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Sensor and Solar Based Irrigation- Eco-Friendly Approach

Faruk Bin Poyen[#1], Pankaj Saha[*2] Deep Mukherjee[#3]
[#]Dept. of AEIE, UIT, BU, Burdwan, India
[3]School of Electronics, KIIT University, Bhubaneswar, India

ABSTRACT - In the field of agriculture, use of proper method of irrigation is important because the main reason is the lack of rain & scarcity of land reservoir water. Again extraction of water from underground is also cost enduring, wasteful and also dependent on other conventional forms of energy. If alternative system can be designed in place of regular methods, electrical cost can be brought down to great extent. The methodology we focus on in this paper is to correlate two different techniques viz. to measure water content in a field and employ solar power to drive motors for running pumps. This procedure will help us in two aspects saving both water as well as electrical or petroleum resources for the future. Solar energy which otherwise goes wasted can be put into effect to great efficacy. The entire set up is to be controlled by microcontroller which will trigger the relay as and when required. The expectations agree to great extent to the desired efficacy.

KEYWORD: Soil moisture sensor, Solar energy, Submersible pump,. Inverters, Batteries.

I. INTRODUCTION

Solar energy, which comes free of cost and does not have any proprietary right, can be put into enormous effect with adequate and proper planning. So far, we have mainly considered solar energy as one method of lighting street lamps and few small household appliances. In this particular paper we look forward to go few steps further and indulge this enormous and pollution free energy source to drive and operate hi-power submersible motors to water irrigation fields and that too automatically controlled. The amount of water required for any **particular** crop will be accounted by a soil moisture sensor made from very easily and cheaply available Gypsum. This paper basically aims at providing ultimate farming solutions specially designed for rural areas. With effective utilization of solar energy to run the motor and micro controller based automatic pumping circuitry the creation of this model is bound to provide decisive solution to rural irrigation woes. The proposal frees one from manually operating the pump and also the sensor network avoids any waste of water which is like gold dust in our rather any part of the world.[1,2,3]

II. OVERVIEW

There are two parts of this entire project set-up. One part deals with automatic sensing of the moisture content of the farming land. Then based on the reading obtained from sensor network, we will take care about how we can employ solar energy for driving hi-power water pumping motors. The motor used by our automatic plant irrigation to water the soil is driven by pure solar energy which makes it highly efficient and conservative.[4,5] Since renewable energy consumption is employed, our work does not rely on any external power source. It is presumed that at "peak sun", **1000 W/m²** of power reaches the surface of the earth. One hour of full sun provides **1000 Wh per m² = 1 kWh/m²** - representing the solar energy received in one hour on a cloudless summer day on a one-square meter surface directed towards the sun.[7,8] Fig. 1 shows the different levels of soil moisture tension for different soil and plant growth conditions.

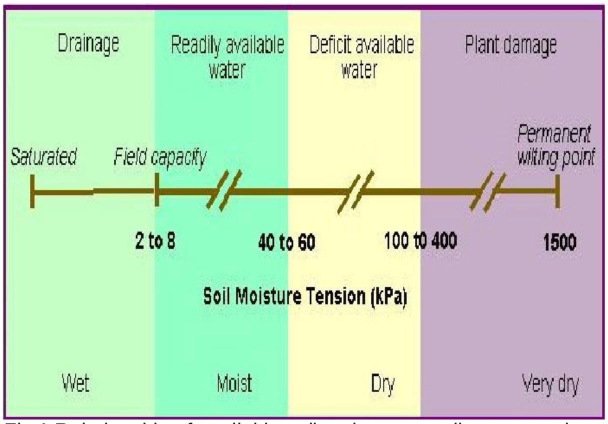


Fig 1 Relationship of available soil moisture to soil water tension

III. Soil Moisture Sensor

There are quite a few very commonly used and easily available chemical compounds which show changes in their physical as well as electrical properties under the presence of different amount of water present in their amorphous as well as crystalline structure. Gypsum ($CaSO_4.2H_2O$) is one such basic compound which has been used as a sensor in this very current context. In principle gypsum block measures soil water apprehension.[19,20,21] One elementary corporeal property of gypsum is that it offers immeasurable confrontation and therefore acts as an impedance material when dry, letting no current to flow through it. On being hydrated, the block allows electrons to pass between the probes efficiently plummeting the amount of resistance between the probes. On being inundated the block offers practically zero resistance. Caring out heuristic analysis and putting those data in table, we can land down with a mathematical relationship that exists between water content and gypsum. The key success of the sensor viz. Gypsum is the number of hydrated molecules[17,18,19]. The impedance property of the crystal is a function of the no. of hydrated molecules present. Therefore the uniqueness of the approach lies with the number of water of crystallization. Fig. 2 shows a very set-up for initial testing done on wet, dry and intermediate sand to check for the sensor functionality.

