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Sun Tracking Solar Panels and Auto Watering of Farm Lands - Extended Work

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***Abstract*— *Appropriate methods are important when it comes to irrigation to ensure maximized yield from the field. Most often it is found that water is not managed scientifically in Indian working environment when it comes to farming leading to a huge wastage of this precious resource. Again sunlight which holds enormous potential cannot be properly utilized due to lack of technology and design. The design we have made presented in this work takes care of both these aspects. Firstly we framed a design where the solar panels will rotate about their axes positioning themselves in alignment with sunbeams so that the panels are exposed to more sunlight increasing manifold the power outputs. The second part of this model comprises a sensor network meant to measure the moisture level of soil employing gypsum as the sensor. The sensor network senses the moisture content, sends it to a controller where a decision is made about water requirement of the field. If found affirmative, it runs a motor. Now the enterprising part of this model is that both rotation of panels and running of motor will be driven by the power generated by the solar panels. Here it requires very efficient design requirements and rigorous analytical calculation to make this ensemble work. The results obtained from the prototype model show great congruence with the expected results. The prototype is ready and the next step lies in actual erection of such systems in real life farms and see it does it fare in actual scenario. Thus the effectiveness of the model is established experimentally.*

Keywords*—*Moisture sensor, solar panels, Ardiuno microcontroller, DC servo motor.

I. INTRODUCTION

With population growing at a burgeoning rate and farming lands getting sacrificed for house building and industrial automation purposes, it is ripe time to consider about the modernization and automation in the field of irrigation. Most of the available natural resources we avail today, are ill handled and managed because of poor farming practices leading to both lesser yield and obliteration of these prised assets. In countries like India and others which are still predominantly agrarian, irrigational automation must be brought to its best to resolve the problems at hands. This demands for a superior water management scheme and utilizing of alternative everlasting and non-conventional energy sources like sunlight to its fullest efficacy.

II. SCHEMA OVERVIEW

The paper aimed at enhancing the utility and efficiency of solar power by designing prototypes enabling the mechanism for superior reception and conversion of solar power. This is achieved by making sure that the panels are exposed to maximum sunlight for longer works of the day. Secondly, a very simple and cheap material viz. Gypsum being used as moisture sensor will help the cause in evaluating the water requirement for a farming lands and based on its assessment, the field will be watered. Now the novelty of this project lies here that both the rotation and solar panels and powering of submersible motors will be done by the power generated by the panels itself. The controller used by us is Ardiuno which are only suitable for small scale implementation.

III. SOIL MOISTURE SENSORS

For measuring the content of moisture in the soil under study, we have used very cheap and easily available gypsum blocks. Gypsum has a unique property where its conductivity changes proportional to introduction of water or moisture to it. This property has been exploited here. The gypsum sensor when made wet, electrons get free passage and the resistance dips massively making the block conductive.

Several gypsum blocks of cylindrical structures wrapped with semipermeable covering around them are erected and placed in the field as an array connected in series – parallel configuration. The wrapping is done to protect the blocks in holding their shape and structure which otherwise will melt down being exposed to much of water over long periods of time. This though brings down the response time of the blocks but this is an acceptable trade off as very high accuracy and precision are not matters of great concern here. The soil tension increases with the dryness of the soil and when fully inundated it stands at

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around 8-10 KPa. Figure 1 showing the relationship between soil moisture levels and soil moisture tension. It is nothing but soil resistance value translated in KPa.

Heuristic results as obtained by us in laboratory taking different types of soil samples and testing them under different temperature conditions are provided in the adjoining table.

Table.1: Resistance offered at Different Temperature (soil type: sand)

SL. No	Temp.	Type of material/ sample	Resistance across probe(Ω)
1.	15 ° C	Open	>8 MΩ
	15 ° C	Super Dry Sand	1.2 KΩ
	15 ° C	Wet Sand	9100 KΩ
	15 ° C	Sand soaked in water	860 KΩ
2.	30 ° C	Open	>10MΩ
	30 ° C	Super Dry Sand	12800Ω
	30 ° C	Wet Sand	8300Ω
	30 ° C	Sand soaked in water	810Ω
3.	45 ° C	Open	>10MΩ
	45 ° C	Super dry sand	13900Ω
	45 ° C	Wet sand	9000Ω
	45 ° C	Sand soaked in water	920Ω
4.	55 ° C	Open	>12 MΩ
	55 ° C	Super dry sand	2.1 KΩ
	55 ° C	Wet Sand	1.77 KΩ
	55 ° C	Sand soaked in water	1.55 KΩ
5.	65 ° C	Open	>13.5 MΩ
	65 ° C	Super dry sand	2.6 KΩ
	65 ° C	Wet sand	2.3 KΩ
	65 ° C	Sand soaked in water	2 KΩ

Figure 2 and Fig 3 depict the circuit and very elementary design and structure of a gypsum block used for measurement of moisture as carried out with sand sample on a table top.

