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Solar Powered Smart Irrigation System

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***Abstract*- Solar-Powered Smart Irrigation System (SPSIS) is a solution to many problems of the agricultural system. In this work, a solar-powered smart irrigation solution is proposed for the farmers of Pakistan facing energy crises. The proposed smart irrigation system is powered by renewable solar energy, which is equipped with solar panel modules to convert sunlight into electrical energy. Arduino microcontroller-based system is designed for automatic operation of the complete system. Due to the automatic working of the proposed system, it will be better than a conventional irrigation system in terms of human effort, time, water and energy consumption to operate the irrigation system. The proposed Solar-Powered Smart Irrigation System (SPSIS) does not rely on grid power due to its self-energy production using solar power, resulting in a significant reduction of power usage from grid power. The proposed SPSIS is equipped with multiple input soil moisture sensors, which measure the humidity of the soil. SPSIS is also equipped with a monitoring setup to intimate the farmers about the water level in the field and the irrigation status of the field. Furthermore, SPSIS is also equipped with an automatic spray system to prevent weeds, insects and pests in the crops. Additionally, a GSM Module has also been added to the overall system for the intimation/controlling of the irrigation process through text messages. Such an implementation of a solar-powered smart irrigation system with additional features of automatic spray and monitoring and control using GSM will be highly beneficial for the formers in terms of power, efforts and resources required for irrigation, spray and monitoring of the crop.**

***Index Terms*- SPSIS, Smart Irrigation, Solar Powered, GSM Module, Energy Crisis**

I. INTRODUCTION

Pakistan has very fertile land, so the major sector of Pakistan's economy depends on agriculture, making Pakistan a great exporter of many agricultural products, including rice, cotton, tobacco etc [1]. Modern agricultural methods can further improve the production and export of agriculture [2].

According to the World Bank collection development indicators in 2018, 47.09 percent of Pakistan's land area is agricultural land [3]. Irrigation of plants is most important in properly utilizing this massive agricultural land. Farmers use ancient methods for irrigation, which are mainly dependent on tube wells and rainwater [4]. There is much room for improvement and up-gradation of the irrigation system used in Pakistan in this modern era.

The conventional irrigation methods cause water wastage and demand a lot of human effort and energy for its operation [5]. In the current electricity crisis in Pakistan [6], there must be a modern irrigation system that minimizes the dependence on grid electricity and reduces the effort and involvement of humans in the irrigation process.

In this era of the modern world, Pakistani farmers should also shift to the new technology side instead of using time taking and tough methods for agricultural purposes. The quality and quantity of the crop productivity depend on the way crops are irrigated. Drip irrigation is considered the most effective and good way to irrigate the fields [7]. In this irrigation method, there are fewer chances for wastage of water, as water is allowed to drip into the roots of the crops slowly [8]. So, the purpose of drip irrigation is to directly provide water to only the root of the plant to minimize water evaporation.

On the other hand, in the case of water sprinkling, there are more chances of water getting evaporated [8]. Suppose these considerations are not made while irrigating the field. In that case, it will lead to a poor irrigation system, which will cause a loss of moisture in the soil, eventually making it unfit for crops production [9].

Furthermore, there is no proper system for pesticide spraying on crops. Conventional systems of spraying pesticides involve a lot of human involvement and effort. This is a time-consuming process and, more importantly, can also cause health issues with the person involved in manual spraying due to his interaction with these poisonous chemicals [10].

So, this work aims to design and implement a smart irrigation and pesticide spray system. The proposed system will improve water management, minimize electricity dependence on grid power, and minimize the former's effort, as the former's involvement in the irrigation and spraying process will be minimized due to an automatic system.

The proposed system will also be Eco friendly, as sunlight is one of the most eco-friendly sources to get energy [11]. Solar-based renewable energy also facilitates overcoming the energy crisis by providing a cost-effective alternative [12]. Solar panels are widely used in solar furnaces [13], water heaters [14], mobile houses and electric vehicles [15]. Thus, it was decided to benefit from solar energy to operate the proposed system.

