Mini Solar Power Bank

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***Abstract*—The increasing use of portable electronic devices such as smartphones, smartwatches, tablets, and wireless accessories has created a strong demand for efficient and portable charging systems. Conventional power banks require frequent charging from electrical outlets, which limits their usability in outdoor and emergency conditions. This paper presents the design and implementation of a Mini Solar Power Bank that utilizes renewable solar energy for charging electronic devices. The system consists of a 5V solar panel, TP4056 lithium battery charging module, 18650 lithium-ion battery, DC-DC boost converter, and USB output port. The solar panel converts sunlight into electrical energy, which is stored in the rechargeable battery through the charge controller. The boost converter increases the battery voltage to a stable 5V output suitable for charging USB-powered devices. The proposed system is compact, cost-effective, and environmentally friendly. Experimental testing shows stable output performance under sufficient sunlight conditions and reliable charging capability for small electronic devices. This project promotes the use of green energy solutions and provides an effective alternative to conventional charging systems.**

***Index Terms*—Solar Energy, Power Bank, Renewable Energy, TP4056, Boost Converter, Li-ion Battery, USB Charging.**

I. INTRODUCTION

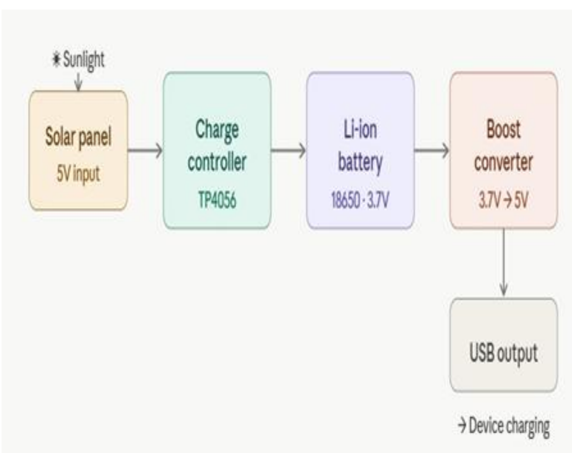
Portable electronic devices have become an essential part of daily life. From communication to entertainment and education, smartphones and other gadgets are constantly used throughout the day. However, these devices require frequent charging, and in many situations such as travelling, camping, outdoor work, or emergency conditions, access to electricity may not be available. Traditional power banks provide temporary backup power but depend entirely on electrical charging from the grid. This creates dependency on conventional electricity and reduces flexibility in remote areas. As the demand for sustainable and renewable energy increases, solar energy becomes one of the most practical alternatives for portable charging applications. Solar energy is clean, abundant, and freely available. By using photovoltaic panels, sunlight can be converted directly into electrical energy without causing environmental pollution. This makes solar-powered charging systems highly suitable for portable applications.

II. LITERATURE REVIEW

Many researchers have worked on portable solar charging systems using photovoltaic technology. Traditional solar chargers mainly use solar panels directly connected to charging circuits. However, these systems often suffer from unstable voltage, inefficient charging, and poor battery protection. The TP4056 charging module is widely used in solar power bank applications because it provides controlled charging for lithium-ion batteries. It protects the battery from overcharging, over discharging, and overheating, which improves safety and battery life. Similarly, DC-DC boost converters are important for converting the battery voltage of 3.7V to a stable 5V output required by USB devices. Without proper voltage regulation, charging performance becomes unreliable. Some advanced systems use Maximum Power Point Tracking (MPPT) to improve solar panel efficiency. Although MPPT improves energy harvesting, it increases circuit complexity and cost. For low-cost student projects and compact portable systems, a simpler design using TP4056 and boost converters is more practical. Based on previous studies, this project combines essential components into a compact and efficient solar power bank while maintaining low cost and easy implementation.

