

Implementation of Soft Switching with Cascaded Transformers to drive the PMDC Motor

P.Ranjitha¹, V.Dhinesh², M.Muruganandam³, S.Saravanan³

PG Student [PED], Dept. of EEE, Muthayammal Engineering College, Rasipuram, Tamilnadu, India ¹

Assistant Professor, Dept. of EEE, Muthayammal Engineering College, Rasipuram, Tamilnadu, India ²

Professor and Head, Dept. of EEE (PG), Muthayammal Engineering College, Rasipuram, Tamilnadu, India ³

ABSTRACT: This paper presents a soft switching technique used along with the cascaded transformer to run a PMDC motor. The three level PWM circuits with two active switches and the capacitors are connected in parallel with it. There are only two switches used in the conventional method. In the conventional method there are four switches and four transformers are used. But in the existing system only two transformers can be used, so that the leakage inductance can be reduced. The series resonant converter is used to achieve ZVS turn-on for all power switches and zero-current switching for all rectifier diodes. The switching losses of the switches and the reverse recovery loss of the diodes are reduced. The resonant converters has wide range of switching frequency that can be overcome by adopting the PWM method to regulate the output voltage. The cascaded transformer are used in the primary and secondary side to balance and share the current which is supplied to the load. The PMDC motor can be used as load. The conventional method does not use any controller to control the resistive load. The voltage of the motor can be sensed by using the fuzzy logic controller. The leakage inductance can be reduced by making the frequency constant.

KEYWORDS: ZVS, ZCS, Fuzzy logic controller, PMDC motor, Converter, Cascaded Transformer.

I. INTRODUCTION

In the conventional system three Dc converters has been used obtain high output voltage and current. A resonant circuit in the power path, the switches can be configured to operate at either zero current or voltage points in the waveform, greatly reducing their stress levels, the resonant sine wave minimizes higher frequency harmonics reducing noise levels. Three level ZVS or ZCS converters [1-3] have been proposed to reduce the switching losses at the desired load range. To extend the range of the ZVS or ZCS the additional circuitry or leakage inductance has been used. The series resonant converters with variable switching frequency have been presented to have the advantages of high voltage gain and high circuit efficiency with a wide load range. The series resonant converters have been widely adopted in the commercial computer and communication products [3-6]. A resonant mode system gives the several benefits avoids many of the disadvantages occurred due to higher frequencies. While using a resonant circuit in the power path, the switches can be easily operate at either zero current or voltage in the waveform, so that the stress level of the switches can be reduced; the resonant sine waves reduces the higher frequency harmonics that minimises the noises and so the circuit now requires inductance and capacitance, parasitic elements may enhance the circuit performance. This benefits helps, power systems operating in the range of 500 kHz to 2.0 MHz. Even though the resonant converters has wide range of frequency from light load to full load the magnetic components in the series resonant converters are not easy to design at the optimal condition. so it is better that the dc-dc converter has the advantages of ZVS and ZCS functions in the series resonant converter and the constant switching frequency with duty cycle control. A new two level ZVS converter is presented for high input and current applications. The switches in the existing system are less than the conventional system. The selected switching frequency is less than the series resonant frequency. Thus, power switches can be turned ON at ZVS and rectifier diodes can be turned OFF at ZCS within nearly entire load range. The switching loss of MOSFETs and the reverse recovery loss of diodes are reduced. The voltage stress of MOSFETs is clamped at one-half of input voltage due to the three-level circuit topology. The capacitors are used instead of the

