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Simulation Modelling on ZVS Based MOSFET Inverter and IGBT Converter Fed PMDC Drive

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Abstract: This project proposes a zero voltage switching technique based combination of MOSFET inverter and IGBT converter fed PMDC drive. The proposed converter topology reduces voltage stress and conduction losses using zero voltage switching technique and also performs speed control of PMDC motor using PI controller. Proposed converter provides very efficient power conversion due to low voltage stress, less switching losses and requirements of power devices less. The proposed converter topology permits all switching devices to operate under zero voltage switching technique. Moreover, the voltage stress of the primary switches is reduced by using voltage divider which makes the low-voltage rated power devices available to improve the circuit performance and speed control of PMDC Motor using PI controller.

Keywords: Zero Voltage Switching, MOSFET inverter, IGBT converter, PI controller, PMDC motor.

I. INTRODUCTION

This Voltage stress and switching losses is major problems in much power conversion application. Power conversion from high input voltage to low load voltage is great significance in many application but major problem is voltage stress in controlled and uncontrolled power semiconductor devices such as IGBT,MOSFET,GTO,DIODE and other devices. Normally the voltage stress can be reduced with help of soft switching technique. In this project mainly focuses on improving conversion efficiency with help of reducing voltage stress across a power semiconducting devices and perform speed control of Permanent magnet DC motor using proportional and integral (PI) controller. There are many circuit topology introduced to reduce the voltage stress and voltage ripples among them phase shifted controlled converter topology is efficient for reduce above mentioning problems. In [1] Wide voltage gain for high input voltage application based converter topology is proposed. Here dc/dc converter topology consist two side like as primary and secondary side in primary side consist MOSFET switches connected in same leg bridge. It is act as three lever inverter circuit. In secondary side half bridge rectifier is used. In addition power losses are mainly comes due to improper manner of ON and OFF switching devices, secondary side rectifier uses diode is act as a switches. It is uncontrolled devices its trigger with help of hard switching technique. It produce more power losses and reduce the conversion efficiency due to voltage surges so it requires voltage production circuit for secondary side rectifier it improves the converter cost [2].Normally the voltage stress on primary side i.e. input voltage of an any converter or inverter, it can be reduced with help of voltage divider. In many power circuit capacitor is act as an voltage divider depending upon application. The switches are connected in series manner to obtain the more voltage stress. In [3] voltage level of a primary side can be reduced in one-third of an input voltage. Here main reason is switches are connected in series manner it is help full for voltage stress reduction. Let us consider high input voltage application like as railway, power communication system major problem is power conversion. It can be further reduced with help of multiphase power conversion technique here multiphase transformer act as connector between both sides of circuit topology. More number of switching devices is operated under soft switching technique; here zero voltage switching technique is used for triggering switches. In most application need large step down conversion it is obtain with help of multiphase power conversion in only one step but it need large amount of switching devices it leads more switching losses[4] so it is need proper conditioning system. Further converter topology is modified like combination of half bridge and full bridge converter [5], it is improved structure of hybrid converter topology. It is useful for high input voltage application. Diode rectifier is used in secondary side so rectification filter is no need. Resonant converter is consisting so many types,LCC circuit topology is also proposed to reduce the voltage stress and improve the conversion efficiency for high and wide input voltage application. In[6] proposed LCC series resonant converter topology for high input voltage application; here LCC circuit tank present in three level structure of primary side circuit and sharing the common transformer and resonant inductor. In the case of light load condition based application like switched mode power supply required adjustable wide range regulated voltage source [7] here switching devices are operated under soft switching technique. It is based on maximum operating frequency level and dead time of an region of inductance.

