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ANALYSIS OF SERIES RESONANT INVERTERS WITH PWM AND PDM TECHNIQUES FOR INDUSTRIAL HEATING APPLICATIONS

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ABSTRACT: This paper presents the simulation of series resonant inverter with PWM and PDM techniques for industrial heating applications. A full bridge IGBT based series resonant inverter is proposed. A comparative analysis is done for PWM and PDM technique.

I.INTRODUCTION

The metals to be welded, melted or hardened are heated using Series Resonant Inverter as in [1]-[3] or Parallel Resonant Inverter as in [4]-[7].These resonant inverters comprising of an induction coil and a charging capacitor which forms a resonant tank is an "Induction Heating Generator".

Conventionally the SRI's are fed from a converter [bridge rectifier] designed to supply a variable dc voltage. As this method involves few drawbacks of size and cost, an inverter with power control by frequency [8],[9] or phase shift[10]-[12] is used. Even this system possess increased switching losses and electromagnetic noise due to the incapability of the switching devices to be turned on and off at zero current. In order to resolve the above mentioned problem the system frequency must be automatically adjusted close to the resonant frequency allowing Zero Current Switching inverter operation. The output power control of such a system is carried out by employing Pulse Density Modulation. The paper analyses the former and latter approach.

The induction heating system comprises of a dc voltage fed inverter and a series resonant circuit with a matching transformer. On studying the characteristics of the semi-conductor switching devices, MOSFET's are found to be suitable for high frequency applications, whereas Isolated Gate Bipolar Transistors are preferred for high power applications involving a low loss power control scheme. As PDM is a low loss power control scheme, IGBT's are employed here.

The context in the above literature analyses only the operation of the inverters based on various power control techniques. This paper intends to compare the performance of the inverters using conventional PWM and PDM techniques.

II.INDUCTION HEATING PRINCIPLE

The magnetic field is induced in the coil when it is fed with an alternating current. This produces eddy current in the work piece and these gives rise to heating effect. Induction heating loads can be modeled by series combination of its equivalent resistance, R_L and inductance, L_L.

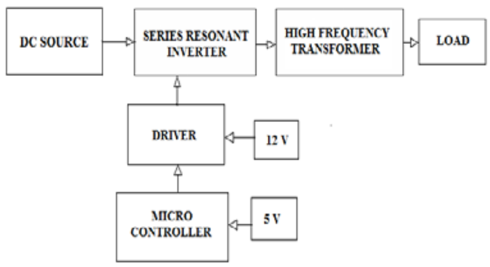

Figure.1.Block Diagram

The block diagram illustrates a series induction heating generators. The output power stage consists of a dc voltage fed inverter with IGBT's. The output of the inverter is fed to the series resonant circuit with matching transformer.

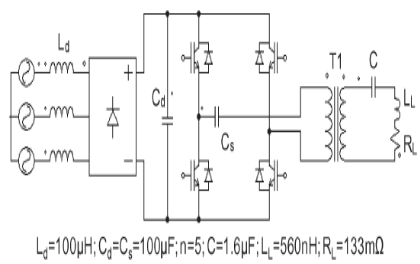

Figure.2.circuit diagram

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IV.SIMULATION RESULTS USING PWM TECHNIQUE

The circuit above in fig 2 has been simulated using pulse width modulation technique and the results are illustrated in this chapter.

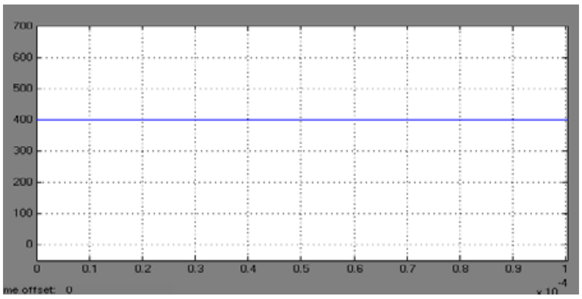

Figure3. Dc input voltage

A fixed DC voltage of 400V is applied at the terminals of the inverter circuit. It is illustrated in fig.3.

