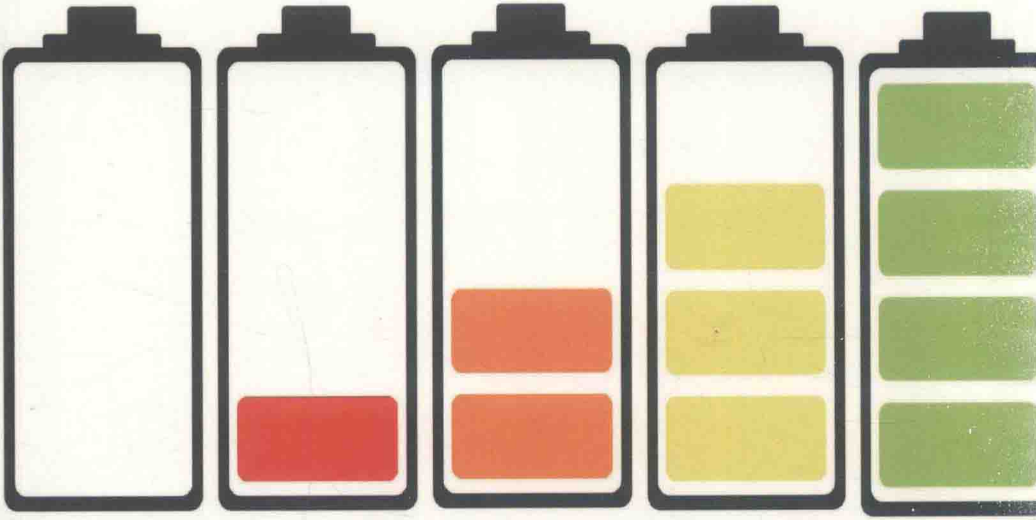

Debolina Dey

Gunjan J. Tetar

Bi- Directional DC/DC Converter for Automobile Use

LAP LAMBERT Academic Publishing

Debolina Dey
Gunjan J. Tetar

Bi- Directional DC/DC Converter for Automobile Use

LAP LAMBERT Academic Publishing

Impressum / Imprint
Bibliografische Information der Deutschen Nationalbibliothek: Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

Bibliographic information published by the Deutsche Nationalbibliothek: The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

Coverbild / Cover image: www.ingimage.com

Verlag / Publisher:
LAP LAMBERT Academic Publishing
ist ein Imprint der / is a trademark of
OmniScriptum GmbH & Co. KG
Heinrich-Böcking-Str. 6-8, 66121 Saarbrücken, Deutschland / Germany
Email: info@lap-publishing.com

Herstellung: siehe letzte Seite /
Printed at: see last page
ISBN: 978-3-659-54220-6

Zugl. / Approved by: Chennai, SRM University, Diss.,2012

ABSTRACT

As the development of in-car electronics and automatic parts, the capacity of current 14 volt voltage system no longer meets the demand of onboard devices. An upgrade is imminent. In order to be backward compatible with the existing system (14v) and not to introduce extensive modification, a dual 14/42V system is being developed as a compromising solution. Based on this new system, this project deals with the new bi-directional DC/DC converter. This new converter is able to conduct closed circuit control depending on current direction without changing the hardware control system of the vehicle. This bi-directional DC/DC converter basically uses a combination of Buck converter and Boost converter; so that it can provide voltage to both types of loads, i.e. 14 Volt loads and 42 Volt loads as well, without affecting the existing system.

LIST OF FIGURES FIGURE NO.

LIST OF TABLES

LIST OF ABBREVATIONS

DC	DIRECT CURRENT
AC	ALTERNATING CURRENT
V	VOLTAGE
A	AMPERE
μH	MICRO HENRY
μF	MICRO FARAD

CHAPTER-1:
INTRODUCTION

1.1 OVERVIEW OF THE PROJECT

Bi-directional DC/DC converter has gradually gained interests in both industry and academic world of power electronics, which can perform as the transaction platform of different voltage levels and make management of the power of two voltage level. It has a wide scope in the application of automation electronics, especially in modern day cars, solar photo voltaic technology and wind power generation, etc.

