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Autonomous Solar Powered Irrigation System

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Abstract

This paper gives information related to OFF grid application system, which is independent of supply from the grid. The source to generate electricity through renewable resources, we prefer sunlight as the main source. The objective is to supply water for the fields through solar powered water pump and automate the system for better management of resources. The farmer (user) can water the fields from any place using GSM technique which provides an acknowledgement message about the situation. The main advantage of this project is optimizing the power usage through water resource management and also saving government's free subsidiary electricity. This proves an efficient and economy way of irrigation and this will automate the agriculture sector.

Index Terms— Off-Grid, Solar, GSM, Irrigation

I. INTRODUCTION

Agriculture in India has a significant history. Today, India ranks second worldwide in farm output. Agriculture and allied sectors like forestry and fisheries accounted for 16.6% of the GDP in 2009, about 50% of the total workforce. The economic contribution of agriculture to India's GDP is steadily declining with the country's broad-based economic growth. Still, agriculture is demographically the broadest economic sector and plays a significant role in the overall socio-economic fabric of India.

In India most of the power generation is carried out by conventional energy sources, coal and mineral oil-based power plants which contribute heavily to greenhouse gases emission. Setting up of new power plants is inevitably dependent on import of highly volatile fossil fuels. Thus, it is essential to tackle the energy crisis through judicious utilization of abundantly available renewable energy resources, such as biomass energy, solar energy, wind energy, geothermal energy and Ocean energy.

The projection for irrigation water demand basically depends on irrigated area, cropping pattern, effective rainfall, and soil and water quality. India's current population is 1100 million is expected to stabilize at some stage. The projected population is 1500 million by 2050 with agriculture remaining as the primary source of livelihood in rural areas.

Though our country claims to have developed in terms of science and technology, erratic power supply or complete breakdown for hours together has almost become routine today. If this be the case for urban dwellers, think about the farmers living in remote villages. They need power for irrigating their crops, or lighting their cattle sheds. What can they do?

The reasons for having large gap between requirement and consumed energy could be the wastage of electrical energy. The foremost reason can be that the power supplied for agricultural needs is during the night hours. Farmers Switch on the pump motor and leave it 'on' for the whole night. Farmers do not bother to switch off the pump motor when the land is filled with sufficient water level. This is the main source of wastage of electrical energy from the grid.

II. OFF-GRID SOLAR POWER IN INDIA

Providing adequate and quality power to domestic and other consumers remains one of the major challenges before the country. There is also an increasing concern to reduce reliance on fossil fuels in meeting power needs and opting for cleaner and greener fuels instead. With about 300 clear sunny days in a year, India's potential for producing solar power is far more than its current total energy consumption. However, presently the amount of solar energy produced in India is insignificant compared to other energy resources. Therefore, solar power is being increasingly utilized worldwide as a renewable source of energy. India has huge untapped solar off-grid opportunities, given its ability to provide energy to vast untapped remote rural areas, the scope of providing backup power to cell towers and its inherent potential to replace precious fossil fuels. The solar PV off-grid opportunities in India are huge, given the fact that over 400 million people do not have access to grid connected electricity. The off-grid opportunities are significant, given the cost involved in off-grid applications when compared to huge financial investments to be made to set up grids. Moreover, specific government incentives to promote off-grid applications, rapid expansion of wireless telecom and telecom companies' desire to reduce operating cost for base stations are also expected to prompt growth in off-grid opportunities. The potential of replacing huge usage of kerosene used for lighting rural homes makes off-grid applications desirable. Off-grid PV application examples include remote village electrification, power irrigation pump sets, telecom towers, back-up power generation, captive power generation and city, street, billboard and highway lighting.

The government's solar mission envisages off-grid applications reaching 2,000 Mw by 2022 and deploying 20 million solar lighting systems for rural areas

III. SOLAR POWER UTILIZATION FOR WATER PUMPING

Water is the primary source of life for mankind and one of the most basic necessities for rural development. The rural demand for water for crop irrigation and domestic water supplies is increasing. At the same time, rainfall is decreasing in many arid countries, so surface water is becoming scarce.

