DESIGN AND IMPLEMENTATION OF HYBRID CHARGING STATION FOR ELECTRIC VEHICLES

Project Reference No.: *47S_BE_1728*

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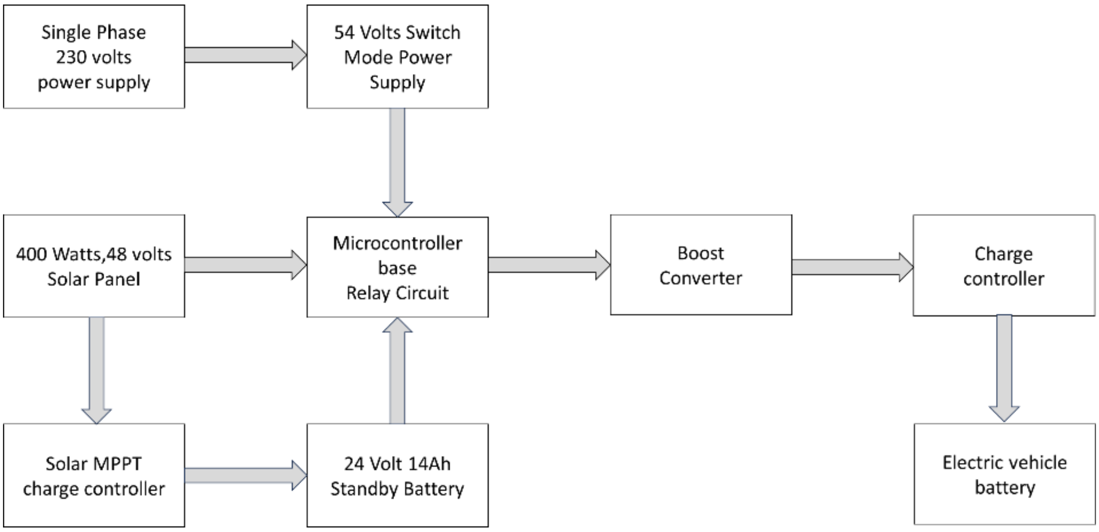
Introduction

Designing and implementing a hybrid charging station for electric vehicles (EVs), addressing the need for efficient charging infrastructure in the context of sustainable transportation as the number of electric vehicles has been increasing due to their dropping price range and zero emission of carbon. There will be several difficulties in power grid design, operation, stability, standards, and safety because of high-level EV integration into the electrical system. To overcome these challenges, the proposed methodology employs the integration of solar and grid power supply with additional standby battery systems charged by using maximum power point tracker control technique. The MPPT, relay controller and battery charger circuit were developed using Easy EDA circuit simulator and the prototype was built and tested to charge 48 volts, 65Ah lithium iron phosphate (LiFePO4) battery with 400 watts,40.87 V and 9.82A solar photovoltaic and stand by battery rating of 24V ,14Ah with 230 volts single phase power supply with charging voltage of 54 volts and 8-10 amps

Objective

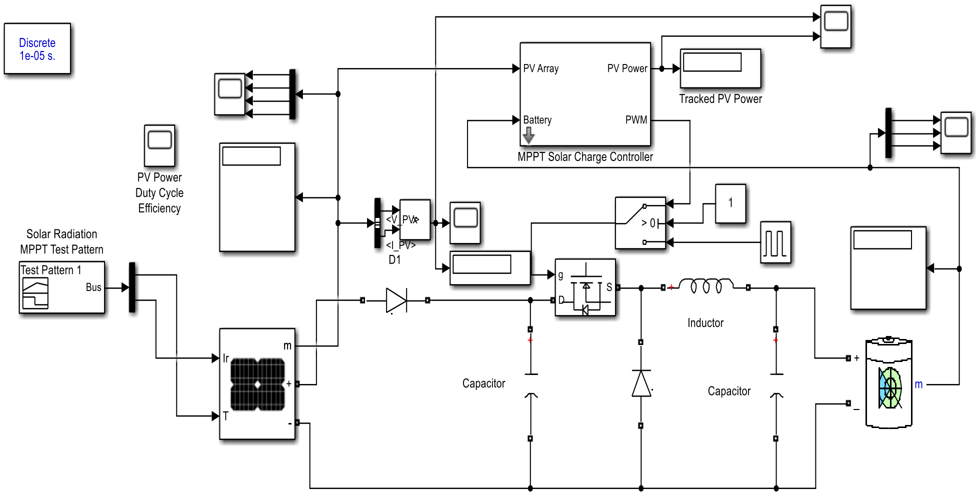
Hybrid charging is a method of efficiently charging electric vehicles using solar power with a backup battery system. This approach ensures that charging occurs during off-peak hours, reducing the strain on the grid during peak hours. The backup battery system is used when solar power is insufficient or unavailable, ensuring continuous charging without relying on the grid. This system design aims to maximize efficiency by utilizing excess solar power for charging and minimizing energy waste. By combining solar power and battery backup, hybrid charging provides a reliable and sustainable charging solution for electric vehicles.