Zero voltage switching (ZVS) MOSGET inverter and IGBT converter fed Permanent Magnet Direct Current (PMDC) drive presented in this paper; Here the proposed converter topology consist two sides like primary side and

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another one is secondary side. This converter topology used IGBT and MOSFET power semiconducting devices it is act as a switches. Primary side circuit formed with help of MOSFET switches it is act as an three level inverter topology. Secondary side topology formed with help of IGBT devices it is act as an fully controlled converter. Both side switches are triggered with help of individual gate pulses. In the secondary side devices IGBT triggered with help of PWM generated gate signals. Here proposed converter topology devices are operated under zero voltage switching technique. Output of an converter is connected to PMDC motor; the motor speed controlled with help of PI controller. Normally speed controlled is obtain comparator is used to compare the reference speed and actual speed of the motor; the error signal regulated with help of PI controller. The output of an controller is given to PWM generator; gate pulses are generated with help of PWM generator this generated signal is given to secondary side switches. Proposed DC/DC converter switching devices are gets individual gate pulse so switching losses are minimized[14]-[18]. Capacitor are placed before the primary side switching devices normally it is act as an voltage divider; the main roll of this divider is divide the input voltage and equal voltages are shared all the switches so voltage stress easily minimized.

II. BLOCK DIAGRAM DESCRIPTION

In the fig.1the Permanent Magnet DC motor speed is controlled by a zero voltage switching based DC/DC converter. PI controller is used to control the operation of motor .The block diagram consist of three level inverter , fully controlled converter, PMDC motor and PI controller. Proposed converter topology functional block diagram operation following as, first DC input source is given to inverter. **Inverter:** A dc-to-ac converter whose output is of desired output voltage and frequency is called an inverter. Based on their operation the inverters can be broadly classified into two ways like Voltage Source Inverters (VSI), Current Source Inverters (CSI) .A voltage source inverter is one where the independently controlled ac output is a voltage waveform. A current source inverter is one where the independently controlled ac output is a current waveform. On the basis of connections of power semiconductor devices, inverters are classified as bridge inverters, series inverters and parallel inverters. Some industrial applications of inverters are for adjustable- speed ac drives, induction heating, stand by air-craft power supplies, Uninterruptible Power Supplies for computers, high voltage direct current transmission lines etc.

Converter: A converter is an electronic device that changes alternating current into direct current. This process is called rectification. It is classified into following way single phase converter and three phase converter according to connection it is further classified as half wave converter, full wave converter and bridge rectifier. Here using single phase fully controlled converter. Single phase uncontrolled rectifiers are extensively used in a number of power electronic based converters. It have some disadvantages liker inability to control the output dc voltage and current magnitude when the input ac voltage and load parameters remain fixed. These two disadvantages are the direct consequences of using power diodes in these converters which can block voltage only in one direction, these two disadvantages are overcome if the diodes are replaced by thyristors, IGBT, MOSFET and other power semiconductor devices the resulting converters are called fully controlled converters.

Transformer: Electrical Power Transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between to windings. It transforms power from one circuit to another without changing its frequency but may be in different voltage level.

PMDC motor: Normally motors are classified into two ways ac motor and dc motor among them dc motor is most suitable for smooth and efficient operation along with a wide range of speed control. In this paper used PMDC motor is a drive Permanent magnet dc motor is similar to ordinary dc shunt motor buy field is provided by permanent magnets

