A MULTI OUTPUT CYCLOINVERTER WITH INPUT POWER FACTOR CORRECTION FOR INDUCTION HEATER SYSTEM

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Abstract— In this paper, power factor correction (PFC) of cyclo inverter fed induction heater system is discussed. Power factor correction is employed here to correct the power factor on input side. The conventional cyclo inverter fed induction heater system with L-filter, T-filter and boost converter are simulated and the results are presented. Above methods reduces the phase displacement between input voltage and input current, thus improves the power factor. The power factor by these methods gives better results than the conventional one.

Knows Word- induction heating system, cyclo inverter, series reactance method, T-filter, boost converter Power factor Correction.

I. INTRODUCTION

Power factor is a measure of the relationship between the input voltage and current waveforms to an electrical load that is powered from an AC source. This source is most often the AC utility mains, but could also be the output of an electronic inverter, motor drive or other localized AC source. The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number between 0 and 1. Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power. In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor. Linear loads with low power factor (such as induction motors) can be corrected with a passive network of capacitors or inductors. Non-linear loads, such as rectifiers, distort the current drawn from the system. In such cases, active or passive power factor correction may be used to counteract the distortion and raise the power factor. The devices for correction of the power factor may be at a central substation, spread out over a distribution system, or built into power-consuming equipment. In (Shengpei Wang et al 1998), an advanced prototype of a voltage-fed single-ended push–pull-type quasi-load resonant inverter using IGBT's and its total system topology with active power filtering function have been presented for high-power high frequency IH cooking appliances in household and business uses. In general, AC motor drives have very poor power factor due to the harmonics in the line current. As compared to conventional analog controllers, digital regulators offer several advantages such as possibility of implementing nonlinear and reduction of the number of control components, high reliability, low sensitivity to component aging, better performance than that in analog implementation with the same cost, reduced susceptibility to environmental variations such as thermal drifts, and negligible offsets (T. V. Narmadhaa and T. Thyagarajan, Feb 2011). Digital control PFC implementations have been investigated by many researchers (Buso et al 1998; Fu 2001 and Zhou et al 2001). Power factor correction of DTC PMBLDCM system is presented by (Salih et al 2007). Single chip integration for motor drive converters with power factor capability is given by Consoli (Alofio 2004). Majority of the work has been done on the implementation of the analog PFC techniques in the digital platform. Energy recovery stage is used for active power control operation. There is very little work in the literature to implement the PFC methods. The above literature does not deal with boost converter-cyclo inverter fed IH system. In the present work, boost converter is proposed at the input side to improve the power factor. The paper is organized as follows. In section II the proposed cyclo inverter with L-filter, T-filter and Boost converter is presented. In section III simulation results of above mentioned circuits are presented. Finally, the conclusions of the work are provided in section IV.

II. PROPOSED TOPOLOGY

The cyclo inverter fed induction heaters with various input filters are considered. Cyclo inverter with L-

filter, T-filter and boost converter are considered in this work.

A. Cyclo inverter circuit

Fig.1 shows the schematic diagram of the cyclo inverter fed Induction heater system. An uncontrolled rectifier is used to convert the single phase AC into a constant DC link voltage which is fed to the cyclo inverter fed induction heater (IH) system. The cyclo inverter is modeled using RLC branches and MOSFET's. The MATLAB simulation of cyclo inverter fed IH system is carried out and the simulation results are presented in section III. Here the phase displacement between input voltage and input current is very large. And L-filter, T-filter or Boost converter may be used on input side to reduce the phase angle further so that the power factor of the system can be improved.