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

mosfets so that the switching losses can be reduced. The primary and secondary of the transformer connected in series to balance the load current and the load can be changed as PMDC motor instead of the resistors connected in the proposed method. The PMDC motor is a dc motor which has stator and rotor with it. The PMDC motor has a permanent magnet as a rotor the other features are like a dc motor. The PWM level has been reduced in the existing system. Three-level PWM circuits with the same power switches are adopted for high output current applications. The main drawback of the conventional method is that to achieve ZVS is very difficult only the energy stored in the leakage inductance of the transformer can be used to achieve ZVS. By adding external resonant inductance in series with the primary side of the transformer [6-9] it will cause duty cycle loss and increase the oscillations on the secondary side of the transformer. The transformer switching losses of power switches are reduced and the reverse recovery losses of rectifier diodes are eliminated. The ZVS, ZCS combination gives leading mechanism of the switches and thus the duty cycle can be increased by making the frequency as constant. The main objective of this method is summarised as,

1. To run the PMDC motor by using the cascaded connected transformer with the help of soft switching technique.
2. To reduce the leakage inductance by making the frequency constant and increasing the duty cycle.

II. BLOCK DIAGRAM

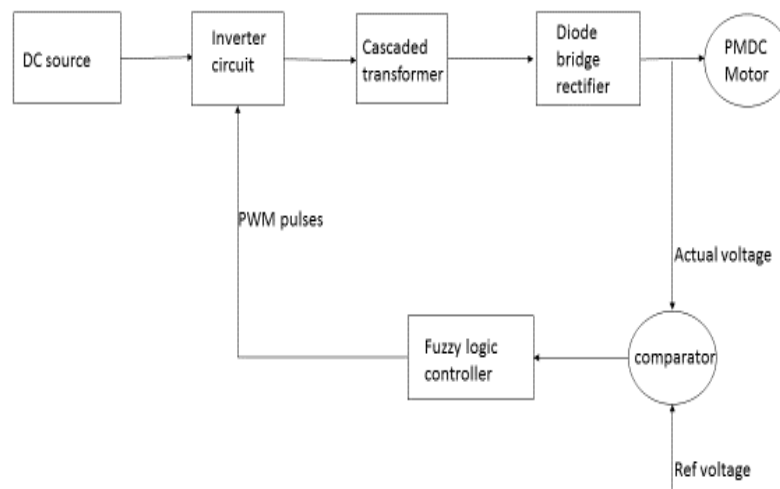


Fig.1.block diagram of proposed

In fig1 the dc supply is given to the switches in the inverter circuit. The converters can be switched on and off to give the signals so that it becomes a pulsating dc. The pulsating dc can be given to the transformers, and then the voltage of 24 can be stepped up by the cascaded transformer to 48v. The cascaded transformer is connected to a diode bridge rectifier it converts the ac in to dc and then it can be gives to the PMDC motor. The actual voltage and the reference voltage can be compared by using a comparator and then the comparator gives signals to the fuzzy logic controller. The controller controls the given signals and gives to the PWM generator, it modifies the width of the pulse and the pulse is gives to the inverter switches. So that the voltage of the PMDC motor can be controlled.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

III. CIRCUIT CONFIGURATION

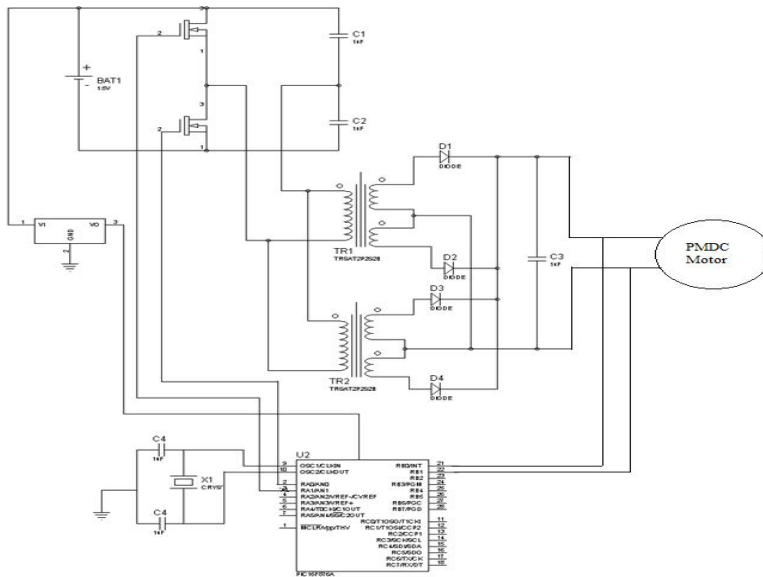


Fig2. Circuit diagram of proposed system.