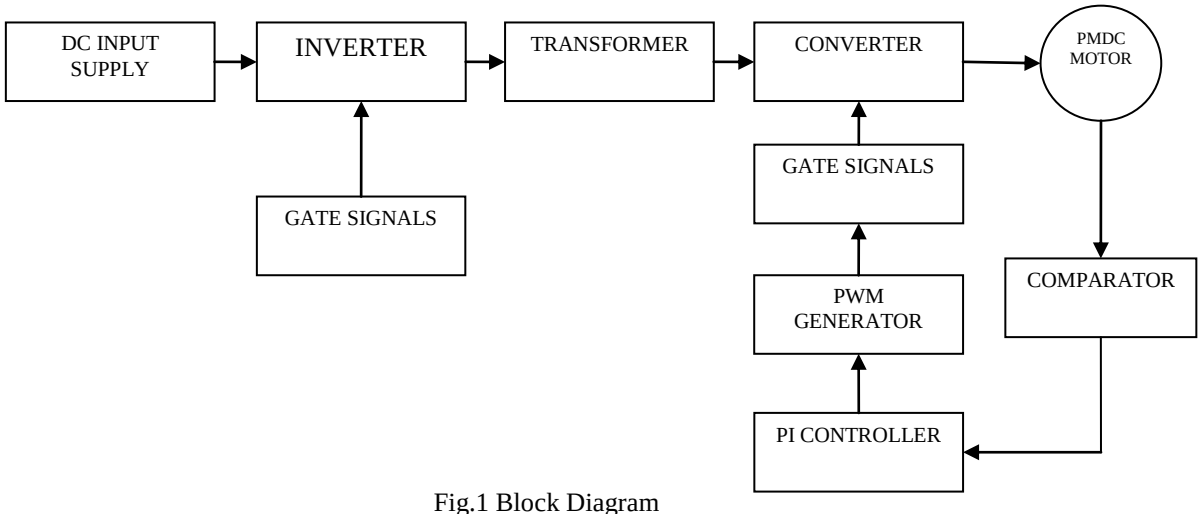

Fig.1 Block Diagram

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instead of salient pole would field structure. Major parts of this motor are stator and rotor. The permanent magnets of the PMDC motor are supported by a cylindrical steel stator which also serves as a return path for the magnetic flux.

The rotor serves as an armature. It has winding slots, commutator segments and brushes as in conventional dc machines. Permanent magnet motor rotors are radically magnetized, north and south poles alternating along the circumference of the rotor. A pole pitch is the angle between two poles of the same polarity, north to north or south to south. Both the rotor and the stator assemblies of PM motors are smooth. Here magnets is major part because field is provided by magnets so following types of magnets are used like alnico magnets, ceramic i.e. ferrite magnets and rare earth magnets these all are residual flux density and high coercivty. Normally PMDC motor used in much industrial application like by vendors of computer peripherals, office equipment, medical instruments, automobiles, robots and others.

PI controller: The controller shown here is a PI controller, where the PI controller get the voltage or speed feedback and it is given as the input .Then the speed error is compared with the reference speed and the output of the PI controller is used to control the fully controlled rectifier switches, i.e. as depends on the output of PI controller the gate pulse to the rectifier switches are produced. A simple PI controller scheme is given as PI controller will eliminate forced oscillations and steady state error resulting in operation of on-off controller and P controller respectively. However, introducing integral mode has a negative effect on voltage of the response and overall stability of the system. Thus, PI controller will not increase the voltage of response. It can be expected since PI controller does not have means to predict what will happen with the error in near future [6]. This problem can be solved by introducing derivative mode which has ability to predict what will happen with the error in near future and thus to decrease a reaction time of the controller.

PWM Generator: Pulse width modulation (PWM) is a modulation technique that conforms the width of the pulse, formally the pulse duration, based on modulator signal information. Although this modulation technique can be used to encode information for transmission, its main use is to allow the control of the power supplied to electrical devices, especially to inertial loads such as motors. The PWM technique classified as single pulse width modulation technique, multiple pulse width modulation technique, space vector pulse width modulation technique these all are different types of pulse width modulation technique. The use of PWM control in rectifiers eliminates the problems caused by using phase controlled rectifiers. The PWM rectifier can perform well in many applications, for example as an active filter, or as an input rectifier for an indirect frequency converter.PWM generator produce pulse width modulation signals given to rectifier.

III. PROPOSED CONVERTER CIRCUIT AND ITS OPRATION

The circuit diagram for proposed converter circuit is shown in fig.2.here single phase dc supply is given to the three level inverter. It will convert the dc voltage to stepped dc voltage. The output of an inverter is given to the fully controlled converter along with a transformer. Primary side of an dc/dc converter topology consist four switches and these all are connected same leg manner. Before the inverter topology two capacitor are connected between supply voltage and primary switches. Normally these capacitors act as an voltage divider. Here primary switches are MOSFETS. A transformer is connected between the primary side inverter and secondary side converter. In secondary side of fully controlled converter gets supply from transformer. Here insulated gate bipolar transistor IGBT act as an switches. The output of a converter is given to the PMDC motor. Here motor speed controlled with help of PI controller. The role of PI controller error signals is neglected and it is given to the PWM generator. And generated gate signals are given to the secondary side switches. As depends on the error signals from the PI controller the PWM generator produces respective gate puls to the secondary side IGBT switches. Here primary side switches triggered with individual gate pulses.