II. LITERATURE

A detailed literature review was done before proposing a smart irrigation system. The detail of some of these existing works in literature is discussed below.

An overview of Solar-power based smart irrigation system was proposed by Durai CR [9]. The proposed system utilized solar power for irrigation purposes. Soil Humidity sensors were set on the field with the responsibility of continuously sensing the water content of the field and giving the information to the user via the GSM module through SMS. Without going to the field, the user can get the moisture content information and control the water pump/motor by communicating with outlying (distant) devices where the system is accessible. However, this system does not have any solution for pesticide spray.

In the context of solar energy as an alternate electricity source, Harishankar. et al. [16] describes that solar power is quite a good source to fulfill many of our energy needs. This is a cost-effective alternative compared to the grid electric power supply. Solar power can also be a solution to the present energy crisis of farmers. Solar power system reduces the electricity consumption from the grid power system and provides an uninterrupted power supply. Solar power is not only a solution to the present energy crisis but also an environmentally friendly form of energy. Photovoltaic generation is a better approach to utilizing solar power.

Similarly, in the context of an understanding of the Global system for mobile communication (GSM), Pavithra D.S. et al. explains the GSM module in detail [17]. GSM is used to intimate the user about the actual field conditions as it is a communication device used to get information through SMS/call using a phone. The data is passed onto the user via SMS/Phone call. GSM module is used for remote control activities such as Gate control, Temperature control, home automation, etc. GSM module consists of a GSM modem assembled with power supply circuit and communication interfaces (like RS-23 USB) for computers like transceiver and receive data interfaces. The modem is the soul of such modules. They generate, transmit, and receive data from the cellular network (2G, 3G, 4G) to generate communication between the cellular networks and computers. These are manufactured for special cellular networks (GSM/UMTS/CDMA) or certain cellular data standards (GSM/UMTS/GPRS/EDGE/HSDPA) or technology (GPS/SIM). They use serial communication to interface with the user and need Hayes compatible AT (Attention) commands for communication with the computers.

Likewise, R.Nandhini. et al. described the importance of proper water utilization in the irrigation system, and proposed an automated irrigation system [18]. Agriculture is economic strength for many developed and developing countries. It uses 85 percent of available fresh water resources worldwide. However, this percentage is decreasing with an increase in growth and food consumption, due to which more water is required for the cultivation of crops and for fulfilling the needs of people around the globe [18]. So due to this reason, efficient water management plays an important role in the cultivation system in an arid and semi-arid zone. An automated irrigation system is required to improve crops' water usage and lessen water loss. The main reason for water loss and crops damage is usually under and over-irrigation [18].

III. METHODOLOGY

As the economy of Pakistan depends on agriculture, so the important factors to focus on for the best crop yield are uninterrupted power supply, the precise amount of water (for irrigation), and the use of technology (fewer men intervention). People living in villages are mostly farming, and their incomes are mostly based on farming [4]. Farmers of Pakistan are facing problems for irrigation in which the major problem is overwatering and under-watering. So, the major cause of the stated problem is sometimes the weather and sometimes the unscheduled irrigation. In this struggling time of Pakistan, our need is to use renewable energy sources, save water, lesser the intense hard work, minimize manual control and save crops from harmful insects. Every problem should have a proper solution.

Figure 1 presents the block diagram of the proposed system, which illustrates different modules and their interdependencies in the proposed system.

The first major block of the proposed system is a solar panel connected to a battery using a charge controller. A solar panel produces electricity from sunlight which charges the battery using a charge controller. This stored electricity is then used for the operation of the proposed system.

Storage of electricity in battery provides both uninterrupted constant electricity supply and a backup in condition when the solar panel cannot produce electricity in the absence of sunlight, for example, at night or cloudy weather. The electricity produced from solar panels varies with daylight changes, so a charge controller is used to charge the battery in varying conditions efficiently.

