Hybrid Electric Vehicle with Solar Integration using BI Directional DC-DC Converter with Fuzzy Logic Control

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Abstract— This work presents the implementation for solar based electric vehicle (EV) system, as well as its applications on hybrid energy storage system. In order to provide long distance endurance and ensure the minimization of a cost function for electric vehicles, a new hybrid energy storage system for electric vehicle is designed in this paper. For the hybrid energy storage system, the paper proposes an optimal control algorithm designed using a Li-ion battery power dynamic limitation rule-based control based on the SOC of the super-capacitor.
Keywords: electric vehicle (EV) system, DC-DC Converter

I. Introduction

Due to the pollution caused by fossil fuel, new energy sources have been continuously developed. Nowadays, embedded energy storage systems in current generation electric vehicles are mostly based on the Li-ion batteries which, with high energy density, can provide long distance endurance for electric vehicles. While compared to the super capacitor, the response of Li-ion batteries is slower than that of super capacitors. Therefore, in order to make electric vehicles comparable to fuel vehicles with regards to fast transient acceleration, energy, and long-distance endurance, a hybrid energy storage system (HESS) consisting of Li-ion batteries and super-capacitors is applied to electric vehicles. For the development of electric vehicles, optimizing the energy storage device is critical, and it is necessary to consider increasing the capacity of the battery, while reducing the size and weight of the battery to increase the charging rate.

DC-DC converters which play an important role in hybrid energy storage system have been developed rapidly over the years. Through a series of innovations, a variety of DC-DC converters are proposed. A new zero Voltage Switch (ZVS) bidirectional DC-DC converter is proposed in [9], which has good controllability to improve conversion efficiency, but is not suitable for electric vehicles due to the complex control and higher cost. It has been shown an isolated bi-directional DC-DC converter with complex structure is able to convert a large power transmission. A new zero-ripple switching DC-to-DC converter with the integrated magnetic technologies is first proposed in by S. Cuk, and the application is very successful. Isolated interleaved DC/DC converter introduces the concept of three-winding coupled inductors, but it is more suitable for power transmission.

It is very important for hybrid energy storage systems to select a suitable energy management strategy. Energy management strategies have been extensively reported in literature in the recent years, including neural networks, fuzzy logic, and state machine control, frequency decoupling method, on/off E line optimal strategies, dynamic programming (DP) and limitation of battery power. The main objective of the optimal control strategies is to ensure a continuous supply by the minimization of a cost function. These strategies can be divided into off-line global optimization and on-line local optimization. For off-line global optimization, it is necessary to acquire the best power distribution between different sources. At the same time, for on-line local optimization, accurate predication driving conditions is necessary.

In this existing work, a new integrated magnetic structure of DC-DC converter is proposed and applied on hybrid energy storage system for electric vehicles. The proposed DC-DC converter gives the specific topology and operating modes, as well as Li-ion battery and super capacitor control. With regards to energy management strategy, the paper proposes an optimization control algorithm designed using a Li-ion battery power dynamic limitation rule-based control based on the state of charge (SOC) of the super-capacitor. In order to improve the life and reduce the size of hybrid energy storage system, the paper uses a hybrid algorithm based on particle swarm optimization and Nelder-Mead simplex approach to optimize the control parameters. Finally, the simulation and experimental analysis verify the hybrid energy storage system performance.
Figure 1 illustrates the currently existing block diagram.

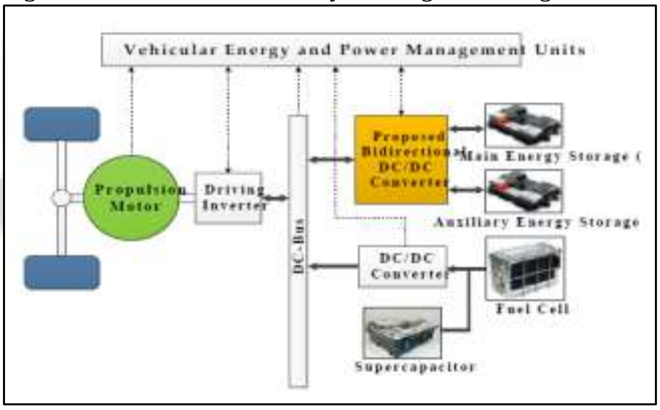

Fig. 1: Existing Block Diagram for Hybrid EV

The low-voltage FC stack is used as the main power source, and SCs directly connected in parallel with FCs. The dc/dc power converter is used to convert the FC stack voltage into a sufficient dc-bus voltage in the driving inverter for supplying power to the propulsion motor. Furthermore, ES1 with rather higher voltage is used as the main battery storage device for supplying peak power, and ES2 with rather lower voltage could be an auxiliary battery storage device to achieve the vehicle range extender concept. The function of the bidirectional dc/dc converter (BDC) is to interface dual-battery energy storage with the dc-bus of the driving inverter.

