A Novel Inverter Based High Power Factor for Single Phase AC Motor

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***ABSTRACT*: This paper presents a novel inverter based on a quasi-active power factor correction (PFC) scheme. In the proposed circuit, the power factor is improved by using an auxiliary winding coupled to the primary supply. The half bridge is placed between the input rectifier and the low-frequency filter capacitor to serve as a magnetic switch to drive an input inductor. Since the ac/ac converter is operated at high-switching frequency, the switches produce a high frequency pulsating source such that the input current conduction angle is significantly lengthened and the input current harmonics is reduced. It eliminates the use of active switch and control circuit for PFC, which results in lower cost and higher efficiency. In order to achieve low harmonic content, and high power factor, this proposed method is very suitable. The scheme is applied to drive a single phase AC motor**

***Keywords*: Bridge, PFC, DCM, Transformer**

I. INTRODUCTION

Conventional offline power converters with diode– capacitor rectifiers have resulted in distorted input current waveforms with high harmonic contents. To solve these problems, so as to comply with the harmonic standards such as IEC 61000-3-2, several techniques have been proposed to shape the input current waveform of the power converter. A common approach to improving the power factor is a two-stage power conversion approach. The two-stage scheme results in high power factor and fast response output voltage by using two independent controllers and optimized power stages. The main drawbacks of this scheme are its relatively higher cost and larger size resulted from its complicated power stage topology and control circuits, particularly in low power applications. In order to reduce the cost, the single-stage approach, which integrates the PFC stage with an inverter into one stage, is developed.

These integrated single-stage power factor correction (PFC) converters usually use a boost converter to achieve PFC with discontinuous current mode (DCM) operation. Usually, the DCM operation gives a lower total harmonic distortion (THD) of the input current compared to the continuous current mode (CCM). However, the CCM operation yields slightly higher efficiency compared to the DCM operation. Generally, single-stage PFC converters meet the regulatory requirements regarding the input current harmonics, but they do not improve the power factor and reduce the THD as much as their conventional two-stage counterpart. The power factor could be as low as 0.8, however, they still meet the regulation.

In addition, although the single-stage scheme is especially attractive in low cost and low power applications due to its simplified power stage and control circuit, major issues still exist, such as low efficiency and high as well as wide-range intermediate dc bus voltage stress. To overcome the disadvantages of the single-stage scheme, many converters with input current shaping have been presented, in which a high frequency ac voltage source (dither signal) is connected in series with the rectified input voltage in order to shape the input current. However, the harmonic content can meet the regulatory standard by a small margin. In, a new concept of quasi-active PFC is proposed to improve the efficiency of a single-stage converter by preventing the input current or voltage stress due the PFC cell from being added to the active switch. In this, the dc/dc cell operates in DCM so that a series of discontinuous pulses is used to shape the input inductor current and the PFC is achieved. As the circuit uses resonance of circuit parameters to achieve PFC, the control of the power factor will be very sensitive to the variation of components values.

Inductor-capacitor-capacitor (LCC) resonant inverters have been considered to be quite attractive for this application because they not only establish the required high start-up voltage during the ignition process, but also maintain a steady-state rated sine-wave current for the CCFLs. They also have other advantages such as circuit simplicity, low cost, potential high efficiency, and so on [5]–[9].

Without a power-factor-correction (PFC) circuit, the current drawn by the inverter from the utility line will contain significant harmonic components and therefore, the inverter will operate at a poor power factor. By adding active PFC circuits, line current harmonics can be reduced effectively and high power factor is achieved, which means that the utility line can be utilized more efficiently [10]–[12]. Also, the inverter effectively consists of two cascaded power conversion stages, where the first stage is a boost converter operating as a preregulator and the second stage is a resonant inverter that provides the regulated high frequency voltage. The input current is controlled to follow the sinusoidal waveform of the input voltage to provide high-power-factor (HPF) to the utility line [11]–[15].

The advantage of this two-power-processing stage approach is that it is easy to optimize each stage, but the disadvantages are, since it has two-power-processing-stage topology, it reduces the inverter reliability, decreases the efficiency, and increases the final cost because more components are needed in this approach. In order to avoid these problems, inverters based on single-stage designs are considered to be desirable and several single-stage inverters have been proposed [17]. These kinds of inverters combine the PFC stage and the inverter stage by sharing switches to form single stage.

