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BONAFIDE CERTIFICATE

Certified that this project report “**SOLAR CHARGING SYSTEM FOR MOBILES AND BATTERIES**” is bonafide work of “**MANIMARAN V (513121106302)**” who carried out the work under my supervision.

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INTERNAL EXAMINER

EXTERNAL EXAMINER

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SOLAR MOBILE PHONE CHARGING-

Abstract –

In environments where access to conventional power sources is unreliable or nonexistent, such as during natural disasters, emergencies, or in remote regions with limited infrastructure, the imperative for alternative energy solutions is crucial. This project presents a comprehensive design and implementation of a solar power bank circuit, offering a sustainable and dependable source of power for charging electronic devices, particularly mobile phones, in such challenging scenarios.

The solar power bank harnesses the abundant energy of the sun through photovoltaic cells, converting solar radiation into electrical power. This renewable energy source provides an independent and environmentally friendly solution, mitigating reliance on finite fossil fuels and reducing carbon emissions. The circuit design is meticulously crafted to optimize efficiency, ensuring maximum energy conversion and storage capacity.

A key feature of the solar power bank circuit is its versatility and ease of use. Utilizing readily available components and a USB connector interface, the system can efficiently charge a variety of electronic gadgets, including smartphones, tablets, and portable music players. Furthermore, the integration of a 1 Watt white LED enables the power bank to serve as a portable lighting solution, enhancing its utility during nighttime or low-light conditions.

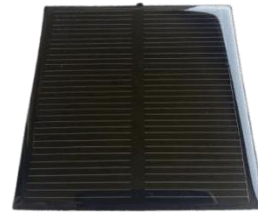
The project emphasizes practicality and accessibility, with an emphasis on simplicity in construction and operation. By employing common breakout boards and components, the solar power bank circuit can be assembled with minimal technical expertise, making it accessible to a wide range of users, including individuals in remote areas or those facing emergency situations.

In addition to its immediate application in disaster relief efforts and off-grid environments, the solar power bank offers long-term benefits in terms of sustainability and resilience. Its ability to operate autonomously, without reliance on external power sources, ensures continued functionality during extended power outages or disruptions to infrastructure. Moreover, the durability and robustness of the device make it well-suited for deployment in harsh or unpredictable conditions.

Overall, the solar power bank circuit represents a practical and scalable solution to address the challenges of accessing reliable power in challenging environments. By harnessing renewable energy and leveraging innovative design principles, this project contributes to enhancing resilience, preparedness, and sustainability in the face of evolving energy needs and environmental pressures.

Requirements -

1. Solar Panel



2. Toggle Switch



3. USB Boost Converter



4. DC-DC Boost Converter



5. LEDs



6. Lithium Ion Battery



7. Li-ion Battery Charger (TP4056)



Circuit Diagram:

