

Design and implementation of a High Frequency Cyclo- Inverter with Multi Output for Induction Heating Applications using Digital Simulation

V.REENA JOSHI VINCE, P.PRAVINA

Assistant Professor, Jeppiaar Engineering College, Chennai, India¹



Abstract:

The paper deals with the designing of an inverter circuit which generates a multi output high frequency AC. The operating principle of utility is AC-low frequency to AC-high frequency and AC power frequency conversion circuit which is defined as high frequency cyclo inverter. This synthesized converter can be considered as a multi-output extension of a full-bridge topology where the AC to DC conversion is done by a bridge converter and again the required multi output AC is obtained with the help of series-resonant inverter circuit. It allows the control of outputs, simultaneously and independently, up to their rated power reducing the component requirement along with the multi converter solution. The additional advantage of such a circuit is that the AC side line current harmonic components and power factor characteristics are improved. This Circuit is simulated using MATLAB Simulink and the simulation results are shown.

1. Introduction

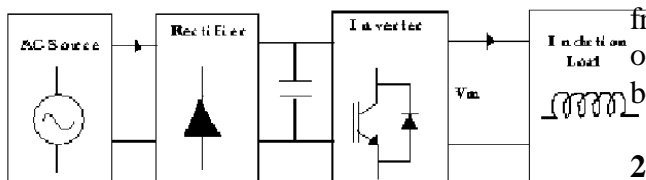
In general, the electromagnetic Induction Heating (IH) is concerned with noncontact, high efficiency, and cleans electric heating method

V.Reena Joshi Vince is currently working as an Asst Prof in Jeppiaar Engineering College, ANNA University, Chennai. (e-mail: reenajosh@gmail.com)

P.Pravina is currently working as an Asst Prof in Jeppiaar Engineering College ANNA University, Chennai (email: smppravi@gmail.com)

due to the energy conversion heated device by induction eddy current based on Faraday's law of electromagnetic induction principle in addition to Joule's heating principle. Attractive IH technology used for industrial and consumer applications is roughly classified as low frequency IH and high frequency IH (over 20 kHz). In recent years, significant verifications of effective applications of IH have been recognized as follows: metal heat treatment process in the industry application fields, including thermal treatment process such as forging and casting, electromagnetic induction based plasma generation process, high-speed dissolution process for the new materials and melting process of semiconductor manufacturing, high frequency induction heating soldering process with the self temperature function using magnetic alloy heating element, and induction fusion processing of the polyethylene pipe. On the other hand, the latest technology developments of IH application products emphasized on the environment have attracted special interest in the consumer application fields as follows: IH cooking device, rice cooker and warmer, boiler, hot-water producer, floor and wall fluid heater, fryer, dryer, wastes treatment and soil sterilization equipment using cleaning, sterilization and drying of atmospheric pressure super heated steamer. A typical arrangement of an induction cooker is shown in Fig. 1. Induction cookers take the energy from the main voltage, which is rectified by a bridge of diodes. Then the inverter topology supplies the high-frequency current to the induction coil.

2.0 Block Diagram



2.1 AC source:

It is the first stage of this project. So it is give the AC supply to rectifier. The input sides having one inductive filter. It is used to improve the input power factor.

2.2 Rectifier:

It converts AC supply to DC supply. DC supply having some ripples. It is filtered with the help of capacitor filter.

2.3 Multiple Output Inverter:

It converts DC supply to Multiple AC output. This output shape is similar to Cyclo converter output waveform. So this inverter is called as cyclo inverter and also generates multiple outputs. So it is called multiple output inverters.

2.4 Load:

The output has high frequency AC. It is used for heating purpose in Industries.

2.5 Micro Controller:

Microcontroller is used to generate triggering pulse for mosfets. It is used to control the outputs. Micro controller have more advantage compare then analog circuits and microprocessor such as fast response, low cost, small size and etc.

2.6 Driver:

It is also called as power amplifier because it is used to amplify the pulse output from micro controller. It is also called as optocoupler IC. It provides isolation between microcontroller and power circuits.

2.1.7 Regulated Power Supply (RPS):

RPS give 5V supply for micro controller and 12V supply for driver. It is converted from AC supply. AC supply is step down using step down transformer Altogether, the proposed converter offers a high-voltage high-power solution that gives soft switching to all the main switches, reduces the voltage stress applied to the main switches thus allowing the use of devices with faster switching speeds, and reduces the complexity of the switching controller so that existing technology can be used for the switching controller.

2. Converter Operational Modes

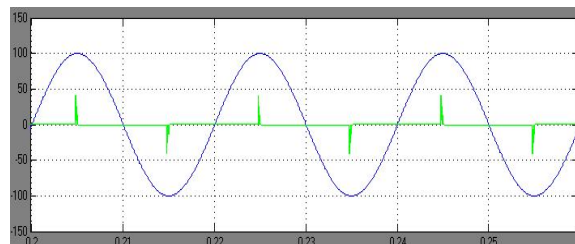
The proposed converter has ten operational modes which are explained in detail with the help of circuit diagram and operational waveforms. (refer fig 1 (b).) The first five of the ten operational modes is for the one half cycle and the other five for the second half cycle which are similar to the first five except the reversal of the voltage and current signs.

