Modified Single Stage Three-Level Ac-Dc Converter For Dc Machine Drives

[1]C. S. Aswini, [2]Mrs. L. Jayasree, [3]Dr. M. Sasikumar

[1]P.G Scholar, [2]Assistant Professor, [3]Professor, Jeppiaar Engineering College, Chennai– 600 119, Tamil Nadu, India

Abstract

A performance of three-level single-stage AC/DC converter based DC machine drive system for industrial applications has been discussed. The difficulty of high power component stress caused due to high rising intermediate bus voltages at light load conditions is not found which is found in other single-stage converters because of its three-level structure. Though little harmonic distortion is found in input current, the operation is over a wider load range with significantly less output inductor current ripple. Here, the operation of the AC/DC converter is explained and analyzed, its results are discussed.

Index terms: *AC–DC power conversion, LC Filter.*

I. INTRODUCTION

The concept of multilevel converters has been introduced since 1975. Subsequently, many other multilevel converter topologies are developed. Though, the basic concept of a multilevel converter to achieve higher power is to use a series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform. Multiple dc voltage sources includes capacitors, batteries, and renewable energy voltage sources. The power switches combine the multiple dc sources in order to achieve high voltage at the output. But the rated voltage of the power semiconductor switches depends only upon the rating of the dc voltage sources to which they are connected. By adding passive filter elements to the traditional passive diode rectifier/LC filter input combination these standards are satisfied. The resulting converter would be very bulky and heavy due to the size of the low-frequency inductors and capacitors. Current-fed converters are connected with a boost inductor which is connected to the input of the full-bridge circuit, this can achieve a near-unity input power factor, but they lack an energy-storage capacitor across the primary-side dc bus, which can result in the appearance of high voltage overshoots and ringing across the dc bus. Multilevel converters can reduce the peak voltage stresses of the converters. They do not have the problem of discontinuous output current, distorted input currents and variable switching frequency.

II. CIRCUIT DESCRIPTION

Resonant converters, it can be controlled by varying switching-frequency control, which makes it difficult to optimize their design as they must be able to operate over a wide range of switching frequency. These converters have two conversion stages that allow a portion of the power that is transferred from the input to the output to be processed only once. It is for this reason that they are considered by some to be single-stage converter, but they have two converter stages and so have the cost and complexity associated with two-stage converter. Voltage-fed, single-stage, pulse-width modulation converters with a large energy-storage capacitor connected across their primary-side dc bus. The drawbacks of resonant and current-fed converters are not present here. They operate with fixed switching frequency, voltage overshoots and ringing from appearing across the dc bus is prevented by the bus capacitor. Voltage-fed converters have the following drawbacks such as: The primary-side dc bus voltage of the converter may become excessive under high-input-line and low-output-load conditions. The high dc bus voltage results in the need for higher voltage rated devices and very large bulk capacitors for the dc bus. The new voltage-fed converter has more advantages than the conventional converters. The peak voltage stresses of the converter devices is reduced, as the switch voltage is limited to half the dc-bus voltage. It is free from distorted input currents, discontinuous output current, and the use of variable switching frequency. The proposed converter has wide output load variation (from 10% of full load to a full load that is greater than 500 W), PWM control, excellent pf, a continuous output inductor current, without its components being exposed to excessive peak voltage stresses. The multilevel converter has dc bus voltage which can be split equally among the capacitors so that the capacitors and the converter switches are not exposed to the full dc bus voltage, but are exposed to half of it. This allows greater flexibility in the design of the converter as there is less need to constrain the dc bus voltage. It has greater flexibility in the converter design that allows for improvements in the performance of a single-stage full-bridge converter. The proposed converter is shown in Fig. 2.1. It consists of an AC input section, a three-level dc-dc converter, and dc link circuitry that is based on auxiliary windings taken from the main power transformer and that contains an inductor *L*in and two diodes.

