Applied GIS

ISSN: 1832-5505

Vol-12 Issue-02 May 2024

TRANSFER POWER WIRELESSLY TO ELECTRIC VEHICLES WHILE ALSO UTILIZING REGENERATIVE BRAKING THROUGH A COMBINATION OF BATTERIES AND SUPERCAPACITORS.

***Mrs. K. Ramya*[1], *SK.Nagurbi*[2], *K. Venkata Narayana*[3], *K. Dhanush Gupta*[4], *B. Vamsii*[5]**

[1] ***Assistant Professor,*** [2,3,4,5]***Students B.Tech-EEE,***

Sree Vahini Institute of Science and Technology., Tiruvuru., NTR District., AP, India

[1]kambhamramya@gmail.com, [2]nagurbishaik32@gmail.com,
[3]kommavarapuvenkat60@gmail.com, [4]dhanushgupta2002@gmail.com,
[5]vamsi1132@gmail.com,

ABSTRACT

These days, wireless power transfer, or WPT, is gaining a lot of attention and could play a big role in our future. WPT being looked into as a potential solution for a range of power application scenarios, from low power ones like charging a cell phone to high power ones like charging an electric vehicle (EV). There are concerns about whether wireless charging technology designed for low power applications can be integrated into this high-power application given the increasing market penetration of electric vehicles. It should also be looked into whether regenerative braking can be integrated into the system as a whole. To facilitate regenerative braking, a number of converters have been proposed (RB). Studies looking at how the two technologies interact at the system level are scarce, nevertheless. The integration of an EV's regenerative braking system with inductive wireless power transfer (IWPT) system is suggested in this study. The advantages of the suggested approach are demonstrated in situations when frequent acceleration and deceleration result in significant power loss. The system level integration of a WPT system and a regenerative braking system into an electric vehicle is studied and reported in this research.

1. INTRODUCTION

The subject of global warming is concerning. According reports from the World Health Organization (WHO), climate change and global warming could have a major negative impact on it the human health in human health in the future. WPT is being studied immediately as a step toward a green and clean future and as a development in the field of power electronics. The world is moving away from non-renewable resources and toward improved renewable technology [1]. The government offers financial incentives to the public to select sustainable products, and green, sustainable lifestyle is encouraged. Electric train systems and other types of locomotive transportation have long been around, and they are recognized as energy-efficient modes of transportation.

Likewise, internal combustion engines are replaced with electric motors in some models of electric vehicles (EVs) that are available on the market. High energy density, high power density, low cost, a wide operating temperature range, and an extended lifespan are all desirable qualities in an energy storage system. Battery-based energy storage systems, or ESSs, are the source of power for electric vehicles. Though they last a long time and are expensive to replace frequently, batteries have a limited power density [2].

Since batteries are charged via cables at charging stations, charging a battery-powered energy storage unit takes longer than charging a typical gasoline-powered vehicle. However, when it's windy, rainy, or snowing outside, plug-in charging for electric vehicles is thought to be problematic. As a result, switching to WPT is advised for a simple charging alternative. Until the battery is charged, the driver can park the electric vehicle above the static WPT is a simpler way to charge the battery because it doesn't require connecting cords to the EV [3].

Researchers are interested in the topic of grid-to-vehicle (G2V) and vehicle-to-grid (V2G) battery charging since it allows for the full use of electric vehicle (EV) batteries. V2G assists in controlling intermittent wind anomalies in homes, and deficiencies or unbalanced electricity on side [4]. Here, a battery and a supercapacitor (SC) make up the energy storage unit.

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ISSN: 1832-5505
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In addition to a battery, a SC is used to prolong the battery's life and improve its performance because repeated charging and discharging might shorten the battery's lifespan. As a result, the energy used for regenerative braking is directed into the SC for storage [6]. SC has a higher power density than batteries. As a result, the SC can charge and discharge quickly because no chemical reaction is occurring.

