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Wireless Charging Case Solar Power Bank as an Alternative to Electricity Charging

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Abstract: The research paper presents the development of a solar power bank with a wireless charging case, a device to provides a portable and sustainable power solution. The primary objectives of the study are to enhance the power capacity of the solar battery, accurately calculate, and measure the input and output voltage of the power bank and determine the charging speed of the device. The device utilizes a solar panel, a battery, and wireless charging technology, making it particularly advantageous for outdoor enthusiasts such as hikers and bikers. By harnessing sunlight as its energy source, the solar power bank offers a convenient and eco-friendly alternative for powering electronic devices. The study contributes to the advancement of solar energy technologies and addresses the growing demand for portable and sustainable power solutions. The result of the study shows normal temperature charging which can be indicated as successful in an indicated hours of six (6) to eight (8) hours when the phone is fully charged. Recharging the power bank is estimated to reach four (4) to six (6) hours before being fully charged. Researchers recommend resizing the case of the power bank into a smaller version, increasing the milliampere of the batteries, and upgrading the transmitter of the wireless pad.

Keywords: Solar Power, Power Bank, Wireless Charging, Charging Case .

I. Introduction

In an era where portable electronic devices have become indispensable, the need for reliable and sustainable power sources has grown significantly. This research focuses on designing a solar power bank with a wireless charging case, offering a novel solution to address these concerns. By integrating solar energy harvesting technology and wireless charging capabilities, this innovative device aims to provide a sustainable and convenient charging experience for smartphones. The study's primary objective is to optimize the solar power bank's design, ensuring efficient capture and storage of solar energy. Through the integration of a solar panel into the power bank case, sunlight will be converted into electrical energy and stored in a rechargeable battery, reducing reliance on traditional power grids. Additionally, the wireless charging case feature eliminates the need for cables, allowing users to effortlessly charge their smartphones by attaching the solar power bank as a protective case. Smartphones, including Android and Iphone devices, are used frequently by millions of people to exchange text messages and emails, browse the internet, and make online purchases. (Meng et al.,2015). A modern smartphone charger that reduces battery capacity fading, which has typically gone unnoticed up until now. The battery is subjected to a high average state of charge as a result of the overly long overnight charging period, which hastens the aging process. As a result, postponing the charging appropriately is needed so that it is finished just before the phone is unplugged. Finding a solution that doesn't compromise usability and calculating the savings in terms of age mitigation accomplished are the two key obstacles to making this possible. In order to do this, a cutting-edge charging system that may be integrated into the firmware of the smartphone (Pröbstl et al.,2015). Smart phones must be operated at greater currents in order to use quick charging in fifth generation mobile phones. In proportion to the charging/discharging current, the charging time, heat generation, and capacity loss of a battery pack increase as resistance rises. A battery pack with low resistance is therefore crucial (Kim et al.,2021).

The state of charge of the battery can be expanded by up to 100% during the charging process. One of the charging habits is to leave the smartphone attached to the charger all night. Batteries that are already at 100% but are still attached to the charger will continue to receive an electric current. Even if the amount is small enough, this can also cause a reduction in battery life and durability (D S R Djuanda, et al., 2020). One of the key components of BMS, is the state of charge (SOC), which indicates how much charge is still in a battery. Long battery life and the avoidance of catastrophic battery failure are both influenced by accurate SOC measurement. Moreover, a reliable and accurate SOC estimation is crucial for effective EV operation (How et al.,2019). The battery must rest in the open circuit condition for at least four hours in order to obtain good readings; lead acid battery manufacturers advise 24 hours. The voltage-based SOC solution is therefore unworkable for a battery that is actively being used (Battery university,2022).

Performance metrics such as energy conversion efficiency, charging speed, and compatibility with various smartphone models will be evaluated to ensure practicality. This research has the potential to promote renewable energy adoption, enhance mobility, and contribute to a greener and more sustainable future in the field of portable electronics.

II. Materials And Methods

COIL

It is used in transmitters and receivers; it is used to transfer the energy from the battery directly to the phone.

***Figure 1**: Coil*

COPPER WIRE

Electricity can pass through wires. Using this can make the wireless charger work faster from the energy/power bank.

***Figure 2**: Copper Wire*

TRANSMITTER & RECIEVER

Consists of the coil that can make the phone charge wirelessly. It is attached inside the phone case and also the receiver located at the top of the device opposite the solar panel.