In fig2 as we discussed in the block diagram, the input dc voltage of 15v is supplied to the half bridge inverter circuit. The inverter ac voltage is fed to the isolator or transformer (Tr1, Tr2) where it can be stepped up to 26v. Since the stepped up voltage is directly fed to the PMDC motor, it has been converted in to a dc voltage by using a diode bridge rectifier. The output voltage is sensed and compared with the reference voltage inside the controller. The controller used here is the micro controller where the fuzzy logic program is installed inside in it. By comparing the output voltage and the reference voltage the micro controller generates the PWM pulses based on the fuzzy logic and the pulses is used as the gate pulses to the inverter circuit.

The switches S_1 , S_2 can be used instead of using large number of MOSFETs the capacitors C_1 , C_2 can be used to minimise the switching losses. The series transformers size are further reduced to reduce the size of magnetic cores and winding turns and to balance the primary and secondary side currents of two circuit cells with the interleaved connection of transformer secondary windings.

A resonant converter, like all switching regulators, requires an output filter to smooth the power delivered to the load. This output filter must have a break frequency less than one fifth the /lowest switching frequency. Therefore we assume the current through L_o and the voltage across C_o are both essentially constant at the switching frequency. Instead of resistance the PMDC motor has been used as load [11-12]. The voltage stress of each power semiconductor is clamped at $V_{in}/2$ and the current stresses of each transformer secondary winding and the rectifier diodes are equal to half load current. There are two modes in the existing system that is shown below.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

IV .OPERATING MODES OF CONVERTERS

MODE1:

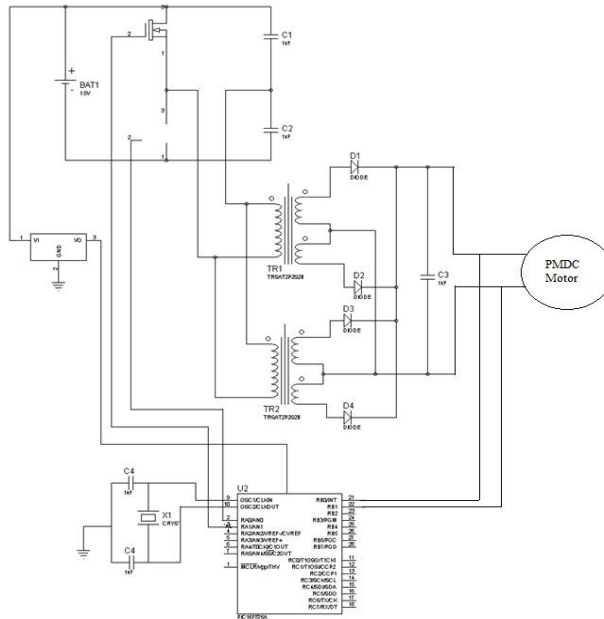


Fig3.Model1 circuit configuration.

Fig3 illustrates model1 at $t < t_1$ the switch S_1 is conducting S_1 can be turned on with zero voltage and the transformers primary voltages are negative for first transformer and primary voltage of second transformer are positive the primary of transformer T_1 , T_2 can be coupled the magnetising current i_{lm1} decreases linearly and i_{lm2} is simultaneously increases. The capacitor C_1 , C_2 stores some amount of energy before the switch is turned off in case of excessive power is need at that time the capacitor gives the power to the switches. Then the given voltage can be stepped up and gives to the bridge rectifier the output is given to the PMDC motor. The voltage can be sensed and controlled by the controller and gives PWM pulses to the inverter circuit.