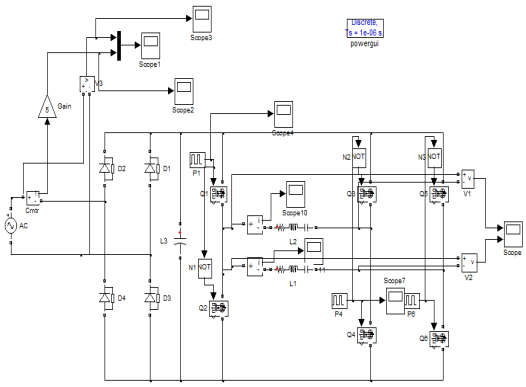


Fig.1 Cyclo inverter Circuit

B. Cyclo inverter circuit with L-filter

Inductors and capacitors are used in conjunction with the diode rectifier bridge to improve the waveform of the current drawn from the utility grid. The simplest approach is to add an inductor of 2300mH on the AC side of the bridge rectifier as shown in Fig. 2. The phase angle between input voltage and input current can be reduced by using L-filter.

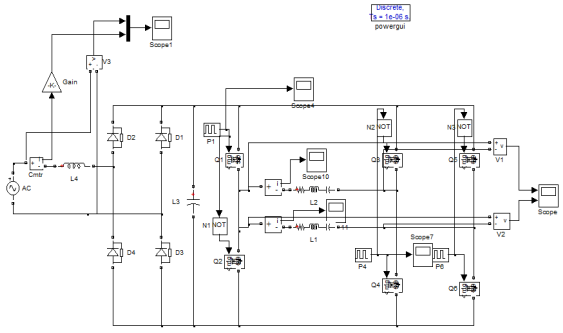


Fig.2 Cyclo inverter Circuit with Series inductor

C. Cyclo inverter circuit with T-filter

It is possible to improve the power factor further by introducing a T-filter on input AC side as shown in Fig.3. The values chosen for T-network are $L_4 = L_5 = 2.4H$ and $C = 0.001\mu F$. The AC line current can also be smoothened by using filters in the line just before the power electronic converter system. Inductors L_4 and L_5 basically increase source side inductance and higher order harmonics in the current. The capacitor suppresses the high frequency harmonics and transients from being coupled to and from the source. The T-filter is designed such that X_L is greater than X_C.

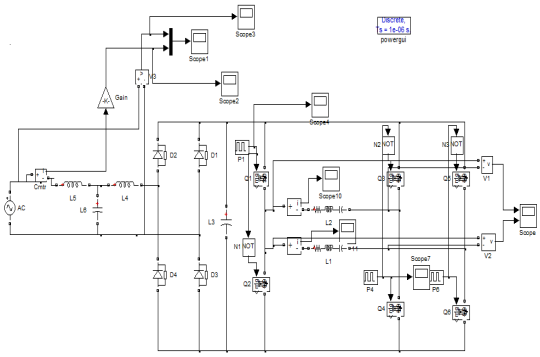


Fig.3 Cyclo inverter Circuit with T-network

D. Cyclo inverter circuit with Boost converter

It is possible to further improve the power factor using boost converter. Diode rectifiers are the most commonly used circuits for applications where the input supply is AC. The power factor of diode rectifiers with a resistive load can be as high as 0.9 and it is lesser with a reactive load. With the aid of modern control techniques, the input voltage ripple and current stresses on the rectifiers can be made sinusoidal and inphase with the input voltage, thereby having an input power factor of approximately unity. The unity power factor circuit that combines boost converter and cyclo inverter circuit fed IH system is shown in Fig.4.