Generally, the FC stack and battery storage devices have different voltage levels. Several multiport BDCs have been developed to provide specific voltages for loads and control power flow between different sources, thus reducing overall cost, mass, and power consumption. These BDCs can be categorized into isolated and non-isolated types.

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II. LITERATURE REVIEW

For energy, environment, and many other reasons, the electrification for transportation has been carrying out for many years. In railway systems, the electric locomotives have already been well developed for many years. A train runs on a fixed track. It is easy to get electric power from a conductor rail using pantograph sliders. [3] However, for electric vehicles (EVs), the high flexibility makes it not easy to get power in a similar way. Instead, a high power and large capacity battery pack is usually equipped as an energy storage unit to make an EV to operate for a satisfactory distance. Until now, the EVs are not so attractive to consumers even with many government incentive programs. Government subsidy and tax incentives are one key to increase the market share of EV today. [4] The problem for an electric vehicle is nothing else but the electricity storage technology, which requires a battery which is the bottleneck today due to its unsatisfactory energy density, limited life time and high cost. In an EV, the battery is not so easy to design because of the following requirements: high energy density, high power density, affordable cost, long cycle life time, good safety, and reliability, should be met simultaneously. Lithium-ion batteries are recognized as the most competitive solution to be used in electric vehicles [1]. However, the energy density of the commercialized lithium-ion battery in EVs is only90–100 Wh/kg for a finished pack [2].1This number is so poor compared with gasoline, which has an energy density about12 000 Wh/kg. To challenge the 300-mile range of an internal combustion engine power vehicle, a pure EV needs a large amount of batteries which are too heavy and too expensive. The lithium-ion battery cost is about 500$/kWh at the present time. [6] Considering the vehicle initial investment, maintenance, and energy cost, the owning of a battery electric vehicle will make the consumer spend an extra 1000$/year on average compared with a gasoline-powered vehicle [1].

III. OBJECTIVE

The objectives of this work are:

- To do extensive research work on electric vehicle system
- To reduce the complexity of the system by involving the use of special algorithms like fuzzy logic controller to reduce any error.
- To improve the performance of the electric vehicle system by introduction of solar based electric vehicle