Four soil moisture sensors were placed at different points in the field, and they were connected using AND gate to develop

a boolean logic for moisture sensing. Initially, when there is no moisture in the soil, all four sensors will detect this and provide '0' at their outputs, indicating no moisture condition.

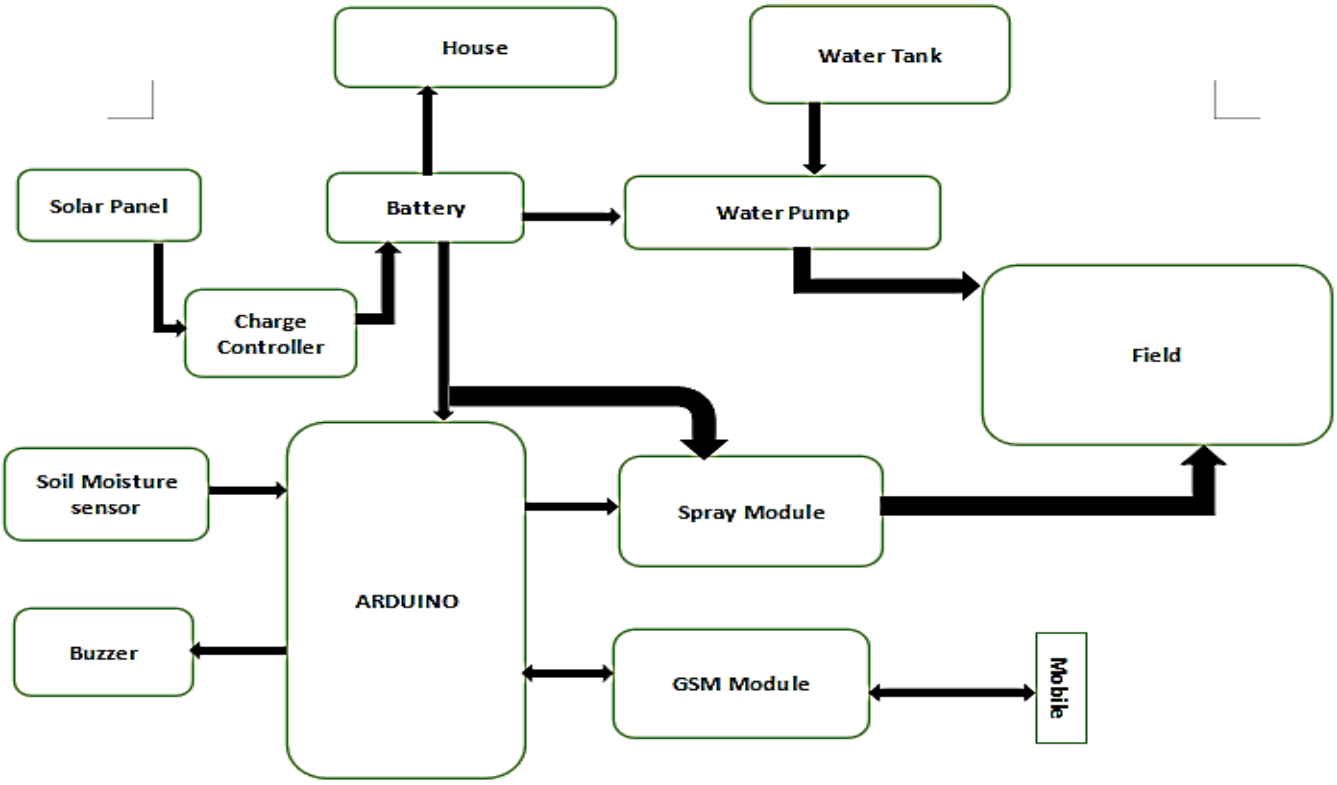

FIGURE 1. Block Diagram of Solar Powered Smart Irrigation System

The outputs of moisture sensors are connected to the input of an AND gate, so any '0' at the input of AND gate will result in a '0' at the output of the AND gate, indicating a low moisture condition. This Low moisture conditions in the field should be tackled by irrigation, so Arduino automatically sends a command to the water pump, which begins irrigating the field by switching the water flow towards the field.

