National Conference on Emerging Trends in Computer, Electrical & Electronics (ETCEE-2015)
International Journal of Advance Engineering and Research Development (IJAERD)
e-ISSN: 2348 - 4470 , print-ISSN:2348-6406,Impact Factor:3.134

A Electronic Power Transformer with Power Factor Correction for Induction Motor Application

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***Abstract*—This paper presents topology of power electronic transformer. In the design process, the converters and high frequency transformer have been used. The proposed power electronic transformer performs typical functions and has advantages such as power factor correction, voltage regulation, voltage sag and swell elimination. The DC-DC converter realizes magnetic isolation of power electronic transformer and reduces the transformer size. Power quality improvement with proposed power electronic transformer has been verified by the simulation results.**

***Keywords*— PSIM, SPWM, IM, PFC**

I. INTRODUCTION

Distribution transformers are fundamental components in power distribution systems. They are relatively inexpensive, highly reliable, and fairly efficient. However, they have some disadvantages such as heavy weight, large size, sensitivity to harmonics, voltage drop under load, (required) protection from system disruptions and overload, protection of the system from problems arising at or beyond the transformer and environmental concerns regarding mineral oil. These disadvantages are becoming increasingly important as power quality becomes more of a concern. In this case, power electronic based transformer is a good option for solving above problems[1].

Electronic power transformer and solid state transformer , is a new sort of power transformer which based on power electronics and high-frequency isolation. Although it was discussed conceptually in 1970s, it has received much attention in recent decade as power electronic technology developed. In fact, a significant advantage of Electronic power transformer is that the magnitude and phase angle of voltages in both the primary side and the secondary side of Electronic power transformer can be controlled in real-time through power electronic converters to achieve flexible regulation of the current and power. It can be widely used in transmission systems and distribution systems[5].

A special characteristic of Electronic power transformer is that the voltage level and frequency are able to change simultaneously. This means that Electronic power transformer can offer the custom power supply with particular voltage level and particular frequency without additional power transformer and frequency conversion equipment. This feature makes Electronic power transformer have the potential to be applied to the distributed generation systems [5].

This paper presents a new topology of PET that improves the Sudhoff topology and enhances its performance. In the proposed topology, the PFC and DC-DC converters have been integrated to reduce the power losses and increase the efficiency. The topology is insensitive to the harmonics, performs input power factor correction, has zero regulation, eliminates voltage sag and swells, reduces the voltage flicker, prevents user faults from affecting the power distribution system, and does not utilize mineral oil or other liquid dielectrics[1].

II. SYSTEM CONFIGURATION

A Boost converter (DC-DC converter) in continuous conduction mode is an excellent choice for the power stage of an active power factor corrector because the input current is continuous and this produces the lowest level of conducted noise and the best input current waveform. The boost regulator input current must be forced or programmed to be proportional to the input voltage waveform for power factor correction.

Feedback is necessary to control the input current and either peak current mode control or average current mode control may be used as discussed before. In the Peak current mode control approach, the peak current of the inductor is used to force the input current to follow the reference. This approach has a low gain, wide bandwidth current loop which generally makes it unsuitable for a high performance power factor corrector since there is a significant error between the programming signal and the current. This will produce distortion and a poor power factor. For Average current mode control An amplifier is used in the feedback loop around the boost power stage so that the input current tracks the programming signal with tiny error[5].

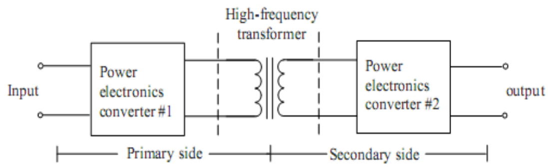
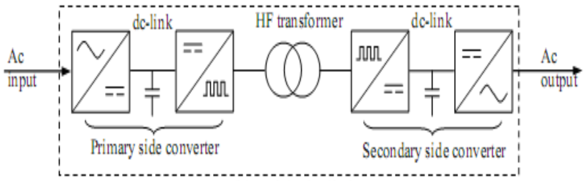


Fig. 1. concept diagram of Electronic power transformer

In Fig 2 , the proposed topology is shown in block diagram form. Electronic power transformer should have abilities such as power factor correction, high efficiency and high electrical isolation. For achieving these goals, the PFC converter and isolated DC-DC converter should be integrated. This idea leads to the loss reduction, by processing the power in one stage instead of two stages. Also the electrical isolation will be gained by high frequency transformers (HF)[5].



(b) With dc-link

Fig. 2. Two configurations of Electronic power transformer

III. ANALYSIS OF ISOLATED FULL BRIDGE COTROLLER

This integrates the PFC and DC-DC converter functions. The PFC converter programs the input current waveform and makes the power factor near to one. The DC-DC converter regulates the output DC voltage and makes the electrical isolation using HF transformer. For performing power factor correction, there are different methods such as variable hysteresis control, peak current control and average current control. The main disadvantage of variable hysteresis control is that it operates at variable switching frequency and the disadvantage of peak current control is that it generates some distortion in the input current inherently.