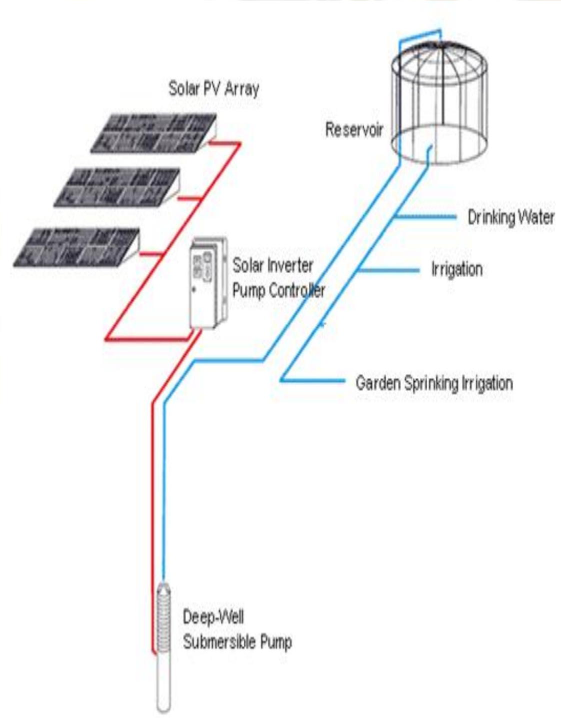

Fig.1 Solar Power Based Irrigation system

As these trends continue, mechanized water pumping will become the only reliable alternative for lifting water from the ground. Diesel, gasoline, and kerosene pumps have traditionally been used to pump water. However, reliable solar (photovoltaic [PV])are now emerging on the market and are rapidly becoming more attractive than the traditional power sources. These technologies powered by renewable energy sources (solar), are especially useful in remote locations where a steady fuel supply is problematic and skilled maintenance personnel are scarce.

Table.1 Case Study on rural irrigation system

CASE STUDY: WATER PUMPING	
Name	Chattisgarh State Renewable Energy Development Agency(CREDA)
Location	Across several districts of Chattisgarh State, India
Application	To pump water for irrigation and drinking
Commissioned Date	2006-2007

IV. DESIGN METHODOLOGY

This project objective is to supply water for the fields in alternative way by generating electricity (through solar panels) in order to save 22% of the total power production in INDIA. Here, we introduce an advanced technique of control through GSM module. The components required for the project is solar panel, battery, relay, dc pump, GSM module, microcontroller, water tank.

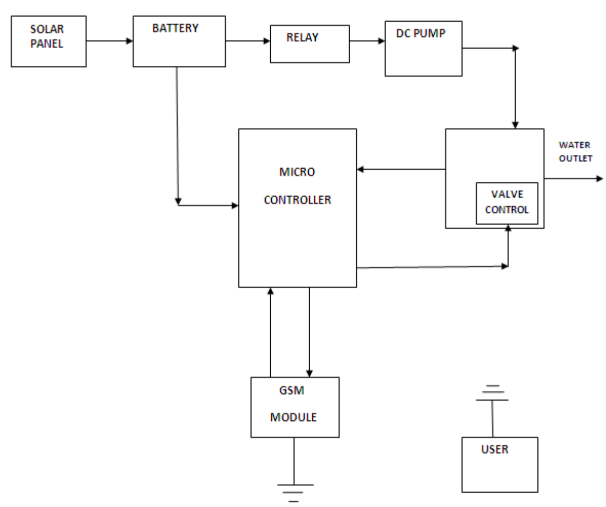

Fig.2 Overview of the proposed system

When the sunlight falls on the solar panel, it liberates the electrons within the material which then move to produce a DC current. This dc power is stored in the battery so that the pump can operate even in the night time by discharging the battery. The other end of the battery is connected to the relay and relay is connected to DC PUMP.A water tank is present in order to store the water for watering the fields. Water tank consists of 4 sensors in order to sense the level of water in the tank and send it to PIC micro-controller (16F877A) and water tank is also having valve and this valve action is controlled by small servo motor. The GSM module is used which is a hardware component that allows the capability to send and receive SMS to and from the system.

