Adaptable Speed Charging Dock for Electric Vehicles

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doi: https://doi.org/10.21467/proceedings.160.46

ABSTRACT

The depletion of fossil fuels and the environmental challenges they pose have created new obstacles in the search for alternative energy sources. The advancement of electric vehicle (EV) technology is possible to address these issues However, traditional method of EVs charging is not only time-consuming but also inconvenient. To address this problem, we propose wireless fast-charging system that employs two receiver coils, in contrast to the usual method that uses only one receiver coil. The addition of two receiver coils maximizes the charging power. Innovations like the Usage of the Super Capacitor, RFID tag, Smart Energy Manager, and Speed reduction using ultrasonic sensor are included in our proposed system. The super capacitor can deliver power quicker than the batteries thereby reducing the charging time of an electric vehicle. The RFID tags for an electric vehicle can record and view vehicles' real-time status and location. The smart chain energy manager can automatically direct energy to EVs as per the requirements during peak time.

Keywords: Electric vehicles, Super Capacitor, Smart energy manager.

1 Introduction

To address range anxiety in electric vehicles and cost reduction of on-board batteries, dynamic power transfer is a viable solution. However, the conventional method of charging EVs is often slow and time-consuming. To overcome this issue, we suggest a latest wireless fast-charging system for EVs that utilizes two receiver coils instead of the typical one receiver coil method. This approach can significantly reduce charging time and increase convenience. Compared to one receiver coils the usage of two receiver coils can increase the efficiency of the system. Because of the need for extensive charging hours, EVs are less efficient today. Electric vehicles (EVs) require fast charging to improve their performance and reduce charging time. To achieve this, a suggested solution is to incorporate a super capacitor with the EV. As the number of EVs are more, traditional fossil fuel-based charging networks are no longer efficient or cost-effective.

Charging electric vehicles (EVs) at a station that uses non-conventional sources has potential to lower carbon emissions and provide more control over the charging process. In the present situation, a charging station is being designed for EVs that uses solar power and a Battery Energy Storage System to store excess energy.

Solar energy is a renewable and freely available source of energy that is rapidly gaining popularity due to the continuous technological advancements in photovoltaic panels. As the efficiency of solar cells increases, their cost continues to decrease, making them a cost-effective solution for generating electricity. To leverage this technology, we propose the installation of solar panels on EV charging stations as an additional source of energy to charge EV batteries. By combining solar energy with EV charging, we can significantly reduce our reliance on fossil fuels and move towards a more sustainable future. Electricity is generated from several sources, and electric vehicles must be powered by renewables.

Electric vehicles are rapidly gaining popularity. To satisfy peak demand, a new system called Smart Energy Manager is being installed. The electric vehicle charging system employs a two-channel switch that draws

Proceedings DOI: 10.21467/proceedings.160; Series: AIJR Proceedings; ISSN: 2582-3922; ISBN: 978-81-965621-9-9

power from the grid based on the EV's requirements. With the help of sensors, the system can accurately estimate the demand for electricity. An ultrasonic sensor detect items within a particular range, and motor's speed is slowed when the object is detected. It emits high-frequency sound waves that bounce off things, then measures how long it takes for the sound waves to return. They don't even need to touch the object they are sensing, making them easy to use in all kinds of different applications from industrial automation to car safety systems. RFID is a type of technology used for wireless identification and data capture.

The technology involves using programmed electronics, such as tags, antennas, or coils, to store unique information, which can be read by a reader device and interpreted using specialized software. One convenient feature of RFID is that battery status can be monitored in real-time through mobile applications. Users are automatically notified when the battery is fully charged. The proposed system is straightforward, precise, and easy to set up. Future research should focus on analyzing and designing the system to further enhance its efficiency.

2 Literature Review

WPT systems for EVs are used to assure high-efficiency EV battery charging Discusses the comparison of energy performances of EV with one and two receiver coils. The performance of wireless power transfer can be evaluated by analyzing various external and internal factors such as the receiver's position and face. The emissions to both the air and the ocean surface are significant.

