Implementation of Soft Switching in Resonant Converters

A Thesis Submitted to the Department of Electrical & Electronic Engineering of BRAC University

By

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Declaration

This is to declare that this thesis titled "Implementation of Soft Switching in Resonant Converters" is submitted to the department of Electrical and Electronics Engineering of BRAC University for the limited fulfillment of the degree of Bachelor of Science in Electrical and Electronics Engineering. This is our unique work and was not submitted elsewhere for the award of any other degree or any other publications.

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Abstract

Switch is an electrical component that can turn on or off in an electrical circuit, interrupting the current or diverting it from one conductor to another. In power electronics sector hard switching and soft switching are mostly used switching scheme. Hard Switching is the commonly used method of switching. There are some obstacles in hard switching. When hard switching occurs it is very difficult to diminish the longing of voltage due to high frequency. Snubber circuits, RC circuits etc. can be used as the solution for this method of switching. Soft switching is the most efficient solution for this problem.. By utilizing up-to-date technology within MOSFETS's, it is probable to decrease the switching loss. Hard switching is totally opposite to the soft switching. While using of soft switching circuits, at first it is begun with hard switching circuit and then supplement sub circuit to (power component) make it to use a soft. Soft defines that to accomplish plane current /voltage conversions in the switching instant. In order to get smooth transitions, the major standard for all 'Soft Switching' techniques are to make switching in the time at zero current and zero voltage, in the main switching devices. Soft switching methods are used to get better efficiency and reduced switching pressure at high frequency. In the scheme of Zero-Voltage Switching (ZVS) before turning on the voltage across the device is zero. Instead, in Zero-Current Switching (ZCS), before turn off the current over device is zero just. By simulating circuits, it can be found that in soft switching, reduction of switching loss happens. This will give more appropriate result for using soft switching. In this thesis soft switching process is done by the application of resonant converter circuits. Using soft switching. In this thesis soft switching process is done by the application of resonant converter circuits.

Chapter 1

Background of Converter & Inverter Circuitsand Switching Techniques

1.1 Introduction

Converter and Inverter is presently utilized equipment in designing application and furthermore in day by day life. In Electrical designing Converter implies an electronic device or hardware that converts ac to a dc control at a looked-for output voltage and frequency. Then again, inverter implies an electronic device that converts dc to ac control at a looked-for output voltage and frequency. The frequency, input voltage and output voltage and, and overall power handling depend on the scheme of the exact expedient or circuit board. The inverters do not transport any power; the power is prearranged by the DC source. Using full bridge and half bridge networks, these converters and inverters works. So internal switching loss occurs when inverter and converter operate. There are a few techniques to reduce this power loss. Hard switching, soft switching and resonant converter are commonly used among them.

1.2 Classification of Inverter and Converter

There are different ways to classify Converters. [1][2]

1.2.1 According to the semiconductor device used

1.2.2 According to application

1.2.3 According to the input source

1.2.4 According to modulation technique

1.2.5 According to output wave shape

1.2.6 According to output phases

1.2.7 According to circuit configuration

1.2.1 According to Semiconductor Device Used:

i. **Line Frequency Converter**: The devices are switched off by the service linevoltage at one side of the converter and switched on, phase attached to the line voltage waveform by an activating circuit.

ii. **Forced Commutated Converter**: When the frequency is high compare with the line frequency the well-disciplined switches in the converters areturned on and off.

iii. **Resonant Converter**: At zero current or zero current, controllable switches turn of or turn off

1.2.2According to Application:

A power converter can be completely electronic or may be a mixture of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

i. Solar

ii. UPS

iii. DC power utilization

iv. Induction Heating

v. HVDC power transmission

vi. Electroshock weapon

1.2.3According to the Input Source:

In case of input source, converters can be current source or voltage source. In case for current source converter, current is fixed and voltage depends on load. On the other hand, for voltage source converter voltage is fixed and current depends on the load. Voltage source converters are used in this thesis.

1.2.4 According to Circuit Configuration:

Base on configuration converters can be of two types.

i. Full bridge type.

ii. Half bridge type.

For construction of the bridge, power semi-conductor devices are used.

1.2.5 According to Output Wave Shape:

From the point of output wave shape, converters can be classified as sine-wave, square wave and quasi square wave. In case of sensitive load, sine wave converter is a must. On the other hand, for low power application square wave converter is required. In quasi-square wave converter switching of the semiconductor devices are made in such a way as between high and low level transition and intermediate zero level exist.

1.2.6 According to the Phases:

According to phase, converter can be of two types.

i. Single phase type.

ii. Three phase type.

Depending upon the load phases single or there phase converters constructed.

1.2.7 According to the Modulation Technique:

As per the modulating wave utilized the converter can be developed as square wave converter or Pulse Width Modulated (PWM) converter. In PWM inverters the output voltage and frequency can be kept up by changing the modulating signal. PWM inverters are additionally called switch mode converter.

1.3 Basic Semiconductor Devices

Power Semiconductor Devices means devices which have high voltage and current ratings. The Devices can be categorized into many classes supported their on, off capability, variety of gate signal's variation , and steering Capability of current and withstanding ability of voltage. [3]

Some basic semiconductor devices are given below:

RCT, GTO, MOSFET, BJT, TRIAC, MCT, IGBT etc.

Semiconductor devices can be classified in many ways. They are described below:

1.3.1 Based on Turn ON and Turn OFF Capability:

i. **Uncontrollable Power Semiconductor Devices**:

   Diode: on and off state are not dependable to control signal. Rather they depend on the power source.

ii. **Partially Controllable Power Semiconductor Devices**: SCR, TRIAC, DIAC, turned on by gate signal but turned off by load.

iii. **Fully Controllable Power Semiconductor Devices**: Power BJT, MOSFET, IGBT, GTO. Can be turned ON and turned OFF both by gate signal.

1.3.2 Based On Current Conduction Capability:

i. Unidirectional Current Devices

   Example: - SCR, GTO, BJT, MOSFET, IGBT

ii. Bidirectional Current Devices

   Example:- TRIAC, RCT(Reverse Conducting Thyristor)

1.3.3 Based on Voltage Withstanding Ability:

i. Unipolar voltage withstanding devices

   Example: - BJT, MOSFET, IGBT

ii Bipolar voltage withstanding devices

   Example:- SCR, GTO

1.3.4 Power MOSFET (PMOS)

The Power MOSFET is a sort of MOSFET. The operational principle of power MOSFET is similar to the overall MOSFET. The power MOSFETS are very special to handle the high level of powers. It shows the high switch speed and by comparison with the traditional MOSFET, the power MOSFET can work better. The power MOSFETs is wide employed in the n-channel improvement mode, p-channel improvement mode, and within the nature of n-channel depletion mode. It is specially designed to handle high-level powers. Considering this facilities in the simulation part PMOS, is used as switch.[3]

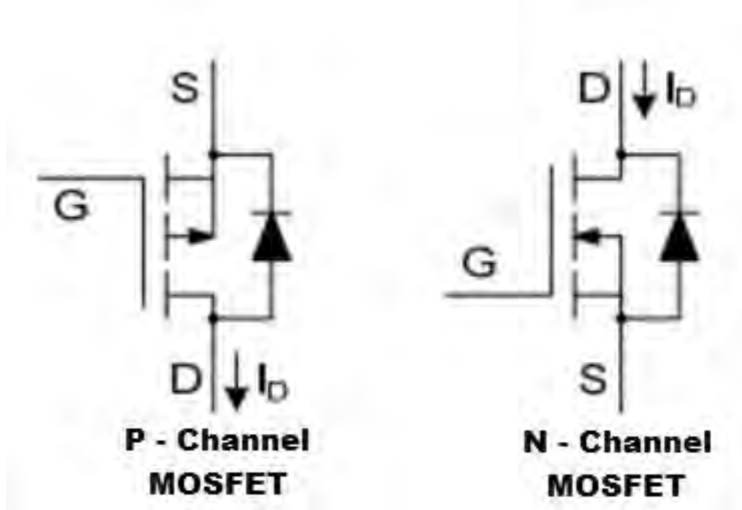

Figure 1.1: Power MOSFET

1.4 Switching Techniques

There are two types of switch in power electronics

1. Hard Switching.
2. Soft Switching.

1.4.1Hard Switching

Hard switching needs less number of capacitors and inductors in its circuit scheme. This advantages decrease the amount of cost, complexity, losses. The yield voltage does not depend on load. With the help of buck converter, a switching converter can be constructed. Utilizing PWM the buck converters voltage can be maintained. [4]

Advantages of Hard Switching:

A hard switch is a self-contained switch with on and off scheme. Aside from the theoretical case, it must be applied as a neutral switch in a replacement circuit with least isolated strength store. While applying an impartial switch, the current and voltage drips to nil at exchanging. The hard switch might be equipped with two manageable choices, which is exclusively customization turn-on and off. With a hard switch, high switching power distresses make most extreme device replacements reasonable. This takes into consideration the entire outline to be worked utilizing the PWM control technique.

Disadvantage of Hard Switching:

One of the greatest test associated with hard switching is absolutely associated with electro-magnetic noise created at the time of switching. When the switching time is short the frequency will be high. As long as the frequency increases noise problem will be more acute and is getting worse to control the noise

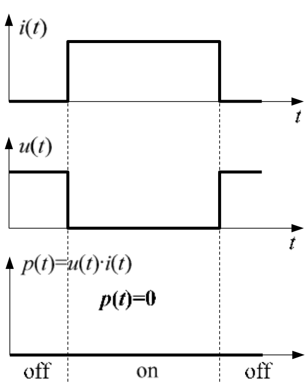

Figure 1.2(a):Power losses in ideal switches

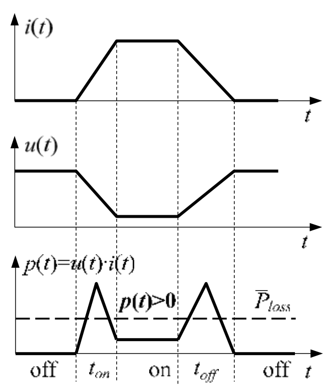

Figure 1.2(b):Power losses in real switches

So there are some problems in hard switching. In this switching, it is not possible to minimize the impulse of voltage due to high frequency when hard switching occurs. There are some solutions to this problems like using snubber circuits, RC circuits etc.

1.4.2 Soft Switching

Soft-switching is formed as a technology for preventing transistor-based change from creating switching loss or receiving electromagnetic interference. It is already being used in electromagnetic change of state utensils, switching power supplies, etc. With the development of high-speed transistors, this technology is being considered to be used in converters and inverters for massive power application. Soft switching is must for very high frequency operation.[5]

Operation principle and implementation of soft switching will be discussed later in chapter 2.

1.5 SnubberCircuit

Improving the performance and protection of semiconductor devices Snubber circuits' deal with a very good job.

i. Cut back current and voltage spikes.

ii. Custom the load line to stay inside the safe in operation space.

iii. Transmission of power dissipation between load and switch.

iv Cut back complete losses for switching.

iv. Diminish EMI by checking voltage and current.