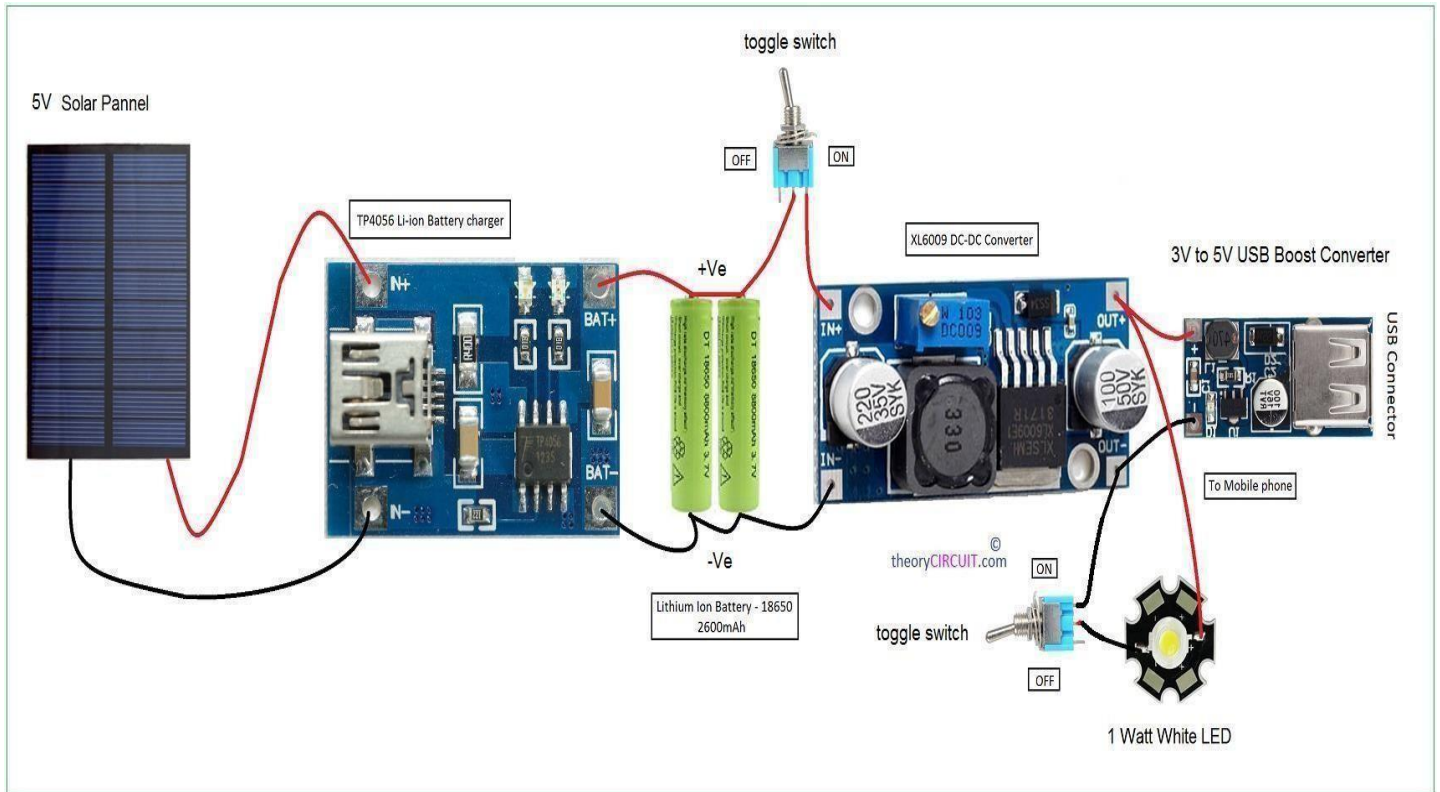


Fig 1

Solar Power Bank Circuit

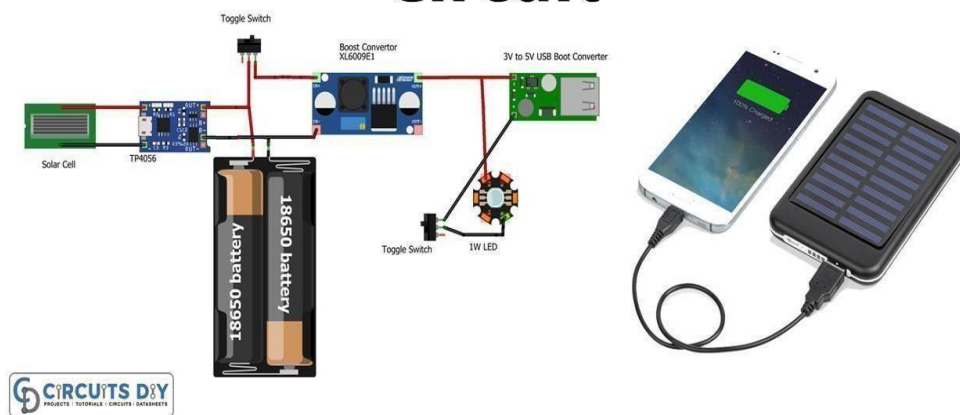


Fig 2

- **USB Boost Converter :**

A USB boost converter is a specialized DC-DC converter designed to elevate a lower input voltage, typically around 3V, to a higher output voltage, usually 5V, suitable for powering USB devices. Comprising key components such as an inductor, capacitor, switch (often a MOSFET), and control circuitry, its operation revolves around energy storage, switching, and feedback mechanisms. When the switch is closed, current flows through the inductor, storing energy in its magnetic field. Upon opening the switch, the inductor's resistance to changes in current induces a voltage, augmenting the input voltage and elevating the output voltage. This boosted output, regulated by the control circuitry via a feedback loop, ensures a stable 5V output. Efficiency is optimized to minimize energy losses, although some heat dissipation is inevitable, necessitating thermal management measures. Ultimately, the USB boost converter serves as a crucial intermediary, enabling USB-compatible devices to draw power from lower voltage sources like batteries or solar panels, facilitating their operation and charging. The USB boost converter plays a pivotal role in bridging the gap between different voltage requirements in electronic systems, facilitating the seamless operation of USB-powered devices. Its compact and efficient design makes it an integral component in various applications, ranging from portable electronics to renewable energy systems. By efficiently converting lower input voltages to the standardized 5V output required by USB devices, the boost converter enables the widespread adoption of USB connectivity in a myriad of devices, enhancing connectivity and interoperability. Furthermore, advancements in semiconductor technology have led to the development of highly integrated and cost-effective boost converter ICs, further driving the proliferation of USB-powered devices in the consumer electronics market. With the growing demand for energy-efficient and portable electronic solutions, the USB boost converter continues to play a crucial role in enabling innovation and powering the next generation of electronic devices and systems.

- **DC-DC Boost Converter :**