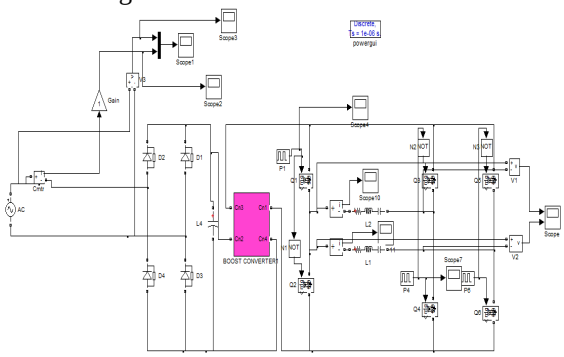


Fig.4 Cyclo inverter Circuit with Boost Converter

III. IMULATION RESULTS

The Cyclo inverter circuits with various filters with PFC for IH load are simulated with MATLAB-Simulink software and the results are presented. Parameters used for simulation are as follows: $L_1 = L_2 = 60uH$,$C_1 = C_2 = 0.1uF$, $R_1 = R_2 = 10\Omega$, with an switching frequency of 1kHz, Resonant frequency of 64.974kHz, Duty cycle of MOSFETs Q_1 & Q_2 as 0.5, Q_3 & Q_4 as 0.4 and Q_5 & Q_6 as 0.2. The input voltage given to the entire configuration is 120v, 50Hz ac supply. The dc link capacitor is 1uf.

E. **Cyclo Inverter Circuit**

The AC input voltage and current are shown in Fig. 5a. The voltage across loads 1 & 2 are shown in Figures 5b and 5c respectively. The output currents of load 1 & 2 are shown in Figures 5d & 5e respectively. It is seen that the phase angle between input voltage and input current is large; hence the power factor is poor. The harmonic Spectrum of cyclo inverter fed Induction heater system is shown in Fig. 5f. The total harmonic distortion (THD) is 23.08% when the load is operated at 50 Hz frequency.

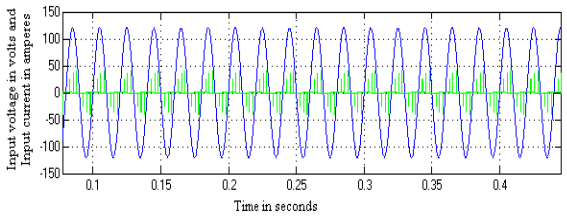


Fig.5a AC Input Voltage and Current. X-axis time in seconds, Y-axis Voltage in volts and current in amperes.

