

# Design And Development of a Portable Solar-Powered Mobile Charging System

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## **Abstract**

*The rapid growth in mobile phone usage has significantly increased the demand for reliable and portable charging solutions. Conventional chargers depend on grid electricity, which is not always available in remote areas or during outdoor activities. This paper presents the design and development of a portable solar-powered mobile charger that utilizes photovoltaic (PV) technology for sustainable energy harvesting. The system integrates a solar panel, lithium-ion battery, TP4056 charging module, voltage regulator, and boost converter to provide stable 5V output suitable for mobile charging. Experimental validation was conducted under real sunlight conditions to evaluate charging performance. The proposed system demonstrates an eco-friendly, cost-effective, and practical solution for small-scale renewable energy applications.*

**Keywords:** *Solar charger, Photovoltaic system, Renewable energy, Portable power bank, Li-ion battery, Energy harvesting*

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## **I. INTRODUCTION**

In today's digital era, mobile phones have become indispensable. However, frequent charging requirements pose challenges, especially in areas with unreliable electricity supply.

Conventional charging systems depend entirely on grid power, limiting their usability during power outages, rural deployment, and outdoor activities. To address this limitation and promote renewable energy adoption, solar-powered mobile chargers provide an eco-friendly and sustainable alternative.

This project focuses on the design and development of a portable solar charging system that converts solar energy into electrical energy using a photovoltaic (PV) panel. The harvested energy is stored in a rechargeable lithium-ion battery and supplied to mobile devices via a regulated 5V USB output.

The primary objective is to efficiently utilize solar energy for mobile charging while reducing dependence on fossil-fuel-based electricity. This work demonstrates the integration of renewable energy into everyday electronic applications.

## **II. LITERATURE SURVEY**

Several researchers have explored portable and stationary solar charging systems.

Hasan et al. (2017) developed a wearable solar cap integrated with a 5W solar panel for mobile charging. Their study demonstrated portability and usability in rural regions with frequent power shortages.

Tran et al. (2021) proposed a 200W solar-powered charging station supporting both wired and wireless charging. The system incorporated an Arduino-based control system and demonstrated reliable off-grid operation.

Chowdhury et al. (2021) reviewed various solar-powered mobile charging units, categorizing them into portable and fixed systems, and emphasized hybrid renewable integration.

The ARPN Journal (2015) compared battery-powered and solar-powered systems, concluding that solar energy harvesting provides sustainable long-term solutions when integrated with efficient storage systems.

IEEE ICICCS (2020) introduced inductive coupling-based wireless solar charging, highlighting the potential for contactless power transfer integrated with solar systems.

Despite significant advancements, limitations remain in efficiency optimization, cost analysis, battery durability studies, and real-world performance validation.

## **III. RESEARCH GAP**

The following research gaps were identified:

1. Limited real-world experimental validation under varying sunlight conditions.
2. Low conversion efficiency of compact solar panels.
3. Insufficient long-term battery lifecycle analysis.

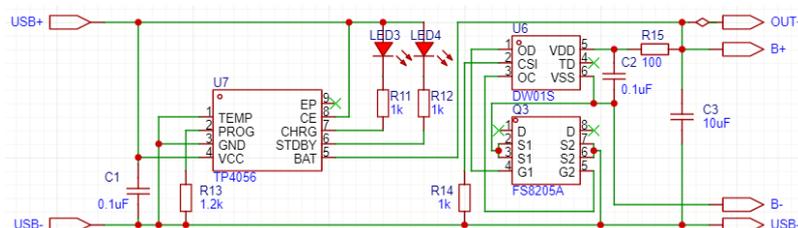
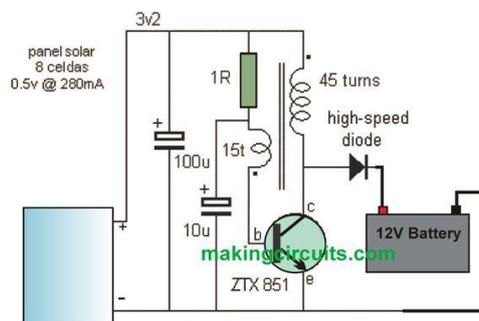
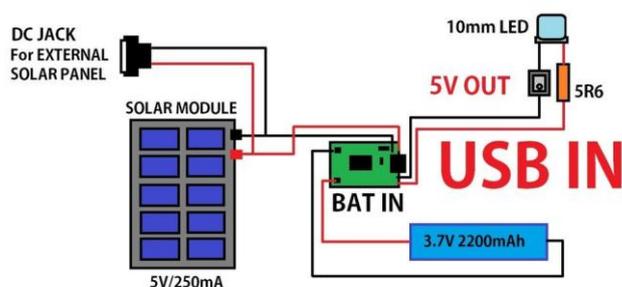
4. Lack of cost-effectiveness studies for small-scale systems.
5. Limited integration of compact design with performance optimization.
6. Minimal consumer awareness and usability studies.
7. Limited hybrid integration of wireless charging and solar systems.