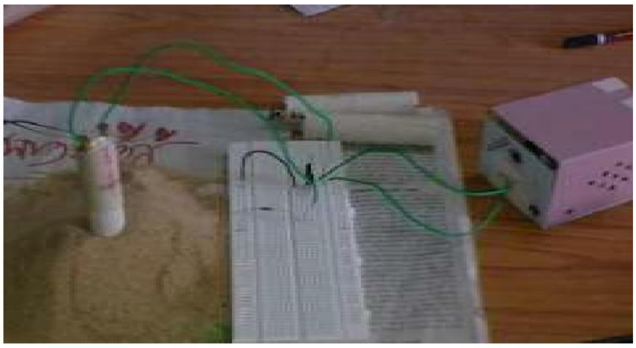


Figure 2 Diagram of the soil moisture sensor

IV. Experimental Result Of Sensor (CASO4.2H2O)

Table 1[22,23] reflects the values of resistance offered by sand under different temperature conditions for different amount of water content in it. Table 2[22,23] provides a comparative analysis establishing a relationship between moisture tension, resistance offered and the amount of potential generated when clay is the sample under test.[14,15,16] The range from 10 kPa to 75 kPa is in fact the most important range for irrigation purposes as different schemes typically maintain tension within this range. Shock et al. came up with the following equation as the most suitable best fit to the data within this range. Fig. 7 represents the graphical representation between soil moisture, soil impedance and volt response.

kPa = (3.213 * kΩ + 4.093)/ {1- 0.009733 * kΩ - 0.01205 * Celsius} ……….. (i) [15,17]

TABLE I
Impedance Response Under Different Temperature Conditions For Sand

SL. No	Temp.	Type of material/ sample	Resistance across probe(Ω)
1.	10 ° C	a) No sample	>10MΩ
	10 ° C	b) Sand (DRY)	10000Ω
	10 ° C	c) Sand (semi WET)	7100Ω
	10 ° C	d) Sand (dipped in water)	790Ω
2.	25 ° C	e) No sample	>10MΩ
	25 ° C	f) Sand (DRY)	12800Ω
	25 ° C	g) Sand (semi WET)	8300Ω
	25 ° C	h) Sand (dipped in water)	810Ω
3.	40 ° C	i) No sample	>10MΩ

	40 ° C	j) Sand (DRY)	13900Ω
	40 ° C	k) Sand (semi WET)	9000Ω
	40 ° C	l) Sand (dipped in water)	920Ω
4.	50 ° C	m) No sample	>10MΩ
	50 ° C	n) Sand (DRY)	13000Ω
	50 ° C	o) Sand (semi WET)	9100Ω
	50 ° C	p) Sand (dipped in water)	1200Ω
5.	60 ° C	q) No sample	>10MΩ
	60 ° C	r) San (DRY)	16500Ω
	60 ° C	s) Sand (semi WET)	10500Ω
	60 ° C	t) Sand (dipped in water)	1800Ω

TABLE II
IMPEDANCE AND VOLTAGE RESPONSE VS SOIL MOISTURE TENSION
T 25 ° C FOR CLAY SOIL

Sl. No.	kPa (25 ° C)	Ohms	Volts(mV)
1.	0	0	1707
2.	0	2	1702
3.	0	4	1697
4.	0	8	1686
5.	0	16	1666
6.	0	48	1588
7.	0	96	1485
8.	0	128	1426
9.	0	256	1230
10.	0	512	980
11.	0	550	923
12.	9	1000	745
13.	10	1100	640
14.	12	1536	596
15.	15	2000	510
16.	25	4096	377
17.	35	6000	347
18.	48	8192	295
19.	55	9200	288
20.	75	12200	272
21.	100	15575	259
22.	120	16384	250
23.	200	28075	233
24.	250	32768	226
25.	**500**	**65536**	**214**
26.	**650**	**131072**	**208**
27.	**800**	**262144**	**205**
28.	**1500**	**10000000**	**201**