Few types of snubbers are available. Among them two mostly used are resistor-capacitor (RC) damping network and the resistor-capacitor-diode (RCD) turn-off snubber. [6]

Both are given below:

1.5.1 RC Snubbers

RC snubber is the bonding of resistor and capacitor in series. This combination is used to conquer the huge rise in voltage across a thyristor which prevent the enormous turn on of the thyristor. It happens by limiting the rate of rise in voltage (dv/dt) across the thyristor. A proper designed RC snubber can be used with either AC or DC loads. This kinds of snubber basically used in inductive loads for example electric motor. The voltage across the capacitor don't change instantaneously, so the benefit is a few decreasing transient current will flow through it with a small amount of time (fraction of time). Determination of voltage rating may be difficult owing to nature of transient waveform and defined by the power rating of the snubber component and the function of RC snubbers can be made discretely and also built as a single component.[6]

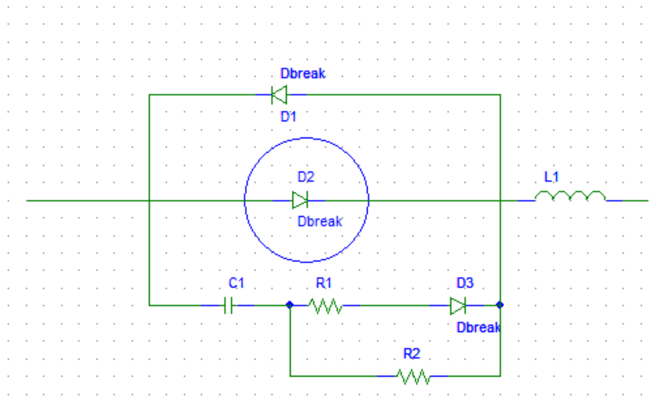

Figure 1.3(a): RC Snubber

1.5.2 Diode Snubbers

When DC current flowing, a simple rectifier diode acts as a snubber. The snubber diode is connected in parallel with an inductive load (relay coil or electric motor). The main reason of installing diode is it doesn't conduct under normal conditions. The inductor current flow instead through the diode when the external driving current is interrupted. The stored energy of inductor is gradually dissipated by the diode voltage drop. The main disadvantage of using rectifier diode as a snubber is, the diode allows current to continue flowing for some time. As a result the inductor will remain active for little bit longer than expected.[6]

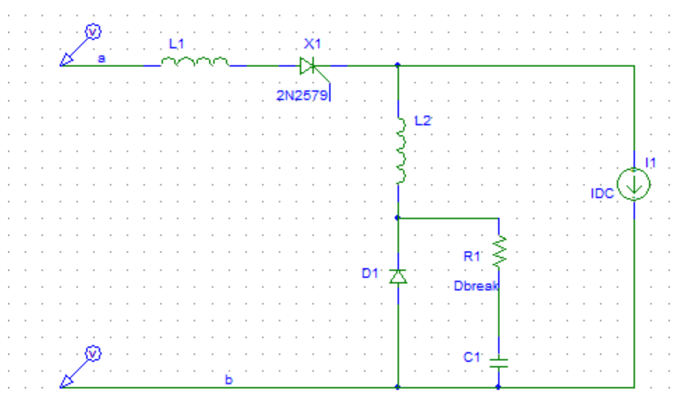

Figure 1.3(b): Diode Snubber Circuit

1.6 Turn On and Off Principal of Snubber Circuit

Turn-on snubber: A turn on snubber is basically utilized to reduce voltage across the BJT while the current are trying to constructing up. The shortening or reduction of voltage across the semiconductor device due to the voltage drop at the snubber inductance

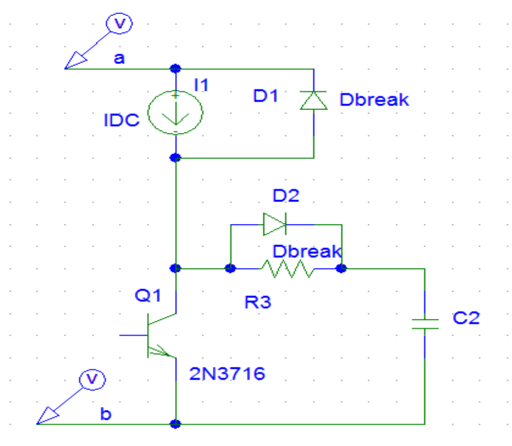

Figure 1.4(a): Turn On Principle Using BJT

Turn off:

Turn-off snubber is used to prevent voltage spikes and voltage oscillations across a PMOSFET (power MOSFET) during switching of the device .By controlling the gate current the large peak current and the switching speed of can be maintained. This can erase the necessity for a turn on snubber in most cases.[6]

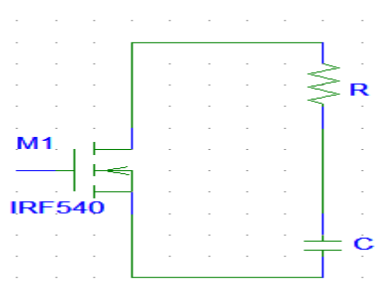

Figure 1.4(b): Turn Off Principle Using MOSFET

1.7 Motivation of Work

Various types of converter characteristics exist for power consumption such as: ac-dc, dc-ac, dc-dc. The circuit schemes for these conversions can be implemented through square wave PWM (pulse width modulation) & resonant converter. In the case of PWM and square wave converters, it is required to turn-on & turn-off the switches to control the entire load current. At the time of switch mode operation, there are high switching power losses and it can be increased linearly with corresponding to the switching frequency. . Also in PWM & square wave converter there is EMI (electromagnetic interference) problem due to large di/dt & dv/dt .Considering the following facts, resonant power conversion has been implemented. Resonant converter is characterized as a type of converter in which the topology constitutes of no less than as a resonant sub circuit. These sub circuit comprises of no less than one inductor and one capacitor. The above mentioned problems can be eliminated by using resonant converter. The power switches are turned-off under zero current and turned-on with vast increment of device current. The resonant converter can be worked either above or underneath resonance. Likewise the resonant converter produces power in sinusoidal shape. In this way, thinking about diminished part Measure and weight particularly at or over 100 kHz, good reliability and lessened EMI/RFI alongside the capacities of zero voltage and current switching (soft switching) resonant converter has turned out to be very well known among power supply fashioners.

1.8 Organization of Thesis

In chapter 1 different types of converters,few semiconductor devices, switching techniques andsnubber circuit will be emphasized. After that, in chapter 2 soft switching, and its application through resonant converter, zero current switching, zero voltage switching will be discussed. After that, in chapter 3 simulations of circuits consisting half bridge, full bridge schemes using resonant converters will be shown. Lastly, in chapter 4, soft switching in resonant converter will be implemented with the applications and with scope of future development.

Chapter 2

Soft switching Implementation

2.1 Soft Switching

Switching loss is mitigated when newest technology in the area of MOSFET is applied. Soft Switching is quite different than Hard Switching. In case of soft switching at first hard switching circuit is used with additional power components which enables it to become soft. It is all about reducing power loss when the switch is turned on or off at the moment of voltage or current transition. On the other hand Hard Switching implies that no extra circuits are added for smooth switching. Voltage and/current is made zero so that smooth switching transitions occur. The efficiency can be increased by using high frequency soft switching. In this case switching stress will also be reduced. Before turn on voltage is zero in zero voltage switching. On contrary, current is zero in zero current switching. [4]

Table 2.1 Difference between Hard and Soft Switching [4]

	Hard Switching	Soft Switching
Loss at Switching	Unalterable	Nearly Nil
Efficiency	Ordinary	Probably Upper
Condition on heat-sinking	Ordinary	Possibly Lower
Hardware Count	Ordinary	More
Density of Power	Ordinary	Possibly Upper
EMI problem	Unalterable	Little
dv/dt problem	Unalterable	Little
Modulation Structure	adoptable	Incomplete
Maturity	Developed	Developing
Cost	Standard	Advanced

2.2 Soft Switching in Resonant Converters:

Soft switching has the capability of moderating a percentage of the mechanisms of exchanging misfortune and potentially lessen the age of EMI Losses because of high voltage and high current remain in switch amid changes, e.g. because of diode reverse recovery Losses because of shorting capacitance's Semiconductor devices are turned on or off at the zero intersection of their voltage or current waveforms:

Zero-Current Switching When current is zero transistor switches off. The effect of current on the MOSFET causes loss and this loss can be removed by zero current switching. [1]

Zero-Voltage Switching: When voltage is zero transistor turns on.One of the used semiconductor devices for zero voltage scheme is diode. When diode is charged there are some voltage drops happen on diode. Which will increase the switching loss. By utilizing Zero-voltage switching loss across diode can be reduced. This zero voltage scheme is mostly usable for resonant converter which use MOSFET as a switch. [1]

2.3 Zero Current Switching:

The fig 2.1a is alike a buck converter.Here LCcircuit introduce oscillations. This is like an advantage to reduce losses across switches in a DC-DC converter. Current across L2 is same as load and it is considered as ripple free.

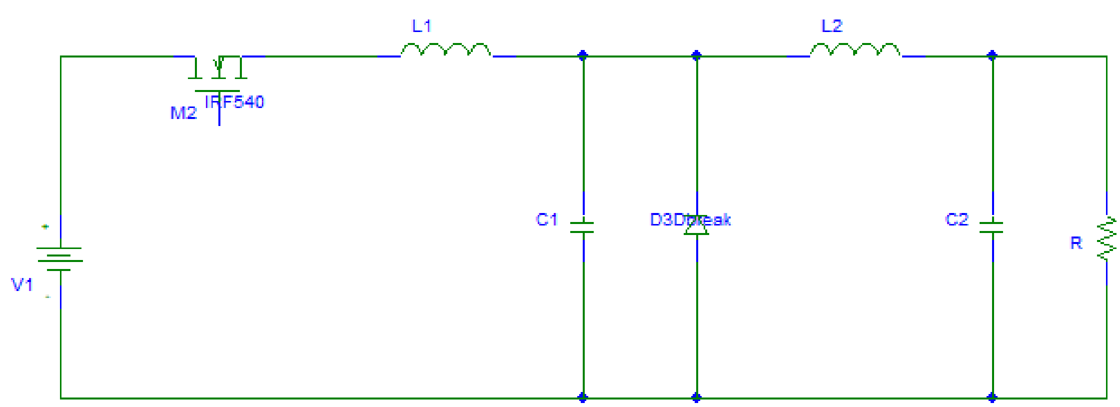

Figure 2.1(a): Resonant Converter with Zero Current Switching

Table 2.2 Parameters& Value Used During Simulation:

Parameters	Value
$V1$	12v
$L1$	10uH
$C1$	1u
$I1$	1A

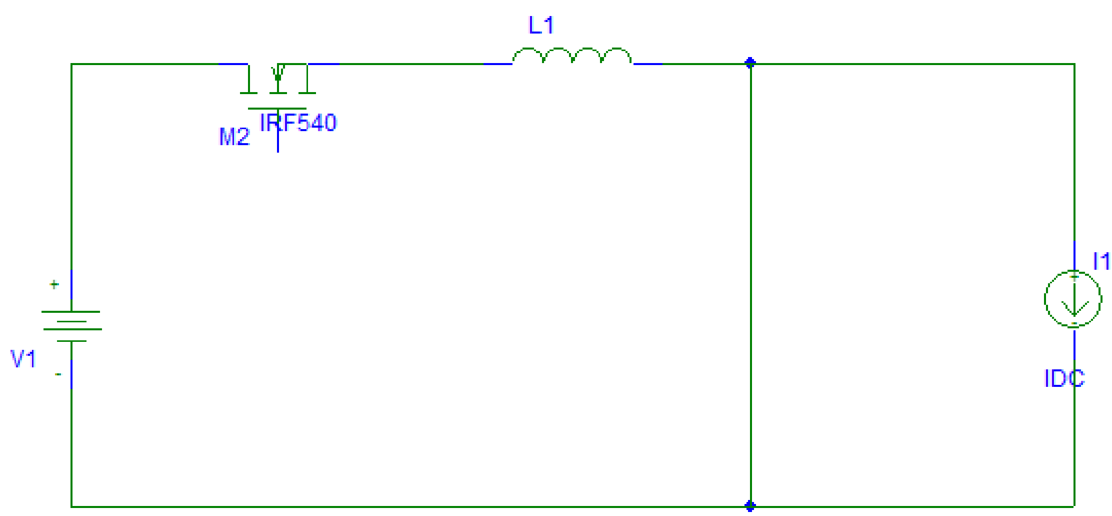

Figure 2.1(b): Switch Closed and Diode On (0 < t < t1)

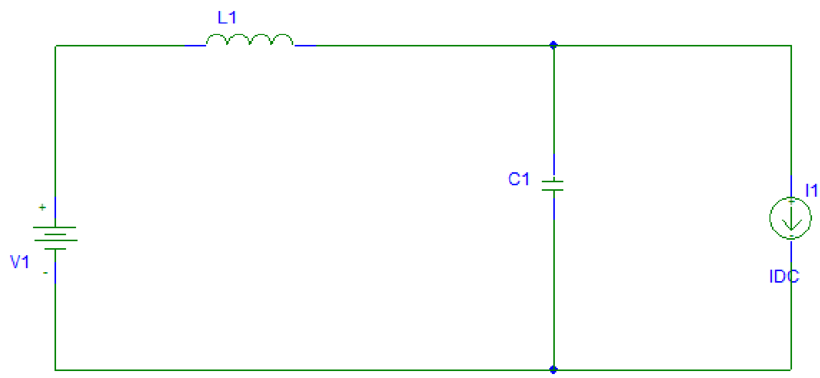

Figure 2.1(c): Switch Closed and Diode On (0 < t < t1)

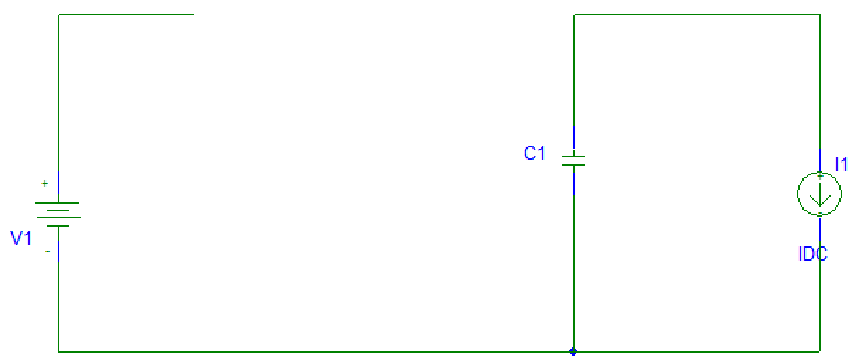

Figure 2.1(d): Switch Open and Diode Off

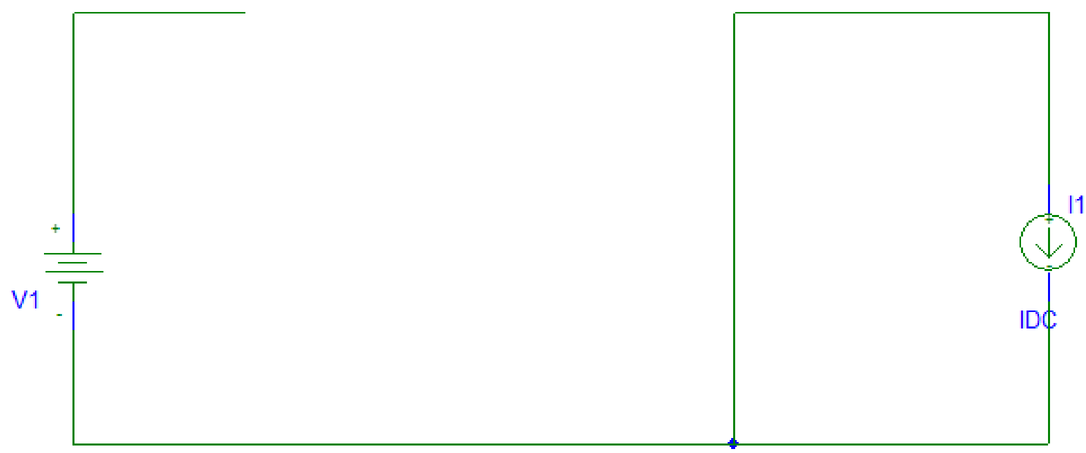

Figure 2.1(e): Switch Open and Diode On (t3<t<T))

At the time of turn off mood,the diode becomes forward-biased and transmit the output inductor current, and the corresponding voltage in C1 is zero. While turning on, the diode initially remains forward-biased to carry current across L2, and the voltage across L1is the same as the source voltage V1= 20V(Fig. 2.1(*b*)). The current in L1increases linearly, and the diode remains forward-biased while current across L1 is less than the current across L2. When current across L1 reaches the current across L2, the diode turns off, and the equivalent circuit is that of Fig.2.1(c). If current across l2is a constant, the load appears as a current source, and the under dampedLCcircuit oscillates. Consequently, reactance current reaches to zero and remains there, assuming the switch is unidirectional. The switch is turned off after the current reaches zero, resulting in zero-current switching and no switching power loss.

(f) Waveforms:

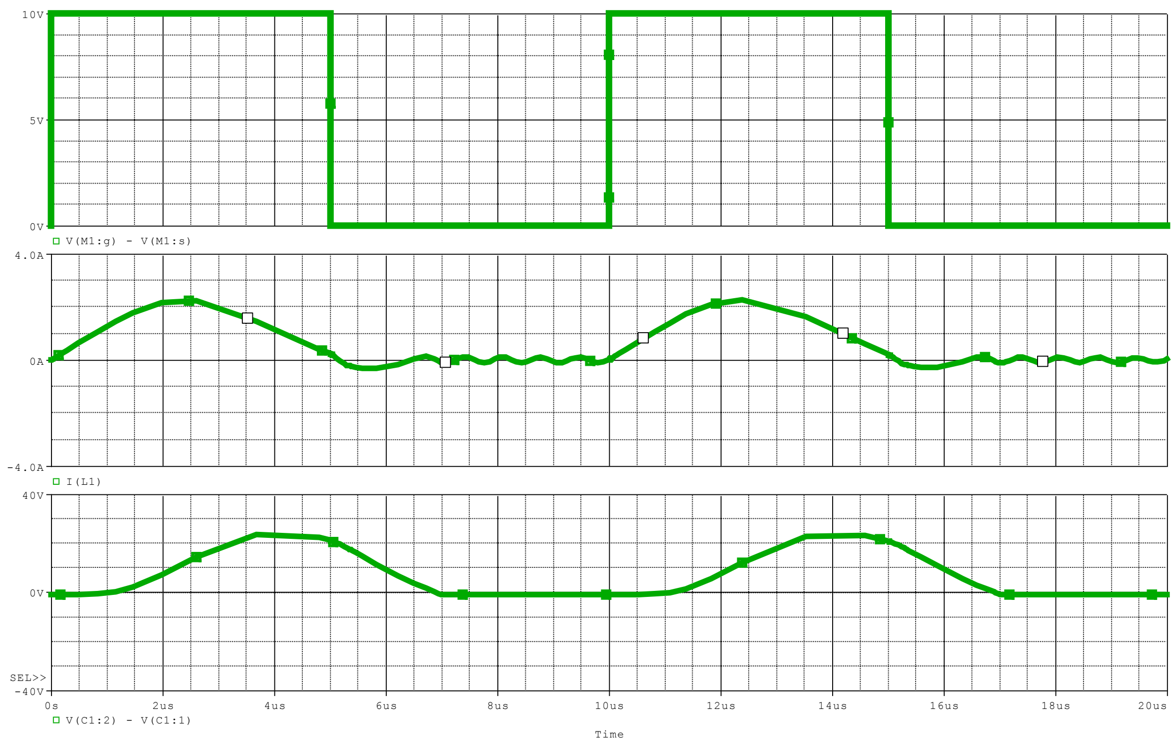

Figure 2.1(f): Waveform

After the current in the switch reaches zero, the positive capacitor voltage keeps the diode reverse-biased, so load current I1flows through Cr, with capacitor current = I1 (Fig. 2.1(d)). If I1is constant, the capacitor voltage decreases linearly. When the capacitor voltage reaches zero, the diode becomes forward-biased to carry I1

(Fig.2.1*e*). the circuit is then back at the starting point.

2.4 Zero-Voltage Switching

In Fig 2.2(a) Zero Voltage Switching technique is used in a resonant converter. A ripple free current is produced across L2 is undertaken in this analysis. Switch is closed at first and the currents in D1, D2 and the current in the switch and current across L2 are zero, and the voltage across the switch and C1 is zero.

