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# PV Panel and SRM Drive For EVS with Flexible Energy Control Functions

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**ABSTRACT:** Electric vehicles are gaining popularity due to their low carbon footprint and ease of integration with renewable energy. They are an important element in the smart grid ecosystem. Increasing the driving range of storage driven electric vehicles is the biggest challenge facing the light weight electric vehicle industry. A literature review has been performed to identify various techniques to improve the driving range. Various methods of driving range improvement such as new storage topologies, switching techniques, motor configurations are studied. In this paper Hybrid Electric vehicle (HEV) technology provides an effective solution for achieving higher fuel economy and better performances with reduced greenhouse gas emissions. In order to extend the EVs' driving miles, the use of photovoltaic (PV) panels on the vehicle helps decrease the reliance on vehicle batteries. Based on phase winding characteristics of SRMs, a tri-port converter is proposed in this paper to control the energy flow between the PV panel battery and SRM. Six operating modes are presented, four of which are developed for driving and two for standstill on-board charging. In the driving modes, the energy decoupling control for maximum power point tracking (MPPT) of the PV panel and speed control of the SRM are realized. In the standstill charging modes, a grid-connected charging topology is developed without a need for external hardware. When the PV panel directly charges the battery, a multi-section charging control strategy is used to optimize energy utilization. Simulation results based on Matlab/Simulink prove the effectiveness of the proposed tri-port converter, which has potential economic implications to improve the market acceptance of EVs.

**KEYWORDS:** Electric vehicles (EVs), photovoltaics (PVs), power flow control, switched reluctance motors (SRMs), tri-port converter

## I. INTRODUCTION

Electric vehicles have been around since early 19$^{th}$ century. However, the electricity was primarily generated using coal and other fossil fuels. Driving electric vehicles meant double energy conversion, first one was from fossil fuel to electric energy and the second one was from electric energy to kinetic energy. This made it economically expensive solution. In addition to that, ample oil reserves were discovered and gasoline powered vehicles became the most cost and energy efficient means of transport. Now that the world is facing severe shortages in the gasoline and rising effects of environmental pollution such as climate changes, efforts are being carried out to reduce the pollution and improve the carbon footprint. Every country has set out policies and framework for achieving this target. This has given a significant boost to the research and development in the areas of renewable energy sources and electric vehicles. There is a strong connection between the two. As the renewable energy sources have become cheaper and commercially attractive, more energy is being generated by them. These sources are intermittent and hence they need storage for their complete utilization. With ever-evolving storage technologies, the electric vehicles became economically a more viable option. Besides giving power to the electric vehicles, storage made them an important element in the smart grid.

There are many different terminologies for the electric vehicles based on their utilization of electricity. Grid connected electric vehicles are the ones which use the electricity from overhead or underground cables. Typically, electric trains and trolley buses are developed using this concept. Battery based electric vehicles have rechargeable batteries on the vehicles. The vehicle uses the energy from the battery. Battery needs to be charged after the drive. The Hybrid Electric Vehicles (HEV) use

a battery and conventional fuels to run the vehicles. The battery in the hybrid electric vehicles does not need separate charging as it gets charged from the vehicle stoppings, also known as regenerative braking. The Plug-in Electric Vehicles (PEV) use batteries which can be charged from regular electricity power outlet in a house or any commercial place. The plug-in hybrid electric vehicle uses a similar concept for a hybrid electric vehicle. Since large-scale grid-connected electric vehicles like trains and trolley buses require a lot of infrastructures, most of the electric vehicles research focus is shifted towards either entire storage based electric vehicles or hybrid electric vehicles which have the ability to run on electricity and conventional fuels.
Depending on the type of the electric vehicle, various technology areas are being worked upon. One of the technology areas in the electric vehicles is the development of newer control architectures. Researchers are working on many different electrical topologies and control strategies to improve the overall performance of the electric vehicles. These topologies are primarily for driving the electric motor. Development of battery charging circuits is another research area. Various battery chargers such as on board, off board and wireless chargers are being developed. Grid stability and electrical load management issues are also studied extensively in connection with the electric vehicles. Using the battery in electric vehicles, excess grid energy from the renewables can be stored and also the same battery can be used by the grid operator to help the grid recover from short-term voltage sags and dips caused by load changes. Despite this academic level research on various aspects, the entire growth in the storage device driven electric vehicle industry in the commercial segment is focused on a single problem. This problem is to extend its driving distance with longer charge durations.