The majority of the emissions are highly polluting, and oil leaking from the vessel may produce a coating of oil on the water's surface. Smart car development necessitates the development of new sensors capable of measuring distances ranging from a few centimetres to a few metres [1]- [4].

Compared to traditional automobiles that require only a few minutes to refuel, electric vehicles using normal charging or fast charging methods usually take a longer time to charge [4]-[5]. Before 2012, batteries was storage system in EVs. The uneven loading of EVs, the battery's lifetime becomes less. By using batteries and super capacitors these problems can be overcomed [6]- [9] The utilization of supercapacitors (SCs) in electric vehicles (EVs) can help to bear the high-power demands and prolong the battery's lifespan.

Combining SC modules with the battery storage system in EVs can provide benefits such as improved vehicle acceleration and overall drive efficiency, resulting in increased driving range [5]. The advantage of SCs is their ability to release energy quickly, in less than 0.1 seconds [9], whereas batteries of the same size cannot provide the necessary energy in such a short amount of time. Additionally, SCs can sustain numerous charge/discharge cycles without losing quality [9]- [11].

Lithium-ion batteries used as a power source in mass-produced EVs, but thermal mode violation can cause capacitance decrease and resistance increase [12], [13]. Utilizing super capacitors can slow down battery degradation by excluding huge peak currents during starts, as mentioned in [14]. The use of super capacitors can help reduce the time and cost of charging electric vehicles, taking advantage of their properties. Charging systems for electric vehicles can be either conductive, which involves a wired connection and a large plug, or wireless, which eliminates the need for physical contact and provides safety and convenience for users. Wireless charging systems are also weatherproof and can Withstand harsh conditions [15], [16]. Figure 1 depicts a typical electric vehicle wireless charging setup [17]– [18].

Optimal magnetic coupling occurs when the Tx and Rx coils share the same centre, but misalignment can occur, leading to decreased system efficiency. In previous versions, a position detection mechanism was implemented to ensure that both coils are aligned for maximum efficiency. The implementation of this method is complex and requires additional circuits like a rectifier and a filter. Researchers proposed a coil-misalignment detection technique that uses a tunnelling magneto resistive (TMR) sensor. The brief periods of light exposure can result in the capture of current, which can be supplied to the battery via SC.

Proceedings DOI: 10.21467/proceedings.160
ISBN: 978-81-965621-9-9

Series: AIJR Proceedings
ISSN: 2582-3922

The use of IoT technology in charging stations can efficiently control charging, making the system user-friendly, with data being uploaded to the cloud and smartphones simultaneously. With IoT's help, monitoring car parking and charging automobiles simultaneously can be made simpler, which can aid in synchronised parking. Additionally, storing data on the cloud and accessing it from anywhere at any time is another advantage of using IoT.

3 Components

3.1 DSPIC30f2010 Microcontroller

The dsPIC30F2010 Controller Board is perfect for motor controller applications because to its small size and low cost. Calculations are performed using the powerful, high-performance Microchip dsPIC30F2010 microcontroller.

3.2 RFID reader & tag

RFID have a reader having one or more antennas and a tag. The reader device is equipped with one or more antennas that emit radio waves, which activate the RFID tag and receive signals from it. The tag, on the other hand, is attached to an object and transmits radio waves when it is activated by the reader's signal. When the tag sends a wave back to the antenna, the data is converted and can be interpreted by the reader device.

3.3 1F 5.5V Super capacitor

A supercapacitor, also known as an ultracapacitor, have more storage capacity than regular capacitors, but with a lower voltage limit. It absorbs and release energy faster, and they can withstand more charge and discharge cycles. They typically have an energy storage density that is 10 to 100 times greater than electrolytic capacitors. In this study, the characteristics of supercapacitors are utilized to reduce charging time.

