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SOLAR POWERED SMART IRRIGATION SYSTEM

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ABSTRACT

This paper focus on Solar powered smart irrigation system which is cost effective and a middle-class farmer use it in farm field. It is the proposed solution for all present energy crisis for the Indian farmers of remote areas. Today in the era of 21st century where automation is playing important role for human life. Automation gives opportunity to control appliances automatically. It not only provides comfort but also reduce energy consumption, manpower and increase efficiency. So here a system is designed as a solar powered smart irrigation technology which is usable by Indian famers. The objectives of this paper to control pump motor automatically and select the direction of the flow of water in the farm field with the help of soil moisture sensor.Finally send the information (operation of pump motor direction of water) of the farm field to the mobile massage of the user (famer). Cost effective solar power can be answer for all energy needs to the Indian farmer. This system conserve electricity by reducing the usage of grid- power and conserves water by reducing water loss.

Keywords: SPV Arrey, Automatic Solar tracker (Arduino-Uno based), battery. Smart irrigation system, Servomotors, Display, Driver (fitted with water pipe), GSM Module.

INTRODUCTION

Solar energy is the most abundant source of energy in the word. Solar power is not only an answer to today's energy crisis but also an environment friendly form of energy. Photovoltaic generation of electrical power is an efficient approach for using solar energy. Solar panels (array of photovoltaic cells) with automatic solar tracker for harnessing maximum power are now a days extensively used to meet domestic loads, street lights. The cost of solar panels has been constantly decreasing which is energetic usage in various sectors. One of the application of this technology is used in irrigation systems in farm fields. As automation is playing an important role in modern age in industries to reduce manpower and energy consumption and time saving also increases efficiency. So here in this paper a solar powered smart irrigation technology is utilized to avoid frequent visits of farms to check soil moisture level of their farm fields and based on moisture level water is pumped by motor to irrigate respective fields where needed and wait for certain period for switch 'ON' or 'OFF' motor so that water is allowed to flow in sufficient quantity in respective farm fields. This irrigation method takes a lot of time and efforts particularly where a farmer needs to irrigate multiple agriculture farm fields distributed in different areas, traditionally farmers will present in their fields to do irrigation process.But now a days farmers needs to manage their agricultural activities along with other occupations, Automation in irrigation system makes farmer's work easier. Sensor based solar

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powered smart irrigation system provides promising solution where presence of farmers in their farm fields is not compulsory, small processor's programmes for control a servo driver (fitted with pipe) to start watering in the required direction of farm field and automatically stopped when the moisture level of the soil reaches up to required level. Really farmers need cheap and simple user interface for controlling automated irrigation system. Now a days internet is widely used. By using internet farmer knows about the agriculture farm field irrigation status. This helps farmers to know about the status of watering of direction in the field through message even though the farmer is far away from the farm field. The water pump and the direction of watering will be automatically 'ON' or 'OFF'.

This paper presents a fully automated accessing of irrigation motor where prototype includes 2 number of soil moisture sensors node placed in different directions of the farm field / kitchen garden. Each sensor is integrated with a wireless (GSM) network device and the data received by the ATMEGA-328P microcontrollers which is on an "Adriano UNO" development board. The Arduino UNO is used for send message through internet correspondence to the microcontroller processor for experimentation. Here two sensors in different direction of field (kitchen gardens) is sensed by sensor node and the sensed data is sent to microcontroller mode through device. On receiving value (sensors), when soil moisture in a particular direction of field is not up to required level the controller mode switch 'ON' pump motor and servomotor horn (fitted with water outlet pipe nozzle) to irrigate associated field and the GSM powers all data and notified SMS is send to mobile phone user (farmer) which is registered in GSM. The GSM is monitoring with a display screen to see the current status of the irrigation (soil moisture level) and use for change the setting as user required.

IRRIGATION AND ITS IMPORTANCE

Irrigation is a system of supplying (land) with watery means of artificial canals, ditches etc. to promote the growth of food crops. Different irrigation system is suited to different soil and climate.The importance of irrigation systems is very high, the process through which controlled amount of water can be supplied through artificial means such as pipes, ditches, sprinklers etc. The main objective of irrigation system is to help agriculture crops growth and reduce the effect of inadequate rainfall etc.

METHODS OF IRRIGATION

There are different types of methods for irrigating farm fields for different parts of India depending on climate and nature of soil.

