

Development of a Solar-Powered Power Bank

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Abstract

This paper demonstrates the development and operating principle of a power bank which is powered by solar energy. The necessary solar panel, lithium batteries, power bank modules, wires and other accessories have been assembled as per the proposed circuit diagram. The power bank has been tested and found to have effective charging potential for smartphones and tablets.

Keywords: Solar panel, power bank, integrated circuit, mobile app, charging

Introduction

Today we are living in the world of renewable energy and portable power solutions. In this era where our reliance on electronic devices continues to grow, it becomes essential to find sustainable and efficient ways to keep them charged on the go. This is where the revolutionary concept of a solar-powered power bank comes into play. A solar-powered power bank combines the convenience of a portable charging device with the eco-friendly benefits of harnessing solar energy. It offers a reliable and renewable source of power, allowing you to charge your devices anytime, anywhere, while reducing your carbon footprint. A solar-powered power bank combines the convenience of a portable charging device with the eco-friendly benefits of harnessing solar energy. It offers a reliable and renewable source of power, allowing us to charge our devices anytime, anywhere, while reducing our carbon footprint.

Unlike traditional power banks that rely solely on electrical outlets or batteries for charging, a solar-powered power bank utilizes photovoltaic cells to convert sunlight into electricity. These solar cells are strategically integrated into the power bank, capturing solar energy and storing it in its internal battery for later use. Moreover, a solar-powered power bank serves as a sustainable alternative, reducing our dependence on conventional energy sources and minimizing the environmental impact associated with fossil fuel-based power generation. By utilizing renewable solar energy, we contribute to the global shift towards cleaner and greener energy solutions. One of the remarkable advantages of a solar-powered power bank is its versatility. Whether you're hiking in the wilderness, camping under the stars, or simply spending time outdoors, you can harness the power of the sun to charge your smartphones,

tablets, cameras, and other USB-compatible devices. It offers a portable energy solution that is not bound by traditional power sources

In this project, we have undertaken the development of a cutting-edge solar-powered power bank, aiming to combine efficiency, durability, and user-friendliness. We have incorporated advanced solar cell technology, optimized charging algorithms, and high-capacity battery storage to ensure reliable and rapid charging even in challenging conditions. Our objective is to provide you with a portable power solution that not only meets your daily charging needs but also aligns with your commitment to sustainability.

Objectives

The objectives of a solar-powered power bank project can vary depending on specific needs and goals. However, here are some common objectives for a solar-powered power bank

- **Portable and Convenient Charging:** The primary objective is to create a power bank that is portable, lightweight, and easy to carry, allowing users to charge their electronic devices while on the move.
- **Harness Solar Energy:** The project aims to effectively capture solar energy through high-quality solar panels or photovoltaic cells integrated into the power bank. The objective is to maximize energy conversion and optimize solar charging efficiency.
- **Energy Storage and Power Capacity:** The project aims to design a power bank with adequate energy storage capacity, ensuring it can store sufficient power generated from solar energy.
- **Fast and Efficient Charging:** The project focuses on developing efficient charging circuits and algorithms that allow the power bank to deliver fast and consistent charging to connected devices. The objective is to provide comparable charging speeds to conventional power banks, despite relying partially on solar energy.
- **Durability and Robustness:** The project aims to create a durable and robust power bank that can withstand outdoor conditions, including exposure to sunlight, moisture, and physical impacts.
- **User-Friendly Features:** The objective is to incorporate user-friendly features such as LED indicators to display the power bank's charging status and remaining power, multiple charging ports to accommodate various devices, and potentially additional functionalities like built-in flashlights or wireless charging capabilities.
- **Environmental Sustainability:** One of the primary objectives of a solar-powered power bank project is to promote environmental sustainability. By utilizing solar energy as a renewable power source, the project contributes to reducing carbon emissions, dependence on fossil fuels, and overall environmental impact.
- **Cost-effectiveness:** The project aims to strike a balance between affordability and performance, ensuring that the solar-powered power bank remains accessible to a wide range of users.

