iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VI **Month of publication:** June 2017

DOI:

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Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Automatic Buck-Boost Dc/Dc Converter for Automotive Application

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Abstract*: dc/dc power converter is an electronic device that converts a source of direct current from one voltage level to another voltage level. It is a type of electric power converter. Power levels range from very low to very high voltage power transmission. With the development of the electronics in car and automatic parts the capacity of the current 14 volt voltage no longer meets the demand of the on board devices in the automobile. A dual 14v/42v system is developed as a solution to this problem. This paper proposes a bi-directional dc/dc converter. This converter will work in both buck and boost mode. Extensive study on compatibility and stability, it indicates that under changing power direction, this new converter is able to perform a closed loop control depending upon the value of current and direction.*
keywords: *bi- directional, dc/ dc converter, closed loop control.*

I. INTRODUCTION

DC/ DC power converters are employed in a variety of applications, including power supplies for personal computers, office equipment, spacecraft power systems, laptop computers, and telecommunications equipment, as well as dc motor drives. The main aim of this paper is to study different types of power converters and Design a Bi- directional DC/ DC converter**.** Bi- directional DC/ DC converter has gained interest in both the industries as well as in academic field of power electronics, which can act as a platform for transaction of different DC voltage values and make management of power at the two level of power system. The demand to improve the performance, fuel economy and passenger convenience and safety has grown drastically in recent times. The standard 14 Volt electrical power systems can no longer meet the demand of the modern day automobiles. The present in car voltage level from 14 volt to 42 volts can be boosted which in turn increases the power capacity to 8 KW. Here we are introduce a Bi- Directional DC/DC converter, It contains control circuit which is able to determine the operating mode based on the direction of inductance current, after that it stabilizes the closed loop without changing the present parameters of the system. The DC/DC converter which is used for automobiles has a strict requirement for cost, volume and efficiency. A Buck/ Boost converter is used for this requirement. Switching power supplies offer higher efficiency than traditional linear power supplies. They can step-up, step-down, and invert. Some designs can isolate output voltage from the input. This article outlines the different types of switching regulators used in DC-DC conversion. It also reviews and compares the various control techniques for these converters. DC/DC converter has gained interest in both the industry and in the academic world of the power electronics field, which can perform as a platform for the transaction between different voltage values and make management of power at the two level of power system

II. RELATED WORK

In reference paper [1] authors introduce a Power electronics system that is implemented in the automotive systems and it is expected to work under environmentally harsh conditions while achieving high power densities. One such example is the bi-directional dual voltage DC/ DC converter that is utilized in the dual voltage networks of ultra modern vehicles. This paper presents the design and implementation of such an automotive converter for an Integrated System Module. The presented prototype achieves a high power density in extreme environment conditions using liquid coolant technology. In reference paper [2] authors introduce a phase locked bi-directional converter with a pulse charge function is proposed to increase the efficiency of the battery charge. The topology of the phase locked bi-directional converter is same as that of a current- pump phase locked loop (CP- PLL). Using CP- PLL inherent characteristics a new bi-directional DC/ DC converter is designed with a better efficiency and performance characteristics. In reference paper [3] a Current bi-directional dc/dc converter used in standalone PV system was introduced. The converter circuit topology and operation principle of presented was analyzed, a control strategy of PWM duty cycle and phase shifting technology was proposed. The ZVS realization of MOSFET, output power characteristics, was analyzed theoretically and the converter small signal model was established based on analysing in state space average mode. Finally the simulation result illustrates the system

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Volume 5 Issue VI, June 2017
ISSN: 2321-9653
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analysis with a prototype. In reference paper [4] authors presented a process for the design of a buck-boost dc/dc converter for the use of a generator controller in series hybrid electrical vehicle. The converter allows a single permanent magnet dc (PMDC) to be used for both engine starting and generating modes. The power electronics and the control system methodology are studied and refined using PSCAD/EMTDC transient simulator as a design tool. Several operation scenarios are studied using parametric tools. A control system is designed for which the parameters are designed and optimized using non-linear simplex simulation technique.