3.4 12V & 1.3amps battery

A lithium-ion battery, rechargeable battery that operates by moving lithium ions between the electrodes during discharge and charging. The positive electrode of a Li-ion battery typically uses intercalated lithium compounds, while the negative electrode is usually made of graphite. Li-ion batteries have high energy density, which translates into a longer lifespan and lower cost per unit of energy stored. In this research, a 12V Li-ion battery is used for energy storage in both the charging station and electric car.

3.5 BLDC Motor

BLDC motors have a higher torque-to-weight ratio and this is important for EVs as it allows us to maintain the correct torque while making the car lighter. BLDC motors are thought to be more energy efficient than brushed DC motors. Because brushes have less friction, BLDC motors can convert more electrical power into mechanical power, making them more efficient than brushed motors.

3.6 IRF840 MOSFET

The IRF840 is an N-channel power MOSFET with a switching voltage of 500V. The mosfet can switch supplies up to 8A and can be powered by applying a gate voltage of 10V between the gate and source pins. Therefore, this MOSFET cannot be used in high switching applications.

3.7 Ultrasonic Sensor

It use high-frequency sound waves to estimate the distance between two objects. It travel at higher frequency than the sound that humans can hear. It have two primary components: the emitter, which produces sound using a piezoelectric crystal, and the receiver, that detects the sound.

3.8 SEPIC

SEPIC, a type of DC-DC converter that can increase, decrease, or maintain the same DC output voltage as the input. The polarity of input and output are same. This feature is often referred to as polarity preservation or polarity inversion.

3.9 FR207 DIODE

FR207 is a fast reverse axial lead rectifier diode. These diodes have high current capability, low forward voltage drop and reliability. Maximum reverse voltage: 1000V, forward current: 2A, maximum forward voltage 1.3V.

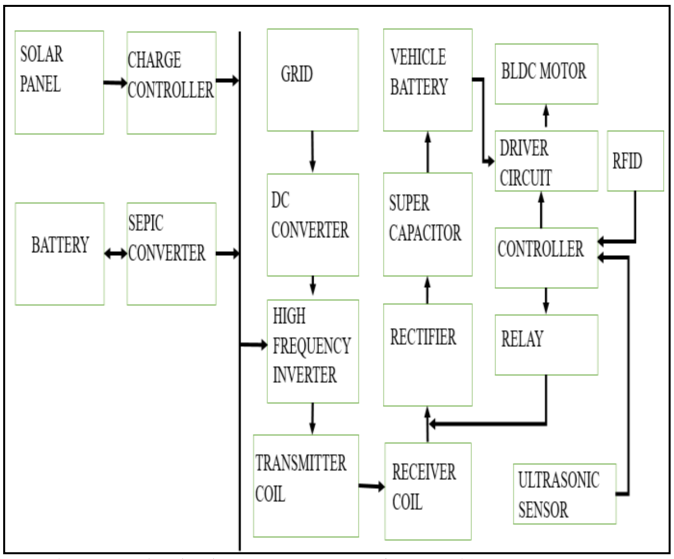
4 System Description

The proposed system aims to build a wireless power transmission system using solar energy harvesting to charge electric vehicles. The project has two sections as shown in figure 1. One is the solar-powered charging station and the other is the fast-charging circuit inside the EV. The station includesa 50W solar panel, a charge controller, a 12V battery, Single Ended Primary Inductor Converter, DC Converter, High-frequency Inverter, and Transmission Circuit. The EV consists of a receiver circuit, Microcontroller, Relay module, Rectifier, RFID reader, Ultrasonic Sensor, BLDC Motor, Driver Circuit, and Battery. The RFID reader recognizes the tag and activates the wireless charging circuit, then power is sent from the wireless charging circuit's receiving coil to the EV's battery. Ultrasonic sensors determine the distance between two objects. Super capacitors are used in the receiver circuit to speed up charging.
The system consists of the following components:

- Microcontroller (ESPIC30f2010)
- Solar panels
- Charge controller
- Battery 12V
- Relay module
- RFID reader and tag
- 1F 5.5V Super capacitor
- IRF840 MOSFET
- Ultrasonic Sensor
- SEPIC Converter
- BLDC Motor