IV. FACILITIES REQUIRED

MATLAB 2016a, Windows 10 PC/Laptop

V. SIMULATION RESULTS

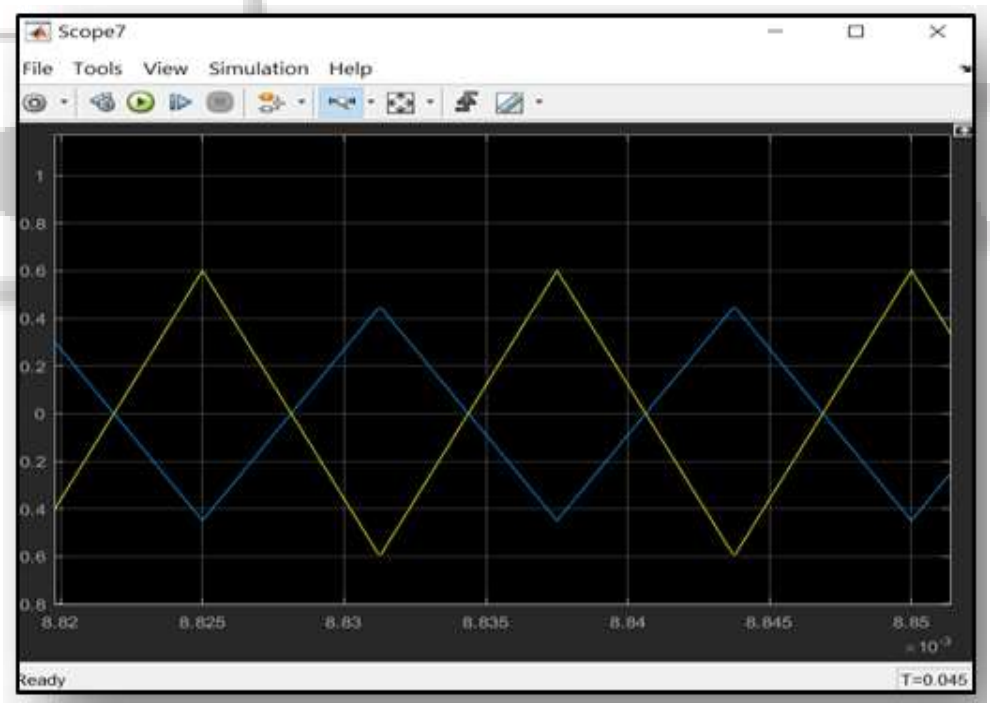

Fig. 5.1: Output for Control System for PI based inputs

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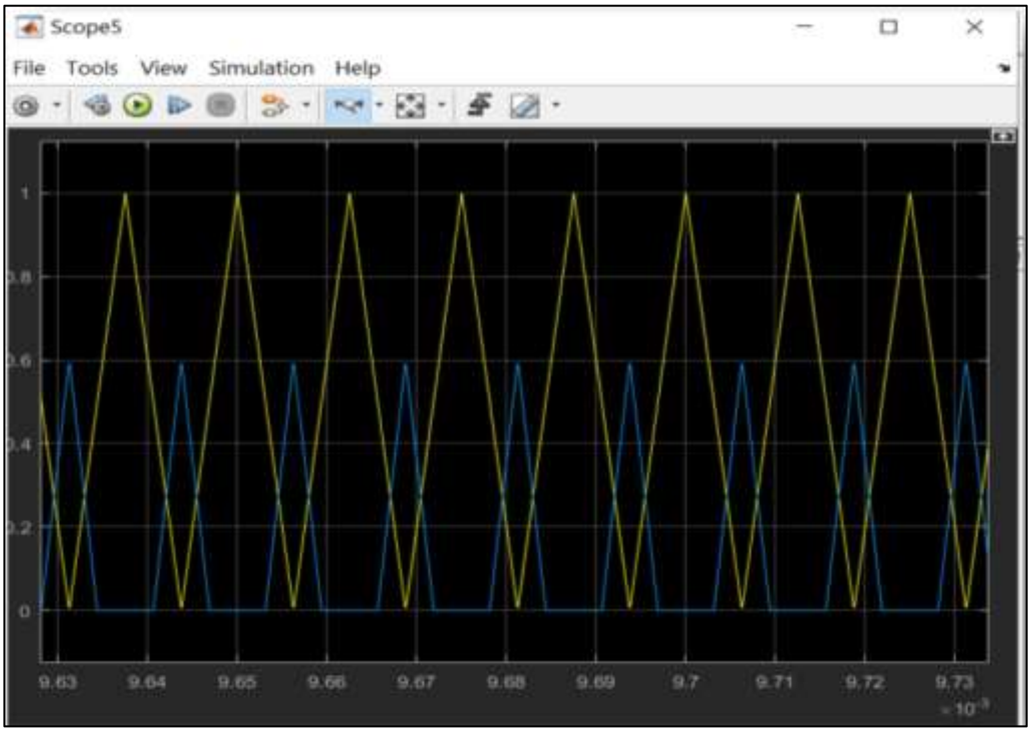

Fig. 5.2: Repeating Sequence for PI based Implementation for

VI. EXISTING WORK

In the work it is seen the current values for inductor have been smoothened, the fluctuations on below graphs have been improved. Photovoltaic frameworks as a feature of bigger appropriation frameworks for the creation of power have non-direct current-voltage attributes. These qualities rely upon the temperature of the sunlight-based cells and insolation of boards. The technique for the hunt of the most extreme force or MPPT is generally known, and there are many offered calculation arrangements. This regulator utilizes support converter to control the terminal voltage of PV framework to work at the greatest force point. The heap side comprises of battery and control changes to control the force stream from the PV framework to the battery and the heap. The framework is displayed utilizing MATLAB/Simulink program.