Methodology

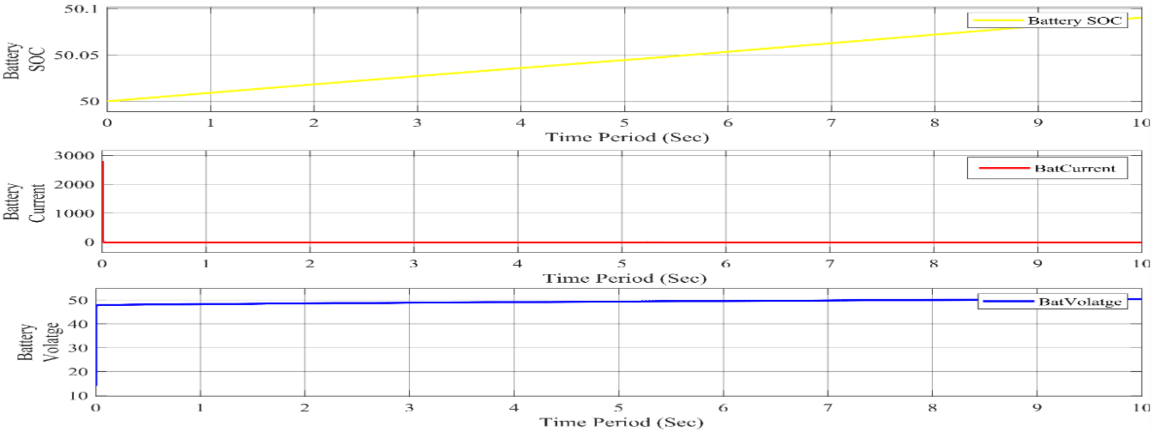


The system operates sequentially to optimize energy utilization and minimize dependence on grid electricity. The primary charging source is solar power, utilizing photovoltaic panels to harness renewable energy from the sun. When an EV is connected for charging, the system first checks the availability of sufficient solar energy. If solar power is adequate, the EV battery is charged directly from the solar panels, promoting clean and renewable energy usage. In case of insufficient solar energy, the system automatically switches to the standby battery system. The standby battery, equipped with an MPPT charge controller, acts as a backup power source to supplement charging during periods of low solar efficiency. Charging from the standby battery ensures an uninterrupted power supply to the EV, enhancing reliability and availability. After charging from the standby battery, the system reevaluates the solar energy availability. If solar conditions improve and sufficient energy is available, the charging process reverts to utilizing solar power directly. If solar energy remains insufficient or falls below a threshold voltage level, the system seamlessly transitions to grid supply as a backup charging source. Grid