The control method for PFC, the integration mechanism of PFC converter with DC-DC converter should be defined. For achieving this goal, the single-switch in boost converter is replaced by an isolated-switch and the PWM output is modified by some additional logics shown in Fig. . By these corrections, the Isolated Full Bridge PFC converter is achieved (see Fig. 4b). The operation principle of this approach will be similar to boost converter which is controlled by average current control method. For instance, when the single switch in boost converter is on, all switches in Isolated Full Bridge PFC will be on and the boost inductor will be energized. In this case, the transformer primary voltage will be zero. Also, when the single switch in PFC converter is off, the diagonal switch pairs in Isolated Full Bridge PFC will be on and off alternatively[1].

By this switching state, the transformer primary voltage will be positive and negative symmetrically. In fact when the switch pair (S1,S4) is on and the switch pair (S2,S3) is off, the inductor current will be conducted through HF transformer and makes the diode pair (D1,D4) be on. So the primary voltage becomes nVo. Similarly when the switch pair (S2,S3) is on and the switch pair (S1,S4) is off, the diode pair (D2,D3) become on and voltage becomes –nVo[1].

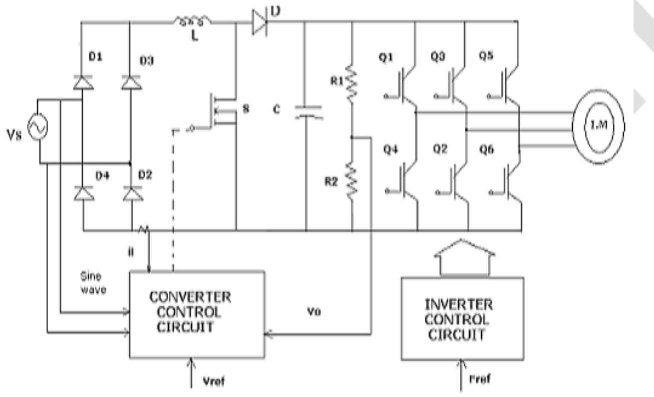


Fig. 3. circuit configuration

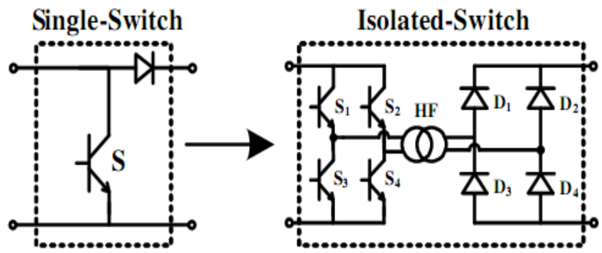


Fig.4 a Replacement of single switch with proposed Isolated switch

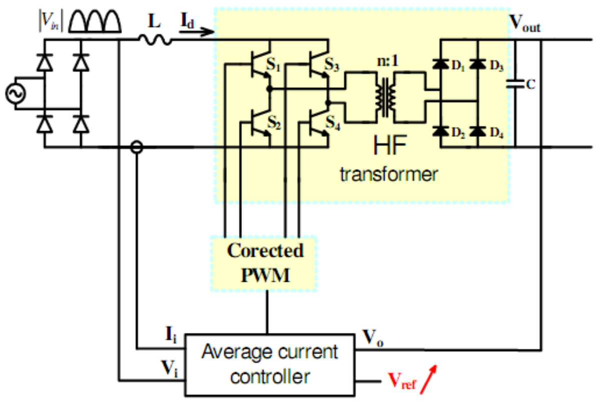


Fig.4b Isolated Full Bridge PFC

IV. SIMULTION RESULT

In fig show complete circuit of the Isolated Full Bridge converter. Output voltage is maintain constant 400Vrms at 50Hz. The PFC converter and isolated DC-DC converter should be integrated.

