MOSFET BASED THREE PHASE BRIDGE INVERTER FOR INDUCTION HEATING APPLICATIONS

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ABSTRACT: Induction heating is an efficient non-contact technique for heating metals or any other electrically-conductive materials. The intensity of the heating action and input, output power is need to be controlled for the proper heating of metals without any damages. In order to achieve an efficient and useful product some switching schemes and control methods have been developed in this area. Earlier valve oscillator based power supply, self exciting class 'c' oscillator were employed due to their flexibility and potential frequency range. Some traditional methods like, Thyristor power control, three phase variacs, two part tank coil were used for the power control of the system. The inverters like SCR, IGBT are being used for the switching purposes. Recently voltage-fed, current-fed, class-D. Series and parallel resonant inverters are widely used in switching schemes. In this project proposal a modified three phase inverter with full bridge topology by using asymmetrical voltage cancellation control is implemented for induction heating applications. The operating frequency is automatically adjusted to maintain a small constant lagging phase angle under load parameter variation and it is controlled using phase-locked loop to track for the resonant frequency. The asymmetrical voltage cancelation technique controls the output power by adjusting the switch duty cycle. The efficiency of the induction heating system is increased due to this technique. The proposed method is verified through computer simulation using MATLAB.

Key words: Phase –locked loop, Asymmetrical voltage cancelation, Induction heating

I.INTRODUCTION

Induction heating is a non-contact heating process which is used to bond, harden or soften metals or other conductive materials. It uses high frequency electricity to heat materials that are electrically conductive. Since it is non-contact, the heating process does not contaminate the material being heated. Induction heating offers an attractive combination of speed, consistency and controlling many modern manufacturing processes

In 1920's the Induction heating basic principles have been understood and applied to manufacturing industries. It mainly focused on lean manufacturing and emphasized on improved quality control. Induction heating is so fascinating and unique in industries as the heat is actually "induced" within the work piece.

Induction heating process: Induction heating system mainly consists of four components, control system, power inverter, transformer, heating coil (inductor). Inside the inductor coil the work piece is placed without making any contact with the coil. When a dc supply is given to the power inverter, the inverter converts the dc to ac supply. This alternating current is applied to the primary of a transformer thus, creating a magnetic field. Due to the magnetic field in the primary of a transformer, an electric current is induced in the secondary of a transformer. When this electric current is passed through an inductor coil an eddy currents induced within the coil. The metal or work piece placed inside the coil is heated due these currents. At the high frequency currents the metal will be heated more quickly.

The metal or work piece placed in the working coil is to be heated properly at a particular point without contaminating the work piece. In order to achieve this, the supply power and the output power at the work piece should be controlled, so to control the output power at the work piece inverters are required. Inverter is an electronic device or circuitry that changes direct current to alternating current. The input voltage, output voltage, frequency, and overall power handling depend on the inverter design. Either current fed or voltage fed inverters is used to control the power, but in recent developments voltage source inverters are widely used due to its advantages over current source inverters.

In this paper three phase voltage source Inverter Bridge is designed. The three phase inverter with asymmetrical voltage technique (AVS) is applied to control the output power and frequency at the heating coil.

II.THREE PHASE BRIDGE INVERTER

Three phase voltage source inverters are used widely in motor drives, active filters, power controllers and uninterrupted power supplies to generate controllable frequencies and AC voltage magnitudes using various pulse width modulation (PWM) strategies, PWM are used to reduce the harmonic distortions.

