Design and Implementation of a Battery Powered Induction Stove

A PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of degrees of

MASTER OF TECHNOLOGY

IN

CONTROL AND INSTRUMENTATION

IN ELECTRICAL ENGINEERING

BY

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DEPARTMENT OF ELECTRICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY MADRAS

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CERTIFICATE

This is to certify that the project titled "**Design and Implementation of a Battery Powered Induction Stove**" being submitted to the Indian Institute of Technology Madras by **Doulat Ram Yadav (EE18M027)**, in partial fulfilment of the requirements for the award of the degrees of **Master of Technology in Control and Instrumentation in Electrical Engineering** is a bonafide record of work carried out by him/her under my supervision. The contents of this project report, in full or in parts, have not been submitted to any other institute or university for the award of any degree or diploma.

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ABSTRACT

Induction heating is the process of heating electrically conductive materials by a process called electromagnetic induction. One of the many applications of induction heating is cooking. The induction stove, while not yet a part of most households, is becoming increasingly accepted as a useful, energy efficient method of preparing food. Benefits of induction cookers include efficiency, safety and speed. Drawbacks include the fact that non-ferrous cookware such as copper, aluminum and glass cannot be used on an induction stove. However, no existing commercial stoves nor academic research have attempted to create an induction stove powered from a low voltage 48V DC source.

This paper presents the design of a low voltage current-fed, full-bridge parallel resonant converter stove. The dynamics of this new topology are discussed in detail and simulations are provided to analyze the behavior. Additionally, a practical implementation of a 1 kW stove is described.

Contents

List of Figures

List of Tables

Chapter 1

INTRODUCTION

Induction cooking is often considered one of the most efficient technologies for stovetop cooking. This technology relies on the principle of magnetic induction, in which eddy currents are excited in a ferromagnetic cookware when in the presence of an oscillating magnetic field. These induced currents dissipate heat by the Joule effect, generating the heat for cooking directly in the cooking vessel. As such, less heat is lost in inefficient thermal conduction between heating element and cookware.

A typical induction cooker is composed of a switching power electronics circuit that delivers high-frequency current to a planar coil of wire embedded in the cooking surface. The cookware is magnetically coupled to the coil by the oscillating magnetic field, analogous to the coupling between primary and secondary coils of a transformer. Current flows in the cooking vessel due to the low resistance of the metal, with power dissipation given by I2R. The resistance of the vessel is dependent on the magnetic permeability (μ) and resistivity (ρ) of the cookware, as well as the frequency of excitation.

To generate sufficient heat for cooking, cookware must be used that has relatively high permeability and resistivity. Typical induction cookers operate at switching frequency between 25 kHz and 50 kHz. In this regime, induction cookers are only able to couple with ferromagnetic cookware, such as cast iron and some alloys of stainless steel. Thus, modern induction cooking technology is not compatible with cookware made from copper, aluminum and non-magnetic alloys of stainless steel.

1.1 Motivation

In the case of rural areas, cooking is heavily dependent on inefficient biomass (Wood and kerosene and gases) based cooking[1]. The main problems include the time that is needed to collect the firewood and other biomass by the people, indoor air pollution induced health hazards and various other environmental concerns (greenhouse gases)[2]. These things also operate at a very low efficiency, with only a small amount of the stored chemical energy being converted into heat for cooking or light for working.

In the case of urban induction cookers as an alternative solution to LPG due to portable, controllability and less cost. But regular power cuts prevented them from doing so. And even when people used induction cookers while grid power was available, excessive loading caused faults in distribution transformers causing substantial loss for repair and maintenance. So, lots of people were interested in running the induction cooker from a battery which required use of costly and over rated inverters. At that stage, people had increasing interests and confusions regarding the use of induction cookers directly from batteries using solar panels.

This project focuses on improving cooking for those in developing countries. There has been a large body of work established already in this field.This project will focus on electric power heating as a clean alternative. Electric heating emits no soot or greenhouse gases. Electric heating also allows fine heat control that wood and fossil fuel burning stoves do not. Furthermore, electric heating can be significantly more efficient, with a much higher percent of energy going into heating the food than is achievable by traditional methods [3].

1.2 State Of The Work

This section provides a comprehensive review of the literature to the different resonant topologies for induction heating . Emphasis is given to both historical papers of classical importance , as well as to the current state of the art.

Many literatures exist in the academic world regarding the design of AC powered induction cookers that convert like 230volts AC to 325 volt DC, But very few literatures exist in the academic world regarding the design of low DC like battery (48volts) powered induction cookers. There are a number of converter topologies that exist for efficiently producing the time varying magnetic field needed for induction heating.

There are two common ways for electric stoves to function. The first method is driving current through a resistive element. This produces ohmic heating and the thermal energy is transferred to the pot or pan through thermal conduction. This was deemed infeasible due to low efficiency, since only 60% of power consumed may be used to heat the pot containing the food or water [3].

The second method, which we will examine more completely as the focus for this proposal, is the use of induction to heat the pot directly. In an induction stove, the stove produces a strong, time varying magnetic field. If the pot, made of an appropriately conductive material, is placed in the field, currents will flow in the pot to generate a magnetic field to oppose the exciting field according to Maxwell's equations. These induced current in the pot, called eddy currents, create ohmic heating directly in the pot itself [4]. Therefore, the only lost energy is that required to drive the circuitry controlling the magnetic field of the stove. Using induction heating, efficiencies as high as 90% or more can be realized [3].

1.2.1 Literature Review

The voltage or current administered to the switching circuit can be made zero by the resonance created by an L-C resonant circuit. As a resonant converter provides most of the energy conversion efficiency in a power system by minimizing switching loss, it is widely used in a variety of industries and domestics, and this is also the reason why the converter is adopted in the induction power system topology.

The resonant converter can be further classified into major types: a half bridge series resonant converter and quasi- resonant converter. K.H.Liu,R.Orugant and F.C.Lee proposed Resonant topologies & characteristics in IEEE Power Electronics Specialists conference[5]

H.Ogiwara, A.Okuno and M.Nakaoka presented the paper which was mainly concerned with a resonant capacitor voltage - clamped type half - bridge topology of new instantaneous resonant current vector-regulated high- frequency inverter with phase-shifting control, which efficiently operates at zero-current soft-switched quasi-resonant and load resonant tank circuit sub-resonant hybride soft-switching schemes . Its analytical results and performance evaluations were described through computer-aided simulation method[6].

The efficient single ended type high-frequency induction-heating quasi resonant inverter circuit using a single advanced 2nd generation IGBT for soft-switching and its specially designed driver IC, which operates at a zero-voltage soft switching mode under PFM-based power regulation strategy was presented by Izuo Hirota,Hideki Omori, Kundu Arun Chandra and Mustsuo Nakoaka. The generic voltage-fed and current-fed circuit version of single-ended resonant inverters for home power electronics appliances were systematically proposed and classified on the basis of the soft-switched PFM mode inverter family. These new technologies are especially developed for quasi-resonant ZVS high frequency inverters with working coil-linked induction- heating loads. This high-efficient high=frequency quasi-resonant inverter system with high power factor correction and sine wave line current shaping function is practically demonstrated including a high frequency IGBT with reduced saturation voltage characteristics, and discussed on the basis of high- power density home power electronics appliances in the next generation[7].

In this way there is also a large body of work from academia and industry. There are a number of papers discussing quasi-resonant converter induction stoves, as well as fully resonant induction stoves. This is a very mature field, with a number of cutting edge designs presented each year from academia [8][9]. The literature from industry is diverse, including datasheets for induction stove specific ASICs, application notes discussing induction heating, and reference designs for stoves. These publications regularly achieve efficiencies in excess of 90% [4]. However, typical efficiencies in industry fall into the 70-80% range [10][11]. However, a major shortcoming of the existing literature is the lack of other converter topologies explored. There are several academic works presenting designs of Class E amplifiers for induction stoves, but no other converter topologies have been thoroughly investigated for induction cooking.

1.2.2 Topologies

There are many topologies, Some of the topologies for induction heating are shown in the following figures. Figure 1.1 (a) and (b) show the full bridge [12], half-bridge [13] (b), and two single switch inverter topologies with Zero Voltage Switching (ZVS) [14] (c) and Zero Current Switching (ZCS) operation [15] (d). All the modulation strategies commonly applied to control output power are based on modifying either switching frequency or duty cycle to achieve the desired power [16]. Each power converter topology offers different performance features with specific requirements in terms of costs and hardware and control complexity. Such systems are well known in literature as well as the design criteria for all their main parameters.

The most popular topologies for induction heating are the Half-Bridge (HB) series-resonant converter and the Single switch Quasi-Resonant (QR) or QR flyback. The Resonant Half-Bridge series resonant is very common for the four burner cooktops, and it is popular in the European market. While the Quasi-Resonant or QR flyback is very common for the single burner. and it is most popular in the Asian Market.