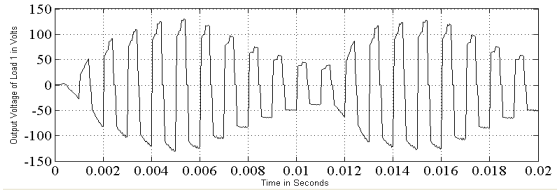


Fig.5b Output voltage of load 1

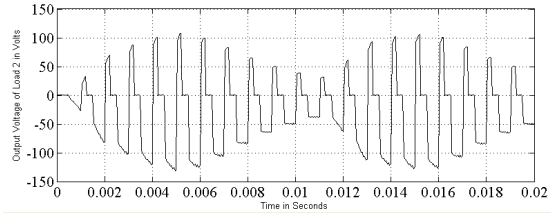


Fig.5c Output voltage of load 2

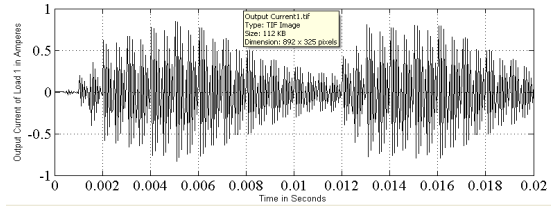


Fig.5d Output current of load 1

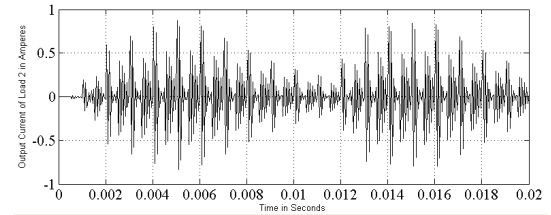


Fig.5e Output current of load 2

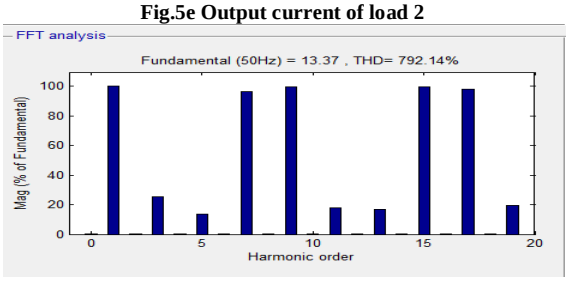


Fig.5f Harmonic spectrum of input current

F. **Cyclo inverter with L-filter**

The AC input voltage and current are shown in Fig. 6a. The phase difference between input voltage and input current is comparatively less than that of conventional cyclo inverter fed IH system. Fig 6b shows the harmonic Spectrum of cyclo inverter fed Induction heater system with input L-filter and the corresponding total harmonic distortion is 11.22%. Thus THD is reduced by adding inductor filter.

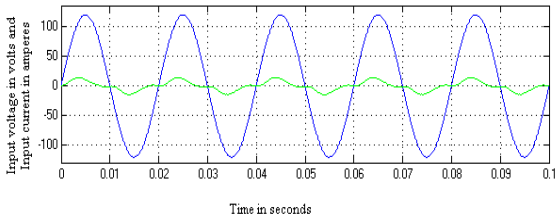


Fig.6a AC Input Voltage and Current. X-axis time in seconds, Y-axis Voltage in volts and current in amperes.

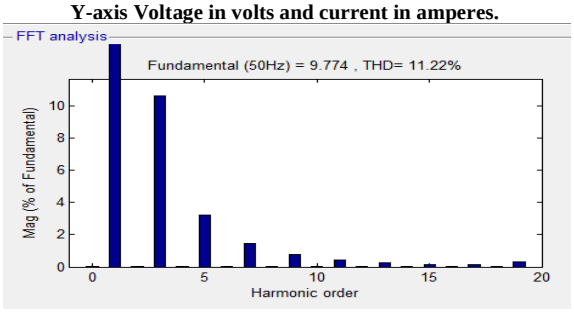


Fig.6b Harmonic spectrum of input current

G. **Cyclo inverter with T-network**

The AC input voltage and current are shown in Fig. 7a. It is seen that the phase difference between the input voltage and input current is reduced hence the power factor of the T-filter fed IH system is increased. Fig. 7b shows the harmonic Spectrum of cyclo inverter fed Induction heater system with input T-filter. The total harmonic distortion reduces to 4.48% by using T- filter at the input.

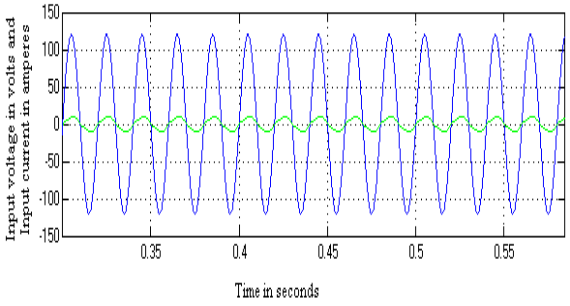


Fig.7a AC Input Voltage and Current. X-axis time in seconds, Y-axis Voltage in volts and current in amperes.

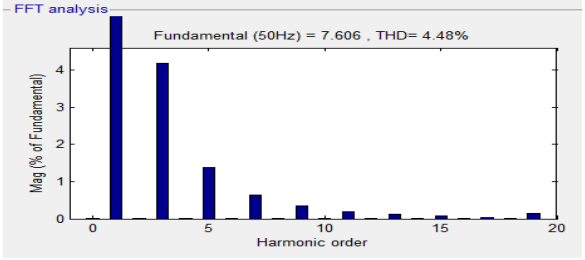


Fig.7b Harmonic spectrum of input current

H. **Cyclo inverter with Boost Converter**

The AC input voltage and current are shown in Fig. 8a. It is seen that the phase difference between the input voltage and input current is highly reduced and hence the power factor is improved nearer to unity. Fig. 8b shows the harmonic Spectrum of cyclo inverter fed Induction heater system with Boost converter where the total harmonic distortion is 54.64%.