III. OPERATING PRINCIPLE OF BI-DIRECTIONAL DC/DC CONVERTER

The implementation of 14v/42v converter with a buck- boost topology using an active switch instead of a diode is more desirable. As bi-directional operation is possible without any additional requirement of components and efficiency is very high than a typical buck-boost converter using a diode. The two active switches turn on and off alternatively through the main switches or the freewheeling diodes as per the mode of operation. The DC/DC converter is connected parallel with the batteries with 42 volt and 14 volt loads on either side of the circuit. The control method which is used is the current control method instead of a voltage control method, since the mode of operation is detected by the change in the inductor current, not by inductor voltage and more over current control method has a faster response than voltage control method. The further advantage is stability as current control loop is more stable than a voltage control loop. The three modes of converter operation can be listed as follows, (i) when the inductor current is above zero, the converter works in the buck mode and the 42 volt energy bus provides energy to the sides, 42 Volt loads as well as charge the batteries also. The second mode of operation involves (ii) when the inductor current is above zero; the converter operates in the boost mode. The 14 volt bus provides
energy to the both sides of the load and charge the battery, (iii) when the inductor current repeats working through the zero, the converter operates in the alternating mode.

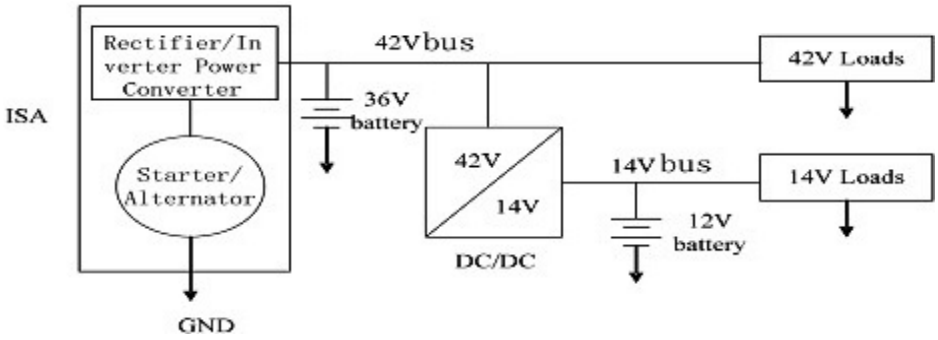

Fig 1: Fundamental Block diagram of 14/ 42V System.

The working is determined by the loads and the voltage of buck and boost converter, but it is un necessary to design two separate buck and boost converter, so the main aim of this article is to design a single converter implemented with both boost and buck action.

IV. METHODOLOGY

The experimental design and analysis of the bi-directional DC/DC converter circuit is implemented using the MATLAB (SIMULINK) software. The simulation of the circuit is needed in order to design the real time prototype circuit with the exact design parameter. The details about the software and the simulation procedure are given in detail in the next paragraph.

Simulink SIM POWER SYSTEM is a package that comes under the MATLAB software. Simulink software is a simulation tool kit, which can be used to design as well as to simulate the operation and output of a circuit with the given required parameters. The blocks of the Simulink software are pick and place types, which can be picked and place in the front panel and can be worked. The most common types of blocks to be used in the SIM POWER SYSTEM of the Simulink software are: Power electronic elements, Measurement, Sources, Power guided user interface, etc.

The circuit of the bi-directional DC/DC converter is first simulated using the Simulink software. Before realizing the closed loop response of the converter circuit, the open loop response of the circuit is obtained and then as per the required parameters the controller is design and then with the combine response of the open loop circuit and as well as the controller the closed loop response is obtained.

The simulation of the buck converter and the boost converter circuit is done by using the MATLAB (SIM POWER SYSTEM) software. The response or the output of the converters is obtained in the form of a response graph.

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ISSN: 2321-9653

Buck converter: - for the buck converter the input voltage is given as 12 volt and the output is obtained at 4 volt. There is a step down of voltage from a higher level to that of the lower level in case of a buck converter.

Boost converter: - for the boost converter the input voltage is given as 4 volt and the output voltage is obtained as 12 volt. It works just the opposite of the boost converter. It boosts up the voltages from a lower value to a higher value.