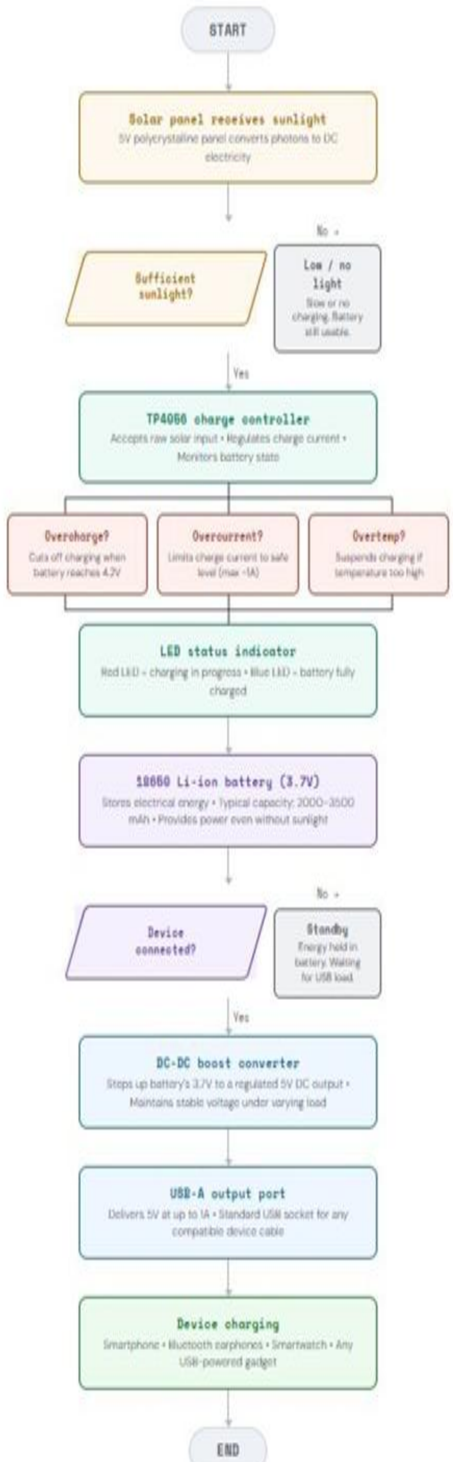
III. METHODOLOGY

The Mini Solar Power Bank is developed using a simple and effective energy conversion and storage process. The system begins with a 5V solar panel that captures sunlight and converts solar radiation into electrical energy using photovoltaic cells. The output of the solar panel is connected to the TP4056 charging module. This module controls the charging process of the 18650 lithium-ion battery and ensures safe battery operation by preventing overcharging and excessive current flow. The stored energy in the battery is then supplied to a DC-DC boost converter. Since the lithium-ion battery provides approximately 3.7V output, the boost converter increases the voltage to a stable 5V, which is required for charging mobile devices through a USB port. The system is first tested on a breadboard to verify proper functioning of each stage. After successful testing, the circuit is assembled into a compact enclosure for better portability and practical use. The overall methodology includes: 1. Solar energy harvesting using photovoltaic panel 2. Safe battery charging using TP4056 module 3. Energy storage using lithium-ion battery 4. Voltage boosting using DC-DC converter 5. USB output for device charging.



BLOCK DIAGRAM

The working principle of the Mini Solar Power Bank is based on solar energy conversion, battery storage, and voltage regulation. When sunlight falls on the solar panel, electrical energy is generated in the form of DC voltage. This voltage is supplied to the TP4056 charging module, which regulates the charging of the lithium-ion battery. The module ensures safe charging conditions and protects the battery from damage. The charged battery stores the energy for later use. When a device is connected through the USB port, the battery supplies power to the DC-DC boost converter. The converter increases the voltage from 3.7V to a stable 5V output required by most USB charging devices. This allows the system to function both during sunlight and even after sunlight is unavailable, making it useful for continuous portable charging applications. The practical implementation of the Mini Solar Power Bank involves assembling all selected components into a functional charging system. The solar panel is connected to the input terminals of the TP4056 charging module. The output terminals of the TP4056 are connected to the 18650 lithium-ion battery for energy storage. The battery output is then connected to the input of the boost converter. The boost converter output is adjusted to provide a stable 5V output and connected to a USB port for charging mobile devices. LED indicators on the TP4056 module help monitor battery charging status. The complete circuit is first tested using a breadboard and later assembled using proper soldering for improved reliability. A compact plastic enclosure is used to house the components, improving safety, portability, and appearance. The prototype successfully charges mobile devices under sufficient sunlight conditions and stores backup energy efficiently.



FLOWCHART

IV. RESULTS AND DISCUSSION

The Mini Solar Power Bank was tested under different lighting conditions to evaluate system performance. Under direct sunlight, the solar panel generated sufficient voltage to charge the lithium ion battery efficiently. The TP4056 charging module worked effectively by providing safe charging and battery protection. The boost converter maintained a stable 5V output, allowing successful charging of smartphones and small USB-powered devices. The charging speed depended on sunlight intensity. Under strong sunlight, better charging performance was observed, while under low-light conditions the charging speed reduced significantly. This is expected in solar-powered systems due to dependence on environmental conditions. The overall performance of the prototype was reliable, portable, and practical for outdoor and emergency usage. The project successfully demonstrated the use of renewable energy for portable charging applications.

V. CONCLUSION

The Mini Solar Power Bank successfully demonstrates the practical use of solar energy for charging portable electronic devices. The system integrates solar energy harvesting, battery storage, and regulated output into a compact and efficient design. The project reduces dependency on conventional electricity and promotes the use of renewable energy sources. Its compact size, low cost, and portability make it highly suitable for students, travelers, and emergency situations. The TP4056 charging module ensures safe battery operation, while the boost converter provides stable USB charging output. Although charging efficiency depends on sunlight availability, the system performs effectively under normal outdoor conditions. Future improvements may include the use of larger solar panels, fast charging technology, MPPT-based optimization, and wireless charging support. This project provides a strong foundation for further development of portable renewable energy systems.

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