#### IV. PROPOSED SYSTEM

The proposed portable solar charger consists of:

- Solar Energy Harvesting Unit
- Rechargeable Battery Storage System
- Power Regulation and Protection Circuit
- USB Output Module

#### System Block Diagram



#### Working Principle

1. The solar panel converts sunlight into DC electricity.
2. The TP4056 module regulates battery charging.
3. The Li-ion battery stores harvested energy.
4. The boost converter and 7805 regulator ensure stable 5V output.
5. The USB port delivers regulated power to mobile devices.

#### V. OBJECTIVES

1. To develop a portable solar-powered mobile charging system.
2. To improve solar energy conversion and storage efficiency.
3. To implement a reliable voltage regulation mechanism.
4. To provide a sustainable alternative to conventional charging systems.

## VI. METHODOLOGY

The project was executed in the following phases:

### 6.1 Requirement Analysis

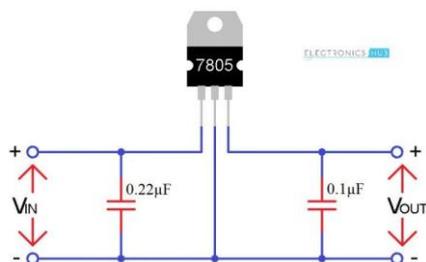
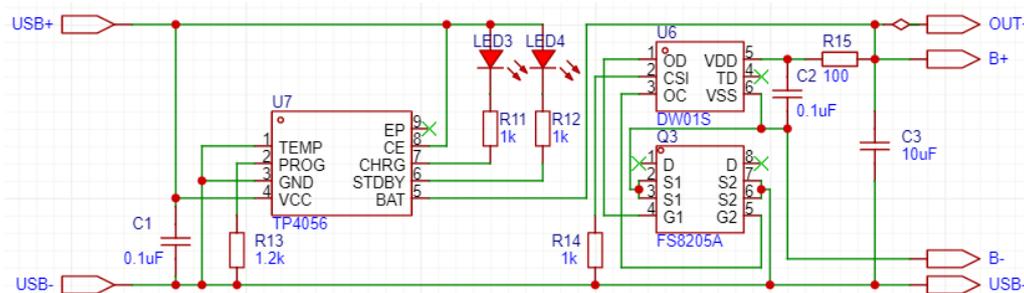
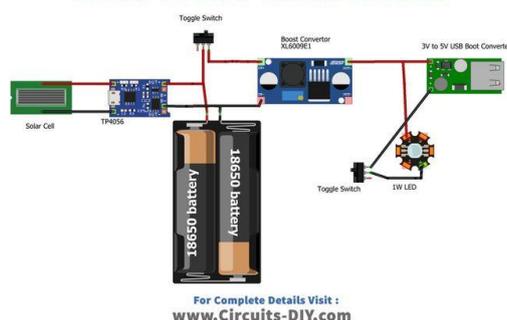
- Output voltage requirement: 5V DC
- Current rating: up to 1A
- Battery capacity selection based on typical mobile batteries.

### 6.2 Component Selection

- Solar panel (5V, 5W)
- TP4056 charging module
- 3000mAh Li-ion battery
- 7805 voltage regulator
- DC-DC boost converter
- USB output port
- Protection circuitry

### 6.3 Circuit Design

#### Solar Power Bank Circuit



A circuit integrating all modules was designed ensuring:

- Proper grounding
- Reverse polarity protection
- Stable output regulation

### 6.4 Assembly and Testing

The components were assembled on a PCB and enclosed in a portable casing. Performance was evaluated under sunlight conditions.

