution for energy crises.



Figure 5: Designed Solar Tracker System

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