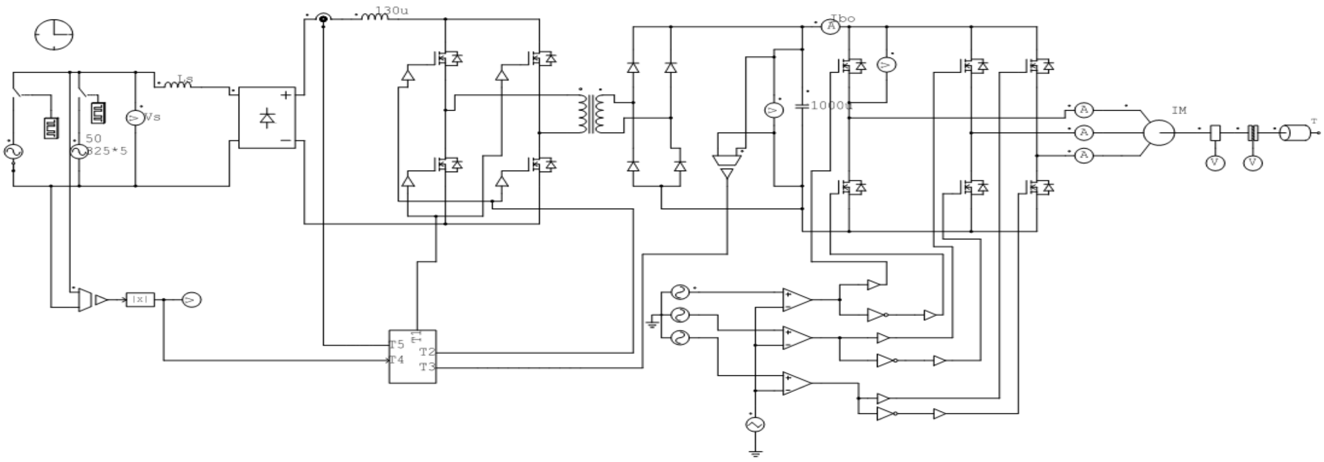


Fig. 5. Isolated Full Bridge converter

Case I: power electronic transformer handles the voltage sag conditions

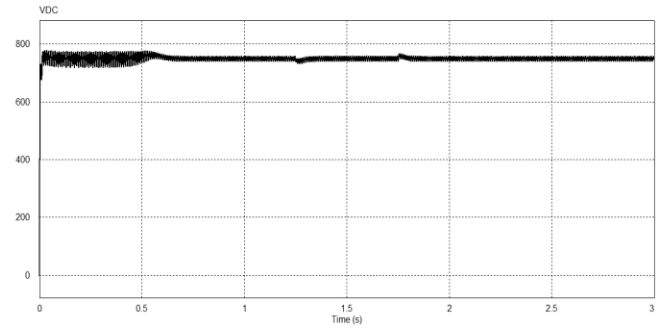


Fig. 6. i/p voltage of inverter.

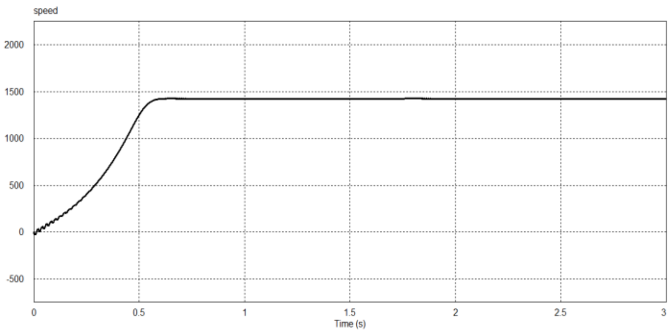


Fig. 7. speed of induction motor

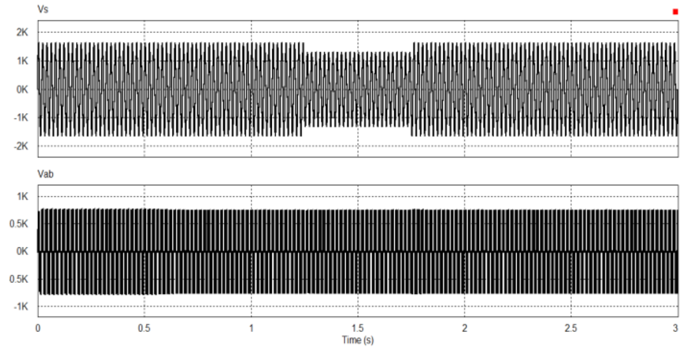


Fig. 8. power electronic transformer handles the voltage sag conditions

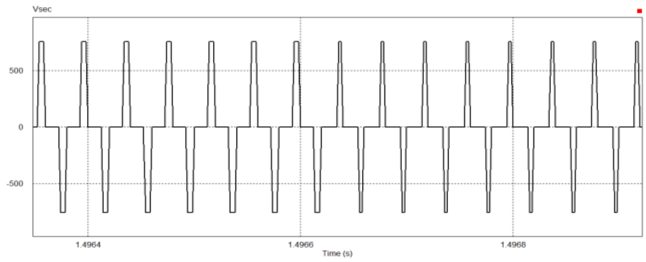


Fig. 9. show transformer secondary voltage

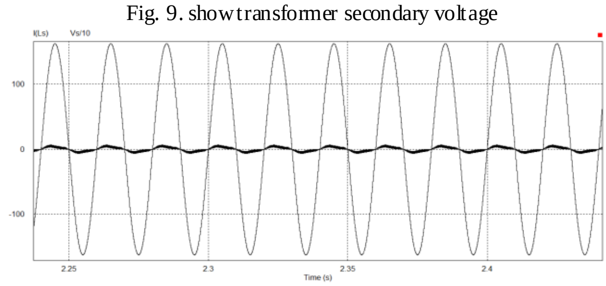


Fig. 10. input power factor correction ability

In fig 7 shows speed of induction motor .In fig 6 shows i/p voltage of inverter .Fig. 8 show how the power electronic transformer handles the voltage sag conditions.