These objectives collectively aim to develop a solar-powered power bank that empowers users with a sustainable and reliable portable charging solution.

Components Required

- I. **Solar Panel-** The solar panel (Fig.1) is a crucial component of a solar-powered power bank as it captures solar energy and converts it into electrical energy. Higher efficiency panels can generate more power from the same amount of sunlight. It is important to select solar panels with a good balance of efficiency and cost. The power output of a solar panel is measured in watts (W) and indicates the maximum electrical power it can generate under specific conditions. The power output depends on factors such as the size of the panel, the efficiency of the cells, and the intensity of sunlight. Check the voltage and current ratings of the solar panel to ensure compatibility with your power bank's charging circuitry. Make sure the panel's output matches the input requirements of your power bank's charging circuit.



Fig.1: Solar Panel

- II. **Lithium Batteries:-**Lithium batteries (Fig.2) are widely used in solar-powered power banks due to their high energy density, long lifespan, and lightweight nature. There are two common types of lithium batteries used in power banks. Li-ion batteries [2000 mAh \times 4 = 8000 mAh] are more prevalent and offer good energy density, while Li-Po batteries provide flexibility in terms of shape and size due to their pouch-like structure. The capacity of the lithium battery determines how much energy it can store and deliver to charge electronic devices. It is measured in milliampere-hours (mAh) or watt-hours (Wh). Higher capacity batteries can provide more charging cycles or charge multiple devices before requiring recharging. Lithium batteries typically have a nominal voltage of 3.7 volts per cell. Depending on the power bank's requirements, multiple cells may be connected in series or parallel to achieve the desired voltage and capacity. Lithium batteries offer high charging and discharging efficiency, allowing for effective energy transfer between the battery and connected devices. The physical dimensions and weight of the lithium battery should align with the size and portability requirements of the power bank. Compact and lightweight batteries are desirable for enhancing the portability and

usability of the power bank. It is crucial to handle and use lithium batteries according to the manufacturer's guidelines to prevent any potential hazards and maximize their lifespan.



Fig.1: Lithium Batteries

- III. Power Bank Module:-The power bank module (Fig.3) is a crucial component that integrates and manages the charging and discharging processes in a solar-powered power bank. Power bank module includes a charging circuit that regulates the charging process of the battery. It ensures efficient and safe charging by monitoring the incoming power from the solar panels and controlling the charging rate to prevent overcharging. The power bank module should be designed to maximize the charging efficiency and conversion rate from solar energy to electrical energy. This ensures that the power bank optimally utilizes the available solar power and delivers efficient charging to the connected devices. The power bank module also incorporates a discharging circuit that regulates the power flow from the battery to the connected devices. It ensures that the power output is stable and compatible with the charging requirements of various electronic devices. The power bank module also incorporates a discharging circuit that regulates the power flow from the battery to the connected devices. It ensures that the power output is stable and compatible with the charging requirements of various electronic devices. The power bank module typically includes a voltage regulation mechanism to stabilize the output voltage. This ensures that the power bank delivers a consistent and reliable voltage level to the connected devices, protecting them from voltage fluctuations. The power bank module features USB ports or connectors through which the devices are connected for charging. It may include multiple USB ports to accommodate different devices simultaneously. The power bank module incorporates various protection mechanisms to ensure the safety of the power bank and the connected devices. These may include over current protection, overvoltage protection, short-circuit protection, and temperature protection. Many power bank modules have LED indicators that display the charging status, remaining battery capacity, and other relevant information. The power bank module is typically implemented on a printed circuit board

(PCB). The PCB hosts the various electronic components, including the charging and discharging circuits, voltage regulation components, and protection mechanisms. When selecting a power bank module, it is important to consider its compatibility with the solar panels, battery, and other components of the power bank.