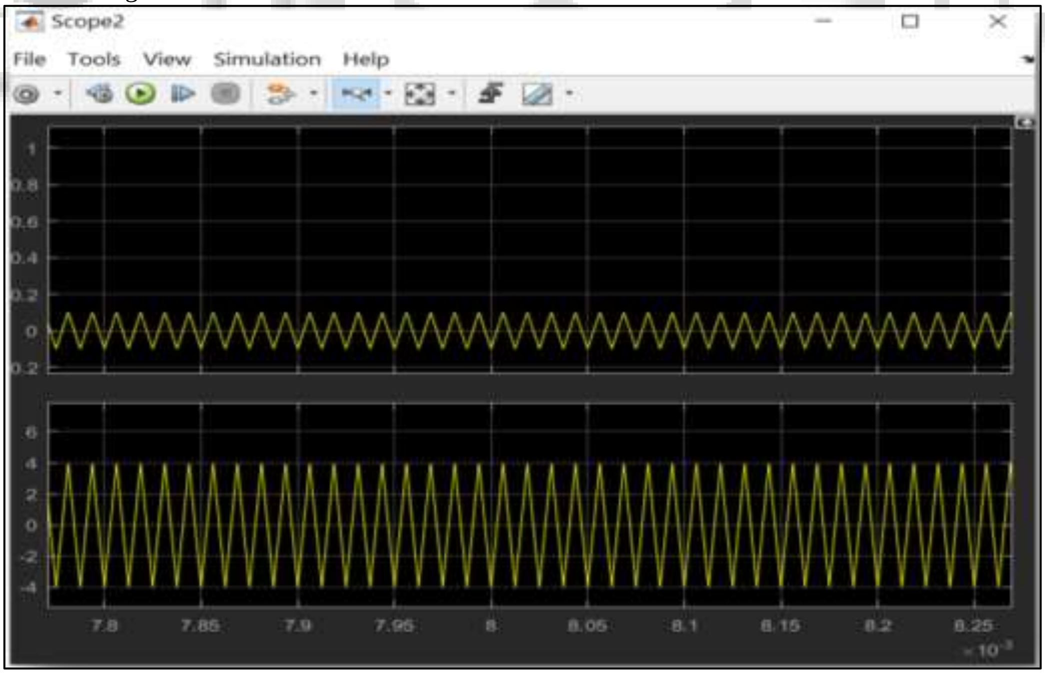

Fig. 5.3: Existing method fluctuations in Inductor Currents

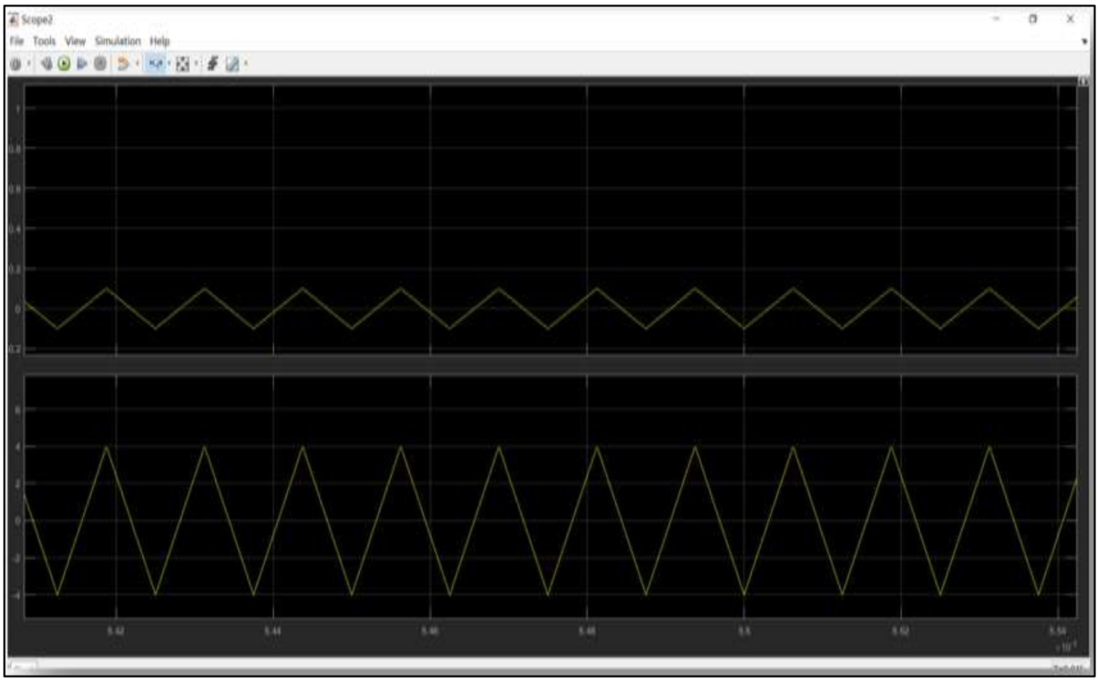

Fig. 5.4: Proposed method fluctuations in Inductor Currents

