DESIGN AND OPTIMIZATION OF AN INTELLIGENT, MULTI-FLEXI BRANCH ENERGY HARVESTING SOLAR TREE FOR ECO-SPARK CAFE TABLES

Abstract

The Intelligent Solar Tree is an innovative, multi-functional solar energy harvesting system designed to maximize energy efficiency through dynamic solar tracking and adaptive energy distribution. The system features 10 movable solar panels (each 2x1 feet, producing 20 watts) arranged in a 360-degree tree-like structure, enabling optimal sunlight capture throughout the day. Unlike conventional fixed-panel systems, this prototype incorporates an intelligent tracking mechanism that adjusts panel orientation based on solar trajectories, ensuring continuous energy optimization. The harvested energy is regulated via advanced charge controllers and stored in two high-capacity batteries with efficient load balancing. The system supports 4 high-efficiency LED pole lights for campus illumination, multi-port charging stations for laptops and mobile devices, and integrated wireless charging modules for mobile phones. This project, funded by **Ashoka Women's Engineering College**, demonstrates a unique integration of smart tracking, modular energy distribution, and wireless power transfer, offering a sustainable solution for smart campuses and beyond.

Background of the Invention

This invention pertains to renewable energy systems, with a focus on solar energy harvesting and distribution. The system integrates advancements in solar tracking, energy storage, load balancing, and IoT-based monitoring to enhance efficiency and adaptability. Unlike conventional solar setups that rely on fixed or rudimentary tracking mechanisms, this innovation utilizes intelligent multi-flexi branch tracking technology, ensuring optimal sunlight capture throughout the day.

By leveraging tracking algorithms and smart energy routing, the system dynamically adjusts its panels to maximize energy generation. This enhances sustainability by reducing energy losses and improving storage efficiency, making it an ideal solution for applications such as campus energy infrastructure, smart urban environments, and off-grid power solutions. Additionally, real-time IoT integration enables continuous monitoring of system performance, predictive maintenance, and efficient energy utilization. The modular and scalable design allows for customization in various settings, making it a versatile energy solution for diverse applications, including public spaces, disaster relief sites, and remote areas. The phase diagram of the proposed design is shown in figure 1.