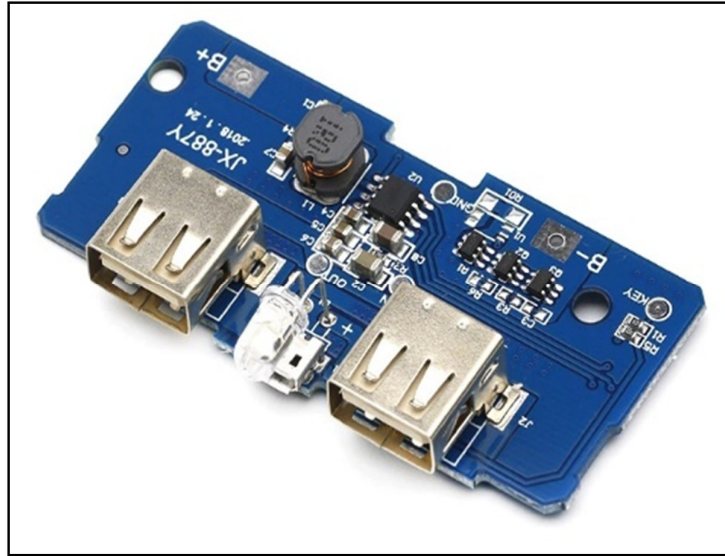


Fig. 3: Power Bank Module

- IV. Wires:- Wires (Fig.4) play a crucial role in connecting and transmitting electrical signals between various components in a solar-powered power bank. There are different types of wires used in power banks, such as copper wires or tinned copper wires. Copper wires are known for their excellent electrical conductivity, making them a common choice for power transmission. The wire gauge or thickness determines its current-carrying capacity. Thicker wires have lower resistance and can handle higher current loads. The wire gauge should be chosen based on the maximum current requirements of the power bank and the connected devices. The wiring configuration depends on the power bank's design and the specific requirements of the components. The wires connect the solar panels, battery, charge controller, USB ports, and other electronic components in the power bank, ensuring proper electrical connections and power flow. The length of the wires should be determined based on the physical layout of the power bank and the distance between components. It is important to use high-quality wires that are durable and capable of withstanding the demands of the power bank's operation. Reliable and durable wires contribute to the overall performance and longevity of the power bank. Strain relief mechanisms, such as cable ties or grommets, can be used to secure and protect the wires from excessive bending, pulling, or strain. This helps prevent wire damage and ensures long-term reliability. When working with wires, it is crucial to follow proper wiring techniques and adhere to safety guidelines to minimize the risk of electrical hazards.

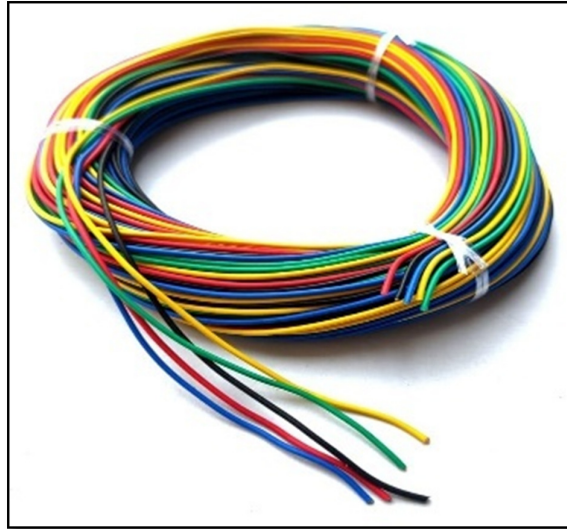


Fig. 4: Wires

- V. **Cardboard:-** Cardboard is used in the outer construction of a solar-powered power bank. It is used for packaging the power bank components during transportation or storage. It provides protection against physical damage and helps keep the components organized. In some cases, cardboard can be used as a material to create a prototype enclosure for the power bank. This allows for a low-cost and quick way to visualize the size, shape, and overall design of the power bank before manufacturing a more durable enclosure. Cardboard can provide some level of thermal insulation, which may be useful in certain scenarios to protect the power bank components from extreme temperatures or to mitigate heat dissipation issues. Cardboard is a recyclable and biodegradable material, making it an environmentally friendly choice.