V. SYSTEM SET-UP

The accessories we need for the set-up are

a) Gypsum based soil moisture sensor.
b) solar panels
b) submersible pumps
c) inverters
d) batteries

The system starts from the sensor network and ends at the watering system and in between the microcontroller acts as brain of the set-up. The motor used by our automatic plant irrigation to water the soil is driven by pure solar energy which makes it highly efficient and conservative. Since renewable energy consumption is employed, our initiative doesn't rely on any external power source. The work presented here irrigates agricultural fields regularly not requiring any observation. The circuit comprises sensor parts built using op-amp IC LM324. Op-amp's are configured here as a comparator. A sensor network has been netted to monitor and record the content of moisture in the field. The Micro controller is used to control the whole system. It monitors the sensors and when more than two sensors sense the dry condition then the micro controller will switch on the relay and vice versa. The micro controller does the above job after it receives the signals from the sensors, and these signals operate under the control of software which is stored in ROM. Fig. 3 provides a schematic diagram of the set-up.

On the other hand solar engine works as follows: 1. The solar cell starts charging the capacitor and the voltage rises. 2. As soon as the capacitor reaches around 2.7 V the 1381 turns pin 1 high and turns the 3904 ON. 3. When the 3904 turns on, it brings the base of the 3906 low which turns the 3906 ON. 4. With the 3906 ON current is supplied to the base of the 3904 which keeps it ON.

5. Now current can flow through the motor and it starts running.

6. When the voltage gets down to 0.7V the transistors turn OFF and the process is repeated, as explained in Fig 4.

Fig. 5 (a), (b) and (c) show the circuit diagrams of the sensor network and controller.