In this case, the proposed system works in concert to optimise grid energy use. The solar-powered wireless charging station's side harvests solar electricity directly for the EV from a battery powered by solar panels. When solar energy cannot charge the battery, it will use the energy from the grid, thus reducing the additional load on the grid. Electricity from the grid and solar panels is converted and sent to the charging station, where it is used to charge the vehicle's battery. The super capacitor attached to the battery enables for faster charging by shortening the charging time. This is accomplished by utilising the fast-charging ability of SC, which charges with the slow charging of the battery, and this SC will slowly transport the stored energy to the battery, thereby reducing the time in the charging station without impacting the battery life. The RFID receiver in the charging station detects the vehicle through the RFID transmitter in the vehicle, then it checks the response of the infrared sensor to know whether the coils are in the correct position or not. Based on the payment status, charging is initiated by the microcontroller, and after the required charging, it is stopped by activating the relay.

Figure 1: *Block Diagram of EV and Charging Station*



Note. The Basic Principle on Which the System Works is Electro Magnetic Induction

The system is separated into two parts. The first section is the charging station shown in figure 2. The charging station has a 50 W solar panel connected to a controller that adjusts the supply from the solar panel to the load as needed. The finite primary inductor is connected to a DC-DC converter called a converter. Because it is a bidirectional converter, the converter's output flows to the battery connected to it and vice versa.

Since the charging station is dependent on two sources one is the renewable energy from the solar panel and the other is the grid supply. The supply from the grid is given to a DC converter whose output and the power from the solar panel is given to a high-frequency inverter.

The transmitter coil is in the charging station where electric current is exchanged. The essential operating concept of the system is Electromagnetic Induction, which allows current to pass via the receiver coil in the Electric Vehicle. The smart energy manager technology in the charging station is useful to meet the high demand. It works based on the queueing time. The queuing time activates the installed four sensors. When all four sensors are active, extra power can be taken from the grid using a bidirectional switch.

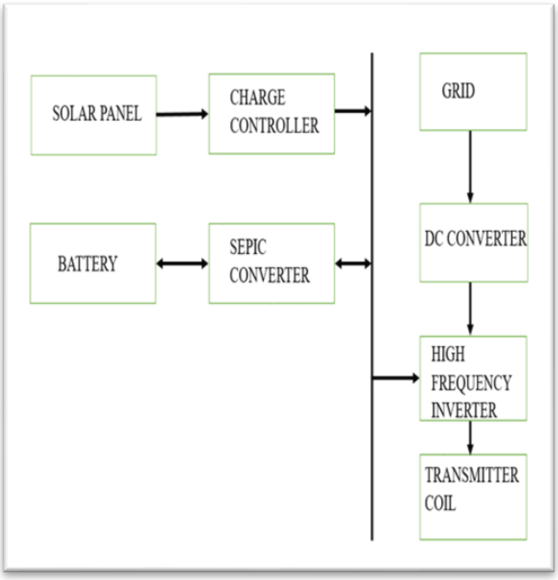


Figure 2: *Block diagram of Charging Station*

Note. Here the system consist of two power source one is from the grid and other is the solar panel.

The second section is Electric Vehicle, shown in figure 3. The current from the receiver coil is transferred to a rectifier, which from there is given to the EV battery. The EV consists of a Super Capacitor which can reduce the time taken to charge battery of the vehicle. Supercapacitors have a very high capacitance that allows them to charge and discharge faster than batteries and outlast and discharge more than rechargeable batteries.

In addition to advantage of reduced charging time due to the use of a super capacitor, an electric vehicle has numerous other advantages, such as it can prevent accidents by using ultrasonic sensors.

