A Zero Current Switching AC-AC Resonant Converter

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ABSTRACT

Induction heating is a fast, efficient, precise and repeatable non-contact method for heating metals or other electrically-conductive materials. Induction heating is a process which is used to bond, harden or soften metals or other conductive materials. For many modern manufacturing processes, induction heating offers an attractive combination of speed, consistency and control. The induction heating power supply converts AC line power to a higher frequency alternating current delivers it to a work coil and creates an electromagnetic field within the coil. This paper proposes a new concept unlike previous method, i.e. the direct conversion of ac-ac converter for reducing the component count, reduce cost, improve reliability, and also efficiency. Generally, the proposed converter is a voltage-source based series-resonant converter used for controlling output power, and minimizing the control complexity.

KEYWORDS: Induction heating, Power electronics, Resonant converter

I. INTRODUCTION

Generally, the term Induction heating is the process of heating an object by electromagnetic induction. The component used for induction heater are an electromagnet, a high-frequency alternating current is passed through it. Due to magnetic hysteresis losses present in the materials and have sufficient permeability also causes for generating heat [2]. For domestic and other classifications of induction heating at low and medium power appliances (such as military canteens, machine building and other industries) uses generally static frequency converters. The basic converter, which is used for controlling Induction Heating (AC-AC) is two stage conversion process i.e. first one is rectifier for converting AC-DC and second converter is a high frequency inverter which is used for converting DC-AC at constant/variable frequency [7]. The inverter used in above process is a two leg, four switch circuit [10], [4]. And the control design constructed for this inverter is an open loop, so it is difficult to control the output. And this type of two stage conversion converter is more economical at low efficiency.

Of these topologies are used often to achieve multiple-output converters. The modulation strategies commonly applied to control output power are based on modifying either The basic ordinary circuit of an AC-AC converter for induction heating typically consists of a control rectifier and a high frequency controlled current source or voltage source based inverter [2]. However, this inverting circuit is constructed by a
traditional mode with controlled switches. Inverter topologies commonly used for Induction Heating are the full-bridge and half-bridge operations. Some deviations witching frequency or duty cycle to achieve the desired output power.

Resonant power converters are constructed with combination of L-C resonant elements, who’s its output is changes periodically. So, the variations in magnitude are occurred in these waveforms. So, for eliminating these variations a small scale converter [5] is not suitable. Classification of resonant converters is as follows:

Ac-Ac resonant converters
Rectifying-Inversion Process.

The main advantage of this type of resonant converters are, low switching losses and the concept like turn-on and turn-off switching transitions for semiconductor device can occur also due to zero voltage and zero current switching techniques in resonant tank voltage and current waveforms.

II. AC-AC CONVERTER

Generally, the direct AC-AC converter employs a high frequency switching devices for reducing switching losses thereby improving system efficiency. For regulating the output these type of AC-AC resonant converters [8] require a variable frequency control [4]. The Schematic diagram for proposed power converter (as shown in fig 1) is designed to include the rectifier within the inverter stage, eliminating therefore the component redundancy and switch count when compared with classical direct ac–ac solutions as in fig 2. In addition to this, the proposed converter optimizes the switching conditions.

![Fig: 1 Proposed AC-AC Converter](image1)

![Fig: 2 Proposed Direct AC-AC Converters](image2)

The power converter operation modes depend on the mains voltage sign. Six different configuration states. States I to III correspond to positive mains voltage, whereas states IV to VI correspond to negative mains voltage [2].

In present scenario the application of these ac to ac conversion are increased for providing an efficient and better solution with negligible energy storage elements. Also, the Matrix type converters have been applied to resonant loads under 3-phase induction heating appliances [9].

IV. CLOSED LOOP CONTROL DIAGRAM

The control signals for controlling the high frequency inverter is obtained by the method of pulse width modulation. The reference signal for this modulation technique is obtained by using output voltage and currents comparison. And also this paper discuss about parks transformation which is used for transforming three phase coordinates to two phase coordinates i.e. direct and indirect quantities. Two proportional integral controllers are used to regulate the current errors. Since the controllers produce the reference voltage commands. The control diagram for this resonant converter is shown in figure 5.

![Fig: 3 Control Diagram for AC-AC Resonant Converter](image3)

V. EXPERIMENTAL DISCUSSION

The proposed three phase type resonant AC-AC configuration [5] have been successfully simulated and verified the output waveforms through Matlab/ Simulink. The controlling circuit for this
inversion stage is implemented in closed loop form and also shown in this Simulink. The Experimental diagram and results are shown below. The parameters used for components used in the circuit are shown in table 1.

![Fig 4](image1)

**Fig 4:** shows the pulse generation

![Fig 5](image2)

**Fig 5:** shows output voltage and current waveform of the switches.

![Fig 6](image3)

**Fig 6:** currents flowing through the four diodes.

### VI. CONCLUSION

Direct ac-ac conversion has proved that it is an efficient technique and also can be extended version to basic inverters which is present used in most household appliances. The proposed converters have combine features of higher power density with a reduced number of conversion stages and energy-storage elements. In this paper, a three phase application for induction heating based matrix converter has been proposed. The control strategy used in this paper for maintaining a direct commutations between the base main states and the normal main states. The results are shown for three phase and from this experimental setup we proves that these converters have low switching losses and have high efficiency as compared to conventional two stage conversion converters.

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