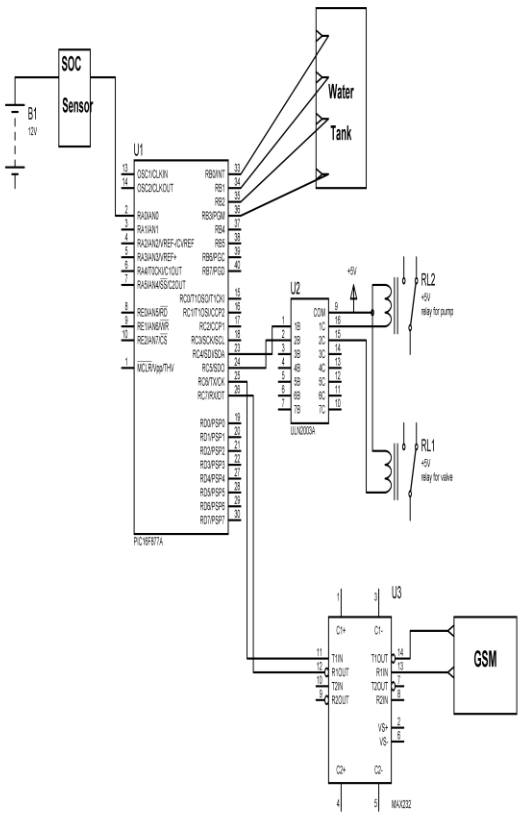

Fig.3 Overview of Circuit Design of the System

If the user (farmer) sends the text message via mobile phone as [@.ONX] it checks the level of tank and depending on the level of tank the operations takes place. We can know the level of water with the help of level sensors. If the task is completed then the GSM module sends the simple message as "WATERING IS DONE" to the user. If the task is not completed it sends message as "WATERING IS NOT DONE LAGGING RESOURCES". The state of charge of the battery is sensed by charge sensor and sends it to Micro-controller and the level sensor sense the level of water in tank and send it to the micro controller.

HARDWARE DESIGN METHODOLOGY

1. **PV SIZING**: Different size of PV modules will produce different amount of power. To find out the sizing of PV module, the total peak watt produced needs. The peak watt (WP) produced depends on size of the PV module and climate of site location. To determine the sizing of the PV modules, calculate as follows:

STEP 1: **Calculation of Total Load Connected**
Total Load Connected =[D.C Pump Power Rating * Time of usage] + [Remaining Components Power Rating* Time of usage]

STEP 2: **Calculation of Total PV Panels Energy Needed**
Total PV panels energy needed= Total Load Connected + Losses

STEP 3: **Calculation of Total Wp Of PV Panel Capacity Needed**
Total Wp of PV Panel Capacity Needed = Total PV panels energy needed/ No of Illumination hours

STEP 4: **Calculation of No. of PV Panels Required**
No. of PV panels = Total WP of PV panel capacity needed/ Rating of the PV Panel

2. **BATTERY SIZING:** The Amp-hour (Ah) Capacity of a battery tries to quantify the amount of usable energy it can store at a nominal voltage. All things equal, the greater the physical volume of a battery, the larger its total storage capacity.

STEP 1: **Calculation of total Load Connected**
Total Load Connected = Sum of all appliances (power rating of each device * Time of usage)

STEP 2: **Calculation of Battery (Ah)**
Total Load Connected*Days of Autonomy/ Battery Losses*Depth of Discharge* N.B.V

3. **VALVE CONTROL**: A valve is outlet of the tank. The valve opening and closing will be done by user through GSM. Whenever User sends a message to the GSM module, it transfers the message to the Micro-Controller. The Micro-Controller will check for the syntax and opens the valve if the resources of the system are sufficient and doesn't open the valve if the syntax is not correct or the resources of the system are not sufficient. For driving the valve, a servo motor is used for opening the valve. For opening the valve, the motor has to rotate in clockwise direction and for closing it has to rotate in the reverse direction. This operation is controlled by Micro-Controller whenever user sends a message to GSM module.

SOFTWARE DESIGN METHODOLOGY

Algorithm Description for Flowchart-1

Step1:-start
Step2:-If user sends the message, go to step4
Step3:-condition -2and then go to step1
Step4:-Check for the syntax and if syntax is correct go to
Step 5, else go to step 6
Step5:-condition-1 and then go to step1
Step6:-Resend the message and go to step1

