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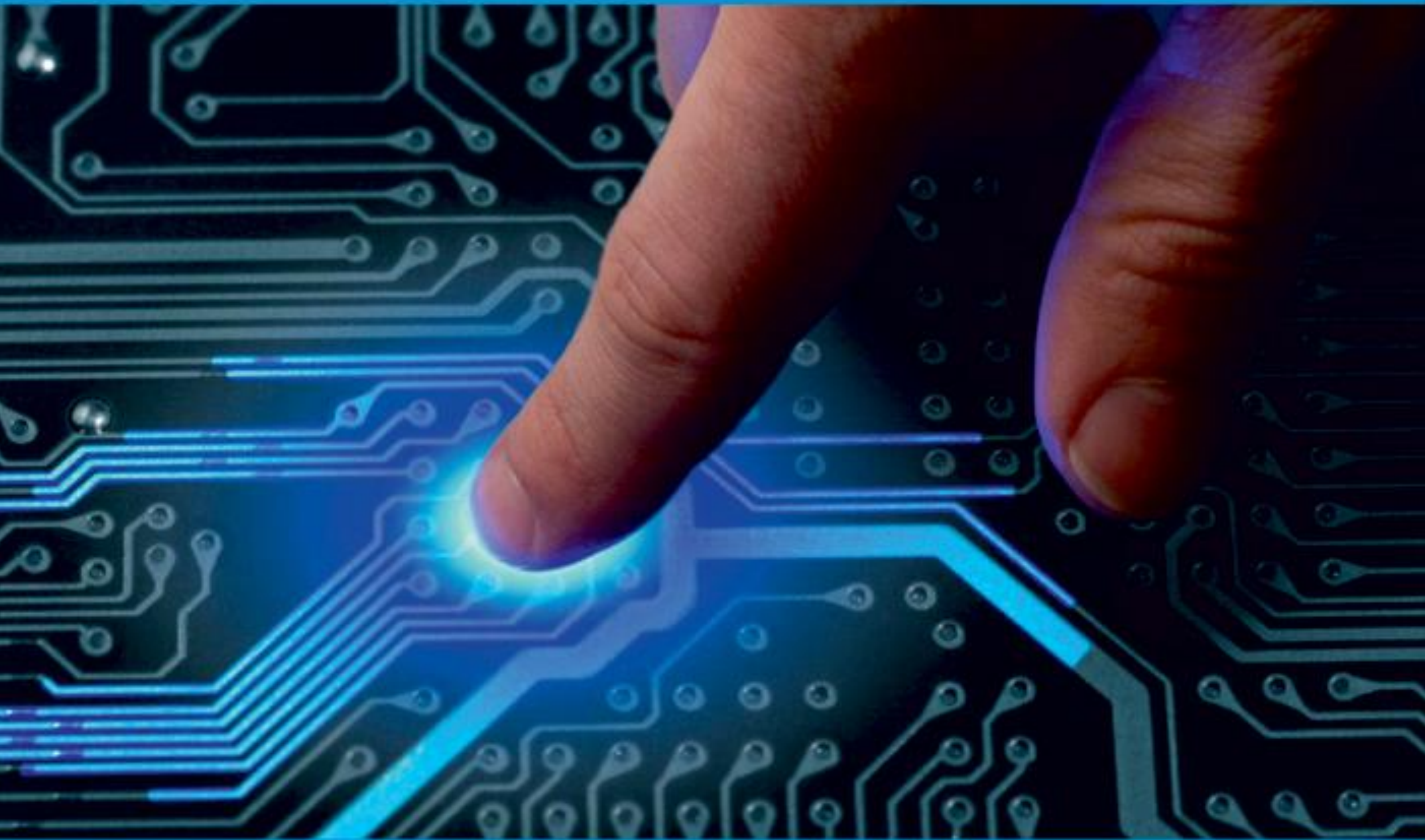

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Smart Irrigation System Using Dual Axis Solar Tracker