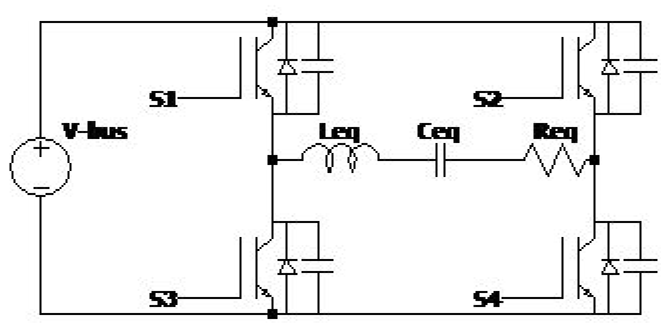


Figure 1.1 (a) Full Bridge

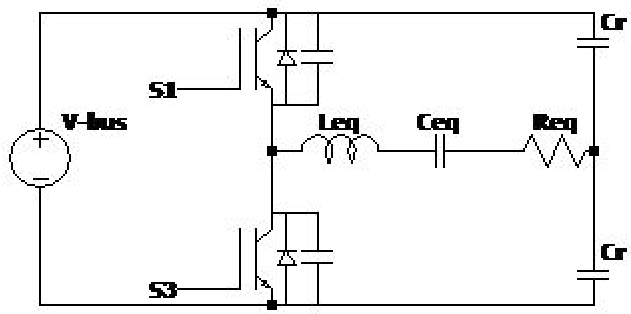


Figure 1.1 (b) Half Bridge

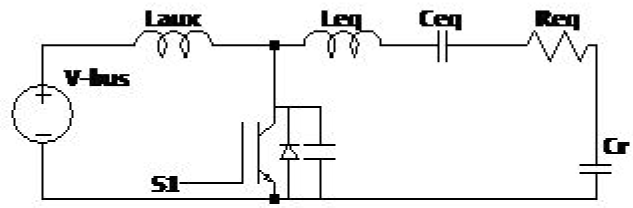


Figure 1.1 © ZCS Operation

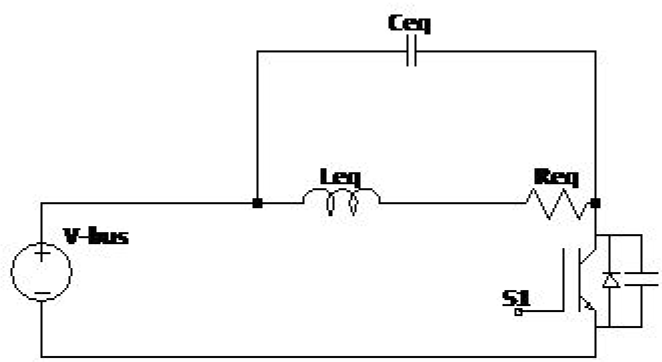


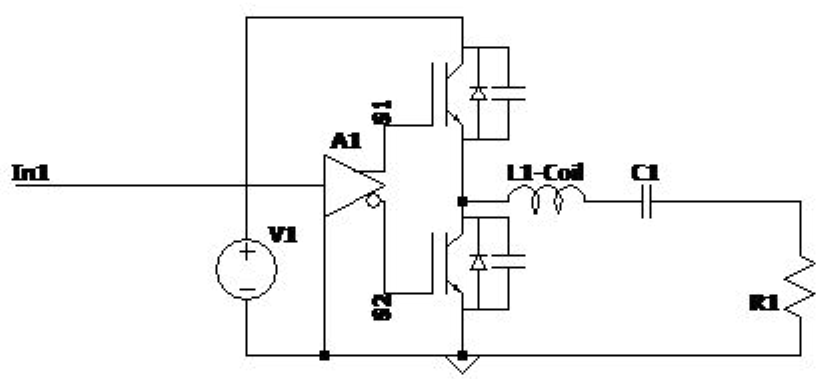
Figure 1.1 (d) ZVS Operation

These topologies are of interest because, to the best of the author's knowledge, all existing induction cooking literature industries examine one of these two topologies.

The series resonant converter consists of a series resonant tank. This tank is fed by a voltage fed bridge, switching at the resonant frequency of the tank. The resonant frequency of any resonant tank is given by the equation in Figure 1.2 . By driving the tank at its resonant frequency, large resonant currents are induced, which in turn are responsible for heating the cookware. Additionally, the power devices are inherently soft switched with this control mechanism. The driving bridge can either be a half bridge with two power devices (as shown in figure 1.3) or full bridge with four devices.

$$f_\circ = \frac{1}{2\pi\sqrt{LC}}$$

Figure 1.2 Equation For the Resonant Frequency of an LC Tank



1.3 Schematic of a Series Resonant Converter with Half-bridge

The series quasi-resonant converter also uses a resonant tank, but just a single power device. The device is turned on and the tank is allowed to resonate for one half cycle. At the zero crossing, the device is switched off. This alternate method also guarantees soft switching, but the controller must now pulse the power device to achieve heating (as shown in figure 1.1 (d)).

1.3 Limitations and Disadvantages of Existing Stoves

Existing stoves have disadvantages, especially in the context of use in developing areas. First , although high efficiencies of 90% are well within grasp, many commercial offerings don't even reach 80% efficiency, likely because they were designed in countries with cheap, reliable mains power [17].

Furthermore, no existing stoves have built in mechanisms of dealing with brown-outs or black-outs. If a family relied on an induction stove in one of many cities or mostly in villages without high quality electricity, they would be unable to cook their meals on a regular basis.

Additionally, no existing stoves have the ability to run off low voltage inputs, cheaper or more efficient stoves.

1.4 Objectives

The primary goal of this project is to model, design, control and implement a Full Bridge parallel resonant circuit for domestic induction heating applications. Reducing intermediate losses of inverting, and providing a cost effective and environmentally friendly for people in both rural and urban areas. In simple terms, the project aim is to heat a household pot inductively as well as vary the temperature by controlling the power applied to the induction coil and pot.

To achieve these goals and to broaden my understanding of the subject, the following milestones will have to be reached.

- Design of Full-Bridge inverter

- For control using Digilent Analog discovery kit to implement the open loop control
- Design and implementation of drive circuits in small signal conditions
- Select all component values
- Test the complete system for different duty cycles
- Provide a full simulation in LTSpice
- Test the circuit under 48V DC, 1KW conditions
- Compare Simulated and Experimental results.

Chapter 2

INDUCTION STOVE SYSTEM DESIGN

2.1 General Approach

This design for low voltage DC power, high efficient induction stove powered by 48V DC source. 48V DC supply is the connection of four car batteries in series. 48V is an extremely common output for solar installations, and one of only a few standardized output voltages for photovoltaic panels. This makes it appropriate for direct integration with a roof top solar installation or solar-based microgrid [18] Traditionally, to hook up an electric appliance, such as an induction stove, an inverter is connected to the solar battery to produce mains AC voltages. This step is usually at most 90% efficient, and frequently significantly less. Then the stove internally must rectify the AC voltage back to DC to use it, again with a loss of efficiency. Figure 2.1 shows a conventional approach, with losses at each step.

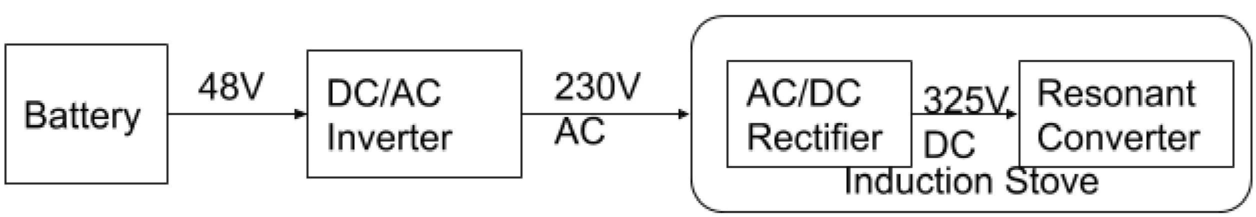


Figure 2.1 Block diagram of conventional approach for powering a induction stove

From a battery

By feeding our stove directly off the battery, we eliminate the inefficiencies associated with converting solar energy to AC for compatibility with appliances and then back to DC in the stove itself. Eliminating these steps could cut the wasted power of an induction stove in half. Figure 2.2 shows our approach for comparison.

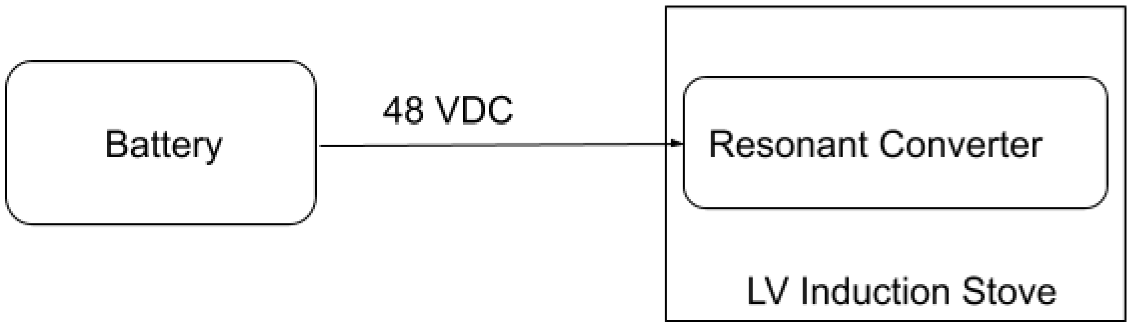


Figure 2.2 Battery power induction stove

2.2 General Converter Topology

The topology that is used here is not one of the conventional topologies used for induction cooking. Instead of using a series resonant, series quasi-resonant, or class E inverter, we choose the current-fed parallel resonant converter. This converter has some use in industrial induction heating applications.Figure 2.3 shows an example of this topology.