***Figure 3**: Transmitter & Reciever*

BATTERY

The battery in the Solar Powerbank serves a crucial role in storing the energy collected from the sun. Without the battery, the device would not be able to function. It efficiently stores all the gathered energy and enables its transfer to the phone or other devices for charging purposes.

***Figure 4**: Battery*

SOLAR

The Solar Powerbank utilizes a 150x86mm 5V Solar Panel to harness energy from the sun. This compact size allows for efficient energy capture while also ensuring a space-saving design that can easily fit inside the charging case. The harvested energy is then stored in the battery for later use, providing a convenient and portable power solution.

Figure 5*: Solar*

BATTERY HOLDER

The battery holder is responsible for keeping the batteries securely in place within the Solar Powerbank. To simplify the process and make it easier, the researchers connected each piece of the battery holder using

soldering. This ensures a strong and reliable connection between the batteries, making it convenient to assemble them into the device.

Figure 6*: Battery Holder*

POWERBANK CUIRCUIT BOARD

It is used in order to transfer power from the battery. The circuit board the researchers used were programmed circuit boards to transfer power from the battery to the transmitters.

Figure 7*: Powerbank Circuit Board*

VOLTAGE METER

It is used to test and measure the voltage of the Solar power bank with Wireless Charging Case.

Figure 8*: Voltage meter*

DC-DC BOOST MODULE

To increase voltages or convert energy, the researchers incorporated a USB-type boost module into the Solar Powerbank's design. This module is connected in a series, starting from the solar panel and passing through the battery. It enables efficient voltage boosting or energy conversion, ensuring optimal performance and effective utilization of the collected solar energy.

Figure 9: DC-DC Boost Module

SOLDERING TOOL

Helps to solder the wires in the circuit board. Every wire in the device were soldered by the researchers from the batteries, solar panel, and the circuit boards. By soldering each and every materials the device will function normally.

***Figure 10**: Soldering Tool*

SOLDERING LEAD

The soldering tool is utilized in the process, where the lead of the soldering material is melted by the tool's heat. As the lead melts, it creates a connection between the wires. After a short period, the melted lead solidifies and dries up, securely holding the wires in place. This soldering technique allows for precise placement of the wires, ensuring reliable and durable connections within the Solar Powerbank.

***Figure 11**: Soldering Lead*

PHONE CASE

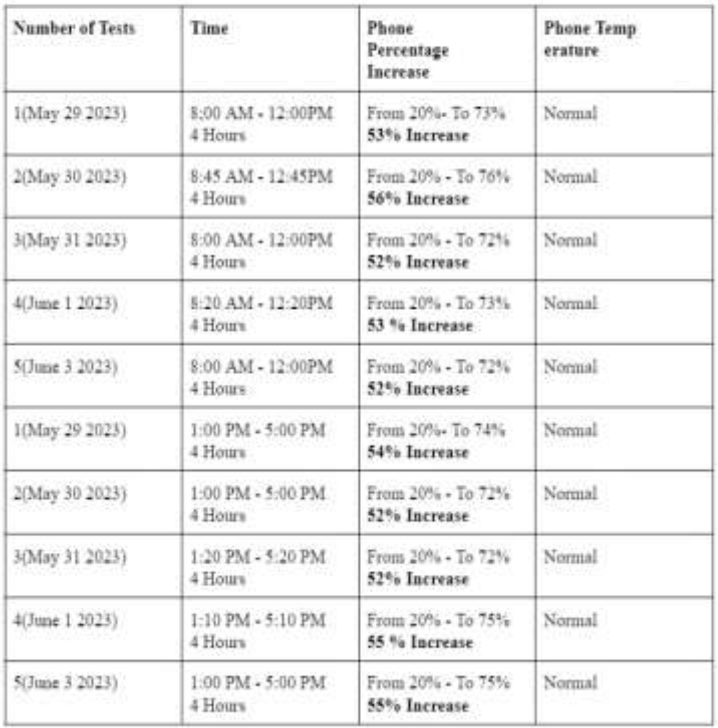
To finalize the device, a case is necessary, and the researchers opted for a 3D printing approach to create the casing. The case is printed using a type of plastic called polylactic acid (PLA), which ensures successful and accurate printing of the case. PLA is a commonly used material in 3D printing due to its ease of use, durability, and eco-friendliness. By utilizing 3D printing technology and PLA plastic, the researchers were able to achieve a custom-fit and functional case for the Solar Powerbank.