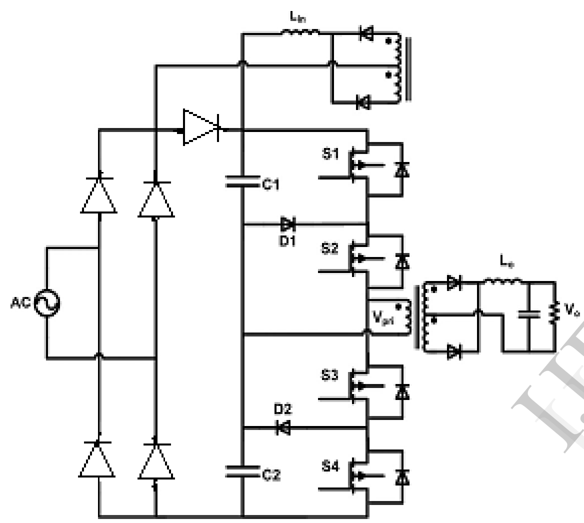

Fig 2.1 Proposed single stage AC/DC Converter

Diode D_3 only conducts current to charge the dc bus capacitor when the converter starts up. This does not operates when the converter is in steady-state. The dc link circuit acts like the boost switch in an ac-dc PFC boost converter. When the two converter switches are ON, a voltage is impressed across each auxiliary winding so that the voltage across one of the windings cancels out the voltage across the dc link capacitors which is the sum of the voltage across *C*1 and *C*2. This is opposite to the boost switch being ON and current in L_{in} rises.

III. THEORY OF OPERATION

During this mode, switches S1 and S2 are ON and energy from the dc-link capacitor *C*1 flows to the output load. Since the auxiliary winding generates a voltage that is equal to the total dc-link capacitor voltage (sum of *C*1and *C*2), the voltage across the auxiliary inductor is the rectified supply voltage. The characteristics of single stage AC/DC converter is shown in fig. 3.1. This allows energy to flow from the ac mains into the auxiliary inductor during this mode, and the auxiliary inductor current increases, according to

$$i_{L_{\text{in},k}}(t) = \frac{|v_{s,k}|}{L_{\text{in}}} \cdot t \qquad (1)$$

where |*vs,k* | is the rectified ac supply voltage during switching cycle interval *k*. The supply voltage can be considered to be constant within a switching cycle as the switching frequency is much higher than the line frequency. The current in the auxiliary inductor *L*in at the end of Mode 1 is

$$i_{L_{\text{in},k,\max}}(t) = \frac{|v_{s,k}|}{L_{\text{in}}} \cdot \frac{D}{2f_{\text{sw}}}. \qquad (2)$$

Duty cycle, *D*, is defined as the time when S1 and S2 are both ON during the first half cycle or when S3 and S4 are both ON during the second half cycle. These two cases correspond to energy transfer modes of operation. Since *D* is defined with respect to a half switching cycle *T*sw /2 or 1/2*f*sw , (where *f*sw is the switching frequency) the duration that is used in (2) is *D*/(2*f*sw).

Similarly, the output inductor current can be expressed as

$$i_{L_o}(t) = \frac{(V_{\text{bus}}/2N) - V_L}{L_o} \cdot t \qquad (3)$$

where *V*bus is the average dc-link voltage, *VL* is the load voltage and *N* is the transformer ratio between input and output (*N* =*N*pri /*N*sec). If the output inductor current is continuous then peak ripple current can be expressed as

$$\Delta i_{L_o} = \frac{(V_{\text{bus}}/2N) - V_L}{L_o} \cdot \frac{D}{2f_{\text{sw}}} \qquad (4)$$

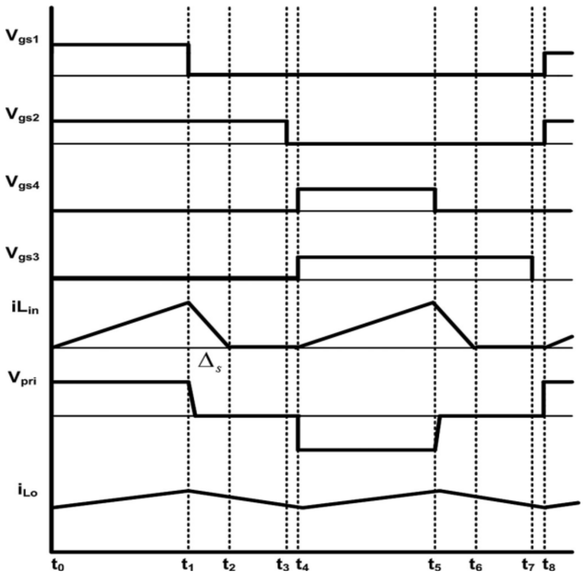

Fig 3.1 Waveforms of Three stage AC/DC Converter

IV. SIMULATION RESULTS

The simulation model of proposed circuit is given in fig 4.1.