VI. Block And Circuit Diagram Representation

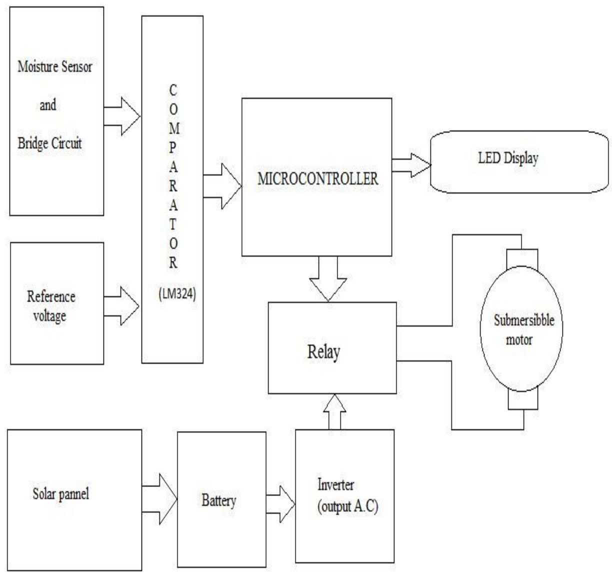


Fig. 3 Block Diagram Representation of entire Set-Up

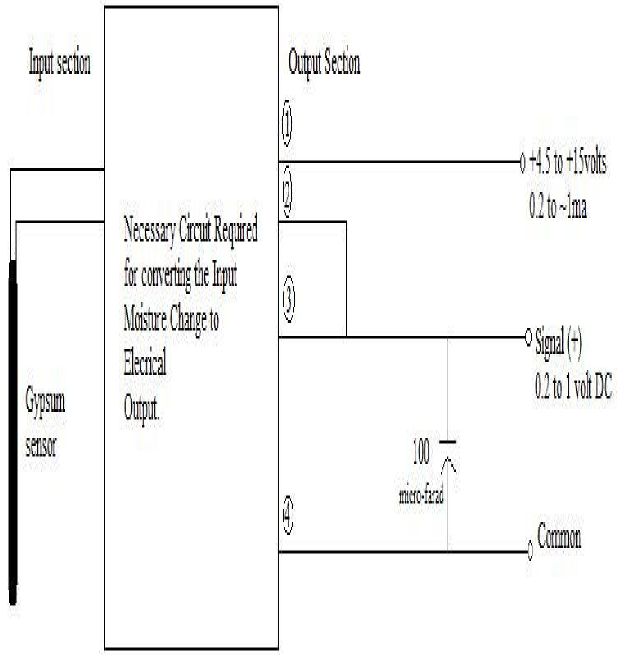
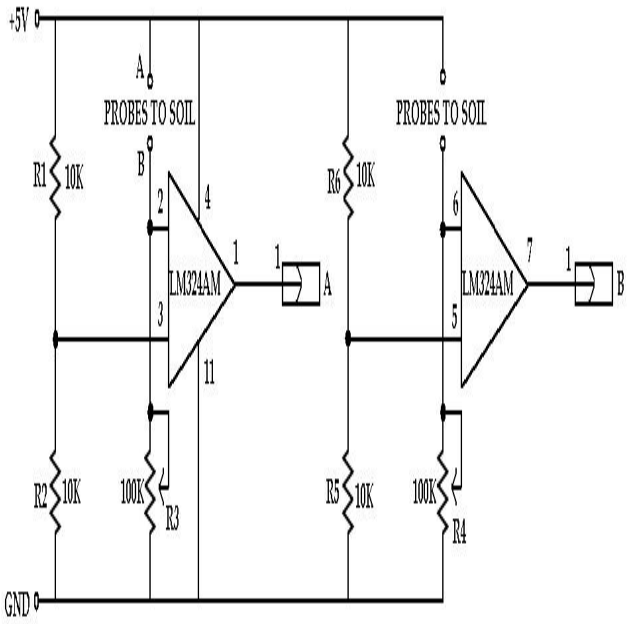


Fig. 4 Moisture content to Volt output



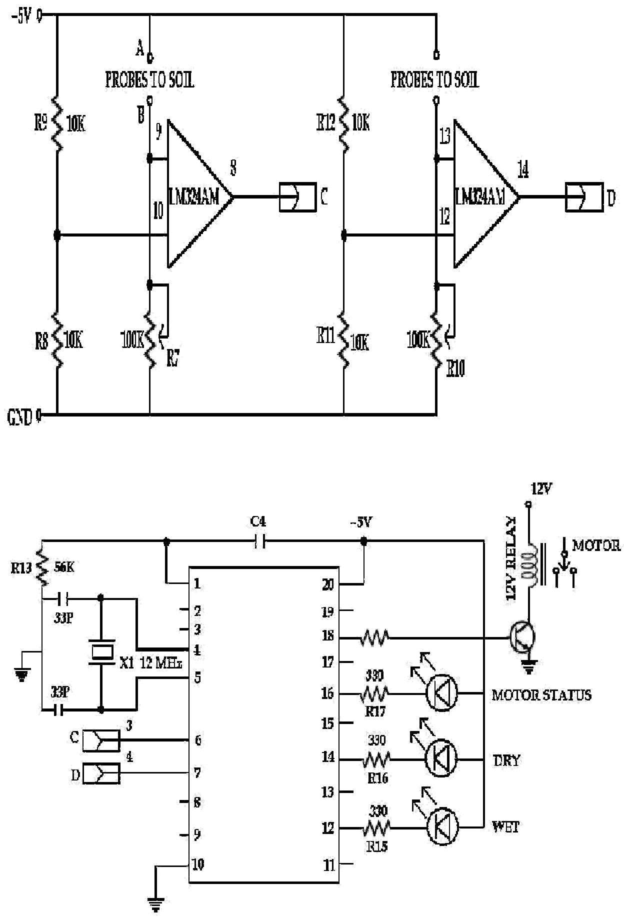


Fig. 5 (a), (b), (c): Circuit Diagram Representation Of Sensor Network and Controller

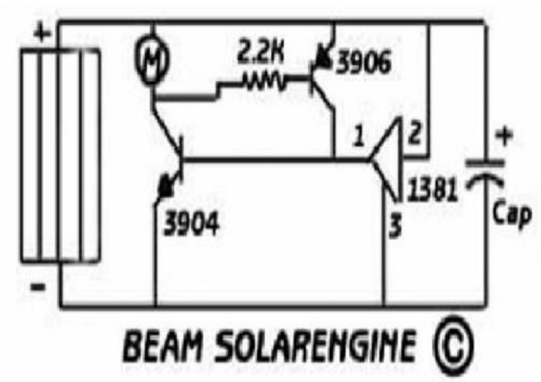


Fig. 6: Solar Energy Conversion

Algorithm:

Step 1: Design a moisture sensor network in such a way that the O/P voltage in case of dry soil (75kPa, 270 mV) is more than wet condition (8kPa, 720 mV).