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***ABSTRACT*:** Solar power being the most promising form of renewable energy, sun trackers significantly increase the photovoltaic (PV) system's ability to generate power. A dual-axis solar tracker is proposed here in order to demonstrate effective solar power. To maximize power output, the tracker actively monitors the sun and adjusts its location at the desired angle for maximum output. Light dependant resistors and Arduino-operated control circuit drive linear manipulators for the movement of solar panels, a cloud monitoring system is attached here for the power generation and load of varying information. Static and dynamic variations of the panel were done and maximum power and efficiency was recorded and analyzed. This research presents a novel irrigation system designed for efficiency and convenience, utilizing an Arduino Mega 2560 integrated with GSM technology. The system employs moisture sensors in the soil to automatically water plants when the ground is dry or allows manual control via SMS from the farmer or homeowner's mobile device. This integrated system offers a sophisticated, user-friendly approach to managing irrigation and water resources in agriculture and home gardening.

KEYWORDS: Solar tracking, GSM module, Irrigation System, Soil Moisture, Arduino, Water Pump.

I. INTRODUCTION

1.1 BACKGROUND

For the irrigation system atomization is very much essential because of the shortage of water in soil and lack of rain. Automatic irrigation system with solar tracking is the alternative solution for this type of situation. Agricultural system in world is always in need and depends on the presence of water in the soil. The continuous pulling out of soil water will reduce the moisture level of the soil. To overcome this issue intended irrigation system has to be followed. The better utilization of the available water will reduce the amount of wastage of water significantly. For this reason, automatic irrigation system is to be designed which will use the solar energy. The automatic irrigation with solar tracking system receives sun light through photo-voltaic cells. Therefore this system is not dependent on electric power. This automatic irrigation with solar tracking system uses solar energy to power the irrigation pump and the circuit comprises of sensors which will sense the soil for its dry or wet condition. The main objective of this project is to rotate the solar panels according to the sun's position automatically and to use the water. in most efficient ways. By using some hardware and software components we can design dual axis solar trackers with irrigation systems. The hardware components involved are LDR (Light detecting resistor), .gear motor, solar panel, moisture sensor and software component is micro controller. The LDRs are used to take sunlight as input from the sun. Four LDR are connected to the solar panel. These LDRs will trigger the motor to move the solar panel so that the solar panel will face the sun throughout the day. One of the most important aspects to maximize crop production is watering the crops but due to water scarcity and manual irrigation system the amount of water to be supplied could get higher or lower than the requirement. So this project includes an automatic irrigation system that involves a moisture sensor. The moisture sensor will sense the exact amount of moisture content in soil that will help in supplying the exact amount of water. This project is divided into two parts- Dual axis solar tracker and Irrigation System.

1.2 PROBLEM STATEMENTS

Irrigation is the most important cultural practice and most labor intensive task in daily agriculture sector. Knowing when and how much to water is two important aspects of irrigation. To do this automatically, sensors and methods are available to determine when plants may need water. Automation involves mechanism of all the industrial activities so as to improve the speed of production, reduction of cost, effective use of resources. With the growing requirement of electricity and concern for the environmental impact of fossil fuels, implementation of eco-friendly energy sources like solar power is rising. The efficiency of the single axis tracking system over that of the static panel is calculated to be 32.17% and the dual-axis tracking system over that of the static panel is calculated to be 81.68%.

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Due to seepage in drains, wastage of water is caused there is imbalance in distribution of labour. After growth of crops, water reaches the basins in disproportionate quantity thereby causing wastage of water, creation of problem of water logging.

1.3 MOTIVATION

Before starting our project, we did research on different problems that are present in Agriculture land. During our research we found the struggle of farmers trying to figure out the solution to solve this problem for proper crops irrigation and energy source management. Thus we strike on the idea of developing a smart irrigation system based on solar power. This system would eradicate the problem faced by farmers to proper irrigation of farm land and increase in production of crops. We, being the student of Electronics and Communication Engineering Faculty, we thought that it would be our responsibility to develop such system which would solve the problem faced by farmers.

