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An Exclusive Design of EMI-RFI Suppressor for Modified Half Bridge Inverter Fitted Induction Heating Equipment

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Abstract

This paper presents an exclusive design of EMI-RFI suppressor for Modified Half Bridge inverter based induction heating equipment. With the growing use of high frequency inverter in induction heating equipment, the problem of injected harmonics to the input side becomes critical. A low pass a filter is incorporated between the inverter and the power supply network for reduction of this harmonics. The design of low pass filter is according to the harmonics standards that determine the level of current harmonics injected into the supply side. To reduce the radiated and conducted interference from electronic equipment to sensible level a low pass filter is employed. The input filter of the switching power supply is matched with the power supply when associated with passive loads. The characteristics and suppression may significantly change when used to power active high frequency electronic circuits. Some methods are suggested by the authors to reduce the interference problem for the application in a power supply system of high frequency Modified Half Bridge inverter fitted induction heating equipment. A simulated analytical comparison of Total Harmonic Distortion has been made between two induction heating equipment's including and excluding the EMI and RFI suppressor.

Keywords: *EMI, RFI, Suppressor, Modified Half Bridge Inverter, LPF, Induction Heating, THD, FFT, PSIM.*

1. Introduction

The contribution of high frequency induction heating equipment is mostly to grow rapidly in the near future. For development of high frequency induction heating equipment new regulations and recommendations are needed [1]-[4]. The need of inverters in induction heating has clarified the significance of high frequency operation [6]-[14]. This high frequency switching operation effects the grid voltage distortion which leads to poor power quality [5]. The problem due to harmonics can attenuate by using well designed filter. With the passive filter not only affects inverter harmonic injection but also impacts on the harmonics produced by a coupled non-linear

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load. There are several techniques for controlling harmonic current flow such as harmonic current injection, DC ripple injection, series and parallel active filter systems, magnetic flux compensation. For reduction of voltage harmonics and current distortion in power supply system sometimes passive harmonic filter is incorporated.

The harmonic current injection with a high frequency inverter as follows,

(1) High frequency harmonics and
(2) Switching frequency harmonics.

The current harmonics generation can cause the malfunction of sensitive apparatus connected to the same bus, if injected into the grid. According to the harmonic standardization it determines the level of current harmonics injected into the power supply network, and the incorporated power filter should attenuate the harmonics to specific levels. [15]- [25] Induction heating equipment is to be needed to place interface filters to attenuate the injection of current harmonics [26]-[28].

2. Noise Remedial Process using Filter

A filter is a network that provides the signal with frequencies in certain pass-band region and infinite attenuation in the stop-band regions. Such ideal characteristics cannot be attained, and the goal of filter design is to approximate the ideal requirements to within an acceptable tolerance. Filters are used in all frequency ranges and are categorized into three main groups i.e. Low-pass filter (LPF), High-pass filter (HPF) and Band-pass filter (BPF). Low-pass filter (LPF) transmits all signals between DC and some upper limit ω_c and attenuates all signals with frequencies above ω_c. As the high frequency inverter of induction heating equipment generates unwanted harmonics and that prevents with this filter [19]. The characteristic of a passive filter can be described using attenuation function approach or transfer function approach. In low frequency circuit the transfer function (H (ω)) description is used while at high frequency the attenuation function is preferred [23]. The characteristic of low pass passive filter is shown in Fig. 1.

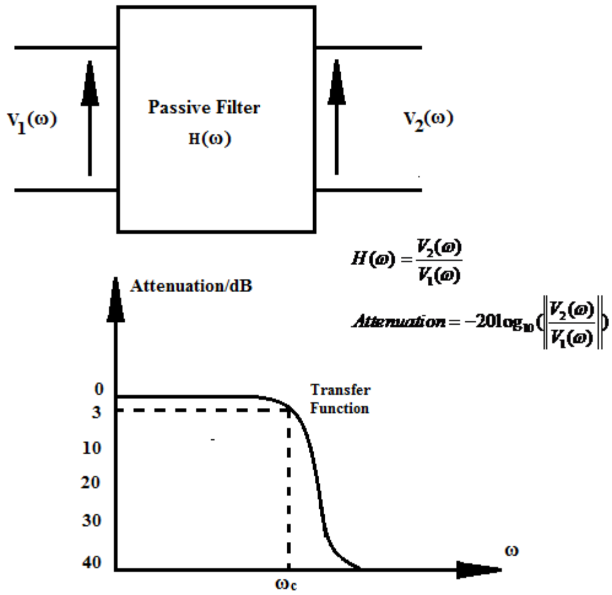

Figure 1: Low pass filter frequency response

3. Realization of Filters

Considering frequency below 160 kHz then filters are usually implemented using lumped elements such as resistors, inductors and capacitors. For active filters, operational amplifier is sometimes used. Basically there are two low-frequency filter techniques are referred namely the image-parameter method (IPM) and the insertion-loss method (ILM). The image-parameter method provides a relatively simple filter design approach but the disadvantage is that an arbitrary frequency response cannot be incorporated into the design. The IPM approach divides a filter into a cascade of two-port networks and attempt to come up with the schematic of each two-port, give the required frequency response such that when combined. The insertion-loss method begins with a complete specification of a physically realizable frequency characteristic, and from this a suitable filter structure is synthesized. Although the image parameter method is not concentrated only concentrate on the insertion loss method, whose design procedure is based on the insertion loss and attenuation response of a filter. The insertion loss of a two port network is given by:

$$P_{IL} = \frac{P_{in}}{P_{load}} = \frac{1}{1-\left|\lambda(\omega)^2\right|}$$

Where, λ is the reflection coefficient looking into the filter.

