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HIGH EFFICIENCY THREE-PHASE SINGLE-STAGE ISOLATED FLY BACKBASED PFC CONVERTER WITH A NOVEL CLAMPING CIRCUIT

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ABSTRACT:

The widespread use of non-linear loads, like variable speed drives(VSDs), power factor improvement has become harder. The cause of harmonic currents cause power capacitors to absorb them as capacitor impedance is inversely proportional to frequency. The consequences overheating and dielectric stress of power capacitors that lead to their premature failure. These ancient approaches may move with harmonics, resulting in harmonic amplifications at resonant frequency, which may damage the capacitors or parts of the system. A new integrated three-level ac–dc convertor is presented. The proposed convertor combines the operation of the boost power factor correction and the three-level dc–dc convertor. The convertor is formed to control with two independent controllers an input controller that performs power factor correction and regulates the dc bus and an output controller that regulates the output voltage. The input controller holds the dc-bus voltage from becoming excessive while still allowing a single-stage convertor topology to be used. The paper explains the operation of the new convertor very well and discusses its features and a procedure for its proper design.

Keywords: AC–DC Power Conversion, Single-Stage Power Factor Correction (PFC).

INTRODUCTION

Recently developments in power electronics and semiconductor technology have lead improvements in power electronic systems. Pulse Width Modulation variable speed drives are increasingly applied in many new industrial applications that require superior performance. Hence, different circuit configurations namely inverters have become popular and considerable interest by researcher are given on them. Variable voltage and frequency supply to A.C drives is invariably obtained from a three-phase voltage source inverter. To overcome the limited semiconductor voltage and current ratings, some kind of series and/or parallel connection will be necessary. Due to their ability to synthesize waveforms with a better harmonic spectrum and attain higher

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voltages, multilevel inverters are receiving increasing attention in the past few years. THE ac–dc power supplies with transformer isolation are typically implemented with some sort of input power factor correction (PFC) to comply with harmonic standards such as IEC 1000-3-2 [1].With the rapid rise in the use of electrical equipment in recent years, power converter manufactures are being pressed by regulatory to implement some form of PFC in their products. High power factor and low input current harmonics are more and more becoming mandatory performance criteria for power converters. Although it is possible to satisfy by adding passive filter elements to the traditional passive diode rectifiers/LC filter input combination. The result of this converter is very bulky and heavy due to the size of the low frequency inductors and capacitors. Active power factor correction techniques have been used in AC-DC converter to improve power factor and reduce the harmonics. Active power factor correction can be classified into two stage scheme. Two stages PFC contain two independent power stages in cascade with PFC stage and DCDC regulator. The total efficiency of the two stages is lower because the total power has to be processed twice with two cascade power stage. Cost of the circuit is increase several schemes have developed to combine stage into one stage [13]. This paper introduces the new converter is interfaced to induction machine drive to check the performance of the drive characteristics, explains its basic operating principles and its modes of operation, and discusses its features and its design.

CONVERTER OPERATION The proposed converter and its key waveforms are shown in Figs1 and 2, respectively. The proposed converter uses auxiliary windings that are taken from the converter transformer to act as ―magnetic switches‖ to cancel the dc bus capacitor voltage so that the voltage that appears across the diode bridge output is zero. When the primary voltage of the main transformer is positive, auxiliary winding 1 (Naux1/N1 = 2) cancels out the dc bus voltage so that the output voltage of diode bridge 1 (DB1) is zero and the currents in input inductorsLa1, Lb1, and Lc1 rise. When the primary voltage of the main transformer is negative, auxiliary winding 2 (Naux2/N1 = 2) cancels out the dc bus voltage so that the output voltage of diode bridge 2 (DB2) is zero and the currents in input inductors La2, Lb2, and Lc2 rise. When there is no voltage across the main transformer

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primary winding, the total voltage across the dc bus capacitors appears at the output of the diode bridges and the input currents fall since this voltage is greater than the input voltage. If the input currents are discontinuous, the envelope of the input current will be sinusoidal and in phase with the input voltages. The converter modes of operation are explained in this section. The typical converter waveforms are shown in Fig. 2. The equivalent circuit in each stage is shown in Fig.3. The converter goes through the following modes of operation

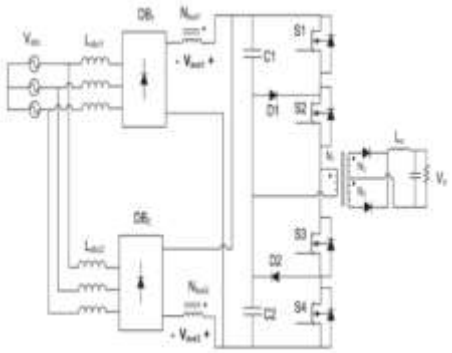

Fig.1. Proposed interleaved three-phase three-level converter.