Once the desired moisture level is achieved, sensors will indicate this condition by giving '1' at their output, which will also produce '1' at the output of AND gate. Arduino will detect this condition and will send the stop command to the water pump to terminate the irrigation process. It is necessary to mention that irrigation will start if the output of any one of the sensors is low. The desired system output is shown in Table 1.

Table 1: Desired system output

Sr. No	Humidity of Soil	Water Pump	Buzzer	Home (load)
1.	High	OFF	OFF	ON
2.	Low	ON	ON	OFF

The proposed system also includes a pray module, which sprays pesticides on the crops after a specific delay. This delay can be easily adjusted by programing according to the need of crop and weather conditions.

Additional energy produced by the proposed system after utilization in the irrigation process was fed to the former house. This will save thousands of rupees per month for each former benefitting from the proposed system [19]. If we produce electricity on the Industrial level, it can be sold to power companies in the country, which will help overcome the energy crisis at the country level.

The addition of GSM in the system has enabled two different modes of operation, i.e., User-defined mode of operation and Automatic Mode of Operation. GSM also enables formers to receive intimations about the field and remotely manage the irrigation process. The modes of operation are briefly discussed subsection .

A. User-Defined Mode of Operation:

The proposed system has a special button for mode selection. In the user-defined mode of operation, the user will have intimation about the status of the field through messages on mobile. The user will be asked, "Do you want to ON the Pump" in low moisture conditions. If the user sends "YES", the pump will switch on, and irrigation will start. In case the user sends "NO" or does not send anything, it will not perform an action and wait till the user sends "YES".