In the second category, motion is produced as a result of the variable reluctance in the air gap between the rotor and the stator. When a stator winding is energized, producing a single magnetic field, reluctance torque is produced by the tendency of the rotor to move to its minimum reluctance position. This phenomenon is analogous to the force that attracts iron or steel to permanent magnets. In those cases, reluctance is minimized when the magnet and metal come into physical contact. As far as motors that operate on this principle, the switched reluctance motor (SRM) falls into this class of machines.

## II. LITERATURE SURVEY

**1) Power electronics and motor drives in electric, hybrid electric, and plug-in hybrid electric vehicles.**
**A. Emadi, L. Young-Joo, and K. Rajashekara**
With the growing call for environmentally friendlier and better fuel economy cars, automotive corporations are that specialize in electric automobiles, hybrid electric powered motors (HEVs), plug-in hybrid electric automobiles (PHEVs), and fuel-mobile automobiles. These cars could also enable meeting the demands for electrical electricity due to the growing use of the digital capabilities to enhance vehicle overall performance, gasoline economic system, emissions, passenger consolation, and protection. In electric motors, HEVs, PHEVs, and gas-cellular automobiles, the demanding situations are to acquire excessive efficiency, ruggedness, small sizes, and low prices in electricity converters and electric powered machines, in addition to in associated electronics. In unique, in fuel-cellular vehicles, a energy-conditioning unit which includes a dc–dc converter for matching the gas-mobile voltage with the battery % will also be vital. In steer-through-wire and brake-by means of-cord applications, a fast-reaction motor, inverter, and control gadget are important and need to be capable of function in unfavorable environmental situations. Furthermore, the integration of actuators with power electronics now not best improves the general machine reliability however also reduces the cost, length, and so forth. In addition to power electronics, the era of the electrical motor plays a prime function inside the vehicle's dynamics and the form of power converter for controlling the vehicle running traits.

**2) J. De Santiago et al., "Electrical motor drivelines in commercial allelectric vehicles: A review," IEEE Trans. Veh. Technol., vol. 61, no. 2,**
**pp. 475–484, Feb. 201.**
This paper affords a essential evaluation of the drivelines in all-electric powered automobiles (EVs). The motor topologies which might be the first-rate applicants for use in EVs are offered. The benefits and downsides of each electric motor kind are mentioned from a device perspective. A survey of the electrical cars utilized in business EVs is offered. The survey shows that car manufacturers are very conservative when it comes to introducing new technology. Most of the EVs in the marketplace mount a unmarried induction or everlasting-magnet (PM) motor with a traditional

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mechanic driveline with a differential. This paper illustrates that comparisons between the unique motors are difficult with the aid of the big wide variety of parameters and the lack of a recommended check scheme. The authors suggest that a standardized pressure cycle be used to test and evaluate cars.

**3) Z. Amjadi and S. S. Williamson, "Power-electronics-based solutions for plug-in hybrid electric vehicle energy storage and controlment systems," IEEE Trans. Ind. Electron., vol. 57, no. 2, pp. 608–616, Feb. 2010.**
Batteries, ultra capacitors (UCs), and gasoline cells are extensively being proposed for electric cars (EVs) and plug-in hybrid EVs (PHEVs) as an electric energy source or an power garage unit. In fashionable, the design of an smart control approach for coordinated power distribution is a essential issue for UC-supported PHEV power structures. Implementation of numerous manipulate techniques has been presented inside the beyond, with the purpose of improving battery existence and common car performance. It is obvious that the control targets range with recognize to automobile speed, electricity call for, and state of fee of both the batteries and UCs. Hence, an top of the line manipulate strategy layout is the maximum critical factor of an all-electric powered/plug-in hybrid electric automobile operational characteristic. Although tons effort has been made to improve the life of PHEV power garage systems (ESSs), including studies on power storage tool chemistries, this paper, at the opposite, highlights the truth that the essential problem lies inside the design of electricity-electronics-based electricity-control converters and the improvement of smarter control algorithms. This paper to begin with discusses battery and UC characteristics and then is going directly to provide a detailed contrast of various proposed manipulate techniques and proposes the use of specific power electronic converter topologies. Finally, this paper summarizes the benefits of the numerous strategies and indicates the most viable answers for on-board power control, more unique to PHEVs with more than one/hybrid ESSs.

## III. EXISTING METHOD

The existing method describes that the electric vehicles have taken a significant leap forward, by advances in motor drives, power converters, batteries and energy management systems. However, due to the limitation of current battery technologies, the driving miles is relatively short that restricts the wide application of EVs. In terms of motor drives, high-performance permanent-magnet (PM) machines are widely used while rare-earth materials are needed in large quantities, limiting the wide application of EVs.