The current through the inductor and resistor is given for model1,

$$i_{Lr1}(t) = \frac{nV_s - v_{Cr1}(t_0)}{\sqrt{L_r C_r}} \sin \frac{t-t_0}{\sqrt{L_r C_r}} + i_{Lr1}(t_0) \cos \frac{t-t_0}{\sqrt{L_r C_r}} \quad (1)$$

The voltage through the capacitor and resistor is given below,

$$v_{Cr1}(t) = nV_s - [nV_s - v_{Cr1}(t_0)] \cos \frac{t-t_0}{\sqrt{L_r C_r}} + i_{Lr1}(t_0) \sqrt{\frac{L_r}{C_r}} \sin \frac{t-t_0}{\sqrt{L_r C_r}} \quad (2)$$

MODE2:

In mode2 begins at $t_1 < t < t_2$ the switch S_2 is starts to conduct with the zero voltage and then slowly the voltage will increases to 26v by stepping up by the transformer then it can be converted in to the dc by using the bridge rectifier

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

before the supply is given to the PMDC motor the ripples can be filtered by the filter capacitor and then the output voltage can be sensed and controlled by using the fuzzy logic and the controller generates the PWM pulses which is used as input signals for the inverter circuit that is shown in fig4.

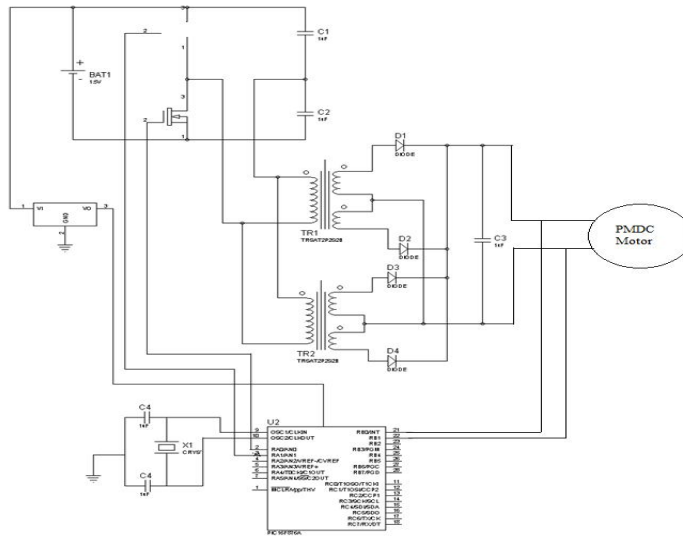


Fig.4.Mode2 circuit configuration.

For mode2 the current through the inductor and resistor is given as,

$$i_{Lr2}(t) = \frac{V_{in} - nV_o - v_{Cr2}(t_0)}{\sqrt{L_r C_r}} \sin \frac{t-t_0}{\sqrt{L_r C_r}} + i_{Lr2}(t_0) \cos \frac{t-t_0}{\sqrt{L_r C_r}} \quad (3)$$

The capacitor and resistor voltage is given for mode2,

$$v_{Cr2}(t) = V_{in} - nV_o - [V_{in} - nV_o - v_{Cr2}(t_0)] \cos \frac{t-t_0}{\sqrt{L_r C_r}} + i_{Lr2}(t_0) \sqrt{\frac{L_r}{C_r}} \sin \frac{t-t_0}{\sqrt{L_r C_r}} \quad (4)$$

Where, I_m is the peak value of magnitude inductor current.