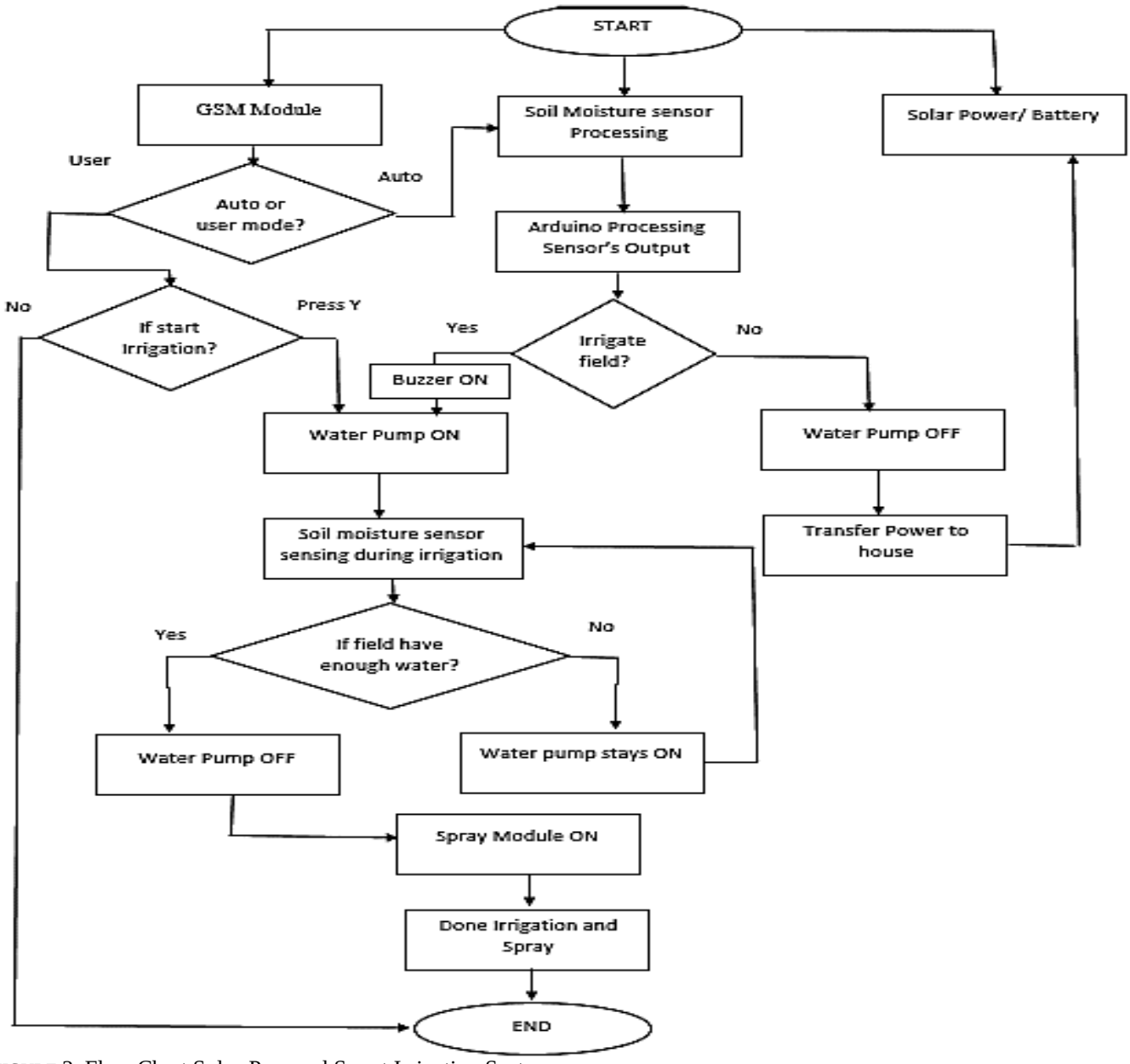

FIGURE 2. Flow Chart Solar-Powered Smart Irrigation System.

B. Automatic Mode of Operation:

In this mode, all actions will be performed according to the programming of Arduino, and no instruction will be required from the user. This mode is specially designed for situations where the user is out of town and unable to give instructions.

A buzzer is also included in the proposed system to facilitate illiterate people who cannot use mobile properly. They will be intimated about the irrigation process and any required action through buzzer sounds.

Figure 2 presents a flow chart that explains the working of the whole system, starting from the sensing unit, GSM module, and solar power utilization in irrigation and house.

IV. RESULTS

Before hardware implementation, proteus-based simulation of complete setup was done. Fig. 4 presents a simulation model prepared in proteus. After simulations, hardware implementation was done using the components discussed in the methodology section. The complete system is shown in Fib. 4.