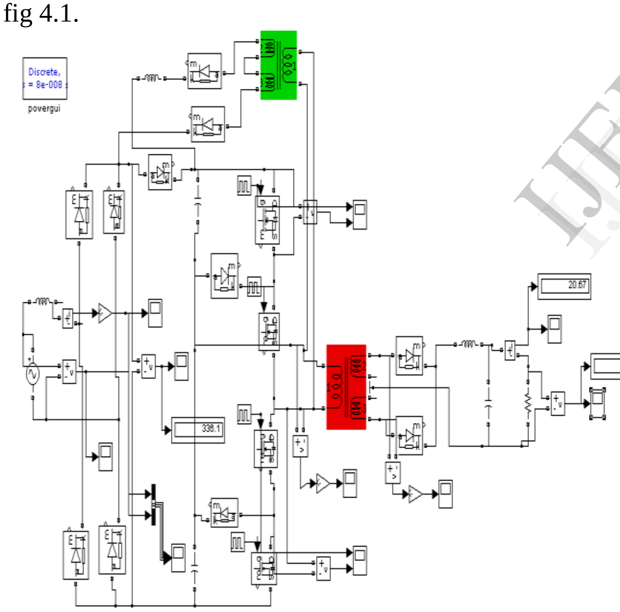

Fig 4.1.Proposed circuit

The input voltage, current of proposed circuit is shown in fig 4.2 & 4.3.

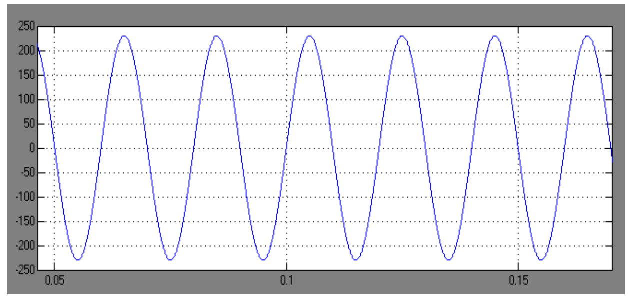

Fig 4.2 Input voltage

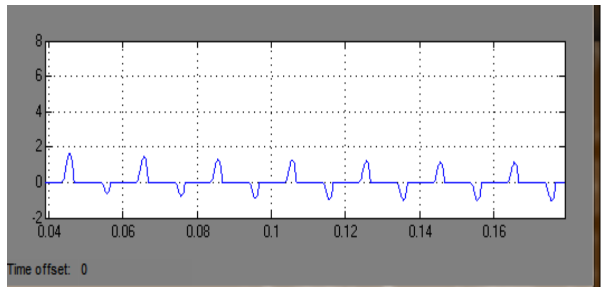

Fig 4.3 Input current

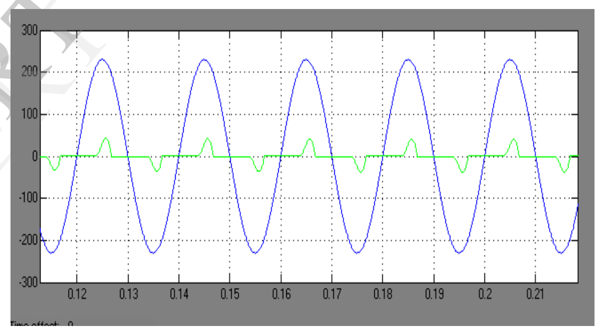

Fig 4.4 Applied voltage and current

The primary and secondary voltage of proposed circuit is shown in fig 4.5 & 4.6.

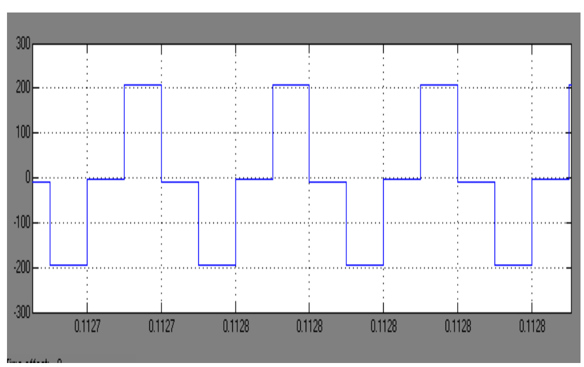

Fig 4.5. Primary voltage of proposed circuit

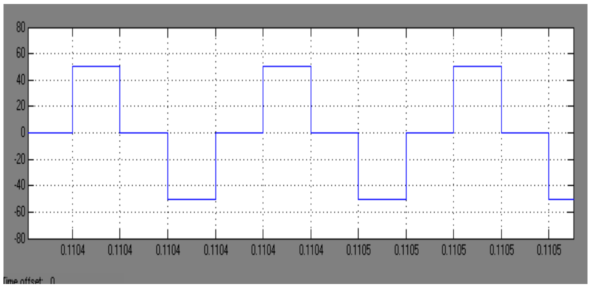

Fig 4.6. Secondary voltage of proposed circuit

The output current, voltage and power of proposed circuit is shown in fig 4.7 – 4.9.