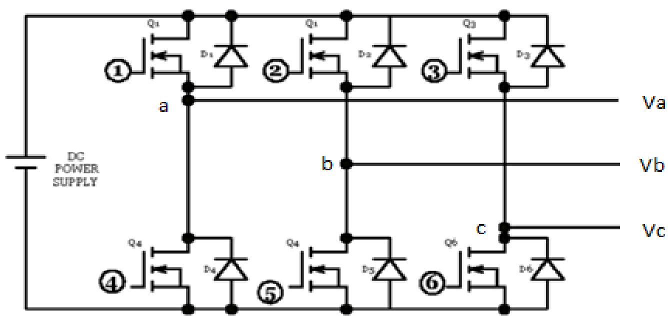

Fig1.Three phase bridge inverter

Three phase bridge inverter are used for high power applications. Three phase bridge inverter consists of six switches and six diodes, here MOSFET has been chosen as the switch. The main function of the three phase bridge inverter is to invert the DC voltage to AC voltage; hence this is achieved by applying the correct switching sequence. A three phase inverter is formed by three single phase inverters which are connected in parallel; the gating signals of single phase inverters should be delayed by 120° with respect to each other to obtain three phase balanced voltages. Here the MOSFETS's are controlled by gate drive; each gate drive will control one MOSFET. Hence for six MOSFET's six gate drives are needed for the operation.

III.OPEARTION OF THREE PHASE INVERTER

When the MOSFET Q1 is switched on, terminal 'a' is connected to the positive terminal of the DC input voltage and when MOSFET Q4 is switched on terminal a brought to the negative terminal of the DC source. There are six modes of operation in each cycle and the duration of each mode is 60°. The switches of any leg of the inverter should not be switched on as it results in short circuit across the voltage supply.

State No.	S1	S2	S3	S4	S5	S6	Vab	Vbc	Vca
1	1	1	0	0	0	1	Vs	0	-Vs
2	1	1	1	0	0	0	0	Vs	-Vs
3	0	1	1	1	0	0	-Vs	Vs	0
4	0	0	1	1	1	0	-Vs	0	Vs
5	0	0	0	1	1	1	0	-Vs	Vs
6	1	0	0	0	1	1	Vs	-Vs	0
7	1	0	1	0	1	0	0	0	0
8	0	1	0	1	0	1	0	0	0

Table1. Switch states for three phase voltage source inverter

IV.MOSFET BASED THREE PHASE FULL BRIDGE INVERTER OPERATION

The inverter designed here involves a power supply, switching device MOSFET's, a filter, step down transformer and unbalanced load. When a DC power supply is given to the MOSFET switches, the MOSFET's performs its modes operation and converts the DC to AC. The converted alternating current is passed through the filter to reduce the harmonics. This input is fed to the primary of the transformer and as the transformer here used is the step down transformer the voltage is stepped down.

According to the principle of the transformer "When the current in the primary coil is changed the flux linked to the secondary coil also changes, consequently an EMF is induced in the secondary coil". This induced magnetic flux in the secondary coil induces the current in the load i.e., in the heating coil. The metal or work piece placed inside this coil heats up due to the increased current with high frequency. Hence the metal will be heated in a matter of seconds using this three phase voltage source bridge inverter.

