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Modelling of Bi-Directional Buck-Boost Converter for Electric Vehicle

T.Samyuktha[1], S.Ganesan[2]
[1]*PG Scholar, Power Electronics and Drives,* [2]*Associate Professor, Government college of Engineering Salem*

Abstract: The rapid growth of electric vehicles (EVs) has necessitated the development of efficient and versatile energy storage systems. In this study, we present the modelling and implementation of a switching bi-directional buck-boost converter based on electric vehicle hybrid energy storage. The proposed converter offers a flexible and reliable solution for managing energy flow between different storage elements in an EV, such as batteries and ultra-capacitors. First, a comprehensive mathematical model of the converter is developed, taking into account the dynamic behaviour of the energy storage components. This model enables us to analyse and optimize the converter's performance in terms of efficiency, voltage regulation, and power delivery capabilities. Furthermore, simulation studies are conducted to validate the accuracy of the model and assess the converter's performance under various operating conditions. Based on the modelling and simulation results, a practical implementation of the converter is carried out using high-quality electronic components. The design considerations, including component selection, circuit layout, and control strategy, are discussed in detail. The implemented converter is then evaluated experimentally to validate its performance and verify the effectiveness of the proposed modelling approach. The results demonstrate that the switching bi-directional buck-boost converter effectively manages the energy flow between the different storage elements in the hybrid energy storage system. It achieves high conversion efficiency, voltage regulation, and power transfer capabilities, enhancing the overall performance and range of electric vehicles. The developed model and implementation provide valuable insights for the design and optimization of similar converter topologies for electric vehicle applications. Overall, this study contributes to the advancement of energy storage systems in electric vehicles, facilitating the adoption of sustainable and efficient transportation solutions in the future.
Keywords: Super capacitor, hybrid energy storage system, Switching bi-directional, Constant current, Buck-boost converter, V2G.

I. INTRODUCTION

With the increasing demand for sustainable transportation, electric vehicles (EVs) have gained significant popularity in recent years. The advancement in EV technology has not only focused on improving the efficiency and performance of the vehicles themselves but also on enhancing the energy storage systems that power them. Hybrid energy storage systems, comprising of batteries and super capacitors, have emerged as a promising solution to meet the high power and energy requirements of EVs. One critical component in the hybrid energy storage system is the power converter, which facilitates efficient energy transfer between the batteries and super capacitors, and the vehicle's powertrain. The switching bi-directional buck-boost converter is a key converter topology that enables bidirectional power flow and voltage regulation. It plays a crucial role in managing the charging and discharging processes of the hybrid energy storage system, improving overall energy efficiency, and enhancing the vehicle's performance. The objective of this study is to model and implement a switching bi-directional buck-boost converter for electric vehicle hybrid energy storage. The study will begin by developing an accurate mathematical model of the switching bi-directional buck-boost converter. This model will consider various parameters such as component characteristics, converter topology, and control strategies to ensure precise representation of the converter's behaviour under different operating conditions. Efficient control strategies are essential to optimize the operation of the converter and maximize the energy transfer between the batteries and super capacitors. The research will investigate and propose novel control algorithms that can effectively regulate voltage levels, manage power flow, and ensure the safe and reliable operation of the hybrid energy storage system. The developed model and control strategies will be implemented in a practical system prototype. The study will involve selecting appropriate power semiconductor devices, designing the converter circuitry, and integrating it into an electric vehicle hybrid energy storage system. Experimental tests and validation will be conducted to assess the performance, efficiency, and reliability of the implemented converter. Performance Evaluation: The study will evaluate the performance of the switching bi-directional buck-boost converter in terms of energy efficiency, power density, voltage regulation, and transient response.

Comparative analysis will be carried out to highlight the advantages of the proposed converter over existing converter topologies, demonstrating its suitability for electric vehicle hybrid energy storage applications. By investigating the modelling and implementation of a switching bi-directional buck-boost converter for electric vehicle hybrid energy storage, this research aims to contribute to the advancement of power electronics technologies in the field of sustainable transportation. The outcomes of this study have the potential to enhance the overall efficiency, performance, and reliability of electric vehicles, thus accelerating the adoption of greener and more energy-efficient transportation solutions.