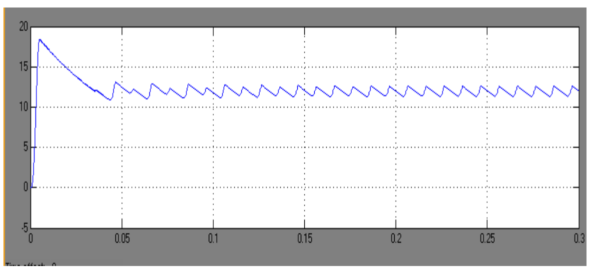

Fig 4.7 Output current of proposed circuit

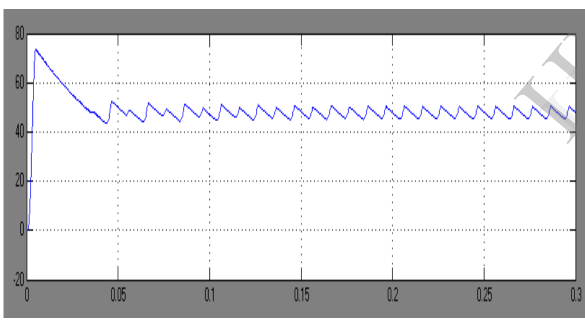

Fig 4.8 Output voltage of proposed circuit

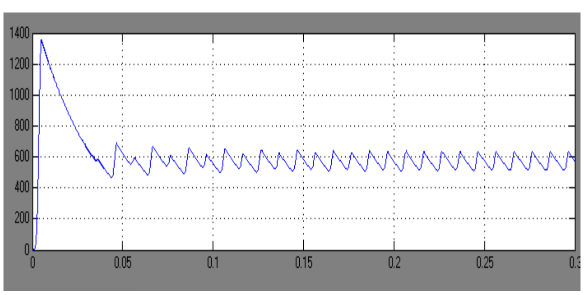

Fig 4.9. Output power of proposed circuit

Closed loop with motor load

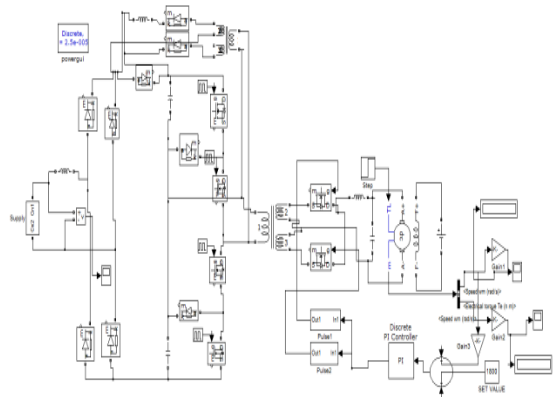

Fig 4.10 Closed loop with motor load

Input Voltage

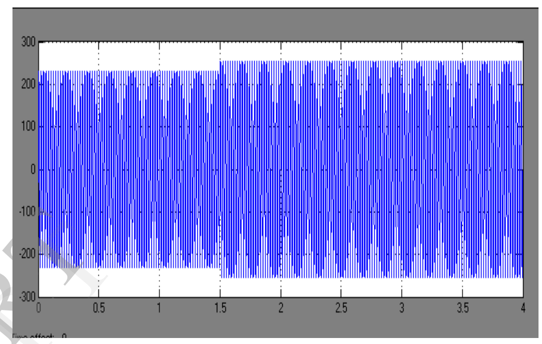

Fig 4.11 Input Voltage of Closed loop with motor load

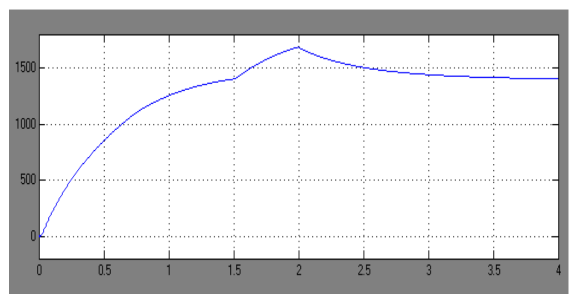

Fig 4.12. Speed of Closed loop with motor load

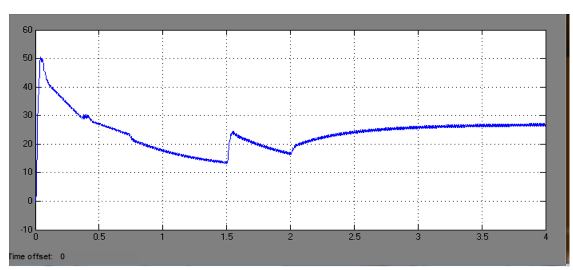

Fig 4.13. Torque of Closed loop with motor load

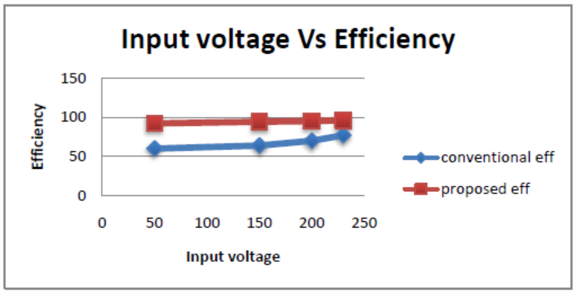

Fig.4.14 Comparative analysis of Proposed system with Conventional System

V. CONCLUSION

Thus a single-phase, single-stage voltage-fed, three-level, ac/dc converter which operates with a single controller was shown. This converter can operates with a better efficiency and with less output inductor current ripple and universal input voltage and wide load operating range. The results of simulation for conventional and proposed method with R load and closed loop with motor is presented and the results are obtained.

REFERENCES:

1. H. Athab and D. Lu (2001), "A single-switch ac/dc flyback converter using a CCM/DCM quasi active power factor correction front-end," IEEE Transactions on Industrial Electronics, Vol. 7, No. 3, pp. 187–192.
2. H. J. Chiu, Y. K. Lo, H. C. Lee, S. J. Cheng, Y. C. Yan, C. Y. Lin, T. H. Wang, and S. C. Mou (2011), "A single-stage soft-switching flyback converter for power-factor-correction applications," IEEE Transactions on Industrial Electronics, Vol. 57, No. 6, pp. 2187–2190.
3. Y. Jang, M. M. Jovanovic, and D. L. Dillman (2006),"Soft-switched PFC boost rectifier with integrated ZVS two-switch forward converter," IEEE Transactions on Power Electronics, Vol. 21, No. 6, pp.1600–1606.