IV. EXPERIMENTAL SET UP

Here we discuss about the devices and equipment used while designing the prototype. The accessories used are mentioned below

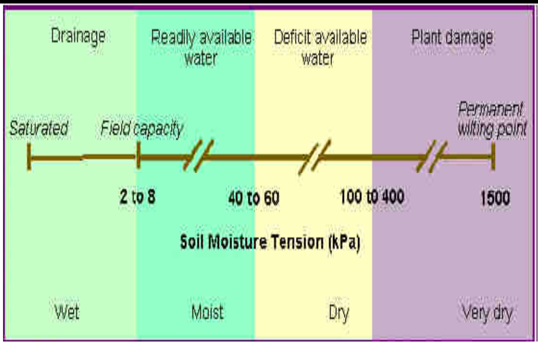

Fig.1: Soil Moisture to water tension of soil conditions

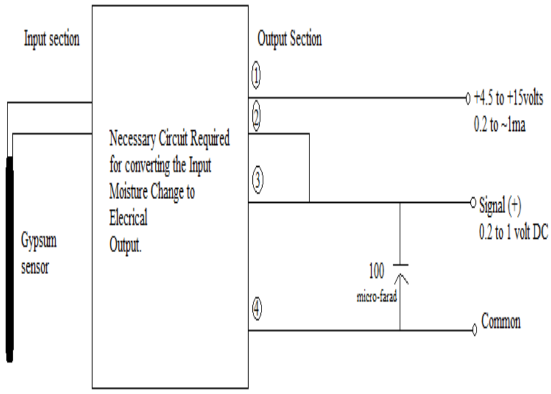

Fig.2: Voltage output against moisture capacity

Fig.3: Gypsum Moisture Sensor Block

i) Gypsum based soil moisture sensors in arrays (6X10)
ii) 100 W solar panels: 4 pcs, (5 A, 21.6 V, weight 8 kg approx.)
iii) Mechanical gear arrangement for panel rotation. (25:1)
iv) CdS (LDR) light sensors (4 for each panel)
v) AD0804 A/D converter for signal conversion.
vi) Comparator circuit and differential amplifier.
vii) DC motor (12 V/30 W) for driving the solar panels.
viii) Submersible pump PS 150 (12 -24 V DC, Wattage 12 W, flow rate 1100 gallon/hour)
ix) Inverter (120/240 V AC)
x) Deep cycle batteries (360 amp-hr, 20 hour)