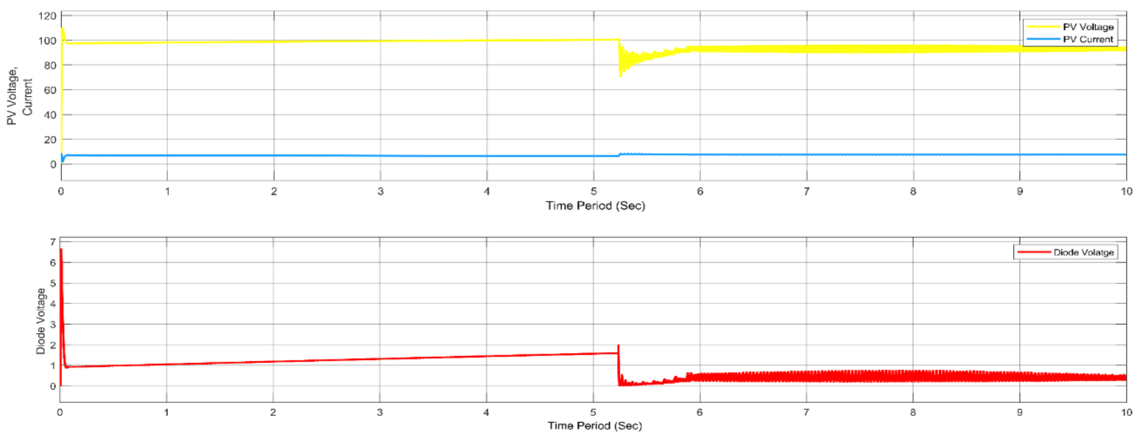
Solar MPPT Simulation using MATLAB/SIMULINK