2.1 Operational Mode 1:

During this mode, the switches S1, S4, and S6 conducts. The current flows through RLC load RLC1 and RLC2 to produce positive output voltages +Vo1 and +Vo2 respectively.

2.2 Operational Mode 2:

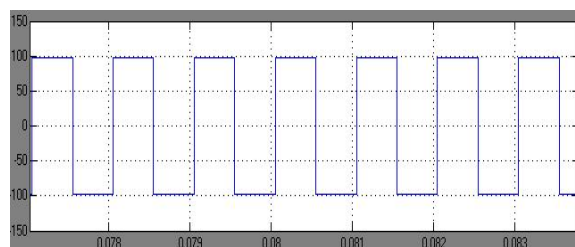
During this mode, the switches S1 and S4 conduct. The current flows through RLC load RLC1 to produce positive output voltage +Vo1.



Input voltage and current waveform

2.3 Operational Mode 3:

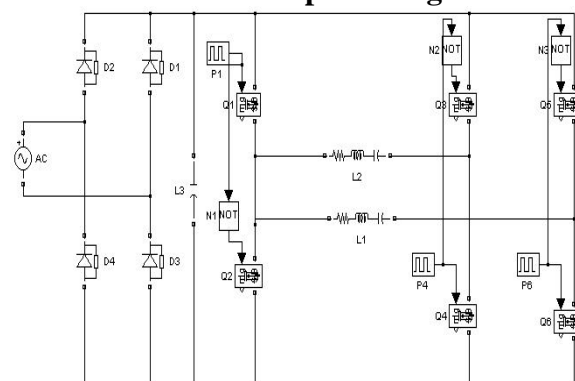
During this mode, the switches S2,S3, and S5 conduct. The current flows through RLC load RLC1 and RLC2 in the reverse direction to produce negative Output voltages -Vo1 & -Vo2 respectively.



Inverter output voltage

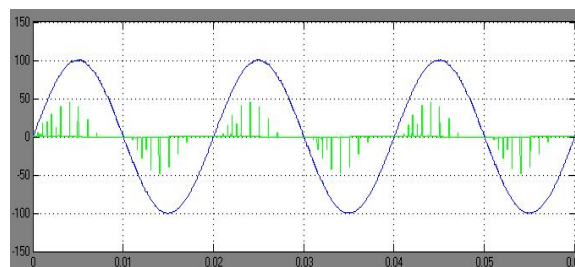
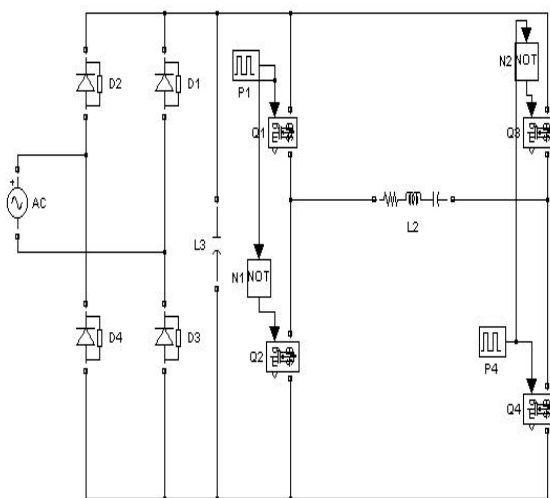
2.4 Operational Mode 4:

During this mode, the switches S2, S3, and S5 conducts. The current flows through RLC load RLC1 and RLC2 in the reversedirection to produce negative voltage -Vo1 and -Vo2 respectively.