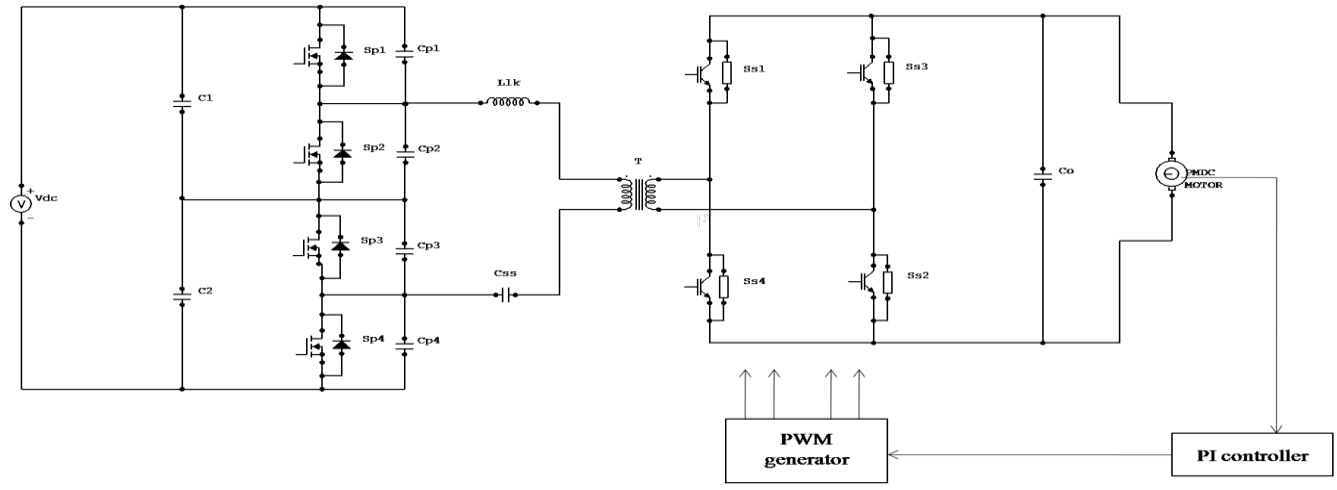

Fig.2 Circuit Diagram for MOSFET inverter and IGBT converter fed PMDC drive

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A. PRIMARY SIDE INVERSION OPERATION

Let us consider primary side circuit of proposed topology zero voltage switching based dc/dc converter. Here four MOSFETs are act as an primary switches namely Sp_1,Sp_2,Sp_3,Sp_4 and two capacitor are act as an voltage divider namely C_1 and another one C_2. In the wide range of high input voltage application primary side of a circuit switches operated under zero voltage switching condition. In the primary side circuit consist two pair of switches these pairs are operated in simultaneous manner. Here SP1 and SP4 act as an outer pair of switches and SP2 and SP3 act as an inner pair of switches and then outer pair of switches triggered with same gate signals and inner pair of switches triggered with opposite gate signals of outer gate signal. Two capacitor divide the input voltage and equal amount of voltage should be shared between the inner and outer pair switches. Gate pulses are given to the MOSFET switches then only start conduction and pairs of switches operated simultaneously. Normally voltage ripples comes due to huge amount of voltage surges these can be eliminated with help of divider so we can reduce the voltage ripples in input side. The output of an inverter is given to the fully controlled converter through transformer. Here transformer in connected between inverter and controlled converter. Here L_{lk} stands for transformer leakage inductor and capacitor is connected with transformer, this capacitor is used for blocking purpose. Each MOSFET connected across equal range of parallel capacitor. First outer pair switches are conducted and later inner pair of switches start conduction here all the switches operated with same duty cycle range. Fig shows the primary side operation of zero voltage switching based dc/dc converter fed PMDC motor.