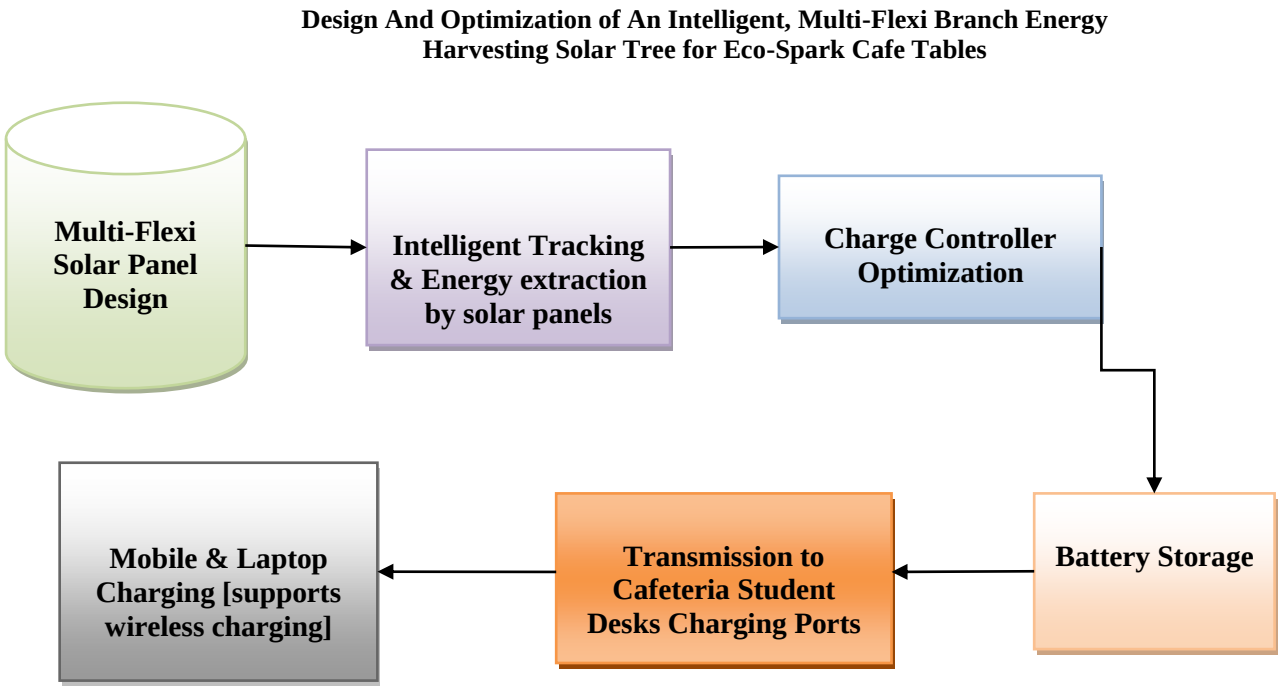

FIGURE 1: VARIOUS PHASES OF THE PROPOSED INVENTION

Traditional solar energy systems are often limited by their fixed panel orientation, reducing their ability to adapt to the changing position of the sun. This results in suboptimal energy harvesting, especially in regions with fluctuating sunlight conditions. Basic single-axis and dual-axis solar trackers improve efficiency but often lack advanced real-time optimization algorithms. Many of these systems function through predefined movements rather than

responding dynamically to real-time solar position data, leading to energy inefficiencies and unnecessary mechanical wear. Conventional energy distribution systems fail to incorporate intelligent load balancing, causing power wastage and inefficient routing. This limitation reduces the ability to prioritize energy allocation dynamically, making it challenging to integrate multiple power-consuming applications such as charging stations, LED lighting, and wireless charging modules. Furthermore, many existing solar installations require manual monitoring and maintenance, which is time-consuming, costly, and prone to errors. The lack of automated diagnostics and predictive maintenance increases operational inefficiencies, making conventional systems less viable for long-term sustainable applications. This invention addresses these limitations by integrating real-time tracking, smart energy management, and IoT-enabled monitoring, ensuring maximum efficiency, adaptability, and scalability.

Description of the Invention

The Intelligent Solar Tree is designed to overcome the limitations of conventional solar energy systems by integrating advanced tracking, energy management, IoT-based monitoring, and modular scalability. This innovative system ensures maximum energy efficiency, adaptability, and sustainability while providing a multi-utility renewable energy solution. One of the key features of this system is its Advanced Solar Tracking Mechanism, which incorporates AI-based algorithms and sensor-driven technology to dynamically optimize the orientation of solar panels in real-time. Unlike conventional single-axis or dual-axis trackers, this system utilizes predictive analytics to adjust panel positioning based on solar trajectories, ensuring continuous maximum exposure to sunlight. It also considers weather conditions and adjusts accordingly to minimize energy losses due to shading, cloud cover, or adverse environmental factors. By dynamically adapting to sunlight variations, the system significantly improves power generation efficiency compared to traditional fixed solar panels. The solar tree prototype is shown in figure 2.

FIGURE 2: PROTOTYPE OF MULTI-FLEXI BRANCH ENERGY HARVESTING SOLAR TREE

Another major innovation is the Smart Load-Balancing and Energy Routing System, which ensures efficient distribution of harvested energy. Traditional solar setups often lack intelligent energy prioritization, leading to inefficient power allocation. This system dynamically distributes energy based on real-time demand, optimizing power usage across multiple applications. It supports multi-port charging stations for laptops, mobile devices, and other electronics, while also integrating wireless charging modules for seamless mobile phone charging.

This adaptability ensures that power is allocated efficiently, preventing unnecessary wastage and enhancing the system's reliability in public spaces, campuses, and off-grid environments. The Auto-CAD Schematic View is shown in figure 3.

