Implementation Of Closed Loop Control Of Ac-Ac Converter For Power Factor Improvement

Neeraj Priyadarshi
Sr Asst.Professor
Geetanjali institute of technical studies Udaipur(Rajasthan)

Abstract— This paper presented a control strategy for AC-AC Converter for Power factor improvement. A Single-switch parallel resonant converter for Induction heating is simulated and implemented. The circuit consists of input LC-Filter, bridge rectifier and one controlled power switch. The switch operates in soft commutation mode and serves as a high frequency generator. Output power is controlled via switching frequency. Steady state analysis of the converter operation is presented.. A closed loop circuit model for AC to AC converted induction heating system is also proposed. Experimental results are compared with simulation results. The converter input current is practically sinusoidal and its power factor is close to unity. The circuit topology is very simple since includes only one power switch. This switch operates in a soft commutation mode. The converter provides a wide-range power control. This converter has advantages like reduced hardware, reduced stresses and high power density. Closed loop circuit model is developed and it is successfully used for simulation studies. Simulations were obtained using MATLAB/SIMULINK. The simulation and hardware results proved that the control scheme have the advantages of better static and dynamic characteristics, small overshoot of the system response, rapid dynamic response and good robustness.

***Keywords*: Induction heating, soft commutation mode, AC-AC Converter etc.**

I. INTRODUCTION

As power electronic systems are extensively used not only in industrial field but also in consumer products. Static frequency converters have been extensively applied in industry as a medium –frequency power supply for induction heating and melting installations. They are applied in all branches of the military, machine-building industries, jewellery, smithy heating, domestic heating cooking devices and other purposes. The ordinary circuit of an AC-AC converter for induction heating typically includes a controlled rectifier and a frequency controlled current source or a voltage source inverter. It is a well known fact that the input rectifier does not ensure a sine wave input current, and is characterized by a low power. Recently many studies of high power factor rectifiers with a single switch have been made. These schemes are also characterized by a close to sine wave input current. In addition, in the scheme of the AC-AC converter for induction heating is described. The input circuit of the converter is constructed similarly to the input circuit in which also ensures a high power factor. However the inverting circuit is constructed by traditional mode with four controlled switches. From the simulation results, the proposed control scheme and controller have the advantages of better static and dynamic characteristics, small overshoot of the system response, rapid dynamic response and good robustness.

II. CIRCUIT DIAGRAM AND PRINCIPLE OF OPERATION

In the scheme (Fig.1) of the AC-AC converter there are two main advantages: It is characterized by a high power factor and a sine wave input current. On the other hand the inverter circuit is constructed with a single controlled switch, which serves as a high-frequency generator for induction heating. In the scheme (Fig.1) of the AC-AC converter there are two main advantages: It is characterized by a high power factor and a sine wave input current. On the other hand the inverter circuit is constructed with a single controlled switch, which serves as a high-frequency generator for induction heating.

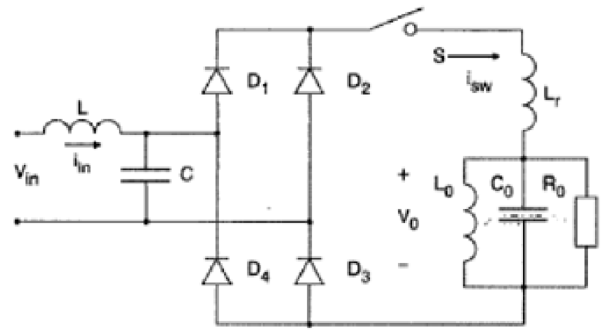

Fig1.circuit diagram

We suppose the switching frequency is much higher than the input line frequency and in the analysis we arbitrarily chose the time interval where $v_{in}>0$

III. MODE OF OPERATION

The operating principles of the circuit are illustrated by Fig.2 and the theoretical waveforms

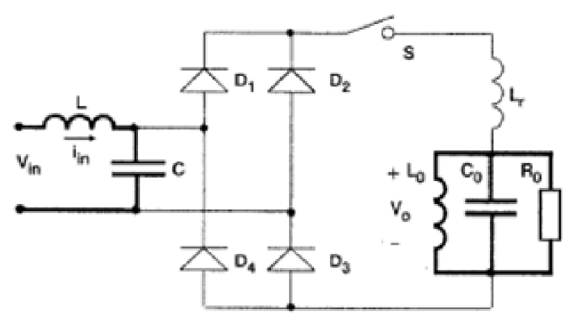

Fig2(a).Mode I

Interval 1: $t_0<t<t_1$

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The equivalent circuit is shown in Fig.2a. Four diodes D1-D4 and the switch S are off. In this interval the capacitor C charges up practically linearly at a rate and a polarity corresponding to the instantaneous input voltage vin.