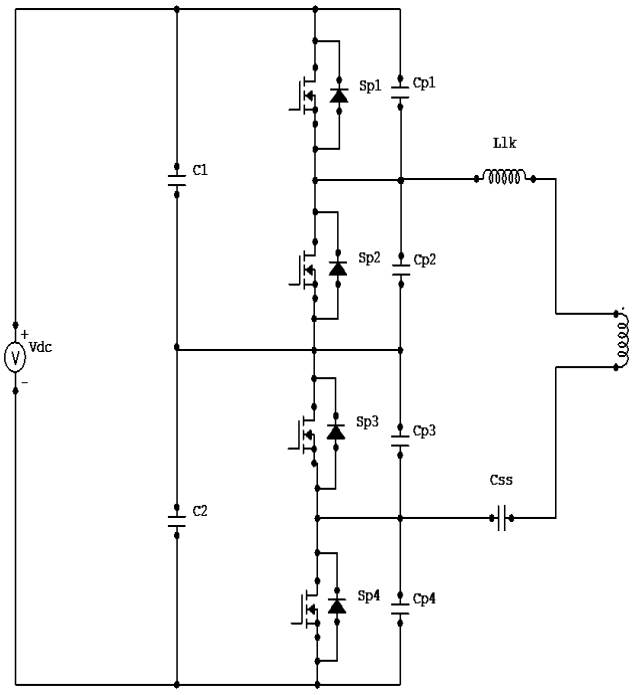

Fig.3 Primary side circuit

B. SECONDARY SIDE CONVERSION OPERATION

In the secondary side of converter topology gets supply from transformer. Previously three level inverter output is given to the transformer and output of its is given to input of secondary side fully controlled converter. Here it is act as an rectifier; in [1]-[2] semi controlled rectifier is employed in secondary side and also

Full bridge rectifier is use in [5] and [7] it has diode act as an switches it is uncontrolled devices formed secondary side topology. These all are produce some issues regarding conduction of diodes it is gives fixed dc output outage and each diode rectifying element conducts for one half cycle duration that is diode conduction angle is equal to the π radians. In [5]-[7] replaced with fully controlled rectifier; here insulated gate bipolar transistor (IGBT) in the fully controlled circuits so we can get variable dc output voltage and average current by varying the trigger angle i.e. phase angle. Here four IGBT switches namely Ss_1, Ss2, Ss3, Ss4 it is divided into two groups like upper and lower group. Ss_1 and Ss_3 present in upper group and Ss_2 and Ss_4 present in lower group of secondary side fully controlled rectifier

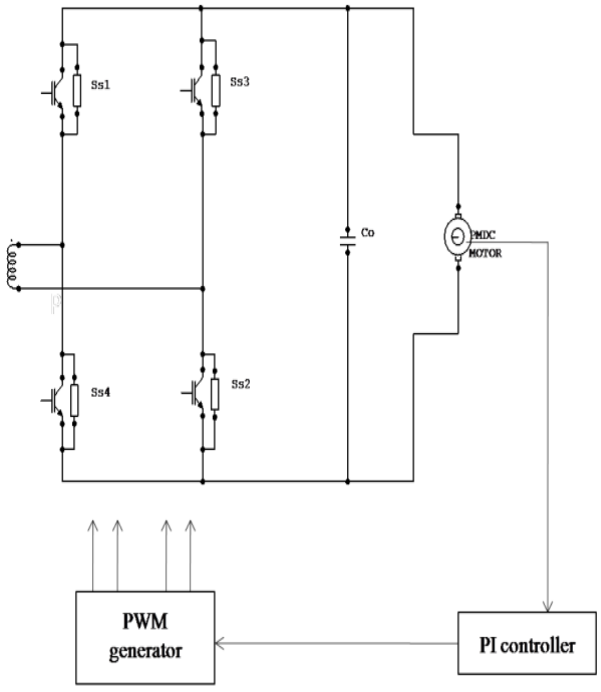

Fig.4 Secondary side circuit

IV. EXPERIMENTAL RESULTS

The proposed circuit is developed and analyzed with MATLAB software. MATLAB simulation modeling on zvs based MOSFET inverter and IGBT converter fed PMDC drive is shown in fig 5