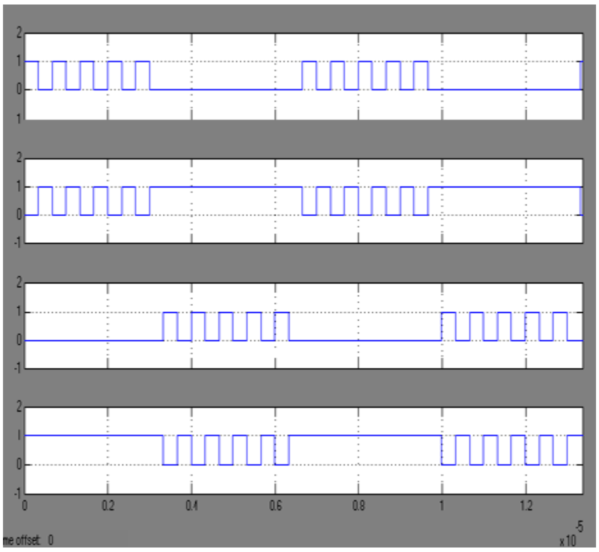

Figure.4 .PWM Triggering pulses

The thyristor switches are fired according to the pulse pattern generated using multiple pulse width modulation is illustrated in fig4.2.

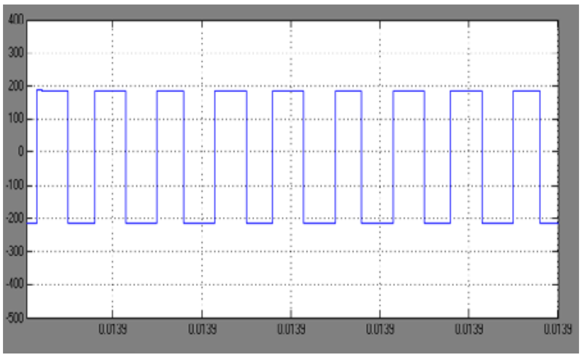

Figure5.Inverter output voltage

The voltage waveform at the output terminals of the inverter stage is found as in fig 4. And the output power at the series resonant circuit is shown in fig 5.

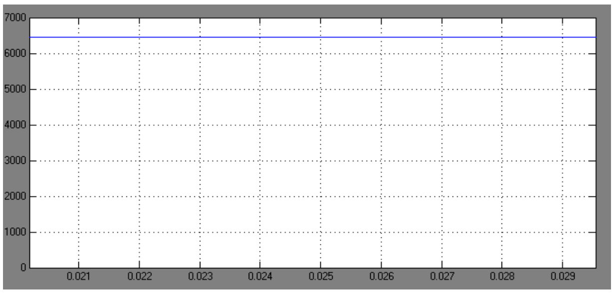

Figure6 Output Power

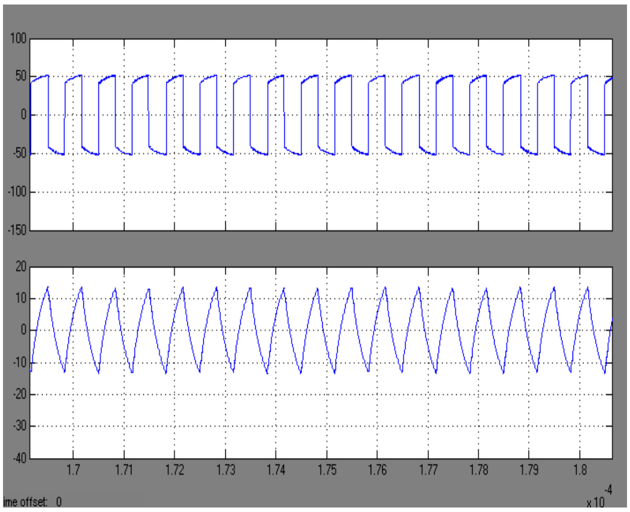

Figure7 Output voltage and current

The voltage and current waveforms at the final stage of the inverter module are shown respectively in fig 7.

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V.SIMULATION RESULTS USING PDM TECHNIQUE

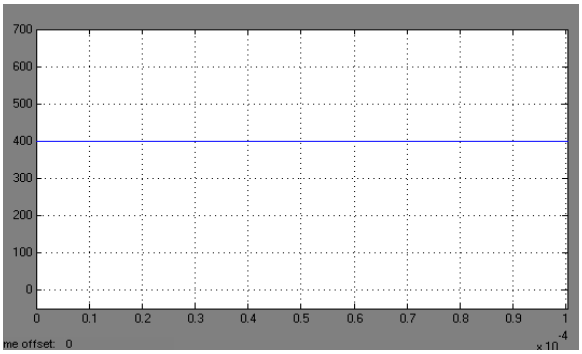

Figure8.Dc input voltage

A fixed DC voltage supply of 400V is applied to the inverter module which is shown above in fig.8.

