Direct Ac-Ac Resonant Full Bridge Converter For Efficient Domestic Induction Heating Applications

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***Abstract* — The induction heating technology is more preferable scheme in domestic applications, due to its fast heating process for short time consumption. The main features of the proposed converter the switching stress is reduced, due to full bridge converter efficiency is improved compared to the existing half bridge converter. In the proposed converter simulation is done by MATLAB software and the result is compared with the existing system. The simulation results prove the feasibility of the proposed converter for the induction heating application. The Induction heating works at high frequency for directly heating the material itself.**

Keywords— high frequency, eddy current, resonant full bridge converter, Induction heating.

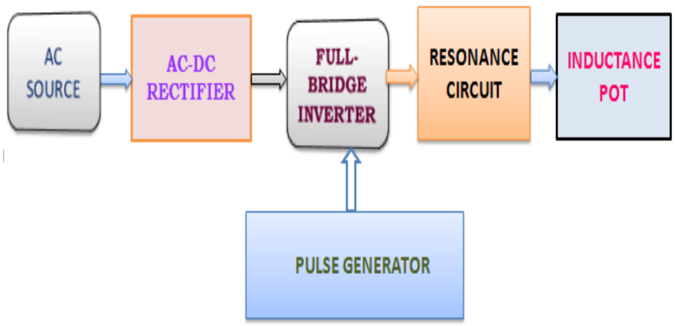
I. INTRODUCTION

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. In the most common heating methods, a torch or open flame is directly applied to the metal part. But with induction heating, heat is actually "induced" within the part itself by circulating electrical currents. The basic principle of induction heating, which is an applied form of Faraday's discovery, is the fact that AC current flowing through a circuit affects the magnetic movement of a secondary circuit located near it. Its application, however, has not been flawless Inverters convert low frequency main AC power to a higher frequency for use in induction heating.

The converter proposed in this paper is based on the direct ac-ac resonant full bridge converter. The full bridge converter can be doubled the output power when compare to the half bridge converter. It is also used for power level above 1KW. At a reasonable cost and load durable more appropriate configuration 15 KW. These converters are more efficient because of reducing Switching losses, filter capacitor count and EMC filter requirements. The full-bridge series resonant inverter (FB-SRI) featuring some semi conductor devices like IGBTs, MOSFETs is commonly used for the domestic IH applications. In this paper MOSFET is used, because the MOSFET has positive temperature co-efficient for resistance. If a MOSFET shares increased current initially, it heats up faster, and it is a voltage control device. Due to high frequency power factor will be improved when compare to class E&D it is better. It works in (0-500V) medium, when compare to IGBT it is cost wise cheaper. In addition the ZVS soft switching conditions are used to reduce the both conducted and radiated EMC issues. The soft switching condition is similar to the PWM converters. The classification of soft switching conditions are resonant converter and resonant (zero current or zero voltage) transistor converters. In this paper, a Direct AC-AC converter is used to obtain variable ac output voltage from a fixed ac source. It is a voltage controller. Its main advantages are high power factor and a sine wave input current. The ac-ac converters are used to change either the voltage level (or) the frequency. The frequency is usually at higher than 20 KHZ and lower than the 100KHZ to reduce the switching losses.

II. INDUCTION HEATING

Induction heating is a direct application of two laws of physics: the Lenz law and the Joule law. When immersed in a variable magnetic field (generated by an induction coil or inductor), any substance that conducts electricity carries the electrical current induced, also called Foucault currents (or) eddy currents. According to the Joule effect, the movement of the electrons creating these currents dissipates the heat in the substance where they were generated.



Block diagram for induction heating appliances.