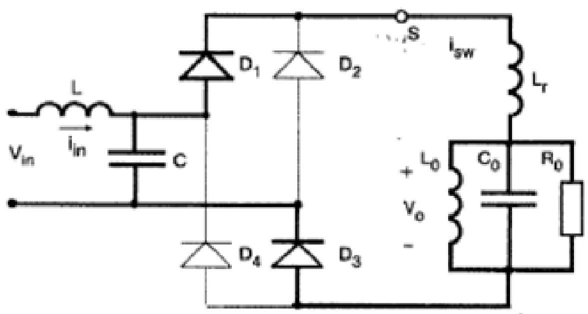

Fig2(b).Mode II

Interval 2: t1<t<t2

The equivalent circuit is shown in Fig.2b. Two diodes D1, D3 and the switch S are on. In this interval the capacitor C is discharging via the circuit C-D1-S-Lr-load-D3. This interval ends when the capacitor voltage reduces to zero.

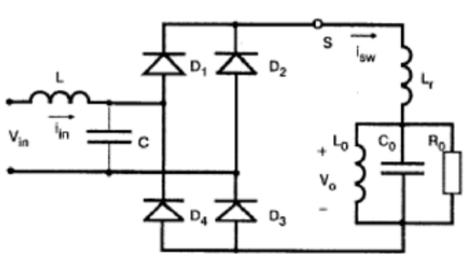

Fig2(c).mode III

Interval 3: t2<t<t3

The equivalent circuit is shown in Fig.2c. All the diodes and the switch S are on. In this interval the current through switch S flows via two parallel bridge branches. This interval ends when this switch current decreases to zero. At this moment the switch turns off and the process starts from the beginning.

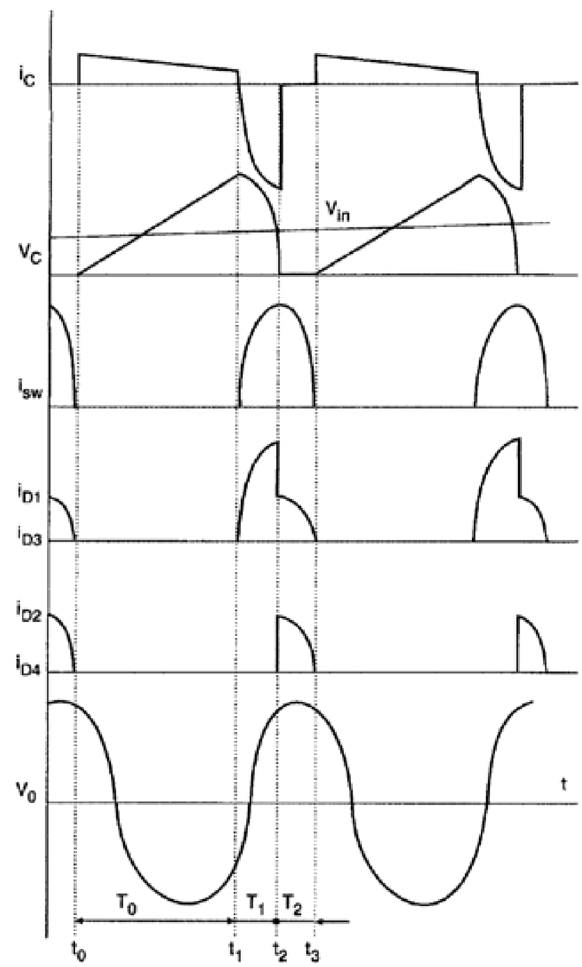

Fig3.Switching Waveforms

IV. INDUCTION HEATING

Induction heating is the process of heating an electrically conducting object (usually a metal) by electromagnetic induction where eddy currents (also called Foucault currents) are generated within the metal and resistance leads to Joule heating of the metal. An induction heater (for any process) consists of an electromagnet, through which a high-frequency alternating current (AC) is passed. Heat may also be generated by magnetic hysteresis losses in materials that have significant relative permeability. The frequency of AC used depends on the object size, material type coupling (between the work coil and the object to be heated) and the penetration depth.

V.PI CONTROLLER

PI Controller (proportional-integral controller) is a feedback controller which drives the plant to be controlled with a weighted sum of the error (difference between the output and desired set-point) and the integral of that value. It is a special case of the common PID controller in which the derivative (D) of the error is not used.