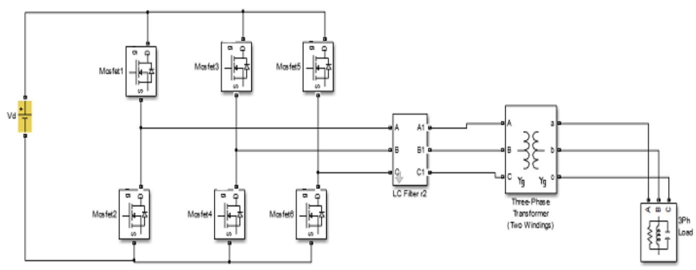

Fig2. Three phase bridge inverter

V.SIMULATION RESULTS

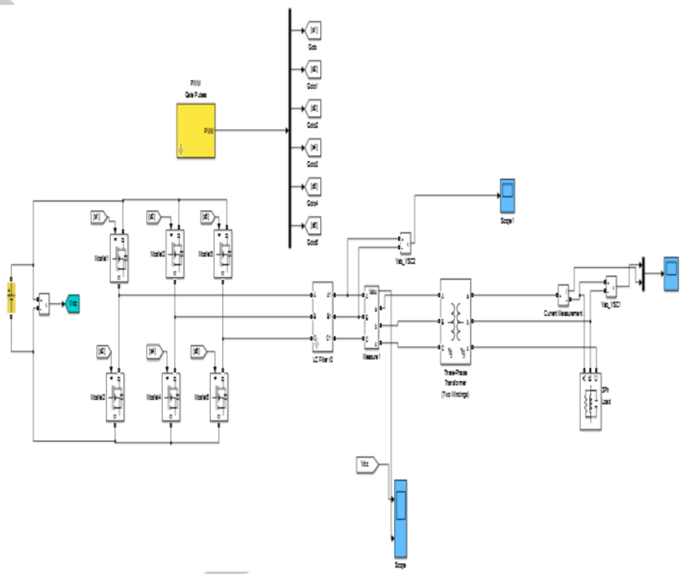

Fig3. Simulated circuit three phase bridge inverter

Waveforms

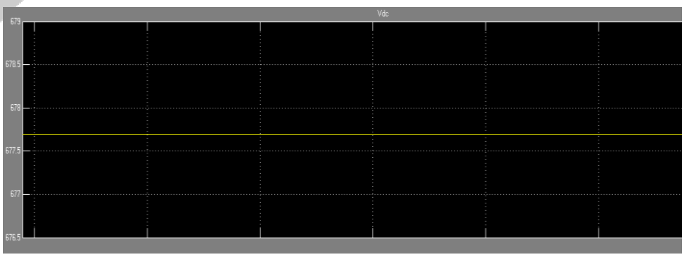

Fig4. Dc output voltage waveforms

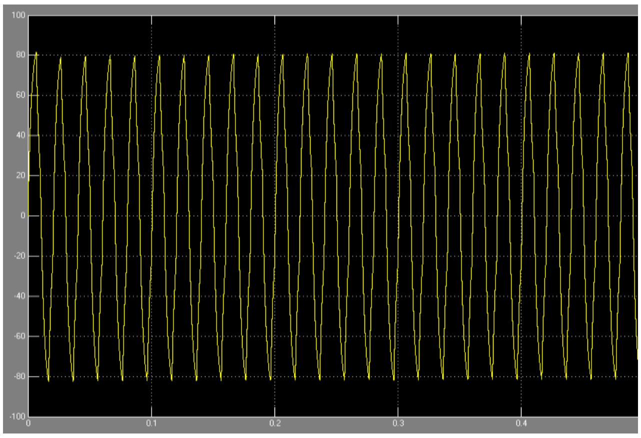
Fig5. Primary transformer voltage waveform

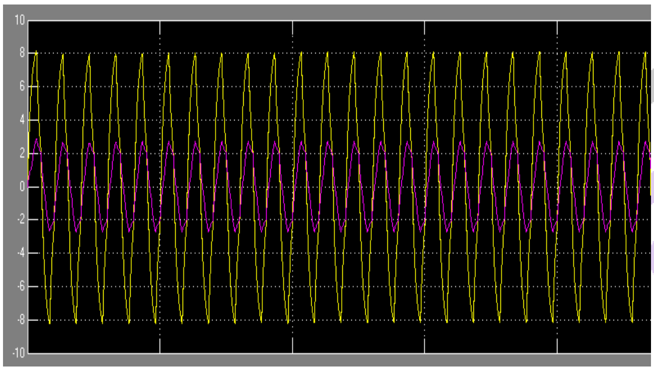
Fig6. Output voltage Vo and output current Io

VI.CONCLUSION

In this paper a MOSFET based three phase bridge inverter is designed for induction heating applications. This inverter can be simulated for various loads and can be implemented hardware version too. Whenever the supply is given to this design it heats up the material placed inside the coil. It also protects the transformer from dangerous short circuits and reduces the power losses. The harmonics are welcomed here as the filter removes them and it can also be implemented for symmetric voltages.

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