The induction heating method requires high frequency current supply which develops a high frequency eddy current which circulating in the load material, due to resonant converter the ZVS is applied. Electromagnetic induction formula according to Ampere's law is given below:

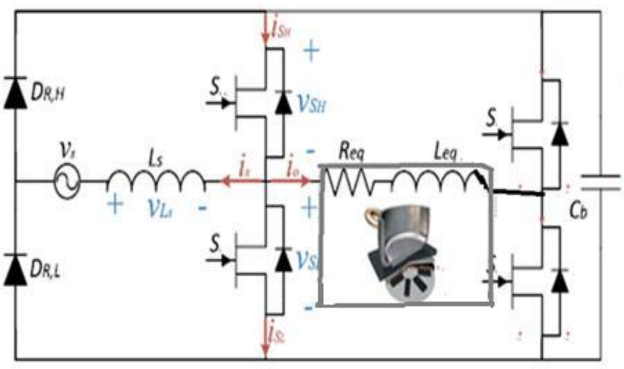
$$\int Hdl=Ni=F$$

$$\phi=\alpha HA \qquad (1)$$

According to Faraday's law the current on the surface of object which generates the eddy current is shown in the formula:

$$E=d/dt=Nd\varnothing/dt \qquad (2)$$

The heat produced in a part in a induction coil due to electrical current circulating in the part itself. The copper wires are the good conductors. It is used to carry electricity through power lines because of the low heat losses during transmission. By increasing the current in the circuit makes the power and efficiency should be increased in the electrical power system is $P=I^2R$. The proposed topology reduces both conduction and switching losses, increasing significantly the power converter efficiency. To getting the maximum efficiency chosen different diameters of induction coils.



PROPOSED CIRCUIT USING FULL BRIDGE CONVERTER

III. FULL BRIDGE RESONANT CONVERTER

This paper deals with the operation principle of a Direct AC–AC Resonant Full Bridge Converter for Efficient Domestic Induction Heating Applications is proposed. In order to avoid the audio frequency is set at over 20KHZ. In practical terms, electromagnetic induction involves putting a part (usually made of electrical conductive material) inside a magnetic field, which is kept variable with an "inductor coil" (inductance), which itself is connected to a power source and a capacitor bank, and the assembly forms an oscillating circuit at a so-called "resonance" frequency.

$$f_o=1/2\pi fc=1/2\pi\sqrt{LC} \qquad (3)$$

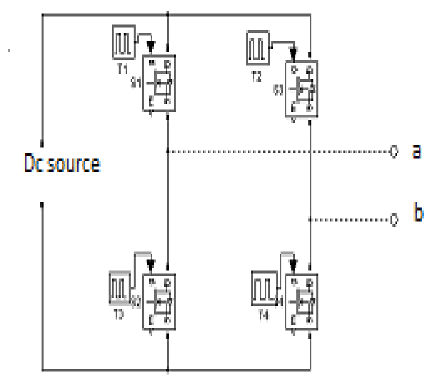
In induction heating the resonant converter is very important one. The switching frequency lies between 25 to 35 KHZ for both series and parallel resonant converters. An advantage of series resonant circuit is that both zero current and zero voltage switching is possible Capacitor reaction is equal to Inductive reaction to heat the coil so resonant converters are used in the induction heating.

$$X_L=2\pi fL \;\&\; X_C=1/2\pi fc \qquad (4)$$

The main features of this proposal are the improved efficiency, reduced component count, and increase the output current, proper output power control. In this proposed system AC source is given input to the system and then converted into dc by rectifier operation. Again that dc converted into ac by using full bridge inverter operation. The proposal system choosing a full bridge because to reduce the Capacitor size and the output power can be doubled like its power level is above 1 KW. In full bridge only one smoothing capacitor is at the input for this configuration and for the same transistor type as of half bridge. This type of operation result is negligible of switching losses. The experimental results are in good agreement with the analytical ones and prove the feasibility of the proposed converter for the IH application.