I.4 OBJECTIVE

- The main objective of this project is to provide two separate systems i.e. Dual axis solar tracker to take maximum input from sunlight and produce solar energy whereas irrigation systems to optimize use of water in irrigation systems.
- To involves mechanism of all the activities so as to improve the speed of production, reduction of cost, effective use of water resources.
- The project has a GSM module to send a short message service (SMS) to farmer regarding irrigation of different plots and motor ON/OFF condition.

II .LITERATURE SURVEY

The paper presents a study on the Performance Analysis of Dual Axis Solar Tracking System Actuated Through Serial Manipulators, detailing the design and construction of a solar tracking system employing serial manipulators for actuation. Through experiments and simulations, the authors demonstrated its efficacy in enhancing solar energy harvesting, with improvements ranging from 19 to 28% in cloudy weather and 30 to 40.12% on sunny days. Advantages of using serial manipulators for solar tracking are discussed, along with construction and design constraints of the solar panel. The findings suggest significant performance enhancements, particularly in low solar irradiance areas or steep terrain, with potential applications in home heating and densely populated hilly regions [1].

The paper presents an Arduino-based automatic irrigation system that utilizes a microcontroller and GSM network for remote control and monitoring of irrigation processes, tank water levels, and rain detection via SMS commands. This system offers environmental and economic benefits by reducing water waste, labor costs, and effort associated with irrigation while providing a modern alternative to traditional methods. By integrating soil moisture sensors and microcontrollers, it automates irrigation processes and minimizes water usage, resulting in a 60% reduction compared to conventional methods. The system's ease of operation and remote accessibility make it a promising and sustainable solution for efficient irrigation practices [2].

The paper outlines the development of a Solar-Powered Smart Irrigation System (SPSIS) designed to mitigate water and electricity wastage in irrigation processes. Utilizing a wireless sensor network and solar energy, the system operates either manually or via a mobile application, offering significant water and energy savings for farmers. Scalable by adjusting PV panel size, battery storage, and motor capacity, the SPSIS proves beneficial for sustainable agriculture in South Africa, enhancing efficiency even on overcast days. The well-organized document serves as a comprehensive guide for those interested in sustainable irrigation systems, providing detailed insights into its design, implementation, and testing [3].

This paper outlines the development of an innovative irrigation system powered by Arduino and solar technology. It aims to enhance efficiency, save resources, and increase crop quality by utilizing soil moisture sensors to regulate irrigation. The system is designed for areas with water scarcity and lack of electrical infrastructure, offering practical benefits for large-scale farming. The study suggests further enhancements like water level and noise sensors for optimized irrigation and security. Overall, it underscores the importance of renewable energy sources like solar power in improving agricultural practices and crop yields [4].

The paper reviews a Solar Powered Irrigation System utilizing Arduino UNO, aiming to enhance water usage efficiency and reduce waste through renewable resources and IoT technology. It employs sensors to monitor soil moisture and weather, controlled by an Arduino-based microcontroller for automated watering, capable of data

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transmission to a cloud server. Highlighting benefits like improved productivity and reduced human intervention, the system's use of solar power and IoT offers a sustainable solution for addressing water scarcity and food security concerns. Its adaptability to different crops and soil types further underscores its potential impact on enhancing food security while minimizing water wastage [5].

The Solar Based Automatic Irrigation System is a microcontrollerdriven solution harnessing solar power for eco-friendly irrigation in agriculture. It automates watering by detecting soil moisture levels, conserving energy and optimizing crop production. This costeffective system, adaptable to various crops and environments, utilizes renewable solar energy, offering farmers a sustainable and efficient irrigation alternative, ultimately enhancing crop yields while minimizing energy usage[6].

.A microcontroller manages irrigation based on soil moisture levels, ensuring efficient water usage. Notably, the system is cost-effective and easily deployable, offering detailed insights into its components and functionality, promising improved crop yields and reduced water consumption for farmers worldwide [7].