V.RESULT AND DISCUSSION

The DC supply is given to [the switches, there are two switches used and two capacitors can be used to store the excessive energy dissipating in the circuit. The switches can be turned on and off alternatively. The soft switching technique of ZVS and ZCS can be implemented. The ZVS condition can be obtained when the PWM pulse is given to the switch the switch can be turned on at that time the voltages across the switch is zero. If the switches does not goes to the off state voltage remains in the zero. The input waveform of ZVS is shown in fig6

The ZVS condition can be obtained when the PWM pulse is given to the switch the switch can be turned on at that time the voltages across the switch is zero. If the switches does not goes to the off state voltage remains in the zero. The ZVS can be connected to the pulse generator and to the voltage controller. The ZCS condition can be obtained when the pulse is given to the switches the switch is turned on and the current across the switch is full. Whenever the switch is tuned on and off the current is full and goes to zero according to the switch position. The ZCS can be connected to the pulse generator and the current controller [12-13]. Both the ZCS and ZVS can be used to achieve the controlled output when the input is given to the series connected transformer. The output obtained from the PMDC motor is not a

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

controlled output because the fuzzy controller can be used to control the voltage applied to the motor but in future the speed of the motor can be controlled. The input waveform of ZCS is shown in fig7.

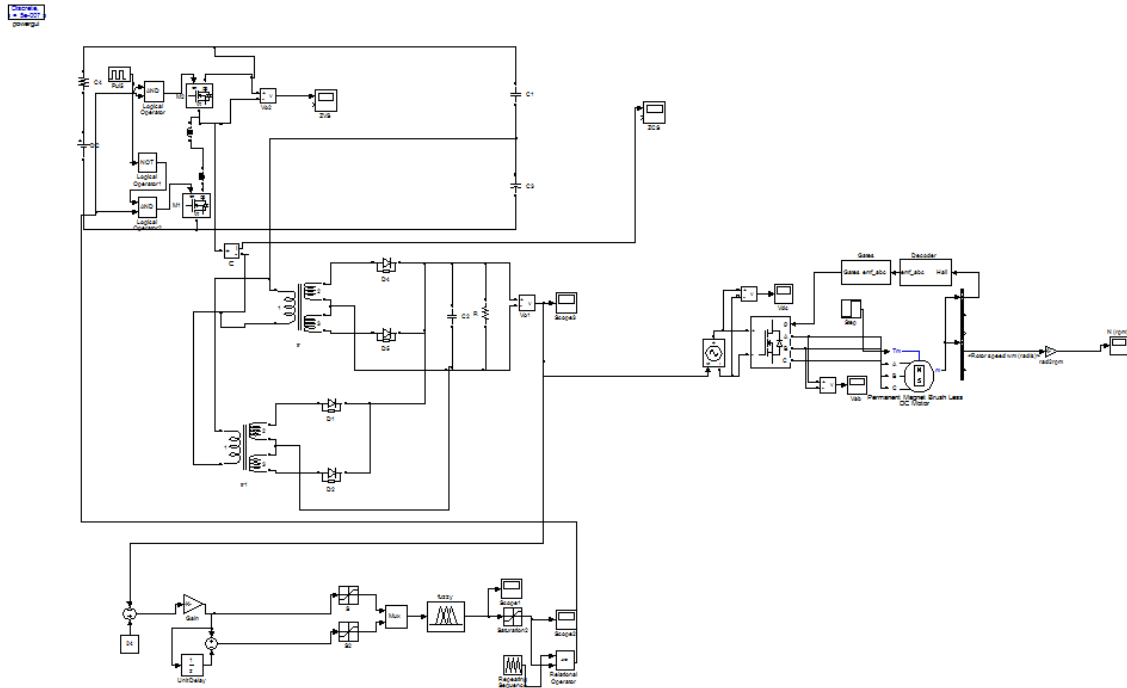


Fig.5.Simulation diagram

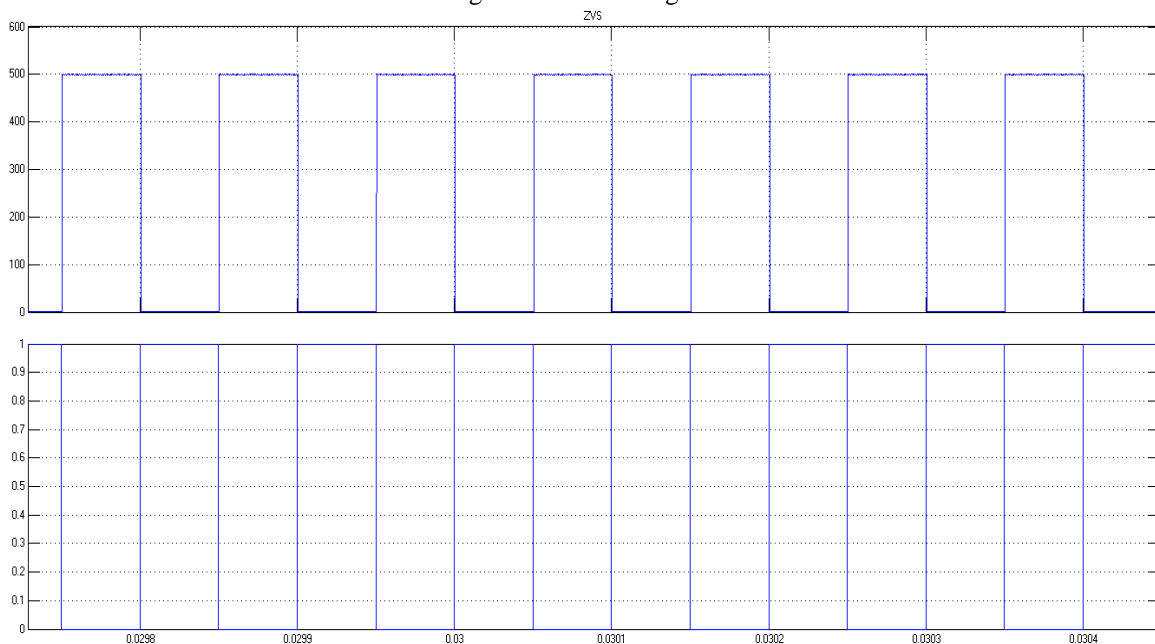


Fig.6. Waveform of ZVS.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

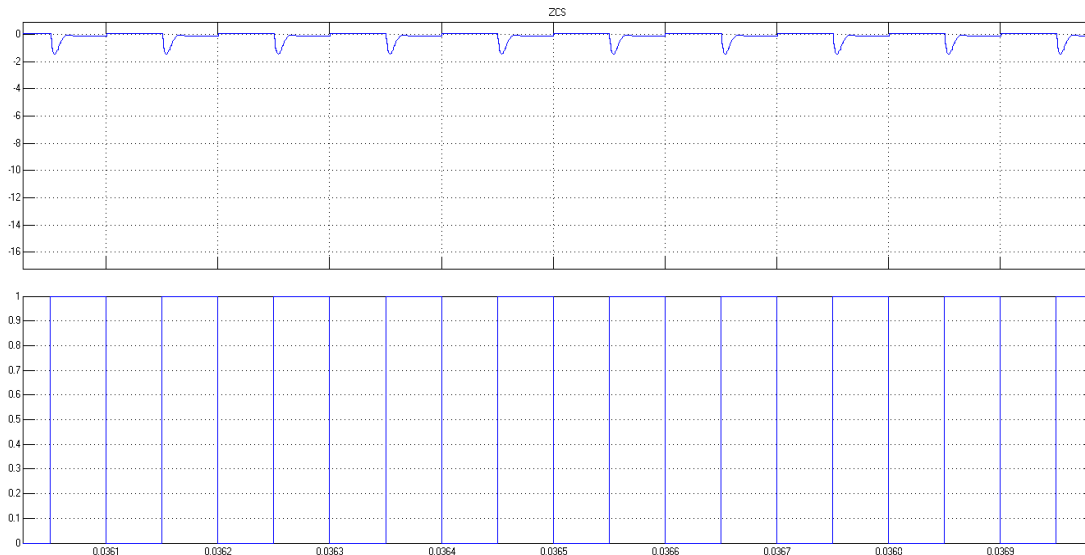


Fig.7. Waveform of ZCS.