***Figure 12**: Phone Case*

III. RESULTS

Data Analysis Of The Solar Powerbank With Wireless Charging Case

Over several days, the researchers conducted tests on a device, each lasting 4 hours, split into morning and afternoon sessions. Starting at 20% battery, the first test showed no significant improvement, but the second test exhibited a notable 56% increase in performance. Subsequent tests continued the positive trend, with the 3rd, 4th, and 5th tests showing 52%, 53%, and 53% improvement, respectively. Despite the increasing performance, the phone's battery also improved during each test, ranging from a 52% to 55% increase. Throughout the series of tests, the device's performance steadily improved with significant percentage increases in most cases, while maintaining stable thermal levels. By the end of the tests, the phone's battery was at 74% to 75%.



Number of Tests	**Time**	**Phone Percentage Increase**	**Phone Temp erature**
1(May 29 2023)	8:00 AM - 12:00PM 4 Hours	From 20%- To 73% **53% Increase**	Normal
2(May 30 2023)	8:45 AM - 12:45PM 4 Hours	From 20% - To 76% **56% Increase**	Normal
3(May 31 2023)	8:00 AM - 12:00PM 4 Hours	From 20% - To 72% **52% Increase**	Normal
4(June 1 2023)	8:20 AM - 12:20PM 4 Hours	From 20% - To 73% **53 % Increase**	Normal
5(June 3 2023)	8:00 AM - 12:00PM 4 Hours	From 20% - To 72% **52% Increase**	Normal
1(May 29 2023)	1:00 PM - 5:00 PM 4 Hours	From 20%- To 74% **54% Increase**	Normal
2(May 30 2023)	1:00 PM - 5:00 PM 4 Hours	From 20% - To 72% **52% Increase**	Normal
3(May 31 2023)	1:20 PM - 5:20 PM 4 Hours	From 20% - To 72% **52% Increase**	Normal
4(June 1 2023)	1:10 PM - 5:10 PM 4 Hours	From 20% - To 75% **55 % Increase**	Normal
5(June 3 2023)	1:00 PM - 5:00 PM 4 Hours	From 20% - To 75% **55% Increase**	Normal

***Table 1**: Test for the Micro USB Solar Powerbank + Wireless Charging Case*

The table displays a series of tests conducted on an iPhone X, all lasting 4 hours. The first test, conducted on May 29, 2023, showed a 69% increase, followed by a 70% increase in the second test, a 71% increase in the third test, a 70% increase in the fourth test, and a 72% increase in the final test. From the data presented in the table, the researchers concluded that within a 4-hour duration, the phone's increase ranged from approximately 69% to 72%.

Number of Tests	Time	Phone Percentage Increase	Phone Temperature
1(May 29 2023)	8:00 AM - 12:00 PM 4 Hours	From 20%- To 89% **69% Increase**	Normal
2(May 30 2023)	8:45 AM - 12:45 PM 4 Hours	From 20% - To 90% **70% Increase**	Normal
3(May 31 2023)	8:00 AM - 12:00 PM 4 Hours	From 20% - To 91% **71% Increase**	Normal
4(June 1 2023)	8:20 AM - 12:20 PM 4 Hours	From 20% - To 90% **70 % Increase**	Normal
5(June 3 2023)	8:00 AM - 12:00 PM 4 Hours	From 20% - To 92% **72% Increase**	Normal
1(May 29 2023)	1:00 PM - 5:00 PM 4 Hours	From 20%- To 88% **68% Increase**	Normal
2(May 30 2023)	1:00 PM - 5:00 PM 4 Hours	From 20% - To 89% **69% Increase**	Normal
3(May 31 2023)	1:20 PM - 5:20 PM 4 Hours	From 20% - To 92% **72% Increase**	Normal
4(June 1 2023)	1:10 PM - 5:10 PM 4 Hours	From 20% - To 93% **73% Increase**	Normal
5(June 3 2023)	1:00 PM - 5:00 PM 4 Hours	From 20% - To 92% **72% Increase**	Normal

***Table 2**: Test for the IOS Solar Powerbank + Wireless Charging Case*

The table presents data on a series of tests conducted on the Type C Solar Powerbank with Wireless Charging Case. These tests took place in the morning and afternoon, each lasting 4 hours. In the morning tests, the percentage increase ranged from 58% to 62%, with an average of 60.2%. The phone's temperature remained consistent throughout these tests. In the afternoon tests, the increase ranged from 60% to 70%, with an average of 63.6% over the 4-hour duration. The phone's temperature also remained within normal levels during these tests.