The research proposes a system aimed at conserving water and energy in agriculture, specifically targeting the challenges faced by Indian farmers. Utilizing soil moisture sensors connected to an Arduino Uno, the system automatically controls irrigation by comparing sensed values with a predefined threshold, promoting water conservation. Integration of solar panels and a solar tracker enhances energy efficiency. The study emphasizes the importance of smart irrigation systems and IoT technology in improving water and energy management in agriculture, acknowledging challenges in testing and suggesting future applications of machine learning for crop data analysis. It underscores the significance of increasing agricultural production to meet the needs of India's growing population and cites related research, highlighting the importance of smart irrigation systems in resource optimization for Indian farming [8].

The paper describes an Automatic Solar Tracking System aimed at enhancing solar panel efficiency through single-axis tracking to follow the sun's movement. This system utilizes semi-transparent silicon solar cells and includes a microcontroller and LDR sensors to control a DC motor, ensuring optimal solar panel orientation. It emphasizes the environmental benefits and importance of solar tracking for efficient energy collection, highlighting various tracker controllers. Overall, the system offers promise for improving solar energy efficiency, promoting sustainability, and addressing energy shortages [9].

The project proposes an innovative irrigation system that integrates sensor technology to optimize crop yields by considering factors like soil moisture and air humidity. Traditionally, farmers spend significant time irrigating without such considerations. However, this system relies on electrical energy for operation, and with increasing costs and depletion of conventional sources like fossil fuels, a photovoltaic (PV) system emerges as a sustainable alternative. The PV system directly harnesses solar energy, converting it into electric power to operate the water pump and sensors, typically comprising a solar panel, voltage stabilizer, and power inverter. While the PV panel initially produces direct current and voltage, which may not match the load circuit's requirements, the inclusion of a voltage stabilizer and power inverter ensures efficient operation of the system [10]

This project proposes an irrigation system integrated with sensor technology to enhance crop yields by optimizing water usage based on factors like soil moisture and air humidity. Unlike traditional methods that often overlook these factors, this system aims to improve efficiency. To address concerns about energy consumption and costs, the project suggests utilizing a photovoltaic (PV) system as a sustainable alternative to conventional energy sources like fossil fuels. The PV system directly harnesses solar energy to power the water pump and sensors, consisting of components such as solar panels, a voltage stabilizer, and a power inverter. These components ensure efficient operation by converting solar energy into usable electric power, enabling the irrigation system to function effectively while reducing reliance on non-renewable energy sources [11]

The paper discusses the advantages of employing a smart irrigation system with solar panels and sensor networks. It highlights the system's efficiency in managing irrigation in fields, gardens, and horticulture. The open-source design promotes recycling and reparability. The system is considered essential amidst the current global silicon shortage. It monitors various parameters to optimize irrigation, preventing over-irrigation. Over-irrigation is a common issue in agriculture due to unpredictable weather and lack of information. The paper references related research on automated trickle irrigation systems. It also mentions solar-powered fan caps for outdoor workers. Figure 5 depicts the user interface of the smart irrigation system. The conclusion emphasizes the eco-friendliness of the system. This is attributed

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to the use of solar panels and recycled lithium-ion batteries. The system ensures irrigation is provided in precise amounts required by the field. It minimizes water wastage and improves resource efficiency. The paper provides valuable insights into the benefits of integrating solar energy with smart irrigation technology. It addresses the specific needs of agriculture and horticulture. The system's ability to adapt to unpredictable weather conditions is highlighted. Its open-source nature encourages innovation and collaboration. The paper contributes to the discussion on sustainable agriculture practices. It underscores the importance of utilizing renewable energy sources in agricultural systems. Overall, the PDF offers valuable information for improving irrigation practices in agriculture and horticulture using solar energy and smart technology.12]

