IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

ISO 3297:2007 Certified ∺ Impact Factor 8.021 ∺ Peer-reviewed / Refereed journal ∺ Vol. 11, Issue 7, July 2023

DOI: 10.17148/IJIREEICE.2023.11704

Efficient Solar Power Management and Illumination System

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Abstract: Solar energy is a crucial and significant renewable energy source, showcasing its utility in various applications such as street lights, basement parking, home lighting, and remote areas. This paper aims to present a solar energy harvesting system that efficiently converts sunlight into electricity to power 20W LED bulb. The primary objective of this project is to design a system capable of absorbing and storing the maximum amount of solar energy available, converting it into alternating current (AC) to illuminate areas with lower lighting requirements. This system offers the advantage of eliminating the need for conventional electricity, resulting in cost-free energy and minimal maintenance once installed.

Key Words: PCB designing, Solar Panels, Charge controller, Booster, Inverter, Transformers.

I.INTRODUCTION

As the demand for sustainable and eco-friendly technologies continues to rise, solar power bulbs have gained popularity as an alternative to conventional lighting solutions. They offer the benefits of renewable energy, convenience, and reduced energy costs, all while contributing to a greener future. In our project, we are designing a system for solar powered bulb by integrating the necessary components. Selecting a solar panel with sufficient capacity to generate required amount of power, selecting a battery to store the solar energy, designing a controller circuit between solar panel and the battery, designing an inverter circuit to convert DC input to AC output.

The Mppt charge control is necessary in order to achieve safety and increase the capacity of the battery. In cities, currently thousands of street lights are operated and the yearly electricity maintenance cost is very high. By improving the design it can give out more energy to more efficient use.

So throughout the world if we use this concept then it will eliminate the energy crisis to a larger extent. It is eco-friendly and utilizes the renewable source of energy very well.

II.LITERATURE SURVEY

K. Karthikeyam et al. [1] presents a paper on Grid connected and Off-Grid Solar Photovoltaic System. The paper put forth efficient methodology of hybrid-tied or battery storage system for stable power supply. Net meter is used to make the system more reliable when solar radiation is insufficient and unable to meet load demand. The stand-alone system are beneficial in remote areas that are isolated from the power distribution network. To addresss the probles, a control strategy for voltage control using voltage source inverter in the voltage control mode is used. M. Mehendi Farhad et al. [2] presents a project on A New Approach to Design of an optimized Grid Tied Smart Solar Photovoltaic (PV) System. The system can provide an opportunity to consume the power from the national grid. The total system is controlled with the help of some sensors and a microcontroller. As a whole significant reduction in the system cost and efficient system

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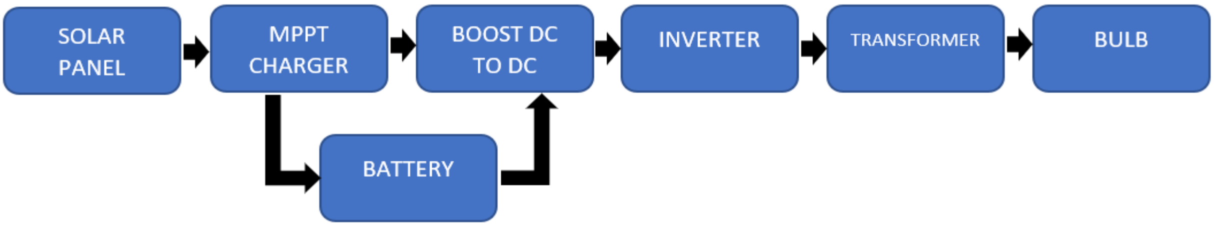
performance can be realised. Swami Prakash Shrivastava et al. [3] presents a report on Solar Energy and its Future role in Indian economy. The Mission of the project is to focus on setting up and enabling environment for solar technology penetration in the country both at centralized and decentralized level. The National action plan on climate change also points out “India is a tropical country, where sunshine is available for longer hours per day in great intensity. Solar energy, therefore, has great potential as future energy source. It also has advantage of permitting the decentralized distribution of energy, thereby empowering people at the grassroots level”.

III.METHODOLOGY

Block Diagram:



Designing a solar-powered bulb involves several steps and considerations.