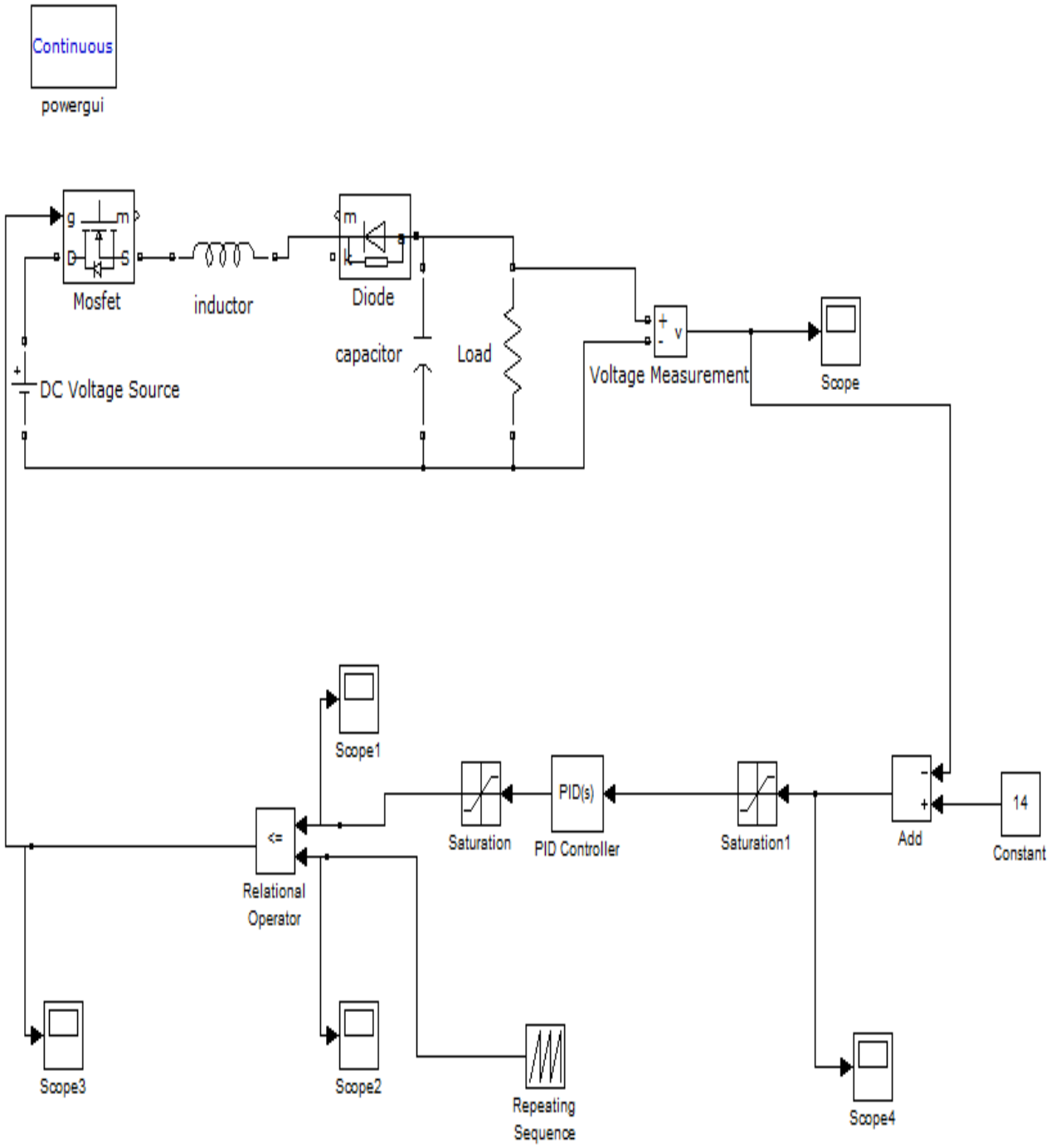

Fig: 2 Shows the closed control loop of Bi- Directional DC/ DC converter.

V. EXPERIMENTAL RESULTS

The proposed strategy was experimentally verified by simulation of a prototype model of Buck- Boost converter. There is no need of designing buck and boost converter separately. The simulated result of the buck and the boost converter is given as below:

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Volume 5 Issue VI, June 2017
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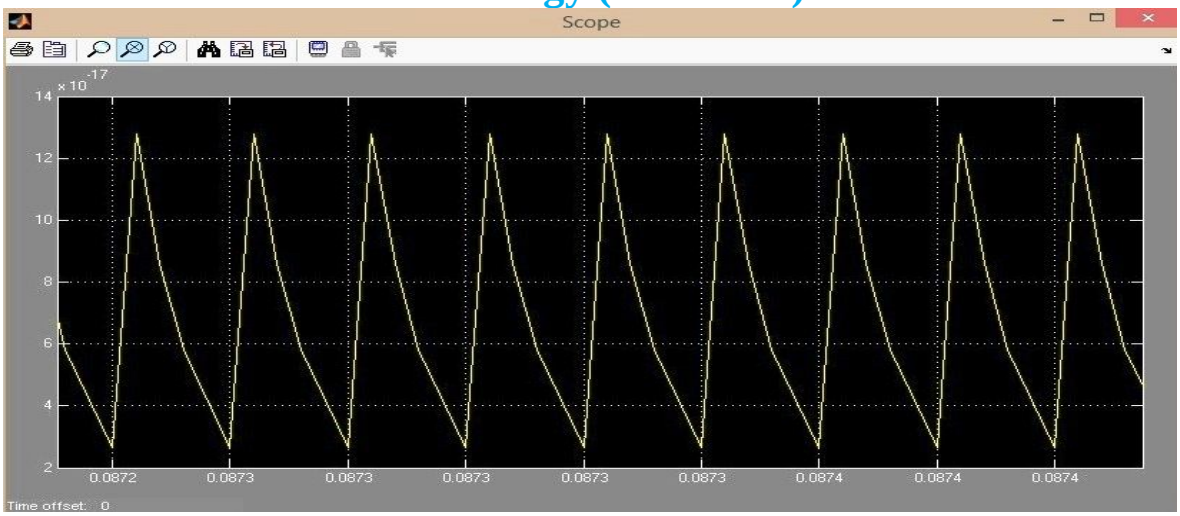