Although the previous single-stage inverters have only one power- processing-stage, they need an extra diode to accomplish the boost operation of the PFC stage. A smaller number of devices are more desirable in terms of efficiency, reliability, and cost. The boost converter or its modified topologies can achieve HPF with simple controls, but their output voltages would need to be considerably higher than the peak amplitude of the line voltage. This increases the voltage stresses on power semiconductor devices.

The proposed single-stage LCC resonant inverter achieves almost unity power factor and ripple-free input current by using a coupled inductor without increasing the voltage stress of the power semiconductor devices, and since the switches of the half-bridge LCC resonant inverter are driven above the resonant frequency complementarily with 50% duty ratio, it realizes zero-voltage-switching (ZVS) and reduces the switching losses. Thus, the proposed single-stage inverter not only provides HPF to the utility line, but also achieves circuit simplicity, low cost, and high reliability compared to the conventional HPF inverters.

II. PROPOSED WORK

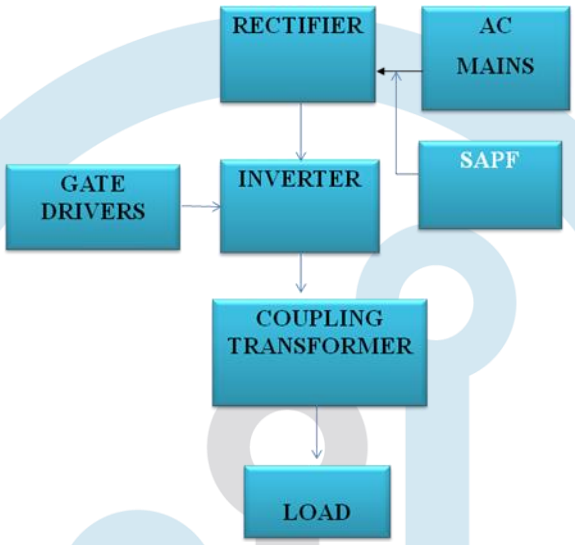

Fig:1 Block diagram of the proposed system

To simplify the analysis, the following assumptions have been made.

1) All semiconductors components are ideal. According to this assumption, the primary switch and the rectifiers do not have parasitic capacitances and represent ideal short and open circuits in their ON and OFF states, respectively.

2) The power transformer does not have the leakage inductances because of the ideal coupling.

3) All the capacitors are high enough so that the voltage across them is considered constant.

4) Finally, the input voltage of the converter is considered constant during a switching cycle because the switching frequency is much higher than the line frequency.

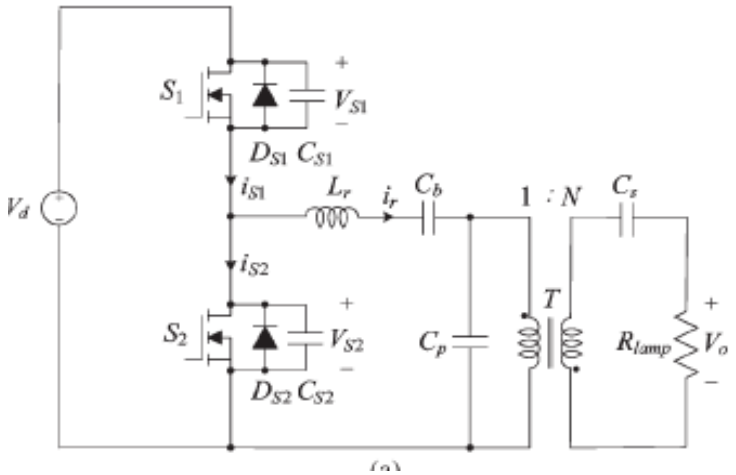

Fig: 2. Proposed Circuit

In this paper a new concept of quasi-active PFC is proposed to improve the efficiency of a single-stage converter by preventing the input current or voltage stress due the PFC cell from being added to the active switch. In this circuit, the dc/dc cell operates in DCM so that a series of discontinuous pulses is used to shape the input inductor current and the PFC is achieved. As the circuit uses resonance of circuit parameters to achieve PFC, the control of the power factor will be very sensitive to the variation of components values. In this letter, a new technique of quasi-active PFC is proposed. The PFC cell is formed by connecting the energy buffer (LB) and an auxiliary winding (L3) coupled to the transformer of the dc/dc cell, between the input

rectifier and the low-frequency filter capacitor used in conventional power converter. Since the dc/dc cell is operated at high frequency, the auxiliary winding produces a high frequency pulsating source such that the input current conduction angle is significantly lengthened and the input current harmonics is reduced. The input inductor LB operates in DCM such that a lower THD of the input current can be achieved.