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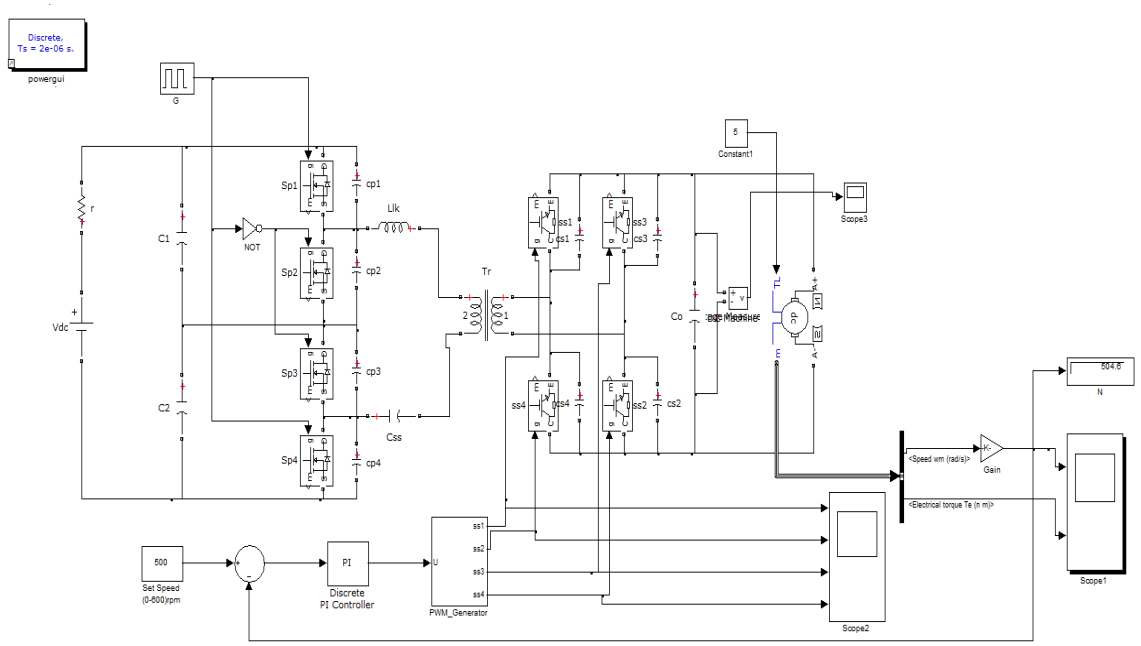

Fig 5 Simulation Diagram

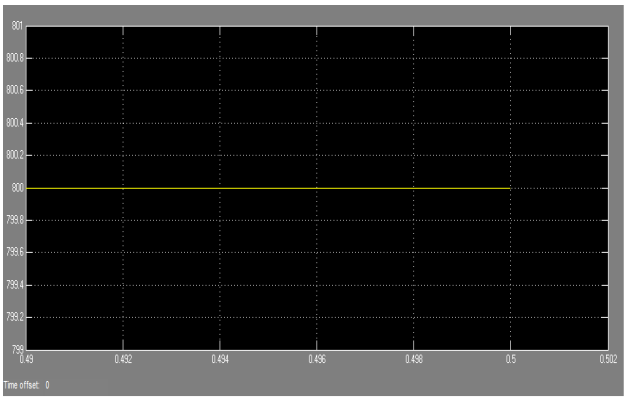

Fig.6 Input Voltage waveform

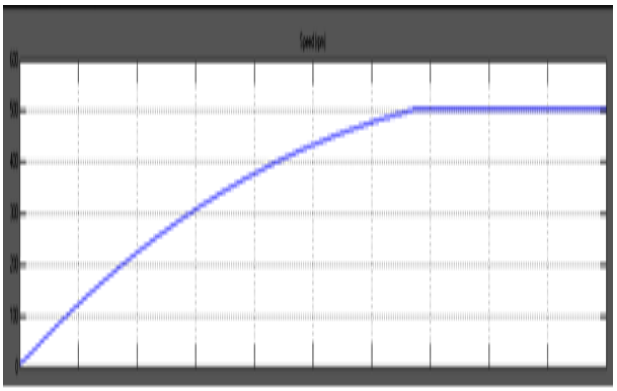

Fig.8 Fig 8 Motor speed waveform

Input voltage of an inverter is shown in Fig 6,In the case of high input application with wide voltage range we give high input voltage value of an inverter. MOSFET inverter is gets supply from dc input source. Fig 7 shows the converter output voltage waveform.

In this project motor speed controlled with help of PI controller. Here reference speed is compared with actual speed of the motor and then generated gate signals are given to secondary side converter. Motor speed is shown in above Fig 8.