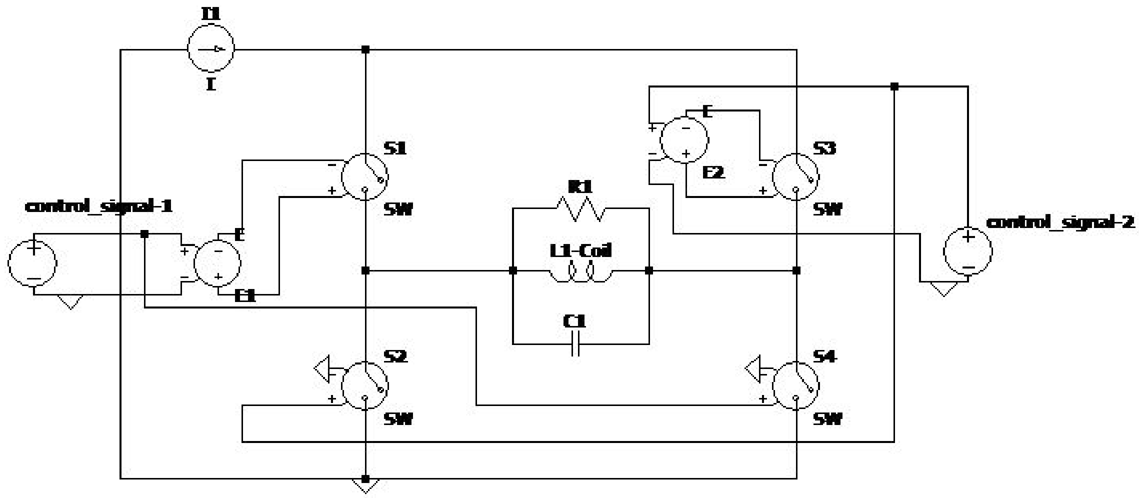


Figure-2-3 Conceptual Schematic of a Current-Fed Parallel Resonant Converter

2.3 General Circuit Analysis

This section will discuss the operation of the Full Bridge Resonant Converter and how characteristics of the circuit are calculated. There are four switches in which switch S1 and S4 are close/open simultaneously by control_signal-1 and switch S2 and S3 are open/close simultaneously by control_signal-2. Control_signal-1 and control_signal-2 work alternatively (not simultaneously high). In ideal conditions current from source will flow only when there is a load(pot).

STATE-1

In this state control_signal-1 is high and control_signal-2 is low , so current flows from source as shown in figure 2.4.

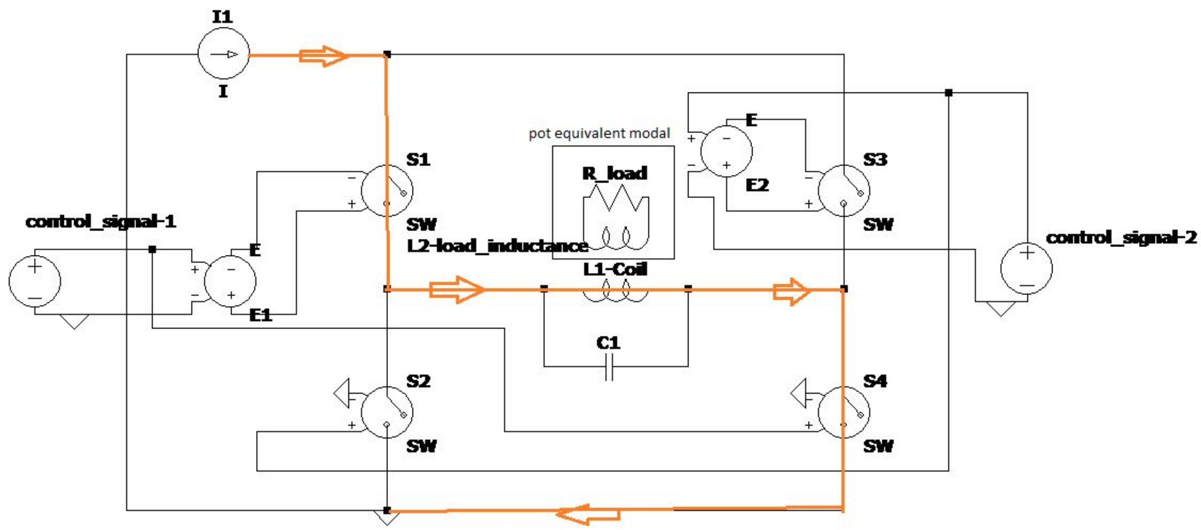


Figure 2.4 State-1

STATE-2

In this state control_signal-1 is low and control_signal-2 is also low , so there is no current flow from source as shown, but resonance and load current will continue in the same direction,but magnitude of these current will decrease.(figure 2.5)

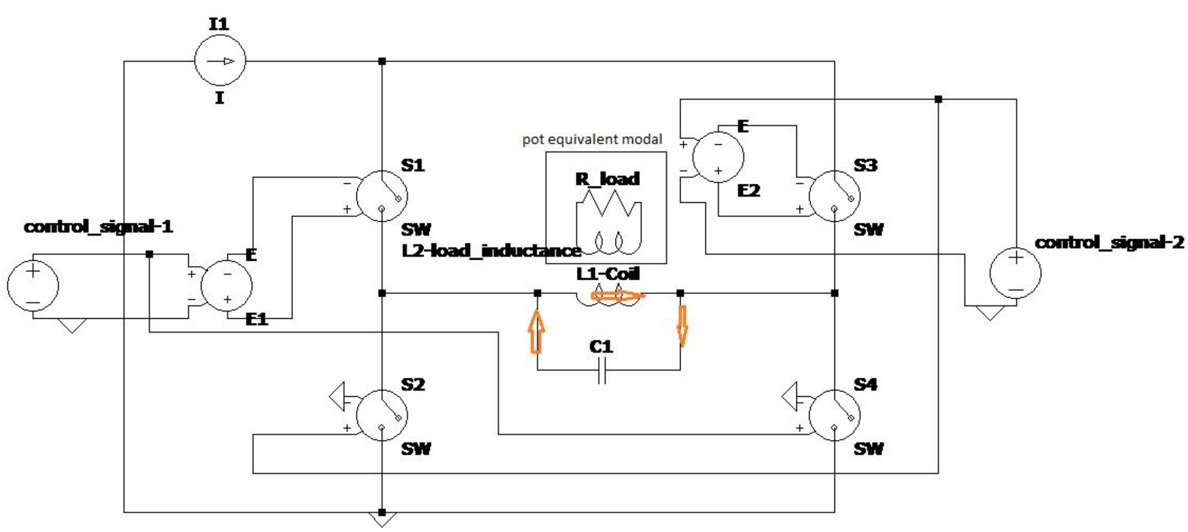


Figure 2.5 State-2

STATE-3

In this state control_signal-1 is low and control_signal-2 is high, current will flow in reverse direction in load as shown in figure 2.6.

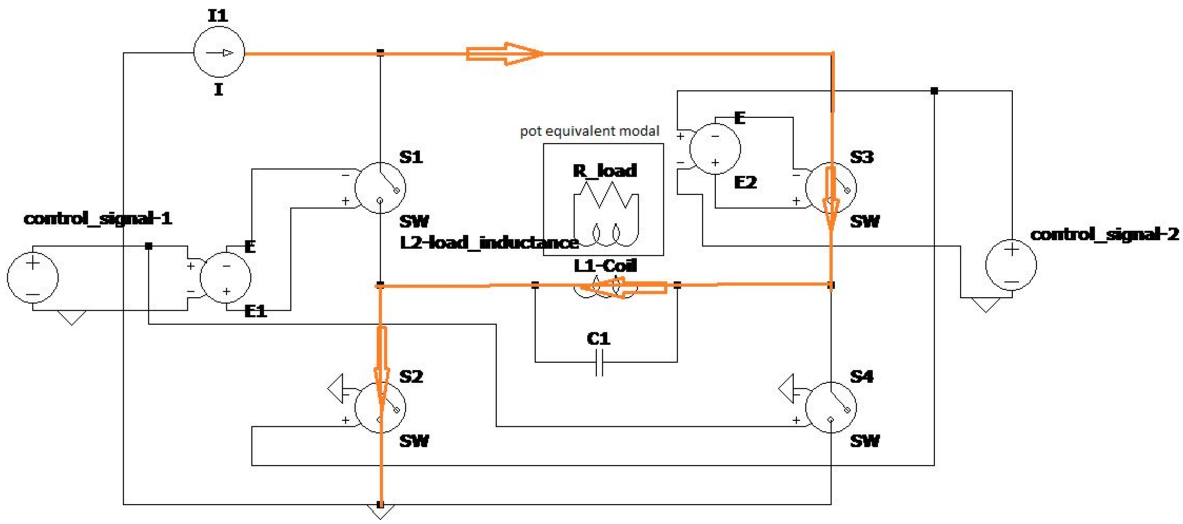


Figure 2.6 State-3

STATE-4

In this state control_signal-1 is low and control_signal-2 is also low , so there is no current flow from source as shown in figure 2.7, but resonance and load current will continue in the same direction,but magnitude of these current will decrease.