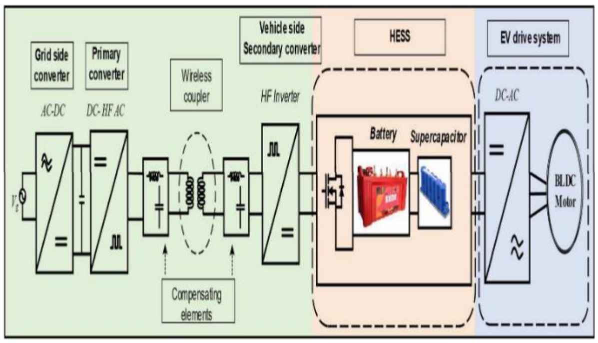

Fig. 1. Block diagram of a battery-powered hybrid electric vehicle (BPT) that uses a BLDC motor for regenerative braking.

Compared to batteries, SCs are speedier, have a higher power density, and have a longer lifespan. As a result, SCs can be used to counteract the drawbacks of batteries in a hybrid energy storage system. Supercapacitors have been used since the 1950s, and at Nuremburg, Germany, the first hybrid bus in Europe was created utilizing SC at 640V. Since then, the use of SCs to store regenerative braking energy, feed transients to the system, and shield batteries from rapid charge and discharge has grown in popularity. While a SC pack cannot completely replace a battery storage unit because of its low power density, which makes it unsuitable for long-term EV use, it is possible to enhance the storage system by combining a battery with a SC pack. Long-term power is typically provided by batteries, while short-term high-current output is provided by SC. The SC in the circuit only supplies short-term high current demands since the electric car needs torque for acceleration; the battery provides the average power needed [5].

The purpose of the research presented in this paper is to create a regenerative braking system that uses less energy and extends battery life when the WPT system is linked to the circuit. Sections II and III of this report provide reviews of previous research findings on WPT and regenerative braking systems (RBS). Section IV uses circuit diagrams to illustrate the proposed research investigation. The control strategy used in this investigation is the subject of Section V. The simulation investigations are briefly explained in Section VI, and the paper is concluded in Section VII.

2.REGENERATIVE BRAKING SYSTEM:

The battery-SC storage unit, commonly referred to as the hybrid energy storage system (HESS), has had a number of converters developed to recover the energy to controller of Conventional energy storage systems are built by directly connecting one or more levels of dc-dc converters to the dc-link. By using these dc-dc converters, power transfer between the battery and SC can be regulated according to the vehicle's needs or the need to charge or discharge transients. Numerous HESS topologies make varying claims about their benefits. When the SC voltage level is lower than the battery voltage level, the vehicle can be powered directly by the battery in the HESS system that is proposed in [9]. This method is only cost-effective at low bus voltages. Higher bus voltages become relevant when the size of the SC increases because the system becomes more expensive. A HESS with a SC connected in parallel to the inverter and strong inrush currents flowing during startup is suggested by the research in [5]. The SC is uncontrollable even though the experiment uses a limiter resistance in series with the inverter and SC. During large transients, voltage and current instability arises because the SC is not controlled by the converter, despite its presence. State of charge (SOC), motor speed, and brake current are the control inputs for a fuzzy logic-based control that is proposed in another work in [10].

To ensure that the motor's torque is constant, a proportional integral derivative (PID) controller is employed. However, because this topology involves frequent charging and discharging, it may shorten the battery's lifespan. The solution in [11] suggests utilizing a battery and SC combo to integrate WPT into an electric scooter. To extend battery life, it advises creating a tiny negative current for a brief amount of time. With the diode bridge rectifier's lack of controlled power transfer and compensation scheme, this approach is regarded as less flexible

3.WIRELESS POWER TRANSFER:

When compared to fuel-powered vehicles, WPT systems are quieter, lessen greenhouse gas emissions, and cause less wear and tear on mechanical components. Additionally, they have short wires, which allows for flexible charging. Because of this, these systems have emerged as viable solutions for the future, particularly when taking into account energy resource availability, sustainability, and dependability. Different study areas, including coil design, control strategy, compensation approach, resonant tank elements, and converter topology, are research investigation. The control strategy used in this used to categorize WPT schemes. In addition to the aforementioned classification, research works have introduced additional developments through the use of several WPT methods.