(i) Traditional

In old days basically Indian farmers use traditional irrigation methods i.e. Moat, chain, pump, dhekli and rahat.

- **(a) Moat irrigation**: Moat also called the pulley system; it involves pulling up water from a well or other such source to irrigate the land. It is an extremely time consuming and labour-intensive systems but very cost efficient also wastage of water is avoided when using a moat irrigation system.

Fig 1. Moat irrigation system

(b) Chain Pump irrigation: It consists of two large wheels connected by a chain. There are buckets attached to the chain. One part of the chain dips into the water source. As the wheel turns the bucket picks up water. The chain later lifts then to the upper wheel where the water gets deposited into a source. And the empty bucket gets carried back down.

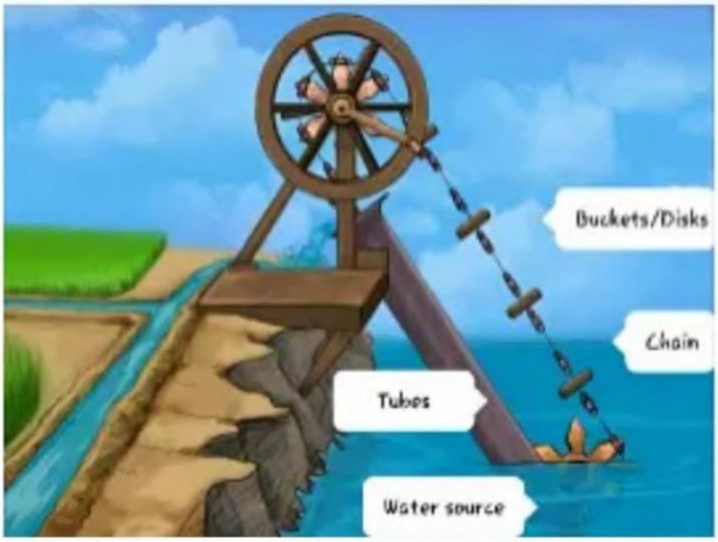

Fig 2. Chain Pump irrigation

(c) Dhekli irrigation: It is a system of drawing water from well or such similar source. Here a rope is tied and bucket to a pole. At the other end, a heavy stick is tied or any other object as a counter balance and this pole is used to draw up water.

Fig 3. Dhekli irrigation

(d) Rahat irrigation: Rahat system of irrigation uses animal tied to a large wheel above the well. An ox or bedfellow would turn the wheel to draw the water from the well.

Fig 4. Rahat irrigation

Traditional irrigation methods are an extensively time consuming and labour intensive but very cost efficient.

(ii) Modern methods of irrigation

There are more efficient systems of irrigation that were invented in the recent decades. These systems helps farmers use of water economically without wastage. These are drip system, sprinkle system, smart irrigation system.

(a) Drip irrigation method: In this system water falls drop by drop at the position of the roots of the plants, it is best technology for watering fruit plants and trees. Water flows through main pipe and divided into sub pipes, specially prepared nozzles are attached to these sub pipes.

In this system waste of water is very less and no worker is needed for irrigation. When farmer know about the status of farm field then starts the pump motor and choose the direction from the nozzles. This starts automatically watering the plants and after some time the farmer checks the status of the moisture of the farm field and while the whole crops are irrigated then motor will be switched off and stopped by the farmer.

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Fig 5. Drip irrigation methods

(i) Sprinkler Irrigation method: This system is more useful whether the water is available in smaller quantity when water pump started the water starts to flow main pipe and also flow through vertical pipe is joined and rotating (automatically) nozzle on the top of the perpendicular (vertical) pipe is joined. This system is very useful on the sandy soil a smaller number of labours require and water loss is less.

Fig 6. Sprinkler Irrigation

(ii) Smart Irrigation System: Above systems are generally operated by farmer but a smart irrigation system tells that the total system is controlled by autonomous mean automatically control the total irrigation system whether the farmer is not present in his farm field and send messages to the farmer about the information of farm field and change in labour (worker) for operating and also waste of water compared to previous methods.