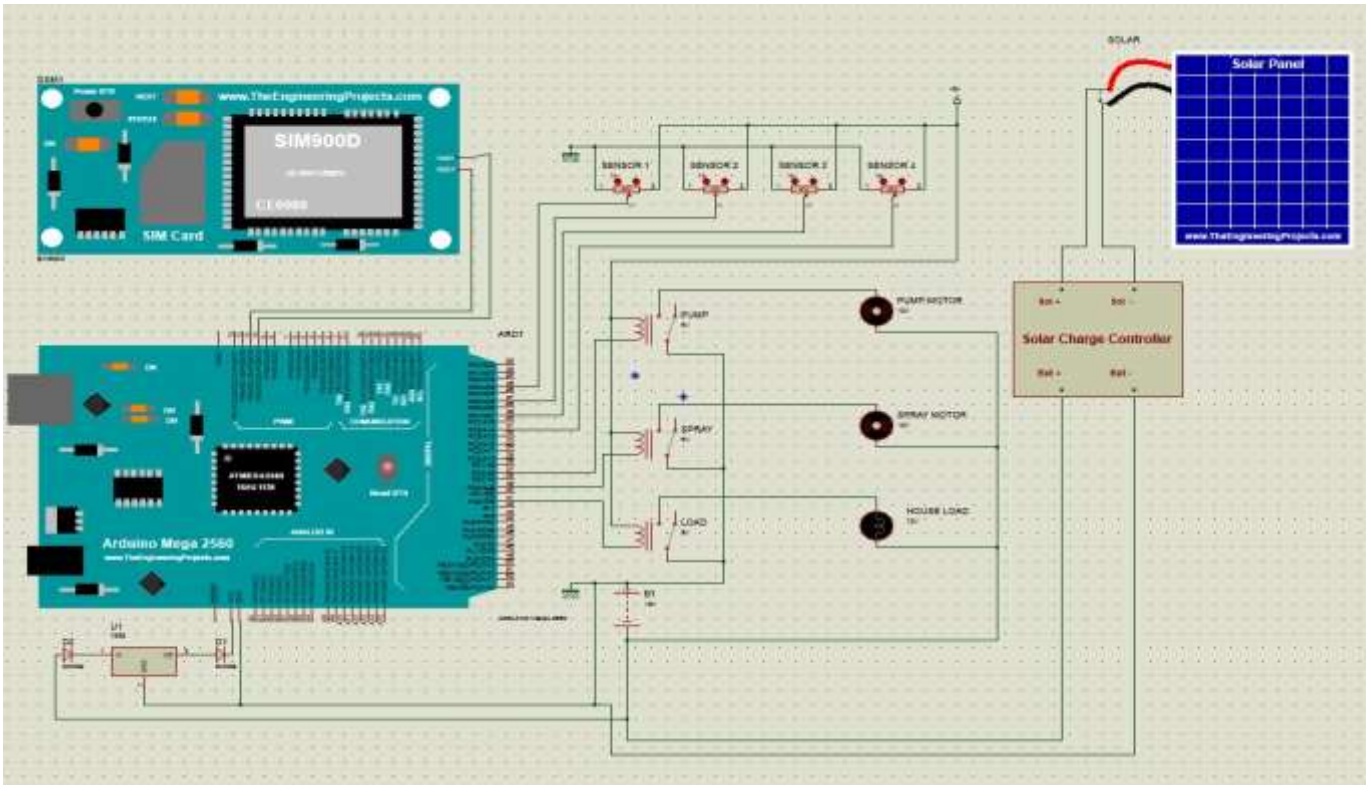

FIGURE 3: Simulation Model

FIGURE 4: Picture showing complete System

FIGURE 5: Picture showing mobile phone notifications with the help of GSM

Figure 5 presents the intimations and action messages displayed on the user. In the case of user-defined mode, a user is sending commands switching on/off the power of the house or irrigation process. While in the case of automatic mode, the system is working on its own and just intimating the user about the current status of the process.

The proposed system has reduced the need for a workforce because all actions are performed automatically, which saves a considerable amount of water from getting wasted. There is a handsome amount of money and time saving by benefiting from the proposed system.

Another important feature of the proposed system is to provide surplus power to the national grids, and last but not least, a buzzer will produce a sound when any specific action is performed.

V. CONCLUSION

Solar Power Smart Irrigation System (SPSIS) makes irrigation of crops much easier for farmers, lessens the User's excessive effort while irrigation, and provides proper management in irrigation scheduling. This system is found reliable and efficient to utilize solar power for the sake of irrigation, to reduce manual control while the irrigating field, and control the irrigation through mobile phones. This systematized system is a coherent body to solve many problems of farmers in the field of agriculture. This system intends to save water and grid power and get more crop yield. Moreover, this system can be used by every non-professional and layman as there is nothing complex in the operating function of the system. To control Solar Power Smart Irrigation System using a phone for irrigation makes it even better. The major advantage of this system is solar power, which is a renewable form of energy, to run the system, which makes it cost-effective.

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