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Consequently, the control techniques of the WPT schemes can also be used to categorize them. The authors of [15] presented a two-layer predictive controller that determines

whether to operate in the charging or discharging mode based on information about power flow direction gathered from the nearby utility grid or vehicle. In addition to this research work, [16] suggested a measured active and reactive power control-based control technique. Working with high frequency parameters necessitates the use of high frequency bandwidth sensors. This

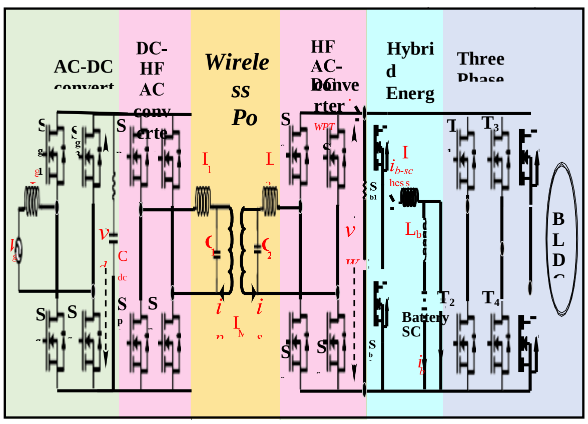

Fig:2. The suggested configuration of IWPT-HESS

Overall system costs, extends battery life with the addition of a solar collector, and recovers power that would otherwise be wasted as heat. An explanation of the suggested system's operation is provided in a later section. During operation, the switches (V1, V2) in the HESS unit are controlled to steady the dc-link voltage. The purpose of SC is to recover as much of the braking energy as feasible by absorbing transients under various speed conditions. Through the use of SC in the storage system, this procedure contributes to a longer battery life [5].

4.PROPOSED SYSTEM:

A battery-SC combination is linked to the WPT charging mechanism that was suggested in reference [11]. The control strategy suggested there calls for a brief negative current to be induced in the battery throughout each cycle in order to extend its life. Regenerative braking is not taken into account in its converter topology, though. In order to integrate WPT with a HESS, this research suggests using a battery-SC combination as an energy storage system. The installation of the suggested method can shorten the intervals between concurrently charging the vehicle and storing the braking energy from the vehicle on slopes, particularly in mountainous areas and in cities with stop-and-go traffic. The dc-link is the common point of contact between HESS and WPT.

The suggested topology is appropriate for 48V commercial electric vehicles, including rickshaws and scooters, as well as other low voltage vehicles [11]. Because most people in the modern world do to with all

not need to be extremely fast or physically strong to get by on a daily basis, this is mostly beneficial to them [2][5][10]. As seen in Fig. 2, the battery-SC are connected to the dc-link through a converter. The HESS and WPT units provide electricity to the EV. The block diagram of the suggested system with a BLDC motor in the EV drive train is shown in Fig. 1. It stores the energy from the regenerative braking feasible by absorbing

The detailed voltage (Vdc) and current flow direction is to Crucial for system operation. As a result, as system motor illustrated in Fig. 3, a closed loop control structure is created to operate the system in several modes. circuit diagram for the regenerative energy storage system is displayed in Fig. 2. Through a dc-link, a bidirectional WPT system is coupled to the battery-SC combination, with a voltage maintained at VWVWV. As seen in Fig. 2, a SC pack with an inductor is linked to the battery and it is connected to the dc-link via a bidirectional DC-DC converter with a voltage of VDY. By managing the switches (V1, V2) in the HESS unit, the dc-link voltage is stabilized during the braking action. The purpose of SC is to recover as much of the braking energy as feasible by absorbing transients under various speed conditions. Through the use of SC in the storage system, this procedure contributes to a longer battery life [5]. To enable the system to enter regenerative braking, where the motor's efficiency is maintained as a function of torque and vehicle speed, the car is driven at different speeds (as illustrated in Fig. 6).