The insertion-loss approach usually begins by designing a normalized low-pass filter (LPF). The LPF is a low-pass filter with source and load resistance of 1Ω and cut-off frequency of 152 KHz.

Proposed low-pass filter (LPF) as shown in Figure 4, which is consists of reactive elements forming a ladder network.

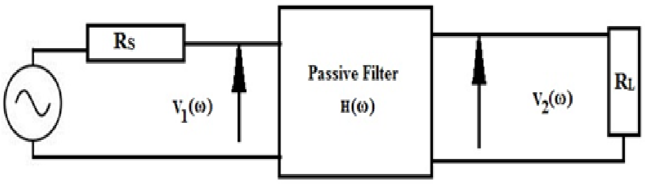

Figure 2: A Low pass filter network with 1 Radian/S cut off frequency

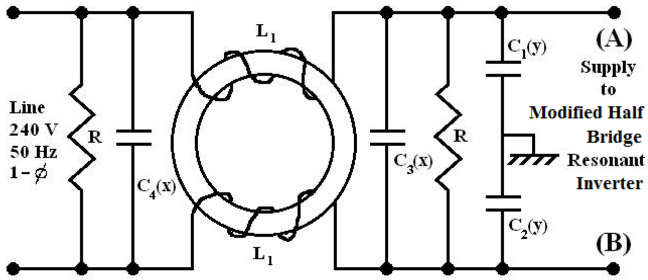

Figure 3: Developed real time low pass filter model using RLC elements

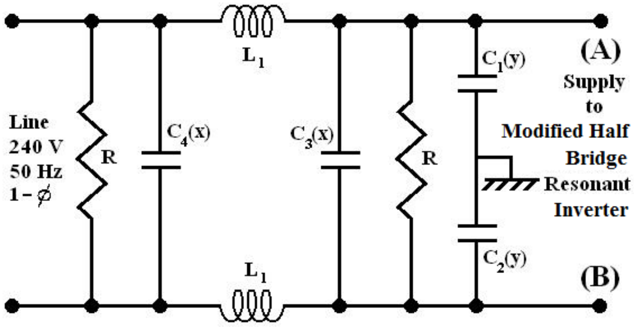

Figure 4: Proposed input ac line filter of modified half bridge inverter power supply for RFI noise suppression

4. Circuit Operation of Single Phase Half Bridge Inverter Based Induction Cooker

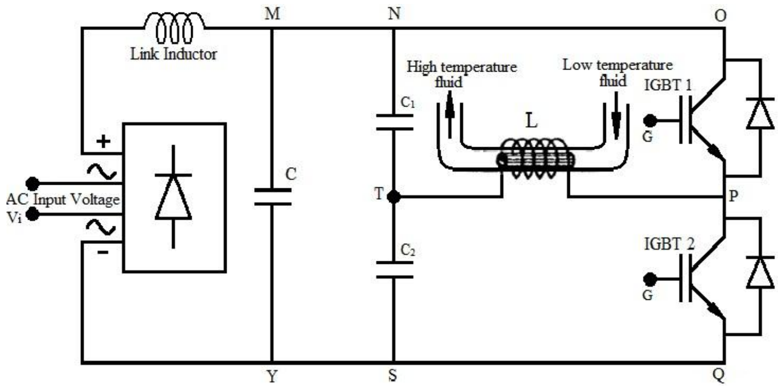

Figure 5: Modified Half Bridge inverter fitted induction heating equipment

Table 1: Switching ON-OFF chart of IGBTs

IGBT1	IGBT2	V_{out}
ON	OFF	$+V_i/2$
OFF	ON	$-V_i/2$

Modified half bridge circuit is normally used for higher power output. Four solid state switches are used and two switches are triggered simultaneously. Here IGBTs are used as solid state switches because it can be exist at high frequency applications. Anti-parallel diodes D1 and D2 are connected with the switches IGBT1 and IGBT2 respectively that allows the current to flow when the main switch is turned OFF. According to fig. 6., when there is no signal at S_1 and S_2, capacitors C_1 and C_2 are charged to a voltage of V_i /2 each. The Gate pulse appears at the gate G to turn IGBT1 ON. Capacitor C_1 discharges through the path NOPTN.