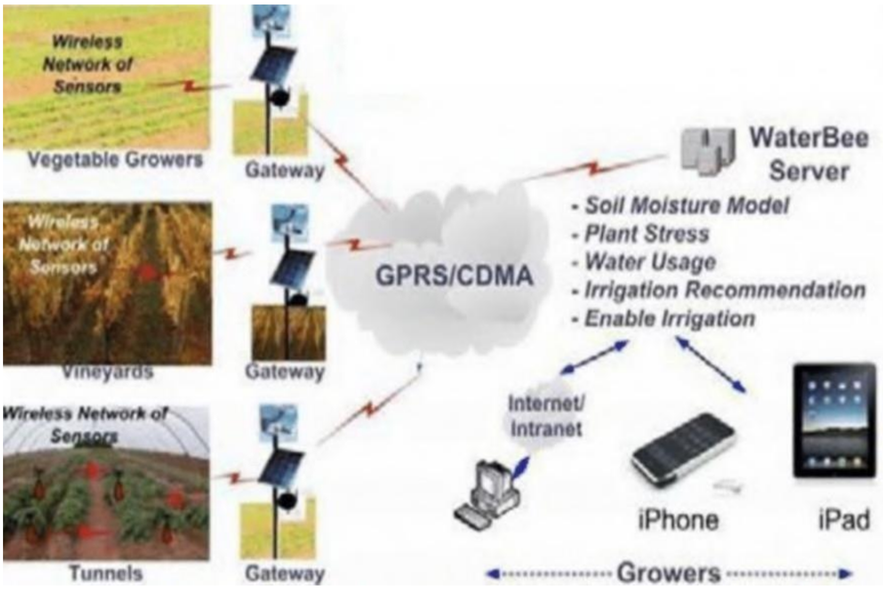

Fig 7. Smart Irrigation System

Dual Axis Solar Tracker

The tracker used is a dual axis tracker, meaning it tracks in both X and Y. To put it into even more simple terms, it goes left, right, up, and down. This means once the tracker is set it will never need to change or adjust anything, since anywhere the sun moves the tracker will follow.

The tracker used is an active tracker which is controlled by computer program (via an Arduino). This means that sensors are used to find the brightest source of light at all times. Even if the flashlight shines at the sensors the tracker would follow it around. While this is the most interactive and exciting kind of tracking one can build, it's also an overkill for larger setups.

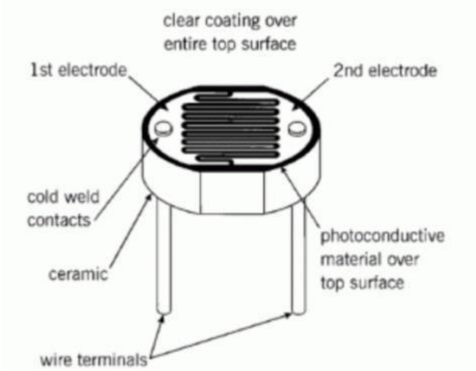

Fig 8. Plastic Coated Photocell

The Arduino platform is also very easy to for anyone to learn or just modify code using a home computer, something that will be explained later on.

Here two "micro" servos in the 9g size are used. The system uses ones with metal gears which is desirable. The metal gear versions also provide a bit more torque than the plastic geared versions. If one wants to use larger servos one can easily modify the laser cut files.

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For sensors used in the system have four light sensitive (detecting) resistors, also known as LDRs Again, these are super common and one can often find them in outdoor garden lights or indoor night lights. They work by changing their resistance level based on how much light is hitting them. The more the light, the less of resistance they have.The program works by comparing the resistance of the four sensors and moving the servos How sensitive the sensors are completely depending on the code. The same goes for the servos. The code is setup so that the servos can only move within a certain predefined area (as to not damage the rest of the project) and at a set speed. These two aspects can also be changed very easily in the code.

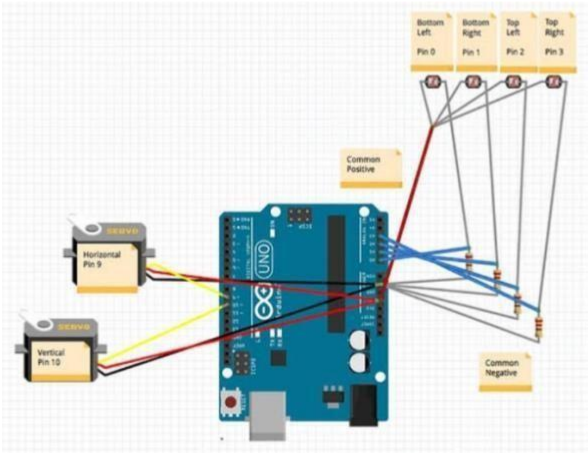

Fig 9. Dual axis solar tracker (Arduino based)

To also help things along and remove a bunch of wiring the system is using an Arduino Sensor Shield. This is mainly to plug the two Servos into. If one is building this from scratch one could go without, but Sensor Shields are inexpensive and makes life a lot easier.