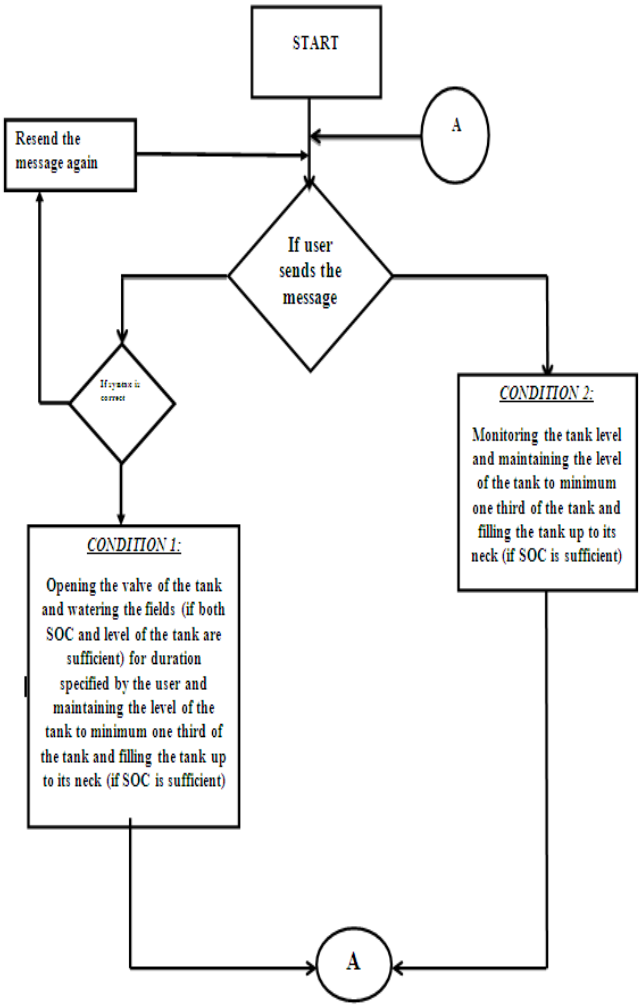

Fig.4 Flow chart-1 of system operation

Algorithm Description for Flowchart-2
Step1:-If level is below half of the tank go to step3
Step2:- Open the Valve and check for duration specified and if the duration specified is over go to step6, else go to step1
Step3:-Check for the SOC (state of charge) of battery and if it is sufficient, ON the motor and open the valve then jump to step5
Step4:-go to step7
Step5:-Check for duration specified and if the duration specified is over go to step6, else go to step3
Step6:-job completed and close valve and go to step8
Step7:-job hasn't completed and close valve and go to
Step1 in algorithm-1
Step8:-go to step3 in algorithm-3

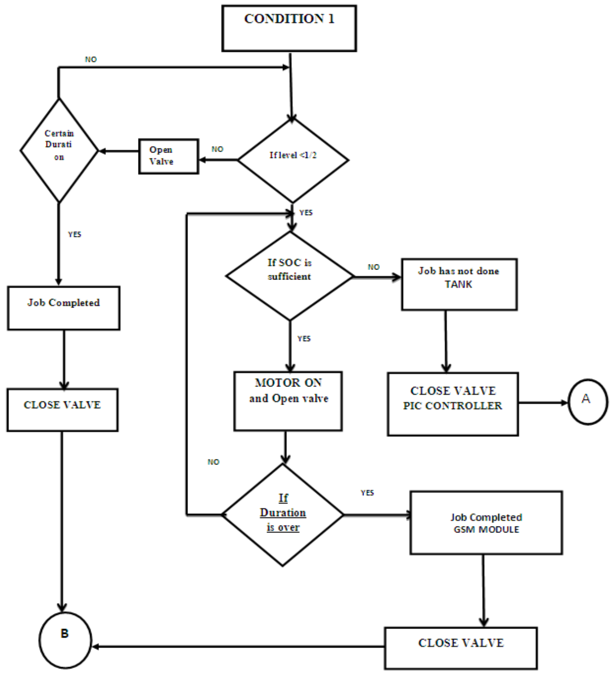

Fig.5 Flow chart-2 of system operation

Algorithm Description for Flowchart-3
Step1:-Check the tank level
Step2:-If the tank level is greater than half of the tank,
OFF the motor and go to step1 in algorithm-1
Step3:-If tank is full, OFF the motor and go to step1 in
Algorithm-1
Step4:-If SOC (state of charge) is sufficient, ON the motor and go to step 3
Step5:-else OFF the motor and go to step1 in Algorithm-1

V. RESULTS AND VALIDATION

The system described above can be tested in the given below scenarios. Each scenario shows the working of the system in various modes of operation.

Test Case 1
Input: If User sends the message (@.ONX) for system operation.
Assumption: Assume the level of the Tank is full and SOC is sufficient to operate the system.
Operation: Whenever the user sends the message to GSM module, the GSM module will transfer the data sent to it to the PIC controller through serial communication and then the