Solar panel: A solar panel is an electronic device that catches sunlight and turns it directly into electricity. In order to maximise the conversion from solar to electrical energy, the solar panel have to be positioned perpendicular to the sun. Thus the tracking of the sun's location and positioning of the solar panel is important so we design an automatic tracking system which can locate the position of the sun. The tracking system will move the solar panel so that it is positioned perpendicular to the sun for maximum energy conversion at all time. It enhances efficiency, reduces costs, and provides valuable data for maintenance. With remote monitoring and control, it optimizes solar power generation and contributes to a sustainable future.

MPPT charger: Maximum Power Point Tracking (MPPT) controllers is a technique used with variable power source to maximise energy extraction as conditions vary. The voltage from the PV module will drop down, with a corresponding increase in the current amperage, to match the battery bank. An increase in amperage will lead to faster recharge. We make use of LT3652 (IC) as our Mppt charge controller.

Solar Panel absorbs the solar energy and pass it to connector, which is then passed to the MPPT charger with a schottky diode to make the flow of voltage in one direction. A feedback circuit is provided to divert the extra voltage coming in the circuit inorder to prevent the Ic from burning. When MPPT charger gets required amount of voltage it passes to the booster circuit through inductor which stabilises the current. When there is more power coming from the circuit it charges the battery simultaneously. A feedback circuit is provided to the battery at BAT pin which controls the charging of the battery. A sense Resistor (0.1Ω) is present which senses the current flowing through it to the boost circuit. The value of the sense resistor is kept very small so current drop across it will be minimum. To provide stability while charging the battery a Capacitor of 100microF is replaced with 5 capacitor of 22microF connected in parallel to reduce the size of circuit.

Booster: A boost converter/booster is a Direct current (DC) to DC power converter that steps up voltage (while stepping down current) from its input (Mppt charger) to its output (Inverter). The key principle that drives the boost converter is the tendency of an inductor to resist change in ciurrent by craeting and destroying a magnetic field. In a boost converter, the output voltage is always higher than the input voltage. However, the input and output power remains the same hence at the output side voltage increases while the current decresses. Thus a source should be able to supply sufficient current for proper operation of the circuit. We make use of BD9306 (IC) as our Boost converter. Output of the Mppt charge controller is connected to boost circuit through Enable and Vcc Pin. A mosfet connected to GD pin controls the switching cycle in the circuit. Vcc boost the coming 12volts input voltage from the Mppt charger and boost it to 120volts output voltage which is then driven to the inverter circuit.

Battery: A battery is a portable energy source that converts chemical energy to electrical energy. Batteries contain three basic parts: the electrode, the electrolyte ans a seperator. There are always two electrodes in a battery: the cathode connected to the positive end, and the anode connected to the negative end. When a battery powers a load, it discharges

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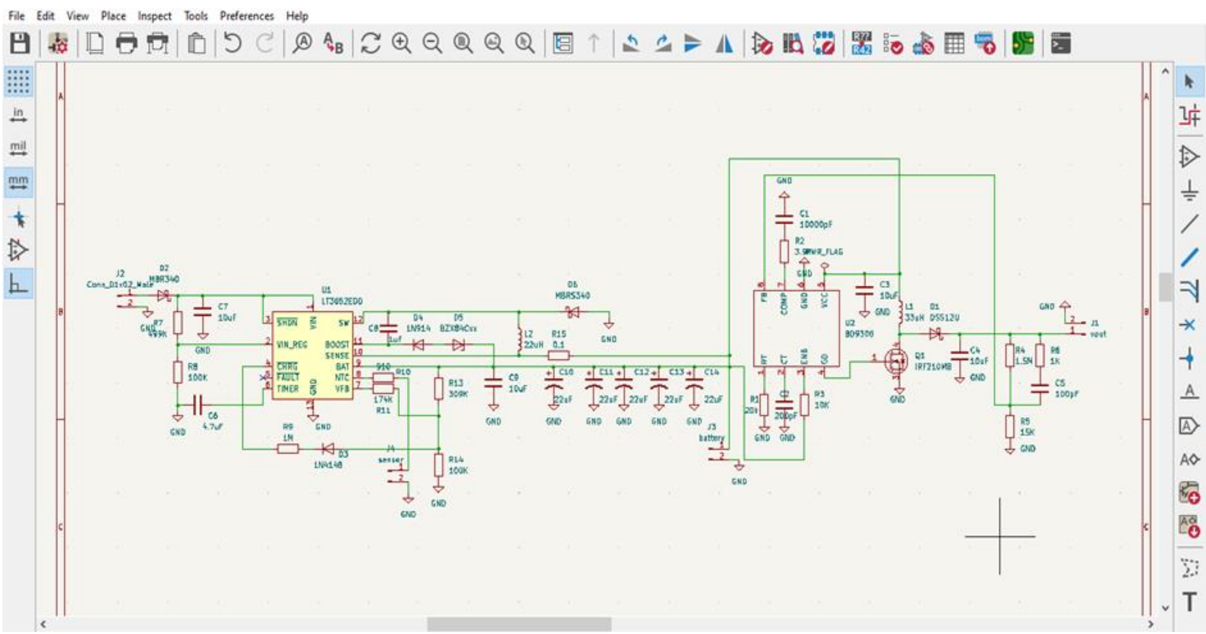
and current flows from cathode to anode. when the battery charges, the current flows from anode to cathode. In our project the Mppt charger has a threshold of 15volts, thus it starts functioning at 15volts input, it provides 12volts to the battery to charge during the day so can be used at nights or during rainy/cloudy climate.