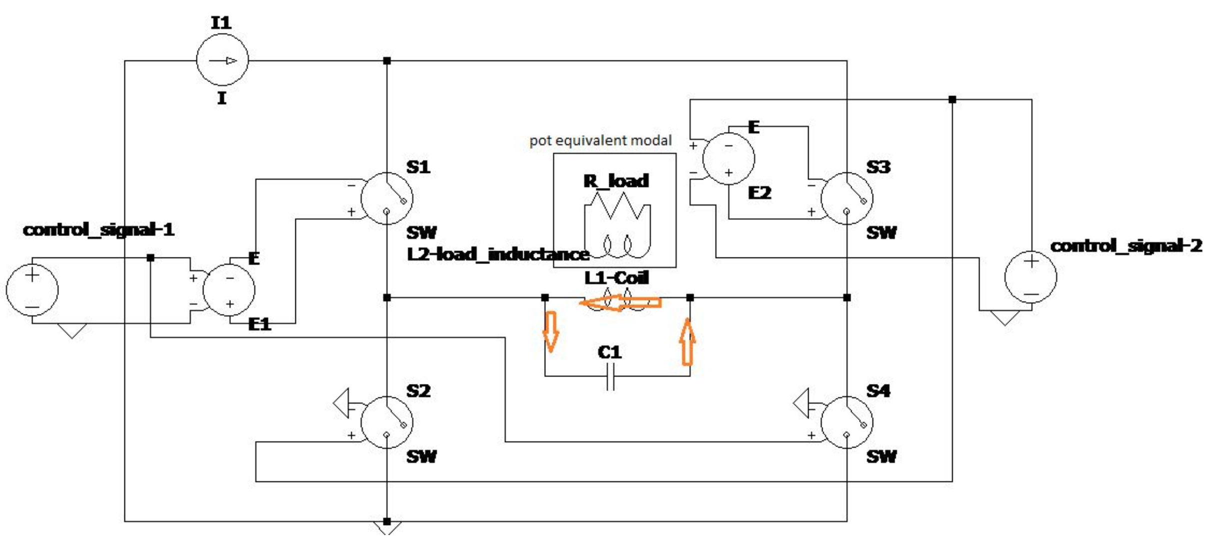


Figure 2.7 State-4

After this state all states will be repeated in the above manner. When all switches are off then load current may be in oscillating form , it depends on load.

2.4 Design Parameters

When designing a Full Bridge Parallel Resonant Converter there are essentially two major design considerations that must be analysed.

1. The value of the resonant capacitor,
2. The switching frequency fo ,
3. Current Source.
4. Switching Topology

In a RLC circuit such as the Full-Bridge Parallel Resonant , resonance occurs because of the collapsing magnetic field of the inductor generates an electrical current in its windings which charges the capacitor; and then the discharging capacitor provides an electric current that builds the magnetic field in the inductor. This resonance occurs at a particular frequency for given values of inductance and capacitance. This resonant frequency is the point of highest electrical energy efficiency and power output. The inverter switching frequency is the frequency at which the Mosfet/IGBT of the Full-Bridge will be switched. Choosing this frequency is of vital importance and is very much dependent on the value of the resonant capacitor and by extension the resonant frequency. The Full-Bridge will operate under Zero Voltage Switching Conditions (ZVS). ZVS is when the voltage across the switch will be zero when turned on .

2.5 Induction stove converter design For Implementation

2.5.1 Topology Selection

Induction stove's resonant converter typically works with large DC voltage (325VDC) ,This design operates with a low voltage 48VDC input,So there many conventional parameters are changed. By using boost converter this problem would be a shoutout but increase intermediate losses. Output power is directly proportional to square of input voltage. So if all other parameter are fixed and reducing input voltage ,output power quadratically reduce. If we want to increase output power, we need to increase the ampere turns in the coil, the frequency, or both and at the same time, to maintain efficiency, we need to minimize loss.

In induction heating, the skin effect produces a favorable outcome for heating a pot. As frequency increases, the effective resistance of the pot increases with the square root of frequency. So if input voltage is decreased by 10 times then for compensating effective resistance frequency should be 100 times. If increase in turns then ampere-turn increase and effectively current would be reduced. So for compensating output power coil current will be high and switching frequency also.Coil inductance is given by

$$L = \frac{\mu_o N^2 A}{l}$$

And energy conversion equation given by

$$\frac{Io}{Vo} = \sqrt{\frac{C}{L}}$$

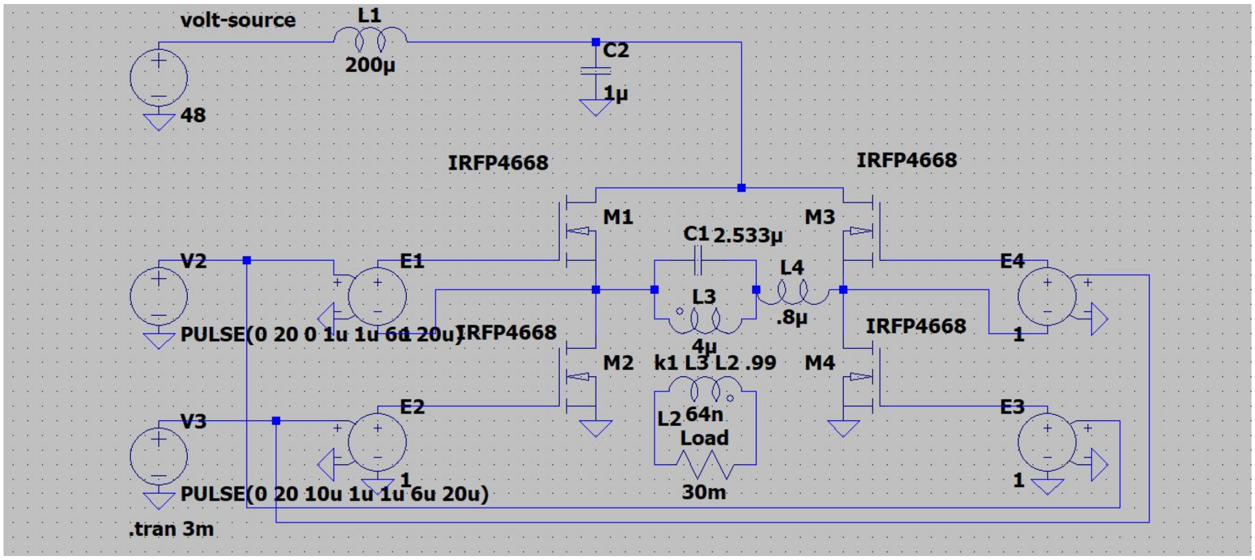


Figure 2.8 Practical Implementation of a Parallel Resonant Converter

Major complication is that a parallel resonant circuit must be current-fed to resonate, that is not easily available and hard to design, so in this case a current source obtained by using a large inductor in series with the battery. There are two more problems, one controlling the current and other requiring a continuous path because when switches of a large voltage spike is generated. A Practical Implementation of a Parallel Resonant Converter is shown in figure 2.8.

There are four power mosfets IRFP4668 .These are 200V N-channel MOSFETs with 8 mOhm $R_{ds(on)}$ and 161 nC total gate charge.

11 pieces of Capacitor MKPH SH 630 AC 1200V DC 50KHz of .33uf. That can handle large current. 50khz resonant frequency.

The coil of ~4uH is made by copper wire that handles 20Amp rms, This coil is made by parallel connection of three coils of ~12uH on a base .

2.5.2 Control Circuit

The circuit was designed to operate off a 48V DC supply. Although this is a relatively low voltage in the scheme of induction heaters, induced currents of 20A rms will alternate across the load and has the potential to cause serious injury or damage to circuit components if improperly managed. Circuit control is the first line of defence against circuit damage or injury.

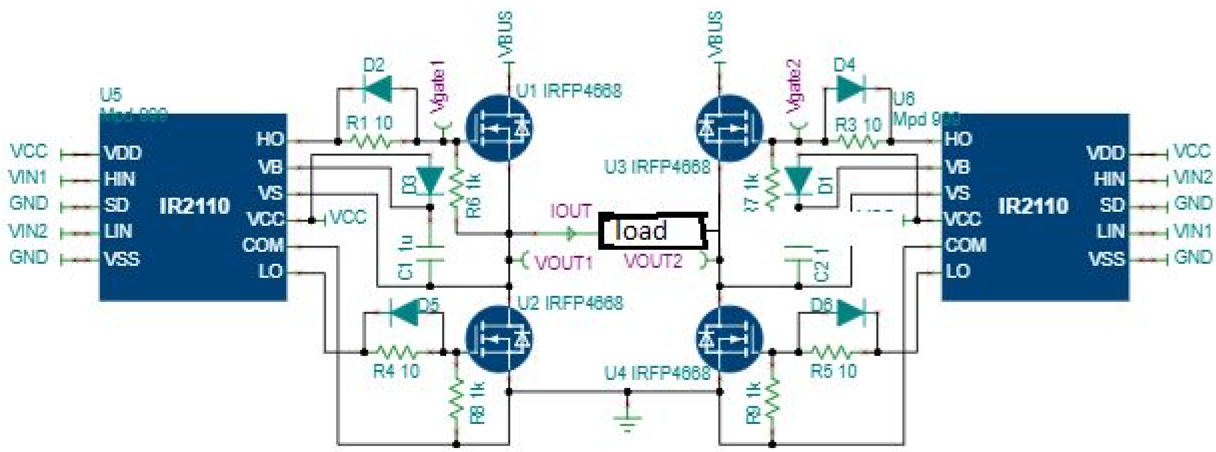


Figure 2.9(a) Mosfet Driver Circuit

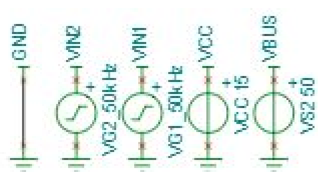


Figure 2.9(b) Control Signal From Analog Discovery kit

There are two IR2110 IC that each drive half bridge and these ICs are control by two control signal VIN1 and VIN2 from ANALOG DISCOVERY(2) KIT that are generated by function generator and one more signal SD that control on /off (SD) of converter circuit. These two signals VIN1 and VIN2 have 180 degrees phase, same duty ratio and duty never exceeded 50%.

