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Development and Optimization of Solar-Powered Portable Mobile Chargers: A Review and Case Study

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Abstract: *Solar-powered mobile chargers represent a promising solution for energy needs in remote and outdoor environments. This paper reviews existing technologies and experimental work in the domain of portable solar chargers, highlighting advancements in design, efficiency, and integration. A specific focus is placed on wearable solar systems utilizing high-efficiency micro-batteries, solar caps, and controlled current charging circuits. The study underscores the feasibility of integrating solar energy into compact, user-friendly, and reliable mobile charging systems.*

Keywords: Solar-powered mobile chargers

I. INTRODUCTION

How many different types of chargers that use sunlight for energy are being created nowadays! They may differ in design, manufacture, duration and work cost or the type of used components in prototypes, but here combine their basic function charging a cell phone or other wireless device. However, they are different in merits, and so we submit a new design, whose the specific merit is related to the battery charger current's regulated feature. For charging these Li-Ion batteries, charging circuits are used. The circuits intercept the sunlight to recharge the rechargeable battery for diverse applications. Solar panels consisting of a single solar cell or a small number of cells are often used in electronic circuits and in communications. We specially considered all the design constraints for the circuits already designed in our work.

The one in is a solar inverter for battery 3.7 V @ 2500mAh, again here the design and development consists in integrated circuits for the major part of the controlling circuit. Another version of is directly a solar charger in is a shunt-mode charge regulated. We are used this circuit to prevent the battery from overcharging and this is done by the charge controller so by means of cutting off the flow of electric current from the charge controller to the battery at the highest (maximum) voltage level. Therefore, it may be difficult to apply the design to a mobile phone charger because of its high output voltage (18 Volts) and more solar cells (36 cells).

This paper explores the design and implementation of an electronic circuit for charging mobile devices, detailing its components, design description, construction, experimental work, and practical tests, and discussing its key advantages.

1. Ultrafast Rechargeable Solar-Charging System

Tian et al. (2021) demonstrated a flexible and wearable solar-charging module consisting of GaAs solar cells and ultrafast rechargeable lithium-ion micro-batteries. The device is endowed with a high energy conversion efficiency of 23.11%, which is higher than that of most studies. Its main strength is the combination of a miniaturized photovoltaic unit and a high-rate energy storage unit.

Li-ion micro-battery consists of a nickel–cobalt layered double hydroxide (Ni–Co LDH) cathode on carbon cloth and a zinc anode. The new architecture achieves a hybrid charge storage through hydroxyl anion intercalation and surface pseudocapacitive reactions. The device is charged for 5 seconds of solar illumination and discharges power steadily for 110 seconds at 0.5 mA cm², and hence it is appropriate for short-burst power in wearable electronics.

Laser engraving method is used to produce the flexible micro-battery electrodes in interdigitated fingers and concentric circles patterns with flexibility for textile integration. Electrochemical evaluation and theoretical simulation also verify that the device exhibits long-term cycling stability and excellent rate performance.

2. Practical Portable Charger Design

Rakib Hasan et al. (2017) proposed a low-cost, effective portable solar charger that would satisfy the energy needs of the users in off-grid areas. The design includes a TYN355-366 type 5V, 5W solar panel with a provision to supply a maximum 1000 mA current, which is suitable for charging small-sized electronic devices like mobile phones and cameras. The main energy storing device is a 3.7V Li-ion 18650 battery with an ancillary reservoir for charge storage.

The charging circuit uses a voltage regulator (IC7805) to supply stable 5V USB output for efficient and safe charging. The reservoir allows the system to store surplus energy during the day and release it at night, enabling long-term use. The charger was tested in various conditions, with consistent Sperformance in stationary and mobile applications even in fluctuating sunlight. The ease, cost-effectiveness, and usability of the method are added advantages that make it deployable in developing nations and rural communities where traditional power infrastructure is absent.