**Drawbacks of existing method:**

- The primary disadvantage of solar power is that it obviously cannot be created during the night.
- The **power** generated is also reduced during times of cloud cover (although energy is still produced on a cloudy day).
- Solar panel energy output is maximized when the panel is directly facing the sun.

## IV. PROPOSED METHOD

In order to overcome these issues, a photovoltaic panel and a switched reluctance motor (SRM) are introduced to provide power supply and motor drive, respectively. Firstly, by adding the PV panel on top of the EV, a sustainable energy source is achieved. Second, a SRM needs no rare-earth PMs and is also robust so that it receives increasing attention in EV applications. While PV panels have low power density for traction drives, they can be used to charge batteries most of time. Generally, the PV-fed EV has a similar structure to the hybrid electrical vehicle, whose internal combustion engine (ICE) is replaced by the PV panel. The PV-fed EV system is illustrated in Fig. 1. Its key components include an off-board charging station, a PV, batteries and power converters. In order to decrease the energy conversion processes, one approach is to redesign the motor to include some on-board charging functions.

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**Advantages of proposed method:**

- Solar energy i.e. energy from the sun provide consistent and steady source of solar power throughout the year.
- The main benefit of solar energy is that it can be easily positioned by both home and business users as it does not require any huge set up like in case of wind or geothermal power

**Block diagram of proposed method:**

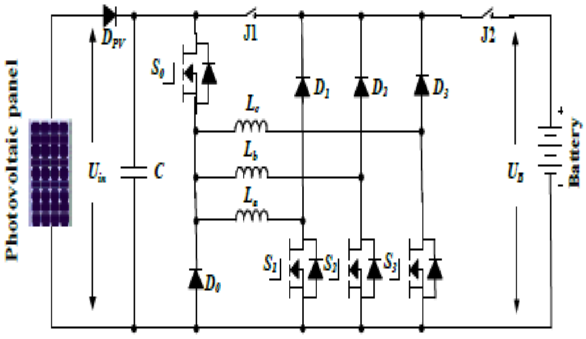
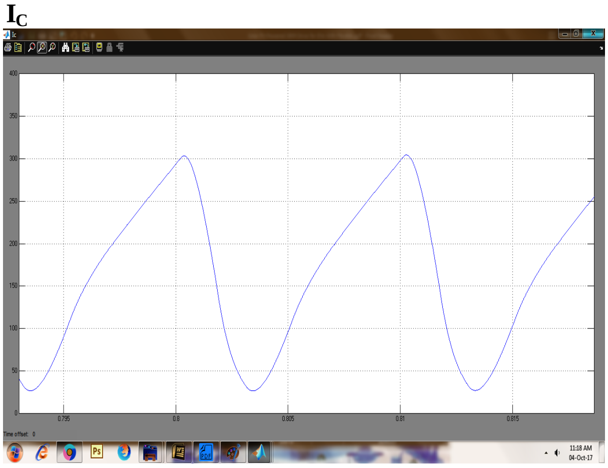



Fig. The proposed Tri-port topology for PV-powered SRM drive.

## V. SIMULATION REULTS

**Simulation results of driving-charging mode (mode 1)**

$I_C$



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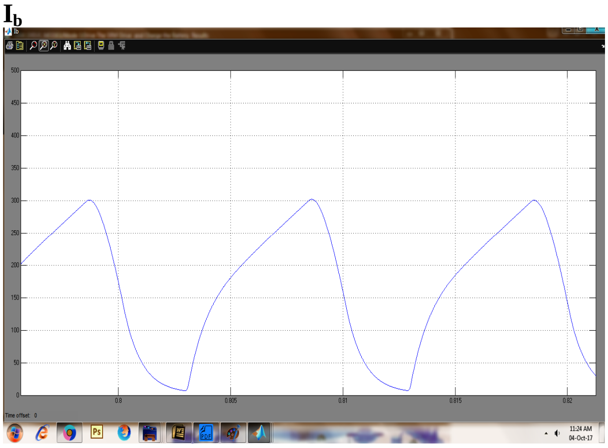
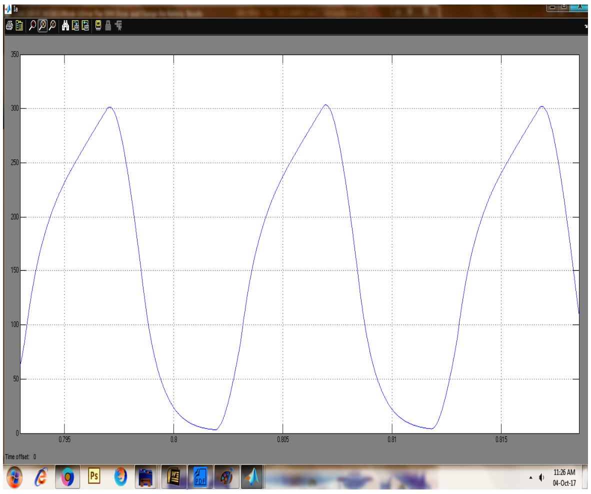
$I_b$



