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Simulation of a Multi-level Unidirectional PFC Rectifier for Higher Efficiency

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ABSTRACT

This paper describes a multilevel unidirectional PFC rectifier topologies suited for applications that gives high efficiency and high power density. The reduced conduction losses are obtained with the help of a single converter instead of conventional configuration. The implementation of bridgeless power factor correction (PFC) with low common mode noise is presented in this paper. The topology survey is obtained in several boost power factor corrected converters which offer high efficiency, high power factor and low cost. The hysteresis current control technique for Diode Bridge with two power switches is adopted to achieve high power factor and low harmonic distortion

Keywords: Unidirectional PFC Rectifier, Bridgeless PFC, AC-DC Converter

INTRODUCTION

The unidirectional high power factor single phase ac-dc converter system by cascading the bridgeless converter topologies presented in this paper .The single phase power factor correction boost type rectifier known as conventional system is broadly used in industry for power conversion below 1 KW. The ac-dc converter system is mainly used for low production cost. This setup shows relatively low common mode emission level. To achieve high power density and low input current total harmonic distortion it requires to operate in the high switching frequencies which leads to switching losses and the diode should be commutated with full dc link voltage (D. C. Lu, 2003). The low conduction losses were introduced in this single phase PFC rectifier topologies. When compared with the conventional system, in this setup we can use appropriate control a Vienna type rectifier. (G. Moschopoulos,2003)Redrawing this and integrating the switching network composed of D1N, D2N, D1 A, D2 A, S1 N, S2 N, S1N S2 A leads to the topology shown in the figure 2 which has half the number of turns off switch. The other topologies are generated by replacing discrete diodes MOSFET in the figure or by changing or incorporating the bidirectional four quadrant switches across the terminal A and N.When compared with the conventional three level circuits, this new topologies present a lower number of semiconductor in the current path. (S.Luo,2005) Moreover the proposed rectifiers avoid the use of selective switches and allow low conduction losses for wide operational range. In addition all commutations occur under half of the dc link voltage although some of the semiconductors are to be rated to withstand the full dc link voltage.This leads to the reduction of the switching losses when compared to the converter (Y. Jang, 2006). This considers only power semiconductor devices, booster inductor and dc capacitors. Though the number of semiconductors is substantially increased for the proposed AC-DC converters when compared to two level solution, these topologies are indicated where high efficiency and or the switching frequencies are required (Sasikumar, 2012). The generated CM voltages are reduced as the circuits are symmetric and present reduced voltage step, in the contrast to one half of the full DC link voltage in typical two level bridgeless rectifiers and CM voltages steps, are one quarter of the full DC link voltage.

Block diagram of the proposed system: The block diagram shows an input AC supply, an EMI filter, three level bridgeless rectifier controlled by a dsPIC microcontroller and MOSFET driver. The output of the three level bridgeless rectifiers is connected to the load. Here EMI filter used to minimize leakage current and also used as passive power factor correction circuit. The three level PFC bridgeless rectifiers is used to perform rectification along with active power factor circuit.DsPIC microcontroller is used for generating the necessary PWM pulses for three level bridgeless rectifiers. MOSFET/IGBT driver is used to perform PWM signal amplification which is generated by dsPIC controller.

Circuit diagram of the proposed system: The rectifiers topologies can be used for increasing the input voltage efficiency and high switching frequency PFC rectifiers which can be achieved by maintaining the exact modulation design.Figure.1 shows a single phase three level boost type rectifiers, where the load plus the dc-link capacitors are replaced by two dc voltage ($v_0/2$) and the single phase power grid plus filter and ac-side boost inductor are replaced by bidirectional current sources. It turns on MOSFET when the inductor current reaches zero and turns off MOSFET when the inductor current meets the desired input current reference voltage.