4. D. D.-C. Lu, H. H.-C. Iu, and V. Pjevalica (2008), "A single-stage AC/DC converter with high power factor, regulated bus voltage, and output voltage," IEEE Transactions on Power Electronics, Vol. 23, No.1, pp. 218–228.
5. A. Lazaro, A. Barrado, M. Sanz, V. Salas, and E. Olias (2007), "New power factor correction AC– DC converter with reduced storage capacitor voltage," IEEE Transactions on Industrial Electronics, Vol. 54, No. 1, pp. 384–397.
6. J.-Y. Lee (2007),"Single-stage AC/DC converter with input-current dead-zone control for wide input voltage ranges, "IEEE Transactions on Industrial Electronics, Vol. 54, No. 2, pp. 724–732.
7. M. S. Agamy and P. K. Jain (2009),"A three-level resonant single-stage power factor correction converter: Analysis, design, and implementation industrial electronics," IEEE Transactions on Industrial Electronics, Vol. 56, No. 6, pp. 2095–2107.
8. P. Das, S. Li, and G. Moschopoulos (2009), " An improved AC–DC single-stage full-bridge converter with reduced DC bus voltage, "IEEE Transactions on Industrial Electronics, Vol. 56, No. 12, pp. 4882–4893.
9. P. K. Jain, J. R. Espinoza, and N. Ismail (1999), "A single-stage zero-voltage zero-current-switched full-bridge DC power supply with extended load power range, "IEEE Transactions on Industrial Electronics, Vol. 46, No. 2, pp. 261–270.
10. M. G. Egan, D. L. O'Sullivan, J. G. Hayes, M. J.Willers, and C. P. Henze (2007), "Power-factor corrected single-stage inductive charger for electric vehicle batteries, "IEEE Transactions on Industrial Electronics, Vol. 54, No. 2, pp. 1217–1226.
11. G. Moschopoulos, Q. Mei, H. Pinheiro, and P. Jain (2003), " PWM full-bridge converter with natural input power factor correction, "IEEE Transactions on Aeronautical Electrical System, Vol. 39, No. 2, pp. 660–674.