Table 1: Comparison of Panel Voltage with and without Tracking

TIME	SOLAR PANEL VOLTAGE	
	WITHOUT TRACKING	WITH TRACKING
08:00 am	3.62 V	5.78 V
10:00 am	5.10 V	7.08 V
12:00 pm	7.26 V	8.98 V
01:00 pm	8.42 V	9.62 V
02:00 pm	8.15 V	9.58 V
04:00 pm	5.42 V	8.23 V
06:00 pm	3.24 V	6.27 V
08:00 pm	0.12 V	0.38 V

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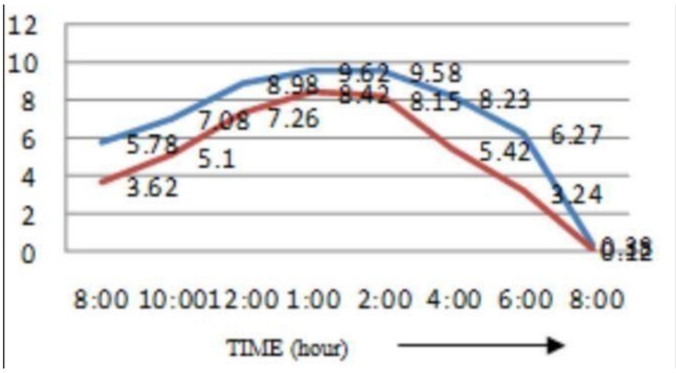

Fig. 10: Graphical Representation of Data

Table 2: Efficiency gain data

Time (Hours)	Efficiency ηf (%)	Efficiency ηt (%)	Efficiency ηt* (%)	Efficiency ηt** (%)	Efficiency gain	Efficiency gain*	Efficiency gain**
7:00	3.64	5.63	6.32	8.43	1.99	2.68	4.79
8:00	4.25	6.97	8.67	8.13	2.72	4.42	3.88
9:00	5.62	6.57	6.78	7.17	0.95	1.16	1.55
10:00	5.74	7..06	6.73	6.97	1.32	0.99	1.23
11:00	6.39	7.05	7.13	6.72	0.66	0.74	0.33
12:00	7.63	7.38	7.61	7.00	-0.25	-0.02	-0.63
13:00	7.09	7.58	7.55	6.84	0.49	0.46	-0.25
14:00	5.69	7.12	7.19	7.27	1.43	1.49	1.58
15:00	2.74	6.45	6.68	5.62	3.71	3.94	2.88
16:00	2.74	5.56	6.48	6.28	2.82	3.74	3.54
17:00	2.80	5.90	9.09	8.21	3.10	6.29	5.41
18:00	0.80	5.68	9.77	9.21	4.88	8.97	8.41
19:00	0.45	2.71	9.64	6.67	2.26	9.19	6.22
Average	4.27	6.28	7.67	7.27	2.01	3.39	2.99

Where,

ηf-fixed system efficiency,

ηt=Tracking system efficiency,

ηt*=Tracking at latitude angle efficiency.

ηgain (%) = ×100 7.67-4.27 7.67 = ×100=44.25%

Efficiency Gain = ηt - ηf = 5.63-3.64=1.99%

Efficiency Gain* = ηt – ηf = 6.32-3.64-2.68%

Efficiency Gain* = ηt** - ηf = 8.43-3.64-4.79%

Arduino-UNO: Arduino UNO is a micro controller board based on the ATMEGA 328AP, it has 14 digital I/O pin (if which can be used as USB connection PWM outputs) 6 analog inputs a 16 MHZ ceramic resonator, a USAB connection, a power jack, an ICSP header and a rest button, it contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with solar power battery or A.C. to D.C. adopter of 12 V, 1 amp, rating to get started.