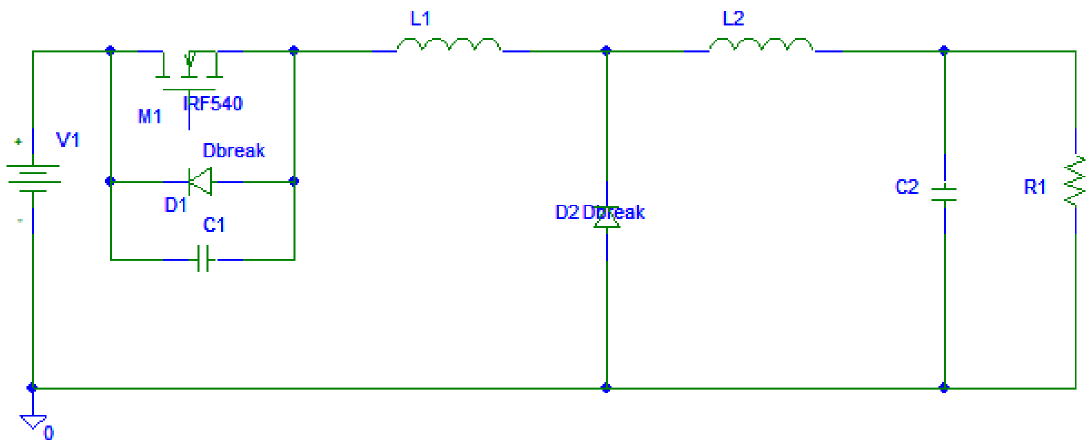

Figure 2.2(a): A Resonant Converter with Zero-Voltage Switching

Table 2.3 Parameters & Value Used During Simulation:

Parameter	Value
$V1$	20v
$C1$	.047u
$L1$	1uH
$I1$	5A

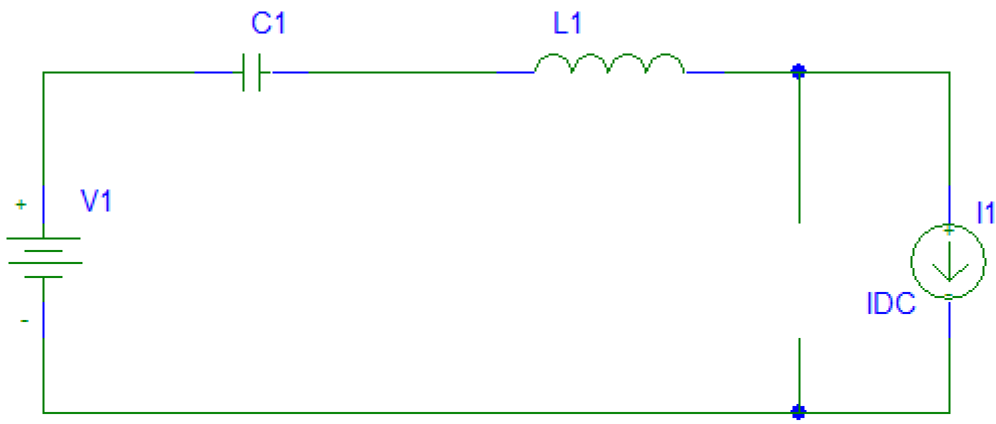

Figure 2.2(b): switch open and D1 off (0<t<t1)

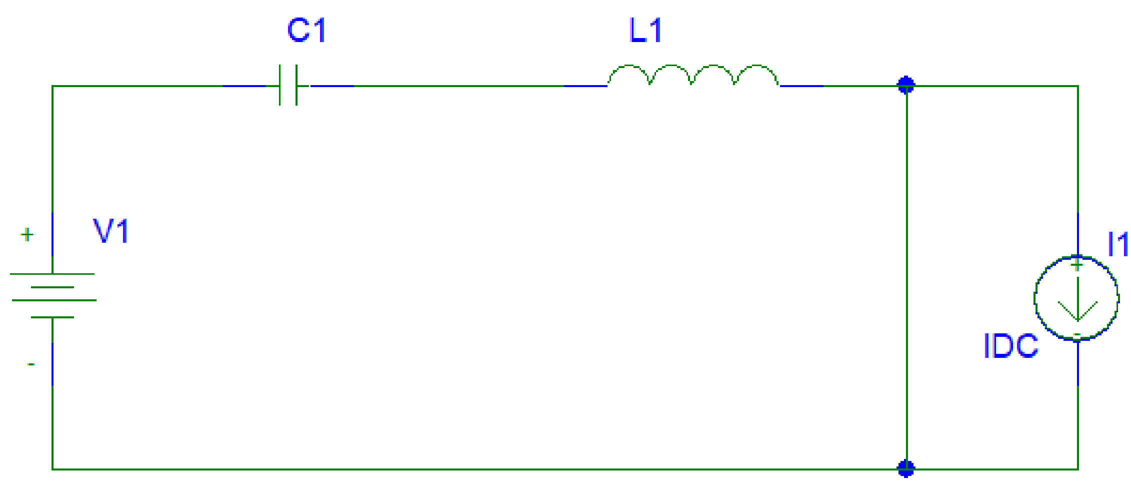

Figure 2.2(c): Switch Open and D2 on

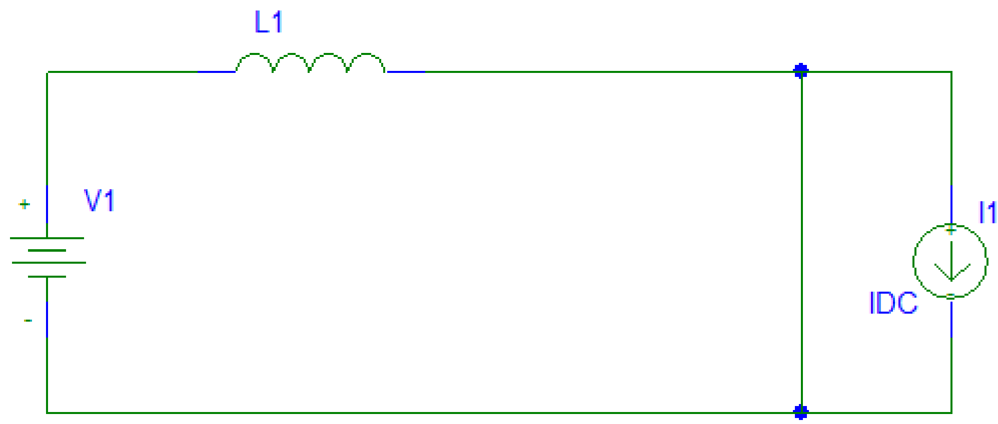

Figure 2.2(d): Switch Closed and D2 On

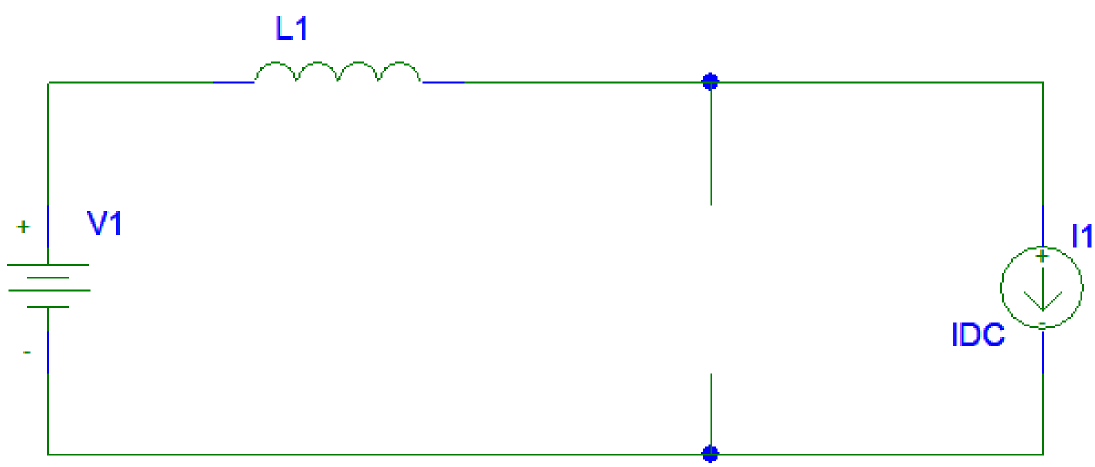

Figure 2.2(e): Switch Closed and D3 Off(t3<t<T)

The switch is opened (with zero voltage across it), and current across L1= current across L2flows through the capacitor C1, causing voltage across C1to risedirectly (Fig. 2.2*b*). When voltage across C1grasps the voltage source V1 and D2turn out to be forward-biased, resulting inmaking a series circuit with V1, C1, and L1as given in Fig. 2.2c. In this moment, oscillation of the voltage across L1as well as the voltage across C1in this underdamped series circuit begins. When voltage across C1 yields to zero, diode D1turns on to transfer current across L1, which is negative (Fig. 2.2*d*). The voltage across L1 *is* V1, causing current across L1to increase linearly. For zero voltage, the switch is closed just after D1 is on. When current across L1becomes positive, D1 is off and current across L1is passed by the switch. When current across L1grasps the current across L2, D2 is off, and circuit is back to its old state.

(f) Waveforms:

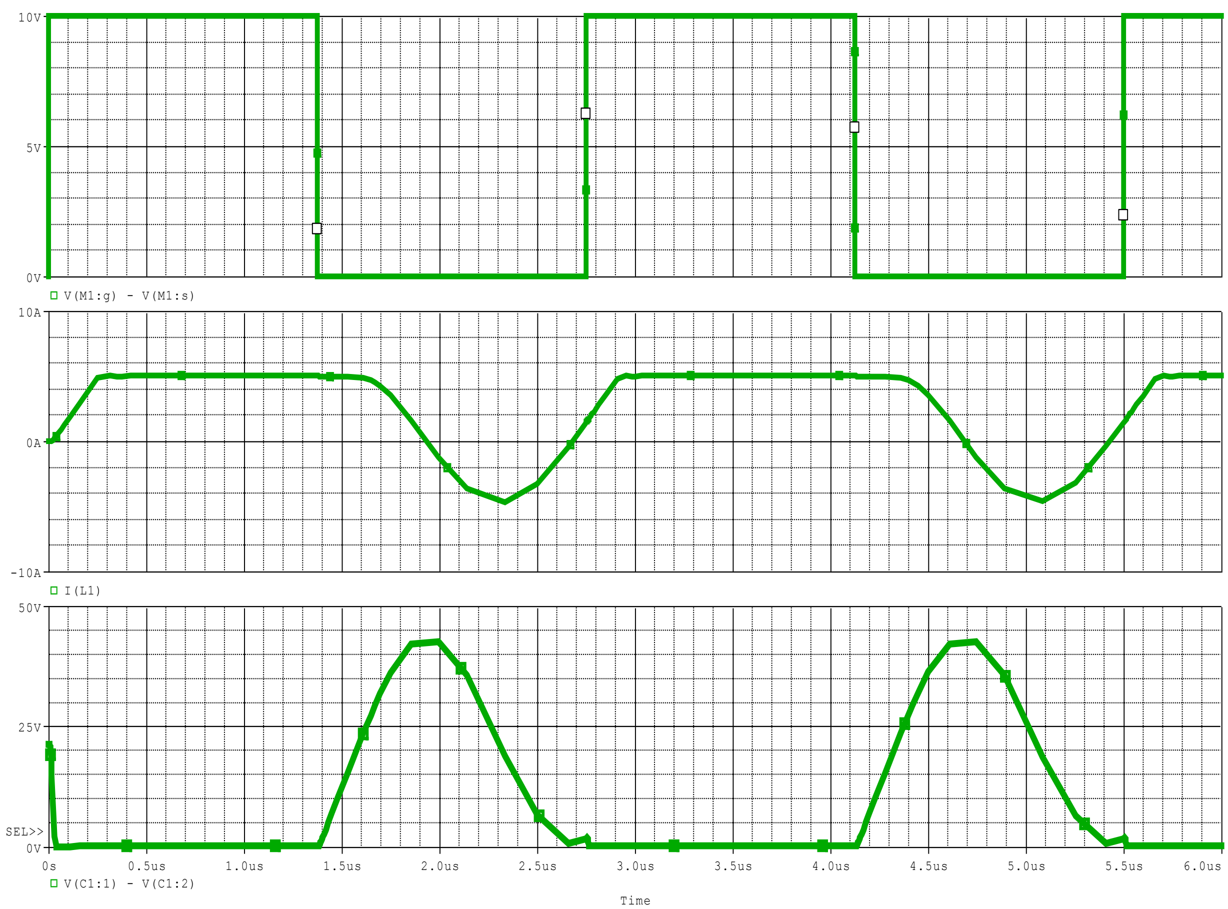

Figure 2.2(f): Waveform

Chapter 3

Proposed Circuits for Practical Implementation

In this chapter Series Resonant DC-AC converter, Series Resonant DC-DC converter, Parallel Resonant DC-DC converter, Series-Parallel Resonant DC-DC converter circuits are emphasized throughOrcad Schematics PSpice simulation. Here output voltage,fft (Fast Fourier Transform)

3.1 Series Resonant DC-AC Converter:

The Simulation of Series Resonant DC-AC converter is done for Resonant Frequency of 10 KHz.