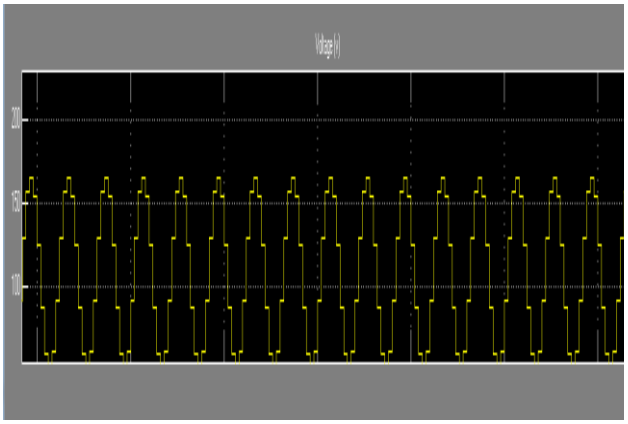

Fig .7 Output voltage

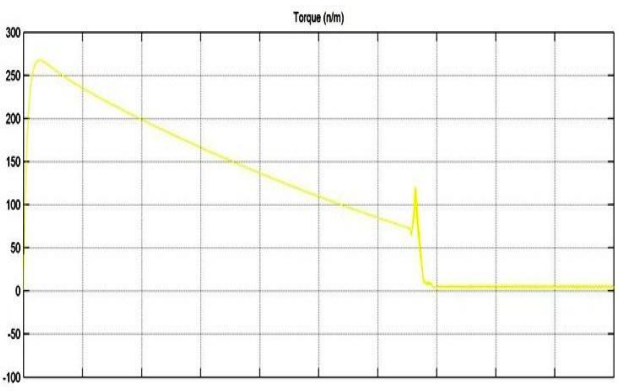

Fig 9 Motor torque waveform

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vel zero voltage switching technique based DC/DC converter fed PMDC motor, which has several advantages like voltage stress of an both sides effectively minimized and requirements of switches reduced. Here all the power semi conducting switches are operated under zero voltage conditioning. Secondary side phase shift pulse width modulation technique is used to control the fully controlled rectifier in the secondary side of the topology and thus regulates output voltage. The output of an phase controlled topology is given to PMDC motor and speed control is achieved by the help of controller. It is well suitable in application of high input voltage with wide range and high power like high voltage dc transmission and communication power system. In this work, the operation of this zvs based dc/dc converter topology and a method of speed control its steady-state operation were presented with PMDC motor as load. The feasibility of the converter was confirmed with results obtained from a Simulation prototype.

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BIOGRAPHY

Dr.Govindaraj Thangavel born in Tiruppur , India in 1964. He received the B.E. degree from Coimbatore Institute of Technology, M.E. degree from PSG College of Technology and Ph.D. from Jadavpur University, Kolkatta,India in 1987, 1993 and 2010 respectively. His Biography is included in Who's Who in Science and Engineering 2011-2012 (11th Edition). Scientific Award of Excellence 2011 from American Biographical Institute (ABI). Outstandin Scientist of the 21st century by International Biographical centre of Cambridge, England 2011.

Since July 2009 he has been Professor and Head of the Department of Electrical and Electronics Engineering, Muthayammal Engineering College affiliated to Anna University, Chennai, India. His Current research interests includes Permanent magnet machines, Axial flux Linear oscillating Motor, Advanced Embedded power electronics controllers,finite element analysis of special electrical machines,Power system Engineering and Intelligent controllers.He is a Fellow of Institution of Engineers India(FIE) and Chartered Engineer (India).Senior Member of International Association of Computer Science and Information. Technology (IACSIT). Member of International Association of Engineers(IAENG), Life Member of Indian Society for Technical Education(MISTE). Ph.D. Recognized Research Supervisor for Anna University and Satyabama University Chennai. Editorial Board Member for journals like *International Journal of Computer and Electrical Engineering*,International Journal of Engineering and Technology,International Journal of Engineering and Advanced Technology (IJEAT).International Journal Peer Reviewer for Taylor &Francis International Journal "Electrical Power Components & System"United Kingdom,Journal of Electrical and Electronics Engineering Research,Journal of Engineering and Technology Research (JETR),International Journal of the Physical Sciences,Association for the Advancement of Modelling and Simulation Techniques in

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