Fig.11: Arduino UNO Board

Summary of Arduino UNO board

ATMEGA 328 P	Microcontroller
5V	Operating voltage
7-12 v	INPUT VOLTAGE (RECOMMENDED)
14 PIN	Digital I/O pins (of which spins provided PWMN output)
6 pin	PWM Digital /O
6 pin	Analog input
20 mA	D.C. Current per I/O pin
50 mA	D.C. current for 3.3. V pin
Flash memory 32 KB (AT MEGA 328P) of which 0.5 KB used by boot loader.	
SRAM 2 KB	(ATMEGA328P)
EEPROM IKB	(ATMEGA328P)
Clock speed	16 MHz
LED Buitin	13
Length	68.6 mm
Width	53.4 mm
Weight	25 gms

Soil moisture sensors are used to sense the moisture level in soil and send the data to wireless network (GSM) deice and the data from network device send to Arduino-UNO where an ATMEGA-328 P microcontroller process the data are voltage values using an analogrithm

Voltage Sensor value (5/1023) Percent (Voltage/5)/100

The Arduino UNO board has 1- bit analog to digital converter. This means that will map input voltage between O and 5 V into integer values between 0 and 10.23. This yields a resolution between readings of 5V/1024 units of 0.0049 Volts (4.9 mV) per unit, it takes about 100 microsecond (µSc) (0.000 (Se) to read an analog input, so the maximum reading rate is about 10,000 times a second. Which generate a large number of data, so a delay of 5 minutes is taken. In each minute. In each minute ARDUINO-UNO give output value of percentage in dryness. The value of dryness fed to GSM to control the servomotor horn and operate motor driver. Farmer(user) knows the status of the farm field through a message to the registered mobile number

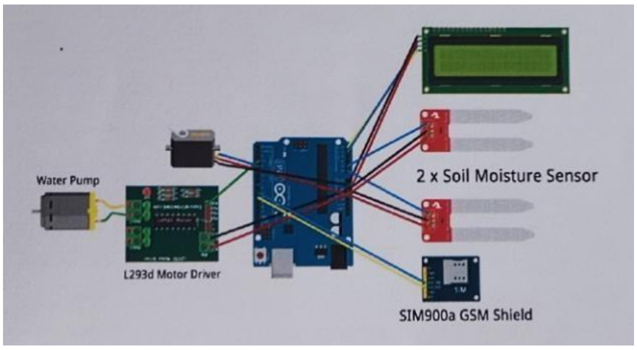

Fig. 12: Smart Irrigation System with GSM Module

GSM Module (SIM 900A)

The GSM is used for control the irrigation system and connects with internet to send data to the registered mobile number of users. Automatic message sending is developed using GSM. If the farmer is far away from his farm field, he always updates with his field status through mobile message. The GSM check the condition in which direction of the farm field is dry then it operates the servomotor horn (fitted with water pipe out let nozzle) at the corresponded direction and 'ON' the water pump motor.

Specifications of GSM Module SIM 900a

Dual-Band 900/800 MHz.

GPRS multi-slot class 10/8GPRS Mobile-station Class B.

Compliant to GSM Phase 2/2+class 4 (2W@ 850/900 MHz).

Class 1 (1 W @ 1800/1900 MHz).

Control via AT Commands (GSM 0.7, 0.7, 0.7, 0.5 and SIM CON enhanced at Command).

Low power consumption 1.5 mA (sleep mode)

Operation temperature -40°C to +85°C

Status indicator (D5)

Network LED (D6).

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Soil Moisture Sensor: Soil moisture sensor includes comparators (LM 393) which converts analog data to discrete. Two soil probes consist of 5 cm length which can be immersed into the soil under test. The circuit gives the two thin copper wires each voltage output corresponding to the conductivity of the soil. The soil between the probes acts as variable resistance whose value depends upon moisture contents in soil. The resistance across soil probes can vary from infinity (for completely dry soil) te a very little resistance across probes (Rs.) leads to variation in forward bias voltage which leads to corresponding variation in output base current (Iµ)B. For common Emitter (Ec) configurations collector current (lc) = BIs. Where B is current amplification factor. Hence a small variation in base current (lµ) leads to large variation in emitter current and hence the emitter voltage (Vc) is taken as the voltage output for sensor