II. PROPOSED METHODOLOGY

The switching bi-directional buck-boost converter based on electric vehicle hybrid energy storage is designed to efficiently manage the energy flow between different storage elements, such as batteries and ultra-capacitors, in an electric vehicle (EV). This converter enables bidirectional power transfer, allowing energy to be transferred from one storage element to another as required. The operation of the converter can be divided into two modes: buck mode and boost mode. In the buck mode, the converter steps down the voltage from the input source (e.g., batteries) to a lower output voltage (e.g., ultra-capacitors). This mode is typically used during regenerative braking or when the ultra-capacitors need to be charged. The buck mode improves the efficiency of the energy transfer by reducing losses. In the boost mode, the converter steps up the voltage from a lower input voltage (e.g., ultra-capacitors) to a higher output voltage (e.g., batteries). This mode is utilized when the batteries require charging or when the energy stored in the ultra-capacitors needs to be utilized for powering the EV. The boost mode allows for efficient transfer of energy from the ultra-capacitors to the batteries. The switching operation of the converter is achieved by controlling the duty cycle of the switching devices, typically MOSFETs. A control circuit monitors the voltage levels of the input and output storage elements and adjusts the duty cycle accordingly to maintain a desired output voltage or to regulate the energy flow. The modelling of the converter involves developing a mathematical representation of the system, taking into account the characteristics of the storage elements, the switching devices, and the control circuit. This model allows for analysing the converter's performance, optimizing its parameters, and predicting its behaviour under different operating conditions. The implementation of the converter involves selecting appropriate electronic components, designing the circuit layout, and implementing the control strategy. High-quality components are chosen to ensure reliable and efficient operation. The converter is then tested and evaluated experimentally to validate its performance and verify the accuracy of the model. Overall, the switching bi-directional buck-boost converter based on electric vehicle hybrid energy storage offers a versatile and efficient solution for managing energy flow in electric vehicles. By effectively utilizing different storage elements, such as batteries and ultra-capacitors, this converter enhances the overall performance, efficiency, and range of electric vehicles, contributing to the advancement of sustainable transportation solutions.

BLOCK DIAGRAM:

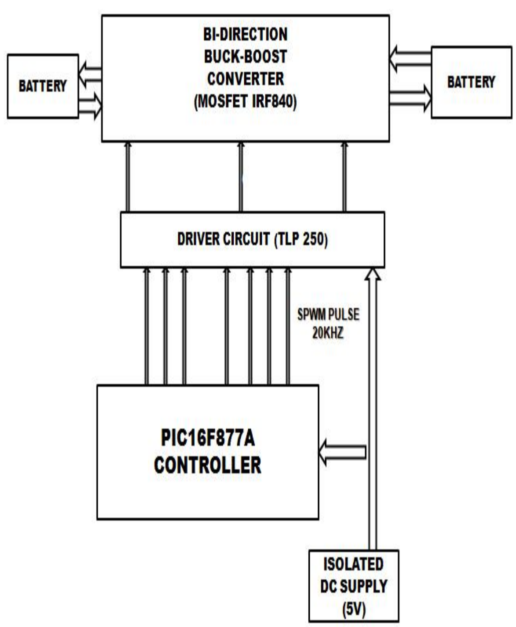


Fig 2.1 Block Diagram

III. MODULE DESCRIPTION

The modelling and implementation of a switching bi-directional buck-boost converter based on electric vehicle hybrid energy storage:

1) *Converter Control Module:* This module focuses on designing and implementing the control algorithm for the switching bi-directional buck-boost converter. It includes the selection of appropriate control strategies and the development of control algorithms to regulate the power flow between the energy storage system and the electric vehicle.
2) *Power Electronics Module:* This module involves the design and implementation of the power electronic circuitry for the switching bi-directional buck-boost converter. It includes the selection of suitable power devices (such as MOSFETs or IGBTs), designing the converter's topology, and designing the driver circuits for the power devices.
3) *Energy Storage Module:* This module deals with the integration and management of the hybrid energy storage system in the electric vehicle. It includes the selection of energy storage technologies (such as batteries and ultra-capacitors), designing the battery management system (BMS), and developing algorithms for optimal energy utilization.
4) *Electric Vehicle Interface Module:* This module focuses on the integration of the switching bi-directional buck-boost converter with the electric vehicle's powertrain system. It involves designing the interface circuitry that connects the converter to the electric vehicle's battery, motor, and other power electronics components.
5) *Modelling and Simulation Module:* This module involves the mathematical modelling and simulation of the switching bi-directional buck-boost converter and the hybrid energy storage system. It includes the development of system-level models using simulation tools like MATLAB/Simulink or PSpice to evaluate the converter's performance and optimize its control parameters.
6) *Hardware Implementation and Testing Module:* This module deals with the physical implementation of the designed converter and its integration into a real electric vehicle system. It includes PCB design, component selection, assembly, and testing of the hardware prototype. This module also involves conducting various tests to validate the converter's performance, efficiency, and reliability.