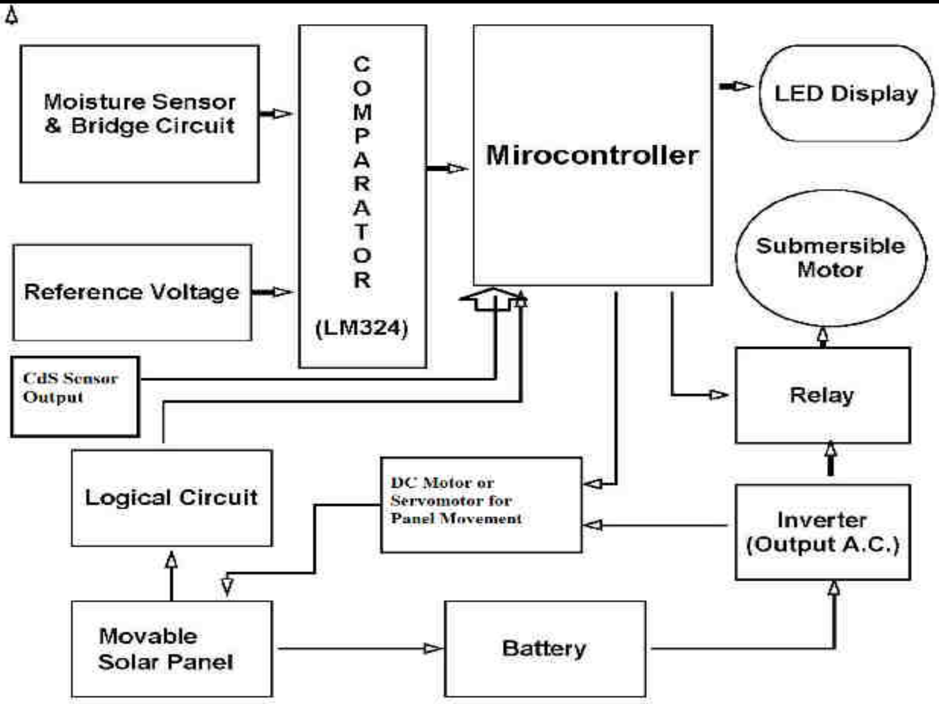

Fig.4: System Set – Up Block Representation

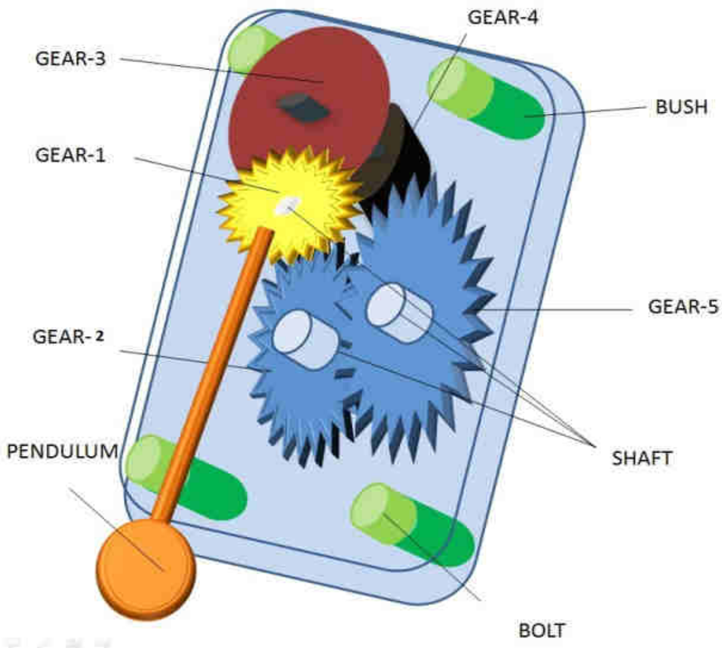

Fig.5: Gear Box Arrangement for Motor rotation

The heart and soul of this project is the Ardiuno microcontroller which controls the entire mechanism based of signal received from the sensors and followed by comparison as provided by the algorithm.

Here there are two aspects of the electronic circuit, firstly sensor network array fed to the microcontroller which decides whether to water the plot or not. Second aspect is to rotate the PV panels based on sensor data directing the DC motor to rotate the panels accordingly.

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Fig.6: Actual System Snapshot

Algorithm I: Steps: Motor driver logic

1: Delineate moisture sensor with ratings of (75 kPa, 270 mV) for dry sample and (8kPa, 720 mV) for drenched sample.

2: Fix the voltage reference (equal or less than output voltage) at 750 mV for maximum wet condition (< 8 kPa)

3: Hold comparison between sensor output and ref. input. Set HIGH (1) if O/P is lower than ref. otherwise set LOW (0) or initial state.

4: Check for battery status connected to PV panels parallelly.

5: Check for the under given conditions

a.) O/P is 1 but battery charge insufficient to run motor;

Indicate dry soil status with Red coloured LED, send signal LOW to the relay.

b.) O/P is 1 & battery charged sufficiently to drive motor;

Indicate dry soil status with Red coloured LED, send signal HIGH to the relay

c.) O/P status LOW;

Indicate dry soil status with Green coloured LED, send signal LOW to the relay.

Relay when receives HIGH from controller, it establishes contact between the battery/inverter and the DC/induction type submersible motor and the motor will start.

6: Go back to step 3 and repeat.

Algorithm II: Steps: PV Panel Rotation

Provided below is the most rudimentary algorithm and flowchart diagram for solar tracking, although the actual circuit presentation is much more complex.

1: Based on LDR1 and LDR2, outputs, Q1 & Q2 are generated as per the Boolean Expression:

$$A_1 = LD_1\overline{LD_2} \quad \ldots\ldots\ldots. (1)$$

$$A_2 = LD_2\overline{LD_1} \quad \ldots\ldots\ldots\ldots. (2)$$

2: A_1 and A_2 are inputs to the Microcontroller. The controller checks for input status periodically.

3: The motor will drive the panel towards the direction which reads brighter.