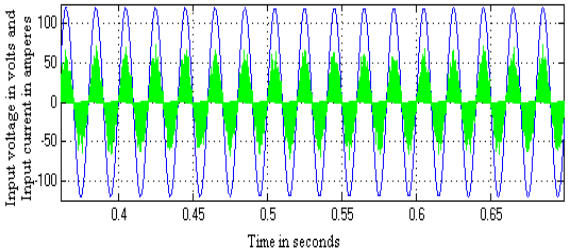


Fig.8a AC Input Voltage and Current. X-axis time in seconds, Y-axis Voltage in volts and current in amperes.

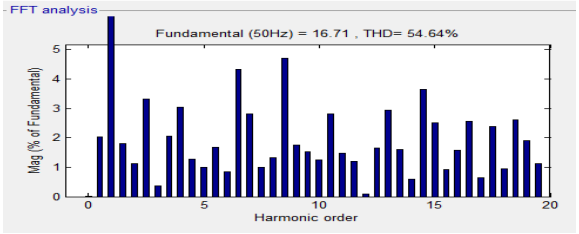


Fig.8b Harmonic spectrum of input current

Table.1 Comparison of THD in Phase current

Type of converter	THD in Phase current %
Cyclo inverter fed IH	792.14
Cyclo inverter with L-filter	11.22
Cyclo inverter with T-filter	4.48
Cyclo inverter with Boost converter	54.64

Table.2 Comparison of phase angle between input voltage and input current

Type of converter	Phase angle between input voltage and input current
Cyclo inverter fed IH	54°
Cyclo inverter with L-filter	27°
Cyclo inverter with T-filter	36°
Cyclo inverter with Boost converter	5.4°

From Table 1, it can be seen that THD in phase currents are lesser in T-filter fed IH system. From Table 2, it can be seen that the phase angle between input voltage and input current is 5.4° in Boost converter fed IH system. This system has unity power factor.

CONCLUSION

A multi output Cyclo inverter with L-filter, T-filter and Boost converter systems are successfully modeled and simulated using MATLAB SIMULINK. The simulation results of these systems are presented, which indicates that the Boost converter fed multi output cyclo inverter system has the best input power factor and Cyclo inverter with T-filter has reduced harmonic on input side.

REFERENCES

[1] Shengpei Wang, Kiyoshi Izaki, Izuo Hirota, Hidekazu Yamashita, Hideki Omori and Mutsuo Nakaoka (1998), "Induction-Heated Cooking Appliance Using New Quasi-Resonant ZVS-PWM Inverter With Power Factor Correction", IEEE Transactions on Industry Applications, Vol. 34, No. 4.

[2] T. V. Narmadhaa and T. Thyagarajan (2011), "Digital Simulation of Pmbldc Motor Drive with Power Factor Correction", Bangladesh Journal of Scientific and Industrial Research, 46(4), 457-464.

[3] Buso. S. (1998). Simple digital control improving dynamic performance of power factor pre-regulators, IEEE Trans. Power Electron 13(5).: 814-823.

[4] Fu.Mand Chen.Q. (2001). A DSP based controller for power factor correction in a rectifier circuit, in Proc. IEEEAPEC Annu. Meeting, Anaheim, CA, Mar. 4-8, pp.

[5] 144-149.

[6] Zhou. J. (2001). Novel sampling algorithm for DSP controlled 2 kW PFC converter, IEEE Trans. Power Electron., 16(2): 217-222.

[7] Alfio.C and Antonia.T (2004), ' Single chip integration for motor drive converters with power factor capability', IEEE Trans. On Power Electronics, 19(6): 1372-1379.

[8] Salih Baris Ozturk, Oh Yang, Hamid A. Toliyat (2007), 'Power factor correction of Direct Torque Controlled Brushless DC motor drive', IEEE Conference, pp 297-304.

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