5. CONTROL STRUCTURE:

When an EV accelerates, it needs a lot of current to sustain the torque need. Similarly, during deceleration, less current is needed. This system's SC prolongs battery life while supporting transients. The system's BLDC motor has a 65V 2kW rating. When in regenerative braking mode, the dc-link voltage is maintained via a PI controller. The controlling systems employed in the WPT system are summed up in Fig. 3. The switches connected to the grid side of the WPT system are $Sg1 - Sg4$. The dc link voltage is defined as 65V when the reference voltage is 65V. The pulse generation for these switches is displayed in Fig. 3. The grid side controller has a set phase shift angle ($\emptyset p$), which is equal to 180°, and converts the ac input to dc. The phase shift angle ($\emptyset x$) and internal phase shift angle ($\emptyset s$) must be regulated in order for the desired power ($P0$) to flow in order for the electricity to flow from the grid to the vehicle (G2V). The relationship between phase shift angle and active power can be expressed as (1), where M represents the mutual inductance between two coils (L1, L2)

$$\rho = \frac{8M}{L_1 L_2 w_r \pi^2} Sin\theta Sin\frac{\emptyset_\rho}{2} Sin\frac{\emptyset_s}{2} V_b V_d \ldots . (1)$$

$$\theta = \emptyset_x - \frac{\emptyset_s}{2} - \frac{\emptyset_p}{2} \ldots \ldots \ldots (2)$$

As illustrated in Fig. 3, the reference power, ρ_{ref}, is compared to the actual power, and the power difference is communicated to the PI controller to generate $\emptyset s$. As a result, there is an angle of $\emptyset x$ between the secondary side H-bridge and the primary side H-bridge. Since the phase shift angle is controlled to regulate power, feedback between the two H-bridges is not necessary. The Dc-Link Voltage shared by the HESS, the converter, and the WPT system on the battery-SC side is represented by the symbol DcW. Fig. 3 shows the BLD to

motor control, along with the bidirectional converter that connects the battery to the SC. When Vef and $v WPT$ are compared, the error is sent to a PI controller, which generates ibref , the reference current. In order to generate PWM pulses for b1-b2, this reference current is further compared to the converter current, i$b{-}sc$, and the error is supplied to the inner PI controller.

The converter's bidirectional operation enables the HESS system to take up RB's electricity. The torque reference, dt, is generated by the PI controller by feeding the error from the comparison of the BLDC motor's speed, dt, with the reference speed, dtef, as illustrated in Fig. 3. In order to determine the rotor position under operating conditions, the input from the hall sensors is decoded. The acquired $\boldsymbol{TU}$ef is then multiplied by the output from the PI controller and compared with the input current to the BLDC motor, or iabc. The resulting pulses are fed into switches ($T1 - T6$) in the BLDC motor inverter.

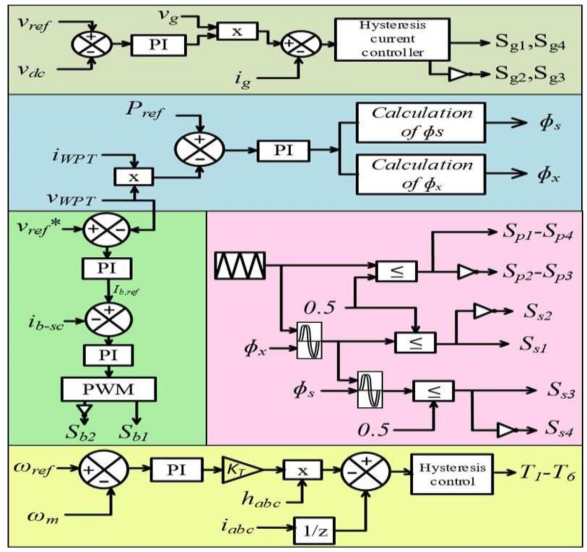

Fig. 3. Control arrangement for the suggested system

6.SIMULATION STUDIES:

The suggested arrangement is simulated using the MATLAB Simulink environment. Table I displays the parameter values that were taken into account when simulating the specified system. The grid voltage is assumed to be 65 volts, and the dc-link takes this same potential into account.