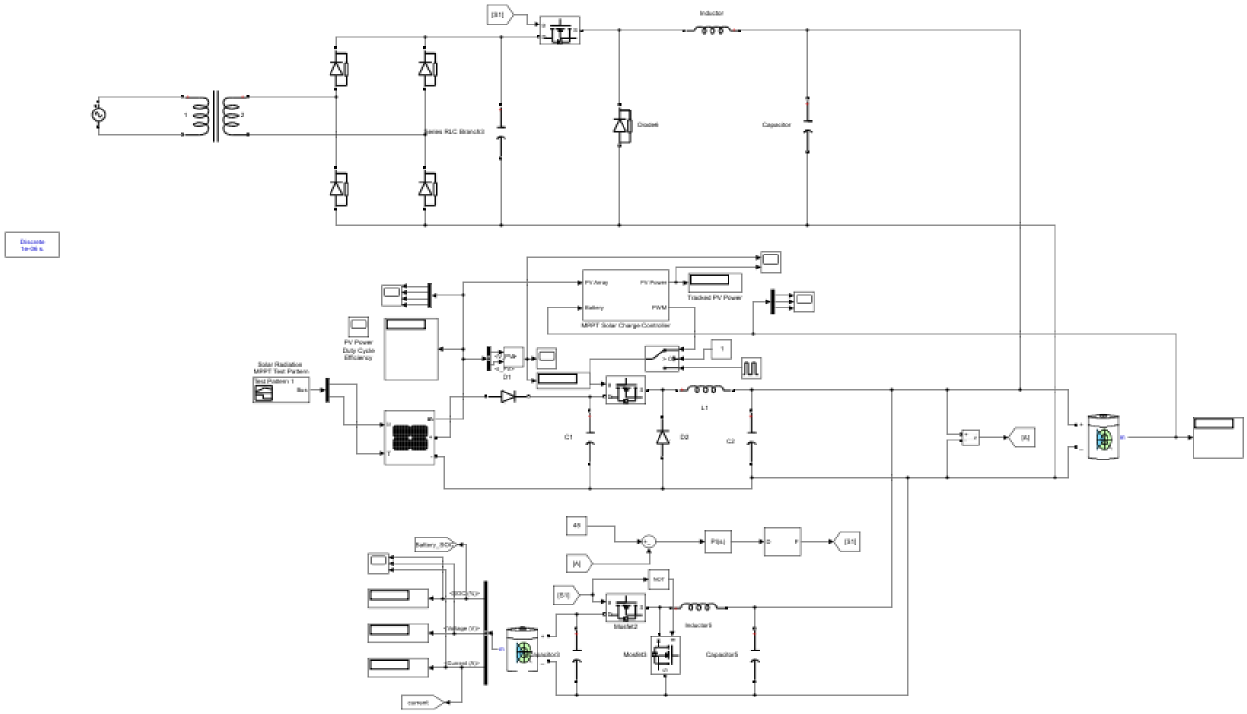
Output waveform



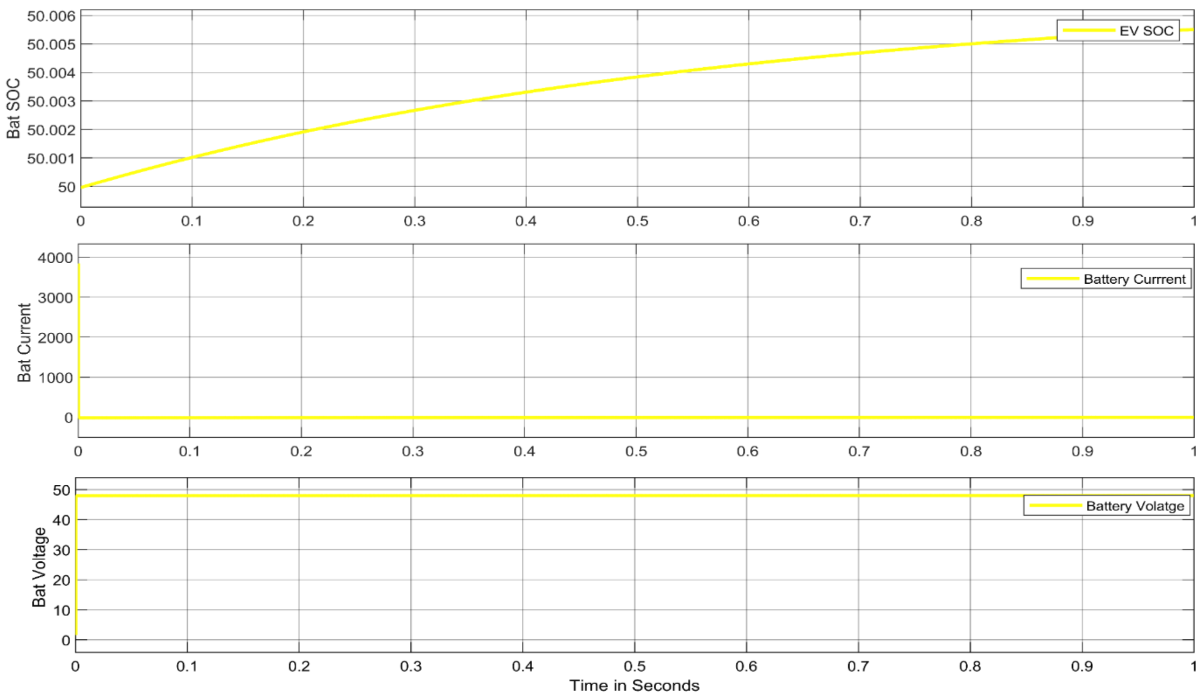
