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COMPREHENSIVE REVIEW ON SOLAR POWERED SMART IRRIGATION SYSTEM

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ABSTRACT

A solar based irrigation system is proposed in this paper to harness maximum solar energy which is further used to power the designed system. Energy from sun is used as the power that facilitates us from uninterrupted power supply to control the overall system. The piece of work for automatic irrigation system is performed by moisture sensor by sensing the moisture of soil. Also, to make the automation more advanced a temperature sensor is also installed in the system. It has a simple circuit structure using Arduino UNO and GSM module that makes it applicable even in remote areas. After the level of soil approaches its lowest and highest threshold value motor starts and stops automatically respectively. A comprehensive analysis of operation, model and design of proposed system in GSM mode is given. Finally, a prototype of the smart plant irrigation system is presented.

Keywords: Solar Power, GSM Module, Arduino UNO, Moisture and Temperature Sensor, LCD Display Etc.

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I. INTRODUCTION

Today, the economy of many countries directly or indirectly depends on advancements in agriculture. Considering India, where economy is agriculture based, requires modern and efficient techniques for providing water in the farms. All those factors that affect the processes related to agriculture should be studied properly to get best results. The aim of irrigation is to supply sufficient amount of water to meet the crops' water needs when fields are facing a phase of less rainfall issue. Irrigation is all about providing water to soil when it is required and stopping water supply when enough water has beensoaked into soil. Water supply is stopped as, excess amount of water in the crops is not good, it not only destroys crops but also wastes water. The continuous raise in the country's population needs a large number of innovations in technology related to food production. Irrigation system is the most important part of agricultural processes [1]. Hence, reliable and innovative methods of irrigation are required.

To make agriculture easier and more sustainable the need for systems has been increased within the past years. Solar energy is the alterative form of energy as it is available in ample amounts. It converts sunlight into electricity, either directly (by means of photovoltaics (PV)) or indirectly (by collecting intense heat energy in solar radiations. The solar panels are constructed with the group of solar cells made up of semiconductor materials to collect the solar radiations during sunshine hours. To extract maximum amount of energy the solar panel must be at right angles to the sun rays. Any system that is based on solar power drives water considering three variables such as power, pressure and flow. The energy collected by the panel runs pumping process of water which is a realistic way of utilizing energy from sun to generate electricity during the sunshine hours. Producing electricity form solar energy and using that energy to dive motor and storing that energy for less insolation period plays vital role in the working of the project. Manual methods of irrigation have certain failures which have forced us to think about some method which is more advanced and we can rely upon. Therefore, the imperfections of manual irrigation methods can be modified by using a process that is automatic. Also, ample effects are induced on agriculture by the efficiency of irrigation system. Anything which is cost effective, uses very less or no labor (runs on its own), energy saving and is easy to use is considered efficient. A smart plant irrigation system that is supplied power by solar energy can be an apt alternative for present state of energy disaster. This project designs a model for smart plant irrigation arrangement based on microcontroller and utilizing solar power as the source of power supply [3]. Several sensors are located in crop fields. In the designed system, operating unit of soil moisture sensortransmits data by collecting sensor info from the root zone of plant. Water level is sensed using sensors unceasingly and data is given to farmer through cellular phone. This provides a reliable water source for plantation and reduces the manual efforts for irrigation of fields. The content of water is constantly determined using the sensors and signal is send to the motor accordingly. As the motor stops and starts automatically, a SMS will be send to the user about the operation status. This project presents the notion of irrigation automation method and the operation of the system sustains this notion. This project have several advantages which includes reduction of error, reduction of water wastage, plant growth to their utmost potential, lesser manual labor and continuous water supply due to uninterrupted solar power [8,10].

II. OBJECTIVES OF STUDY

The main objectives of this project are:

- To minimize the labor cost
- To design an advanced and automatic solar based system for sensor based irrigation.
- To design system that would prevent excess water loss and would use water in more well-organized way for small scale irrigation.

III. BACKGROUND STUDY

Ateeq U. Rehman et al (2017) [1] designed an irrigation system that is based on moisture content and fruitfully implemented along with water flow sensor. Characteristic of the system included temperature and water usage monitoring and closed loop automatic irrigation system. Levels of the moisture content can be easily preset by user. User is regularly updated through LCD display about present value of all parameters.