Inverter: An inverter is an electronic device that changes Direct current (DC) to Alternating current (AC). The inverter does not produce any power, the power is provided by the DC source(here booster). We design H-Bridge Inverter circuit using 4 MOSFETS. To provide switching signals microcontroller is required. Microcontroller has a common ground for all the output pins, so four output pins are used to trigger four MOSFETs. The AND gates provided in the circuit, takes the input from the Ardino and pass it to pulse transformer which is connected to mosfet Q1 and Q3 which acts as a switch in the circuit. Similarly AND gate provides input to the optocoupler transformer which is connected to mosfet Q2 and Q4 which also acts a switch in the circuit. The way these switches are triggered determines the final output. To produce Alternating Voltage switch Q1 and Q4 will be triggered simultaneously current flowing from one direction forming the positive half cycle, after certain amount of time Q1 is switched off but Q4 remains on. To produce negative half cycle switch Q3 and Q4 will be triggered and hence direction of current is reversed forming negative half cycle.

Transformer: A transformer is a static, passive electrical device that transfers the electrical energy between two or more circuits. Transformers are used either step up transformers or step down transformers. We make use of a step up transformer. A step up transformer is a transformer that increases the voltage from the primary coil to the secondary coil while managing the same power at the rated frequency in both coils. It converts low voltage and high current from primary side to high voltage and low current on the secondary side of the transformer. In our project the step up transformer takes the 120volts AC input coming from the inverter at primary end and steps it up to 240volts output at the secondary end which light ups the bulb connected at the end of the circuit.