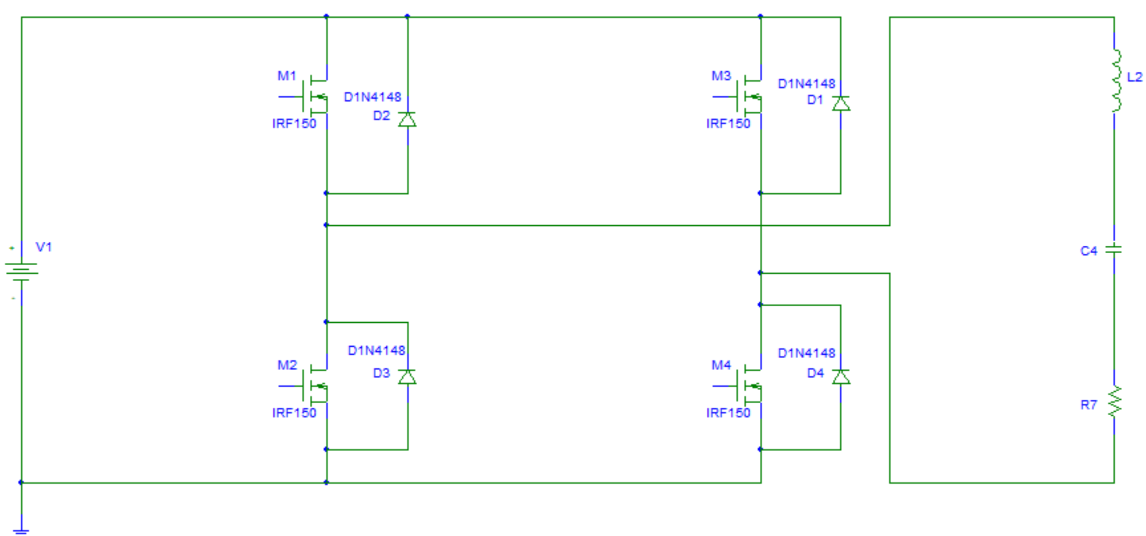

Figure 3.1:Series Resonant Dc-Ac converter.

Table 3.1 Parameters & Value Used During Simulation:

Parameter	Value
Vin	$200v$
$Vout$	$200v$
Fr	$10k$
L_2	$12.6mH$
C	$0.02uF$

Calculation:

$$\omega_r = \frac{1}{\sqrt{(LC)}}$$

$$f_r = \frac{1}{2\pi\sqrt{(LC)}} \dots \dots \dots (1)$$

Where fr is the resonance frequency, 'L' is the Inductive Load and 'C' is the Capacitive Load.

For this Series Resonant DC-AC converter using 10KHz as Resonant frequency and by using equation (1) we get,

$$f_r = \frac{1}{2\pi\sqrt{(12.6 * 10^{-3} * 0.02 * 10^{-6})}}$$

$$fr = 10.02kH_z$$

Where,$= 12.6\ mH \& C = 0.02\ uF$

Graph:

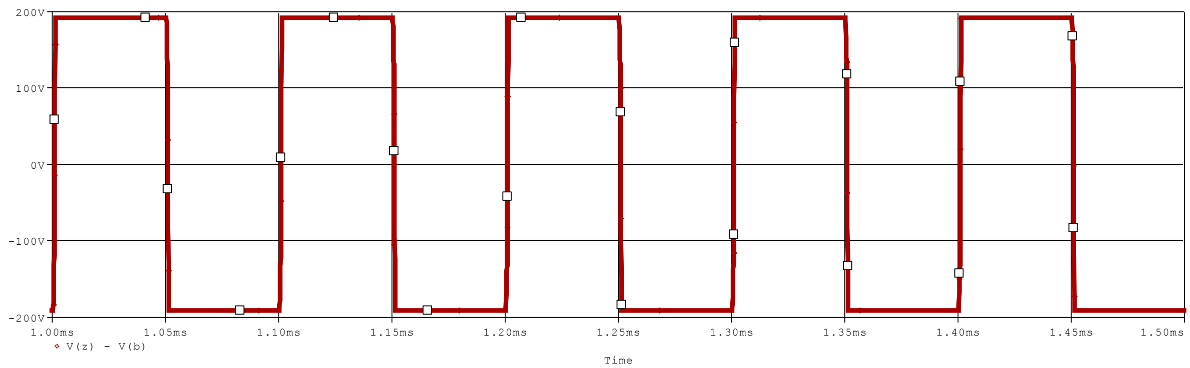

Figure 3.2(a): Series Resonant Dc-Ac Converter (input).

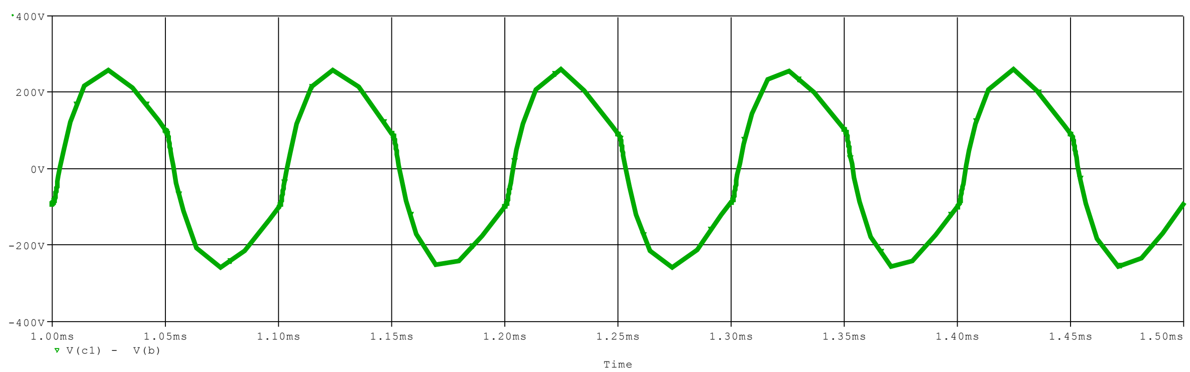

Figure 3.2(b): Series Resonant Dc-Ac Converter (output).

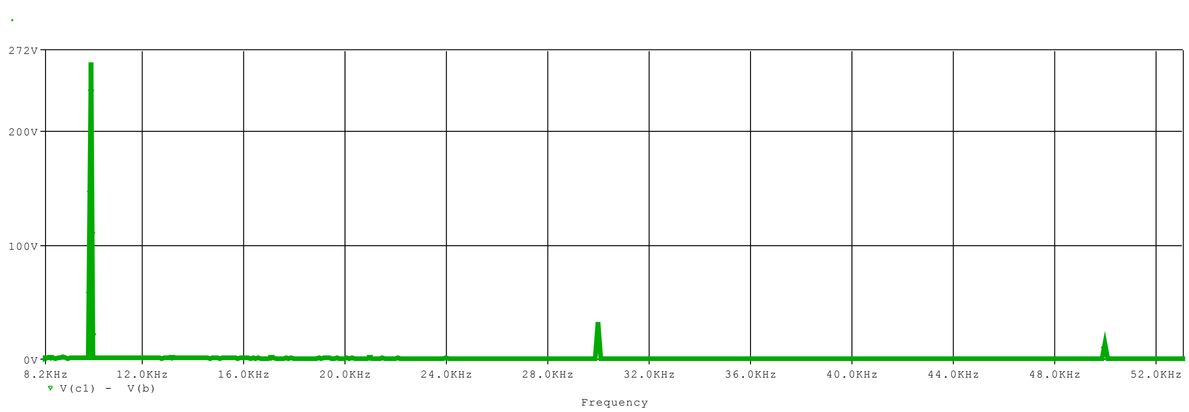

Figure 3.2(c): F.F.T of Wave Shape Across the Output.

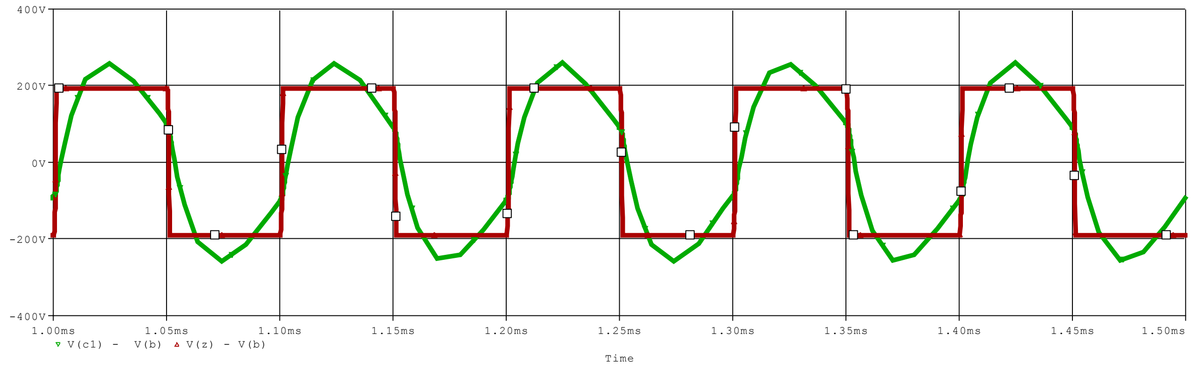

Figure 3.2(d): Series Resonant Dc-Ac Converter (input & output)

3.2 Series Resonant DC-DC Converter:

The Simulation of Series Resonant DC-DC converter is done for Resonant Frequency of 10 KHz.