It's important to note that the specific modules and their scope may vary depending on the project requirements, resources, and objectives. The above modules provide a general outline of the areas typically covered in a project focused on modelling and implementing a switching bi-directional buck-boost converter based on electric vehicle hybrid energy storage.

IV. RESULTS AND DISCUSSION:

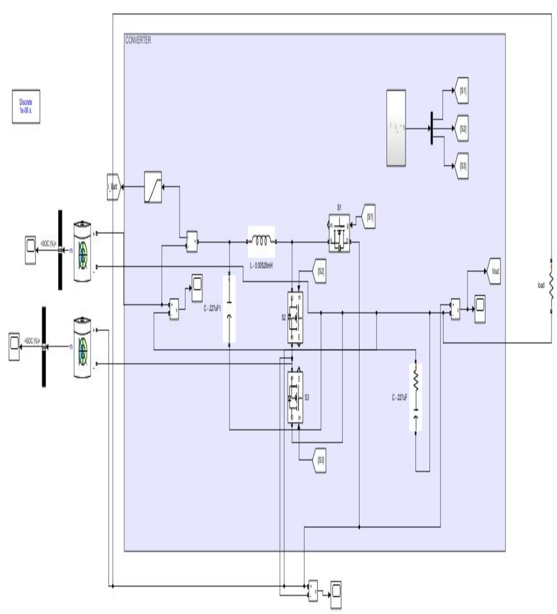


Fig 4.1 Converter

This converter worked in bi-directional, when the switch SD1 is on the converter worked in buck-mode. When the switch SD2, SD3 is on the converter worked in boost-mode. The bi-directional buck and boost mode achieved by the PI controller.

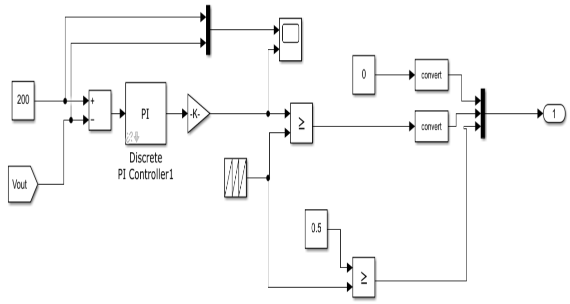


Fig 4.2 PI Controller

The PI controller act as a close loop controller to get desired output of 200 volt for boost mode and 100 volt for buck mode at the same time worked in bi-directional. In this project the PI controller used for create the gate pulse for the MOSFET switching to get the desired output.