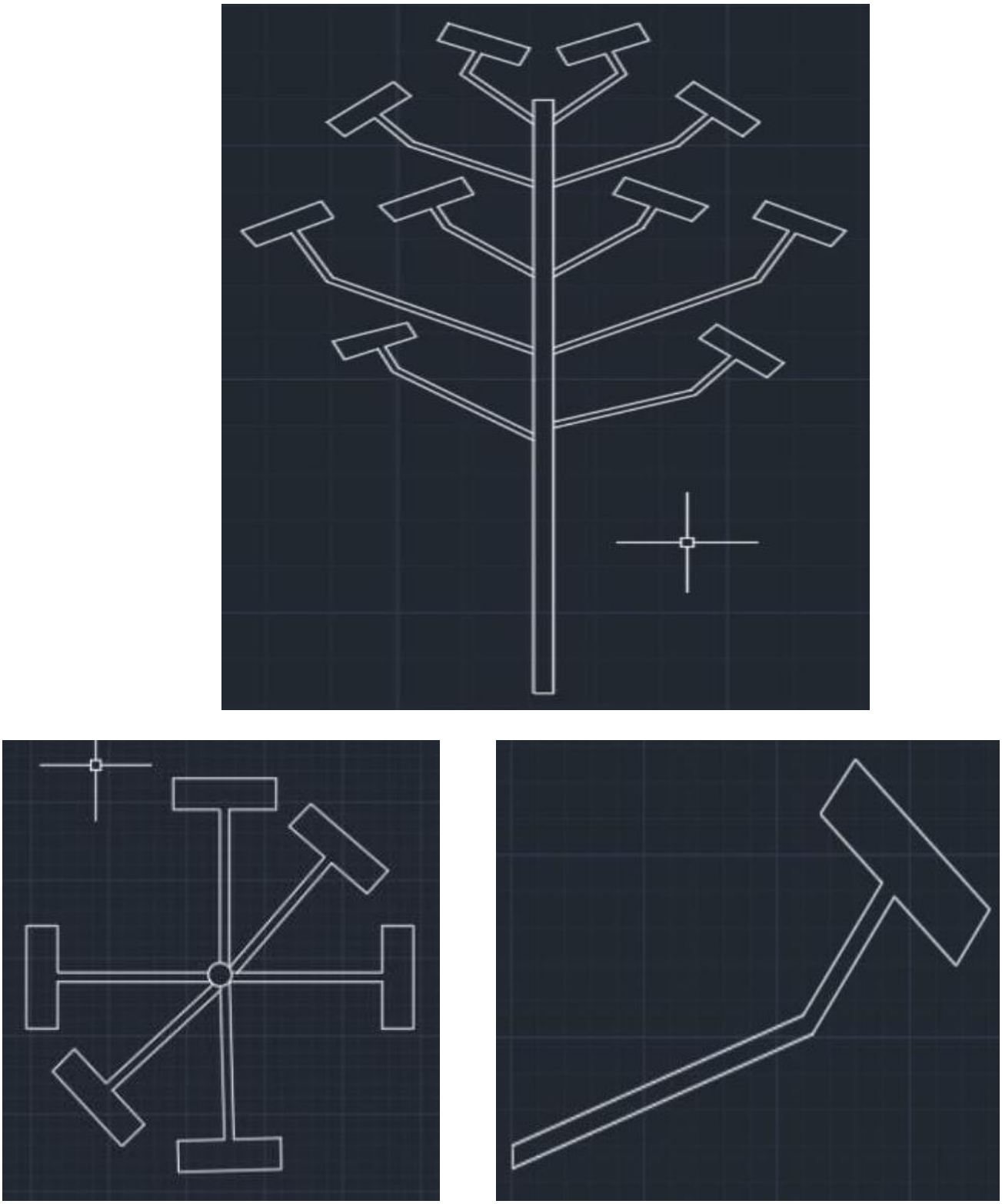

FIGURE 2: DESIGN OF MULTI-FLEXI BRANCH ENERGY HARVESTING SOLAR TREE – TOP & FRONT VIEW

To enhance monitoring and control, the system is embedded with IoT sensors that facilitate real-time performance tracking. The IoT-based monitoring system continuously collects data on solar energy production, battery health, and energy consumption patterns. This data is then processed through cloud-based analytics, allowing predictive maintenance and adaptive energy management. By leveraging remote access and automated diagnostics, the system reduces the need for manual intervention, making maintenance more efficient and cost-effective. Users can monitor the system's performance through a smart dashboard or mobile application, ensuring transparency and proactive management.

The Novel Battery Management System (BMS) is another crucial aspect of the Intelligent Solar Tree. Conventional battery storage systems often face challenges such as overcharging, deep discharging, and inefficient energy retention, which shorten battery lifespan and reduce overall system efficiency. This innovation integrates intelligent charging and discharging cycles, optimizing energy storage and improving the longevity of battery units. The fail-safe mechanisms prevent voltage fluctuations, thermal runaway, and deep discharge conditions, thereby ensuring the safety and reliability of the stored energy. By balancing the energy inflow and outflow, the BMS enhances the sustainability of the system, making it suitable for long-term deployment in various locations.

Moreover, the Scalable and Modular Design of the Intelligent Solar Tree makes it versatile for deployment in urban spaces, remote areas, and disaster relief scenarios. Unlike conventional solar systems that require extensive structural modifications, this system features a modular assembly, allowing easy replication and scalability based on specific energy requirements. The adaptable framework also supports hybrid energy solutions, meaning it can integrate with existing power grids or function as a standalone off-grid system. This feature is particularly beneficial for applications in rural electrification, emergency response setups, and smart city infrastructure, where energy demand fluctuates based on environmental and situational needs.