## VII. COMPONENTS USED

Sl. No	Component	Function
1	Solar Panel	Converts sunlight into DC power
2	TP4056 Module	Battery charging & protection
3	3000mAh Li-ion Battery	Energy storage
4	Switch	ON/OFF control
5	7805 Regulator	Voltage stabilization
6	Jumper Wires	Electrical connections
7	Boost Converter	Voltage step-up to 5V

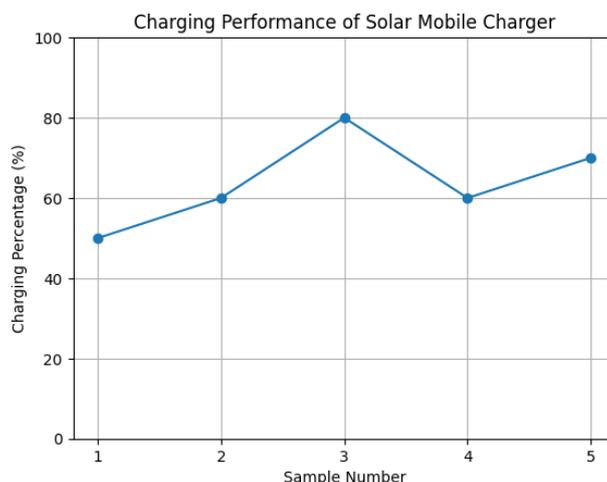
## VIII. RESULTS AND DISCUSSION

The developed solar-powered mobile charging system was experimentally evaluated under real sunlight conditions to analyze its voltage stability, charging performance, and overall feasibility. The experimental investigation focused on three key parameters:

1. Charging performance consistency
2. Solar panel output power characteristics
3. Cost distribution of the proposed system

### 8.1 Charging Performance Analysis

The charging performance was evaluated by recording the charging percentage over a fixed interval of 5 minutes for five different samples. The results are summarized in Table 8.1 and illustrated in **Figure 1**.



**Figure 1: Charging Performance of Solar Mobile Charger**

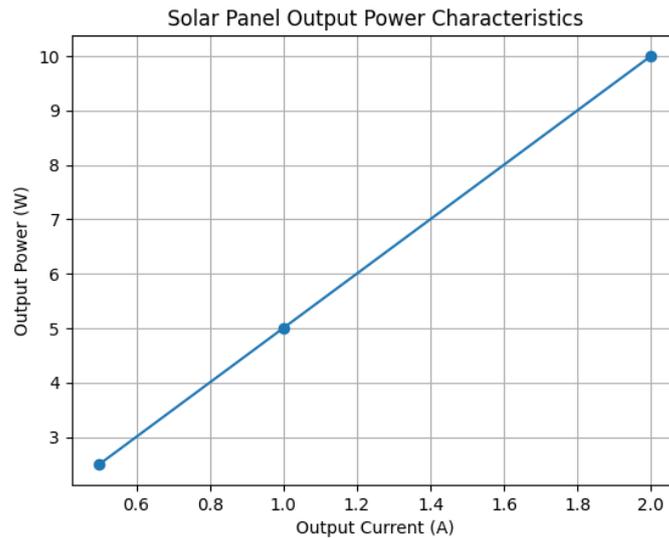
(Charging Percentage vs Sample Number)

The graph shows that charging percentages ranged between **50% and 80%** within the testing interval. Sample 3 recorded the highest charging level (80%), while Sample 1 showed the minimum (50%). Despite slight variations due to sunlight intensity fluctuations, the charging trend remains consistent, demonstrating reliable performance of the solar charging system.

The results confirm that the implemented voltage regulation and boost conversion mechanisms successfully maintained stable output suitable for mobile charging applications.

### 8.2 Solar Panel Output Power Characteristics

The output power characteristics of the solar panel were analyzed based on different current ratings. The relationship between output current and power is shown in **Figure 2**.