The demand to improve the performance, fuel economy, passenger convenience and safety has grown drastically in recent time. The standard 14 volt electrical power system can no longer meet the energy demand of vehicles. Hence prospects have been made towards the boosting of the existing 14 volts to 42 volts, with this come into existence the bi-directional DC/DC converter which can perform both BOOST operation as well as BUCK operation, when ever needed.

The fundamental structure of the dual voltage system is that, two batteries are connected to 14 volt bus and 42 volt bus. The 42 volt bus is supplied with power which charges the 36 volt battery and sends energy to loads on the 42 volt side, the bi-directional DC/DC converter is placed between 14 volt and 42 volt buses and manages the power , allowing them to exchanged and deliver energy to loads on the 14 volt side as well. A control circuit is incorporated with enables the converter to decide the mode of operation, i.e. whether it will work on the boost mode or in the buck mode. The DC/DC converter has the feature of high efficiency, simple circuit and low cost.

1.2 COMPONENTS OF THE DC/DC CONVERTER

The bi-directional DC/DC converter is basically a power electronics based circuit has involves the use of both active and passive circuit components, such as: Active circuit components are MOSFET or Ideal Switches and passive circuit components are Capacitors, Inductors, Resistors and Dc voltage Source.

1.3 CONTROLLER DESIGN

The controller which is used in the bi-directional DC/DC converter is a current controlled loop. The control action which is being taken depends on the current across the inductor. Depending upon the current value, the controller takes actions which results in three operating mode of the circuit, which are as follows:

(1) Buck Mode: In this mode, when the inductor current is below zero, it discharges the circuit resulting it in reduction of voltage from 42 volt to 14 volt, hence it is known as BUCK MODE.

(2) Boost Mode: In this mode when the inductor current is above zero, the circuit starts getting charge; hence the 14 volt is raised to 42 volt. Hence it is called an s BOOST MODE.

(3) Alternating Mode: In this mode the inductor current repeats and the energy flow direction will be determined by the loads.

1.4 SUPPLY VOLTAGE

The circuit of the bi-directional DC/DC converter is supplied with an input voltage of 42V DC. The dc supply can be either obtained by rectifying an ac supply or by stacking batteries of 12 Volt each. In case of a rectifier application, a full wave bridge rectifier is used for the supply voltage, which can convert 230 volt alternating current into some constant DC output voltage.