Chapter 3

CIRCUIT IMPLEMENTATION

3.1 Current Source

Current source is Made by using large inductance value >200uH in series of a Voltage Supply Source 48V followed by a 1uF capacitor.such inductance value readily not available so it is made by using ferrite core and wire of more than 20amp rms rating wrapping around it . A 1uF capacitor is a series combination of 3 MKPH SH 630 AC 1200V DC 50KHz of .33uf. Capacitor. 1uF capacitor used for providing continuous path to current from source when all switches are off.

As shown in figure 3.1.

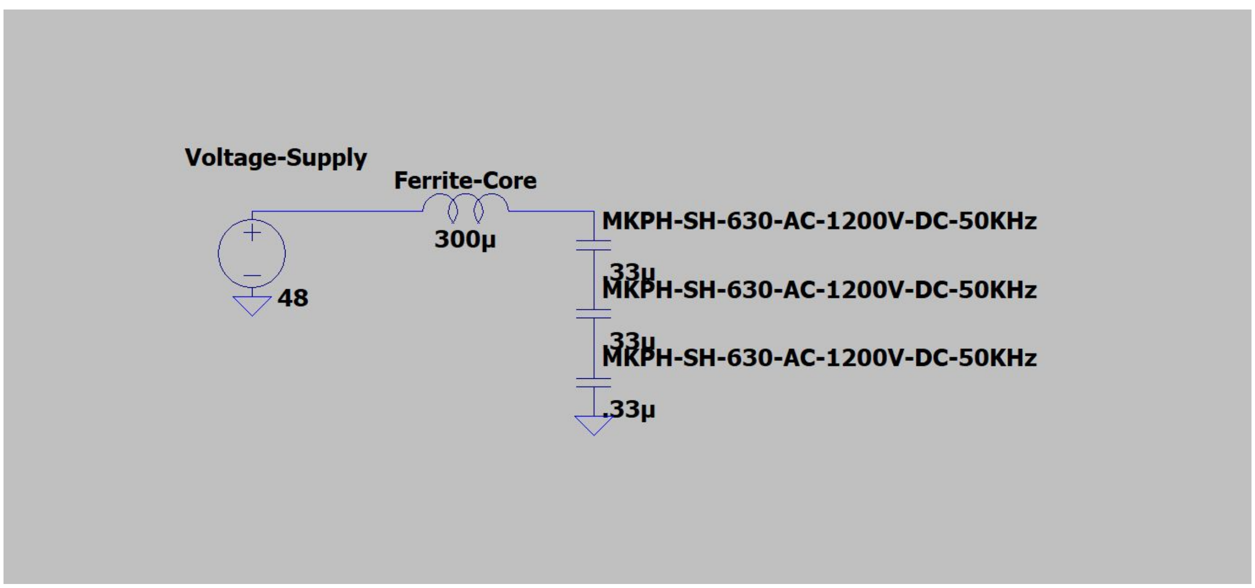


Figure 3.1 Practical Implementation for Current Source

3.2 Control Circuit Implementation

There are two half bridges so the gate driver circuit is made by using two half bridge drivers ic IR2110 . This is chosen due to a lot of reasons.

- Floating channel designed for bootstrap operation
- Fully operational to +500 V
- Fully operational to +600 V version available
- dV/dt immune
- Gate drive supply range from 10 to 20 V
- Undervoltage lockout for both channels
- 3.3 V logic compatible
- Separate logic supply range from 3.3 V to 20 V
- Logic and power ground + /- 5 V offset
- CMOS Schmitt-trigger inputs with pull-down
- Cycle by cycle edge-triggered shutdown logic
- Matched propagation delay for both channels
- Outputs in phase with inputs
- Easily available in the market.

Connection that is used is shown in the above figure 2.9(a) and 2.9(b) . Control Signal that used to drive these ic is from ANALOG DISCOVERY(2) KIT.

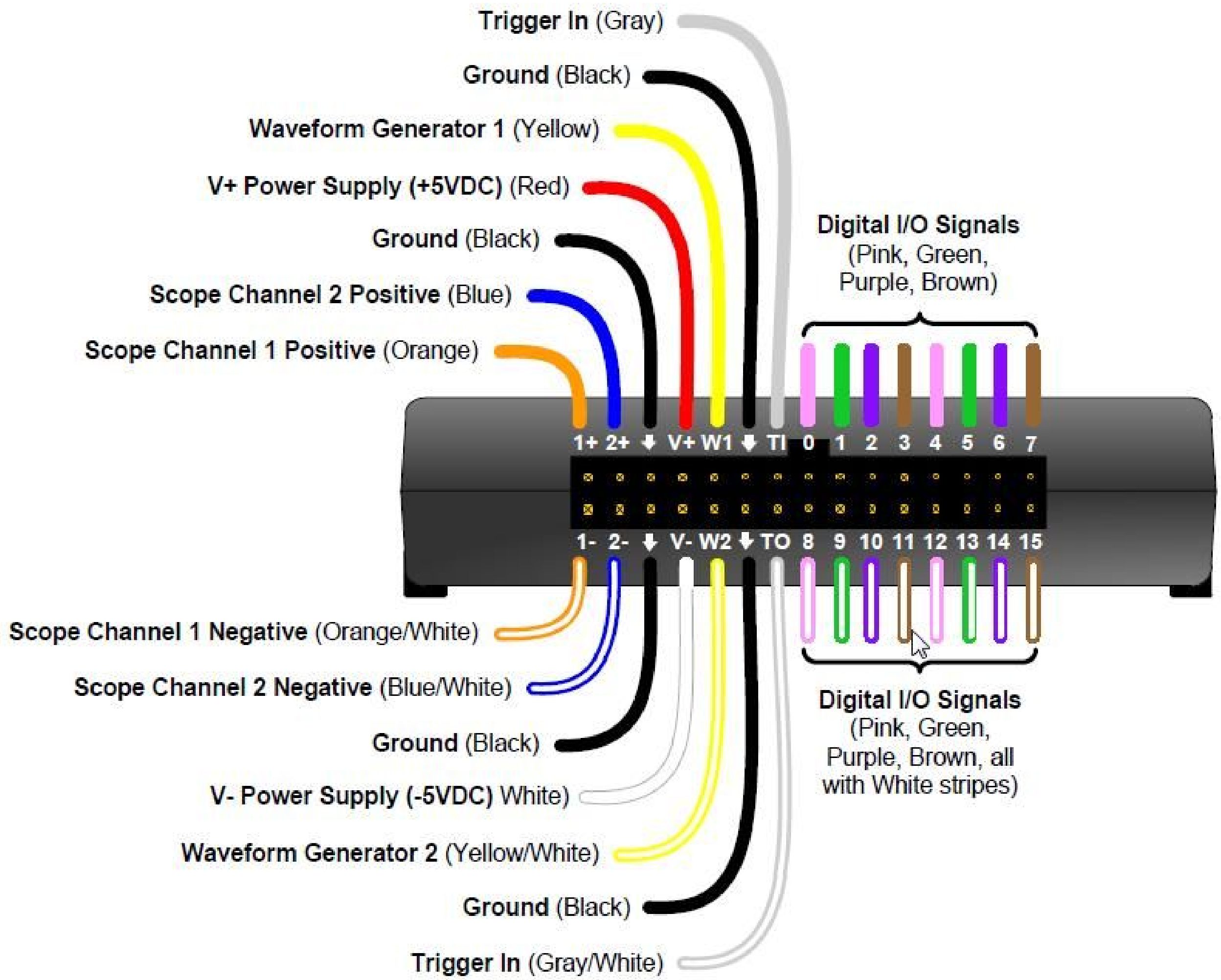


Figure 3.2 Analog Discovery Kit's Output Pins

VDD of IC connect to V+ Power Supply (+5VDC) red wire, VSS to any black wire(Ground)

SD pin is manually connected to +5VDC red wire or ground,PIN HIN and LIN connected to Waveform generator 1 and 2 respectively or vice versa. VCC pin connected to a seperate voltage supply 15VDC. Waveform generators 1 and 2 have 180 degrees phase, same duty ratio and duty ratio is manual set by computer interface, for controlling gate switching,it never exceeds 50%. All other connections for MOSFET driver circuits are made as shown in the above figure2.9(a) And 2.9(b).