The XL6009 is a high-performance DC-DC boost converter integrated circuit capable of increasing input voltages to higher levels. It operates efficiently, making it ideal for various applications requiring voltage step-up, such as powering LED lighting systems, USB chargers, or portable electronic devices. The XL6009 employs a fixed-frequency, pulse-width modulation (PWM) control scheme to regulate output voltage. Its key components include an internal power switch, inductor, diode, and feedback network, all integrated into a single package. When the input voltage is applied, the internal switch rapidly switches on and off, controlling the flow of current through the inductor. During the on-state, energy is stored in the inductor's magnetic field, and during the off-state, this energy is transferred to the output. The output voltage is regulated by adjusting the duty cycle of the internal switch based on feedback from the output voltage.

This allows the XL6009 to provide a stable output voltage even when input voltage and load conditions vary. With its simplicity, efficiency, and versatility, the XL6009 is widely used in various electronic designs requiring voltage boosting capabilities. A DC-DC boost converter is an essential component in modern electronics, providing a versatile solution for increasing voltage levels efficiently. It operates by converting a lower input voltage to a higher output voltage, making it invaluable in applications where a stable and elevated voltage is required. The boost converter consists of several key components, including an inductor, capacitor, diode, and switching element (typically a MOSFET). When the input voltage is applied, the switching element rapidly switches on and off, controlling the flow of current through the inductor. During the on-state, energy is stored in the inductor's magnetic field, and during the off-state, this energy is transferred to the output. By adjusting the duty cycle of the switching element, the boost converter regulates the output voltage to the desired level. This voltage regulation ensures a stable and reliable power supply for various electronic devices and systems. DC-DC boost converters find wide application in portable electronics, battery-powered devices, renewable energy systems, automotive electronics, and telecommunications equipment. Their compact size, high efficiency, and flexibility make them indispensable in modern electronics design, enabling the development of energy-efficient and compact electronic devices. With ongoing advancements in semiconductor technology, DC-DC boost converters continue to evolve, offering higher efficiency, lower cost, and improved performance for a wide range of applications.