Circuit Connections

The circuit connections (Fig.5) of a solar-powered power bank can vary depending on the specific design and components used. The positive (+) and negative (-) terminals of the solar panels are connected to the corresponding terminals of the charge controller. This connection allows the solar panels to supply the generated solar energy to the power bank's charging system. The charge controller manages the flow of energy from the solar panels to the battery, ensuring efficient and safe charging and protects the battery from overcharging. It is connected to the battery's positive (+) and negative (-) terminals. The positive (+) and negative (-) terminals of the battery are connected to the charge controller. This connection allows the battery to receive power from the solar panels through the charge controller for storage. The power bank module is responsible for managing the charging and discharging processes. It is connected to the battery's positive (+) and negative (-) terminals. The power bank module regulates the power flow from the battery to the connected devices through its USB ports. The USB ports of the power bank module are connected to the power bank's circuitry. These ports allow the connection of electronic devices for charging. The USB ports

deliver power from the battery to the devices through appropriate circuitry, ensuring compatibility and safe charging. If the power bank has LED indicators to display charging status and battery capacity, they are connected to the power bank module's circuitry. The LED indicators receive signals from the power bank module to indicate the charging status and remaining battery capacity. The circuit connections should be made with proper wire gauges, ensuring secure and reliable connections. Additionally, attention should be given to proper insulation and protection of the wiring to prevent short circuits or electrical hazards.

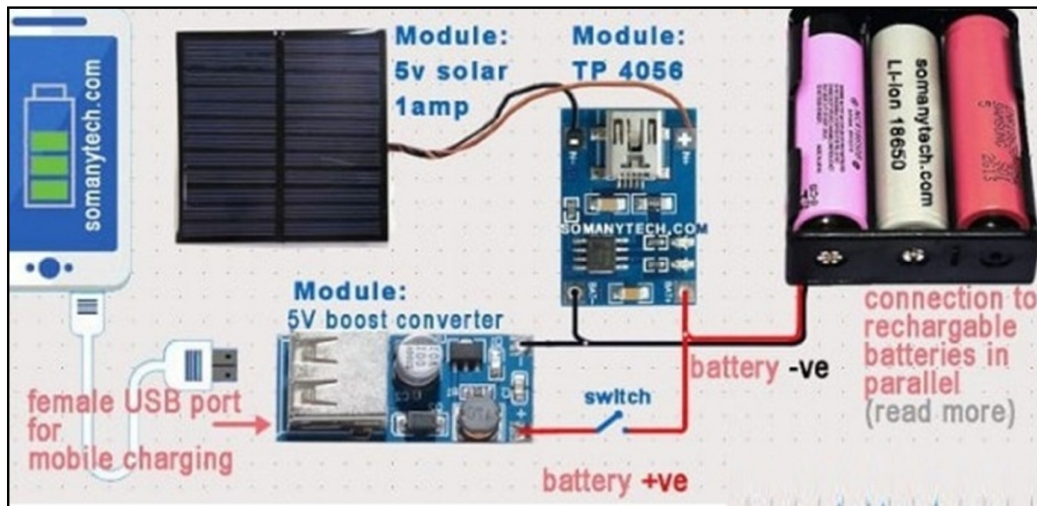


Fig. 5: Circuit Connections

Working Principle

The working principle of a solar-powered power bank involves several steps to convert solar energy into electrical energy and store it in the power bank's battery.