3.3 Converter Circuit Implementation

The Full-Bridge circuit consists of a High and Low side mosfet , inductor coil, pot and resonant capacitors. Parallel resonant tank Circuit is made using a parallel connection of 2.31uF Capacitor (parallel connection of seven .33uF MKPH SH 630 AC 1200V DC 50KHz Capacitor) and 4.38uH spiral Coil made by hand. There is a small inductor 1uH in series also placed ,due to soft switching. Four mosfets IRFP4668 are connected as shown in figure 3.3

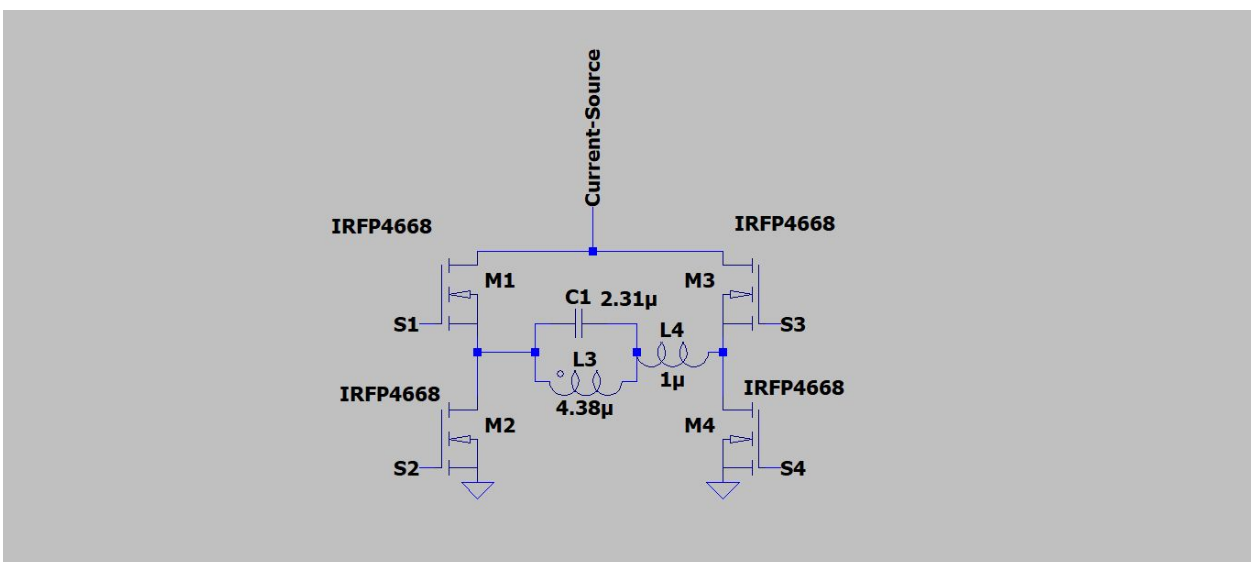


Figure 3.3 Converter Circuit

Here used mosfet due to reducing losses and this design for low input voltages and high switching frequency. Mosfets gates are connected to IR2110 IC's Output pins as shown in above figure 2.9(a) and 2.9(b).

3.4 Simulation

The induction stove was modelled extensively in LTSpice – circuit simulation software. LTSpice is a great simulation tool that allows the user to simulate quite complex circuits very quickly. The Full Bridge inverter simulation uses model file components .

Control circuit working is simulated using TINA Software ,because in LTSpice IC IR2110 is not available .

3.4.1 Converter Circuit Simulation

It is done in LTSpice .

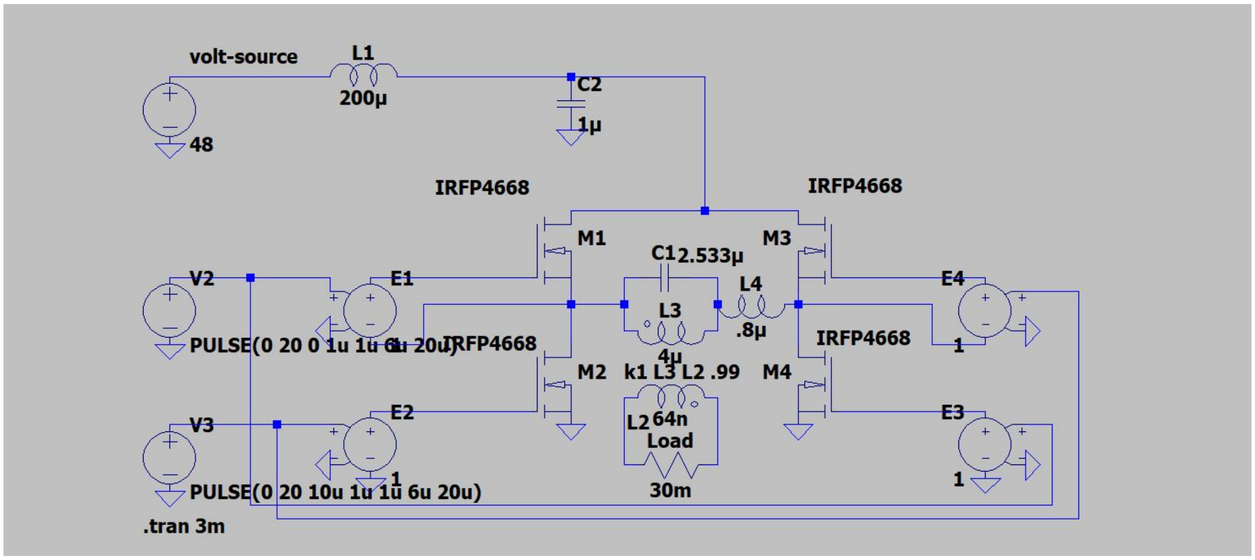


Figure 3.4 Converter Circuit Simulation

Mosfets used a model file for simulation, Switching in LTSpice easily simulates. Some signals are showing in the following figures.