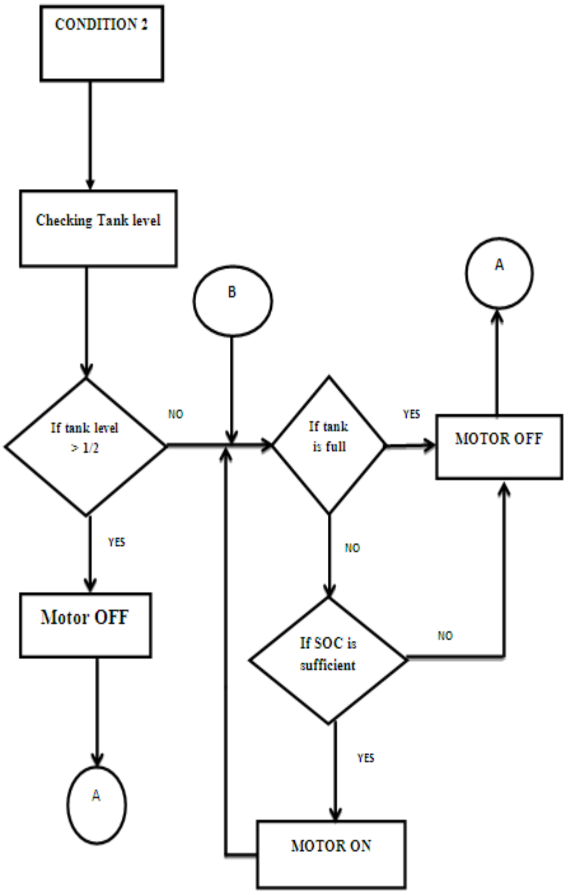

Fig.6 Flow chart-3 of system operation

PIC Controller will check the syntax of the message. If the syntax is correct the PIC controller checks the level of the tank and opens the valve of the tank. When the valve is opened, the PIC controller continuously monitors the level of the tank and checks whether the duration is completed or not. As the tank is completely filled the system can supply the water to the fields for the duration specified by the user. After watering the fields for certain duration, the PIC controller gives a command to close the valve of the tank and gives a command to the GSM to send a message that "Watering is done".

Test Case 2

Input: If User sends the message (@.ONX) for system operation.

Assumption: Assume the level of the Tank is greater than half level of the tank and SOC is sufficient to operate the system.

Operation: Whenever the user sends the message to GSM module, the GSM module will transfer the data sent to it to the PIC controller through serial communication and then the PIC Controller will check the syntax of the message. If the syntax is correct the PIC controller checks the level of the tank and opens the valve of the tank.

In this case the system will operate in two modes:

In the first mode only Watering will be done to the fields by using water in the tank. The PIC controller will continuously monitors the level of the tank and checks whether the duration is completed or not. Until the level of the water in the tank reaches below the half of the tank the system will operate in the first mode and will continuously monitors the level of the tank and checks whether the duration is completed or not. Whenever the level of the water in the tank reaches below the one half of the tank the system will operate in the second mode.

In the second mode whenever the level of the water in the tank reaches below the half of the tank the PIC controller will check the SOC of the battery in order to ON the motor. As SOC of the battery in this case is sufficient enough to operate the system the PIC controller will ON the motor and pumps the water to the tank through Motor. As the water is pumped to the tank watering is done to the fields. In this mode both the valve and motor are in operation. After the duration is completed, PIC controller closes the valve and gives a command to the GSM to send a message that "Watering is done".

Test Case 3

Input: If User sends the message (@.ONX) for system operation.

Assumption: Assume the level of the Tank is below the half level of the tank and SOC is sufficient to operate the system for the duration specified by the user.

Operation: Whenever the user sends the message to GSM module, the GSM module will transfer the data sent to it to the PIC controller through serial communication and then the PIC Controller will check the syntax of the message. If the syntax is correct the PIC controller checks the level of the tank. As the level of the water in this case is below the half level of the tank, the PIC controller now will check the SOC of the battery in order to ON the motor to pump the water into the tank for watering the fields. As the SOC is sufficient to operate the system for the certain duration, the motor is operated by PIC controller and it opens the valve of the tank. The motor and the valve will be in the operation until the duration is completed. Once duration is over, PIC controller closes the valve and gives a command to the GSM to send a message that "Watering is done".

Test Case 4

Input: If User sends the message (@.ONX) for system operation.

Assumption: Assume the level of the Tank is below the half of the tank and SOC is not sufficient to operate the system for the duration specified by the user.

Operation: Whenever the user sends the message to GSM module, the GSM module will transfer the data sent to it to the PIC controller through serial communication and then the PIC Controller will check the syntax of the message. If the syntax is correct the PIC controller checks the level of the tank. As the level of water is below the half level of the tank, the PIC controller now will check the SOC of the battery in order to ON the motor to pump the water into the tank for watering the fields. As the SOC is not sufficient to operate the system for the certain duration, the motor is operated and valve is opened until the SOC is sufficient. After that the PIC controller gives a command to the GSM to send a message that "Watering not done, lagging resources".

VI. CONCLUSION

The history of agriculture dates back thousands of years, and the development has been driven and defined by greatly different climates, cultures and technologies. The main contribution of this paper is to give a overview of project model which will greatly develop the irrigation system in India. The automation of an irrigation system will largely reduce the gap between requirement and consumed energy and further conserves the resources thereby reducing the wastage of resource.

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