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Solar Tracker for Mobile Charging

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Abstract: *This project is a dual-axis solar tracker for effective mobile phone charging with renewable energy. The system adjusts the position of the solar panel automatically to optimize sunlight absorption, enhancing energy efficiency. It employs LDR sensors to monitor sunlight and servo motors to manage panel orientation. A temperature sensor checks the heat levels of the phone to ensure that charging is suspended in case of overheating, thus maintaining battery health. Moreover, a charge time estimation algorithm determines the charge time remaining for a full battery based on real-time battery voltage and current. The system shows vital parameters like battery percentage, charge state, temperature, and estimated charge time on an LCD display. Powered by an ESP32 microcontroller, this intelligent solar tracker optimizes charging efficiency, safety, and reliability, with applications in off-grid locations, outdoor environments, and renewable energy solutions.*

Keywords*:* Dual axis, renewable energy, smartphone charging

I. INTRODUCTION

With the growing need for renewable and sustainable sources of energy, solar energy has become a major solution for powering electronic devices. Traditional fixed solar panels, though, are inefficient since they fail to track the position of the sun during the day, resulting in poor energy absorption. To counter this drawback, a solar tracking system is employed, which keeps the sun in line with the solar panel for optimal energy efficiency. Secondly, longer exposure to the high temperature caused by charging reduces battery life and puts safety at risk. Overheating protection becomes necessary to save mobile devices from burning and damage induced by excessive temperatures. In addition to the foregoing, an intelligent algorithm for estimating charging time is built-in, which estimates the time remaining for a complete charge from real-time battery voltage and charging current. This project envisions a solar tracker for charging phones, with automatic tracking of the sun, temperature overheat protection, and estimation of the charge time. The system uses an ESP32microcontroller for processing sensor inputs and controlling motion of the solar panel through servo motors. LDR sensors are used to sense sunlight intensity in determining optimal orientation for energy harvesting. A DHT11 temperature sensor keeps a check on the heat levels of the phone, with charging suspended in case it exceeds a safe value. The time taken to charge, battery life, as well as the temperature reading is shown on an LCD display to be monitored real-time. This solar tracking smart system increases efficiency, safety, and reliability in charging mobiles, finding application in off-grid power applications, outdoor settings, and environmental-friendly charging stations

II. DESIGN AND METHODOLOGY

A. Analysis of the Proposed System

This setup as shown in Fig 1,includes a Solar panel, Voltage sensor, Light sensor, ESP32 WIFI Module, LCD Display and Smartphone charging. In the design under proposal the procedure begins with Solar panel which detects light rays of sun. The system will change the orientation of the solar panels automatically to absorb maximum solar energy during a day with the assistance of Light sensor, Next the Voltage sensor will obtain the definite amount of voltage needed for the operations. Subsequently it is now fed into ESP32 Controller where all the operations occur. With the help of the output from the Module, the voltage is transmitted to the smartphone for charging the system, LCD display will indicate the charging status of the system.

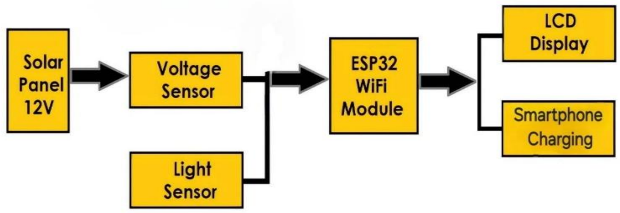

Fig 1.Block Diagram of Solar Tracker System

B. Tools and Materials

To design this solar tracking system and get the intended results, a number of supporting components are required; these include the parts and materials listed in table 1.