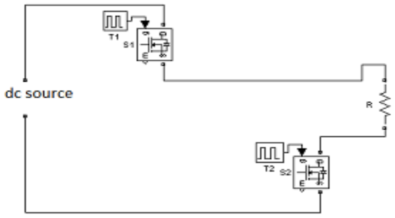
The full bridge converters are ordinary alternating current (220V, 380V) into the high-frequency DC current, a strong eddy current acting reel, and intense electromagnetic field and the corresponding special cookware induction through a series of circuit processing techniques, and directly promote special pot with material internal atomic collision speed stirring, making special cookware itself quickly to produce high temperature heat for processing, cooking food. The load current could be continuous or discontinuous depending on the load time constant & delay angle. While change the duty cycle to generate various power voltage and current. The inverter mode operations are done by using the full bridge resonant converters.

IV. INVERTER MODE OPERATION



They are two mode operations are involved they mode 1 & mode 2operation circuits are given below.

Mode 1 (0˚ to 180˚):



During this mode, switches S1 and S2 is turned ON which yields to the positive half cycle of the output AC voltage waveform. A resonant current flow through s1 &s2, load and supply.

The instantaneous current is calculated by

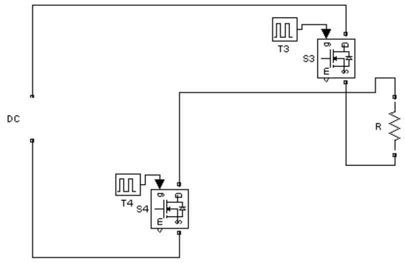
$$L\, dio/dt + Rio + 1/c \int io\, dt + Vc\,(t=0) = Vs \qquad (5)$$

$$io(t) = Vs + Vc/\omega_r L * e^{-\alpha t} \sin \omega_r t \qquad (6)$$

The device s1 & s2 turned off at $t1=\pi\omega_r$

$$Vc1(t)=-(Vs+Vc)e^{-\alpha t}(\alpha \sin \omega_r t+\omega_r \cos \omega_r t)+ Vs \qquad (7)$$

Mode 2 (180˚ to 360˚):



During this mode, switches S3 and S4 is turned ON which yields to the negative half cycle of the output AC voltage waveform. The reverse resonant current flows through s3 &s4 load and supply.he instantaneous load current is calculated by

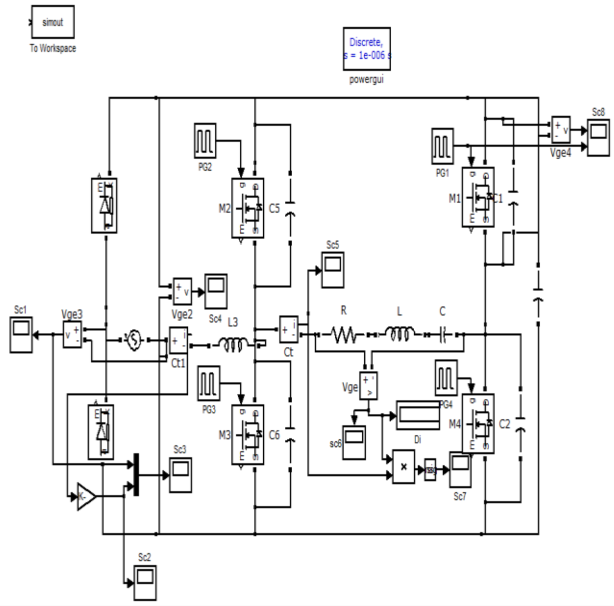
$$L\, dio/dt + Rio + 1/c \int io\, dt + Vc\,(t=0) = -Vs \qquad (8)$$

$$io(t) = Vs + Vc1/\omega_r L * e^{-\alpha t} \sin \omega_r t \qquad (9)$$

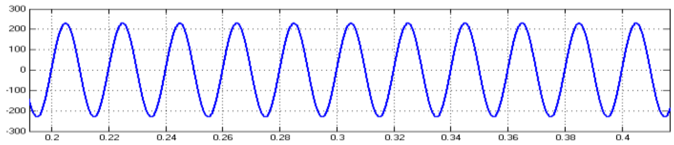
$$Vc(t)= -Vc(t=t1) = (Vs+Vc1)\, e^{-\alpha t/\omega r} + Vs \qquad (10)$$

For the same circuit parameters, the output power of a full-bridge inverter is four times and the device currents are twice that for a half-bridge inverter.