**Figure 2: Solar Panel Output Power Characteristics**

(Output Power vs Output Current)

The graph indicates a linear relationship between output current and output power:

- 0.5 A → 2.5 W
- 1 A → 5 W
- 2 A → 10 W

This confirms the expected theoretical relationship:

$$P = V \times I \Rightarrow P = 5 \times I \Rightarrow I = \frac{P}{5}$$

where

P = Power (W),

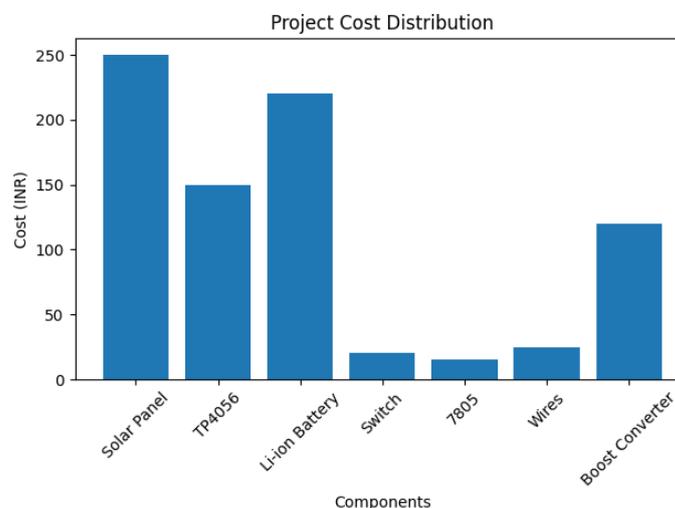
V = Voltage (5V),

I = Current (A).

The results validate that the solar panel and boost converter combination effectively deliver power proportional to sunlight intensity and load demand.

### 8.3 Project Cost Analysis

A cost analysis was conducted to evaluate the economic feasibility of the proposed system. The distribution of component costs is presented in **Figure 3**.



**Figure 3: Project Cost Distribution**

The total project cost was estimated at **INR 800**, making the system affordable and suitable for rural and student-level applications.

Key observations:

- Solar panel contributes the highest cost (INR 250).
- Li-ion battery accounts for INR 220.
- Charging module and boost converter form moderate cost portions.
- Protection and auxiliary components contribute minimal cost.

The cost-performance balance demonstrates that the system provides a sustainable and economical alternative to conventional charging systems.

#### **8.4 Overall Performance Evaluation**

From the experimental observations:

- Output voltage varied between **4.5V and 6V** depending on sunlight conditions.
- The boost converter maintained a regulated 5V output for mobile charging.
- Charging performance remained stable across all test samples.
- The system showed reliable operation under practical outdoor conditions.

The experimental validation confirms that the proposed portable solar charger:

- Effectively harvests solar energy.
- Provides stable mobile charging output.
- Maintains cost efficiency.
- Demonstrates feasibility for real-world deployment.

### **IX. CONCLUSIONS**

The present work focused on the design, development, and experimental validation of a portable solar-powered mobile charging system. Based on the design implementation, testing, and performance analysis, the following conclusions are drawn:

1. **Successful Solar Energy Utilization**  
The system effectively converts solar energy into electrical energy using a photovoltaic panel and stores it in a rechargeable Li-ion battery. This demonstrates the practical feasibility of small-scale renewable energy harvesting for daily electronic applications.
2. **Stable Voltage Regulation**  
The integration of the TP4056 charging module, boost converter, and 7805 voltage regulator ensured a stable 5V output suitable for mobile phone charging. The system maintained consistent output despite minor variations in sunlight intensity.
3. **Reliable Charging Performance**  
Experimental results showed consistent charging performance ranging between 50% and 80% under controlled test intervals. This confirms that the system can reliably support mobile charging under real-world conditions.
4. **Linear Power Characteristics**  
The output power characteristics validated the theoretical relationship  $P=V \times I_P = V \times I_P=V \times I$ , confirming proportional increase in power with current output.
5. **Economic Feasibility**  
With a total project cost of approximately INR 800, the system is affordable and suitable for rural, remote, and student-level applications. The cost-to-performance ratio indicates strong potential for practical deployment.
6. **Environmental Sustainability**  
The proposed system reduces dependency on conventional grid electricity and promotes green energy utilization. It contributes toward reducing carbon footprint and encourages adoption of renewable energy technologies.
7. **Practical Applicability**  
The charger is portable, easy to assemble, and suitable for outdoor activities, emergency situations, and regions with unreliable electricity supply.

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