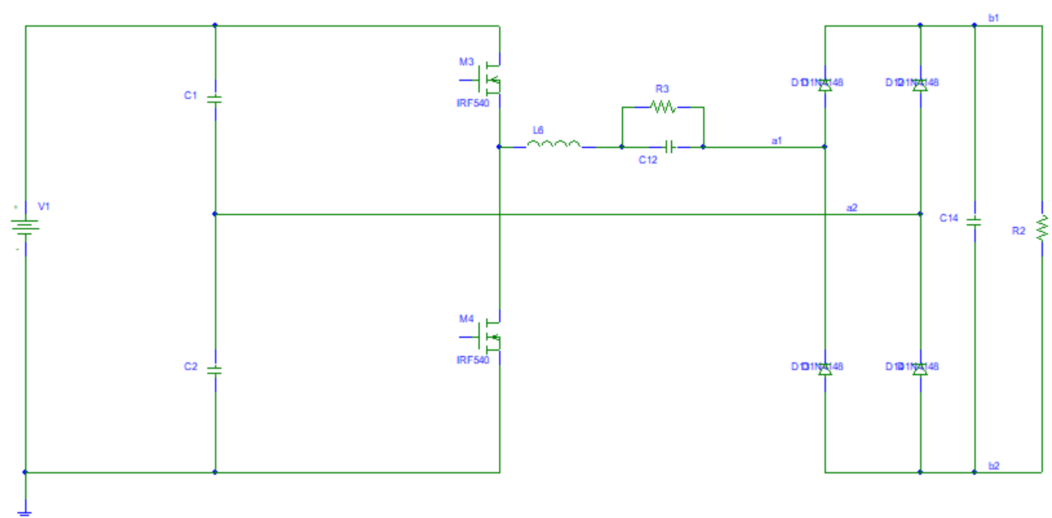

Figure 3.3: Series Resonant Dc-Dc Converter.

Table 3.2 Parameters & Value Used During Simulation:

Parameter	Value
Vin	$200v$
$Vout$	$200v$
Fr	$10k$
L_6	$0.25mH$
C_1, C_2, C_{12}, C_{14}	$100uF, 100uF, 1uF, 1nF$

Calculation:

$$\omega_r = \frac{1}{\sqrt{(LC)}}$$

$$f_r = \frac{1}{2\pi\sqrt{(LC)}} \dots \dots \dots (1)$$

Where 'fr' is the resonance frequency, 'L' is the Inductive Load and 'C' is the Capacitive Load.

For this Series Resonant DC-DC converter using 10KHz as Resonant frequency and by using equation (1) we get,

$$f_r = \frac{1}{2\pi\sqrt{(.25 * 10^{-3} * 1 * 10^{-6})}}$$

$$fr = 10.065kH_z$$

Where, $L = 0.25\ mH$

$C = 1\ uF$

Graph:

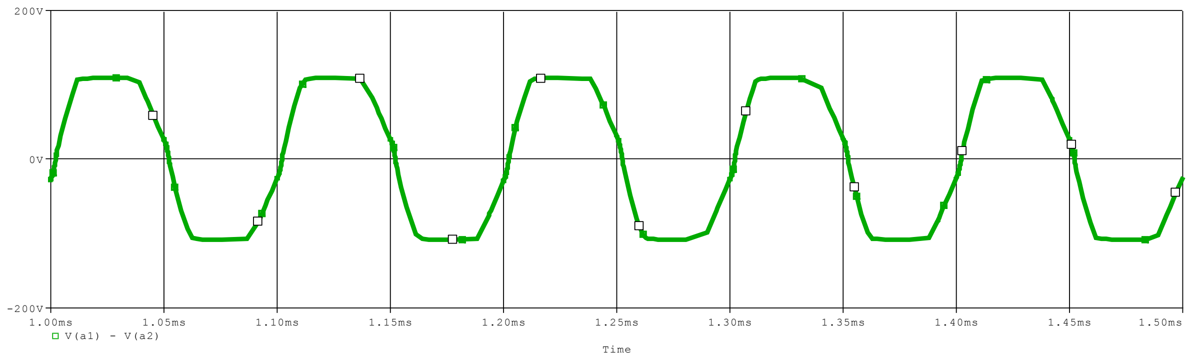

Figure 3.4(a): Wave Shape Across Inductor And Capacitor.

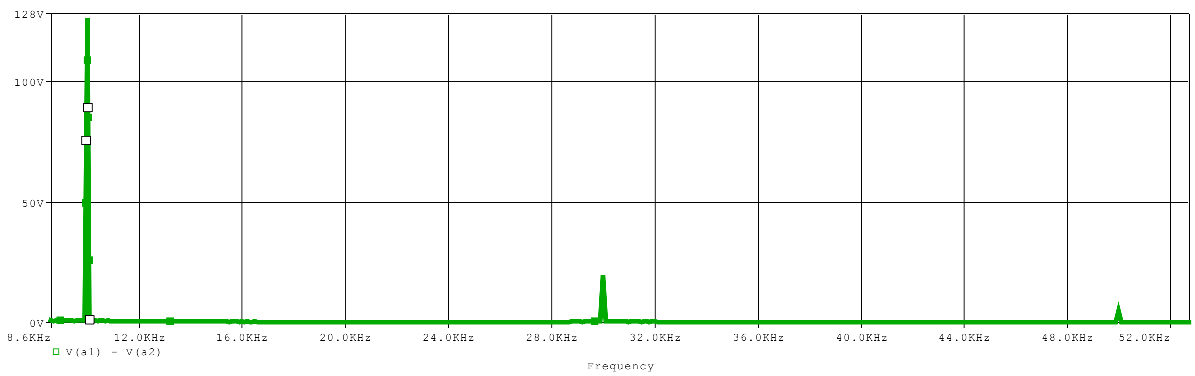

Figure 3.4(b): F.F.T of Wave Shape Across Inductor And Capacitor.

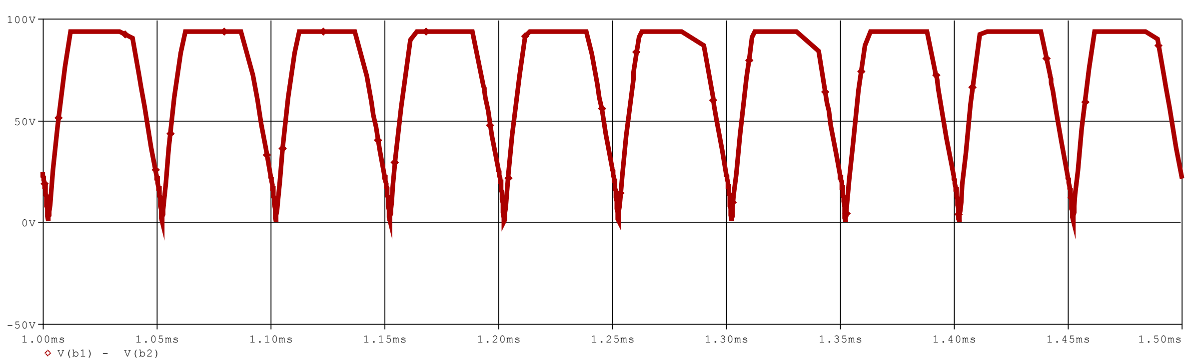

Figure 3.4(c): Output Wave Shape of Series Resonant Dc-Dc Converter

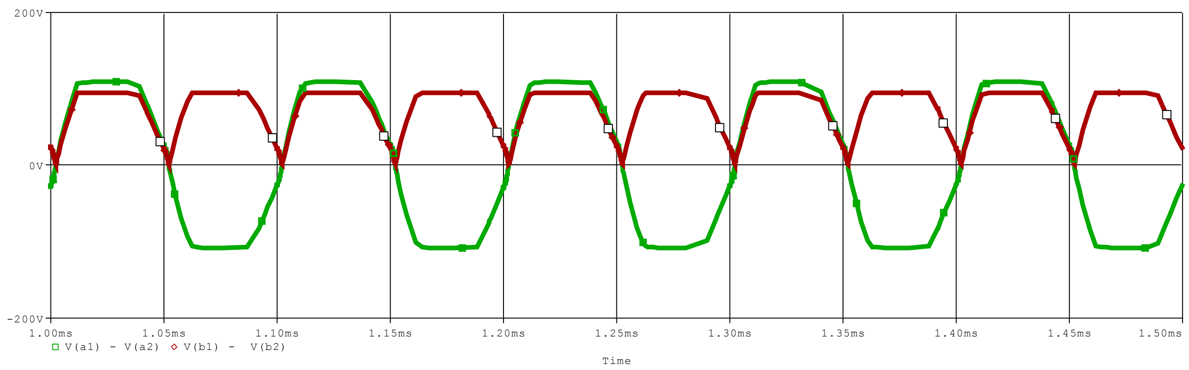

Figure 3.4(d): Combined Wave Shape of Inductor-Capacitor & Output.

3.3 Parallel Resonant DC-DC Converter:

The Simulation of Parallel Resonant DC-DC converter is done for Resonant Frequency of 10 KHz.

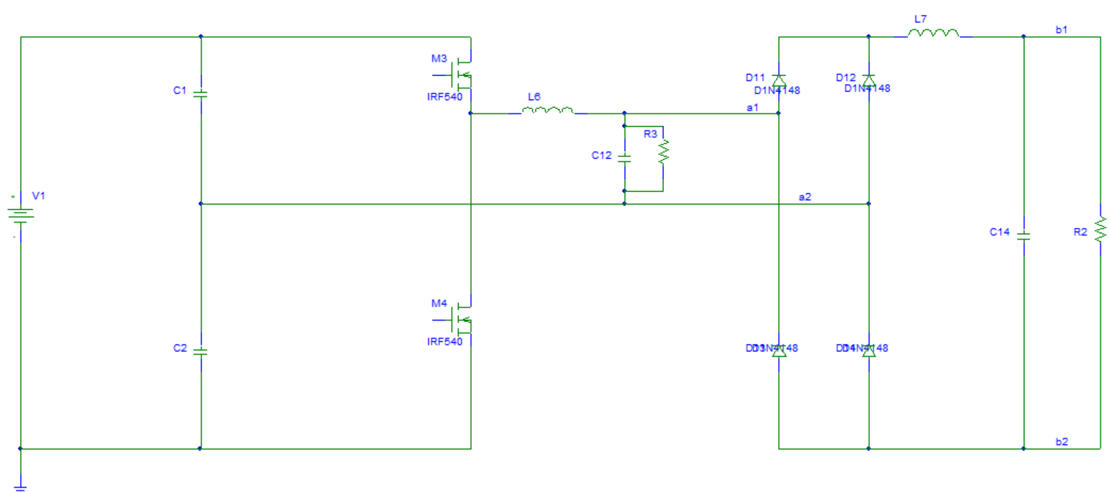

Figure 3.5: Parallel Resonant Dc-Dc Converter.

Table 3.4 Parameters & Value Used During Simulation:

Parameter	Value
Vin	$200v$
$Vout$	$200v$
Fr	$10k$
L_6, L_7	$0.25mH, 10uH$
C_1, C_2, C_{12}, C_{14}	$100uF, 100uF, 1uF, 1nF$

Calculation:

$$\omega_r = \frac{1}{\sqrt{(LC)}}$$

$$f_r = \frac{1}{2\pi\sqrt{(LC)}} \dots \dots \dots (1)$$

Where 'fr' is the resonance frequency, 'L' is the Inductive Load and 'C' is the Capacitive Load.