By combining advanced solar tracking, smart load balancing, IoT-based monitoring, intelligent battery management, and modular scalability, the Intelligent Solar Tree represents a cutting-edge approach to sustainable energy solutions. This system is not only efficient in harnessing solar power but also adaptable to diverse use cases, making it a future-ready innovation in the field of renewable energy.

WE CLAIM

1. A system as claimed in claim 1, wherein the system is an intelligent, movable solar tree comprising a 360-degree arrangement of solar panels with an adaptive tracking mechanism for optimal energy harvesting
2. A system as claimed in claim 2, wherein the system uses a solar tracking system utilizing sensor-driven mechanisms for real-time panel orientation adjustment.
3. A system as claimed in claim 3, wherein the system uses smart load-balancing and energy routing system for dynamic power distribution to multiple end-users.
4. A system as claimed in claim 4, wherein the system powers wireless charging modules and multi-port charging stations in campus.

Dated this 6th February 2024

Signatures

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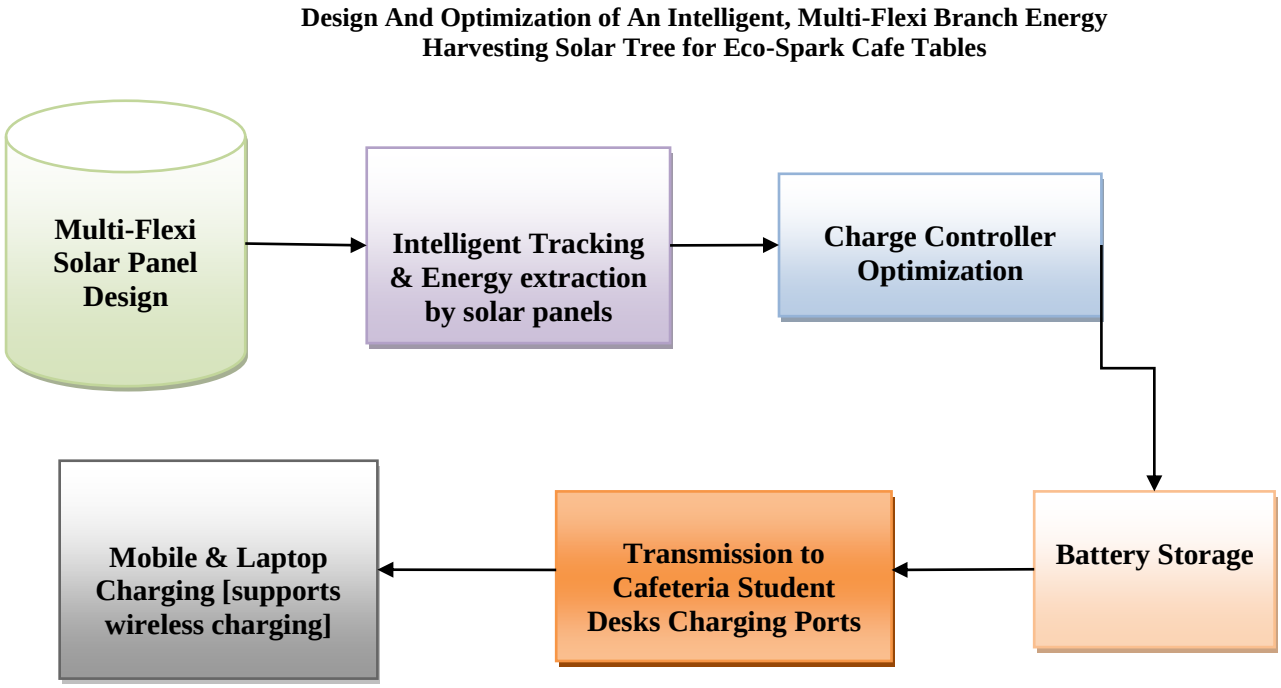