IV.CIRCUIT DESIGN

Designing the circuits using KiCad software



Schematic of Mppt charger & Booster circuit

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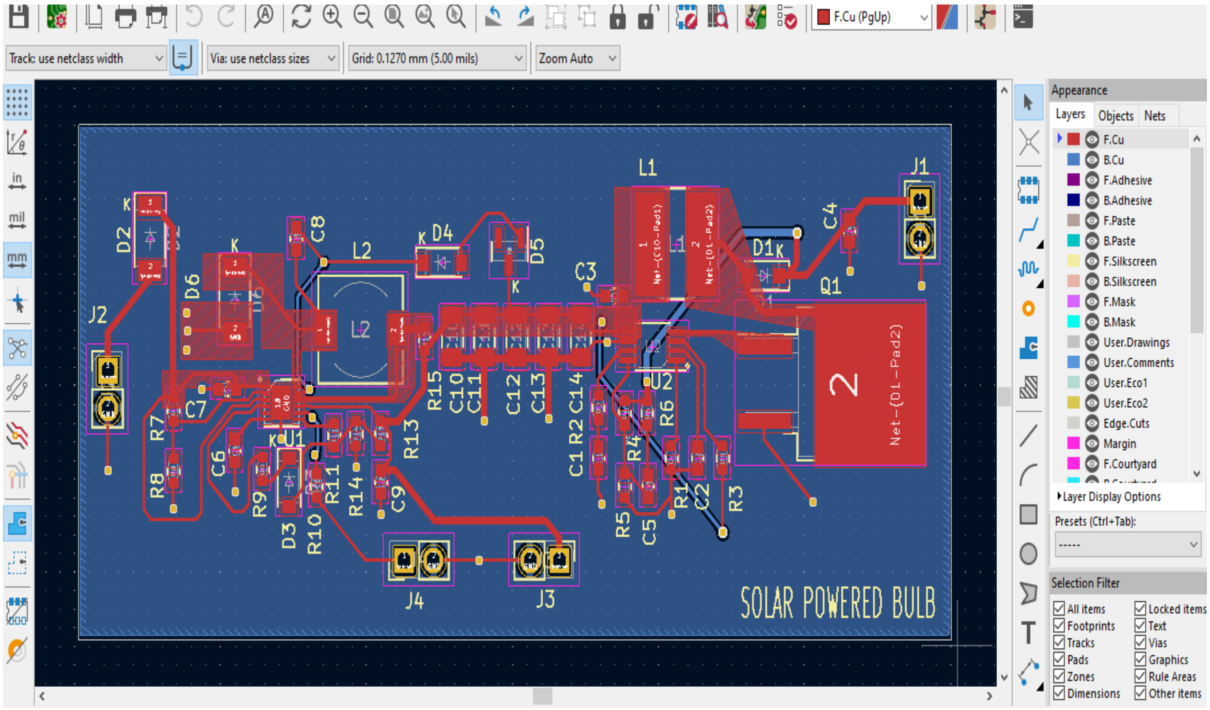
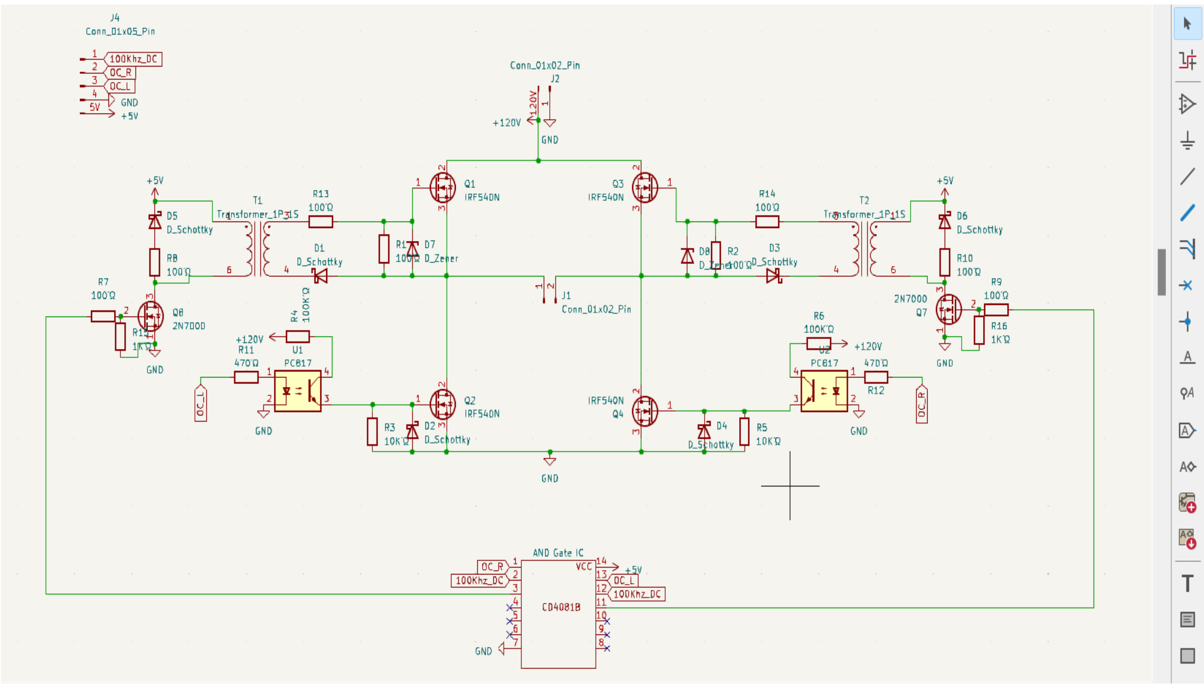