Ia



$I_{by}$

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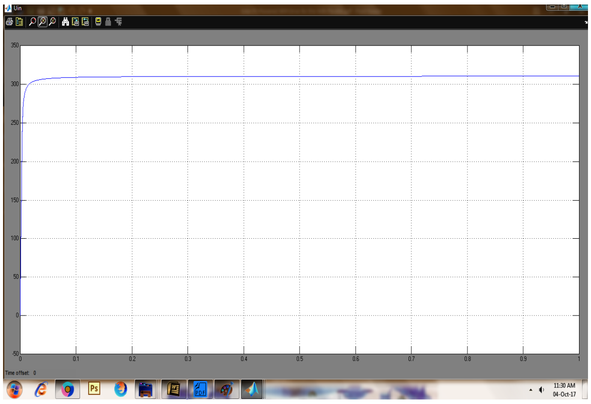
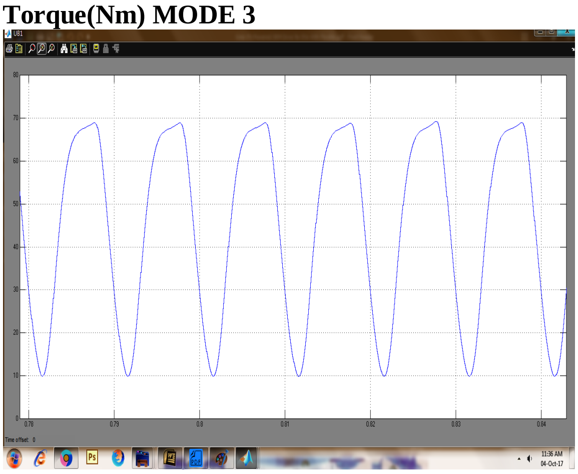
**Uin**

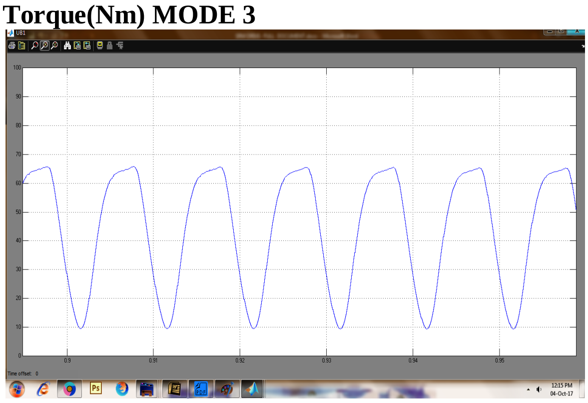


**b) Simulation results of single-source driving mode (modes 3 and 4)**

**Torque(Nm) MODE 3**



**Torque(Nm) MODE 3**



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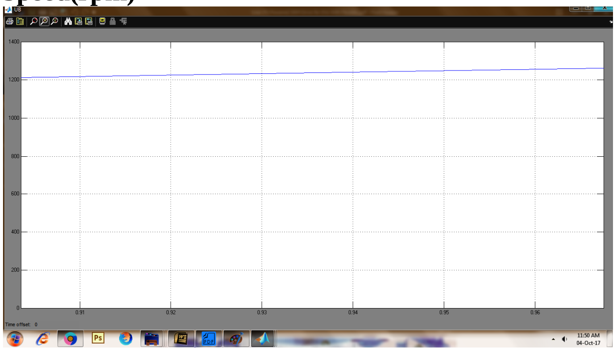
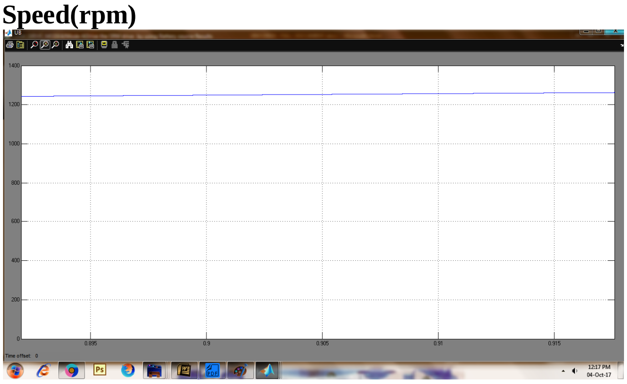
**MODE 3**