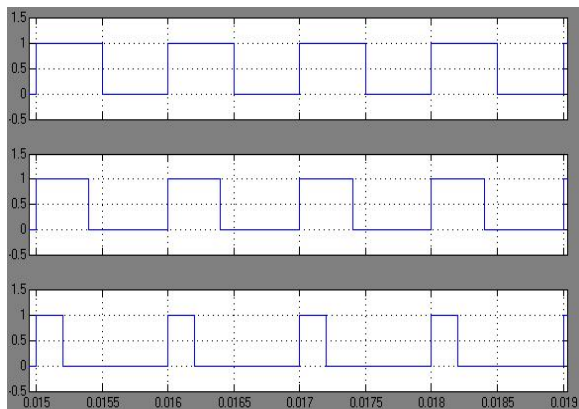


Cyclo inverter circuit diagram

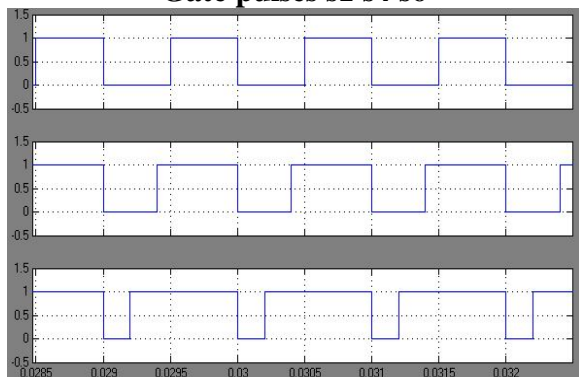
4.0 Simulation Results



Input voltage and current waveform with inductive filter



Gate pulses s1 s4 s6



Gate pulses s2 s3 s5

4.1 General

Simulation has become a very powerful tool on the industry application as well as in academics, nowadays. It is now essential for an electrical engineer to understand the concept of simulation and learn its use in various applications. Simulation is one of the best ways to study the system or circuit behavior without damaging it. The tools for doing the simulation in various fields are available in the market for engineering professionals. Many industries are spending a considerable amount of time and money in doing simulation before manufacturing their product. In most of the research and development (R&D) work, the simulation plays a very important role. Without simulation it is quiet impossible to proceed further. It should be noted that in power electronics, computer simulation and a proof of concept hardware prototype in the laboratory are complimentary to each other.

However computer simulation must not be considered as a substitute for hardware prototype. The objective of this chapter is to describe simulation of impedance source inverter with R, R-L and RLE loads using MATLAB tool.

4.2 Simulation results:

6.0 Experimental Result For The Proposed Inverter

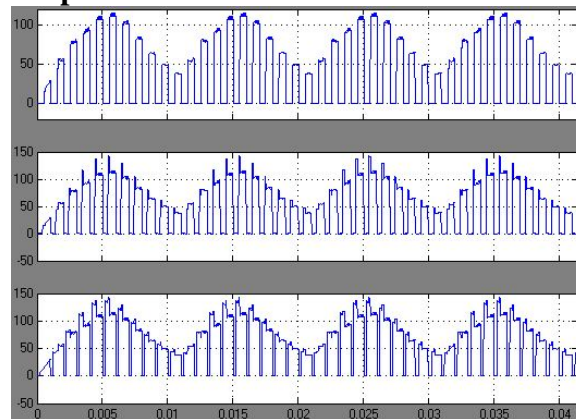
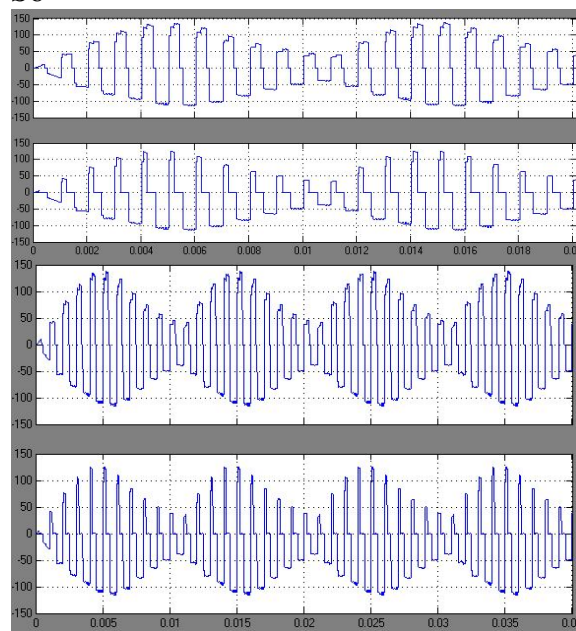


Fig 6.1 Voltage Across Switches S1, S4 & S6



Output Voltage Waveform across Load 1 & 2

7. Conclusion

This paper proposed a HIGH FREQUENCY cyclo-inverter with a simplified switching

scheme for use in induction heating application. The inverter was shown to have the advantages of soft switching and reduced voltage stresses across the devices, allowing higher voltage operation. The operation of the proposed inverter was analyzed. Experimental results further demonstrated the feasibility of the proposed ideas. Future research would include designing a prototype to implement an active clamp to reset the current thus eliminating the series diodes and the losses associated with them. This would have the added benefit of reducing the spikes from the rectifier diodes when the dc voltage is applied during modes 1 to 6.

References:

- [1]. Jose M. Burdio, Fernando Monterde, Jose R. Garcia, Luis A. Barragan, and Abelardo Martinez, "A two-output series-resonant inverter for induction-heating cooking appliances," IEEE Trans. Power Electron., Vol. 20, No. 4, , July 2005, pp. 815-822.
- [2]. J. Davies and P. Simpson, Induction Heating Handbook. New York: McCraw Hill (U.K.) Limited.
- [3]. Hisayuki Sugimura, Tarek Ahmed, Mohamed Orabi, Hyun-Woo Lee, and Mutsuo Nakaoka, "Commercial Utility Frequency AC to High Frequency AC Soft Switching Power Conversion Circuit with Non Smoothing DC Link for IH Dual Packs Heater," The 30th Annual Conference of the IEEE Industrial Electronics Society, November 2 - 6, 2004, Busan, Korea, pp. 1155-1160.