A)Wireless Power Transfer:

For simulation purposes, a switching frequency of 20 kHz is used to model a WPT. The charging coil's it is to be motor voltages and currents on both sides are displayed in Fig. 4. Power moves from the main to the secondary side when the primary coil's voltage is higher than the secondary coil's. Twenty kHz is the frequency of the alternating voltage across the coils. After going via a compensation circuit, the secondary coil voltage is sent through the secondary H-bridge.

The vehicle side resonant tank's reactive power is nearly zero due to a 90-degree phase shift between the two H-bridges. The current needed for grid to vehicle (G2V) operation flows from this lag in H-bridge voltages As the power level increases, the PI is adjusted such that there is a steady state power supply from the WPT side, the overall phase shift stays constant, and the power quality is properly preserved. Even at resonance frequency, there will still be some distortion power present in the system, but it will still be very small. The converter (H-bridge) voltages on either side of the WPT coils are displayed in Fig. 5. The secondary side's quasi-square waveform is intended to supply the necessary power.

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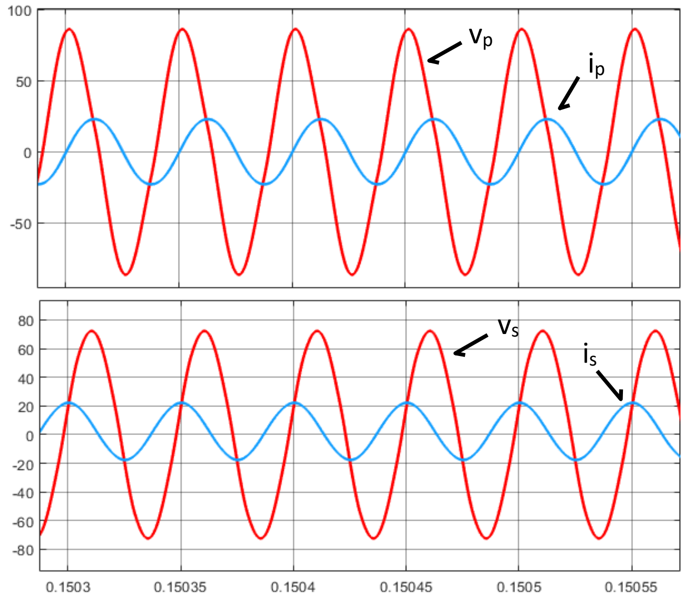

Fig. 4 Currents and voltages in primary and secondary coils

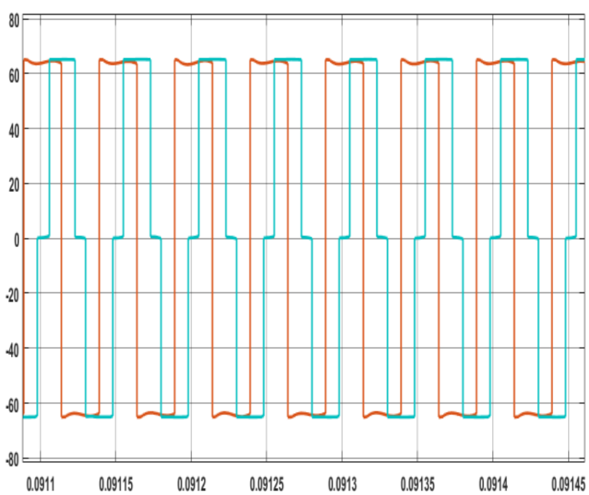

Fig. 5 H-bridge voltages for the primary and secondary

B) Working of BLDC motor and Regenerative braking:

Aside from the hilly terrain, we also frequently stop and start in urban areas due to severe traffic. Thinking about a motor cycle that justifies this kind of simulated environment makes it much easier for us to imagine a situation that is more like the actual one. As a result, these possibilities have been taken into account in simulation studies; the speed profile taken into consideration for simulation is shown in Fig. 6. Transients on the storage side are brought on by a speed profile with abrupt acceleration and deceleration motions. The SC that is attached to the system absorbs these transients. The change in battery and SC current supply during the transient period is shown in Fig. 6.Because of its high energy density, the SC helps extend