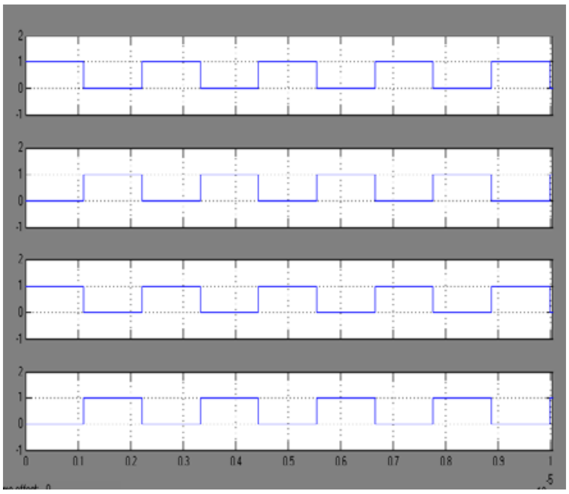

Figure 9 .Inverter output voltage

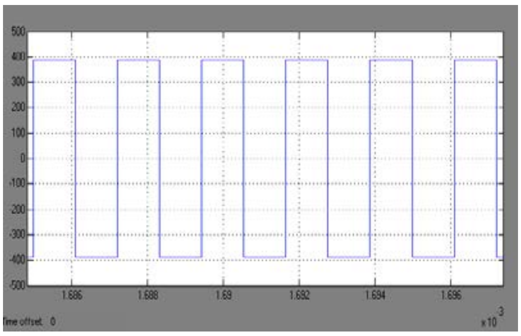

Figure 10 .Triggering pulses

The thyristor switches are fired according to the pulse pattern illustrated in fig5.2.Pulse width , Ton/T=1 is given.

The voltage waveform at the output terminals of the inverter stage is found as in fig 10. And the output power at the series resonant circuit is shown in fig11.

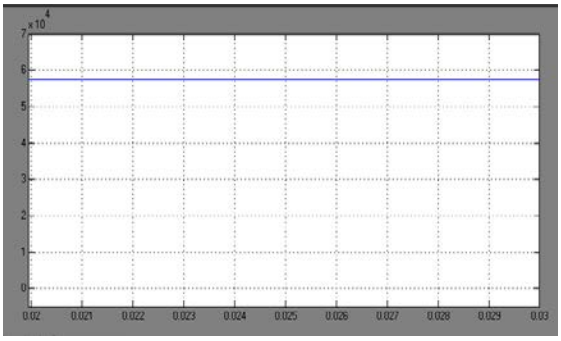

Figure.11.Output Power

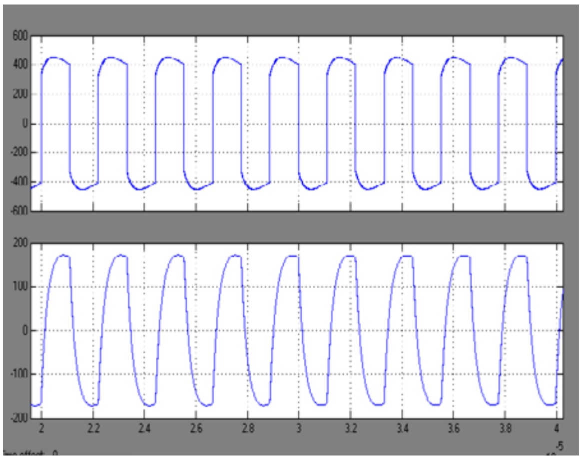

Figure 12 Output voltage and current

The voltage and current waveforms at the final stage of the inverter module are shown respectively in fig 12.

V.RESULTS OBTAINED

The simulation results obtained on the section III and IV are studies and a comparative study of the classical power control by frequency variation(FV) and PDM is made.

The fig.13.and fig14 shows the output power of the inverter module for power control by classical frequency variation and PDM as 6.5kw

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and 58KWrespectively for a input voltage of 400V and a load of resonant frequency 150KHz.

In addition, the output power of the module for various duty cycles of operation is simulated and found to be as in fig15.