Hardware	Software
Solar Panel	ESP-32 Wokwi
ESP-32	Embedded C
Light Sensors(LDR)	
DC Motor	
Jumper Wires And Breadboard	
LCD Display	
Relay	

III. Flow chart

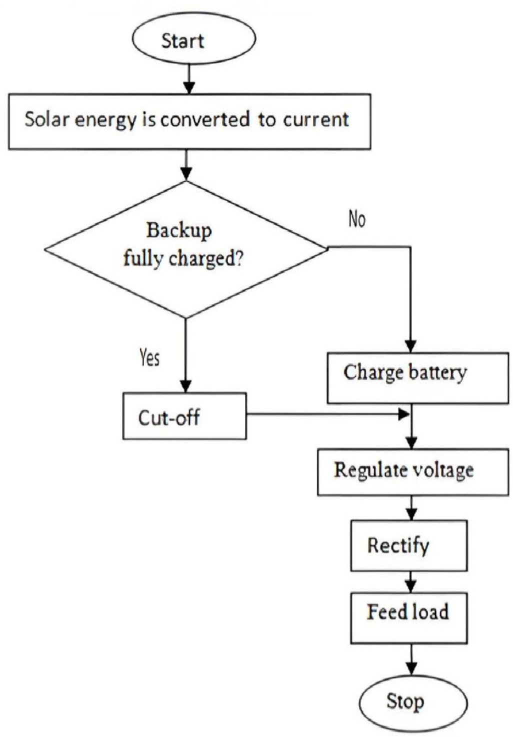

Fig 2. Flow Chart

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A basic solar energy system that transforms solar energy into useful power for a load is depicted in the flowchart. Solar energy is first transformed into current to begin the process. The system ceases charging the backup battery if it is fully charged. Alternatively, the converted solar energy is used to charge the battery. The load is fed with the voltage from the charged battery after it has been adjusted and rectified if needed. The procedure concludes when the load is fed. By using excess solar energy to charge the battery, this system makes sure that the load is powered when the battery is full.

IV. DESCRIPTION

A. Solar Panel

A 12V solar panel is a photovoltaic panel that converts sunlight into electricity and is specifically designed for systems that run at 12 volts. The panels are widely utilized in small-scale solar energy installations, such as off-grid systems, RVs, boats, and outdoor lighting. The panels are produced using monocrystalline, polycrystalline, or thin-film solar cells, with monocrystalline being more efficient. The panel generates between 17-18V of power at peak sun to top off a 12V battery using a solar charge controller that controls voltage and avoids overcharge. The capacity of the power output of such panels is indicated in watts, and their capacities may differ; for instance, a 100W 12V panel has a capacity to deliver about 5-6 amps under full conditions. Long-lasting materials such as aluminum frames and tempered glass are applied to ensure weather and longevity resistance. Efficiency depends on panel orientations, shading, dirt buildup, and temperature.12V solar panels are easy to install and flexible, hence well suited for charging devices such as lights, fans, and small appliances in out-of-the-way locations. They help promote green energy solutions through the reduction of fossil fuel use and carbon emissions.

Fig 3. Solar Panel

B. ESP-32

ESP32 is a low-cost, high-performance microcontroller with built-in Wi-Fi and Bluetooth, commonly employed in Internet of Things (IoT) projects. Released by Espressif Systems, it comprises a dual-core processor, 240 MHz clock frequency, and advanced connectivity features, and supports multiple types of projects. It comes with several GPIO pins, ADCs, DACs, PWM controllers, and I2C, SPI, UART, and CAN interfaces that offer hardware interfacing flexibility. Its onboard Wi-Fi provides ease of network access, and its Bluetooth (Classic and Low Energy) facilitates other device communication. The ESP32 is compatible with multiple programming platforms, such as the Arduino IDE, ESP-IDF, and MicroPython, to make it easy for both beginners and experts. It has low-power modes, which are critical for battery-powered projects, and it lowers power consumption drastically when idle. Common uses of the ESP32 are in home automation, wearable devices, robotics, and data logging. Its integrated security features, such as secure boot and flash encryption, provide safe operation in networked applications. Small, flexible, and packed with features, the ESP32 is a pillar of contemporary IoT development, facilitating creative solutions by virtue of its affordability and high performance.