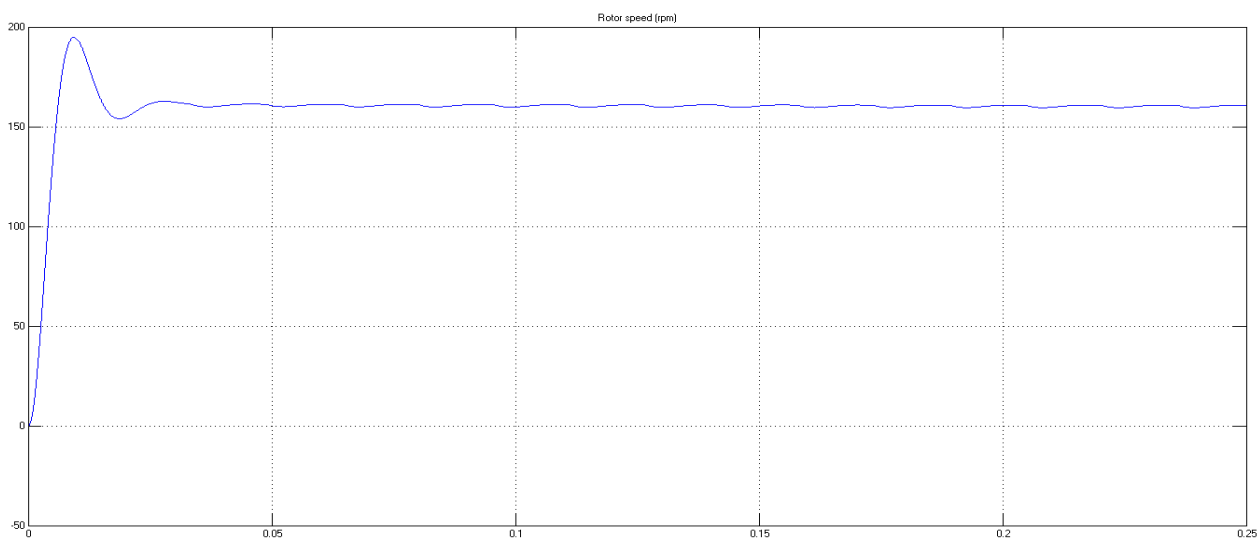


Fig.8. Waveform of PMDC motor

VI.CONCLUSION

A new PWM converter is presented to have the features of ZVS turn-on for all switches from 10% load to full load, ZCS for all rectifier diodes, low voltage stress of MOSFET, less switch counts, and low current stress of rectifier diodes. The PWM circuits sharing the same power switches are adopted to reduce the input ripple current and lessen the current stress of transformer windings and rectifier diodes. The centre-tapped rectifiers are used at the secondary side to have only one diode conduction loss. Compared to the conventional parallel three-level PWM converter, the proposed converter can reduce two MOSFETs, two clamped diodes, one flying capacitor, and one PWM controller and instead of MOSFETs, IGBTs can be used as a switching components since it has the advantages of both MOSFET and BJT [13-14].

In order to balance output currents of the PWM circuits, the transformers are connected in series at the primary and secondary sides. The fixed switching frequency with duty cycle control instead of the variable switching frequency in

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

the conventional series resonant converter is used to regulate the output voltage. The output voltage waveform is shown in fig. Based on the series resonant behaviour (switching frequency is less than series resonant frequency, all switches are turned ON at ZVS and all rectifier diodes are turned OFF at ZCS. Thus, the switching losses on power semiconductors are reduced [14-17]. By making the frequency constant leakage impedance of the transformers can be reduced. In conventional method the load used is resistive and none of the controller is used in that. The PMDC motor can be used as a load at loading condition then output voltage will be 26v and without load the output voltage is 46v.