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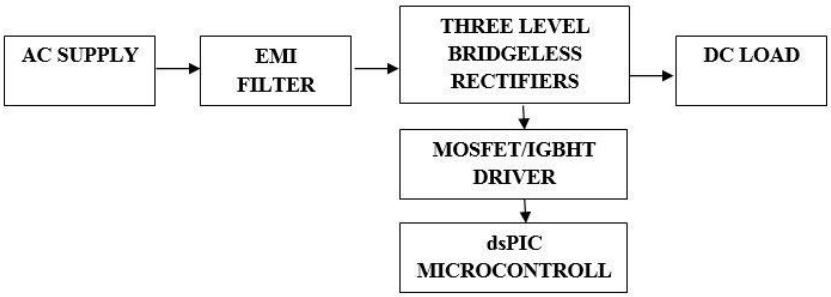

Figure.1.Block diagram of the proposed system

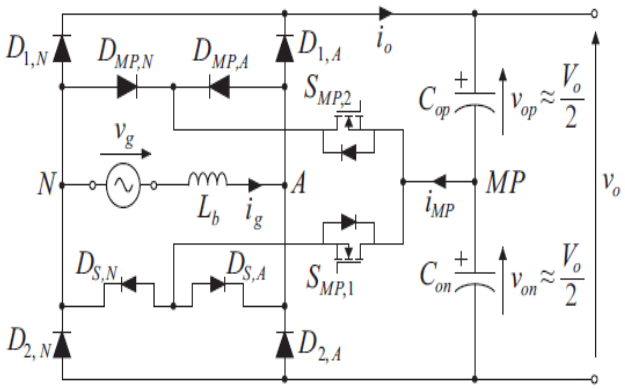

Figure.2. Circuit Diagram of the proposed System

Power factor correction (PFC): An active power factor correction (PFC) controller for boost PFC application which operates in the critical conduction mode is used here. It turns on MOSFET when the inductor current reaches zero and turns off MOSFET when the inductor current meets the desired input current reference voltage. In this way, the input current waveform follows that of the input voltage; therefore a good power factor is obtained

Principle of operation:

Modes of operation:

For positive half cycle Mode 1: All Switches are turned off V_{an}=0

Mode 2: During this state S_{mp1} is turned ON. Now capacitor C_{op} charging to its maxi value of V_o/2 & Van=V_o/2;

Mode 3: Now Smp1 turned OFF and S_{mp2} turned ON. Now capacitor C_{on} is charging and C_{op} is discharging. V_{an}=V_o/2;

Mode 4: Now both S_{mp1} and S_{mp2} are turned OFF. Now both capacitors are charging. V_{an}=V_o;

Negative half cycle: The same procedure repeated for negative half cycle also. But we get same output with negative polarity.

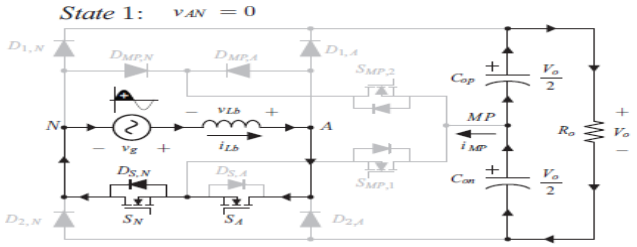

Figure.3.Mode 1 operation of the proposed circuit

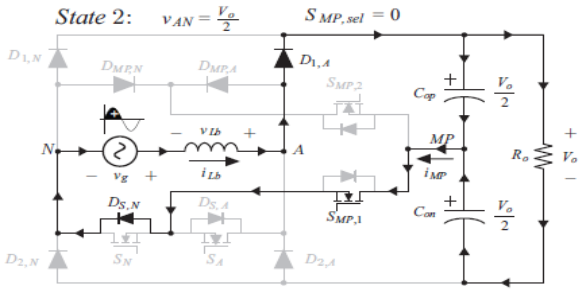

Figure.4.Mode 2 operation of the proposed circuit

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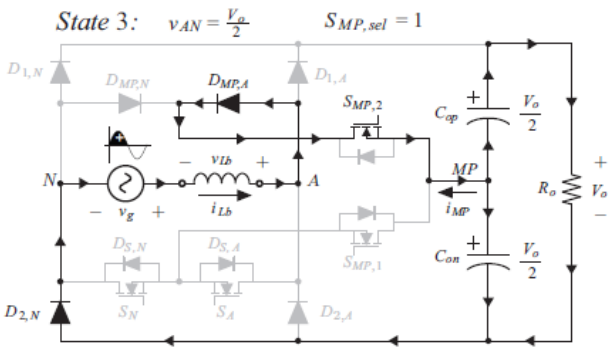