For this Parallel Resonant DC-DC converter using 10Hz as Resonant frequency and by using equation (1) we get,

$$f_r = \frac{1}{2\pi\sqrt{(.25 * 10^{-3} * 1 * 10^{-6})}}$$

$$fr = 10.065kH_z$$

Where, $L = 0.25\ mH$ &$C = 1\ uF$

Graph:

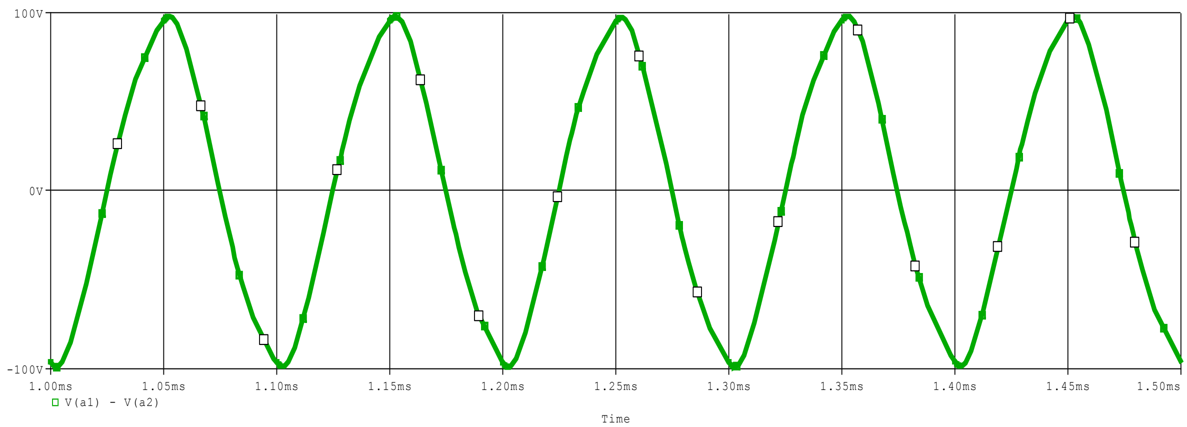

Figure 3.6(a): Wave Shape Across Inductor And Capacitor.

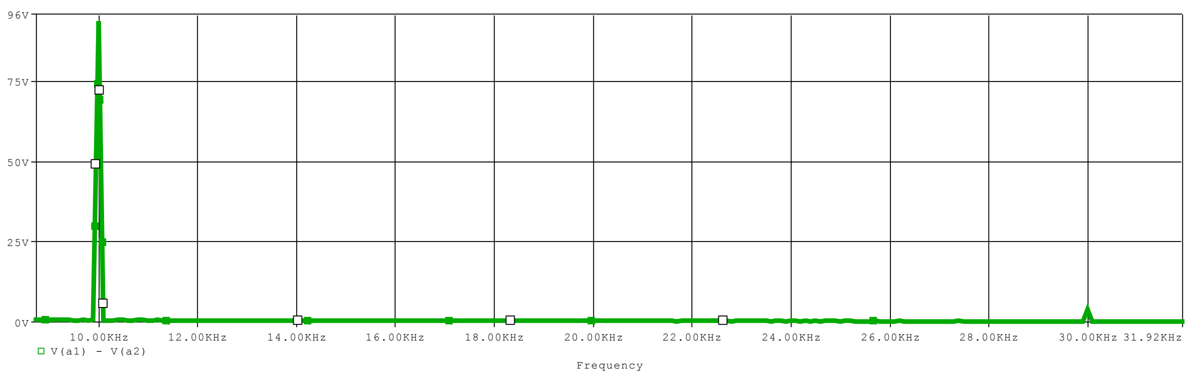

Figure 3.6(b): F.F.T of Wave Shape Across Inductor And Capacitor.

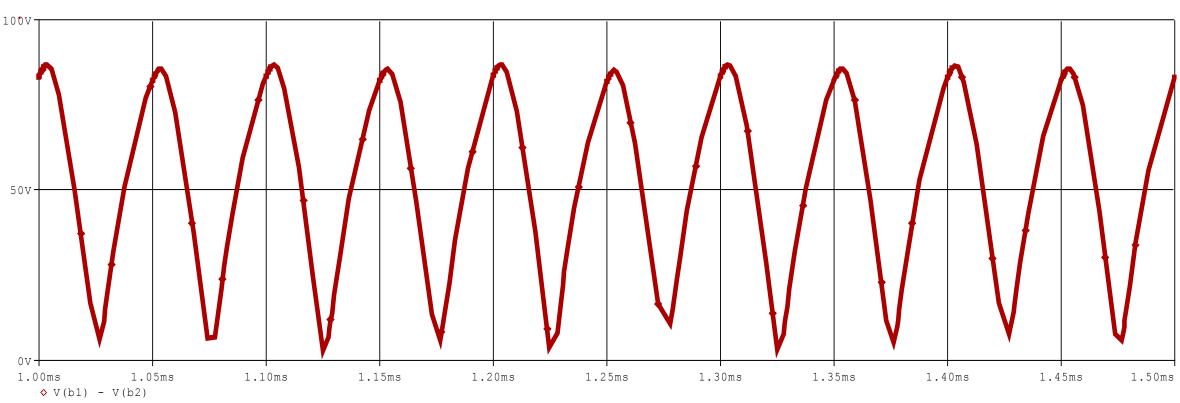

Figure 3.6(c): Output Wave Shape of Parallel Resonant Dc-Dc Converter.

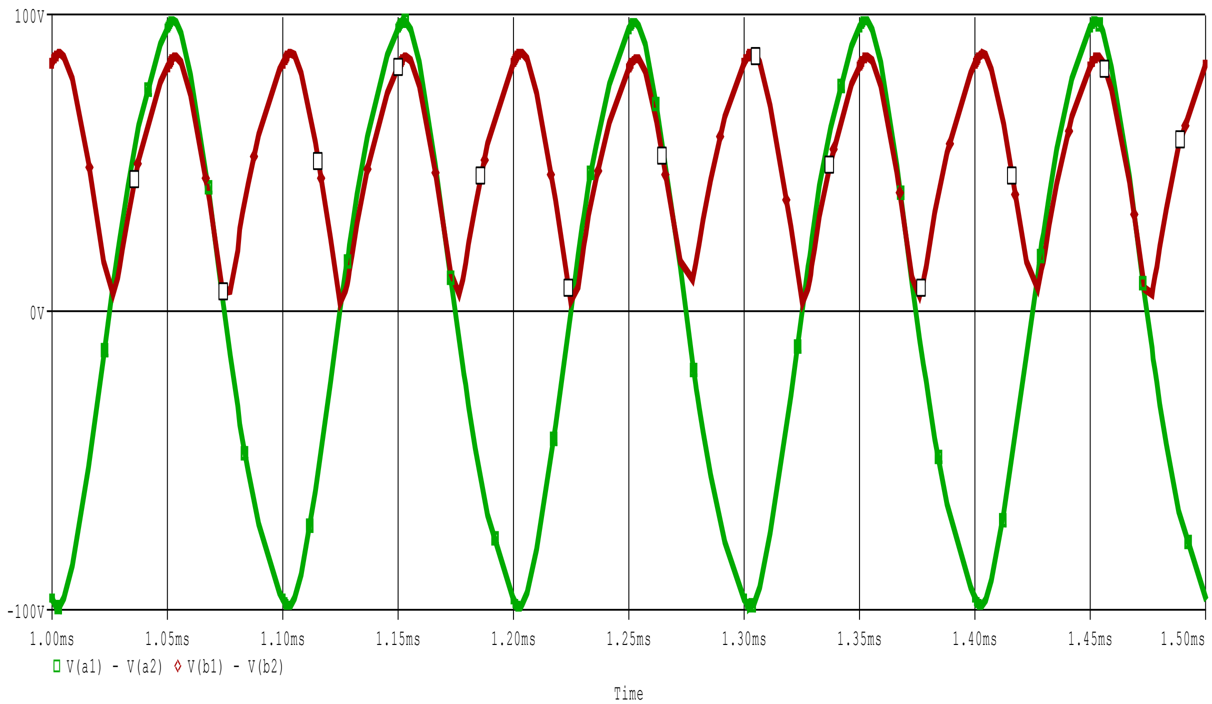

Figure 3.6(d): Combined Wave Shape of Inductor-Capacitor & Output.

3.4 Series-Parallel Resonant DC-DC Converter:

The Simulation of Series- Parallel Resonant DC-DC converter is done for Resonant Frequency of 10 KHz.

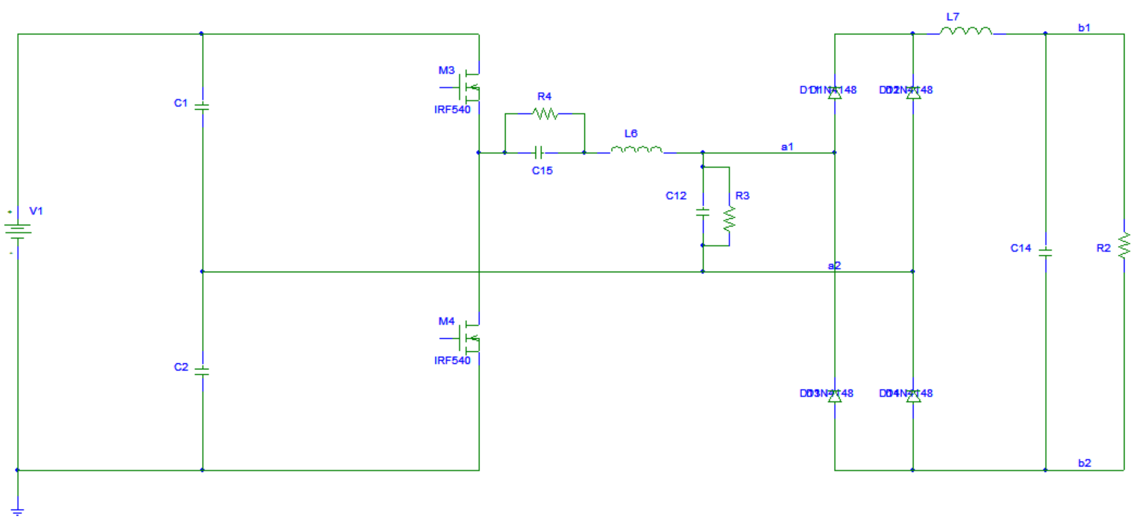

Figure 3.7: Series-Parallel Resonant Dc-Dc Converter.

Table 3.5 Parameters & Value Used During Simulation:

Parameter	Value
Vin	$200v$
$Vout$	$200v$
Fr	$10k$
L_6, L_7	$0.25mH, 10uH$
$C_1, C_2, C_{15}, C_{12}, C_{14}$	$100uF, 100uF, 1uF, 1uF, 1nF$

Calculation:

$$\omega_r = \frac{1}{\sqrt{(LC)}}$$

$$f_{r=\frac{1}{2\pi\sqrt{(LC)}}} \dots \dots \dots (1)$$

Where 'fr' is the resonance frequency, 'L' is the Inductive Load and 'C' is the Capacitive Load.