VI. SIMULATION RESULTS

Simulations have been obtained using MATLAB/SIMULINK. Experimental results have been obtained with a low power laboratory prototype of a single –phase PWM converter. The main parameters are as followings: The circuit parameters are R_0=60Ω; L_0=150μH; C_0=2.35μF; L_r=22μH; L_i=8.0mH; C_{in}=0.94μF and the switching frequency ω_S= (62-113) x10^3 s^{-1}

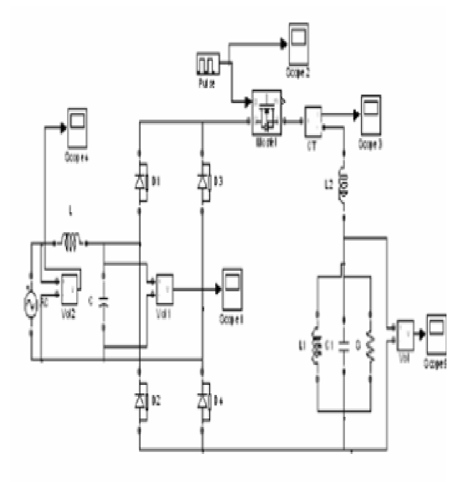

Fig4:Open loop circuit

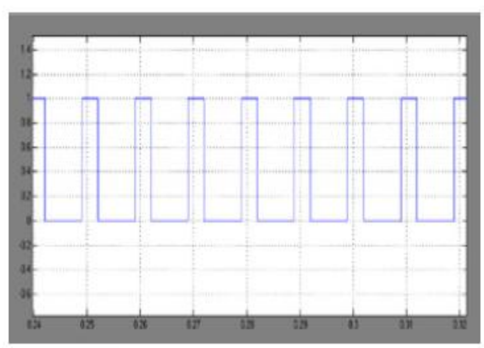

Fig:5 Driving pulses

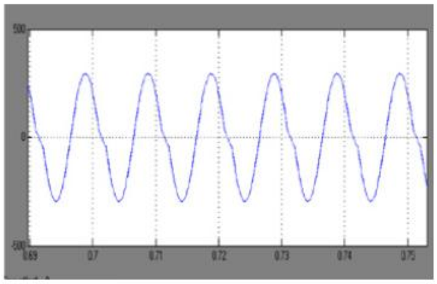

Fig:6 AC output voltage

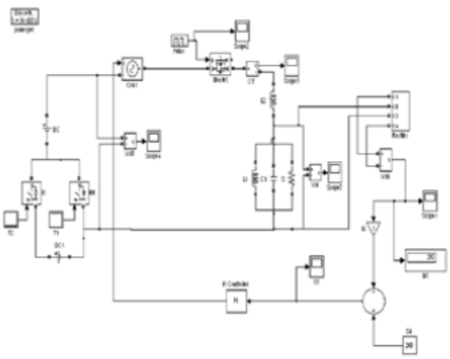

Fig:7 Closed loop controlled AC-AC converter

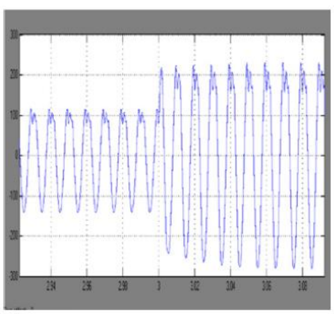

Fig:8 output voltage of open loop system

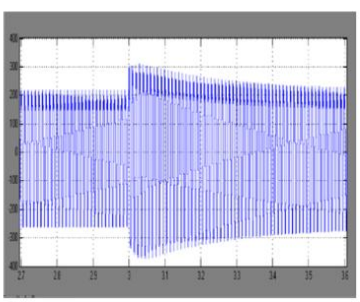

Fig:9 Output voltage of closed loop system

VII.CONCLUSION:

An AC-AC converter circuit for induction heating has been simulated and tested. The converter input current is practically sinusoidal and its power factor is close to unity. The circuit topology is very simple since includes only one power switch. This switch operates in a soft commutation mode. The converter provides a wide-range power control. This converter has advantages like reduced hardware, reduced stresses and high power density. Closed loop circuit model is developed and it is successfully used for simulation studies. The limitation of this converter is presence of DC component in the output current and operating frequency is limited to 11MHz. Simulation and experimental results demonstrate the actual converter capability to control the heat.

VIII. REFERENCES:

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