Waveform with and Without MPPT



Entire System Simulation

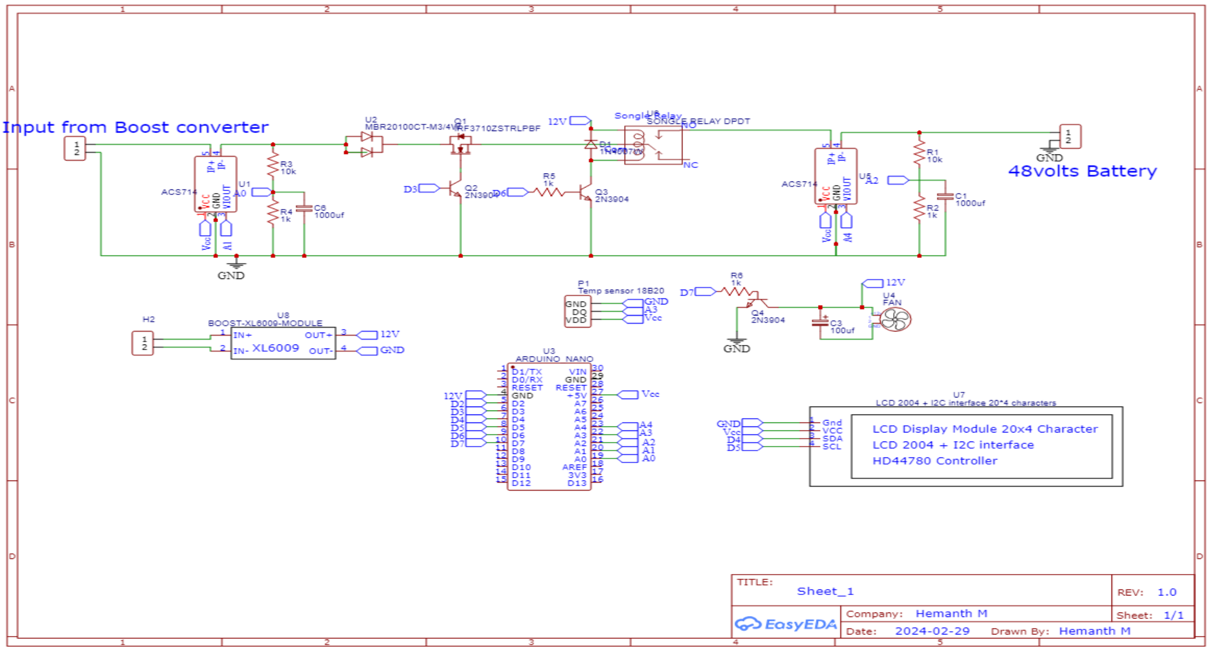


Output Waveform