At the same time capacitor C_2 charges through the path MNOPTSYM. The discharging current of C_1 and the charging current of C_2 simultaneously flow from P to T. In the next slit of the gate pulse, S_1 and S_2 remain OFF and the capacitors charge to a voltage V_i /2 each again. The Gate pulse appears at the gate G so turning on IGBT2. The capacitor C_2 discharges through the path TPQST and the charging path for capacitor C_1 is MNTPQSYM. The discharging current of C_2 and the charging current of C_1 simultaneously flow from T to P. The both switches must operate alternatively otherwise there may be a chance of short circuiting. In case of resistive load, the current waveform follows the voltage waveform but not in case of reactive load. The feedback diode operates for the reactive load when the voltage and current are of opposite polarities.

The logic circuit is designed in such a way that IGBT1 and IGBT2 are not turned on at the same time to avoid short-circuiting of the d.c. source. There must be a dead zone of time between the switching modes.

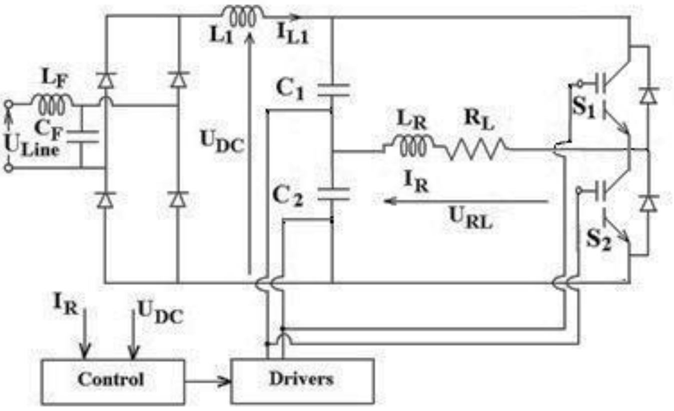

Figure 6: Equivalent circuit diagram for Modified Half Bridge Inverter system for one heating zone

5. Circuit Equations

Instantaneous Current i_0:

With inductive load the equation of instantaneous current i_0 can be obtained as,

$$i_0(t) = \sum_{n=1,3,5,...}^{\infty} \frac{2V_i}{n\pi\sqrt{R^2+(n\omega L)^2}} \sin(n\omega t - \theta_n)$$

Here, $Z_n = \sqrt{R^2+(n\omega L)^2}$ is the impedance offered by the load to the nth harmonic component, $\frac{2V_i}{n\pi}$ is the peak amplitude of nth harmonic voltage, and

$$\theta_n = \tan^{-1}\left(\frac{n\omega L}{R}\right)$$

Output Power:

The output power at fundamental frequency (n=1) is given by

$$P_{1_{rms}} = E_{1_{rms}}.I_{1_{rms}}.\cos\theta_1 = I_{1_{rms}}{}^2.R$$

Where, $E_{1_{rms}}$ =RMS value of fundamental output voltage and $I_{1_{rms}}$ =RMS value of fundamental output current.

$$\theta_1 = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

But
$$I_{1_{rms}} = \frac{2V_i}{\sqrt{2}.\pi.\sqrt{R^2+(\omega L)^2}}$$

$$P_{1_{rms}} = I_{1_{rms}}{}^2.R = \left[\frac{2V_i}{\pi.\sqrt{2}.\sqrt{R^2+(\omega L)^2}}\right]^2.R$$

$$= \left[\frac{4V_i^2.R}{2\pi^2(R^2+\omega^2L^2)}\right] = \left[\frac{2V_i^2.R}{\pi^2(R^2+\omega^2L^2)}\right]$$

In high frequency heating application the fundamental power is more important, the output power due to fundamental current is generally the useful power and the power due to harmonic current is dissipated as heat.

6. Designing and Analysis of a Low Pass Filter (LPF)

The specification of the filter is as follows: R_S = 1KΩ, L= 20µH, C=0.22µF and Cut-off frequency, f_c = 152 KHz.

Step 1- Design the LP filter

To design filter different types of filter variants can be used. The filter selection depending upon the various requirements such as rate at which final roll off is achieved, band ripple etc. Here some simple equations for designing a filter as follow:

$$L = Z_0 / (\Pi \times f_c) H$$

$$C = 1/(Z_0 \times \Pi \times \mathrm{f}_c) F$$

$$f_c = 1/(\Pi\sqrt{LC}) Hz$$

$$f_c = 1/(\Pi\sqrt{20\times10^{-6}\times0.22\times10^{-6}}) Hz = 1.52\times10^{-5} KHz$$

Where,

Z_o=characteristic impedance in ohms
C =Capacitance in Farads
L =Inductance in Henries
f_c = Cut-off frequency in Hertz

Step 2- Perform impedance and frequency scaling

Low pass filters can be used in different wide range of applications. Low pass filters are constructed using passive components for usage in radio frequency applications. Typically, they are used to eliminate unwanted signals present in a band.

For low pass passive filters, inductors and capacitors can be arranged to form of T-network or π-network. In the π-section filter, each section consists of one series component and a component to ground at the both sides. The T-network low pass filter consists of one shunt component and a series in line component on both sides. In low pass filters the shunt components are capacitors and series component are inductors.