REFERENCES

- [1] F. Liu, J. Yan, and X. Ruan, "Zero-voltage and zero-current-switching PWM combined three-level DC/DC converter," *IEEE Trans. Ind. Electron.*, vol. 57, no. 5, pp. 1644–1654, May 2010.
- [2] J. P. Rodrigues, S. A. Mussa, I. Barbi, and A. J. Perin, "Three-level zero-voltage switching pulse-width modulation DC-DC boost converter with active clamping," in *IET Proc.- Power Electron.*, May 2010, vol. 3, no. 3, pp. 345–354.
- [3] Malinowski, K. Gopakumar, J. Rodriguez, and M. A. Perez, "A survey on cascaded multilevel inverters," *IEEE Trans. Ind. Electron.*, vol. 57, no. 7, pp. 2197–2206, Jul. 2010.
- [4] D. Fu, Y. Liu, F. C. Lee, and M. Xu, "A novel driving scheme for synchronous rectifiers in LLC resonant converters," *IEEE Trans. Power Electron.*, vol. 24, no. 5, pp. 1321–1329, Oct. 2009.
- [5] W. Chen and X. Ruan, "Zero-voltage-switching PWM hybrid full-bridge three-level converter with secondary-voltage clamping scheme," *IEEE Trans. Ind. Electron.*, vol. 55, no. 2, pp. 644–654, Feb. 2008.
- [6] K. Jin and X. Ruan, "Zero-voltage-switching multi resonant three-level converters," *IEEE Trans. Ind. Electron.*, vol. 54, no. 3, pp. 1705–1715, Jun. 2007.
- [7] F. Canales, P. Barbosa, and F. C. Lee, "A zero-voltage and zero-current switching three-level DC/DC converter," *IEEE Trans. Power Electron.*, vol. 17, no. 6, pp. 898–904, Nov. 2002.
- [8] X. Ruan, D. Xu, L. Zhou, B. Li, and Q. Chen, "Zero-voltage-switching PWM three-level converter with two clamping diodes," *IEEE Trans. Ind. Electron.*, vol. 49, no. 4, pp. 790–799, Aug. 2002.
- [9] J. Rodriguez, J.-S. Lai, and F. Zheng Peng, "Multilevel inverters: A survey of topologies, controls, and applications," *IEEE Trans. Ind. Electron.*, vol. 49, no. 4, pp. 724–738, Aug. 2002.
- [10] Zhu and Howe (2000), "Influence of design parameters on cogging torque in permanent magnet machines," *IEEE Trans. Energy Convers.*, vol. 15, no. 4, pp. 407–412.
- [11] M Saravanakumar, C Harris Naveena, M Muruganandam, "Bidirectional Modular Multilevel DC/DC Converter with Wide Range of Control", *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol.4, issue,2, pp. 984-989, feb.2015
- [12] M Saranya, S Ramkumar, M Muruganandam, "Modelling and Simulation of High Step-Up DC/DC Converter for On-Site Generation System", *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol.4, issue,2, pp. 687-693, feb.2015
- [13] M Meera, M Muruganandam, "SEPIC Converter Based Switched Mode Power Supply Design for Battery", *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol.4, issue,2, pp. 679-686, feb.2015
- [14] Thangaraju, M Muruganandam, M Madheswara, "Performance Analysis and Experimental Verification of Buck Converter fed DC Series Motor using Hybrid Intelligent Controller with Stability Analysis and Parameter Variations", vol.10, issue,2, pp 518-528.
- [15] M.Muruganandam Haris Naveena.C , S.Dhanapriya, "Evaluation of Diabetic Macular Edema From Color Retinal Images", *International Journal of Advanced and Innovative Research*, vol.3, issue.12, pp.no, 284-287, dec.2014
- [16] J Vinoth, T Muthukumar, M Muruganandam, "Implementation of Distributed Maximum Power Point Tracking for Partially Shaded PV Systems", *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol.4, issue,2, pp. 702-709, feb.2015
- [17] P Ranjitha, V Dhinesh, M Muruganandam, "Soft Switching with Cascaded Transformers to Drive the PMDC Motor", *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol.4, issue,2, pp. 787-794, feb.2015