PCB layout of Mppt charger & Booster circuit



Schematic of Inverter Circuit

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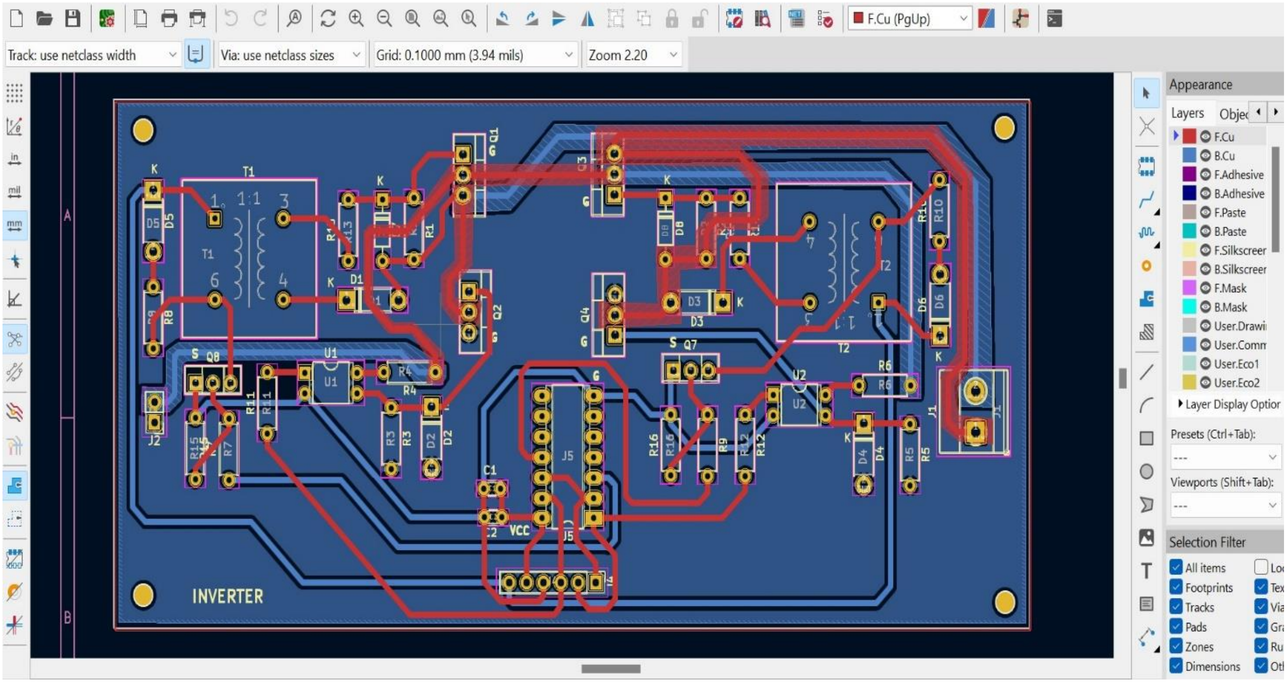

PCB Layout of Inverter Circuit

V.RESULT

Mppt charger has a threshold of 15volts, thus it starts functioning at 15volts input. The output of Mppt is connected to the Booster circuit which boost the coming 12volts from the Mppt charger to 120volts, simultaneously it provides 12volts to the battery to charge when no output is connected. Inverter takes 120volts DC input from the booster and converts it to 120volts AC output. The transformer further steps up the 120volts output from the inverter to 240volts in order to light the bulb.

VI.CONCLUSION

This project introduces circuits for efficiently harnessing solar energy to power a 20W bulb with maximum efficiency. The MPPT, Booster, and Inverter circuits have been developed and tested to ensure optimal performance. The MPPT circuit dynamically tracks solar panel output to maintain maximum power transfer. The Booster circuit efficiently steps up the voltage from the solar panel for powering the bulb while minimizing losses. The Inverter circuit converts the DC output to AC, enabling integration into existing applications. This solar-powered system reduces reliance on traditional electricity grids and offers versatile applications. It represents a significant advancement in efficient solar energy utilization. Street lights and home automation systems can benefit from this eco-friendly power supply. The system's specialized circuits ensure maximum power extraction and optimal performance. Overall, this project contributes to a cleaner and more sustainable future by harnessing solar energy effectively.

VII.FUTURE SCOPE

Advancements in photovoltaic materials, panel designs, and LED efficiency will lead to increased power generation and improved lighting output. The system strength can be increase with improving the design more efficiently.
Implementing Solar panel tracking to maximise power absorption capacity from any position of the sun.

ACKNOWLEDGEMENT

The success of our project is incomplete unless we mention the names of our respected teachers who made it possible, whose guidance and encouragement served to beacon light and crowned our efforts with success. We want to thank our **Prof. Devendra Sutar** for helping us and being kind to every time and patient and resourceful and we consider ourselves to be lucky to have you as our final year project guide. We are also very thankful to **Abhishek Chari** for helping us during the entire time.

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