Automatic Sunflower Solar Tracking and Panel Positioning System

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***Abstract*— Solar energy is a promising alternative to fossil fuels, converted into electricity by photovoltaic cells and stored in batteries for later use. However, its dependency on sunlight poses challenges for continuous energy generation. To address this, projects are needed to optimize solar energy utilization. Strategies may include advanced energy storage solutions like batteries to store excess energy for use during periods of low sunlight. Additionally, hybrid systems integrating multiple renewable sources can ensure a more reliable energy supply. Smart grid technologies enable efficient distribution and management of solar power, while energy efficiency measures and management systems help maximize its utilization. By implementing these approaches, we can harness solar energy effectively and mitigate reliance on polluting fossil fuels.**

***Index Terms*—Biomedical instrument, automatic defibrillator, heart monitoring, temperature tracking, IR sensors, IC358, IC3524, ferrite core transformer.**

I. INTRODUCTION

Solar tracking systems are designed to optimize power generation from sunlight by automatically adjusting the position of solar panels to maximize sunlight exposure. These systems utilize controllers to sense the position of the sun and adjust panel orientation accordingly. While microcontrollers play a vital role in modern control systems, the basic signal processing in solar tracking often relies on analog circuitry. The use of analog to digital converters facilitates the integration of analog information into microcontroller-based systems. As fossil fuel reserves diminish, solar energy emerges as a crucial renewable resource for sustainable power generation. Photovoltaic cells convert sunlight into electricity, with solar panels comprising multiple PV cells. However, fixed solar panel systems have limited efficiency due to variations in incident radiation intensity over time and seasons. Solar tracking systems address this inefficiency by continuously adjusting panel orientation to maintain normal exposure to incident radiation. Despite increased system costs, the significant efficiency gains justify the adoption of solar tracking technology for commercial applications. Overall, solar tracking enhances the viability and performance of solar energy systems, contributing to a cleaner and more sustainable energy future.

II. LITERATURE SURVEY

Solar tracking systems have evolved significantly since C. Finster's initial mechanical design in 1962, leading to increased energy gains and adoption of various tracking technologies. Novel algorithms for single-axis trackers enable automatic rotation of photovoltaic modules, optimizing power generation angles. Intelligent fuzzy-based controllers for dual-axis systems maximize efficiency by ensuring perpendicular sunlight incidence on PV panels. Sun tracking schemes, including a sunflower-inspired strategy, improve tracking accuracy, overcoming limitations of sun pointing sensors. In islanded solar PV microgrids, MATLAB simulations facilitate design and optimization, considering parameters like temperature and irradiance, with MPPT techniques enhancing energy conversion. PV cells serve as active power filters, compensating for nonlinear loads and harmonics, contributing to grid stability and unity power factor operation. With increasing focus on renewable energy, solar tracking technologies play a crucial role in maximizing energy generation and grid integration.

III. SOLAR ENERGY - AN OVER VIEW

Solar energy, derived from the sun's thermonuclear processes, presents a promising alternative to fossil fuels, offering renewable and environmentally friendly power. With only a fraction of the sun's radiation reaching Earth, solar energy still encompasses most energy sources, excluding geothermal and nuclear. To harness

solar power effectively, collectors and storage units are essential due to its intermittent nature. Three main collector types include flat-plate, focusing, and passive collectors, each with distinct applications in heating, cooling, and electricity generation. Solar heating, particularly for water and buildings, is highly efficient and widely implemented, utilizing various storage methods such as phase-changer units and packed beds. Passive collectors, like heat traps and thermos phoning walls, offer additional heating solutions. Solar cooling, albeit more expensive, operates on phase-changing principles, while electricity generation relies on photovoltaic (PV) cells, often combined into modules and arrays for efficiency. While PV cells historically operated at low efficiencies, recent advancements promise higher efficiencies, potentially making solar power more economically viable. Despite its versatility, solar power faces challenges in transportation due to energy density limitations. However, its renewable nature and minimal environmental impact make it a promising energy source for the future, capable of surpassing global energy demands. Different types of solar panels, including monocrystalline, polycrystalline, and amorphous, offer varying efficiencies and costs, with monocrystalline cells being the most efficient but expensive. Overall, solar energy presents a sustainable and adaptable solution to address growing energy needs while mitigating environmental concerns.

IV. BLOCK DIAGRAM

The block diagram and its brief description of the project work “Solar Tracking and Positioning System using Microcontroller” is explained in brief. The complete block diagram of the project work is shown at the end of this chapter. The description is as follows.