Speed(rpm)

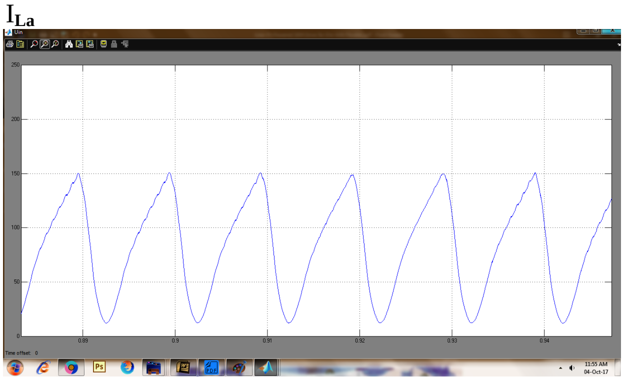


**MODE 4**

Speed(rpm)



$I_{La}$



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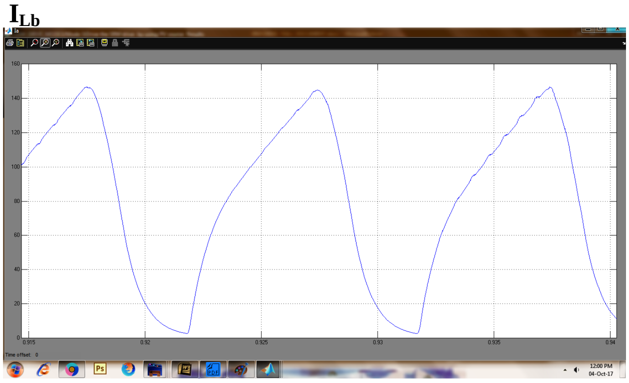
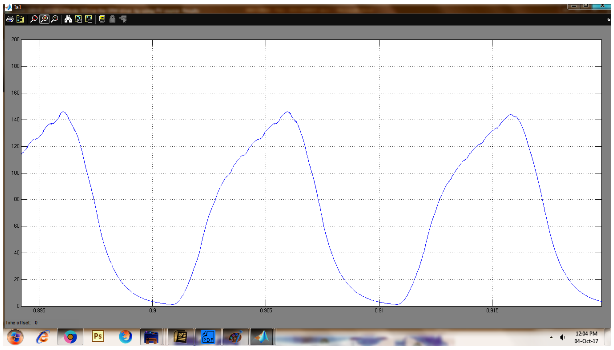
$I_{Lb}$