Figure.5.Mode 3 operation of the proposed circuit

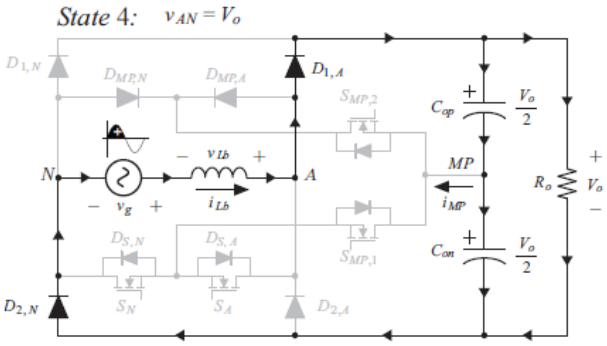

Figure.6.Mode 4 operation of the proposed circuit

SIMULATION RESULT AND DISCUSSION

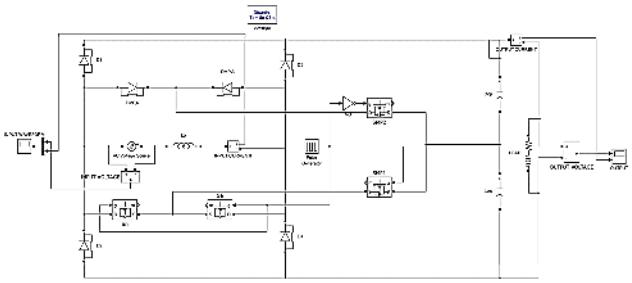

Figure.7.Simulation circuit of the Existing system

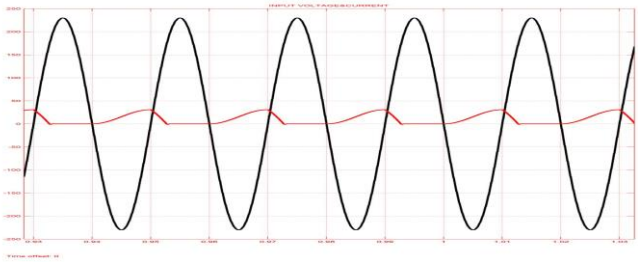

Figure.8.The input voltage and Input current

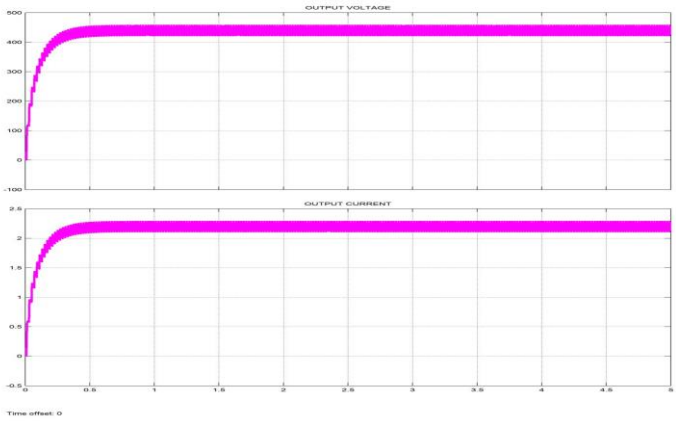

Figure.9.The output voltage and The output current waveform

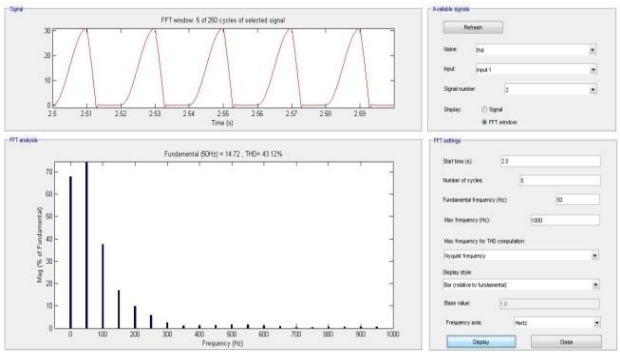

Figure.10.Total Harmonic Distortions

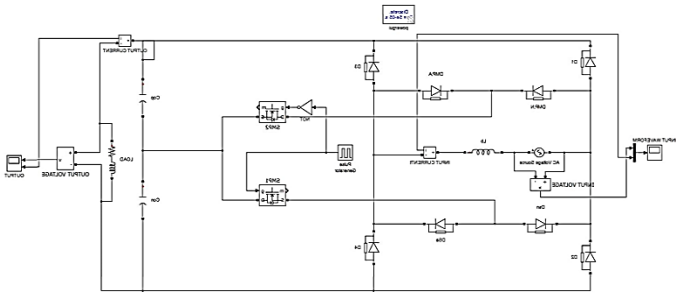

Figure.11.Circuit of the proposed system

The proposed simulation circuit in figure.10 clearly shows the multi-level PFC rectifier