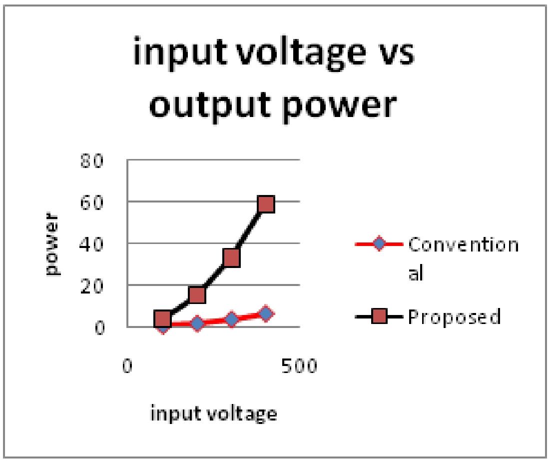

Figure 13. Comparison graph output power for various control techniques

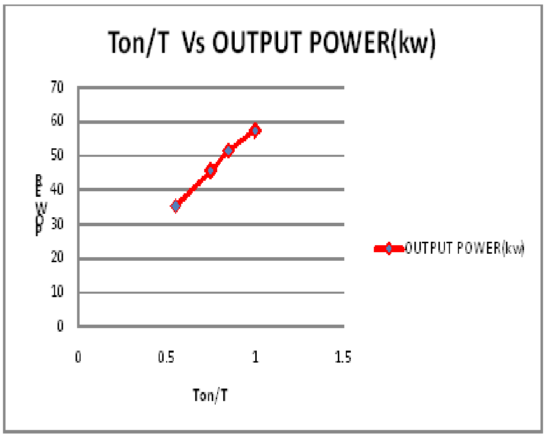

Figure.14.output power for various Ton/T in PDM.

V.CONCLUSION

This paper has proposed a voltage source resonant PDM inverter for industrial induction heating application. The results obtained from the simulation allows to conclude that this PDM inverter is capable ofimproving the efficiency of inverter and thus the output power increases by more than twice that of the inverter applying power control by classical frequency variation. Thisresults concludes that PDM inverter is more suitable for induction heating application at a higher frequency.

REFERRENCES

[1] N.-J. Park, D.-Y. Lee, and D.-S. Hyun, "A power-control scheme withconstant switching frequency in class-D inverter for induction-heating jarapplication," IEEE Trans. Ind. Electron., vol. 54, no. 3, pp. 1252-1260,Jun. 2007

[2] S. Faucher, F. Forest, J.-Y. Gaspard, J.-J. Huselstein, C. Joubert, andD. Montloup, "Frequency-synchronized resonant converters for the sup-ply of multiwinding coils in induction cooking appliances," IEEE Trans.Ind. Electron., vol. 54, no. 1, pp. 441-452, Feb. 2007.

[3] P. Savary, M. Nakaoka, and T. Maruhashi, "A high-frequency resonantinverter using current-vector control scheme and its performance evaluations," IEEE Trans. Ind. Electron., vol. IE-34, no. 2, pp. 247-256,May 1987.

[4] E. Dede, J. Gonzalez, J. Linares, J. Jordan, D. Ramirez, and P. Rueda,"25-kW/50-kHz generator for induction heating," IEEE Trans. Ind.Electron., vol. 38, no. 3, pp. 203-209, Jun. 1991.

[5] A. Shenkman, B. Axelrod, and V. Chudnovsky, "Assuring continuousinput current using a smoothing reactor in a thyristor frequency converterfor induction metal melting and heating applications," IEEE Trans. Ind.Electron., vol. 48, no. 6, pp. 1290-1292, Dec. 2001.

[6] D. W. Tebb and L. Hobson, "Design of matching circuitry for 100-kHzMOSFET induction heating power supply," IEEE Trans. Ind. Electron.,vol. IE-34, no. 2, pp. 271-276, May 1987.

[7] K. B. Zhao, P. C. Sen, and G. remchandran, "A thyristor inverterfor medium-frequency induction heating," IEEE Trans. Ind. Electron.,vol. IE-31, no. 1, pp. 34-36, Feb. 1984.

[8] L. A. Barragán, D. Navarro, J. Acero, I. Urriza, and J. M. Burdío, "FPGAimplementation of a switching frequency modulation circuit for

EMIreduction in resonant inverters for induction heating appliances," IEEETrans. Ind. Electron., vol. 55, no. 1, pp. 11-20, Jan. 2008.

[9] J. M. Espí, E. J. Dede, R. García-Gil, and J. Castelló, "Design of theL-LC resonant inverter for induction heating based on its equivalent SRI," IEEE Trans. Ind. Electron., vol. 54, no. 6, pp. 3178-3187,Dec. 2007.

[10] Z. M. Ye, P. K. Jain, and P. C. Sen, "Full-bridge resonant inverter withmodified PSM for HFAC power distribution systems," IEEE Trans. Ind.Electron., vol. 54, no. 5, pp. 2831-2845, Oct. 2007.

[11] S. Mollov, M. Theodoridis, and A. Forsyth, "High frequency voltagefed inverter with phase-shift control for induction heating," in Proc. Inst.Elect. Eng.—Electr. Power Appl., Jan. 004, vol. 151, no. 1, pp. 12-18.

[12] E. J. Dede, V.Esteve, J. V. González, J. García, E. Maset, and D. Ramirez,"A 12 kW/250 kHz series resonant converter for induction heating,"Trans. SIEE, vol. 86, no. 1, pp. 21-29, Mar. 1995.