The solar panel, which consists of photovoltaic (PV) cells, absorbs sunlight and converts it into direct current (DC) electrical energy. The PV cells contain semiconductor materials that create an electric field when exposed to sunlight. The DC electrical energy generated by the solar panel needs to be converted to a suitable voltage and current to charge the power bank's battery. This is achieved through a charging circuit or charge controller. The charging circuit regulates the voltage and current, ensuring proper charging and preventing overcharging or damage to the battery. The charging circuit connects the solar panel to the power bank's battery. It controls the flow of electrical energy from the solar panel to the battery, enabling the battery to charge. The charging circuit monitors the battery's voltage and current levels, adjusting the charging process accordingly. The battery stores the electrical energy received from the solar panel during charging. It is usually a rechargeable lithium-ion or lithium-polymer battery. The battery's capacity determines how much energy it can store, measured in milliampere-hours (mAh). When you connect a device to the solar-powered power bank, the stored energy in the battery can be used to charge the device. The power management circuit in the power bank regulates the power flow from the battery to the device, ensuring a stable and safe charging process.

When the power bank is exposed to sunlight, the solar panel continues to harvest solar energy. Simultaneously, the charging circuit monitors the battery's charge level. If the battery is not fully charged, the solar panel supplies additional energy to continue charging the battery, replenishing the power bank's energy reserves. It's important to note that the efficiency of the solar-powered power bank depends on factors such as the solar panel's efficiency, the charging circuit's performance, and the battery's capacity.