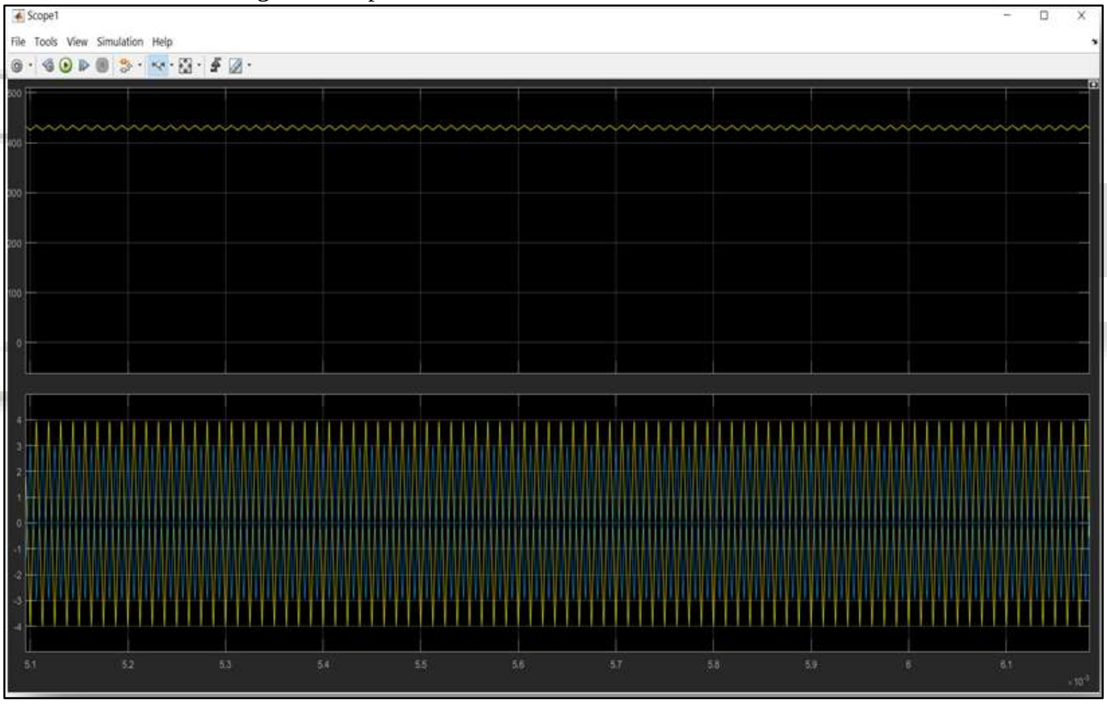

Fig. 5.5: Existing method fluctuations in Output Voltage and Two Source Inductor Current

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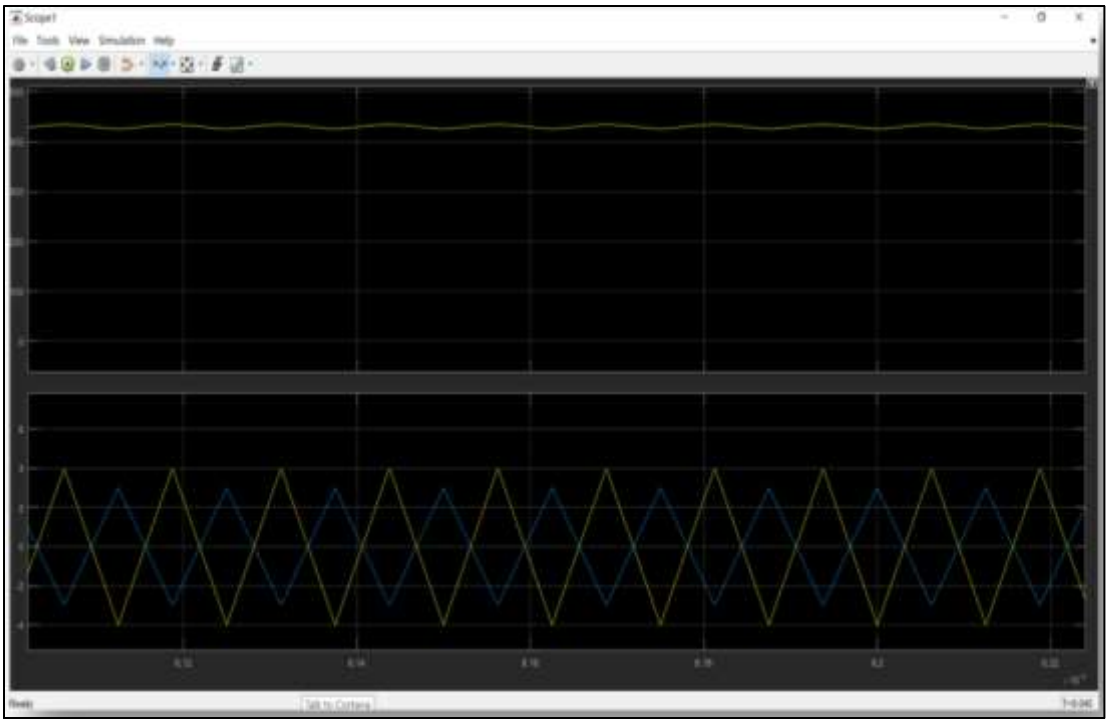