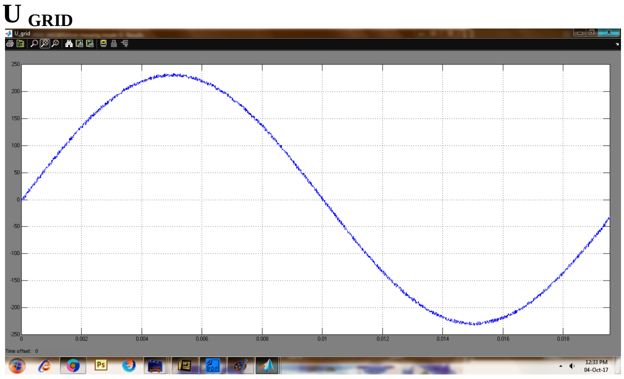


ILc



**II. SIMULATION RESULTS FOR CHARGING MODES. (A) GRID CHARGING (MODE 5).**

$U_{GRID}$



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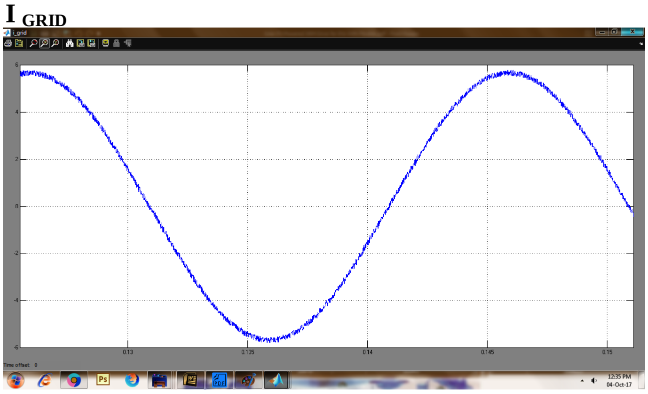
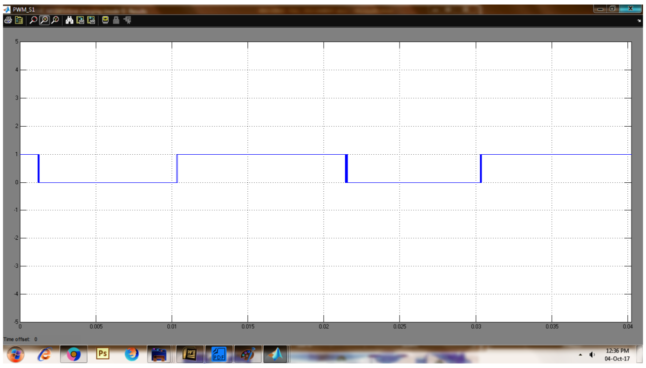
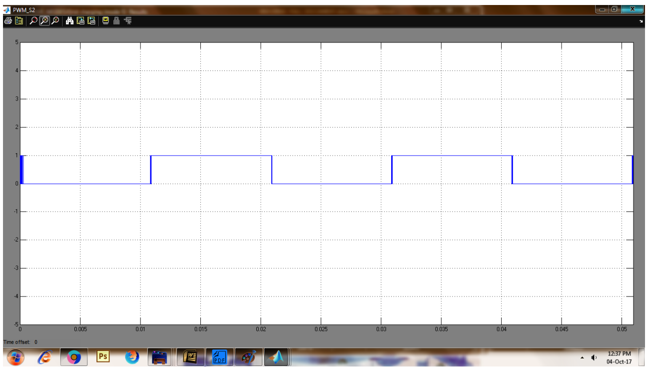
$I_{GRID}$



PWM S1



PWM S2



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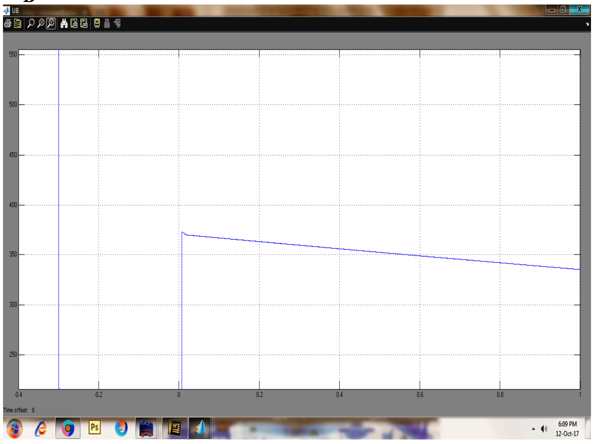
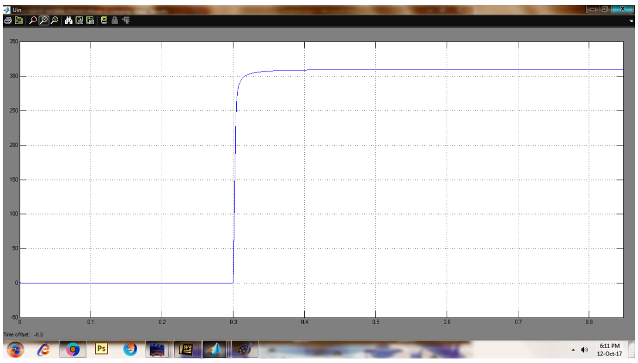
**PV charging MODE 6**
**STAGE 1**