III. RESULTS AND DISCUSSION

The system does not have harmonics and the current harmonics are in the order of 2.2 %. The voltage harmonics are in the order of 0%. The speed regulation is better, which we have to prove in hardware setup. The power factor is maintained near by 0.99.

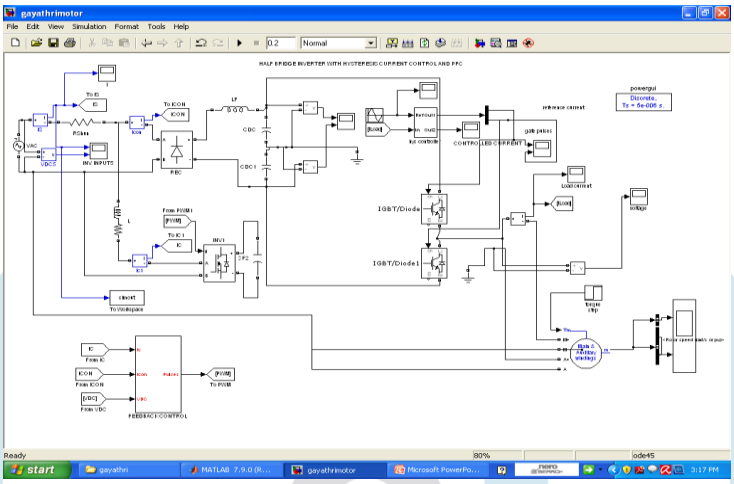

Fig: 3. proposed system Matlab simulation modal

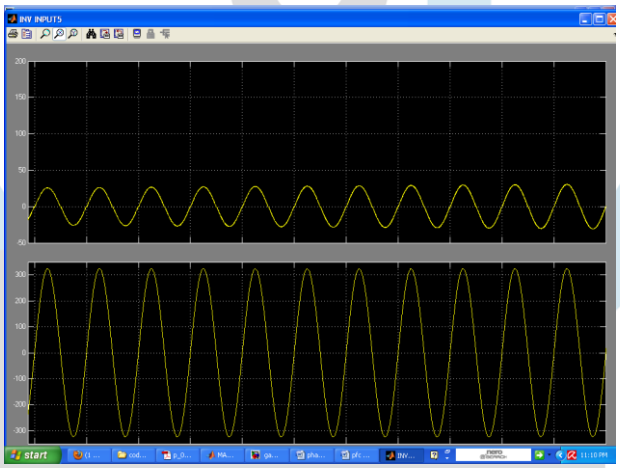

Fig: 4. Input voltage and current

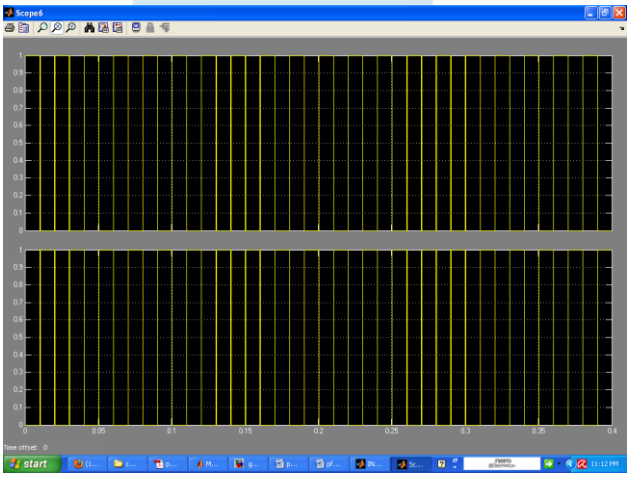

Fig: 5. GATE PULSES

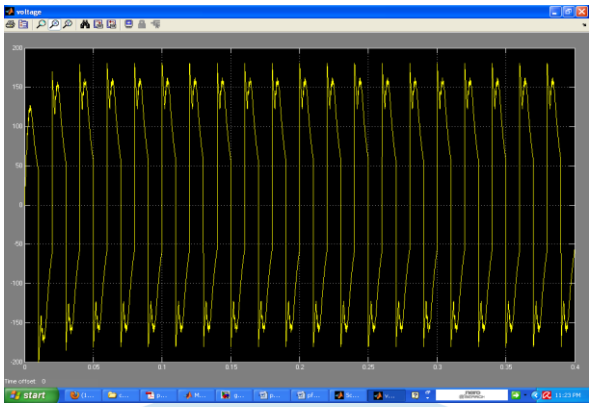

Fig:6. OUTPUT VOLTAGE

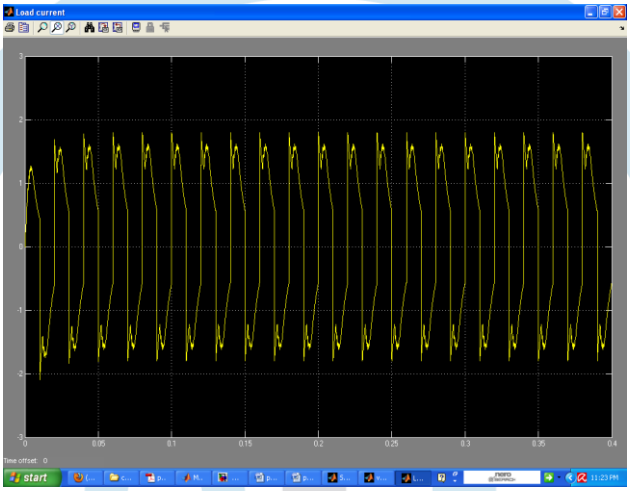

Fig:7. OUTPUT CURRENT

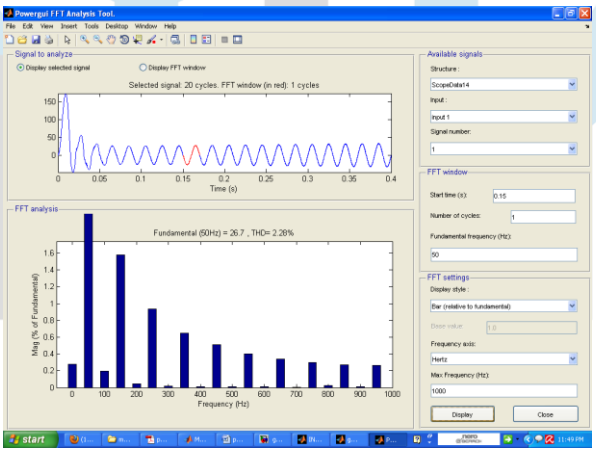

Fig:8. CURRENT THD CONTENT AT THE INPUT (2.28%)

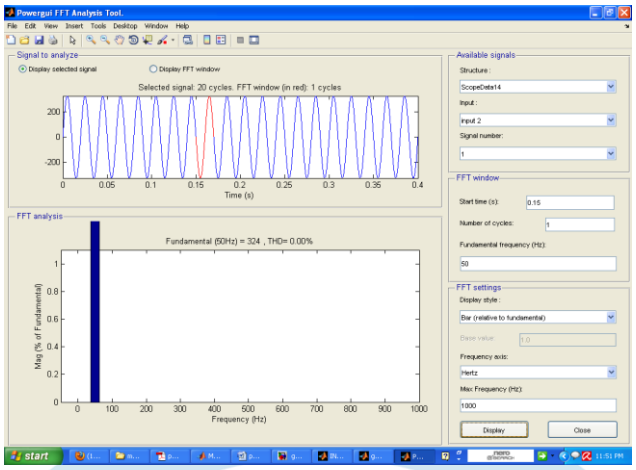

Fig: 9. VOLTAGE THD CONTENT AT THE INPUT (0.0%)

The hardware circuit of the proposed inverter in AC motor connected in parallel was implemented to verify the theoretical analysis. The size of the transformer-type coupled inductor was 12 mm × 29 mm × 29 mm, with tight coupling and the magnetizing inductance Lmc = 1 mH. The turn ratio of the step-up transformer T was 20 : 175 with the magnetizing inductance Lm = 1.45 mH. The proposed inverter was tested at 220 Vrms input voltage and the switching frequency fs = 80 kHz with 50% duty ratio. For unity power factor, (20) gives L < 315 μH, and L = 300 mh was selected. Other parameters of the inverter used for the experiment were as follows:

Lr =430 μH Cb = 1 μF

Cf =0.1 μF Cp = 6.8 nF

Cd =560 μF Cs = 264 pF.