- Mode 1 (t0< t < t1) [Fig. 3(a)]: During this interval, switches S1 and S2 are ON. In this mode, the energy from dc bus capacitor C1 flows to the output load. Due to magnetic coupling, a voltage appears across auxiliary winding 1 which is equal to the dc bus voltage but has oppositepolarity and cancels the total dc bus capacitor voltage; the voltage at the diode bridge output is zero, and the input currents in La1, Lb1, and Lc1 rise.
- Mode 2 (t1< t < t2) [Fig. 3(b)]: In this mode, S1 is OFF, and S2 remains ON. The energy stored in L1(L1 = Labc1) during the previous mode starts to transfer into the dc bus capacitors. The voltage that appears across auxiliary winding 1 is zero. The primary current of the main transformer circulates through D1 and S2. With respect to the converter's output section, the load inductor current freewheels in the secondary of the transformer, which defines a voltage across the load filter inductor equal to −VL.
- Mode 3 (t2< t < t3) [Fig. 3(c)]: In this mode, S1 and S2 are OFF. The energy stored in L1 still is transferring into the dc bus capacitor. The primary current of the transformer charges C2 through the body diodes of S3 and S4. Switches S3 and S4 are switched ON at the end of this mode.
- Mode 4 (t3< t < t4) [Fig. 3(d)]: In this mode, S3 and S4 are ON, and

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the energy flows from capacitor C2 into the load. The voltage appears across auxiliary winding 2 which is equal to the dc bus voltage but acts like a magnetic switch and cancels out the dc bus voltage. The voltage across the boost inductors L2(L2 = Labc2) becomes only the rectified supply voltage of each phase, and the current flowing through each inductor increases. This mode ends when the energy stored in L1 completely transfers into the dc bus capacitor. For the remainder of the switching cycle, the converter goes through modes 1–4 but with S3 and S4ON instead of S1 and S2 and with DB2 instead of DB1.

- Mode 5 (t4 < t < t5) [Fig. 3(e)]: In this mode, S3 and S4 are ON, and a symmetrical period begins. In this mode, the energy flows from capacitor C2 into the load. The voltage across the boost inductors L2 becomes only the rectified supply voltage of each phase, and the current flowing through each inductor increases.
- Mode 6 (t5< t < t6) [Fig. 3(f)]: In this mode, S3 is ON and S4 is OFF, and the primary current of the main transformer circulates through diode D2 and S3. The energy stored in the boost inductors L2 during the previous mode starts transferring into the dc bus capacitor. The output inductor current also freewheels in the secondary of the transformer during this mode.
- Mode 7 (t6< t < t7) [Fig. 3(g)]: In this mode, S3 and S4 are OFF, and the primary current of the transformer charges capacitor C1 through the body diodes of S1 and S2. The energy stored in the boost inductors L2 transfers into the dc bus capacitor.
- Mode 8 (t7< t < t8) [Fig. 3(h)]: In this mode, S1 and S2 are ON. In this mode, the energy from dc bus capacitor C1 flows to the output load. This mode ends when the energy in the inductors L2 completely transfers into the dc bus capacitors. Time t8 is the end of the switching cycle, and another switching cycle begins with the same modes.

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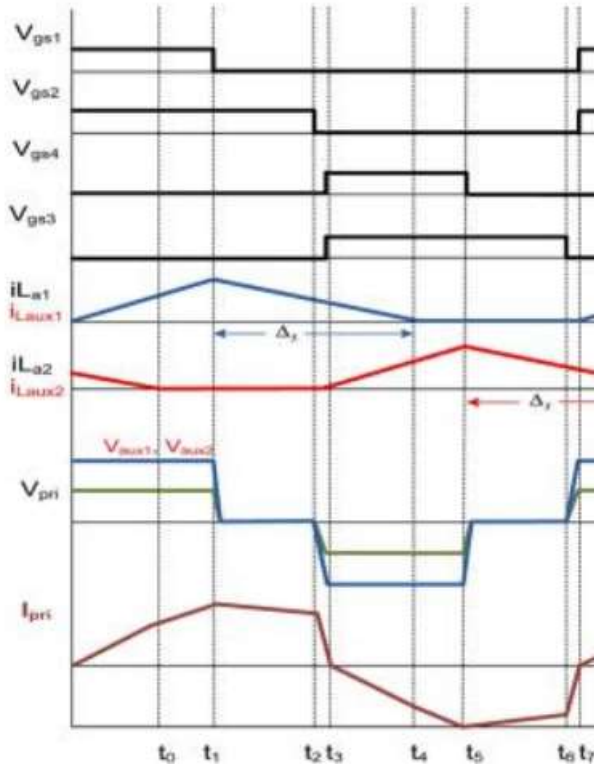

Fig.2. Typical waveforms describing the modes of operation.

CONVERTER ANALYSIS AND DESIGN The analysis and the design of the proposed interleaved converter are almost identical to that presented and therefore are not presented here. Readers are referred to for details. In this paper, only differences in the analysis and the design are presented. With respect to analysis, steady-state operating points are identified using a computer program such as the one presented. The only difference between the analysis of the proposed converter and the one is the analysis and design of the input inductors. In the proposed interleaved converter, there are two sets of inductors (L1 and L2) at the input side, with each set conducting half the current. The analysis needs to consider the current in both these sets instead of just one. The values for L1 and L2 should be low enough to ensure that their currents are fully discontinuous under all operating conditions but not so low as to result in excessively high peak currents. The worst case to be considered is the case when the converter operates with minimum input voltage and maximum load since, if the input current in each set of inductors is discontinuous under these conditions, it will be discontinuous for all other operating conditions, and thus, an excellent power factor will be achieved

CONCLUSION In this paper, a new converter topology has been proposed which has superior features over conventional topologies in terms of the required power switches and isolated dc supplies, control requirements, cost, and reliability. This will add up to the efficiency of the converter as well as reducing the size and cost of the final design. A new multilevel single-stage ac–dc converter is proposed in the paper. This converter is operated with two controllers, one controller that performs input PFC and a second controller that regulates the output voltage. The outstanding feature of

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this converter is that it combines the performance of two-stage converters with the reduction of cost of single-stage converters. The paper introduces the proposed converter, explains its basic operating principles and modes of operation, and discusses its design with respect to different dcbus voltages. By using multilevel Inverter increase power quality and reduce THD.

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