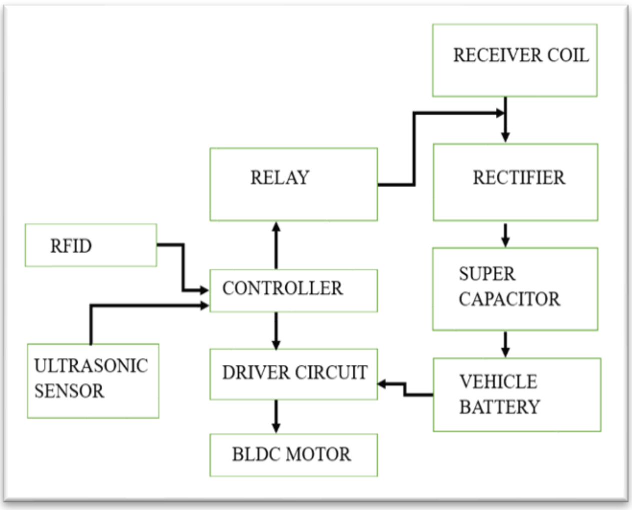


Figure 3: *Block diagram of Electric Vehicle*

Note. The electric vehicle consist of s receiver coil which comes in proximity to the transmitter coil kept in the charging station.

When the sensor detects the distance between the electric vehicle and the object, the driving circuit can start the engine by adjusting the speed of the engine. A brushless DC motor is used in the system. It has

Proceedings DOI: 10.21467/proceedings.160
ISBN: 978-81-965621-9-9

ISSN: 2582-3922

accurate speed control. Suitable for continuous or long-running duty cycles. It provides more power in a more efficient manner. The sensor is made of two have two parts transmitter and receiver. When the ultrasonic pulse from the transmitter travels through the air and collides with an obstacle in front of the electric vehicle, it bounces back to the receiver. The distance can be estimated by multiplying the travel time by the speed of sound. Here brushless DC motor is used to drive the vehicle. The electric vehicle has RFID which contains the details of each vehicle. It is connected to a microcontroller. The microcontroller used is the DSPIC30F2010. Which is connected to the relay. After validating the ID, the relay functions as a switch, allowing the receiver coil to transfer electricity to the rectifier, charging the electric car.

5 Circuit Diagram

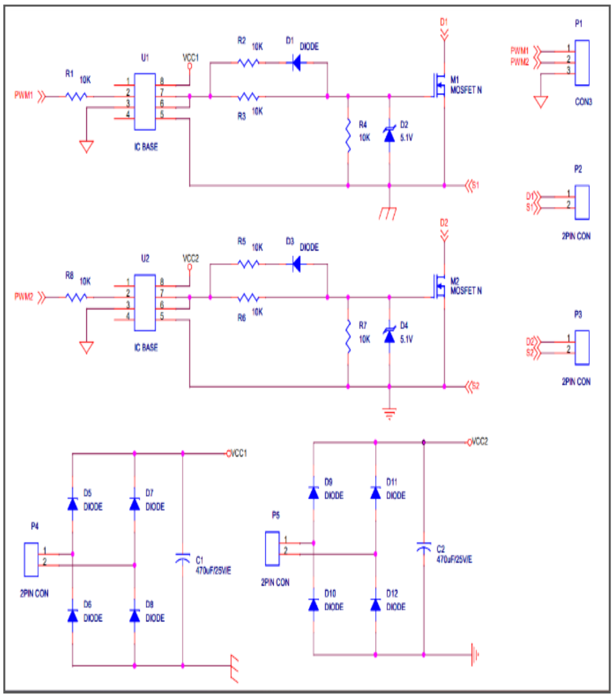


Figure 4: *Circuit Diagram of MOSFET and Rectifier*

Note. This the basic circuit diagram of a MOSFET and the rectifier

Figure 4 is the circuit diagram of the MOSFET and Rectifier. It is the basic circuit diagram. The diagram consists of different ground symbols like chassis ground which connects all the metal parts to the earth ground, signal ground which is attached to every signal being transmitted between devices in a system, and earth ground which provide a path for unwanted current.

6 Experimental Set Up

Figure 5: *Experimental set up of the proposed system*

Note. This is the prototype of the system.

Figure 5 is the prototype of the system. Which consist of the charging station and the electric vehicle.