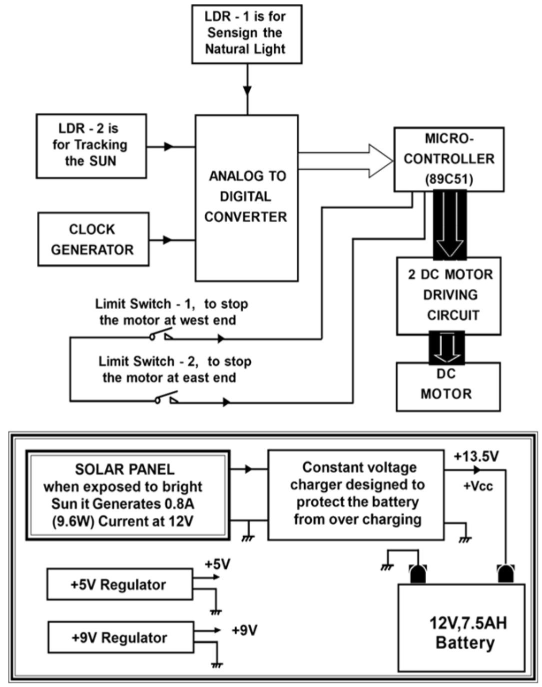

Figure 1: Block Diagram

A. LDR-1 FOR SENSING THE NATURAL LIGHT

An LDR-based circuit detects sunlight intensity for motor drive activation. LDR and 10K resistor form a potential difference network, with reference voltage from midpoint. Variation in light intensity alters reference voltage applied to ADC via the 26th pin. Lower resistance (<1KΩ) when sun is present and higher resistance (>100KΩ) in darkness triggers motor drive circuit. Named LDR-1, it detects sunlight presence regardless of position, ideal for solar panel applications. Ensures automatic motor activation during sunlight hours, aiding energy conversion. Offers surface mounting sensor capability, suitable for diverse panel and sun positions. Detection relies on LDR resistance change, ensuring day-night differentiation. Enables efficient utilization of solar energy by activating motor drive system. Facilitates seamless operation of solar panels, maximizing energy output.

B. LDR -2 FOR TRACKING THE SUN

Another LDR, positioned in a container, detects sun position for solar panel alignment. Container depth ensures direct sunlight exposure to LDR through a hole. LDR output to ADC pin 27, connected to microcontroller for motor control. Assembly language program stops panel at sun position by monitoring

LDR output. Low LDR resistance (<2V reference voltage) de-energizes motors, holding panel position. Automatic alignment enhances solar energy capture efficiency. Panel stops when LDR exposed to sunlight, ensuring accurate tracking. Container design ensures reliable sun position detection for panel orientation. Microcontroller program ensures precise panel alignment for optimal energy generation. LDR-based system offers efficient and autonomous solar panel tracking.

C. ANALOG TO DIGITAL CONVERTER

Analog to digital converter (ADC) transforms continuous analog signals into binary numbers compatible with microcontrollers. Output codes stair-step as input increases, with ideal step width representing least significant bit (LSB) size. Integral and differential linearity errors characterize converter accuracy, ideally less than 0.5 LSB. ADC 0809, an 8-bit converter, converts LDR analog voltages to digital pulses for microcontroller processing. The converter employs a comparator comparing unknown input voltage (VX) with time-dependent reference voltage (VR). Built-in multiplexer allows automatic channel selection, enhancing versatility. ADC conversion crucial for microcontroller comprehension of peripheral signals. Accurate conversion ensures reliable data transmission for precise control algorithms. Least square fit or terminal point method used for error determination in ADCs. Converter performance vital for efficient analog-to-digital signal conversion.

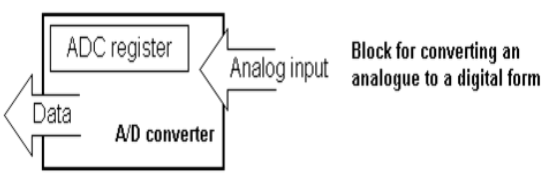

Figure 2: Analog to Digital Converter

D. CLOCK GENERATOR

Clock generator circuit utilizes a 555 Timer IC in Astable Mode for free running oscillator operation. External resistor and capacitor adjust frequency, set above 100 KHz. Output from the 555 Timer IC is directed to the A-D converter. 555 Timer IC facilitates precise frequency control for the system. Astable mode configuration ensures continuous oscillation without external triggering. Frequency adjustment achieved through resistor-capacitor combination. High-frequency output essential for A-D converter operation. Clock signal provides timing reference for analog-to-digital conversion. 555 Timer IC's versatility enables various timing applications in circuits. Astable mode design enhances circuit stability and reliability.