• **Li-ion Battery Charger :**

The TP4056 is a widely used integrated circuit for charging lithium-ion (Li-ion) and lithium-polymer (LiPo) batteries, commonly found in portable electronic devices and power banks. Operating in a constant-current charging mode, it regulates the charging current to a preset value determined by an external resistor, ensuring safe and efficient charging. Once the battery voltage reaches a predefined threshold, typically around 4.2V for Li-ion batteries, the TP4056 terminates the charging process to prevent overcharging, providing built-in overcharge protection. Charge status indication is provided through an integrated LED or status pin, allowing users to monitor the charging process easily. The TP4056 also incorporates various protection features, including over-discharge protection and thermal shutdown, to safeguard the battery and charging circuitry. With compatibility with standard USB power sources and a compact, cost-effective design, the TP4056 offers a reliable and straightforward solution for charging Li-ion and LiPo batteries in a wide range of applications. The TP4056 stands out as a reliable and efficient solution for battery charging due to its user-friendly features and robust built-in protections. Its constant-current charging mode ensures optimal charging rates, extending battery lifespan and performance. Moreover, its ability to terminate charging once the battery reaches the predefined voltage threshold prevents overcharging, safeguarding the battery from potential damage or degradation.

Additionally, the TP4056's integrated LED or status pin provides convenient charge status indication, allowing users to easily monitor the charging process and battery level. Furthermore, the TP4056 incorporates various protection mechanisms, including over-discharge protection and thermal shutdown, enhancing safety and reliability during operation. Its compatibility with standard USB power sources makes it versatile and accessible for a wide range of applications, from consumer electronics to DIY projects and industrial applications. With its compact and cost-effective design, the TP4056 continues to be a preferred choice for charging Li- ion and LiPo batteries, offering dependable performance and peace of mind to users worldwide.

• **5V Solar Panel :**

A 5V solar panel is a photovoltaic module designed to generate electrical power from sunlight and output it at a voltage level of 5 volts. These solar panels typically consist of multiple solar cells connected in series to achieve the desired voltage output. When exposed to sunlight, each solar cell generates a small amount of electrical energy through the photovoltaic effect, where sunlight is converted into electricity. By connecting multiple cells in series, the voltages generated by each cell are added together, resulting in a higher total output voltage. The 5V output from the solar panel makes it compatible with a wide range of electronic devices and applications, such as charging USB devices, powering small electronic circuits, or providing backup power for low-voltage systems. Depending on the size and efficiency of the solar panel, its output voltage may vary slightly based on factors such as sunlight intensity, angle of incidence, and temperature. Overall, a 5V solar panel offers a convenient and environmentally friendly solution for harnessing solar energy to power various electronic devices and applications. A 5V solar panel, while primarily known for its compatibility with USB devices and small electronic circuits, offers additional benefits and applications. Its portability and ability to generate electricity from sunlight make it ideal for off-grid use in outdoor activities like camping or hiking. Furthermore, its integration into electronic systems provides a sustainable power source, reducing reliance on fossil fuels and minimizing environmental impact. With ongoing advancements in technology improving efficiency and durability, 5V solar panels continue to play a pivotal role in the transition towards renewable energy solutions. Additionally, their alignment with USB specifications simplifies the implementation of solar-powered charging solutions for smartphones and other gadgets, promoting convenience and sustainability in everyday life. Overall, the versatility and eco-friendliness of 5V solar panels contribute significantly to the advancement of renewable energy adoption and the reduction of carbon emissions.

• **Lithium Ion Battery :**

A lithium-ion battery, often abbreviated as Li-ion battery, is a rechargeable energy storage device widely used in portable electronics, electric vehicles, and renewable energy systems.

It operates based on the movement of lithium ions between positive and negative electrodes during charging and discharging cycles. The battery typically consists of a positive electrode (cathode), a negative electrode (anode), and an electrolyte solution that facilitates the ion flow. During charging, lithium ions move from the positive electrode to the negative electrode, where they are stored. Conversely, during discharging, the ions move back to the positive electrode, generating electrical energy that powers the connected device or system. Li-ion consumer electronics to DIY projects and industrial applications. With its compact and cost-effective design, the TP4056 continues to be a preferred choice for charging Li- ion and LiPo batteries, offering dependable performance and peace of mind to users worldwide.