Sharath Patil et al (2015) [2] designed a system through the use of reliable and efficient methods such as wireless sensor networking, and SMS technologies to control pump automatically. This system was designed to help the farmers to get a better yield and on a larger scale, help the economic and agricultural growth of the country.

Ankit Singh et al (2017) [3] used GSM, Microcontroller AT89C51, crystal ocillator and moisture sensor. Analog output is given by the sensor but only the digital data is accepted by the processor. Microcontroller is connected to GSM with the help of UART or MAX 232 IC. When user gives a particular command the corresponding sensor will activates immediately and reads and sends the present info results to the same user through GSM networks.

Nayankumar Kapse et al (2018) [4] proposed a system for the benefit of farmers. Single axis sun tracker device was designed to facilitate orientation of PV panel according to sun on the basis of values obtained from LDR sensors. It used a sensor network which is wireless because of GSM. It helps it in becoming more flexible and robust.

M. A. Murtaza et al (2017) [5] found the monitoring of water level in fields and controlling motor of system based on GSM technology using 8051 series microcontroller.

Snigda Verma et al (2017) [6] studied survey of agriculture based industry and concluded that it is lagging with efficient, cost effective and new innovative techniques. The overcome this problemaautomated system proposed for the controlling and monitoring operations of Greenhouse Environment and other agricultural sectors also.

IV. METHODOLOGY

A. Components Used

i. Solar Panel

A set of electrically connected PV modules is known as Solar Panel. A PV module is a packaged and connected assembly of solar cells. They generate electricity and supply it for residential and commercial applications. The irrigation is liberated from the load shedding by installation of PV panels in the system. The requirement of water is determined using sensors present in the system and data is transmitted by them to the solar circuitry which fulfills the assigned task by providing sufficient DC power to command the motor. Solar panel which we are using is our system is a 12V, 5W. A diode is connected in reverse bias with the solar panel to avoid backflow of current. This PV panel is then connected in parallel with the battery to store energy [4].

ii. GSM module (SIM 900A)

GSM is the acronym for Global System for Mobile Communications and is used for digital cellular networks of second generation (2G). In this project, GSM module, SIM900A provides a wide range to control system remotely from anywhere. The ease of communicating became more robust. Simply, it can be connected to a PC and can be used to send SMS to the user when inserted with a SIM card via a COM (serial or USB) port. The networks of GSM module operate in a wide range of carrier frequency, mostly, in the 900 MHz band or 1800 MHz band. This module makes the system wireless [4]. The module used in the designed system is GSM SIM 900A module as shown in Fig.1.

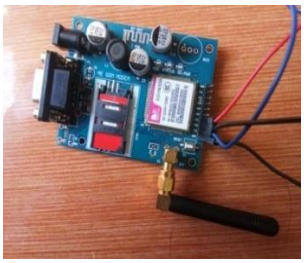

Fig. 1: SIM 900A GSM Module

Table 1: The GSM specifications

PCB Size	71.4 mm X 66.0 mm X 1.6 mm
Indicators	PWR status LED, NET status LED
Power supply	5V

Table 2: Status of NETSTATUS LED

Status	Description
Off	SIM900 is not running 64 ms ON/ 800ms
Off	SIM900 is not registered
64 ms ON/ 3000ms OFF	SIM900 registered the network
64 ms ON/ 3000ms OFF	GPRS communication is established

iii. Arduino UNO

In Italian, "Uno" defines one. It is a board based on the Atmel ATmega328. Software Arduino (IDE) 1.0 was also released along with the microcontroller board. Both, the Software (IDE) version 1.0 and Uno board were the basic versions of Arduino. These have now transformed into newer releases. Arduino is the heart of system as all processes taking place in the designed system are linked with each other through it. All the components are assembled and connected in system through different ports of Arduino. Components are dependent on the instruction provided by Arduino. Due to its versatile nature Arduino Uno has been used. This is most documented and used board of the whole Arduino family. Arduino Uno has a definite pin structure which includes 6 analog inputs, 14 digital input/output pins (out of which 6 can be used as PWM outputs), a connection for USB cable, a quartz crystal of 16 MHz, a reset button and a jack for external power supply. It comprises of all the features required to support the microcontroller. So, to start it we have to simply power with a battery or AC-to-DC adapter or connected to a computer via USB cable.