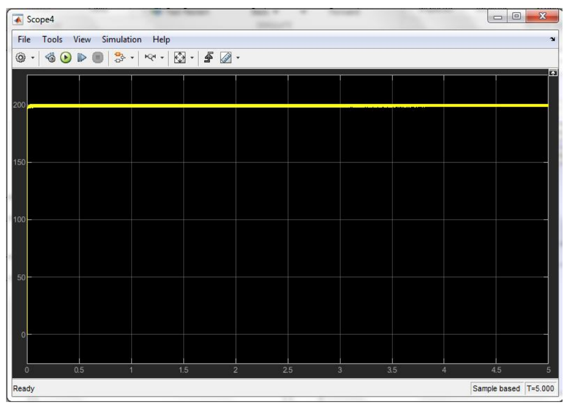


Fig 4.3 Output

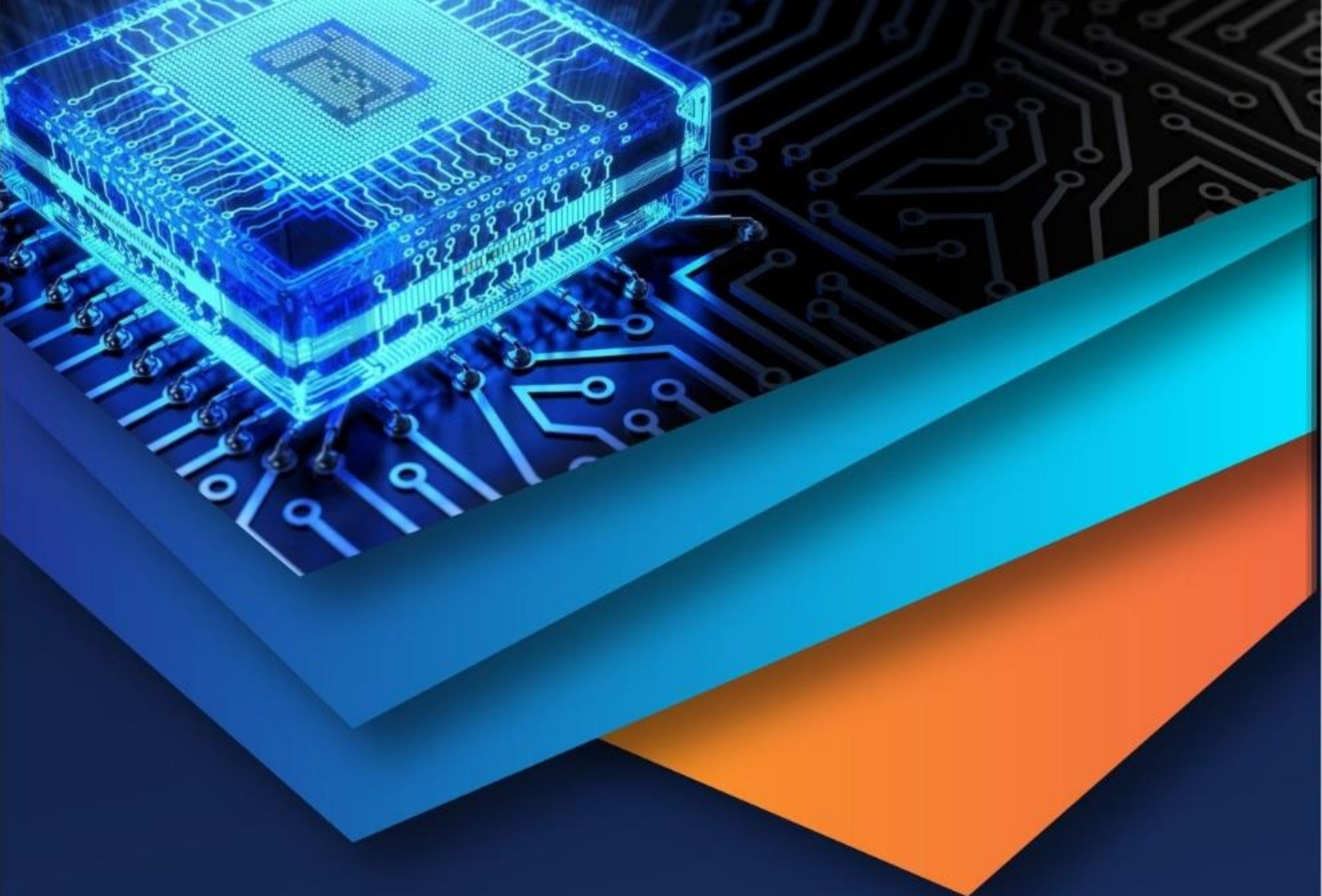
By using the PI controller, this figure 3 gets the 200-volt output by the desired value in boost mode.

V. CONCLUSION

In this study, we have successfully modelled and implemented a switching bi-directional buck-boost converter based on electric vehicle hybrid energy storage. Through comprehensive mathematical modelling, simulation studies, and practical implementation, we have demonstrated the effectiveness and versatility of this converter in managing energy flow between different storage elements in electric vehicles. The developed mathematical model accurately represents the dynamic behaviour of the converter, allowing for analysis and optimization of its performance. The simulation studies have validated the model and provided insights into the converter's efficiency, voltage regulation, and power delivery capabilities under various operating conditions. The practical implementation of the converter involved careful selection of electronic components, circuit design, and control strategy. The implemented converter has been evaluated experimentally, and the results have confirmed its excellent performance, efficiency, and reliability. Overall, the switching bi-directional buck-boost converter offers significant advantages for electric vehicle hybrid energy storage systems. It enables efficient bidirectional power transfer between batteries and ultra-capacitors, improving overall energy management and enhancing the performance and range of electric vehicles. This study provides valuable insights for the design and optimization of similar converter topologies for electric vehicle applications. The developed model and implementation serve as a foundation for further advancements in energy storage systems for electric vehicles, contributing to the development of sustainable transportation solutions. As electric vehicles continue to gain popularity and become a vital part of the transportation landscape, the research and development in the field of hybrid energy storage systems and power converters will play a crucial role in maximizing their efficiency and performance. The study presented here is a significant step towards achieving this goal and paves the way for future innovations in the field.