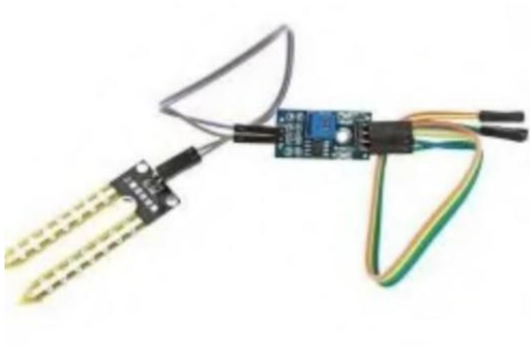

Fig.13: Soil moisture sensor

Servo Motor Driver: It operates on the program in the Arduino-UNO reads the moisture value (level) from the sensor energy 20 seconds. If the value read the threshold voltage the program does the following three functions.

Fig.14: Servo driver

1. It moves the servomotor horn along with water pipe fixed on it towards the section of field whose moisture level is less than predetermined/threshold level.

2. It starts the motor pump to supply water to the section of field for fixed period of time and then stops the water pump.

3. It beings back the servomotor horn to its initial position.

Cost Analysis: With eighteen thousand tube wells being used in every state of India around Rs.20 million of energy is used for pumping water for irrigation. This amount of money used for electricity can be saved with the help solar powered smart irrigation system. Annually the cost of nearly six-million-kilowatt hour of energy can be spared. Even though the initial investment is high, it can be come back in 3-to-4-year time. If the cost of power is assumed to be Rs. 1.5 million per kilo watt hour Rs. 20 million is used for pumping of water alone in a year for energy annually. By using the solar powered smart irrigation system, one can save up to 4.8 million kWh of energy annually, which saves a lot of energy. The excess energy can also be sold to the power grid with appropriate modification and investment in the circuit, which can add to the revenue of the farmer.

Table 3: Component Costing

S.No.	Item Description	Qty.	Rate @	Cost in Rs.
1.	Arduino UNO	2	400	800
2.	GSM Module SIM 900a	1	750	750
3.	Solar Charge Controller	1	250	250
4.	Solar Panel	1	600	600
5.	L 293 D Motor Driver	1	150	150
6.	LCD Screen display	1	180	180
7.	i 2c LCD Controller	1	160	160
8.	Soil Moisture sensor	2	200	400
9.	Battery 12 v	1	350	350
10.	9 g metal gear servomotor	2	250	500
11.	Water pump (Submersible) 12V	1	100	100
12.	9 g servo	1	120	120
13.	LDR	4	20	80
14.	Resistor 10 k	4	2	10
15.	Post Terminal Block 2x5	2	10	20
16.	Post terminal block 2x4	2	10	20
17.	LED Voltmeter	1	180	180
18.	Arduino cables	L.S.	80	80
19.	Tubing	2mt.	100	200
20.	Bread board	1	150	150
21.	Acrylic sheet/ plywood sheet (Thin)	L.S.	1150	1150
22.	Jumper wires	L.S.	220	220
23.	Hot glue gum	1 ltr	250	250
Total				6720

FUTURE ASPECT

By implement the solar powered smart irrigation system, there are various benefits for the farmers or it conserve energy and water, as there is minimal water loss, reduces humane intervention for farmers. The surplus energy produced by solar panels (Array of photovoltaic cells) can also be given to the power grid with appropriate modifications it the system, circuits which can be a source of farmer thus encouraging farming in India and sometime giving a solution for energy crisis. Proposed system is easy to implement and environmentally friendly solution for irrigating field.

CONCLUSION

This paper presents a prototype for automatic controlling an irrigation system Here prototypes includes sensor mode and control mode. The sensor mode is deployed in irrigation field for sensing moisture value and the sensed data is sent to controller mode on receiving sensor value the controller mode check it with required soil moisture level the motor is switched 'ON' to irrigate associate agricultural field and alert massage is send to registered mobile phone of the farmer. The experimental results show that the prototype is capable for automatic controlling of irrigation motor (pump motor) on the feedback of soil moisture sensor. This system is used in remote areas and there various benefits for the farmers. It saves energy also as it automatically control the system. Excess power generated by solar panels can be used in other agricultural activities and domestic load. Smart irrigation system, can be implemented in all types of irrigations such as drip, sprinkler, surface irrigations, furrow irrigation etc.

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