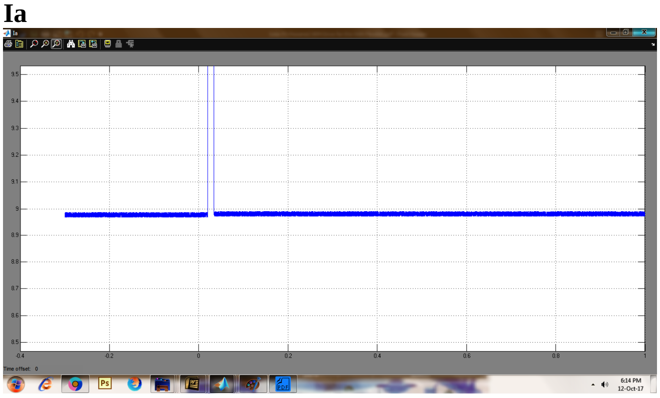
$U_B$



**Uin**



**Ia**



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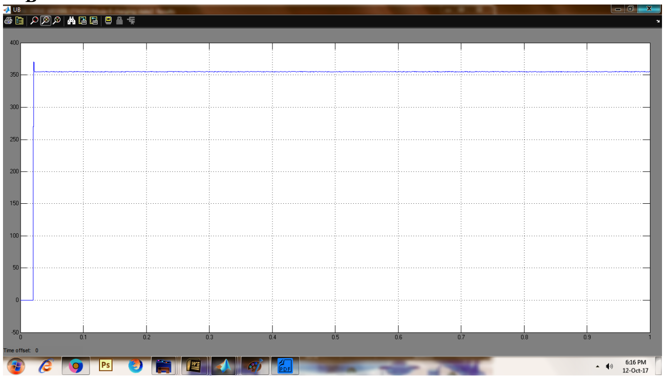
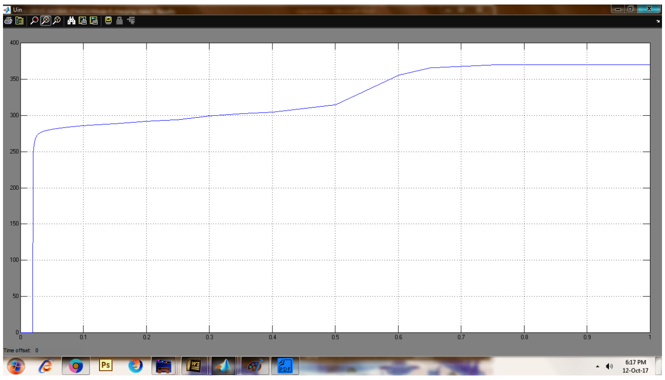
**MODE 6 - STAGE 2**

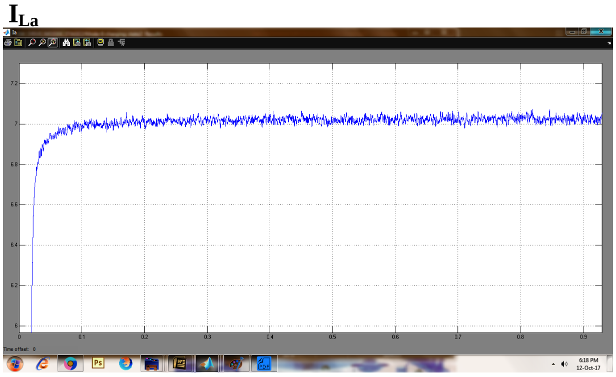
$U_B$



Uin



$I_{La}$



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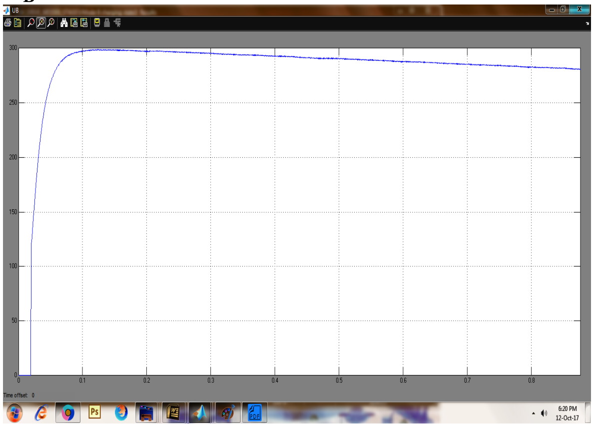
**MODE 6 - STAGE 3**

$U_B$



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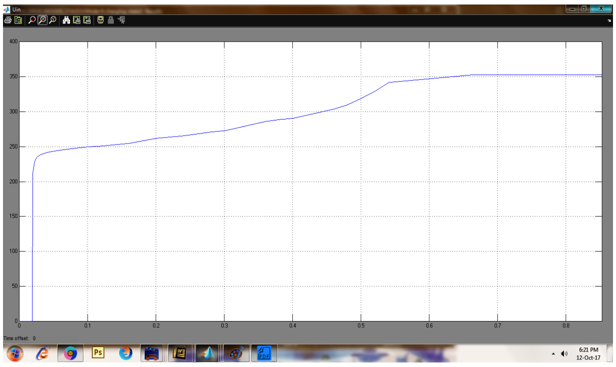

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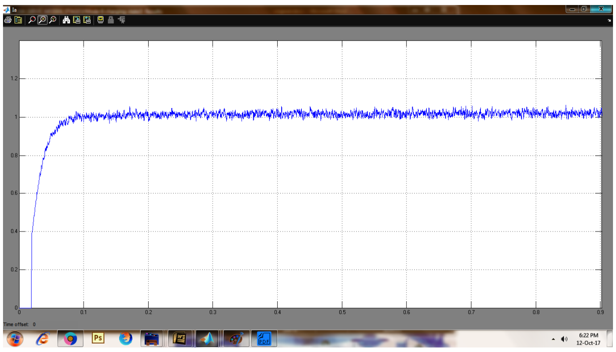