***Table 3**: Test for the Type C Solar Powerbank + Wireless Charging Case*

Number of Tests	Time	Phone Percentage Increase	Phone Temperature
1(May 29 2023)	8:00 AM - 12:00 PM 4 Hours	From 20%- To 80% **60% Increase**	Normal
2(May 30 2023)	8:45 AM - 12:45 PM 4 Hours	From 20% - To 82% **62% Increase**	Normal
3(May 31 2023)	8:00 AM - 12:00 PM 4 Hours	From 20% - To 79% **59% Increase**	Normal
4(June 1 2023)	8:20 AM - 12:20 PM 4 Hours	From 20% - To 82% **62% Increase**	Normal
5(June 3 2023)	8:00 AM - 12:00 PM 4 Hours	From 20% - To 78% **58% Increase**	Normal
1(May 29 2023)	1:00 PM - 5:00 PM 4 Hours	From 20%- To 84% **64% Increase**	Normal
2(May 30 2023)	1:00 PM - 5:00 PM 4 Hours	From 20% - To 81% **70% Increase**	Normal
3(May 31 2023)	1:20 PM - 5:20 PM 4 Hours	From 20% - To 82% **62% Increase**	Normal
4(June 1 2023)	1:10 PM - 5:10 PM 4 Hours	From 20% - To 80% **60 % Increase**	Normal
5(June 3 2023)	1:00 PM - 5:00 PM 4 Hours	From 20% - To 82% **62% Increase**	Normal

DATA ANALYSIS OF THE SOLAR BATTERY POWERBANK

Number of Tests	Time	Battery Power Increase From - To
1(May 24 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 75% **75% Increase**
2(May 25 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 73% **73% Increase**
3(May 26 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 72% **72% Increase**
4(May 27 2023	8:00 AM - 11:00 AM 3 Hours	0% - 73% **73% Increase**
5(May 28 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 73% **73% Increase**
1(May 24 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 76% **76% Increase**
2(May 25 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 75% **75% Increase**
3(May 26 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 74% **74% Increase**
4(May 27 2023	12:00 PM - 3:00 PM 3 Hours	0% - 77% **77% Increase**
5(May 28 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 73% **73% Increase**

***Table 4**: Test for the Micro USB Battery Power Bank*

The researchers conducted a total of 5 tests in the morning on the Solar Battery Powerbank, each lasting 3 hours. The test results showed percentage increases ranging from 72% to 75%, with an overall average of 73.2% per 3 hours. Additionally, the researchers performed ten tests on the same device, each lasting three hours, with an average charging speed of around 2-3 minutes per percent. However, due to the non-constant charging speed, the percentage increase varied in each test, ranging from 69% to 72%. The average percentage increase in the first test was 70.2% over the three-hour duration.

Number of Tests	Time	Battery Power Increase From - To
1(May 24 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 76% **76% Increase**
2(May 25 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 77% **77% Increase**
3(May 26 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 75% **75% Increase**
4(May 27 2023	8:00 AM - 11:00 AM 3 Hours	0% - 74% **74% Increase**
5(May 28 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 75% **75% Increase**
1(May 24 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 74% **74% Increase**
2(May 25 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 74% **74% Increase**
3(May 26 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 72% **72% Increase**
4(May 27 2023	12:00 PM - 3:00 PM 3 Hours	0% - 73% **73% Increase**
5(May 28 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 71% **71% Increase**

***Table 5**: Test for the IOS Battery Power Bank*

The researchers conducted a total of 5 tests in the morning on the Solar Battery Powerbank for iOS, each lasting 3 hours. The test results showed percentage increases ranging from 74% to 77%, with an overall average of 75.4% over the 3-hour duration. Furthermore, the Solar Battery Powerbank for iOS underwent ten tests over the same 3-hour period, specifically during daylight

hours, to assess any potential variations in charging speed throughout the day. The average charging time was estimated to be around 2-3 minutes per percent. However, due to non-constant charging speeds, the percentage increase varied in each test, ranging from 72% to 74%. For example, the first and second tests showed a 74% increase, while the third test had a 72% increase. Therefore, the average percentage increase for the third test over the three-hour duration was 72.8%.