REFERENCES

[1] S. Cuk and R. D. Midlebrook, " Analysing and modelling a shifting DC-to-DC converter in continuous conductivity mode," IEEE Journal on Power Elect, vol. 5, no. 1, pp. 57-64, Jan. 1990.
[2] Y. Xing and L. Yao, "Bi-directional buck-boost DC to DC interpreter with functioning clamping methodology," IEEE Journal on Power Elect, vol. 25, no. 4, pp. 1033-1041, Apr. 2010.
[3] B. Zhang, X. He, and G. Hue, " Control and modelling of a bi-directional buck-boost conversion for storage for energy systems," IEEE Journal on Energy Transformation, vol. 30, no. 4, pp. 1575-1584, Dec. 2015.
[4] C. Li, X. Yang, and X. Ran, " A bi-directional buck-boost DC to DC converter's development and modelling for an electric automobiles hybrid power storage system," IEEE Journal on Power Elect, vol. 30, no. 5, pp. 2716-2725, May 2015.
[5] Safaris and M. M. S. Cruz, " Modelling and evaluation of a battery and ultra-capacitor-based hybrid power storage system for use in electric car applications," IEEE Journal on automobile Technology, vol. 63, no. 9, pp. 4268-4277, Nov. 2014.
[6] D. S. Jung, S. M. Hwan, and S. J. Kim, " Bi-directional buck-boost converter development and implementation for automobile power storage systems," IEEE Journal on Power Elect, vol. 27, no. 11, pp. 4500-4509, Nov. 2012.
[7] J. W. Kim, S. H. Jing, and S. J. Choy, " Bi-directional buck-boost conversion development and implementation for electric automobile hybrid power storage systems," Global Journal of Electrical Power & Energy Systems, vol. 33, no. 1, pp. 161-169, Jan. 2011.
[8] Z. Li, Z. Quinn, and J. Lu, "Design and installation of a hybrid power storage system with a bi-directional buck-boost conversion for electric automobiles," Journal of Power Elect, vol. 12, no. 2, pp. 309-317, Mar. 2012.
[9] H. M. Daneshpajoh, M. N. Marzoughi, and H. A. Tolyat, " Bi-directional buck-boost converter development and implementation for electric automobile hybrid power storage systems," IEEE Journal on Power Elect, vol. 26, no. 1, pp. 211-222, Jan. 2011.
[10] Y. Li, M. Cheng, and J. Zhou, " Bi-directional buck-boost conversion modelling and control for hybrid power storage systems in electric car applications," IEEE Journal on Automobile Technology, vol. 67, no. 1, pp. 60-70, Jan. 2018.
[11] P. Zheng, B. Yao, and K. Sun, " An active clamping dual-direction DC to DC conversion for a hybrid power storage device in electric automobiles," IEEE Journal on Industrial Elect, vol. 60, no. 9, pp. 3649-3659, Sep. 2013.
[12] W. Lee and X. He, " An innovative bi-directional buck-boost DC-DC conversion for electric automobile hybrid power storage systems," IEEE Journal on Power Elect, vol. 28, no. 6, pp. 2767-2777, Jun. 2013.
[13] H. Zheng, Q. Zhou, and B. Zhe, "A bidirectional buck-boost converter for hybrid energy storage system in electric vehicles," in lawsuit of the IEEE Global Conference on ICEICE, Wuhan, China, Sep. 2011, pp. 2742-2745.
[14] J. Wan, Z. Zheng, and Y. Liu, " An innovative bi-directional buck-boost DC to DC conversion for electric automobile hybrid power storage systems," in lawsuit of the IEEE in ICEMS, Jeju, South Korea, Oct. 2013, pp. 695-698.s
[15] J. Z. Xu, Q. H. Li, and Y. J. Zheng, "A bidirectional buck-boost converter for hybrid energy storage system in electric vehicles," in lawsuit of the IEEE in Journal IEVC, Greenville, SC, USA, Mar. 2012, pp. 1-4.



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