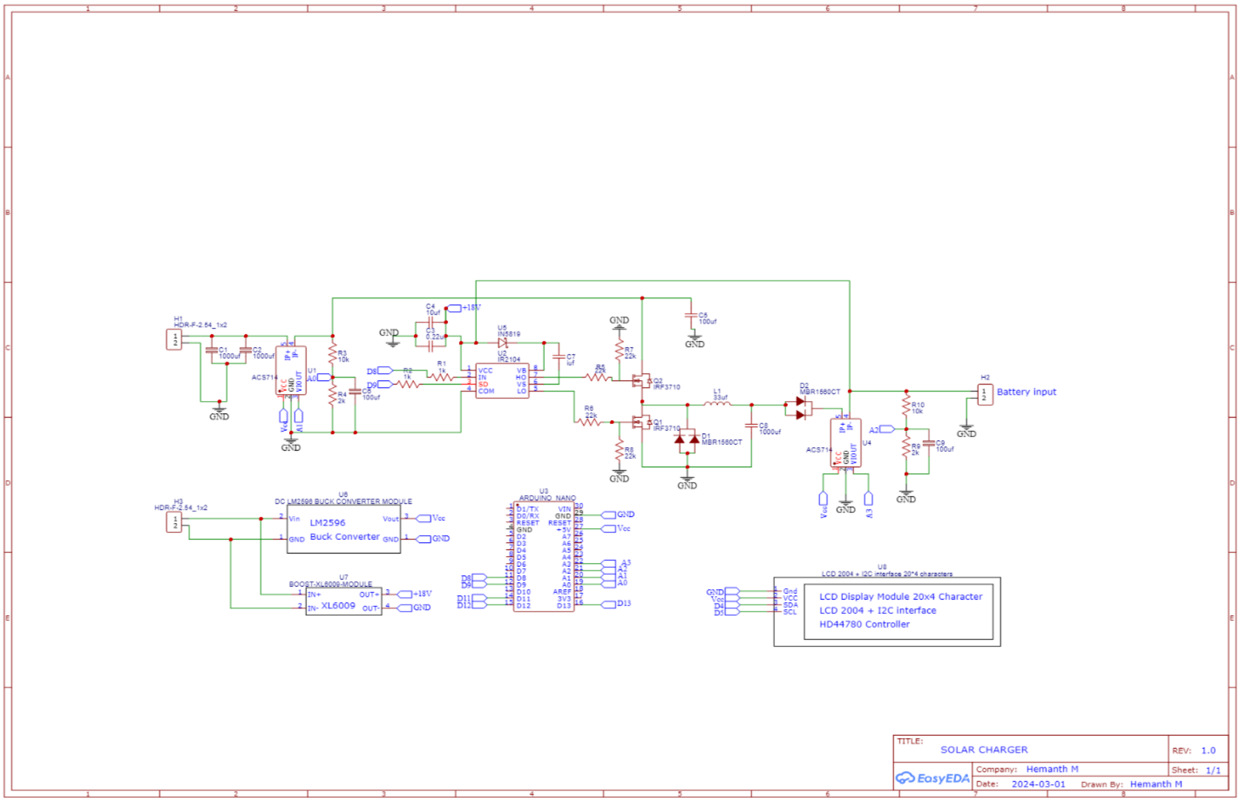


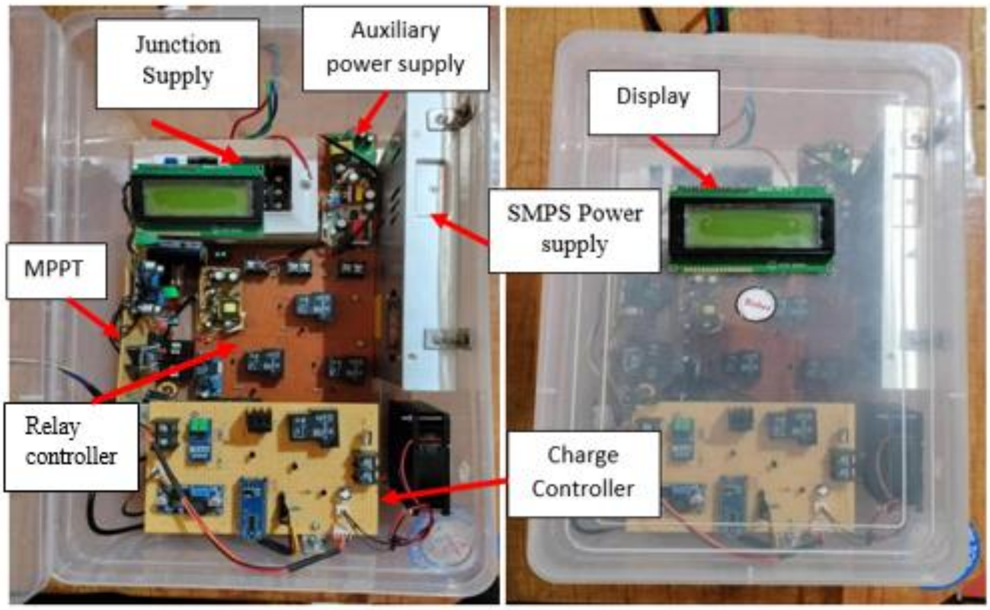
Schematic diagram design using EasyEDA Software