Number of Tests	Time	Battery Power Increase From - To
1(May 24 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 75% **75% Increase**
2(May 25 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 74% **74% Increase**
3(May 26 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 77% **77% Increase**
4(May 27 2023	8:00 AM - 11:00 AM 3 Hours	0% - 76% **76% Increase**
5(May 28 2023)	8:00 AM - 11:00 AM 3 Hours	0% - 76% **76% Increase**
1(May 24 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 79% **79% Increase**
2(May 25 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 76% **76% Increase**
3(May 26 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 77% **77% Increase**
4(May 27 2023	12:00 PM - 3:00 PM 3 Hours	0% - 76% **76% Increase**
5(May 28 2023)	12:00 PM - 3:00 PM 3 Hours	0% - 77% **77% Increase**

***Table 6**: Test for the Type C Battery Power Bank*

The Type C battery power bank underwent a series of ten tests over three hours. In the morning

tests, the percentage increases varied, with the first test showing a 75% increase and subsequent tests ranging from 74% to 77%. Although some tests had the same percentage increase, others differed. On average, the morning tests yielded a 75.6% increase over the three-hour charging period, with an estimated charging speed of 2-3 minutes per percent. In the afternoon tests, with the same three-hour duration, the percentage increases ranged from 76% to 79%, resulting in an average of 77% increase.

IV. Conclusion

Nowadays, many people carry power banks and other charging devices for their phones. However, it's often challenging to recharge these devices when you're out in public. To solve this problem, researchers have developed a study called the Solar Powerbank with Wireless Charging Case. This device only needs sunlight to transfer energy to its battery. It consists of a solar panel, a battery, and wireless technology. It's particularly useful for hikers, bikers, and those who spend a lot of time outdoors. The development of the Solar Powerbank with Wireless Charging Case has successfully addressed the objectives of increasing power capacity, measured input and output voltages, and determining the charging speed. The researchers believe that with the help of others and good mentors, their study can be improved and completed more quickly.

RECOMMENDATION

The researchers are not experts in the field of robotics and technology; conducting a study like this is hard. Here are some of the researchers' recommendations for the study.

i. To develop strategies and complete each stage of the construction process, conduct research. It would be very helpful to do some longer-term research that attempted to qualify the concepts and aid in the resolution of issues that emerged, despite the challenging methodological requirements.

ii. The charging speed of the device, we propose that the next researchers will improve the charging speed compared to the one the Researchers made. It will be amazing if the charging speed of the next version of this device is increased.

iii. The capacity of the battery, we suggest that using increased mAh of the battery is very useful and important. Currently the Researchers are using a 7200mAh battery, using the double of the current mAh in this device will increase people'sSD interest, and make sure that the battery itself is well balanced.

iv. Lastly the design itself, the casing, the casing is made of polylactid acid it is a type of plastic that has low heat resistance and may melt depending on the heat we suggest that using a high resistance plastic like polycarbonate (PC) or polyetherimide (PEI) can make the case better. And also the size, making this a lot smaller or more compact is very useful for its purpose but sadly the Researchers cannot make this smaller because it is designed for different phone sizes. Yes, it is possible to make this smaller for specific and different versions of smartphones.

REFERENCES

[1]. Anand, R., & Gupta, H. (2014). Unlocking the Wireless Smartphone Charging Potential. International Scientific Journal on Science Engineering & Technology, 17 (10), 935, 938.

[2]. Antony, R. G., Hariharan, S., Haran, D. H., & Raj, C. C. (2021, October). Design of Solar Charging Case for Mobile Phones. In Journal of Physics: Conference Series (Vol. 2040, No. 1, p. 012031). IOP Publishing.

[3]. Battery University. (2022, March 3). BU-903: How to Measure State-of-charge. https://batteryuniversity.com/article/bu-903-how-to-measure-state-of-charge

[4]. Bekaroo, G., & Seeam, A. (2016, August). Improving wireless charging energy efficiency of mobile phones: Analysis of key practices. In 2016 IEEE International Conference on Emerging Technologies and Innovative Business Practices for the Transformation of Societies (EmergiTech) (pp. 357-360). IEEE.

[5]. Berger, A., Agostinelli, M., Vesti, S., Oliver, J. Á., Cobos, J. A., & Huemer, M. (2015, March). Phase-shift and amplitude control for an active rectifier to maximize the efficiency and extracted power of a wireless power transfer system. In 2015 IEEE Applied Power Electronics Conference and Exposition (APEC) (pp. 1620-1624). IEEE.

[6]. Cao,P. (2021). Android Phones With Wireless Charging.

[7]. Clark,J(2022). How Solar Battery Charger Work?

[8]. Charishma Gopinath, J. T., & Sathe, S. (2022). Solar Powered Mobile Power Bank System.

[9]. Chen, N. (2016). Electromagnetic induction wireless power transmission efficiency research. Science and Technology Publications.