7. RFI Sources in Switching Power Supplies

Every switching power supply [5] is a source of RFI generation because of the very fast rise and fall times of the current and voltage waveforms inherent in the converter operation. The main source of switching noise is the switching transistor, the main rectifier, the output diodes, the protective diodes for the transistor, and of course the control unit itself. Depending upon the topology of the converter used, the RFI noise level at the mains input varies from bad to worse. Fly back converters, which by design have a triangular input current waveform, generate less conducted RFI noise than converters with rectangular input current waveform, such as feed forward or bridge converters. Fourier analysis shows that the amplitude of the high frequency harmonica of a triangular current waveform drop at a rate of 40 decibel per decade, compared to a 20 decibel per decade drop for a comparable rectangular current waveform.

8. RFI AC Input Line Filter for RFI Suppression

The most common method of noise suppression at switching power supply [5] ac mains is the utilization of an LC filter for differential and common mode RFI suppression. Normally a coupled inductor is inserted in series with each ac lines, while capacitor are placed between lines (called X capacitor) and between each line and the ground conductor (called Y capacitor). The capacitance and inductance of the components may be within the following values:

C_x: 0. 1 to 1 µf
C_y: 0. 1 to 1 µf
L_1: 1 to 100 µH

During filter components selection it is important to make sure that the frequency [17] of the input filter is lower than the working frequency of the power supply. On the other hand, filtering conducted noise becomes much easier as the working frequency of the power supply is increased. The resistor R across the ac line of the filter is a discharge resistor for the X capacitor. X capacitor is above 0.1µf, a discharge resistor of the following value is required in the circuit.

9. Harmonic Content

The input current waveforms of an ideal inverter should be sinusoidal. But, in practice, the input current waveforms are non-sinusoidal. It contains harmonics. The existence of harmonics is visualized either in the time-domain or in the frequency domain easily. The use of proper filter has enabled to reduce the harmonic contents in the input voltage significantly. Total Harmonic Distortion (THD) is a measure of the closeness of a waveform with its fundamental component. The task of the design engineer is to reduce THD. It is accomplished by an Low Pass filter (LPF). LPF attach at the input power supply terminal of Modified Half Bridge Inverter for induction heating equipment. It provides low harmonic impedance to ground.

The quality of input current of a Modified Half Bridge Inverter is obtained by Fast Fourier's analysis. It is a powerful mathematical tool which separates out the fundamental and the harmonics. Fourier's transforms allows us to peep into the frequency domain representation of the wave-form.

Total Harmonic Distortion (THD)

It is a measure of distortion of a waveform. It is given by the following expression:

$$T.H.D = \frac{\sqrt{\sum_{n=2,3}^{\alpha} I_{nr.m.s}{}^{2}}}{I_{1r.m.s}} \qquad (1)$$

It is the ratio of the RMS value of all non-fundamental frequency components to the RMS value of the fundamental. Our aim is to reduce to a minimum. For a rectangular wave: The value is very large. In quasi-rectangular form, the value is relatively less.

Fast Fourier Transform Analysis (FFT)

A Fast Fourier Transform (FFT) is an algorithm to compute the discrete Fourier transform (DFT) and it's inverse. It is a linear algorithm that can transform a time domain signal into its frequency domain equivalent and back. An FFT is a way to compute the same result more quickly. FFTs are of great importance to a wide variety of applications, a better understanding of an unknown signal is obtained in the frequency domain. Peak noise in the input current of Modified Half Bridge Inverter using LPF filter is determined by FFT analysis.

10. Simulation Diagram and Results

In this present work, the high frequency Modified Half Bridge Inverter has been simulated on the PSIM platform with the help of equivalent circuit parameters. At first simulation results are presented without the LP filter. Then simulation results are shown when the LP filter is incorporated at the input of the circuit. The circuit configuration and waveforms are shown below when simulated in PSIM. Fig. 7 depicts the simulation circuit diagram of the present implemented scheme without the LPF filter at input using PSIM. In Fig. 8, the waveforms of load voltage (VP1) and load current (I1) are shown. From the figure it can be found that significant amount of high frequency components are generated and they are superimposed in the 100 Hz envelope in the two waveforms. In Fig. 9, the waveform of voltage across the load (VP1), voltage across the dc link inductor (VP2) and voltage at the rectifier output (VP3) are shown for the Modified Half Bridge Inverter fitted induction heating equipment without filter.

From the figure it can be found that at the output of the rectifier the voltage is of 100 Hz with significant amount of high frequency components superimposed in it. High frequency components are also present in the load voltage and in the voltage across the inductor. Fig. 10 Voltage across the rectifier output (VP3) and voltage across the rectifier input (VP4) for the Modified Half Bridge Inverter fitted induction heating equipment without LPF filter on PSIM software. From the figure it can be found that high frequency components are present in the waveforms of VP3 and VP4 but differ. In Fig. 11, the waveform of the input current (I2) is shown. It can be seen from the figure that very high amount of high frequency components are superimposed on the 50 Hz envelope. And shows RMS value of the input current (I2) for Modified Half Bridge Inverter fitted induction heating equipment without LP filter. The RMS value of I1 is 1.67 Ampere. Fig. 12 shows the frequency response of input current I1 when analysed with FFT.