7 Experimental Result

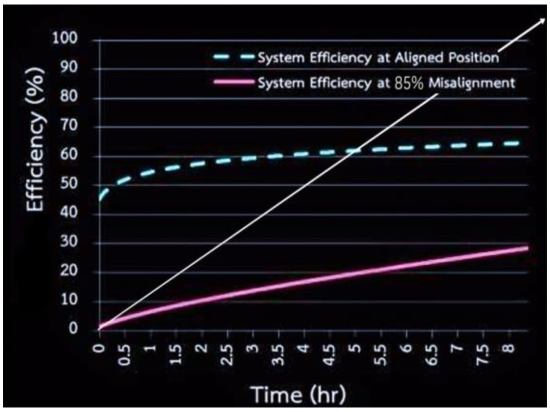


Figure 6: *System efficiency at aligned and 85% misalignment*

Note. The graph gives information regarding the efficiency of the system. When the two coils are not aligned in correct position the efficiency of the system decreases.

Table 1: *Voltage at receiver coil at aligned and misaligned state*

COMPONENT	CONDITION	OUTPUT
Receiver Coil	More aligned	12V
Receiver Coil	Very less aligned	3V

Note. This output reading implies the change in efficiency on variation in the position of the two aligned coils.

The efficiency of the system depends on the position of the transmitter and receiver coil which is clear from the data of figure 6 and table 1.

8 Conclusion

The globe is moving towards electric mobility to reduce pollutant emissions from non-renewable fossil-fuelled vehicles and to give an alternative to expensive transportation fuel because there are so many electric cars on the road, it's not cost effective or better for cars using conventional power lines. Therefore, renewable energy powered wireless charging stations have good capacity and control for EV charging. Also, unlike traditional wireless charging, wireless charging can achieve the best results by placing the wires in a fixed position and picking up the coils. That is, the system uses the principle of electromagnetic induction. Electromagnetic induction, often referred to as induction, is a process in which a conductor is placed somewhere and the magnet changes or the magnet remains stationary when the conductor moves. This causes an EMF (electromotive force) on the electrical equipment. EVs are inefficient now due to the high charging hour requirement. As a result, a fast charger is required for EVs to meet the increasing mileage demand and to shorten the time required to charge electric vehicles, resulting in superior performance than current EVs. Therefore, a super capacitor (SC) is used in conjunction with a Li-ion battery to achieve fast charging. Smart Energy Manager is used to control demand during peak hours. The peak hour denotes the most operations or passengers during the busiest hour on a typical day during a peak month. It is made up of a power MOSFET that is controlled by a driver circuit. The DSPIC30F2010 microcontroller was utilised. The MOSFET and Rectifier circuit diagram is shown in Figure 3. It is the fundamental circuit diagram.

9 Future Scope

This proposed system has many future scopes like protecting the vehicle from getting damaged. Automatic vehicle controlling. Protecting the vehicle from the hands of thieves. Safety precautions from issues like fire, waking up the driver if he is slept off while driving, etc. can also be incorporated. Renewable sources like windmills and other sources can be installed in the charging station. Thereby the demand can be met with zero power cost. By incorporating these new ideas the system can become more efficient, and environment friendly.

10 Publisher's Note

AIJR remains neutral with regard to jurisdictional claims in institutional affiliations.

How to Cite

Vasundharan *et al.* (2023). Adaptable Speed Charging Dock for Electric Vehicles. *AIJR Proceedings*, 351-360. https://doi.org/10.21467/proceedings.160.46

References

[1] Naoui Mohamed a, Flah Aymen a, Mohammed Alqarni b, Rania A. "A New Wireless Charging System for Electric Vehicles Using Two Receiver Coils", Volume 13, Issue 2, March 2022.

[2] The Effect of Coil Position and Number on the Performance of Wireless Systems for Electric Power, IEEE, 2021.