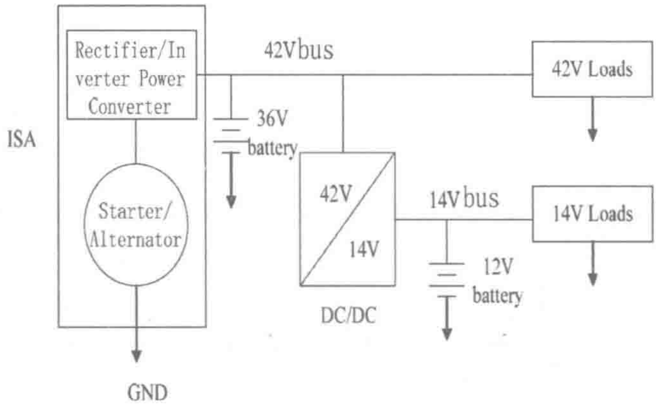

Fig 1.1:Basic Block k diagram of Bi-Directional DC/DC converter

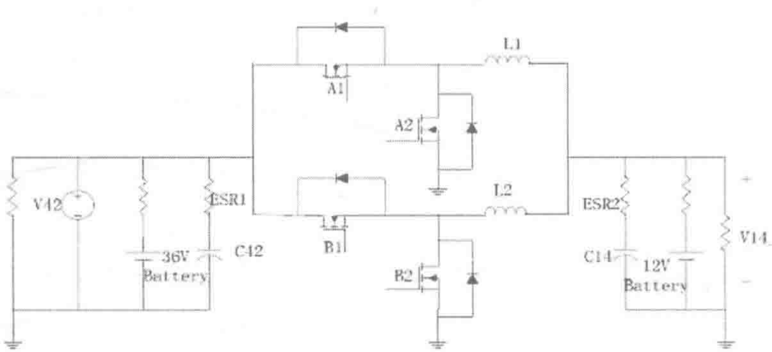

Fig 1.2: Proposed circuit of Bi--Directional DC/DC converter

CHAPTER- 2:
LITERATURE REVIEW

2.0 A BI-DIRECTIONAL ISOLATED DC-DC CONVERTER AS A CORE CIRCUIT OF NEXT GENERATION MEDIUM VOLTAGE POWER GENERATION. (IEEE 2007)-

This paper describes a bi-directional isolated dc-dc converter considered as a core circuit of high power density conversion system in next generation .The dc-dc converter is intended to use power switching devices based on silicon carbide or gallium nitride which will be available easily in the market, in the near future.

2.1 A BI-DIRECTIONAL FORWARD- FLYBACK DC/DC CONVERTER-

By- Fanghua Zhang, Lan Xiao, Yangguang Yao, (IEEE 2004).

This paper proposed a novel type of bi-directional dc-dc converters. The converters have the following merits: 1) the spike of the switches are much less than that of a current-fed type converter, the energy that causes the spikes are much smaller than that in current- fed converter, 2) the current on one side of the converter is continuous and the current ripple is less, 3) there is no start up problem in the forward-fly back type of bi-directional dc-dc converters, 4) it is easy to realize soft switching, 5) the hybrid structure of the forward and the fly back converters makes it suits for high power situation. The paper analyzed the steady state operation principles in detailed. Based on the principle of active clamp forward- fly back bi-directional DC-DC converter, a family of bi-directional DC-DC converters were proposed.

2.2 A BI-DIRECTIONAL DC-DC CONVERTER FOR FUEL CELL ELECTRIC VEHICLE DRIVING SYSTEM-

By- Huang- Jen Chiu and Li-Wei-Lin, Members of IEEE (IEEE 2006).

This paper presents a power converter for a fuel cell electric vehicle driving system. A new bi-directional, isolated topology is proposed in consideration to the differing fuel cell characteristics from the traditional chemical power battery and safety requirements. The studied converter has the characteristics of high efficiency, simple circuit and low cost. The detailed design and analysis were described in the paper.

2.3 A BI-DIRECTIONAL INTERLEAVING DC/DC CONVETER USED IN DUAL VOLTAGE SYSTEM FOR DRIVING SYSTEM-

By- Feng Wang, Fang Zhuo, Huan Guo, Senior Members IEEE. (IEEE 2009).

As the development of the in-car electronics and automatic parts, the capacity of the current 14 volt system does not meet the demand. An up gradation is required in order to be backward compatible with the existing system (14 volt), and not to introduce extensive modifications, a dual 14/42 volt system is invented o compromise with the existing system. Based on this article a bi-directional DC-DC converter was introduced. An experimental model based on the U3525 controller. Research on stability, reliability and capability etc., indicates that under changing power conditions the converter converts a value of dc voltage to another dc voltage and the conversion is carried out in both the directions. This comprises of a couple of boost and buck converters and a current controlled loop are used to drive the controller's logic.

2.4 PHASE LOCKED BI-DIRECTIONAL CONVERTER WITH PULSE CHARGE FUNCTION FOR 14 VOLT/ 42 VOLT DUAL VOLTAGE POWERNET-

By- Liang Rui Chen, Chung Ming Young. (IEEE 2011).

In this paper 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.

2.5 DESIGN AND EVALUATION OF AN AUTOMOTIVE INTEGRATED SYSTEM MODULE-

By- M.Gerber, J.A. Ferreira, N Seliger. (IEEE 2006).

Power electronics systems that are implemented in the automotive systems are 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.

2.6 THE INFLUENCE OF TURN OFF DEAD TIME ON THE REVERSE-RECOVERY BEHAVIOUR OF SYNCHRONOUS RECTIFIERS IN AUTOMOTIVE DC/DC CONVERTER-

By- Dieter Polenov (BMW Group), Tomas Reiter (BMW Group), Roman Burske.