Fig. 5.6: Proposed method fluctuations in Output Voltage and Two Source Inductor Current

Table 5.1 shows the comparison result table below:-

	Existing Work	Proposed Work
Output Voltage	Approx. 435 max	430
Inductor Current	High Fluctuations	Low Fluctuations
Input Source	Battery and Solar	Solar and Battery powered source
Power Tracking	Method not used	Fuzzy Based for Solar combined with Incremental Conductance and Sinusoidal PWM

Table 5.1.: Comparison Results

REFERENCES

[1] Ching-Ming Lai, Member, IEEE, Yu-Huei Cheng, Senior Member, IEEE, Ming-Hua Hsieh, and Yuan-Chih Lin, "Development of a Bidirectional DC/DC Converter with Dual-Battery Energy Storage for Hybrid Electric Vehicle System", IEEE Transactions on Vehicular Technology, 2017

[2] S. Q. Li, and C. C. Mi, "Wireless power transfer for electric vehicle applications," IEEE J. Emerg. Sel. Topics Power Electron, vol. 3, no. 1, pp. 4-17, Mar. 2015.

[3] A. K. A. Kurs, R. Moffatt, J. D. Joannopoulos, P. Fisher, andM. Soljacic, "Wireless power transfer via strongly coupled magneticresonances,"Science, vol. 317, no. 5834, pp. 83–86, 2007

[4] A. P. Sample, D. A. Meyer, and J. R. Smith, "Analysis, experimentalresults, and range adaptation of magnetically coupled resonators forwireless power transfer,"IEEE Trans. Ind. Electron., vol. 58, no. 2,pp. 544–554, Feb. 2011.

[5] B. L. Cannon, J. F. Hoburg, D. D. Stancil, and S. C. Goldstein,"Magnetic resonant coupling as a potential means for wireless powertransfer to multiple small receivers,"IEEE Trans. Power Electron.,vol. 24, no. 7, pp. 1819–1825, Jul. 2009.

[6] V. Etacheri, R. Marom, R. Elazari, G. Salitra, and D. Aurbach, "Chal-lenges in the development of advanced Li-ion batteries: A review,"Energy Environ. Sci., vol. 4, no. 9, pp. 3243–3262, 2011.

[7] Y. D. Ko, and Y. J. Jang, "The optimal system design of the online electric vehicle utilizing wireless power transmission technology," IEEE Trans. Intell. Transp. Syst., vol. 14,no. 3, pp. 1255-1265, Sep. 2013.

[8] W. X. Zhong, and S. Y. R. Hui, "Maximum energy efficiency tracking for wireless power transfer systems," IEEE Trans. Power Electron., vol. 30,no. 7, pp. 4025-4034, Jul. 2015.

[9] D. Ahn, S. Kim, J. Moon, and I. K. Cho, "Wireless power transfer with automatic feedback control of load resistance transformation," IEEE Trans. Power Electron., vol. 31,no. 11, pp. 7876-7886, Nov. 2016.

[10] M. P. Theodoridis, "Effective capacitive power transfer," IEEE Trans. Power Electron., vol. 27,no. 12, pp. 4906-4913, Dec. 2012.