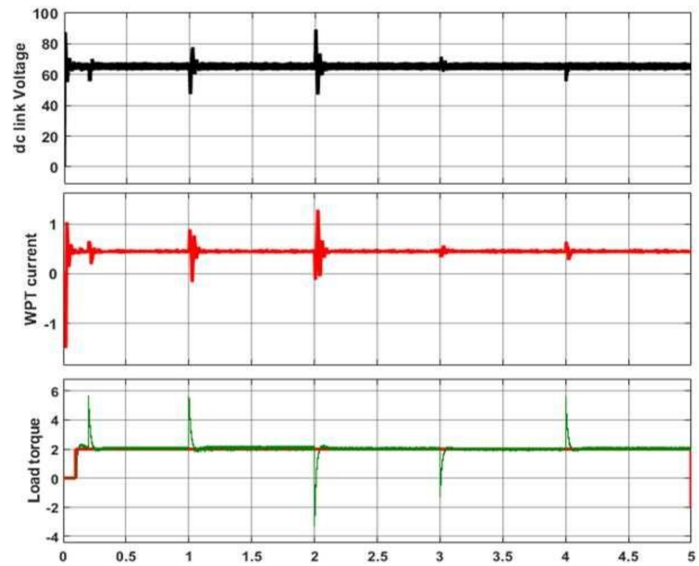

Fig :6 Battery and SC current at different rates.

Figure 6 illustrates how quickly the motor responds to changes in speed, allowing it to attain its target speed. The HESS unit compensates for the transients seen when varying speed by providing the motor with the power to reach the intended speed through an increase in current. While battery current is gradually increasing, SC current exhibits a rapid spike in current. This is a desired reaction from the storage units because there won't be any spikes in battery current because SC absorbs the transients. The torque variation during vehicle motion is shown in Fig: 7, to together with the matching WPT current and dc-link voltage connected to the point of common coupling. By providing power to the setup's dc-link, the WPT maintains a consistent current contribution to the entire system. The system's shift in speed is what causes the transients seen in the dc-link (WWW*PT*). The load torque is reported to be maintained at constant terms despite variations in speed. While the battery and SC are rated at 48V, the dc-link voltage is kept at 65V. Fig. 8 displays the BLDC motor's stator current profile. It has been noted that variations in the motor's speed are reflected in the stator currents. To illustrate the impact of varying speeds, Fig. 8 also shows a zoomed version of the same.

Figure 9 displays the power distribution to each of the system's subsystems. The battery, the SC, and the bidirectional converter that is attached to the dc-link. The power output from the WPT system connected to the dc-link is implied by the power from the WPT unit. The WPT and HES systems supply the power that the BLDC motor receives. This figure allows us to see the individual contributions. The SC helps to prevent excessive peaks in the current increases more slowly.

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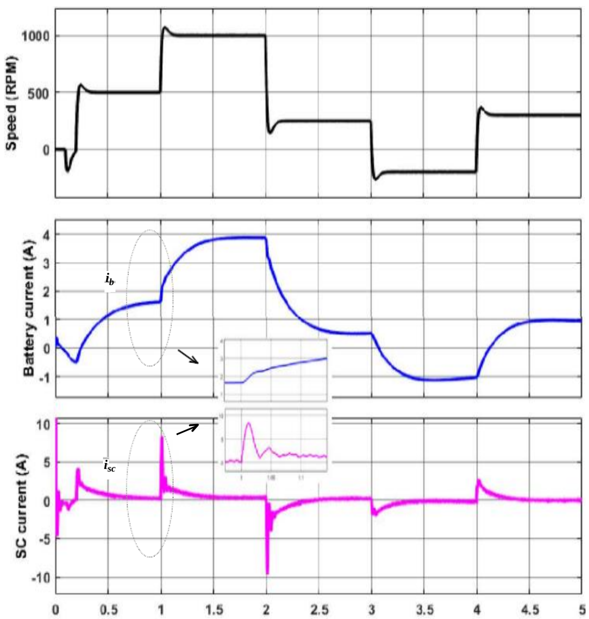