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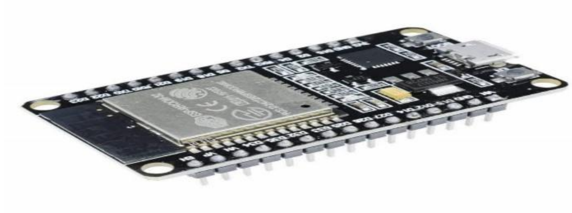

Fig 4. ESP-32

C. Light Dependent Resistors (LDRs)

A Light-Dependent Resistor, also referred to as a photoresistor, is an electronic sensor that senses the level of light. As more light shines, its resistance gets lower. Its application lies in light detection purposes. LDRs consist of semiconductor material such as cadmium sulfide (CdS), which has a photoconductive property.The device works by varying its resistance according to the intensity of light incident on its surface. In the dark, the resistance is high (a few megaohms), but in light, it decreases appreciably (to a few hundred ohms). This makes LDRs suitable to act as variable resistors in a circuit. LDRs are used most frequently in the likes of automatic streetlights, light meters, alarm systems, and displays whose brightness is controlled. They are easy to apply, involving the use of a simple circuit incorporating a resistor as a voltage divider, which may be linked with microcontrollers to process signals. While LDRs are inexpensive and work effectively, their slow response time makes them inapplicable for high-speed applications. They are also sensitive to temperature and can deteriorate with time in direct light. Overall, LDRs are cost-efficient and functional devices for light-detection work, and they find wide applications in academic projects and industrial systems.

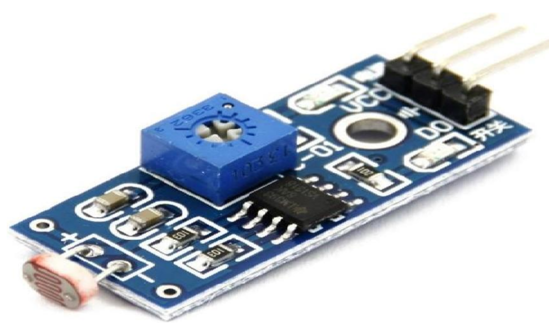

Fig 5.LDR

D. LCD Display

A LCD (Liquid Crystal Display) is a straight panel display technology that employs liquid crystals to create images.

LCDs are used extensively in consumer electronics, such as TVs, smartphones, and embedded systems. LCDs are chosen for their minimal power usage, thin design, and affordability. An LCD functions by utilizing a backlight and layer of liquid crystal molecules between polarizing filters. The crystals' orientation is dictated by electrical signals, admitting or preventing light to create visible characters or images. They are made in many types, including alphanumeric (for plain displays) or graphical (for more complicated imagery). Small LCD modules, such as the 16x2 or 20x4 character displays, are popular in DIY projects and embedded systems These modules can interface directly with microcontrollers through parallel or I2C communication. They tend to have onboard controllers, like the HD44780, making text and data display easy. LCDs are widely used, used in calculators, clocks, IoT applications, and industrial machinery. They are energy efficient, stable, and come in different sizes and resolutions. They might, however, exhibit a reduced viewing angle and a lower level of brightness compared to other technologies such as OLEDs. They continue to be a top option for cost-effective display solutions

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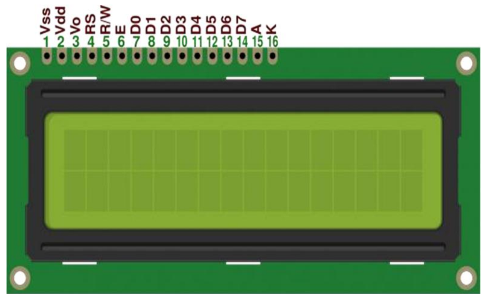

Fig 6. LCD Display

E. Voltage Sensors

A voltage sensor is an electronic instrument employed for the measurement and monitoring of voltage levels within a circuit. The sensor changes the observed voltage into a readable signal, either analog or digital, which can be processed by microcontrollers or other devices for analysis and control.Voltage sensors are created to support an array of voltages, either low or high. They accomplish this by applying methods like resistive voltage dividers, capacitive coupling, or isolation transformers to reduce and isolate the measured voltage safely. Typical sensors to use are modules such as the ZMPT101B for AC voltage or basic resistive dividers for DC. These sensors find their use in real-time voltage level monitoring in applications like power systems, battery management, renewable energy systems, and IoT applications. They make fault detection possible, optimize the performance, and provide safety through the detection of overvoltage or undervoltage. Voltage sensors are prized for their precision, low profile, and simplicity of addition to existing circuits. Yet calibration and isolation are necessary to provide safety and accuracy, especially with high voltages.