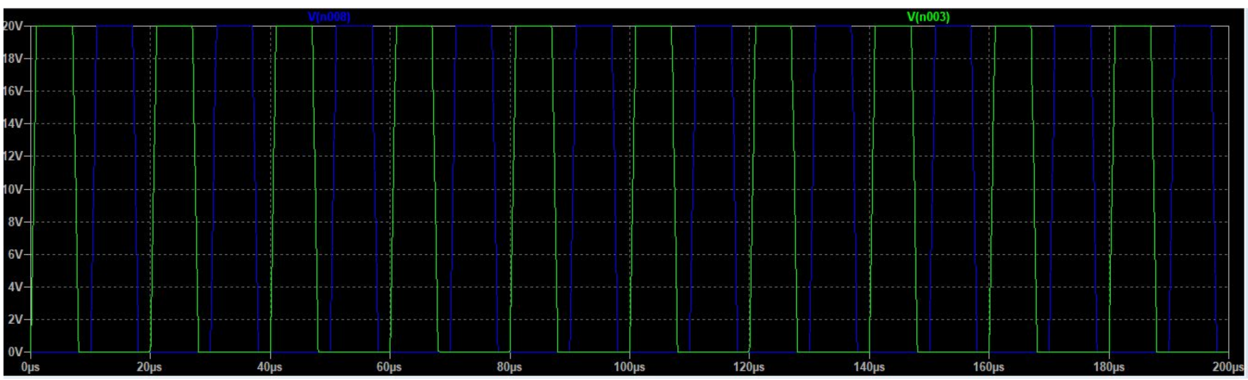


Figure 3.5 Control signal for mosfet drive

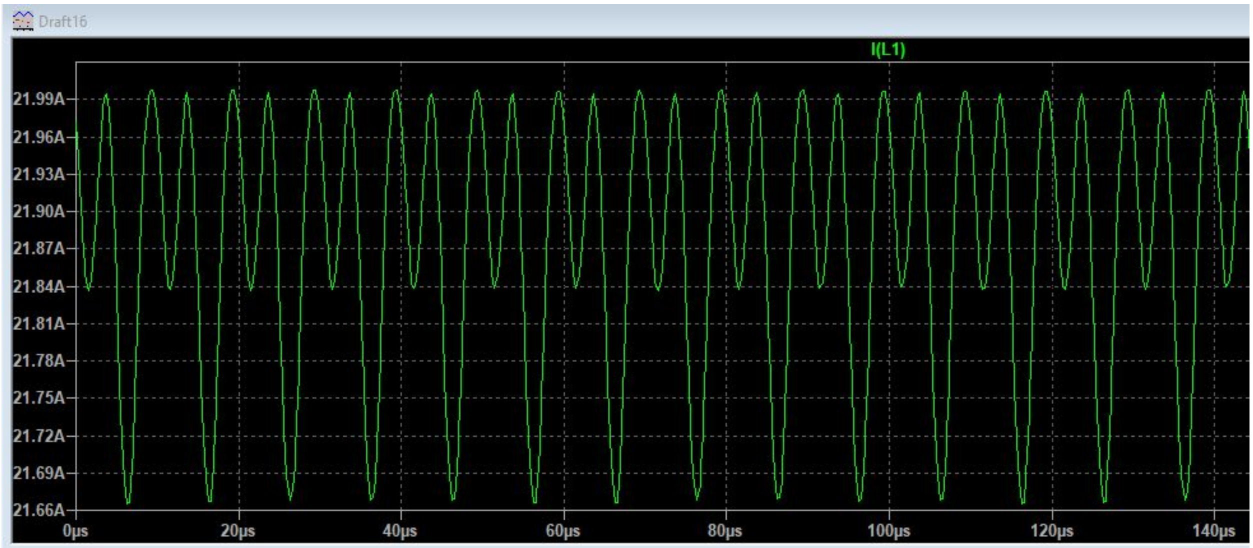


Figure 3.6 Current From Source

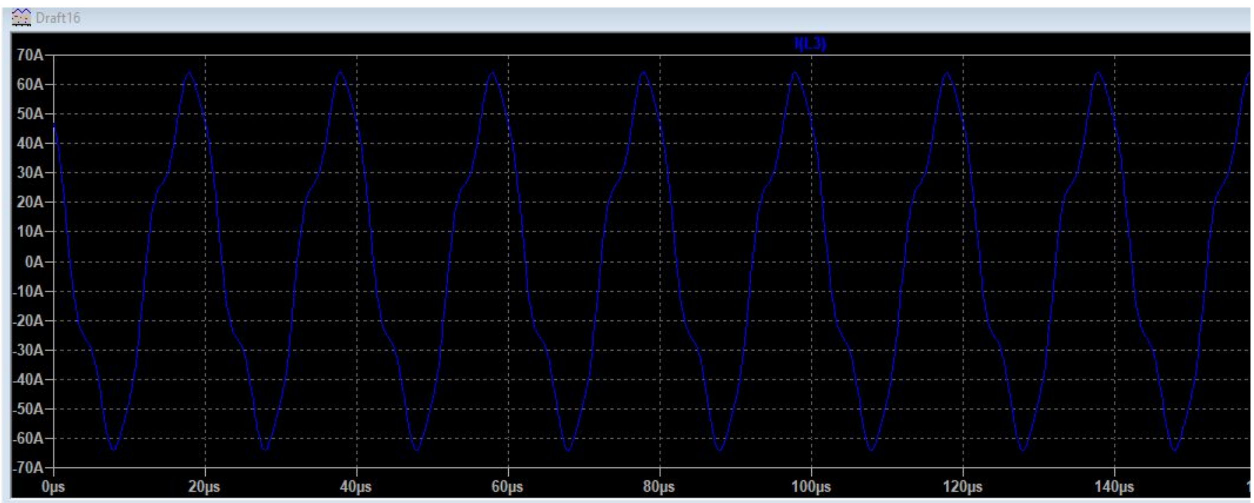


Figure 3.7 Current in Induction coil

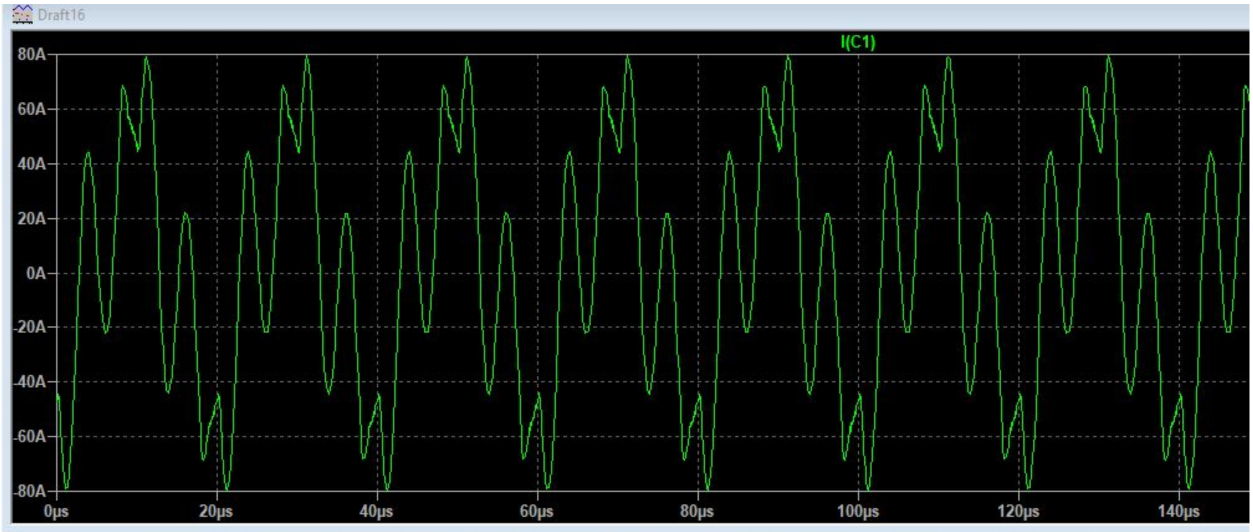


Figure 3.8 Current In Resonant Capacitor

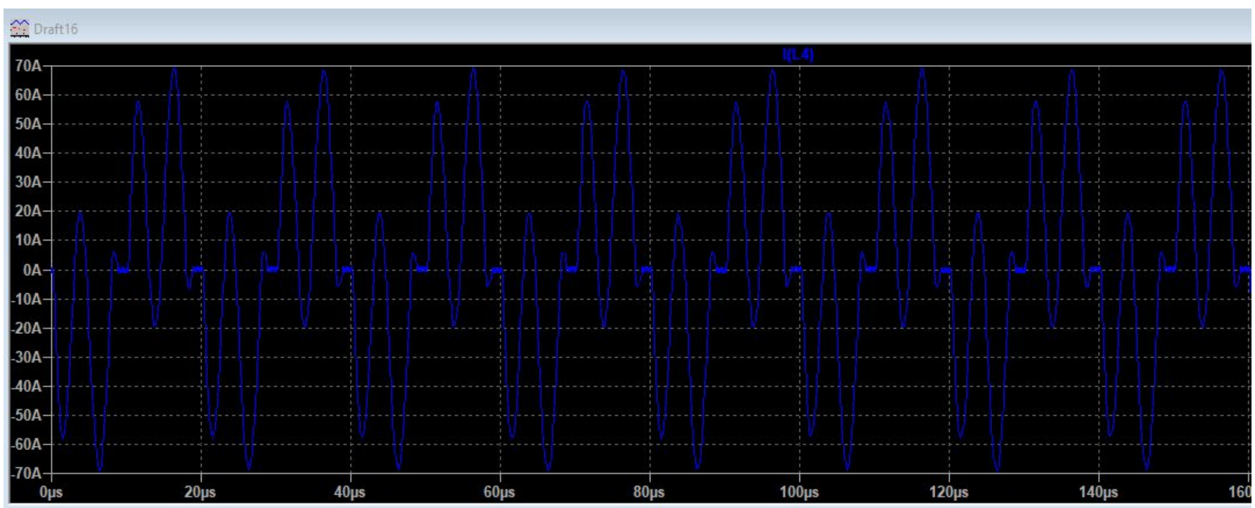


Figure 3.9 Current In Inductor L4

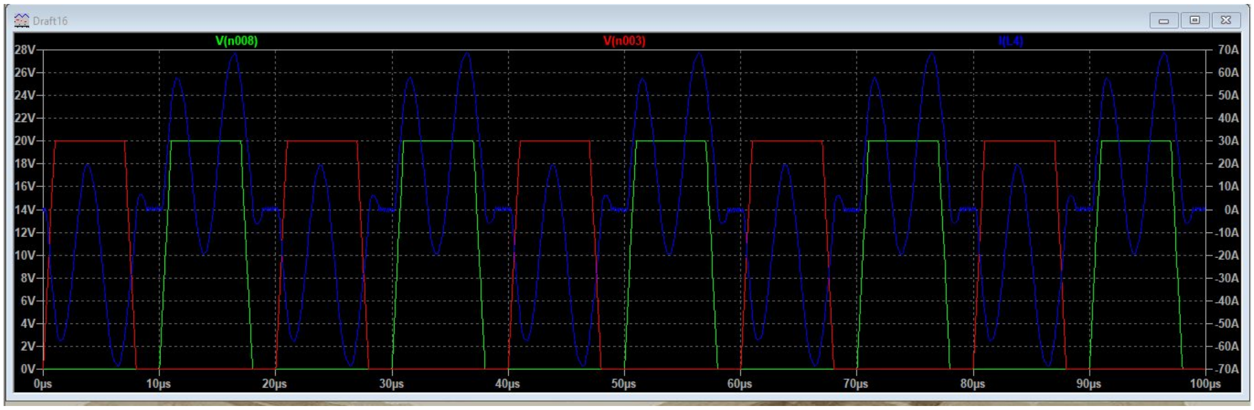


Figure 3.10 Current in L4 and Switching Signal

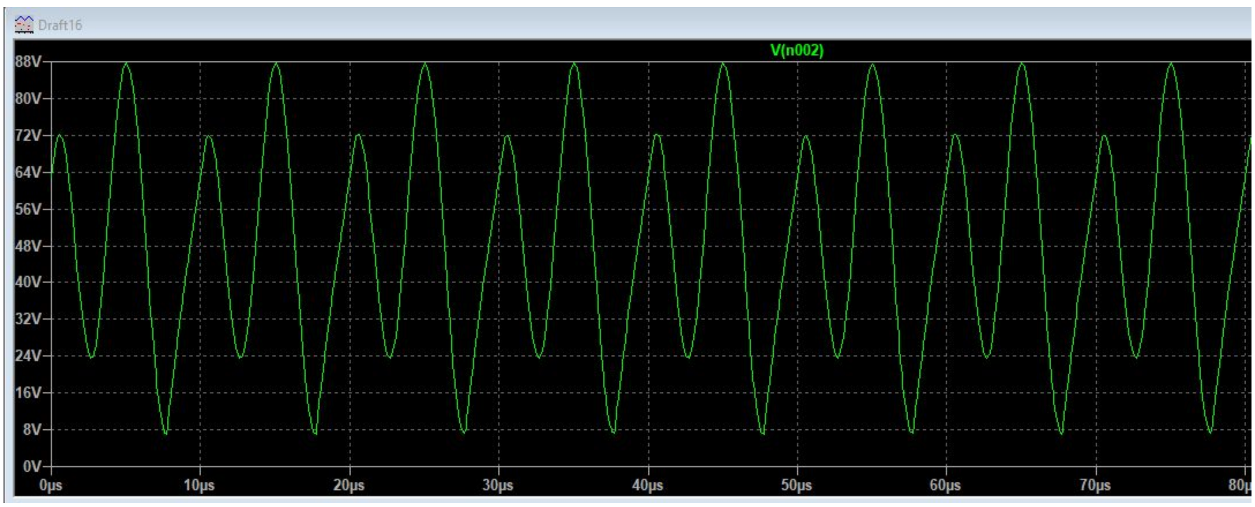


Figure 3.11 Voltage at C2

3.4.2 Control Circuit Simulation

It is done in TINA Software online

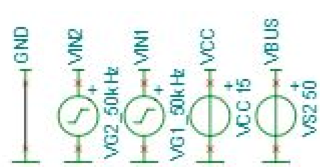


Figure 3.12 Control Signal for IC Simulation

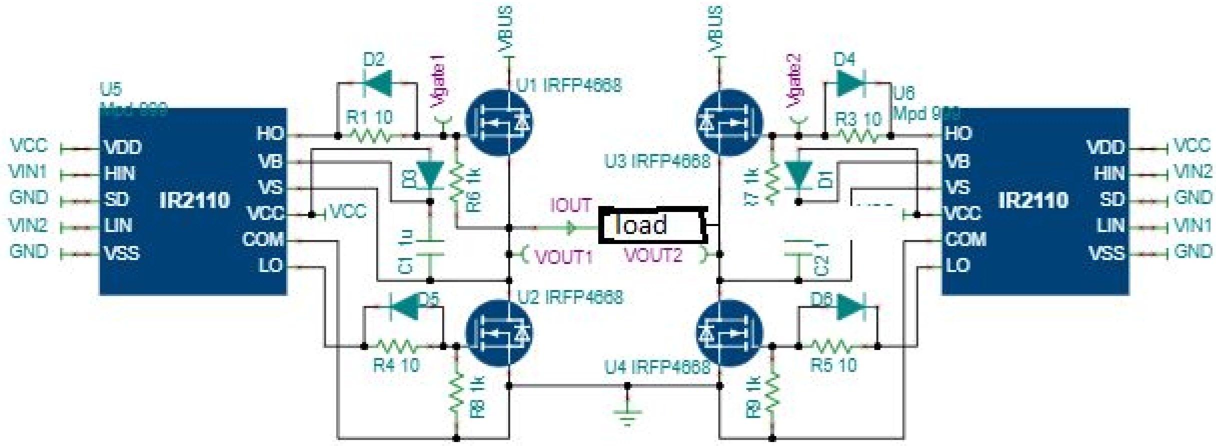


Figure 3.13 Mosfet Driver Circuit Simulation

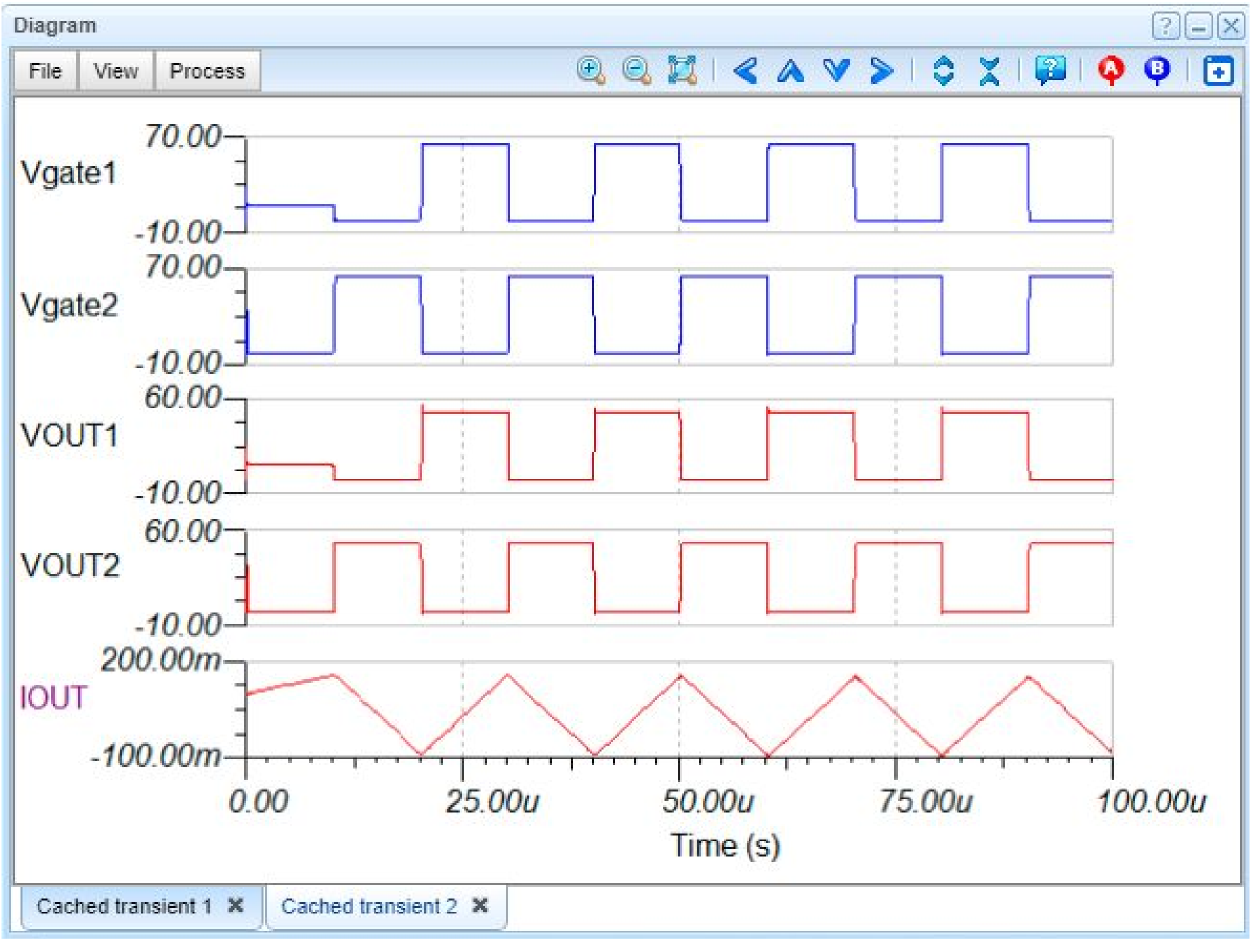


Figure 3.14 Mosfet Driver Circuit Simulation Signal

3.5 Simulation Efficiency

Simulation efficiency for different input power to output power delivered to load (pot) . Output power is controlled by a changed duty ratio of input control signals(V2,V3) of mosfet drivers. Duty ratio of both signals should be same and less than 50%.

Duty Ratio	Input power(watts)	Output power(watts)	% efficiencies
7/20	1127	1109	98.40
6/20	1050	1032	98.28
5/20	621	599	96.45
4/20	335	317	94.62
.5/20	280	271	96.78

Table 3.1 Simulation Efficiency

Power of any component can be determined by pressing alt key + left key of mouse press on that component , it will show power waveform then power value can be determined by pressing ctrl key and mouse left key on title in waveform viewer. This kind of efficiency is due to ZCS(minimum current in L4 at switching) and at switching time reducing in C2 voltage.

3.6 Hardware Testing

The prototype of the designed system is working satisfactorily in the real time environment. Although many milestones and achievements were reached in this project. The induction heater successfully heated a pot inductively as well as controlled the pot's temperature by varying the power applied to the load. Control circuit is also working properly. The final implemented induction heater performed very well and inductively heated a pot to a relatively high temperature. I'm unable to measure efficiency of hardware due to lack of time. Efficiency will be less than simulation efficiency . I saw that the ferrite coil was hand made and it was heated.

Chapter 4