Charge controller schematic

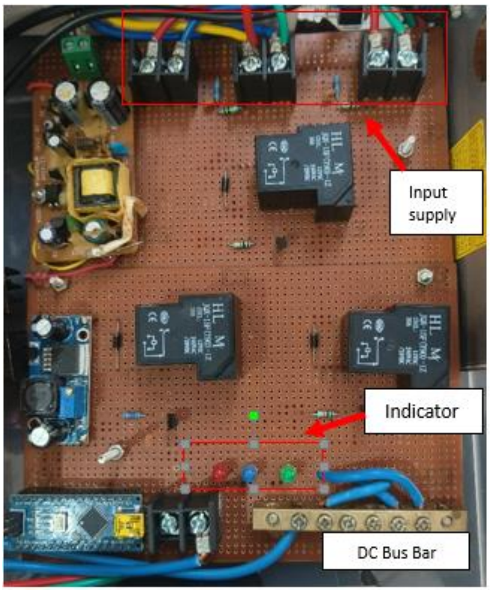


Solar MPPT schmeatic



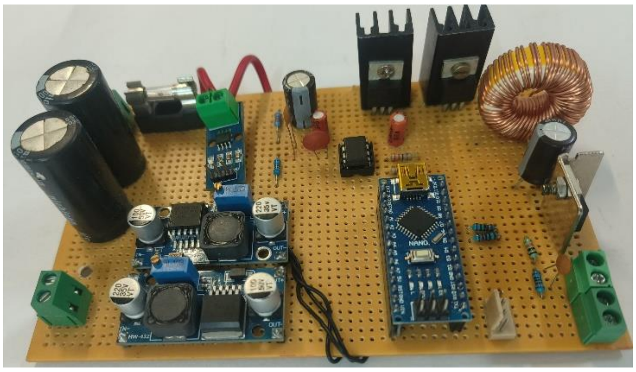


Relay controlling Circuit



Soalr MPPT

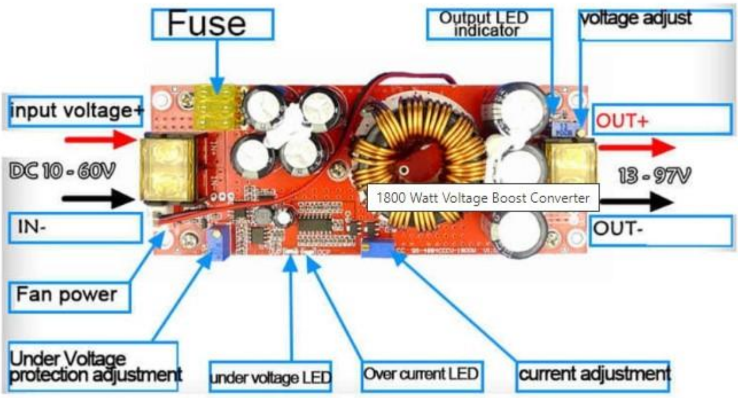
The Maximum Power Tracker finds this ever-changing MPP in an iterative process. We refer to this repetitive process as the hill climbing algorithm, or Perturb and Observe. To get maximum power point tracking (MPPT), the controller modifies the voltage slightly from the solar panel and then measures the power. If the power grows, the controller tries adjusting the direction again until the power stops increasing. When the output power of the solar panel increases, the voltage is first increased and then maintained until the output power begins to decline. The voltage to the solar panel is lowered until the maximum power is achieved once the output power starts to decline. Until the MPPT is reached, this process is repeated. The output power oscillates about the MPP as a result



Design parameters

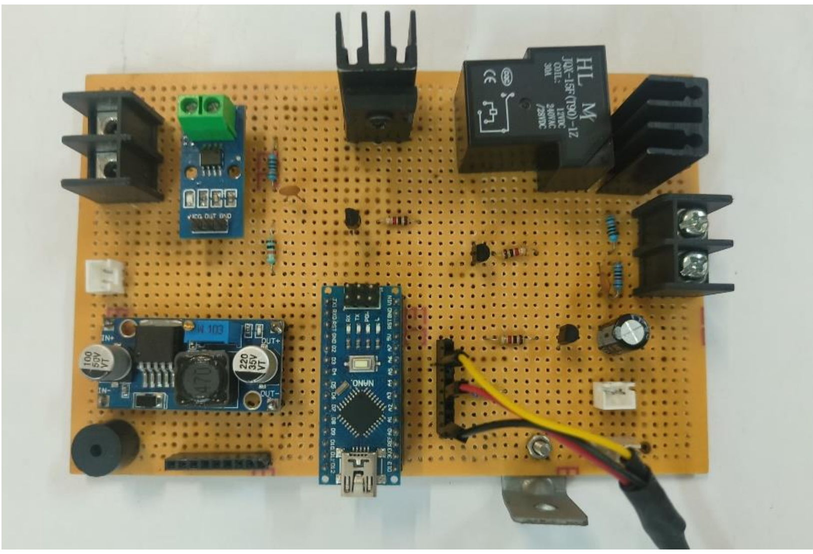
- Input 48 volts
- Output 26 volts for battery charging
- Over voltage and over current protection
- Surge protection