III. BLOCK DIAGRAM

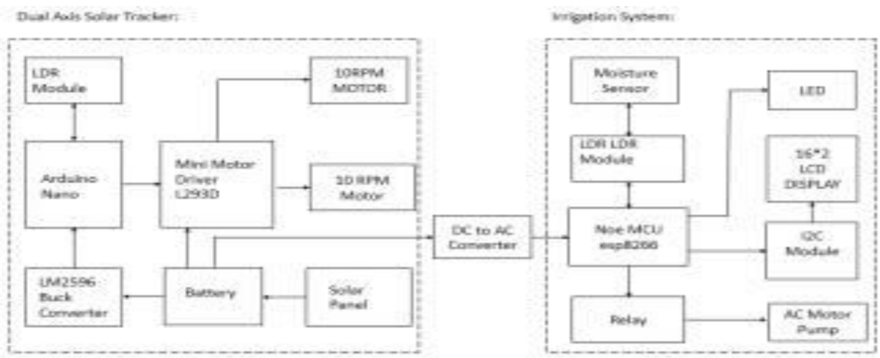

Fig 1. Smart Irrigation systems Using Dual Axis

Solar Tracker

The system discussed over here is based on natural and clean solar power. The decision making part will be carried out by the Microcontroller and GSM. The solar tracking system will help in capturing maximum sunlight from the sun. This energy will be stored in a DC Battery. The stored power will be used to drive the irrigation pump. Here the system will be a sensor based one where the pump will start only when there is the need of water to the land. The control of the irrigation pump will be made through a mobile phone from any remote location or auto decision using sensors. In this section some related works are connected to the monitoring system using GSM services.

IV. METHODOLOGY

System Design and Components Identification: Define the purpose and components of the smart irrigation system, including the dual-axis solar tracker and the irrigation system it.

Dual-Axis Solar Tracker Assembly:
Assemble the dual-axis solar tracker using the listed components such as Arduino Nano, LDR modules, LM2596 buck converter, mini motor drive L293D, batteries, solar panel, and 10 rpm gear motors. Write code for the Arduino Nano to control the movement of the solar tracker based on input from the LDR modules to maximize solar energy absorption.

Power Management:
Implement a DC to AC converter to power the irrigation system components using the solar energy collected by the panels. Ensure efficient power management to maximize the system's uptime, considering battery capacity and charging cycles.

Irrigation System Setup:
Set up the irrigation system components including moisture sensor, LDR module, NodeMCU ESP8266, relay, LED indicators, 16*2 LCD display, and I2C module. Write code for the NodeMCU ESP8266 to monitor the moisture level of the soil using the moisture sensor and ambient light using the LDR module.

Control Logic Implementation:
Develop control logic to decide when to activate the irrigation system based on the data collected from the sensors.

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Use the NodeMCU ESP8266 to control the relay that powers the AC motor pump based on the moisture level and ambient light conditions.

Data Visualization and User Interface:
Integrate the 16*2 LCD display and LED indicators to provide realtime feedback on the system's status.
Implement an interface (web or mobile) to visualize sensor data, system status, and control irrigation schedules remotely.

Testing and Calibration:
Test the entire system under different environmental conditions to ensure proper functionality and efficiency.
Calibrate sensor thresholds and motor movements as necessary to optimize system performance.

Safety Measures:
Implement safety features such as overvoltage protection, current limiting, and fail-safes to prevent darnage to the components and ensure user safety.

Deployment and Maintenance:
Install the smart irrigation system in the desired location, ensuring proper alignment of the solar panels for optimal sunlight exposure . Regularly monitor and maintain the system, including checking for component wear, battery health, and sensor accuracy.

V. COMPONENTS USED

HARDWARE USED

ARDUINO NANO:
The Arduino Nano is an open-source breadboard-friendly microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc and initially released in 2008. It offers the same connectivity and specs of the Arduino Uno board in a smaller form factor.
The Arduino Nano is equipped with 30 male I/O headers, in a DIP30-like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and running both online and offline.

NODEMCU:
The NodeMCU (Node MicroController Unit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds.The NodeMCU Development Board can be easily programmed with Arduino IDE since it is easy to use. Programming NodeMCU with the Arduino IDE will hardly take 5-10 minutes. All you need is the Arduino IDE, a USB cable and the NodeMCU board itself.