Fig. 13 shows the simulation circuit diagram for Modified Half Bridge Inverter fitted induction heating equipment with LP filter. Fig. 14 depicts the waveform of load voltage (VP1) and load current (I1) of the circuit with LP filter at input. Comparing with Fig. 8 it can be found that amount of high frequency components in the two cases are almost same. Fig. 15 shows the waveforms of load voltage (VP1), voltage across dc link inductor (VP2) and voltage across the rectifier output (VP3) when the LP filter is installed at the input of the equipment. Comparing with Fig. 9, it can be seen that in the first case (without filter) the waveforms of the voltage across dc link inductor (VP2) and voltage across the rectifier output (VP3) contain greater amount of harmonics. In Fig. 16, the waveforms of voltage across the rectifier output (VP3) and voltage across the rectifier input (VP4) are shown when the circuit with input filter is simulated. When compared with Fig. 10 it is found that without filter there are greater amount of high frequency components present in the two waveforms.

Fig. 17 shows the voltage across the filter inductors (VP5&VP6) and voltage across the transformer secondary (VP4) of the circuit with filter. Fig. 18 shows the input current waveform (I2) for Modified Half Bridge Inverter fitted induction heating equipment with LP filter on PSIM software & represents the RMS value of the input current I2 which is 1.30 Ampere. Fig. 19 represents the frequency response of the input current when FFT analysis is done on it. So, it can be concluded that due to high switching frequency operation associated with Modified Half Bridge Inverter, high frequency harmonics are produced in the load circuit and tries to flow towards the supply system despite the presence of uncontrolled rectifier. These harmonics when flow towards the supply cause in supply waveform distortion and results in poor power quality. So, to eliminate the harmonics and to maintain good power quality, when the proposed low pass filter is connected at the input the distortion is reduced significantly. By quantitative analysis, it has been shown in the paper that without the input filter, the THD (Total harmonic distortion) of the input current is 44.99%. But when the LP filter is incorporated at the input, the THD of the input current is reduced to 17.90%.

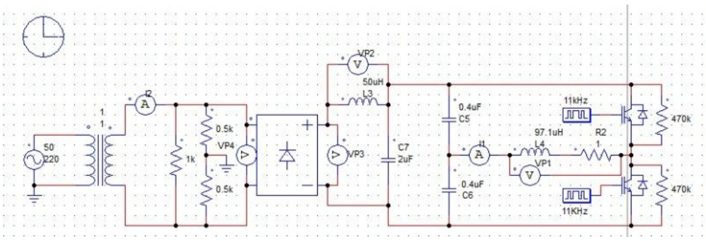

Figure 7: Simulation circuit diagram for Modified Half Bridge Inverter fitted induction heating equipment without LPF on PSIM software

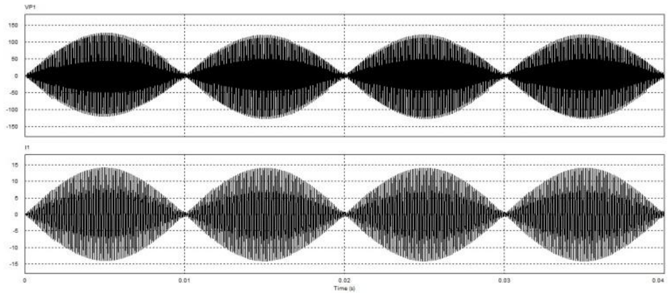

Figure 8: Load voltage (VP1) and load current (I1) for Modified Half Bridge Inverter fitted induction heating equipment without LPF on PSIM software

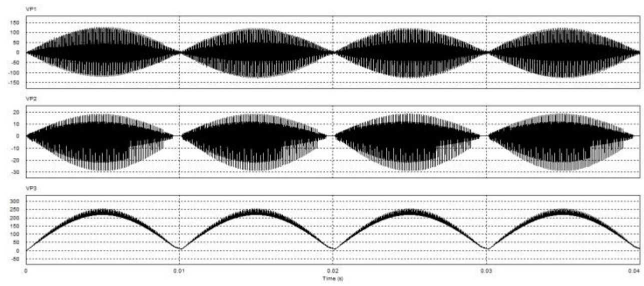

Figure 9: Waveform of load voltage (VP1), voltage across dc link inductor (VP2) and voltage across the rectifier output (VP3) for the Modified Half Bridge Inverter fitted induction heating equipment without LPF on PSIM software

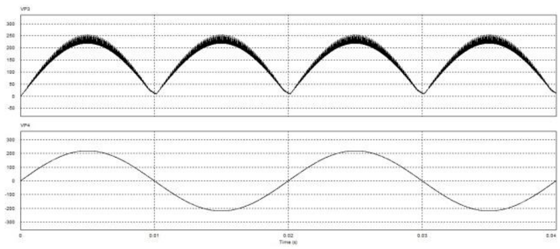

Figure 10: Voltage across the rectifier output (VP3) and voltage across the rectifier input (VP4) for the Modified Half Bridge Inverter fitted induction heating equipment without LPF on PSIM software