[10]. D S R Djuanda, et al. “Automatic Battery Charging System on Android Smartphones.” Iop Conference Series, IOP Publishing, Apr. 2020, doi:10.1088/1757-899x/830/3/032027

[11]. Gopinath, A., Daulayal, S., Kori, A., Vasudha Lakshmi, P. A., & Mudeeb, P. (2022, August). Analysis of solar and wind potential in e-mobility application. In AIP Conference Proceedings (Vol. 2461, No. 1, p. 020002). AIP Publishing LLC.

[12]. Gurung, A., Qiquan Qiao, Solar Charging Batteries: Advances, Challenges, and Opportunities, 2018

[13]. How, D. N., Hannan, M. A., Lipu, M. H., & Ker, P. J. (2019). State of charge estimation for lithium-ion batteries using model-based and data-driven methods: A review. Ieee Access, 7, 136116-136136.

[14]. Kim, G. Y., Park, S. R., & Yu, J. S. (2021). Design and characteristics of low- resistance lithium- ion battery pack and its fast charging method for smart phones. International Journal of Energy Research, 45(12), 17631-17646.

[15]. Kin, L. C., Liu, Z., Astakhov, O., Agbo, S. N., Tempel, H., Yu, S., ... & Merdzhanova, T. (2019). Efficient area matched converter aided solar charging of lithium ion batteries using high voltage perovskite solar cells. ACS Applied Energy Materials, 3(1), 431-439.

[16]. Kuka, C. S. (2021, September 12). Wireless Power Transfer. IntechOpen eBooks; IntechOpen.

[17]. Kumar, R. N., & Sai, T. G. (2017). Investigation on Wireless Charging. of the Paper.

[18]. Lu, X., Wang, P., Niyato, D., Kim, D. I., & Han, Z. (2015). Wireless charging technologies: Fundamentals, standards, and network applications. IEEE communications surveys & tutorials, 18(2), 1413-1452.

[19]. Mano, M., & Sankar, R. (2018). Wireless Charger Networking for Mobile Devices using Bluetooth Technologies. Methodology, 5(1).

[20]. Meng, W., Lee, W. H., Murali, S. R., & Krishnan, S. P. T. (2015, April). Charging me and I know your secrets! Towards juice filming attacks on smartphones. In Proceedings of the 1st ACM workshop on cyber-physical system security (pp. 89-98).

[21]. Nadeem, F., Nunez Garcia, A., Thach Tran, C., & Wu, M. (2021). Magnetic interference on cardiac implantable electronic devices from Apple iPhone MagSafe technology. Journal of the American Heart Association, 10(12), e020818.

[22]. Olvitz, L., Vinko, D., & Švedek, T. (2012, May). Wireless power transfer for mobile phone charging devices. In 2012 Proceedings of the 35th International Convention MIPRO (pp. 141-145). IEEE.

[23]. Pereira, R., Matalonga, H., Couto, M., Castor, F., Cabral, B., Carvalho, P., ... & Fernandes, J. P. (2021). GreenHub: a large-scale collaborative dataset to battery consumption analysis of android devices. Empirical Software Engineering, 26, 1-55.

[24]. Pröbstl, A., Kindt, P., Regnath, E., & Chakraborty, S. (2015, August). Smart2: Smart charging for smart phones. In 2015 IEEE 21st International Conference on Embedded and Real-Time Computing Systems and Applications (pp. 41-50). IEEE.

[25]. Purcher, J. (n.d.). Apple Invents a Wireless Power Transfer System with Unique Optimum Power Scheduling & more. Patently Apple.

[26]. Sanne, L. J., Sheldon, F., & Tran, C. (2018). Mobile Solar.

[27]. Shufian, A., Rahman, M. M., Ahmed, K., Islam, R., Hasan, M., & Islam, T. (2019, May). Design and implementation of solar power wireless battery charger. In 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT) (pp. 1-5). IEEE.

[28]. Sidiku, M. B., Eronu, E. M., & Ashigwuike, E. C. (2020). A review on wireless power transfer: Concepts, implementations, challenges, and mitigation scheme. Nigerian Journal of Technology, 39(4), 1206-1215. The Growing Importance of Wireless Energy Transmission. (2023). Technology.

[29]. Treffers, M. (2015). History, current status and future of the wireless power consortium and the qi interface specification. IEEE Circuits and Systems Magazine, 15(2), 28-31.

[30]. Van Wijk, A. J. M., van der Roest, E., & Boere, J. (2018). Solar power to the people. Ios Press.