SOLAR PANEL:
A solar panel, or photo-voltaic module, is an assembly of photovoltaic cells mounted in a framework for installation. Solar panels use sunlight as a source of energy and generate direct current electricity. A collection of PV modules is called a PV Panel, and a system of Panels is an Array.
Photovoltaics directly convert solar energy into electricity. They work on the principle of the photovoltaic effect. When certain materials are exposed to light, they absorb photons and release free electrons. This phenomenon is called as the photoelectric effect. Photovoltaic effect is a method of producing direct current electricity based on the principle of the photoelectric effect.
Based on the principle of photovoltaic effect, solar cells or photovoltaic cells are made. They convert sunlight into direct current (DC) electricity. But, a single photovoltaic cell does not produce enough amount of electricity. Therefore, a number of photovoltaic cells are mounted on a supporting frame and are electrically connected to each other to form a photovoltaic module or solar panel.

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SOIL MOISTURE SENSOR:

The soil moisture sensor is one kind of sensor used to gauge the volumetric content of water within the soil. As the straight gravimetric dimension of soil moisture needs eliminating, drying, as well as sample weighting. These sensors measure the volumetric water content not directly with the help of some other rules of soil like dielectric constant, electrical resistance, otherwise interaction with neutrons, and replacement of the moisture content.

Soil Moisture Sensor Pin Configuration:

- VCC pin is used for power
- A0 pin is an analog output
- GND pin is a Ground Working Principle:

This sensor mainly utilizes capacitance to gauge the water content of the soil (dielectric permittivity). The working of this sensor can be done by inserting this sensor into the earth and the status of the water content in the soil can be reported in the form of a percent.

This sensor makes it perfect to execute experiments within science courses like environmental science, agricultural science, biology, soil science, botany, and horticulture.

LM2596 BUCK CONVERTER:

The LM2596 is a popular buck (step-down) voltage regulator integrated circuit (IC) commonly used in power supply applications. It is known for its efficiency, simplicity, and versatility. The LM2596 can efficiently convert higher voltage inputs to lower voltage outputs with relatively high current capability. It features adjustable output voltage, overcurrent protection, thermal shutdown, and a wide input voltage range, making it suitable for a variety of electronic projects and applications.

I2C MODULE:

The I2C (Inter-Integrated Circuit) module is a widely used serial communication protocol that enables communication between integrated circuits, microcontrollers, and various peripheral devices with a master-slave architecture. It operates on a two-wire interface consisting of a clock line (SCL) and a data line (SDA), allowing multiple devices to be connected to the same bus. The I2C module facilitates efficient data transmission with features such as addressing, arbitration, and clock synchronization. It is commonly employed in applications requiring communication between sensors, memory devices, display modules, and other components in embedded systems, IoT devices, and consumer electronics. The flexibility, simplicity, and robustness of the I2C protocol make it a popular choice for inter-device communication in a wide range of electronic systems.

MINI MOTOR DRIVER L293D:

The L293D is a widely-used integrated circuit (IC) designed for driving small DC motors and stepper motors in various electronic projects. It is known as a dual H-bridge motor driver, capable of controlling the direction and speed of two motors independently. The L293D operates with a wide range of supply voltages and can handle peak currents of up to 600mA per channel (1.2A in total). Its built-in protection diodes help to prevent damage from back

EMF generated by the motors during operation. The IC also features internal thermal shutdown and overload protection mechanisms, enhancing its reliability and safety. With its compact size, low cost, and ease of use, the L293D is popular among hobbyists, educators, and professionals for driving motors in robotics, automation, and other electro-mechanical applications.

SOFTWARE USED

ARDUINO IDE:

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

It's the powerhouse that compiles and uploads your code to the RedBoard for use and where serial communication is operated from.