Fig 7. Voltage Sensor

F. Relay

A relay is an electromechanical or solid-state and device employed to switch a high-power circuit with its low-power signal. It is a switch operated by an electromagnetic coil or semiconductor technology that allows isolation of the control and output circuits for efficiency and safety.

The low current passing through the coil (in electromechanical relays) creates a magnetic field and, through leverage, moves an armature, which opens and closes electrical connections. This principle enables the relay to switch high currents or voltage levels. SSRs, meanwhile, employ a semiconductor device, such as the thyristor or triac, for the switching action and have faster speed and no movement.Relays find extensive applications in automation systems, household appliances, industrial automation, and automotive systems. They enable multiple devices to be controlled, switched between different circuits, and offer overload protection.

Electromechanical relays are inexpensive and rugged but can suffer from wear and reduced switching speeds. SSRs are more dependable and quicker but tend to be more costly and can produce heat when they operate.

As a whole, relays are a necessary tool for managing high-power devices in low-power settings with versatility, safety, and effectiveness in various electronic and electrical systems.

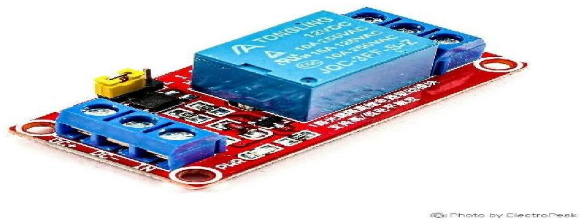

Fig 6. Relay

G. DC Motor

A DC motor is the electromechanical device that transforms direct current (DC) electric energy into mechanical energy. It operates based on electromagnetic induction, in which a conductor withcurrent insertedintoa magnetic field will experience a force on it.A standard DC motor has important parts: a stator (stationary magnetic field), a rotor (rotating armature with windings), brushes, and a commutator. Current through the armature windings interacts with the magnetic field when it is flowing, creating torque that rotates the rotor. The commutator makes the direction of current in the windings switch properly so that there is continuous rotation.

DC motors come in different forms, such as brushed and brushless. Brushed motors are inexpensive and easy to use but need to be serviced periodically because of brush wear. Brushless DC motors (BLDC) are more efficient, long-lasting, and quieter and are suitable for contemporary applications.

These motors find extensive applications in robotics, electric vehicles, domestic appliances, and industrial equipment because of their simplicity in speed control, torque output, and reliability. Small and versatile, DC motors are a key component in systems that demand accurate control and efficient power conversion.

Fig 6. DC Motor

V. CONCLUSION AND FUTURE SCOPE

The two-axis solar tracker maximizes energy efficiency through automatically changing the orientation of the solar panel to receive maximum sunlight. With the use of LDR sensors and servo motors, the system maximizes the use of solar energy harvesting, presenting itself as a good fit for off-grid and green power applications. With an ESP32 microcontroller controlling it, the system offers automatic tracking and live monitoring to enable effective and consistent use of solar energy. In the future, the system can be enhanced with IoT connectivity for remote monitoring, AI-driven tracking algorithms for improved sun alignment, and intelligent battery management for effective energy storage. Scaling the setup for bigger solar installations or incorporating hybrid solar-wind energy systems can additionally increase its suitability. The integration of weather sensors can safeguard the system against harsh environmental conditions as well. The project provides a foundation for sophisticated, automated, and scalable solar energy solutions for different applications.

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