E. MICRO-CONTROLLER

The ATMEL AT89C52 microcontroller is a low-power, high-performance CMOS 8-bit device with 8K bytes of flash memory. It utilizes standard MCS-51 instructions and is ideal for controlling applications due to its flexible and cost-effective nature. Embedded within devices, microcontrollers, also known as embedded controllers, execute specific programs stored in ROM without the need for frequent changes. Typically low-power, they can consume as little as 50 milliwatts, making them suitable for battery-operated applications. Microcontrollers process input from sensors or other devices and control outputs accordingly, often utilizing components like the L293D H-Bridge chip to control motors. With dedicated input and output interfaces, microcontrollers efficiently manage tasks while maintaining a compact form factor.

F. L293D “H”BRIDGE

The L293D motor driver interfaces with the 89C51 microcontroller via IN1 to IN4, with combined enable pins (EN1 and EN2) controlled by the controller. It provides bi-directional drive currents of up to 600mA at voltages from 4.5V to 36V, facilitating DC motor operation. Four drivers within the L293D manage motor rotation, with pins IN1 through IN4 and OUT1 through OUT4 serving as input and output for each driver. EN1 and EN2 enable drivers 1 and 2, and drivers 3 and 4, respectively. Each pair of drivers controls one of the two geared DC motors used to rotate the solar panel based on sun movement sensed by the LDR. Limit switches prevent motor movement at extreme points, prompting the controller to change motor direction when activated.

V. PRINCIPLES OF OPERATION

A dual-axis solar tracking system operates by continuously adjusting the orientation of solar panels or collectors to maximize sunlight exposure throughout the day. It utilizes sensors to detect the position of the sun and motorized mechanisms to move the panels accordingly.In the horizontal axis, the system tracks the sun's east-west movement by adjusting the azimuth angle of the solar panels. This ensures that the panels are always facing directly towards the sun as it moves across the sky.In the vertical axis, the system adjusts the elevation angle to account for the sun's seasonal variation in altitude. By tilting the panels appropriately, the system optimizes sunlight capture throughout the year.

The sensors, often light-dependent resistors (LDRs) or photodiodes, provide feedback to the system's controller, which calculates the precise angles needed for optimal solar panel orientation. Motorized actuators then move the panels based on these calculations, ensuring that they continuously track the sun's position for maximum energy generation. This dynamic adjustment capability significantly improves energy output compared to fixed solar installations, making dual-axis tracking systems ideal for locations with variable sunlight conditions or where maximizing energy production is essential. The principle of operation of a dual-axis solar tracking system revolves around maximizing the absorption of solar energy by continuously adjusting the orientation of solar panels to track the sun's position. The system calculates the sun's position using algorithms or equations based on geographical coordinates, time, and date, ensuring accurate azimuth and elevation angles. Azimuth tracking involves adjusting the horizontal angle of the panels to align with the sun's east-west position, while elevation tracking adjusts the vertical angle to follow the sun's ascent and descent in the sky. A control system coordinates these adjustments in real-time, employing feedback loops for precise tracking. Actuators or motors rotate and tilt the panels accordingly. Safety features such as limit switches and overload protection safeguard the system from damage, while periodic calibration and maintenance ensure optimal performance. Evaluation metrics include energy output and tracking accuracy. This system enhances solar panel efficiency, contributing to renewable energy utilization while offering potential for further technological advancements.

VI. CONCLUSION

The project "Solar Tracking and Positioning System using Microcontroller" has successfully developed and tested a prototype unit. It utilizes small DC motors to rotate the solar panel both horizontally (west to east and vice versa) and vertically (clockwise and anticlockwise) for sun tracking. However, in practical applications, higher-rated motors are recommended for driving heavier loads. A 50cm screw rod coupled to the motor shaft facilitates panel rotation, with the possibility of increasing length through proper support and bearings. For comprehensive tracking in three dimensions (X, Y, and Z), three motors can be employed. The system operates on 12V DC, powered by a 12V, 1.2 Ah lead-acid battery charged by the same solar panel. Additionally, mains charging capability is integrated. Future enhancements may involve PC integration to monitor voltage levels at various points, aiding in efficiency estimation and data recording.

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