Figure 7: WPT voltage and current across load torque

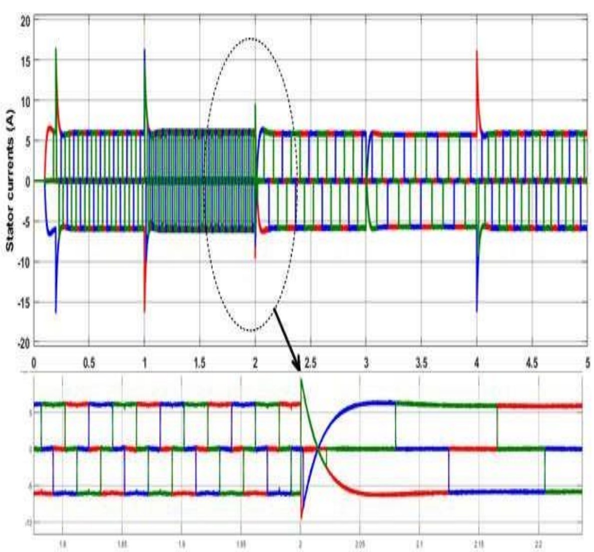

Fig :8 Stator current behavior when speed varies.

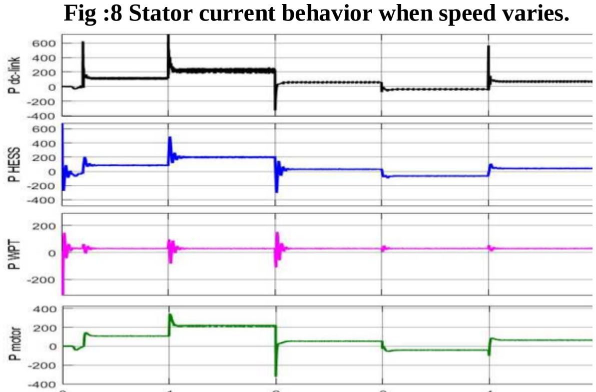

Fig : 9 Distribution of power to storage units.

7.CONCLUSION:

The use of a battery-SC combination for regenerative braking in conjunction with bidirectional wireless power transfer to electric vehicles is suggested. We model and simulate this system and offer observations for different operating conditions. The suggested method permits the battery to react slowly and the supercapacitor to react to transients in contrast to other similar types of regenerative braking schemes. By using SC in the system, the battery lifetime can be extended.

8.FUTURE SCOPE:

Therefore, it can be said that the suggested plan is able to recover braking energy and store it in the battery and SC, allowing the HESS to operate efficiently. It is possible to transform the suggested to providing the life system into a dynamic WPT system that can transmit power simultaneously. Enhancing the compensation topology and introducing dynamic elements to the system would be more advantageous in terms of providing flexibility and extending the battery life of electric vehicles.

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AUTHOR'S BIOGRAPHY

1.

K. Ramya was born in Tiruvuru in 1990. She was obtained the B Tech Degree in Electrical and Electronics Engineering from Sree Rama Institute of technology and science in the Year 2012 .she Completed M Tech In Sree Rama Institute of technology and science. Present working in Sree Vahini Institute of Science and Technology. she presented few papers in national conferences and published one paper in international journal.

2.

ISSN: 1832-5505
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SK. Nagurbi was Born 2003 in Mylavaram. Currently She Pursuing B Tech in EEE at Sree Vahini Institute of Science and Technology.

3.

K. Venkata Narayana was Born 2001 in Mylavaram. Currently Pursuing B Tech in EEE at Sree Vahini Institute of Science and Technology.

4.

K. Dhanush Gupta was Born 2002 in Khambhampadu. Currently Pursuing B Tech in EEE at Sree Vahini Institute of Science and Technology.

B. Vamsi was Born 2000 in Mylavaram. Currently Pursuing B Tech in EEE at Sree Vahini Institute of Science and Technology.