Thus, (24) gives the resonant frequency fo = 62 kHz. The rate current used in this experiment was 14 μA, the voltage was 870 Vrms, and the steady-state resistance was 88 kΩ. The maximum input power was 120 W and the efficiency of the proposed inverter could be as high as 88%.

IV. CONCLUSION

In this paper, a new ac/dc converter based on a quasi-active PFC scheme has been presented. The proposed method produces a current with low harmonic content to meet the standard specifications as well as high efficiency. This circuit is based on adding an auxiliary winding to the transformer of a cascade dc/dc DCM flyback converter. The input inductor can operates in DCM to achieve lower THD and high power factor. By properly designing the converter components, a tradeoff between efficiency and harmonic content can be established to obtain compliance with the regulation and efficiency as high as possible.

In future, the work can be implemented as, hardware section to drive an AC motor along with power factor correction. Also we ensure that the harmonics at the input side is filtered so that the maximum power is delivered to the load. The system will include an Ac to Dc converter and then another stage of Dc to Ac inverter. The PWM pulses given to the motor is adjusted to have a constant speed and good regulation.

REFERENCES

[1] O. Gracia, J. A. Cobos, R. Prieto, and J. Uceda, "Single-phase power factor correction: A survey," IEEE Trans. Power Electron., vol. 18, no. 3, pp. 749–755, May 2003.

[2] R. Redle, L. Balogh, and N. O. Sokal, "A new family of single-stage isolated power factor correctors with fast regulation of the output voltage," in Proc. IEEE PESC 1994 Conf., pp. 1137–1144.

[3] K. M. Rahman, N. R. Patel, T. G. Ward, J. M. Nagashima, F. Caricchi, and F. Crescimbini, "Application of direct-drive wheel motor for fuel cell electric and hybrid electric vehicle propulsion system," IEEE Trans. Ind. Appl., vol. 42, no. 5, pp. 1185–1192, Sep./Oct. 2006.

[4] M. Hinkkanen and J. Luomi, "Braking scheme for vector-controlled induction motor drives equipped with diode rectifier without brakingresistor," IEEE Trans. Ind. Appl., vol. 42, no. 5, pp. 1257–1263, Sep./Oct. 2006.

[5] C. H. Rivetta, A. Emadi, G. A. Williamson, R. Jayabalan, and B. Fahimi, "Analysis and control of a buck dc–dc converter operating with constant power load in sea and undersea vehicles," IEEE Trans. Ind. Appl., vol. 42, no. 2, pp. 559–572, Mar./Apr. 2006.

[6] J. S. Lai and F. Z. Peng, "Multilevel converters—A new breed of power converters," IEEE Trans. Ind. Appl., vol. 32, no. 3, pp. 36–44, May/Jun. 1996.

[7] J. S. Lai, J. Rodriguez, J. Lai, and F. Peng, "Multilevel inverters: A survey of topologies, controls and applications," IEEE Trans. Ind. Appl., vol. 49, no. 4, pp. 724–738, Aug. 2002.

[8] L. M. Tolbert, F. Z. Peng, and T. G. Habetler, "Multilevel converters for large electric drives," IEEE Trans. Ind. Appl., vol. 35, no. 1, pp. 36–44, Jan./Feb. 1999.

[9] C. B. Jacobina, E. C. dos Santos,M. B. de Rossiter Correa, and E. R. C. da Silva, "AC motor drives with a reduced number of switches and boost inductors," IEEE Trans. Ind. Appl., vol. 43, no. 1, pp. 30–39, Jan./Feb. 2007.

[9] L. Schuch, C. Rech, H. L. Hey, H. A. Groundling, H. Pinheiro, and J. R. Pinheiro, "Analysis and design of a new high-efficiency bidirectional integrated ZVT PWM converter for dc-bus and battery-bank interface," IEEE Trans. Ind. Appl., vol. 42, no. 5, pp. 1321–1332, Sep./Oct. 2006.

[10] M. Shen, J. Wang, A. Joseph, F. Z. Peng, L. M. Tolbert, and D. J. Adams, "Constant boost control of the Z-source inverter to minimize current ripple and voltage stress," IEEE Trans. Ind. Appl., vol. 42, no. 3, pp. 770–778, May/Jun. 200