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• **Toggle Switch :**

A toggle switch is a simple yet versatile electrical component commonly used to control the flow of electricity in electronic circuits. It consists of a lever or handle that can be moved back and forth between two positions, typically referred to as "on" and "off." When the toggle switch is in the "on" position, it completes the electrical circuit, allowing current to flow through the switch and power the connected device or circuitry. Conversely, when the toggle switch is in the "off" position, it breaks the

circuit, interrupting the flow of electricity and disconnecting the power supply. Toggle switches come in various configurations, including single-pole/single-throw (SPST), single-pole/double-throw (SPDT), and double-pole/double-throw (DPDT), offering different switching options and capabilities. They are commonly used in electronic devices, appliances, automotive applications, and industrial control systems to provide convenient manual control over power and operation. With their simple operation, reliability, and durability, toggle switches remain a popular choice for a wide range of electrical switching applications.

- **LEDs :**

Light Emitting Diodes (LEDs) are semiconductor devices that emit light when an electric current passes through them. They have become ubiquitous in various applications, from indicator lights on electronic devices to lighting in homes, offices, and outdoor spaces. LEDs offer numerous advantages over traditional light sources, including incandescent and fluorescent bulbs. They are highly energy-efficient, converting a higher percentage of electricity into light compared to other types of lighting, which helps reduce energy consumption and lowers electricity bills. LEDs also have a longer lifespan, typically lasting tens of thousands of hours, which reduces the frequency of replacement and maintenance costs. Furthermore, LEDs are available in a wide range of colors and can produce vibrant, saturated hues without the need for filters or color gels. They also offer instant-on capability, reaching full brightness immediately upon powering on, unlike some other types of lighting that require warm-up time. With advancements in technology, LEDs continue to improve in efficiency, brightness, and color quality, making them an increasingly popular choice for both residential and commercial lighting applications.

Explanation:

The power bank circuit begins with a 5V, 500mA solar panel, which captures solar energy. This energy then flows through a Li-Ion battery charger breakout board (TP4056), regulating the charging process for two lithium-ion batteries (18650). The XL6009 DC-DC boost converter steps up the battery voltage for efficient device charging. Connected to the converter's output is a 1 Watt white LED, controlled by a toggle switch for illumination purposes. Finally, a USB boost converter breakout board transforms the voltage to a standard 5V USB output. This output stage enables the charging of mobile phones and gadgets through a USB to micro-B cable. With the toggle switch engaged, the power bank stands ready to charge devices, providing a reliable source of power derived from solar energy.

The 5V, 500mA solar panel serves as the primary input source, converting sunlight into electrical energy through photovoltaic cells. Its efficiency and output capacity directly impact the charging performance of the power bank.

The TP4056 Li-Ion battery charger breakout board is responsible for managing the charging process of the lithium-ion batteries (18650). It regulates the charging current and voltage to prevent overcharging and ensure the batteries are charged safely and efficiently.

The lithium-ion batteries (18650) act as energy storage units, storing the electrical energy generated by the solar panel. Their capacity and voltage determine the overall energy storage capacity and output of the power bank, influencing its usability and reliability.

The XL6009 DC-DC boost converter plays a crucial role in the power bank circuit by stepping up the battery voltage to a level suitable for charging electronic devices. Its efficiency and stability are essential for maintaining a consistent output voltage, ensuring reliable charging performance for connected devices.

The 1 Watt white LED serves as a versatile feature of the power bank, providing illumination when needed. Controlled by a toggle switch, the LED enhances the usability of the power bank, particularly in low-light conditions or emergencies, adding an element of safety and convenience.

The USB boost converter breakout board transforms the boosted voltage from the XL6009 converter into a standard 5V USB output. This enables the charging of a wide range of electronic devices, including smartphones, tablets, and portable music players, making the power bank highly versatile and compatible with modern gadgets.

Additionally, the inclusion of a toggle switch allows users to control the LED illumination independently from device charging, providing flexibility and conserving battery power when illumination is not required.

Overall, each component in the power bank circuit contributes to its functionality, reliability, and versatility, ensuring efficient energy conversion and reliable device charging capabilities, even in remote or off-grid environments.

Working Mechanism:

The power bank circuit operates as a sophisticated energy management system, leveraging the natural abundance of solar energy to provide a reliable source of power for charging electronic devices. At its core lies the solar panel, a photovoltaic array designed to capture sunlight and convert it into electrical energy through a process of photon absorption and electron excitation.