The current communication from the channel into the body diode of a MOSFET synchronous rectifier as well as the relation of the PWM turn- off dead time and the reverse recovery behaviour are simulated and investigated experimentally. Both reverse-recovery charge and current can be significantly reduced by shortening the dead time to 10usecs. It leads to an overall converter loss reduction of several percent. The improvement of the reverse-recovery behaviour is based on the turn-on dynamics of the diode. In the considered case it takes several 10nsecs to enhance plasma in the n- region of the diode. Therefore turning off of the synchronous rectifier before the plasma has reached a steady state will lead to a lower reverse recovery charge.

2.7 JUMP STARTING- 42 VOLT POWERNET VEHICLES-

By- Paul R. Nicastri and Henry Huang (Ford Motor Company).

The automotive industry today is faced with ever increasing electrical power demands that are stretching the capabilities of the present on- board power supplies. The use of electrical and electronic features to enhance customer comfort, convenience, safety, such as electronic automatic climate cooling, automatic power brakes and anti lock brakes and traction control , etc., leads to the exponential growth in the power demand and also size and complexity of the system. With this ever increasing power demand the old 14 volt dc/dc converter couldn't serve the purpose, so for that a new 42 volt electrical system which consist of an 14/42 volt bi-directional dual voltage system.

2.8 RESEARCH ON A BI-DIRECTIONAL DC/DC CONVERTER APPLIED IN STAND ALONE PV SYSTEM-

By-LIU Shengyong, Zhang Xing, ZHU Yunguo (School of Automation Hefei University of Technology).

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 onanalysing in state space average mode. Finally the simulation result illustrates the system analysis with a prototype.

2.9 DUAL ACTIVE BRIDGE BUCK-BOOST CONVERTER-

By- Sangtaek Han (Student member, IEEE), Deepak Divan (Fellow, IEEE), Georgia Institute of Technology.

A novel isolated bi-directional dc/dc converter suitable for high power application was proposed. The proposed converter has a bi-directional power flow capability with low device rating with a wide range of voltage source. The converter is controlled by varying the duty cycle and the phase pulse of the firing pulse, to achieve power flow in both directions and to increase the current stress resulting in low total voltage device rating. The bi-directional dc/dc converter has a very high efficiency and the cost of implementation is also very less. Thus resulting in a good converter.

2.10 DESIGN OF A BI-DIRECTIONAL BUCK-BOOST DC/DC CONVERTER FOR A SERIES HYBRID VEHICLE USING PSCAD/EMTDC-

By- D. R. Northcott(Westward Industries Ltd.), S. Filizadeh(University of Manitoba), A. R. Chevrefils(Manitoba HVDC Research Center)(IEEE 2009).

This paper presents 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.

CHAPTER- 3:
OPERATION PRINCIPLE OF THE DC/DC CONVERTER

Implementing a 42V/14V converter, a synchronous Buck-Boost topology using an active switch instead of a diode is considered to be more desirable as bi-directional operation is possible without any additional components and efficiency is higher than that of a typical diode Buck- Boost converter. The buck- boost converter is consisted of two synchronous switches A1 and A2 or (B1 and B2), which alternately turns on and off through the main switches or the freewheeling diode according to its operation modes, depending upon the current across the inductor. The DC/DC converter is connected parallel with the loads on both the side of 14 V as well as 42 V side. The main power circuit is interleaving which can reduce to losses in both active and passive components especially low voltage high current converter. Interleaved multiple phases in order to reduce the component stresses. This will ultimately reduce the volume of the entire converter structure will is of prime importance to the project.

3.1 CONTROL METHOD

The control method which we are using is the average current control mode. Current control is preferred over voltage control as it controls the inductor current, which is faster than the voltage control method. Therefore the control system is consisted of the inner current loop and outer voltage loop, a voltage control loop which outputs the current reference is to make the output stable. The controller used in the circuit is mainly a PID controller, which gives a controlled output and also used to determine the modes of operation of the converter, which is completely based on the inductor current values.