At the top is the name of the Arduino „Sketch" along with the program version. A Sketch"s default name is the date with a, b, c,… following depending on the amount you"ve made that day. Underneath that is the Toolbar Ribbon that contains all the different commands you"ll need when completing the projects in this Guide. The File tab contains commands like save, load, new and preferences. The Edit tab contains commands like copy, paste and font sizing. The Sketch tab contains verify, upload, add libraries. Tools contain the serial monitor, port and board selector and finally, the help tab contains general help commands. The Frequent Commands Ribbon is situated below the Toolbar Ribbon

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and, you guessed it, contains commands that are used more frequently than others. The Coding Area is where the programs to be uploaded are written with the Message Area and Debug Window displaying the current status of, and outcome of that process. Finally, there is the Connection area which displays the Port and Board connected to the computer.

VI. PROBLEM FACED

During the progress of our project we encountered numerous varieties of problems that slowed our project. Some of them are mentioned as follows:

- Due to lack of proper equipment facilities we encountered problem to timely manage the modules and components.
- GSM module was not properly connecting to the GSM network of corresponding band.
- Many problems were faced during process of development of this project regarding fault connections, internal device errors, programming etc.
- The problems also raised while properly mounting the solar panel to the tracking frame.

VII. RESULT AND ANALYSIS

Finally, the system was built with the expected output. Many problems were faced during process of development of this project regarding fault connections, internal device errors, programming. We finally devised the system that can really meet the objective of our project. The result revealed that the rotating solar panel captures maximum energy than a static Solar panel.
In smart irrigation Controllers can be adjusted from our phone and can help to identify farm land soil moisture status, monitor and control remotely according to user requirement and the final output of our project is as below:

Fig.2 LCD Display

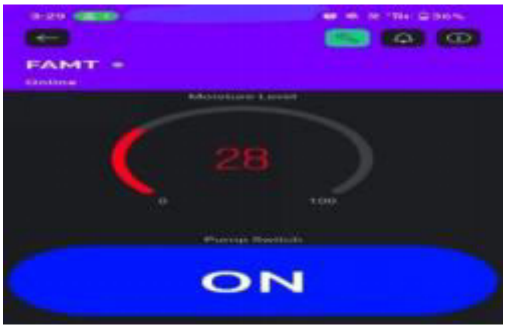

Fig. 3 Irrigation Level & Motor On/Off Status

Fig. 4 Proposed System

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VIII. FUTURE ENHANCEMENT

This technology in future will enable the farmer to control & view farming direction from home through various methods like internet, mobile. The farm can be protected from animals, fire and any anonymous person entering the field. Insects can be detected and avoided. Growth of crops can be informed to the farmers.

This system is used to control home appliances tenuously and offer security when the owner is away from the place. This energy is also used for fencing for agriculture field, lighting, and auto cleaning of the solar panel and GSM technology is used to fetch the information about the motor running and which part of the field is irrigating and moisture level etc.

IX. APPLICATION

- Large farms where manual irrigation is time consuming.
- Gardens where proper and determined irrigation is necessary.
- Nurseries where water resource is limited but the effective irrigation is needed.

X. CONCLUSION

The automatic irrigation system with solar tracking is advantageous to the agriculturists when this system is actualized. At the point when the soil needs water is specified by the sensor by this automatic irrigation system is executed. When the crops require the water it can be automatically supplied by the system. The energy expected to the water pump and controlling system is given by sun powered board. Automatic irrigation system is utilized to optimize the use of water by diminishing wastage and decreases the human work. The system requires insignificant support and consideration since they are self beginning. To additionally upgrade the everyday pumping rates tracking arrays can be executed. This system exhibits the attainability and utilization of utilizing sun oriented PV to give vitality to the directing necessities for sprinkler water system. Even though this system requires more investment but it solves more irrigation problem after long run of this system.

A fairly large solar panel tracker would cost several hundred dollars and will increase the energy produced by 30% to 50% depending on the season and location. The solar panels in the large arrays would cost in the thousands of dollars, so the addition of a solar tracker is very cost effective. Another benefit is the space saved rather than adding extra panels.

To conclude, this project turned out well and met the original requirements and functionality. Although there were many problems and more work on the mechanical side than originally expected, overall it was an enjoyable experience completing this project.

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