Fig 3: Boost mode Converter waveform

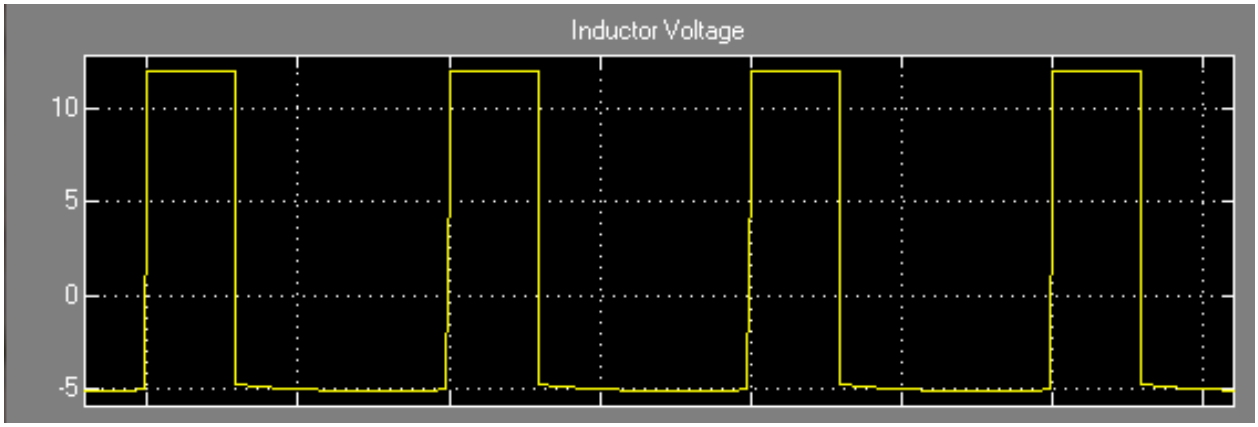

Fig. 4 Simulated Output Inductor Voltage for a Boost Converter

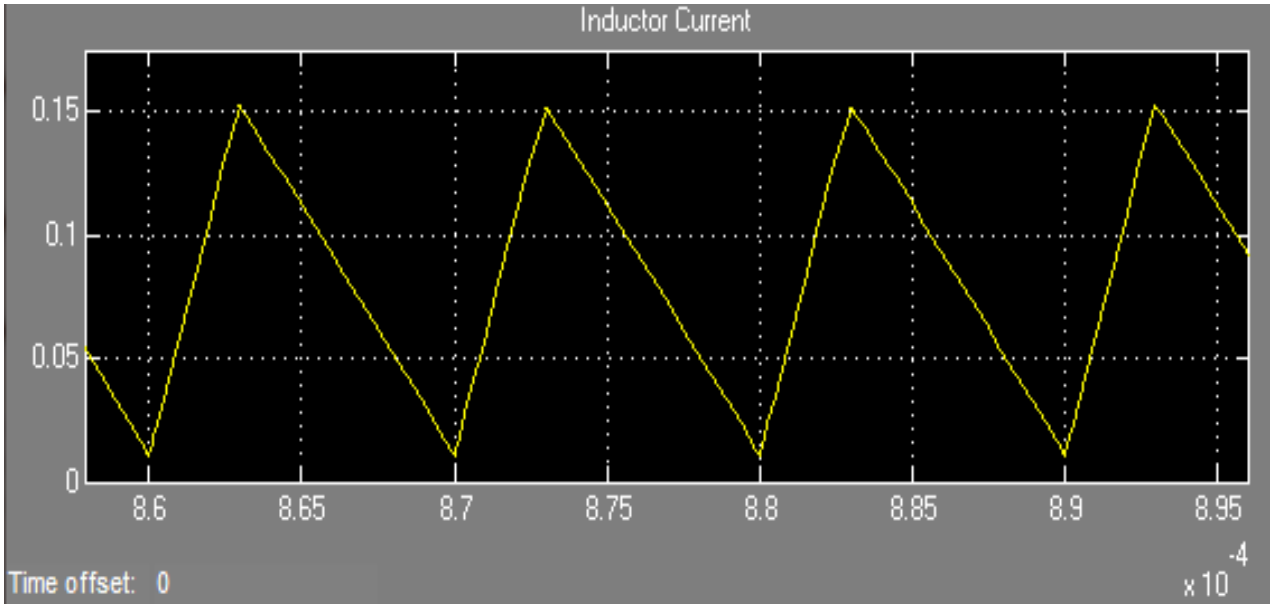

Fig 5: Simulated Output Inductor Current for a Boost Converter

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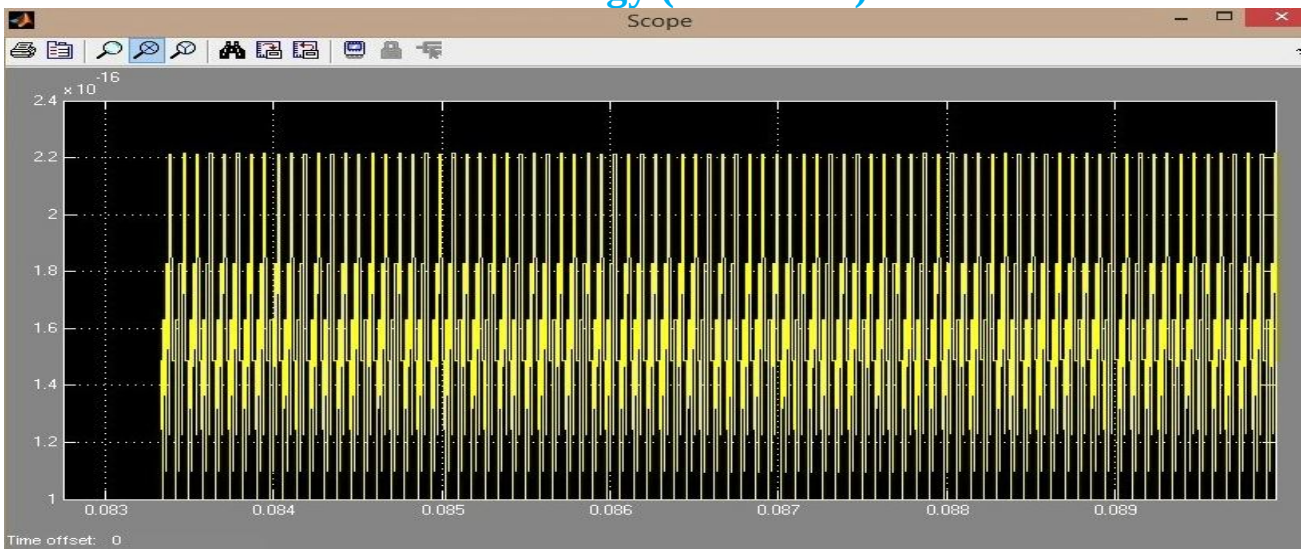
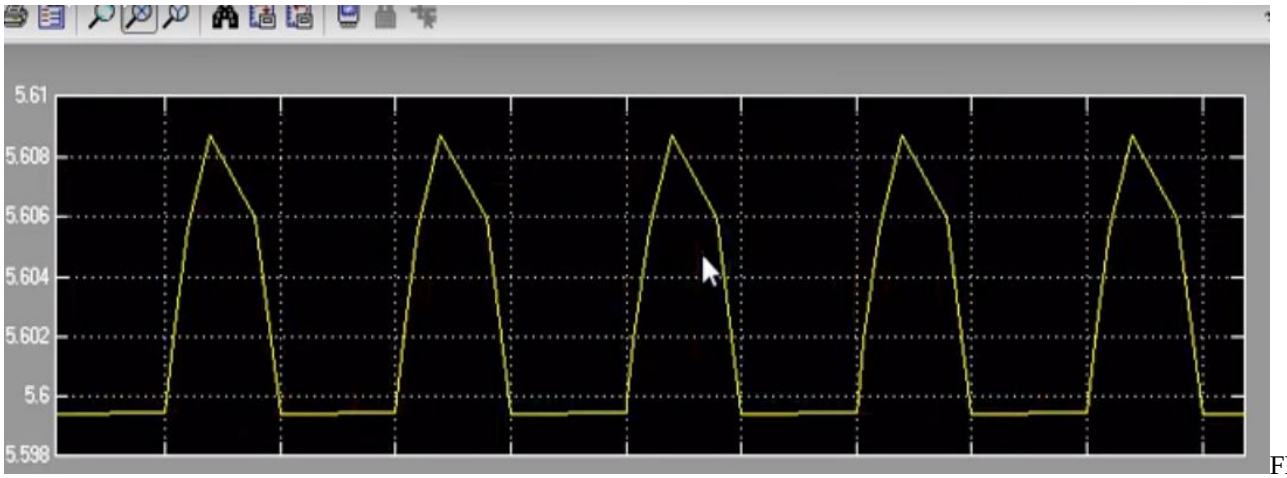