Upon exposure to sunlight, the solar panel initiates a photovoltaic reaction, generating a voltage potential that is directed into the TP4056 Li-Ion battery charger board. This critical component serves as the gateway for energy transfer, regulating the flow of electricity into the lithium-ion batteries connected in parallel.

Lithium-ion batteries are chosen for their high energy density and rechargeable properties, making them ideal for energy storage applications. The TP4056 charger employs a sophisticated charging algorithm, consisting of two distinct stages: constant current (CC) and constant voltage (CV). During the CC stage, the charger supplies a consistent current to the batteries while gradually increasing the voltage until it reaches the predetermined maximum limit. Subsequently, in the CV stage, the charger maintains a constant voltage equal to the maximum limit, allowing the charging current to taper off gradually until it reaches a predefined threshold.

The TP4056 module's integrated PMOS load switch architecture simplifies the circuit design, reducing the need for additional components while enhancing reliability and efficiency. Indicators such as the red LED (L1) signify the ongoing charging process, providing visual feedback to the user. Once charging is complete, the blue LED (L2) illuminates, indicating that the batteries are fully charged and ready for use.

Following the charging process, the XL6009 DC-DC boost converter assumes the role of voltage regulation, stepping up the battery voltage to a higher level suitable for powering electronic devices. This versatile component can convert voltages ranging from 3V to 32V to a desired output voltage, making it highly adaptable to various applications. Connected through a toggle switch, the XL6009 breakout board facilitates the distribution of power to different components of the power bank.

At the output stage of the XL6009 converter, a 1-watt white LED and a 3V to 5V USB boost converter are connected, offering additional functionalities to the power bank. The LED provides illumination, serving as a versatile lighting solution for outdoor activities or emergency situations. Meanwhile, the USB boost converter delivers standard 5V output, enabling the charging of a wide range of electronic devices such as smartphones, tablets, and portable music players. Throughout the operation of the

power bank circuit, careful attention is paid to polarity, output voltage, and current levels at each breakout board. By integrating advanced components and employing a systematic approach to energy management, the power bank circuit exemplifies the potential of renewable energy sources to provide sustainable solutions for power generation.

Future scope:

1. **Enhanced Energy Storage:** Investigating advanced battery technologies or increasing the capacity of lithium-ion batteries can significantly extend the runtime and usability of the power bank. Exploring alternative battery chemistries with higher energy densities or incorporating innovative energy storage solutions, such as supercapacitors, could provide increased energy storage capacity and faster charging times.
2. **Efficiency Optimization:** Continuous research and development efforts can focus on enhancing the efficiency of individual components within the power bank circuit. This includes improving the efficiency of the solar panel through advancements in photovoltaic materials or optimizing the charging algorithm of the TP4056 charger to minimize energy losses during the charging process.
3. **Smart Charging Algorithms:** Implementing intelligent charging algorithms based on real-time environmental conditions and user usage patterns can optimize energy harvesting and distribution. Machine learning algorithms or sensor-based systems can dynamically adjust charging parameters to maximize energy capture from the solar panel and extend battery life.
4. **Integration of Energy Management Systems:** Incorporating sophisticated energy management systems can enhance the overall reliability and performance of the power bank circuit. This includes integrating features such as battery monitoring, temperature regulation, and overcharge protection to ensure safe and efficient operation under varying environmental conditions.
5. **Modular Design for Scalability:** Designing the power bank circuit with a modular architecture enables scalability and customization to meet diverse user requirements. Modular components can be easily replaced or upgraded, allowing users to adapt the power bank for specific applications or to accommodate advancements in technology.

6. **Integration of Renewable Energy Sources:** Expanding the power bank's capabilities to harness other renewable energy sources, such as wind or hydroelectric power, can further enhance its versatility and resilience. Hybrid energy systems that combine solar, wind, and other renewable sources offer a more reliable and consistent power supply, especially in regions with variable weather conditions.
7. **Commercialization and Mass Production:** Transitioning the power bank circuit from a prototype to a commercial product involves rigorous testing, optimization, and mass production. Collaborating with manufacturers and industry partners can facilitate the scale-up process, ensuring cost-effective production and widespread availability of the power bank circuit to end users.



Fig 3



Fig 4



Fig 5