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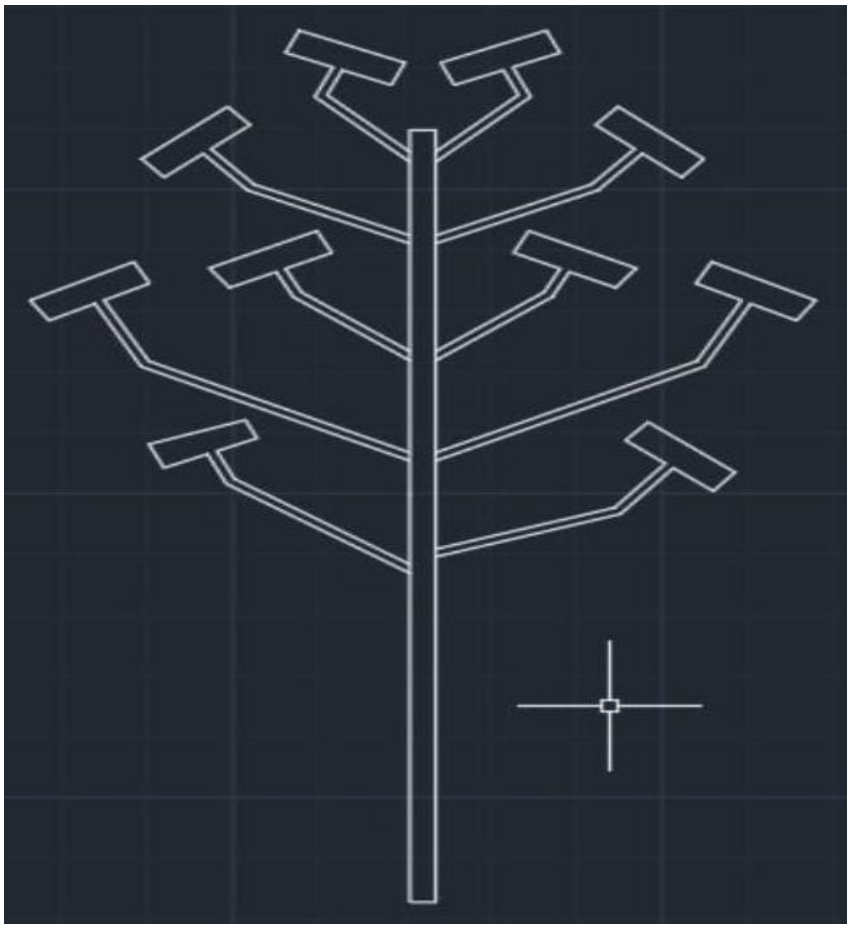

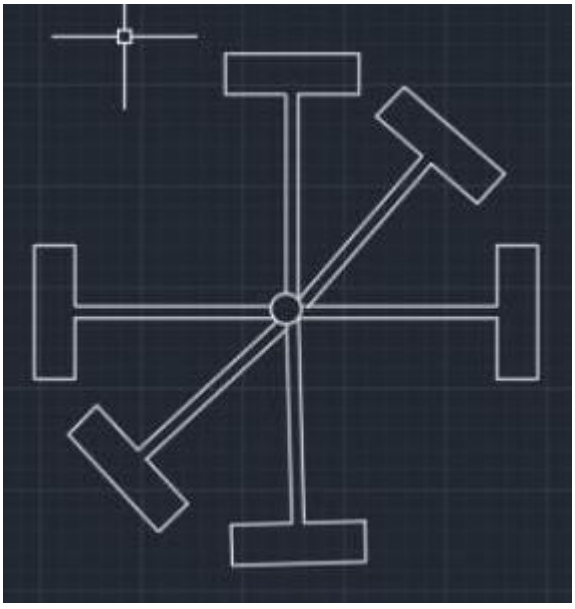

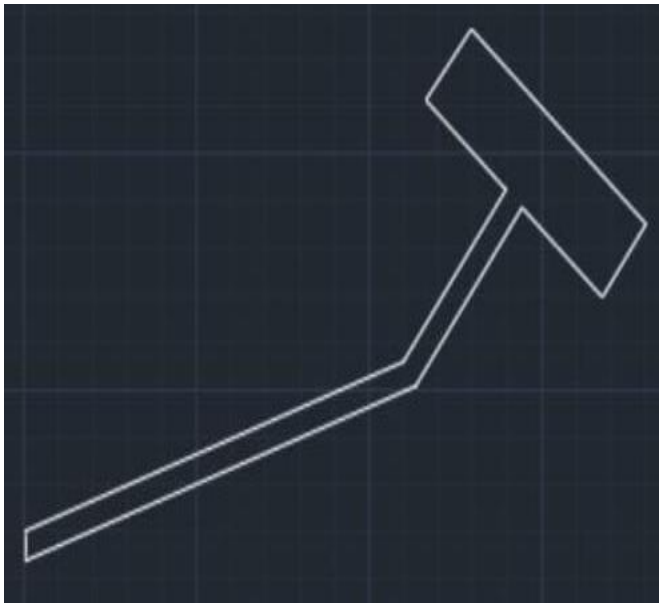

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