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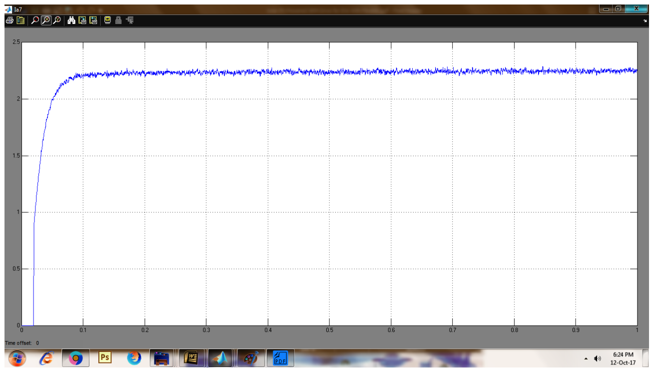

## VII. CONCLUSION

In order to tackle the range anxiety of using EVs and decrease the system cost, a combination of the PV panel and SRM is proposed as the EV driving system. The main contributions of this paper are as follows. 1) A tri-port converter is used to coordinate the PV panel, battery, and SRM. 2) Six working modes are developed to achieve flexible energy flow for driving control, driving/charging hybrid control, and charging control. 3) A novel grid-charging topology is formed without a need for external power electronics devices. 4) A PV-fed battery charging control scheme is developed to improve the solar energy utilization. Since PV-fed EVs are a greener and more sustainable technology than conventional ICE vehicles, this work will provide a feasible solution to reduce the total costs and$CO_2$emissions of electrified vehicles. Furthermore, the proposed technology may also be applied to similar applications such as fuel cell powered EVs. Fuel cells have a much high-power density and are thus better suited for EV application.

## REFERENCES

[1] A. Emadi, L. Young-Joo, and K. Rajashekara, “Power electronics and motor drives in electric, hybrid electric, and plug-in hybrid electric vehicles,” IEEE Trans. Ind. Electron., vol. 55, no. 6, pp. 2237–2245, Jun. 2008.

[2] L. K. Bose, “Global energy scenario and impact of power electronics in 21st century,” IEEE Trans. Ind. Electron., vol. 60, no. 7, pp. 2638–2651, Jul. 2013.

[3] J. De Santiago et al., “Electrical motor drivelines in commercial allelectric vehicles: A review,” IEEE Trans. Veh. Technol., vol. 61, no. 2, pp. 475–484, Feb. 2012.

[4] Z. Amjadi and S. S. Williamson, “Power-electronics-based solutions for plug-in hybrid electric vehicle energy storage and management systems,” IEEE Trans. Ind. Electron., vol. 57, no. 2, pp. 608–616, Feb. 2010.

[5] A. Kuperman, U. Levy, J. Goren, A. Zafransky, and A. Savernin, “Battery charger for electric vehicle traction battery switch station,” IEEE Trans. Ind. Electron., vol. 60, no. 12, pp. 5391–5399, Dec. 2013.

[6] S. G. Li, S. M. Sharkh, F. C. Walsh, and C. N. Zhang, “Energy and battery management of a plug-in series hybrid electric vehicle using fuzzy logic,” IEEE Trans. Veh. Technol., vol. 60, no. 8, pp. 3571–3585, Oct. 2011.

[7] H. Kim, M. Y. Kim, and G. W. Moon, “A modularized charge equalizer using a battery monitoring IC for series-connected Li-ion battery strings in electric vehicles,” IEEE Trans. Power Electron., vol. 28, no. 8, pp. 3779–3787, May 2013.

[8] Z. Ping, Z. Jing, L. Ranran, T. Chengde, and W. Qian, “Magnetic characteristics investigation of an axial–axial flux compound-structure PMSM used for HEVs,” IEEE Trans. Magn., vol. 46, no. 6, pp. 2191–2194, Jun. 2010.

[9] A. Kolli, O. Béthoux, A. De Bernardinis, E. Labouré, and G. Coquery, “Space-vector PWM control synthesis for an H- bridge drive in electric vehicles,” IEEE Trans. Veh. Technol., vol. 62, no. 6, pp. 2441–2452, Jul. 2013.

[10] Y. Hu, C. Gan, W. Cao, W. Li, and S. Finney, “Central-tapped node linked modular fault tolerance topology for SRM based EV/HEV applications,”IEEE Trans. Power Electron., vol. 31, no. 2, pp. 1541–1554, Feb. 2016.