Fig 6: Buck mode Converter waveform



FFig 7: Simulated Output Inductor Voltage for a Buck Converter

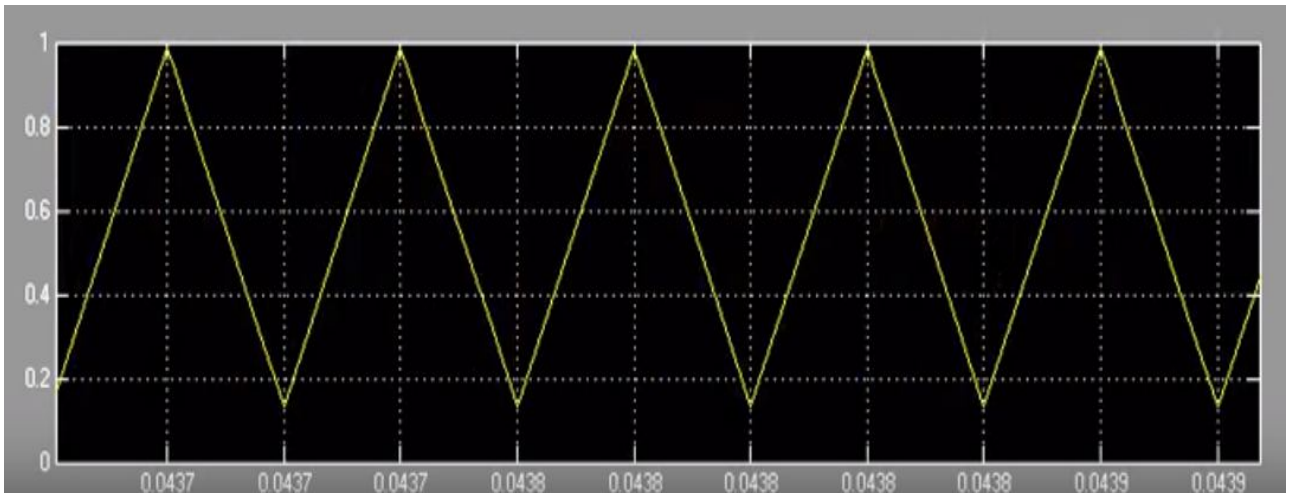


Fig 8: Simulated Output Inductor Current for a Buck Converter

Shows the simulated output wave form for buck and boost converter. The inductor voltages and inductor current for both buck

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mode and boost mode are also shown in waveforms. Both the input and output voltages are DC voltages.

VI. CONCLUSION

The Bi- Directional DC/DC converter has a promising prospect in the automation electronic area. This article proposes a bi-directional DC/ DC converter, which can work in both step up and step down mode. Current control method instead of a voltage control method, stability of current control loop is more stable than a voltage control loop. This proposed circuit can further be reinforced by extensive experimentation and future research.