Working Model

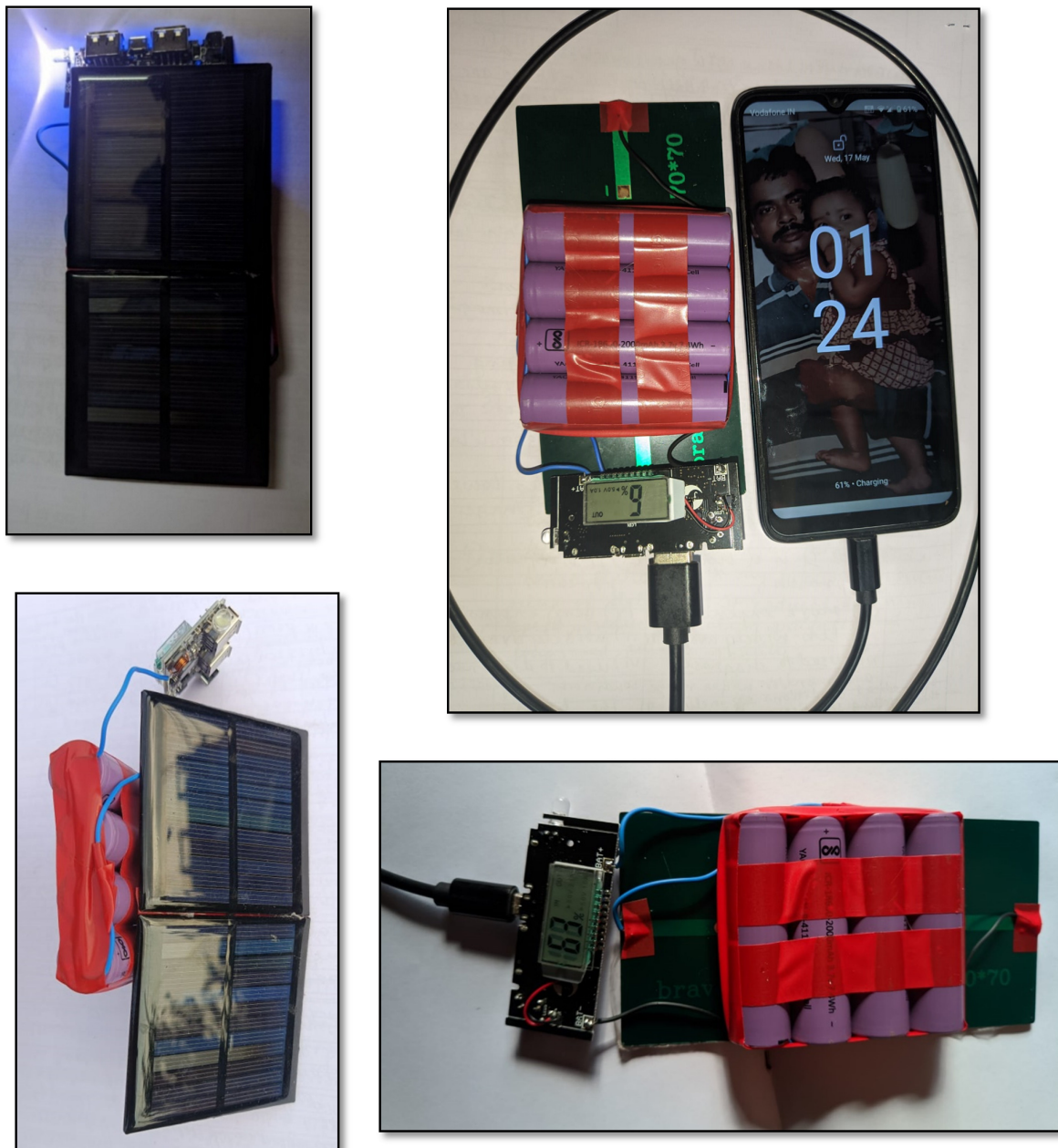


Fig.6: Working Model

Future Scope

The future scope of solar-powered power banks holds significant potential for advancements and improvements. Advancements in solar cell technologies, such as multi-junction cells, perovskite solar cells, and organic solar cells, may lead to higher conversion efficiencies, allowing power banks to charge more effectively and in shorter durations. The development of flexible and transparent solar panels opens up new possibilities for integrating solar cells into various surfaces. Imagine power banks with solar panels integrated into backpacks, windows, or even wearable devices, allowing for seamless solar energy harvesting on the go. As battery technologies continue to evolve, we can expect higher energy densities, faster charging capabilities, and longer battery lifetimes. Future power banks may incorporate Internet of Things (IoT) connectivity and smart features. This integration could enable remote monitoring and control of the power bank's charging status, battery level, and energy consumption through mobile apps or smart home systems. Solar-powered power banks could be designed to accept power input from multiple sources, including solar, USB, and wireless charging. Future power banks may incorporate advanced energy management systems that optimize the energy flow between the solar panel, battery, and connected devices. These systems would intelligently distribute the available energy to maximize device charging efficiency and prolong battery life. With the increasing adoption of renewable energy sources and smart grids, solar-powered power banks could potentially connect to the energy grid to share excess energy or participate in demand response programs.

It's important to note that these possibilities represent potential directions for future development in the field of solar-powered power banks. As technology advances, we can expect to see innovations and improvements that further enhance the performance, usability, and sustainability of these devices.

Conclusion

In conclusion, solar-powered power banks offer a sustainable and portable solution for charging electronic devices on the go. By harnessing solar energy, these power banks provide a renewable source of power, reducing our reliance on traditional grid-based electricity. With the right selection of components, including efficient solar panels, reliable batteries, and well-designed charging and power management circuits, solar-powered power banks can effectively convert sunlight into stored electrical energy.

While current solar-powered power banks provide convenient charging options, the future scope of this technology holds immense potential. Advancements in solar panel efficiency, energy storage technologies, and smart features can further enhance the performance and usability of these devices. Flexible and transparent solar panels, multi-source charging capabilities, and integration with IoT systems are just some of the possibilities on the horizon.

Furthermore, the integration of solar-powered power banks into the larger energy grid and the use of eco-friendly materials in their manufacturing can contribute to a more sustainable and environmentally friendly approach to energy consumption.

As technology continues to advance, solar-powered power banks have the potential to become more efficient, versatile, and integrated into our daily lives. They offer a promising solution for addressing the increasing demand for portable power while reducing our impact on the environment.

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