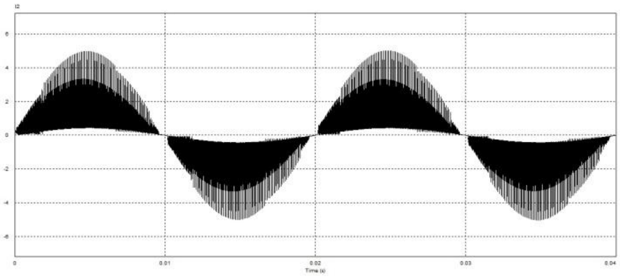

Figure 11: Input current (I2) for Modified Half Bridge Inverter fitted induction heating equipment without LPF on PSIM software

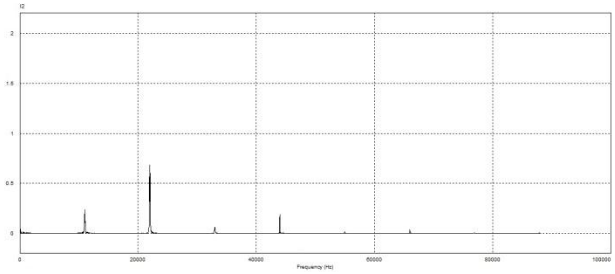

Figure 12: FFT waveform of input current (I2) for Modified Half Bridge Inverter fitted induction heating equipment without LPF on PSIM software

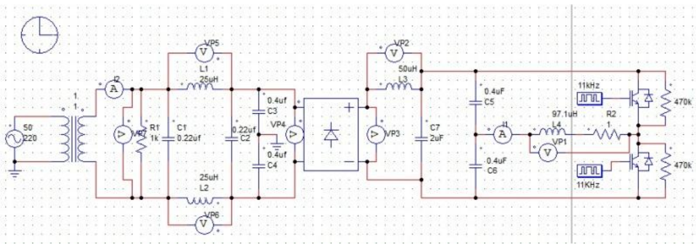

Figure 13: Simulation circuit diagram for Modified Half Bridge Inverter fitted induction heating equipment with LPF on PSIM software

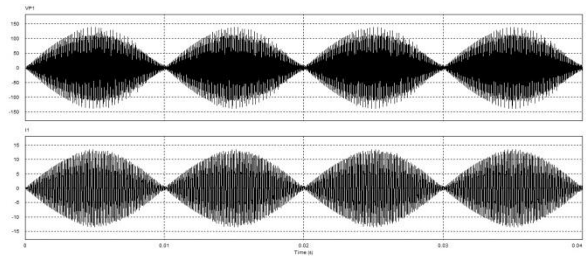

Figure 14: Load voltage (VP1) and load current (I1) for Modified Half Bridge Inverter fitted induction heating equipment with LPF on PSIM software

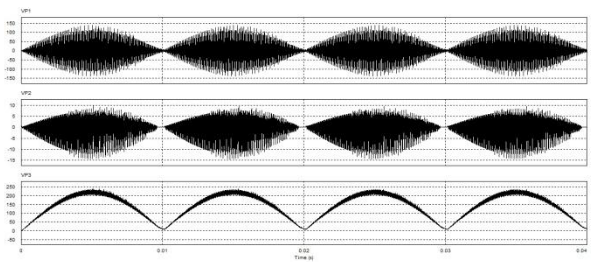

Figure 15: Waveform of load voltage (VP1), voltage across dc link inductor (VP2) and voltage across rectifier output (VP3) for Modified Half Bridge Inverter fitted induction heating equipment with LPF on PSIM software

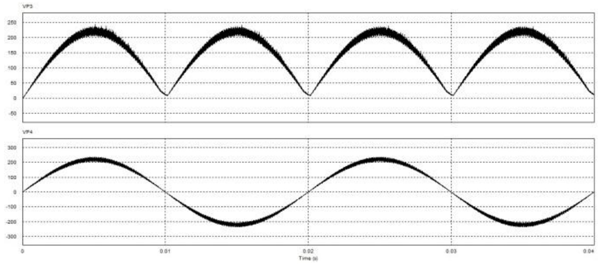

Figure 16: Voltage across the rectifier output (VP3) and voltage across the rectifier input (VP4) for the Modified Half Bridge Inverter fitted induction heating equipment with LPF on PSIM software

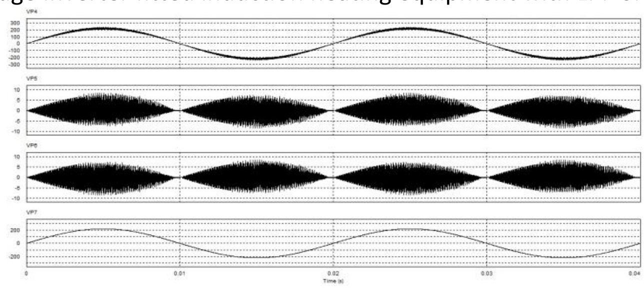

Figure 17: Voltage across the inductors (VP5&VP6) and voltage across the transformer secondary (VP4) for the Modified Half Bridge Inverter fitted induction heating equipment with LPF on PSIM software