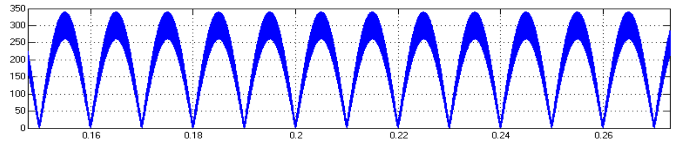
The simulation circuit for the proposed system is given below.



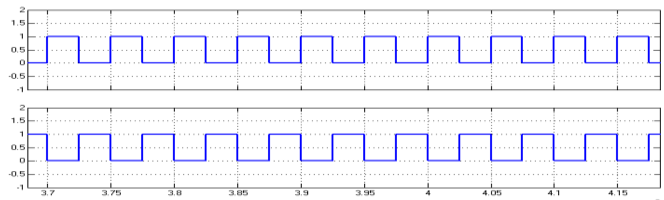
Simulation results:



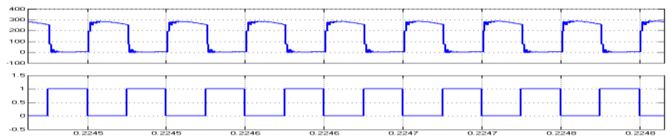
Input voltage



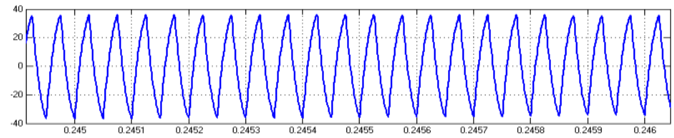
Rectifier output voltage



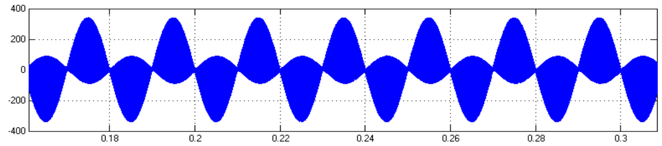
Switching pulse for m1,m3



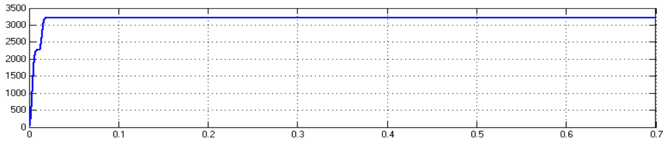
Vds & switching pulse



Output current



Output voltage



Output power

TABLE
Simulation Parameter values

s. no	Parameters	R load	RL load	RLC load
1.	Vin	230V	230V	230V
2.	Frequency	20KHZ	20KHZ	20KHZ
3.	Diode value	1n 4007	1n 4007	1n 4007
4.	Capacitor value	$90e^{-6}$	$90e^{-6}$	$90e^{-6}$
5.	Duty cycle	50%	50%	50%
6.	Vo	220V	220V	220V

Comparison for Existing & Proposed System

Name of the Items	Existing	Proposed
Vin	230V	230V
Vo	220V	220V
Output current	20A	35A
Output power	750W	3215W
Efficiency	77%	93.5%

CONCLUSIONS

The different inverter topologies are used in induction heating applications. Of that the basic half- bridge and full bridge inverter topologies have been compared. New topologies have been proposed. The AC-AC converter circuit for induction heating has been simulated. 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. A direct ac–ac resonant Full Bridge converter applied to domestic IH application was proposed. The main features of the proposed converter include a, high efficiency and ZVS operation, the output current in the existing 20A is increased in the proposed up to 35 A as shown in the simulation waveform. The output power in the half bridge converter is 750W and it is doubled in the proposed system 3215W by using the full bridge converters. The comparison between the existing proposed are proved in the simulation result.

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