[3] Cheng, K.W.E., X.D.Xue and K.H. chan. "Development of zero emission electric ships." 2015 6th International Conference on Power Electronics Systems and Applications (PESA).IEEE, 2015

[4] K. T. Chau ve C. C.Chan, "Emerging Energy Saving Technologies for Hybrid Electric Vehicles", Proc. IEEE, Vol. 9 5, no. 4, pm 821–835, 2004, 2015, 2007.

[5] Alireza Khaligh, Zhihao Li, "Battery, Supercapacitor, Fuel Cell, and Hybrid Energy Storage Systems for Electric, Hybrid Electric, Fuel Cell, and Plug-In Hybrid EVs: State of the Art," IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 59, NO. 6, JULY 2010

[6] Phatiphat Thounthong, Viboon Chunkag, Panarit Sethaku, "Comparative Study of Fuel-Cell Vehicle Hybridization with Battery or Supercapacitor Storage Device," IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 58, NO. 8, OCTOBER 2009.

[7] Ying Wu, Hongwei GAO, "Optimization of Fuel Cell and Supercapacitor for Fuel-Cell EVs," IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 55, NO. 6, NOVEMBER 2006.

[8] M. Y. Ayad, M. Becherif, S. AitCheikh and M. Wack. "The use of Supercapacitors in EV: modeling, sizing and control," Vehicle Power and Propulsion Conference (VPPC), 2010 IEEE.

[9] A. F. Burke, "Prospects for Ultracapacitors in Electric and Hybrid Vehicles," 11th Annual Battery Conference on Applications and Advances, 1996.

[10] E. Ozatay, B. Zile, J. Anstrom, and S. Brennan., "Power distribution control coordinating ultra-capacitors and batteries for EVs," Proceedings of the American Control Conference, 2004.

[11] R. Karangia, M. Jadeja, C. Upadhyay and H. Chandwani, "Battery- supercapacitor hybrid energy storage system used in Electric Vehicle," 2013 International Conference on Energy Efficient Technologies for Sustainability, 2013, pp. 688-691, doi: 10.1109/ICEETS.2013.6533468.

[12] Bopche, LM, Deosant, AA, & Ahmad, M. "Combination of parallel connected supercapacitor & battery for enhancing battery life". 2016 International Conference on Automatic Control and Dynamic Optimization Techniques (ICACDOT), art. no. 7877555, p.77-82, 2016.

[13] Ling, Z., Zhang, Z., Shi, G., Fang, X., Wang, L., Gao, X., Fang, Y., Xu, T., Wang , S. & Liu, X. "Review on thermal management systems using phase change materials for electronic components, Li- ion batteries and photovoltaic modules". Renewable and Sustainable Energy Reviews, vol. 31, p.427-438, 2014.6

[14] Wang Q, Ping P, Zhao X, Chu G, Sun J, Chen C. Thermal runaway caused fire and explosion of lithium ion battery. J Power Sources 2012; 208: 210- 24.

[15] S. Habib, M. M. Khan, F. Abbas, L. Sang, M. U. Shahid, and H. Tang, "A comprehensive study of implemented international standards, technical challenges, impacts and prospects for electric vehicles," IEEE Access, vol. 6, pp. 13866-13890, 2018.

[16] A. Ahmad, M. S. Alam, and R. Chabaan, "A comprehensive review of wireless charging technologies for electric vehicles," IEEE Trans. Transport. Electrific, vol. 4, no. 1, pp. 38-63, Mar. 2018.

[17] A. Ramezani and M. Narimani, "Optimized Electric Vehicle Wireless Chargers With Reduced Output Voltage Sensitivity to Misalignment," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 8, no. 4, pp. 3569-3581, Dec. 2020.

[18] C. Shuwei, L. Chenglin, and W. Lifang, “Research on positioning technique of wireless power transfer system for electric vehicles,” 2014 IEEE Conference and Expo Transportation Electrification Asia-Pacific (ITEC Asia

Proceedings DOI: 10.21467/proceedings.160
ISBN: 978-81-965621-9-9

Series: AIJR Proceedings
ISSN: 2582-3922