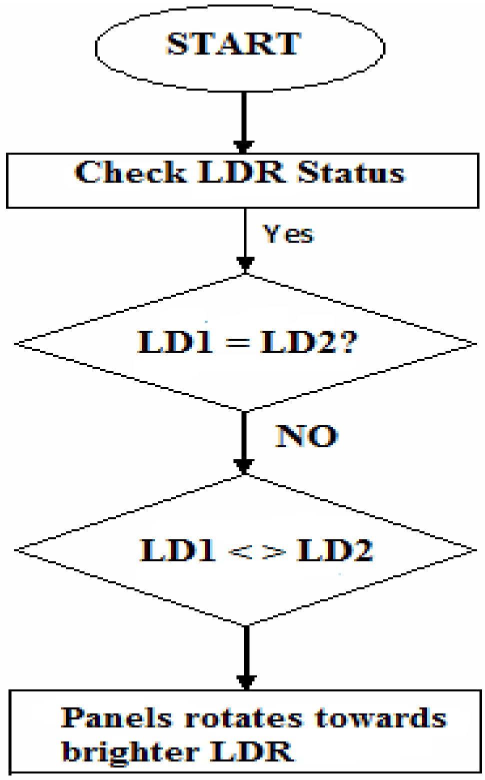

Fig.7: Panel Movement Flowchart

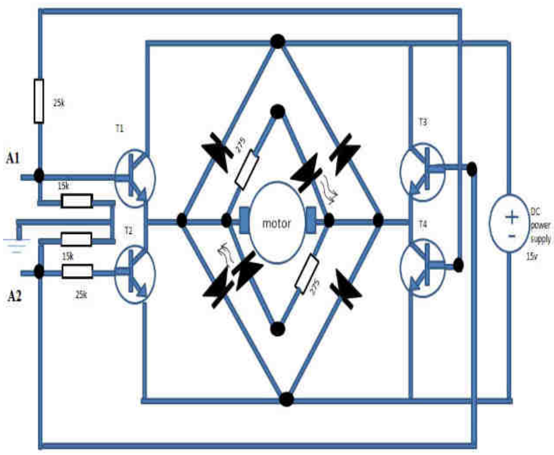

Fig.7: Motor Driver circuit for solar directions

Geared motors (1:200, torque: 5 Kg-cm) offer the benefit of producing better torque which we utilized in rotating the PV panels. As it is not a perpetual rotation but a very slow and steady movement, power consumed by motor is less, hence a reasonably powered motor did the job. Motor Type: DC motor, TG – 05R – AG.

V. PERFORMANCE ANALYSIS

Starting with the rotating solar panels, it was observed that the electrical energy generated is 80 W-hr in comparison to static PV panels that generates 64 W-hr on a bright sunny day averaging over 12 hour time, thus giving a straight forward extra efficiency of 16 W-hr (25 %). The total power consumed in driving the rotation of PV panels and running the submersible pump simultaneously is 45 Watts with maximum current drawn being 4 Amperes which is well within the range of the ratings produced by the PV panels. Again once the field is covered with 1 inch of water level, the pump is turned off automatically as programmed with the microcontroller when the sensor arrays give zero impedance reading. Cost of design of prototype design is INR 10000.

VI. HARDLES AND CHALLENGES

The biggest challenge of this work lies with implementing the project on a massive scale, where coupling of all these electrical and mechanical parts may pose few hiccups. In order to generate more solar power, larger therefore heavier solar panels will be required in huge numbers. It will take a huge amount of power to rotate all these panels in unison. Other than these, there lies many unforeseen and unpredictable hindrances which may surface at the time of industry level implementation. The initial cost of implementation will be huge requiring the procurement of solar panel, mechanical set up for rotation, submersible pumps an d all other ancillary items as it costs more 10000 INR to develop only the prototype.

VII. FINAL OUTCOME

As expected the prototype design has worked really appreciably to the expected outcome. It therefore helped the cause of resource management in two manners. Firstly the potential of the solar panels and that of the incident sunlight have been utilized much effectively. Secondly we also have relinquished ourselves from watering the farming lands, saving a lot of man hour. Also as how much amount of water and when required is known, wastage of this priceless resource is checked to a very high level.

The scope of advancements in this work is still many. The efficiency of the solar panels we used stood at 20 % of their incident solar power. Enhancing this conversion rate will generate a lot more power, although this aspect will be dealt by semiconductor and materials engineers. Making the structural set up light yet durable will reduce the power consumption involved in rotating the panels. We do look forward to many such aspects so that more and more automation may be brought in the fields of agriculture and irrigation.

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