Step 2: Set the ref. voltage, which must be equal or less than the output voltage obtained from the moisture network sensor at fully wet (< 8kPa) state of soil.

Step 3: Compare the sensor O/P with the ref. I/P using a comparator. If the sensor O/P is more than ref. then comparator O/P will be high (logic 1), and if the sensor o/p is equal or less than the ref voltage then comparator O/P will be low (logic 0).

Step 4: Check whether the battery connected with solar system is fully charged or not from the control panel, installed with the solar arrangement.

Step 5: Now check these condition through microcontroller:

a.) If comparator O/P is 1 & battery charge level is not enough to drive motor;
Glow the status LED of dry soil, send a low signal (logic 0) to the relay.

b.) If comparator O/P is 1 & battery charge level is enough to drive motor;
Glow the status LED of dry soil and motor is running, send a high signal (logic 1) to the relay.

c.) If the comparator O/P is 0;
Irrespective of the battery charge condition glow the status LED of wet soil, send a low signal (logic 0) to the relay.

Step 6: When microcontroller sends a high signal (logic 1) at the I/P of relay it make contact between the inverter and the induction type submersible motor and the motor will start.

Step 7: Go to step 3.

VII. Component Specifications And Calculations

Taking certain estimation, we will go ahead with the implementation of the design to see the viablity of the work. Certain assumpions are made to figure out the exact field set up of the system and they are as follows:

Area of land under consideration: 1 Acre

Also it has been presumed that the conditions prevailing are clear sunny sky with normal atmospheric pressure and wind speed and ambient temperature of around 30^{o}C.

Having all these assumpions made, we know

1 Acre = 3 Bighas

1 Bigha = 20 quotas.

1 Qouta = 750 sq. ft.

Therefore 1 bigha = (20*750) = 15000 sq. ft.

1 Acre = 3*15000 sq. ft. = 45000 sq. ft.

The volume of land under water log: [45000 * (1/12)] = 3750 cubic ft.

1 cubic foot = 28.3168 lts.

Therefore, 3750 cubic ft. = (3750 * 28.3168) = 106188 lts.

So assuming a normal dry surface with no water logging, the said field has to be fed with **106188 lts** of water to have a water log height of 1 inch. This assumption is totally hypothetical and is always subject to modification.

Selecting a solar panel of following physical dimensions. [8,9,10]

Using E19/425 series all-back contact monocrystalline solar panel of dimension (1046 (41.18) * 2067 (81.36) * 5.4 (2.13)) produces the following

ratings: Peak power: 425 W

Efficiency η: 19.7 %

Rated voltage: 72.9 V

Rated current: 5.83 A

Open circuit voltage: 85.6 V

Short circuit current: 6.18 A

Energy capacity of the panel: 425*6= 25350 WH

(on a partially cloudy partially sunny day, Av. 6 Hrs).

Maximum system voltage: 600 V

Series Fuse Rating: 15A

Temperature range: 45^{o}C / -2^{o}C.

System weight: 25.4 kg

Cost: INR 70/ watt

Multi contact (MC4) connector.

With the above specifications, we can charge a battery of following specifications

Battery: Three 12 V 200 AH batteries connected in series to generate 36 V 200 AH. Maximum charging current: 60A.

Pump Specificaton:

1 HP/16 Stage KSB Induction type

Submersible. 230V, 8A, 50Hz.

Flow rate: 4000 litres/Hr.

Inverter Specifications:

AC INPUT:

- Rating: 1400 VA/ 2 KVA
- Voltage: 230V+20% - 30%
- Frequency: 50Hz ±10%
- Phase: Single Phase.