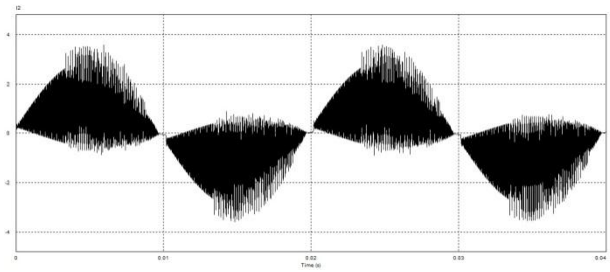

Figure 18: Input current (I2) for Modified Half Bridge Inverter fitted induction heating equipment with LPF on PSIM software

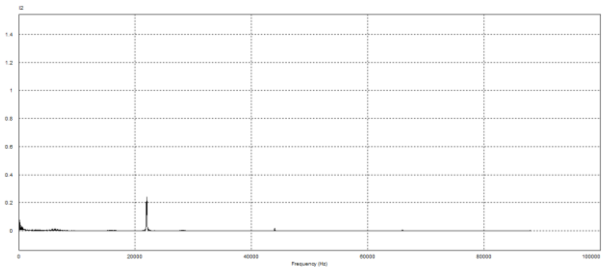

Figure 19: FFT waveform of input current (I2) for Modified Half Bridge Inverter fitted induction heating equipment with LPF on PSIM software

11. THD Calculation

In this present work, the high frequency Modified Half Bridge Inverter has been simulated on the PSIM platform with the help of equivalent circuit parameters. At first simulation results are presented without

THD Calculation from Simulated Results of PSIM Software-
Without Filter:

When the induction heating equipment is without filter, it is seen from Fig. 11 of simulated result of PSIM software that the magnitude of rms value of input current I1 is 1.67 A. The FFT analysis of the input current is done on PSIM software as shown in Fig. 12 and it is seen that the input current consists of six frequency components.

Now,

$$T.H.D = \frac{\sqrt{\sum_{n=2,3}^{\alpha} I_{nr.m.s}{}^{2}}}{I_{1r.m.s}}$$
$$= \frac{\sqrt{(0.2351)^2 + (0.6859)^2 + (0.0558)^2 + (0.1870)^2 + (0.0187)^2 + (0.0241)^2}}{1.67} \times 100$$
$$= 44.99\%$$

With Filter:

When the induction heating equipment is with filter, it is seen from Fig. 18 of simulated result of PSIM software that the magnitude of rms value of input current I2 is 1.30 A. The FFT analysis of the input current is done on PSIM software as shown in Fig. 19 and it is seen that the input current consists of three frequency components.

Now,

$$T.H.D = \frac{\sqrt{\sum_{n=2,3}^{\alpha} I_{nr.m.s}{}^{2}}}{I_{1r.m.s}}$$
$$= \frac{\sqrt{(0.2323)^2 + (0.0164)^2 + (0.0050)^2}}{1.30} \times 100$$
$$= 17.90\%$$

HD Calculation from Laboratory Test Bench-

Without Filter:

When the induction heating equipment is without filter, it is seen from storage oscilloscope that the magnitude of rms value of input current I1 is 1.60 A. The FFT analysis of the input current is done in the oscilloscope and it is shown that the input current consists of six frequency components.

Now,

$$T.H.D = \frac{\sqrt{\sum_{n=2,3}^{\alpha} I_{nr.m.s}{}^{2}}}{I_{1r.m.s}}$$
$$= \frac{\sqrt{(0.2350)^2 + (0.6860)^2 + (0.0550)^2 + (0.1860)^2 + (0.0185)^2 + (0.0240)^2}}{1.60} \times 100$$
$$= 46.95\%$$

With Filter:

When the induction heating equipment is with filter, it is seen from storage oscilloscope that the magnitude of rms value of input current I1 is 1.40 A. The FFT analysis of the input current is done in the oscilloscope and it is shown that the input current consists of three frequency components. Now,

$$T.H.D = \frac{\sqrt{\sum_{n=2,3}^{\alpha} I_{nr.m.s}{}^{2}}}{I_{1r.m.s}}$$
$$= \frac{\sqrt{(0.2320)^2 + (0.0160)^2 + (0.0050)^2}}{1.40} \times 100$$
$$= 16.60\%$$

Table 1: Comparison of THD between Simulated Result and Result Obtained from Laboratory Test Bench

Circuit condition	THD obtained from simulated result (%)	THD obtained from laboratory test bench result (%)
Without filter	44.99	46.95
With filter	17.90	16.60

12. Laboratory Test Bench Photograph

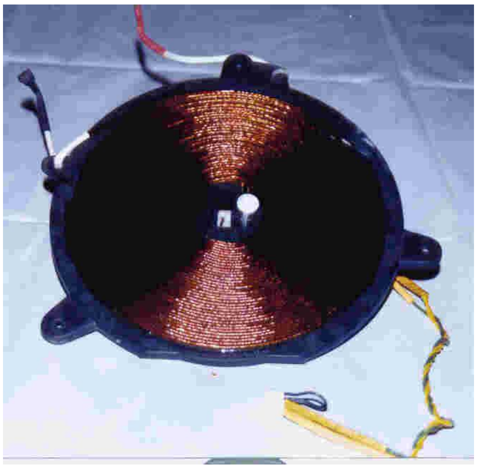

Figure 20: Photograph of induction coil for Modified Half Bridge Inverter fitted induction heating equipment