Aurdino UNO used in system is shown in Fig. 2.

Fig. 2: Arduino UNO board

Battery derivations can be plugged into V_{in} power connector and GND connector. A power supply of 6 to 20 volts is sufficient for the operation of the board which is provided externally. If it is supplied with less than 7V it may not be stable. If more than 12V, the board can get damaged due to overheating of the voltage regulator. The preferred range of power supply for this board is 7 to 12 volts [9].

Table 3: Arduino UNO specifications

Specification	Description
Microcontroller	ATmega328P
Input	7 to 20 volts
Operating Voltage	5 volt
Digital I/O pins	14
Analog Input pins	6
DC Current per I/O pin	20 mA
Flash Memory	32 KB
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz
Length	68.6 mm
Breadth	53.4 mm
Weight	25 g

iv. Soil Moisture Sensor

It is a device that measures the content of water in soil by using resistance (a water content function). Soil moisture sensor is rugged by nature and is inserted into the soil, and the information of water content of the soil is provided to microcontroller.

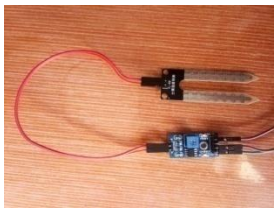

Fig. 3: Moisture Sensor

It is very important to measure the moisture content in soil for certain applications in agriculture. This allows and helps farmers in managing systems installed for irrigation more efficiently. These sensors are used in a number of applications for example, in climate research, horticulture, irrigation planning or environmental and agricultural science [4].

v. Temperature Sensor

Typically, it is a device that provides electrical signal which in turn measures temperature. This device can be a thermocouple or RTD. The series of LM35 sensors have an output voltage which is proportional to the Centigrade temperature linearly. Also, includes several précised integrated circuit temperature devices, the one used in system is shown in Fig. 4.

Fig.4. LM35 sensor

The LM35 device is better than temperature sensors which are linear and calibrated in Kelvin. To get convenient Centigrade scaling user is not required to subtract a large constant voltage value. It does not require any external calibration to obtain accuracies of ±¾°C for temperature ranging from −55°C to 150°C and ±¼°C at room temperature. This device has very low self-heating of less than 0.1°C in still air as it draws just 60 µA from the power supply [1].

vi. LCD (Liquid Crystal Display)

An electronicmodule, basically utilized as a part of various circuits and gadgets. LCDs are prudent devices that are very effectively programmable. It has two registers to be specific which are Data and Command. The ASCII estimation of the character is the information that is shown on the LCD. This device is an electronic visual display on a flat panel using liquid crystals with light modulating properties [10]. Pin diagram of the LCD display is shown in Fig. 5

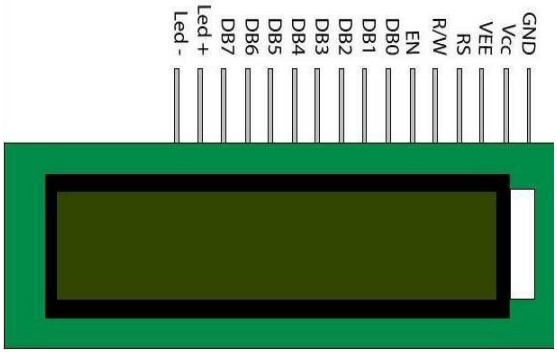

Fig. 5: Pin diagram of LCD

vii. Battery

In this project we are using a rechargeable battery which is also known as secondary cell, accumulator, or storage battery. This is included in a category of electrical batteries which can be charged, discharged and recharged many times into a load unlike, disposable or primary batteries which are supplied fully charge and discarded after use. One or more electrochemical cells are used to construct this kind of battery. The type of battery used in the system is lead acid battery which is of rating 6V-4.5 Ah [9].

viii. DC Motor

A DC motor is included in a class of rotary electrical machines which operate to convert electrical energy into mechanical energy. Since, the designed project is just a prototype for irrigation system so we are using Permanent magnet DC motorshown in Fig. 8. Also, for providing supply to the pump of the irrigation system we can use an inverter and convert the DC supply into AC supply and then provide the power to the pump [4].