SUMMARY AND FUTURE WORK

4.1 Summary

The aim of this project was to design, control and implementation of an Induction Heater using the Full-Bridge Parallel Resonant Topology. The prototype developed fulfils this brief in a safe, effective and stable manner. The design incorporates the following innovations:

- This design for low voltage using batteries that charge from the solar system.
- Used Parallel Resonant Tank.
- Small series inductance for soft switching.
- Current source followed by Capacitor for continued path to current source.
- Used mosfet for high frequency operation.
- It can be easily controlled.
- Massive simulation efficiency.
- Simulation efficiency approximate constant (~95) for range 100 watts to 1.1k watts.

4.2 Future Work

Although many milestones and achievements were reached in this project, this is not a perfect design. The design has the capacity to evolve into a very efficient and safe system and there is plenty of room for improvements and added features.

- Further research is needed in the design of power converter stage. The research on full-bridge parallel resonant topology is needed to explore the possibility of high power (more than 1kW and below 2 kW) systems at 48 VDC.
- Further research must be conducted in pan-coil modeling. This provides accurate models so that it can help in improving induction cooker design.
- Because of the high current and high frequency of the circuit, the PCB should be designed with enough trace width. The PCB should have enough clearance between the components to reduce the parasitic capacitance and inductance.
- Use high resonant frequencies. Higher operating frequencies could lead to more efficient, compact, and affordable solutions.

Induction heating is a very interesting subject and one that is very topical in a society that is increasingly focused on safety and reducing wastage of energy and time in peoples day to day lives. Induction heating marks a step improvement over other cooking methods in all these areas and is without doubt going to become the accepted method of domestic cooking in the future.

APPENDIX

Component	Part number	Quantity
Resistor 1k		4
Resistor 10		4
Diode	IN4007	6
Capacitor 1u 100V	Electrolyte	2
Mosfet	IRFP4668	4
Capacitor .33u	MKPH SH 630 AC 1200V DC 50KH	11
IC	IR2110	2
Resonant Coil		1
Inductor 200u,.8u		2
Power Supply		48VDC
Prototype PCB		3

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