In fig 8 shows voltage dip 10% of supply voltage at time interval of 1.2s to 1.8s. In Fig 9 show transformer secondary voltage. Fig 10 the input current and the input voltages are in phase and have sinusoidal wave shapes

Case II: power electronic transformer handles the voltage Swell conditions

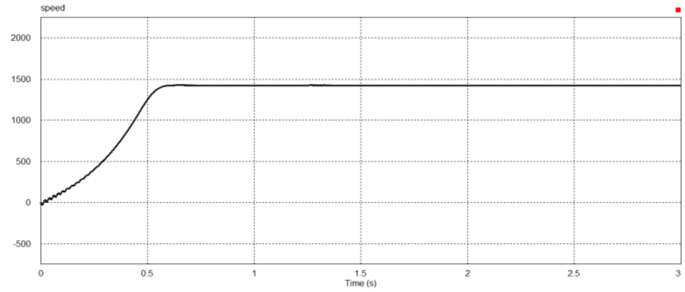


Fig. 11. speed of induction motor

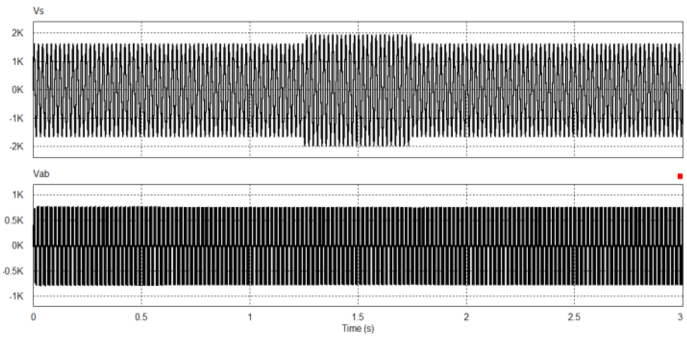


Fig. 12. power electronic transformer handles the voltage sag conditions

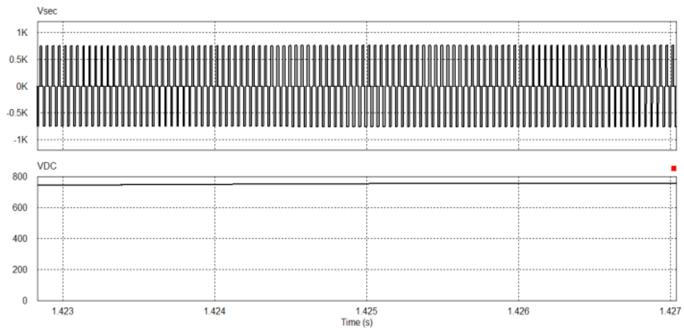


Fig. 13. output voltage and i/p voltage of inverter.

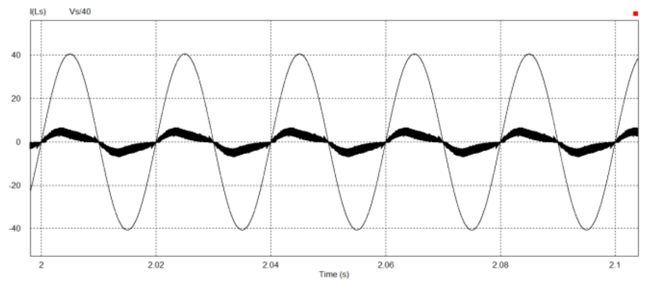


Fig. 14. show the input power factor correction ability

In fig 13 shows speed of induction motor. Fig 12 output voltage and i/p voltage of inverter. Fig. 11 show how the power electronic transformer handles the voltage sag conditions. In fig 11 shows voltage increase 10% of supply voltage at time interval of 1.2s to 1.8s. Fig 14 the input current and the input voltages are in phase and have sinusoidal wave shapes

V. CONCULSION

Power electronic transformers, providing reduction in weight accompanied by additional functionalities, are considered as a viable solution for replacement of heavy low-frequency transformers. To obtain higher efficiency, the AC/DC and DC/AC converters have been integrated in one converter. The topology described in this paper has many advantages such as power factor correction, voltage regulation, voltage sag and swell elimination.

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