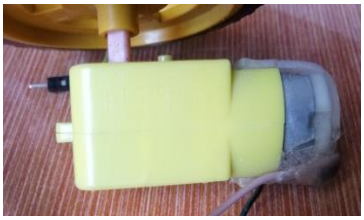

Fig. 6: Permanent magnet DC motor

B. **Block Diagram of System Model**

Basic block diagram of a smart irrigation system is shown in Fig.7 which is monitored and controlled by microcontroller.

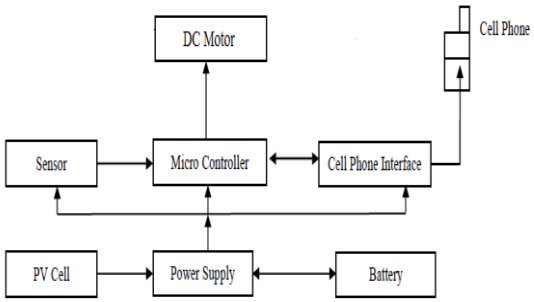

Fig 7: Block Diagram of Smart Irrigation System

V. IMPLEMENTATION

The notion behind the designing of this project is to utilize maximum sunlight that is entering atmosphere from the sun and to store the same in a Lead acid Battery. All the apparatus are internally connected to the Aurdino UNO and GSM module. They control the whole operation of our project. The smart irrigation system initiates with sensors installed, detecting the moisture and temperature. All the conditions of the land are sensed by the moisture sensor to run the motor and the message send to former or owner by using GSM system, that message status is also displayed in LCD display. When the crop land becomes dry automatically motor is turned on. When the crop land is in wet condition the motor is turned OFF. The moisture sensor senses the water content (level) of the farm. The dry and the wet conditions of the soil are determined by the resistance of the soil which is directly proportional to the moisture.

The basic flow chart of the smart irrigation system is given as follows:

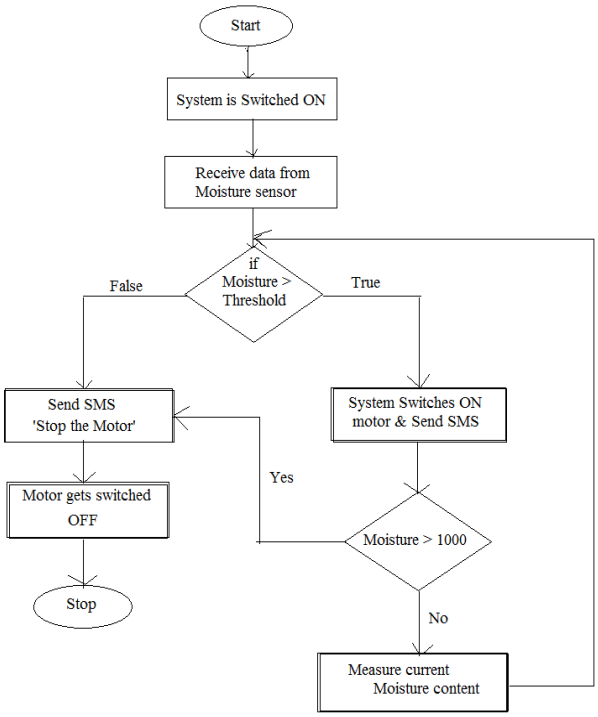

Fig. 8: Flow chart of the smart irrigation system

When the moisture sensor senses the resistance to be high, then the soil is at dry condition and when the moisture sensor senses the resistance to be low then the soil is at wet condition. Microcontroller will sends the signals to motor, depending upon the information from moisture sensor. After receiving info from sensors a command is send to activate the motor through microcontroller. Also, commands GSM to send SMS. When the motor is turned ON water is supplied to the farm and the moisture sensor will send the current level of moisture content to the microcontroller, simultaneously. When it again attains the maximum level it will activate the microcontroller and GSM module that will again send a message to the user about the increased moisture content level. That is how the system will become an automatic system.

RESULTS

After performing all the tests during the implementation of system it is seen that the system is able to function as expected. The moisture sensor is placed in the root zone of the plant, there it senses the amount of moisture present in the soil and gives the microcontroller a signal regarding to that. Microcontroller, which is further connected to GSM module and LCD display, commands them to perform their respective functions. GSM module contains a SIM which sends a message to the cell phone of the user whose number is provided in the coding of Aurdino software. LCD display will show the status of the SMS which is sent to the user.