Boost converter Module



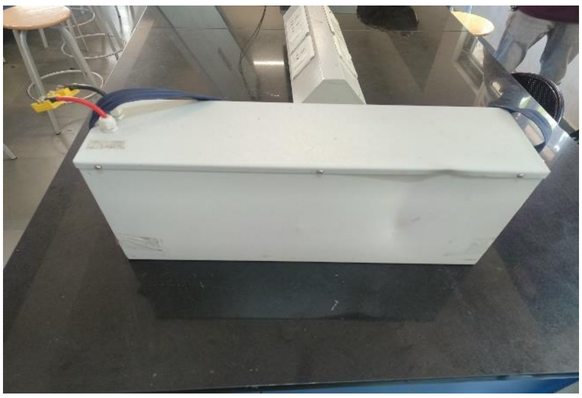
Charge Controller

The charge controller is a critical component for charging electric vehicles which is responsible for managing the charging process and ensuring optimal performance and safety. Our design incorporates several key features to facilitate efficient charging and monitoring: The charge controller includes built-in protection mechanisms to prevent overvoltage and overcurrent conditions, safeguarding the battery and charging system from damage or malfunction. Upon detection of excessive voltage or current levels, the charge controller automatically interrupts the charging process to prevent potential hazards. A 20x4 LCD interface provides real-time monitoring of crucial charging parameters, including voltage, current, power (watts), battery voltage, and charging mode.



Solar Panel Rating

Battery Specification

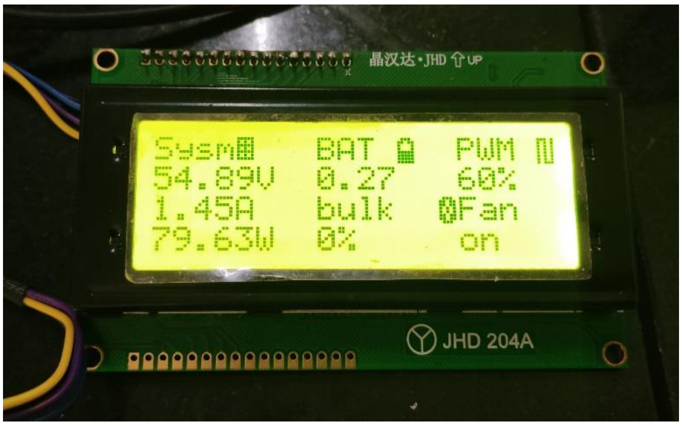


Nominal Voltage	48 V
Nominal Capacity	65Ah
Charging current	13A
Charge cut-off voltage	58.4 V

Standby Battery Specifications

Complete System Setup

System Display



Results and Conclusion

By integrating solar and grid power supplies with standby battery systems, the hybrid charging station aims to overcome challenges in power grid design, operational stability, standards compliance, and safety associated with high-level EV integration into the electrical system. Through the utilization of maximum power point tracker (MPPT) control techniques, relay controllers, and battery charger circuits, the prototype charging station was meticulously developed and tested using the EasyEDA circuit simulator. Real-world testing demonstrated the station's capability to efficiently charge a 48-volt, 65Ah lithium iron phosphate (LiFePO4) battery, utilizing a 400-watt solar photovoltaic array alongside a standby battery rated at 24V and 14Ah, powered by a 230-volt single-phase supply and the set was rested for different sources one by one for the same battery results indicate enhanced charging efficiency, grid stability, reliability, and environmental sustainability, underscoring the potential of hybrid charging stations to revolutionize the EV charging landscape

Innovation

- The battery charging system is optimized for efficiently charging a 48-volt, 10-amp battery.
- It is designed for easy installation near bus stops and auto stands to charge lightweight vehicles.
- The backup battery incorporates an MPPT charge controller to ensure maximum efficiency in drawing power from the solar panel, especially in low solar efficiency conditions.
- A microcontroller-based relay driver circuit is implemented to maximize the battery charging power by monitoring voltage from multiple sources.
- The system features a microcontroller (Arduino) based charge controller that continuously supervises source and battery levels, adjusting the charging mode between bulk and float charging by modulating the PWM signal to the MOSFET.
- Additionally, a phone charger is included for public use.

Scope for future work

The successful implementation of a hybrid charging station for electric vehicles (EVs) sets the stage for future research and development in sustainable transportation infrastructure. Integrating communication protocols will facilitate seamless communication between the vehicle and the charging station. Furthermore, exploring synergies with smart grid technologies, such as vehicle-to-grid systems, holds promise for unlocking new opportunities in energy management and grid support services