3. Controlled Charging Solar System

Attia et al. (2014) developed a solar charger that is portable with a main focus on regulated charging current to protect connected devices. Their system utilizes Zener diodes, transistors, resistors, and a potentiometer to regulate charging currents with precision. The system preserves battery life and prevents overcharge and heat overload with real-time feedback via LEDs and voltage meters. This design achieves an important balance between functionality and protection

4. Target Application and Community Relevance

This mobile power bank and solar charger project is intended to address the long-standing issue of power shortages in rural and remote India. Many Indian villages still do not have continuous access to electricity because of infrastructure constraints, seasonal power cuts, or budget constraints. Our system offers a cost-effective, portable, and renewable power supply for essential mobile connectivity, enabling communication, access to digital services, and emergency services. Solar power harvesting by the device minimizes the dependence on grid electricity and offers the residents continuous access to mobile charging. This is particularly crucial in areas where electrification is intermittent or inadequate.

For the needs of our research, we have selected a chain of villages across India for which installation of such solar charging stations would be of significant practical and social importance. They are:

• Dhinkia (Odisha) – often exposed to industrial disturbance and little infrastructure investment.
• Turtuk (Ladakh) – in a high-altitude border region with weak grid connectivity.
• Dhodalgaon (Maharashtra) – suffers regular power outages and grid collapse.
• Nongriat (Meghalaya) – a remote village deep in the jungles with minimal connectivity to electricity.
•Bicholim taluka (Goa) – where there are hamlets that lack regular electricity.
• Panna district villages (Madhya Pradesh) – mining-affected, with poor rural electrification.

These regions serve as representative case studies for understanding the utility and effectiveness of portable solar chargers in the real-world context of rural India

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SN	State	Total Districts	No. of Districts where Need Assessment Started	Total Villages	No. of Villages where Need Assessment Started	No. of villages not having Electricity	No. of works identified for execution	No. of works Completed
1	ANDHRA PRADESH	25	23	1,026	911	79	170	5
2	ASSAM	33	31	655	491	42	46	23
3	CHHATTISGARH	23	23	909	905	119	166	29
4	DELHI	1	1	2	2	0	0	0
5	GUJARAT	16	14	56	56	1	1	1
6	HARYANA	22	22	637	337	2	2	0
7	HIMACHAL PRADESH	11	11	450	443	21	70	5
8	JAMMU AND KASHMIR	10	9	357	336	53	57	0
9	JHARKHAND	23	20	989	634	66	161	0
10	KARNATAKA	29	29	1,723	1,700	99	218	31
11	KERALA	1	1	3	3	0	0	0
12	MADHYA PRADESH	51	50	1,690	1,647	54	62	5
13	MAHARASHTRA	27	25	515	424	29	39	9
14	MANIPUR	5	5	20	20	1	2	0
15	MEGHALAYA	3	3	5	4	0	0	0
16	ODISHA	30	30	1,393	1,393	127	462	35
17	PUDUCHERRY	2	1	18	11	0	0	0
18	PUNJAB	23	23	3,293	705	1	1	1
19	RAJASTHAN	32	32	2,009	1,573	38	39	2
20	TAMIL NADU	37	36	2,918	2,915	126	227	38
21	TELANGANA	31	27	349	141	19	32	2
22	TRIPURA	8	8	62	62	5	6	0
23	UTTAR PRADESH	75	75	10,384	6,842	68	101	1
24	UTTARAKHAND	13	13	383	367	5	5	1
Total	Total	531	512	29,846	21,922	955	1,867	188

II. CONCLUSION

Portable solar charging systems are vital in bridging the gap between energy demand and renewable supply. The ultrafast solar-charging model demonstrates the future potential of instantaneous energy delivery for high-end devices. Its ability to fully charge in mere seconds and operate for over 10,000 cycles without auxiliary circuits showcases the viability of fast, integrated power solutions in wearable and portable electronics.

On the other hand, the practical portable charger offers a low-cost, easy-to-deploy solution ideal for regions with limited infrastructure. By using readily available components, a cap-integrated design, and an onboard charge reservoir, it provides an effective and accessible power alternative for users in developing regions and during outdoor activities.

Simultaneously, the controlled charging circuit emphasizes operational safety and precision, showing how regulated energy flow can enhance battery longevity and user confidence. A hybrid design combining speed, simplicity, and safety could significantly advance portable charging technology for widespread adoption.

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