The coding which is done in the Aurdino software is compiled and uploaded in the microcontroller. After that the circuit is provided power. The serial monitor of the Aurdino software provides the values of the temperature and moisture content which was being sensed by the sensors.

There are three different cases for different conditions of soil moisture sensor:

a) When the sensor is in wet soil the value of moisture is less than 500 than the microcontroller will give OFF command to the motor and a message will be send to the user that the motor has been turned OFF.LCD will display “Motor is stopped” for the obtained result.
b) When the sensor is in dry soil i.e. moisture content between 500 and 1000 than microcontroller will give ON command to the motor and a message will be send to the user that the Motor has been turned ON. LCD will display “Motor starts” for the obtained result.
c) When the sensor is out of the soil i.e. with moisture content value larger than 1000 as microcontroller can’t take values higher than that than microcontroller will again stop the motor and inform the same to the user. LCD will display “Sensor is out of the soil” for the obtained result.

Hardware implementation of the entire prototype is shown below.

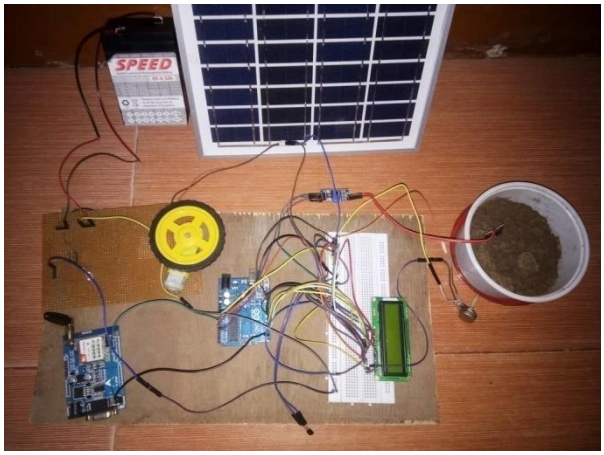

Fig. 9: Prototype of the automatic irrigation

VI. ANALYSIS

A. Advantages:

- It has no power issues since solar energy is used as an energy resource.
- It saves water and increases productivity
- It reduces time and labor cost of farmer to great extent.
- This project requires very low Maintenance
- This system is very flexible in terms of its location and is also harmonious with nature.

B. Disadvantages:

- It is not applicable for fields which are larger in size.
- Initial cost is high.

C. Applications

- It is used for effective irrigation of the fields by providing water to the fields automatically according to the information from installed sensors.
- This project is very efficient because of its operation under GSM mode and smart sensors.

VII. CONCLUSION

In this project automatic controlling of motor to drive pump sets and alerting user by sending SMS has been discussed fruitfully. For communication purpose, GSM is used. Using AT Commands (Attention Commands) we can communicate with the components. To demonstrate the functionality and performance of the controller system, the prototype was implemented and tested. The components required for this type irrigation system is moisture sensor, temperature sensor and GSM. The irrigation is proposed by sensing the soil condition as wet or dry. It produces an efficient use of water in irrigation system.

Results showed that SMS technology will make it possible for users to control and monitor the conditions of their farms, organize the need of water for crops, automatic water level controlling and set control operational conditions in accordance with the water demand of crops. Further, user can take advantage of the prevailing GSM networks because of its low SMS service cost to provide value added services. The overall notion is that users to take advantage of the globally established GSM networks and smart sensors to manage their irrigation system. Our main aim is accomplished by extracting maximum power through the sunlight. Hence, uneven trading power dependency is not needed.

VIII. FUTURE SCOPE

In future, the solar powered smart irrigation system is going to be very useful as sensors related to main soil parameters namely soil electrical conductivity, soil pH can also be integrated in the system. In future, we can modify the system to supply agricultural chemicals like calcium, sodium, ammonium, zinc and fertilizers to the field along with water with addition of new sensors and valves to irrigate fields more effectively. This process is termed as fertigation in common language. Accuracy in the measurement of moisture content can be increased by the addition of more sensors.

Presently, it is operating on DC power; in future, it can also operate on AC power. The smart grid improvements, nano technology and power electronics advances will have vital role in implementing policies of solar energy. Let we have a hope that one fine day all farms in India are installed with smart solar irrigation systems.

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