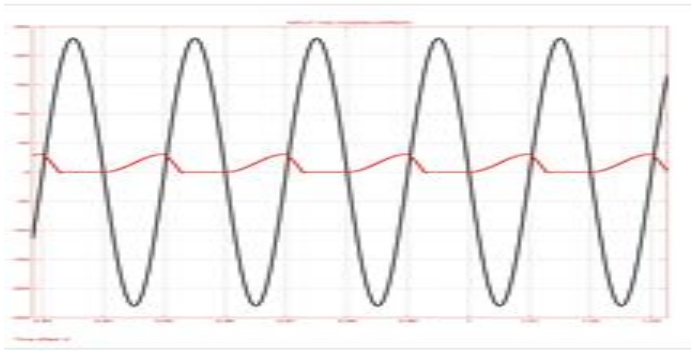

Figure.12.The input voltage and Input current

The input voltage =230V & The input current with some oscillation is obtained.

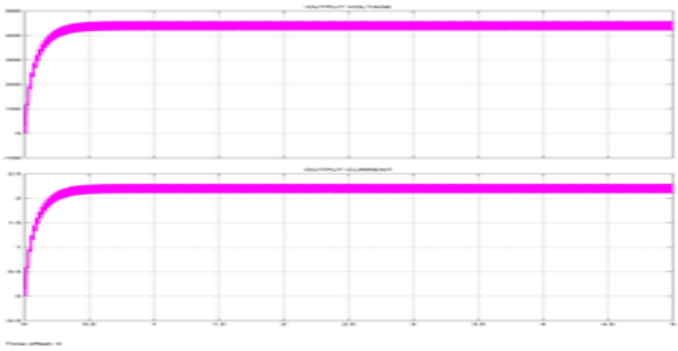

Figure.13.The output voltage and the output current waveform

The output voltage of 450V gives an Output current of 2.3 A.

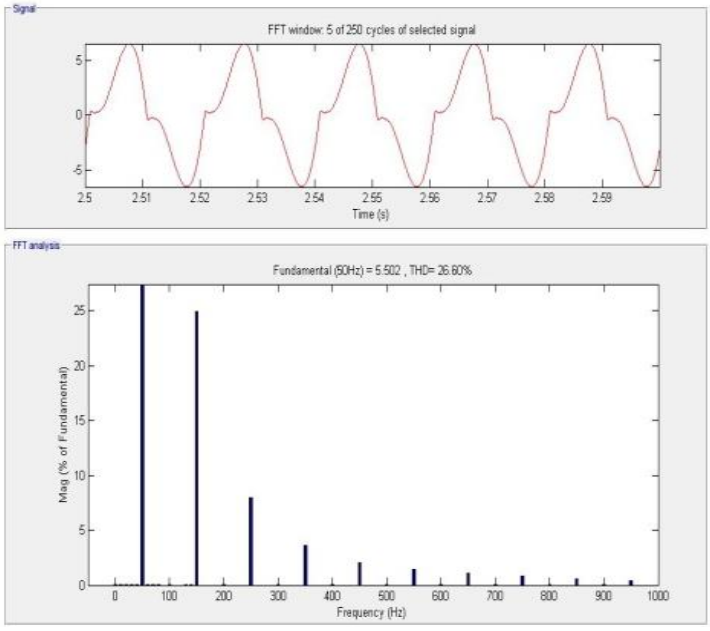

Figure.14.Total Harmonic Distortions

CONCLUSION

In this paper a multilevel unidirectional PFC rectifier topologies is suited for applications that gives high efficiency and high power density. The topology survey is obtained in several boost power factor corrected converters which offer high efficiency, high power factor and low cost. The hysteresis current control technique for Diode Bridge with two power switches is adopted to achieve high power factor and low harmonic distortion is designed in this paper.

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