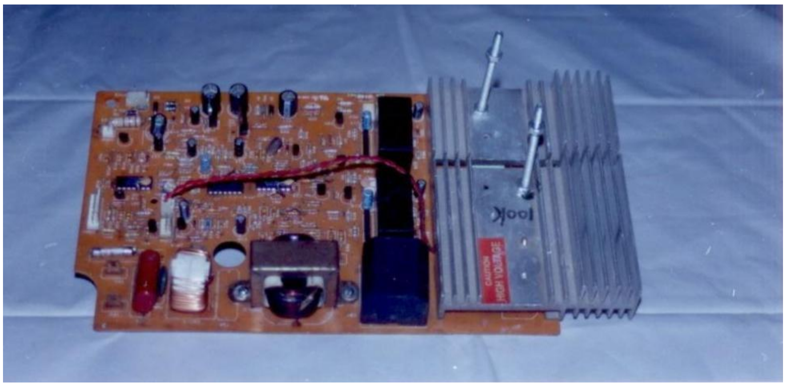

Figure 21: Photograph of the LP filter circuit and heat sink for Modified Half Bridge Inverter fitted induction heating equipment

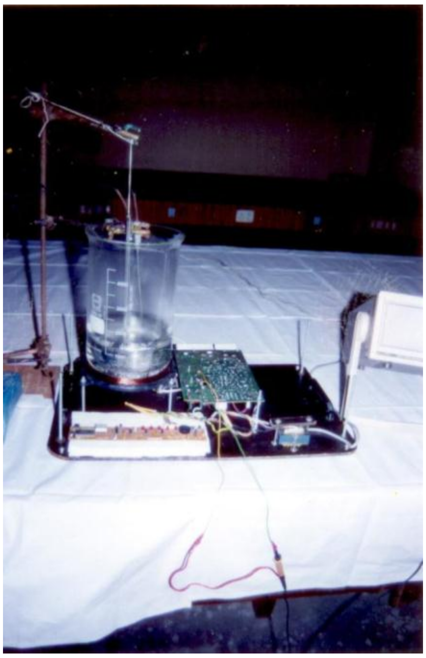

Figure 22: Photograph of the total experimental setup for Modified Half Bridge Inverter fitted induction heating equipment

Description of the Laboratory Test Bench Photographs

Fig. 20: depicts the photograph of the induction coil as used in Modified Half Bridge Inverter fitted induction heating equipment with LP filter. The induction coil used in this high frequency operation is made of litz wire to reduce the skin effect inherent in the high frequency operation. Fig. 21 shows the photograph of the LP filter and the heat sink which were incorporated in the Modified Half Bridge Inverter fitted induction heating equipment with LP filter. Fig. 22 shows the photograph of the total experimental setup along with PC based storage oscilloscope for Modified Half Bridge Inverter fitted induction heating equipment. The PC based storage oscilloscope is used to view and measure the waveform of output voltage and current and to perform the FFT analysis.

Conclusion

In this paper, the scheme is described, which is aimed to design and build up experimental Modified Half Bridge Inverter fitted induction heating equipment for industrial applications as well as domestic applications. The switching operation is controlled using digital controller and the simulation is done on the PSIM platform. In induction heating equipment's, high frequency inverters are required to produce a high frequency alternating magnetic field, which induces eddy currents in the material to be heated. But this high frequency switching results is harmonic distortion. Harmonics are generated due to high frequency switching in the employed inverter of the induction heating equipment. After generation, these harmonics try to flow back to the supply side resulting in deterioration of the power quality. So, with the installation of induction heating equipment, quality of available power is significantly reduced. A well designed filter can attenuate these harmonics and improve the power quality. The current harmonics injected into the power supply should be attenuated by the AC power filter to some specific level according to the harmonic standards. Inverters, which serves as the power supply should be accompanied with power filter to attenuate the injection of current harmonics. The proposed filter, as depicted in Fig. 3 and 4 is employed in the induction heating system to meet imposed utility distortion limits, the injection of current harmonics and improved power quality requirements in the supply end. Consequently it has been shown in PSIM that without filter the THD of the input current (I2) is 44.99%. But when the filter is incorporated at the input, the THD of the input current improves to 17.90%. But it is important to understand that the RFI suppression capabilities of the filter change significantly when the power supply packaging or layout changes. To support on this claim, it can be mentioned that if IGBT or power rectifier which uses high frequency waveform is directly installed on the chassis of the power supply, with placing only a mica insulator in between them, and the chassis connected to the ac ground conductor, the RFI noise produced will be coupled into the ground conductor resulting in deterioration of the effectiveness of the particular mains filter. A solution is to sandwich a metal shield between the mica insulators and to return the shield to the DC ground. In effect, this technique effectively shorts the capacitor created by the mica insulator, resulting in reduced RF noise currents. So, the designer must take care of the power supply and system layouts to design the filter for eliminating RFI-EMI problems.

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