VII. ACKNOWLEDGMENT

I take this opportunity to thank my teachers and my guide who provided constant encouragement and made it possible for me to take up challenge doing this thesis. I am very grateful to Mr. Nishant
for his technical support, valuable guidance, encouragement and consistent help. He has been constant source of inspiration and information for me. Last but not least, I am thankful to entire staff of mechanical department for their timely help and guidance at various stages of the thesis.

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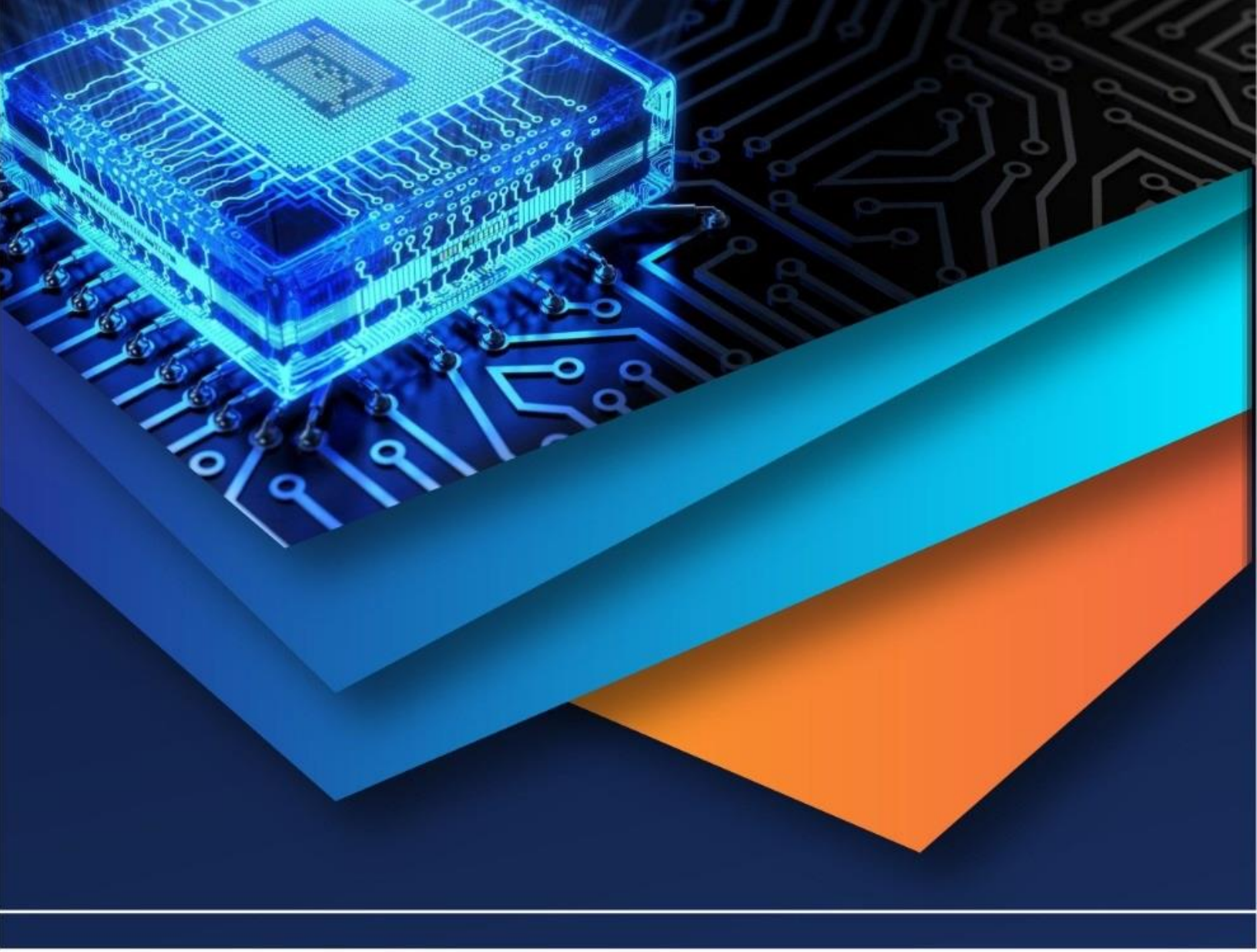

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