DC VOLTAGE: 12 VOLT:

- 1400VA / 1200W: 24V
- 2 KVA / 1600 W: 24V / 36V / 48V
- Charging current: 10 Amps
- Charger Type: SMPS
- Technology: MOSFET

VIII. Scope Of This Project

Whom will this help?

It is the farmers at the receiving end to whom it will come more than handy when it comes to cheap agricultural methods. 65% of India's livelihood still comes from farming which is more than costly to a big percentage of farmers.

How will this help?

Economical and ecological benefits, possibly increased productivity. It can provide better livelihood to farmers who can save a lot from their electrical expenses in driving their water pumping motors. Non employment of electricity will eventually lead to less production of Green House gases and help in controlling global warming indirectly. Brings about social awareness regarding Green energy and manual labour is saved to great extent.

IX. Possible Areas Of Drawbacks

Till date the kind of solar panels that are in use are not capable of maximum utilization of converting the solar energy to electrical energy to the most **efficacy**.

Work needs to be done in improving their conversion ratio. The second main drawback is the rainy season or cloudy sky condition when the solar panels would not be getting the maximum of luminance. But here we can assume that during the rainy **season**, the environment will water the fields all by itself. Still to mitigate this system, back up power supply system needs to be involved. Also the initial cost of the set-up is little bit costly as the solar panels are expensive items.

X. CONCLUSION

The scope of success of this particular project is multi faced. The most important point regarding this paper is, it looks forward to the future and can lead to a revolutionary aspect towards farming and irrigation. There are limitations as well to the proposed work as we need to make the cultivators aware of the far fledged advantages to this technique and have to make them acquainted to how the system works and in case of any problem what actions need to be taken.

This is a renewable and non consumable technique that can last for eternity. It leads to a pollution free techniques and the most salient feature of it is, it is very cost effective and cheap. It also leads to proper utilization of consumable resources stopping it from getting wasted. It frees itself from human interference and thereby saving human resource. The bottom line of the entire talk is if we can resort to this new and revolutionary technique, we can bring about another "Green Revolution", which is highly desirable and need of the hour.

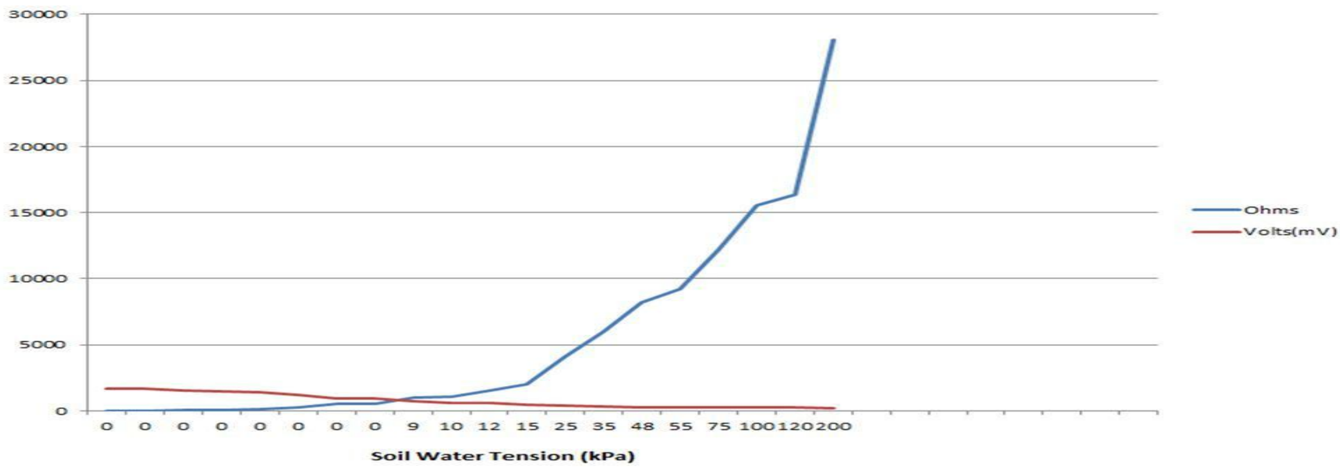


Fig 7 Soil Moisture in kPa vs soil impedance and Voltage response

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