For this Series- Parallel Resonant DC-DC converter using 10 KHz as resonant frequency and by using equation (1) we get,

$$f_r = \frac{1}{2\pi\sqrt{\{.25 * 10^{-3} * (1 * 10^{-6} + 1 * 10^{-6})\}}}$$

$$fr \ = 10.065kH_z$$

Where, $L = 0.25\ mH \& C_{12} = 1\ uF, C_{15} = 1uF$

Graph:

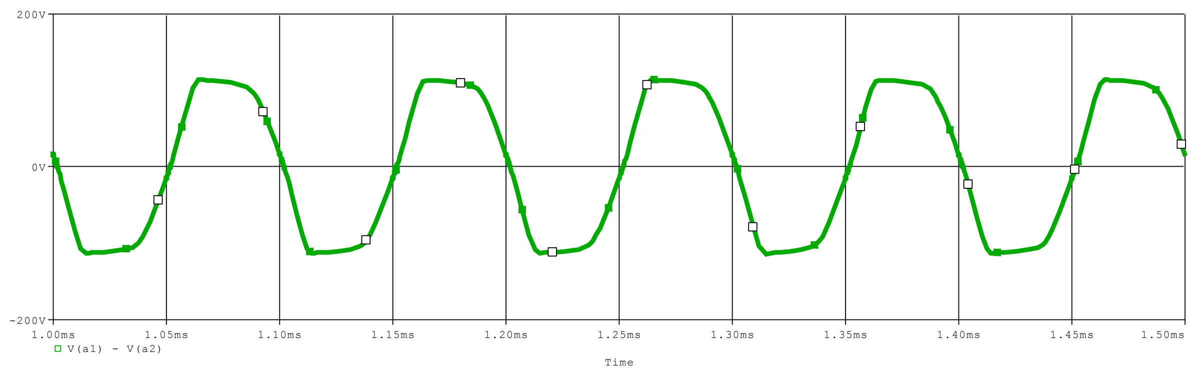

Figure 3.8(a):Wave Shape across inductor and capacitor.

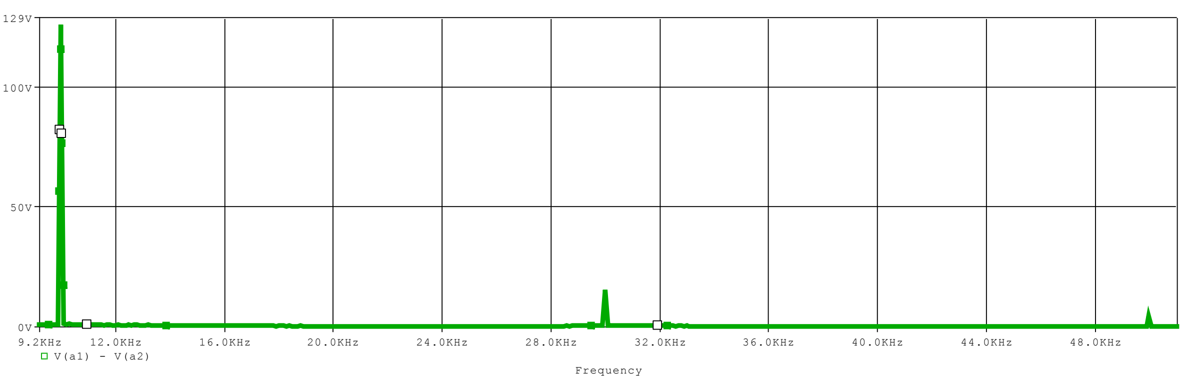

Figure 3.8(b): F.F.T of wave shape across inductor and capacitor.

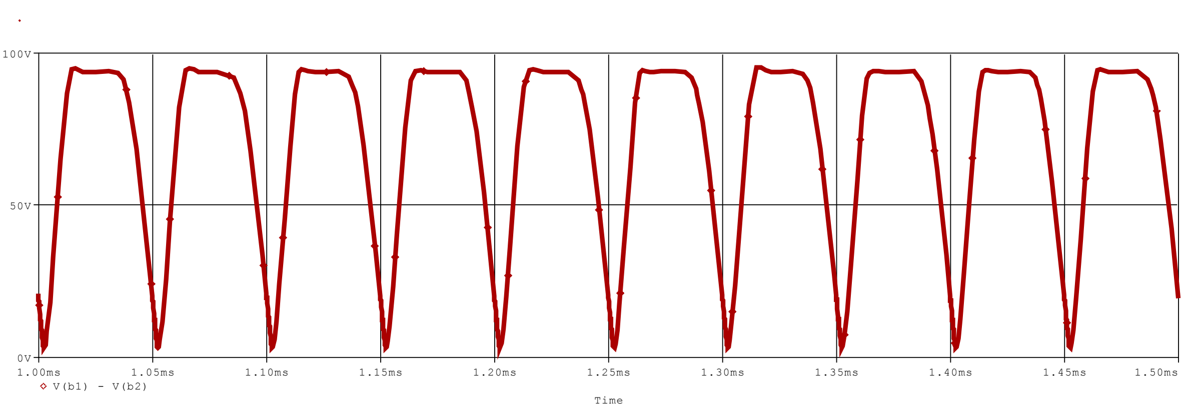

Figure 3.8(c): Output wave shape of Series-Parallel Resonant Dc-Dc Converter.

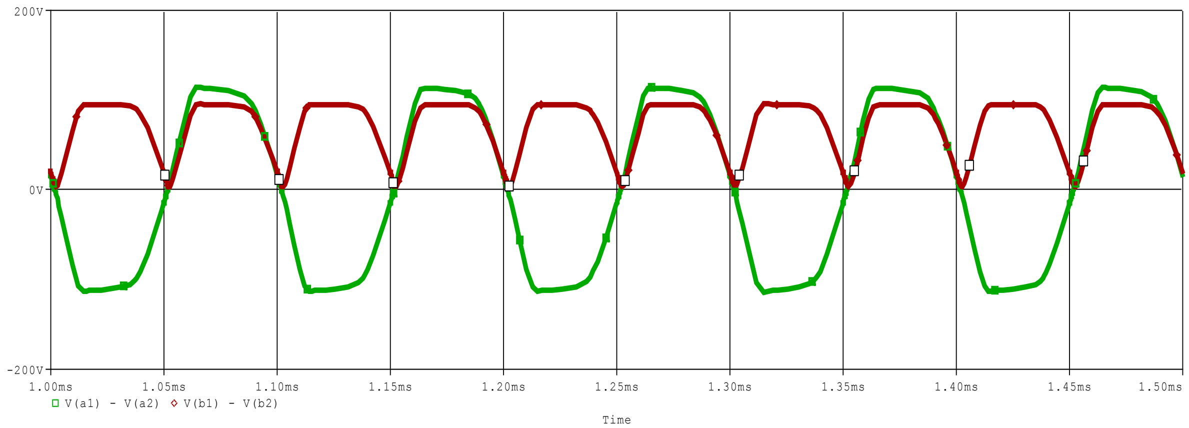

Figure 3.8(d): Combined Wave Shape of Inductor-capacitor & output.

Chapter 4

Future Application and Conclusion

4.1 Application of Resonant Converter

As from the motivation part it was already been emphasized that in the case for PWM & square wave converters there are high switching loss during on and off condition and EMI emissions become significant and must be reduced. Traditional high frequency which generates an AC waveform has used power transistors to make hard switching. During the state of both turn-on and turn-off state of both real switching break (less than 50 microseconds) there is a fixed period when the device starts to conduct, current starts flow and voltage begins to fall. All the more as of late, new power change topologies have been produced which drastically decrease the power disseminated by the principle power transistors during the switching interval. In constant frequency resonant switching system, the energy which is isolated by the dynamic device is reduced to about zero. This methodology, basically called as Zero Voltage Switching (ZVS), ZCS (Zero Current Switching)or soft Switching. These converters use the LC resonance circuit. Resonant circuits are having types of at series and parallel. Few implementation of resonant converter are given below:

In Fixed Frequency Operation: Cinched mode arrangement resonant converters are utilized as a part of outline of attractive segments for resonant sub circuit and filtering since it has an advantage of fixed frequency operation. Above resonant frequency this converter indicates better effectiveness.

Laser Power Supply: Since resonant converter provides higher efficiency and also that laser power supply requires higher charging efficiency option, so series resonant converter is used in laser power supply.

Accessories: Flat TV panels & ATX PCs require efficiency in power density in switch mode power supply so LLC resonant converter is used.

Generators & Radio Frequency: Ultrasonic power generators use resonant converter & radiofrequency generation for electro surgery uses series LCL resonant converter.

Ozone Generator Model: To reduce the size, weight & loss recently basic RLC resonant converter circuit is used to produce alternating current at high frequency.

Fluorescent Lighting: Current resonant converter circuit is utilized as a part of fluorescent light and electronic balance of gas release light. On the off chance that bright light is begun by DC supply mercury gathers toward one side of the tube so a converter circuit is utilized. The circuit begins working above resonance frequency and bit by bit builds voltage touches off the light.

Induction Heating: Most utilized utilization of all. In nowadays when fuel is the other name of scarcity induction heating is one of the most noticeable arrangements. Induction heating is an outstanding system to deliver high temperature for applications. Countless have been produced around there, for example, voltage and current source converter. Late advancements in exchanging plans and control strategies have influenced the voltage-to source resonant converters generally utilized as a part of a few applications that require output power control. At high output frequency (20 kHz-100 kHz) resonant converter produces sinusoidal waveform, decreases losses along switches and stress on power components exchanging misfortune and weight on influence segments. Along these lines it is utilized as an induction heating.[7][8]

4.2 Future Development

Passive elements are usually the limitation on volume, and value of the system. For LLC resonant converter, with integrated magnetic technology, all magnetic elements may be integrated into single magnetic structure. With coplanar magnetic, the resonant capacitors might even be integrated into magnetic structure. This way, all the passive elements except output cap may be integrated. This integration can offer several benefits: high density, less interconnection, higher electrical performance. The foremost vital advantage of LLC resonant convertor for side DC/DC application is that it may be optimized for top input voltage. In fact, apart from this, there are many alternative advantages. First, the voltage stress on the secondary rectifier is reduced to 2 times output voltage solely. Second, switch loss of LLC resonant convertor may be reduced. Third, while not output filter electrical device, the transient of LLC resonant convertor may be in any time. With of these benefits, LLC resonant converter could be a doable candidate for alternative applications like isolated purpose of load converter too. Higher frequency operation of LLC resonant converter With LLC resonant converter, switch loss may be reduced. By management magnetizing inductance lumen, switch loss might even be controlled. This gave us chance to push to higher switch frequency. For a few state of the art magnetic materials, the best in operation frequency may be as high as megacycle. LLC resonant converter alters United States of America to utilize these new materials before finish application. The difficulty is a way to trade off the look between magnetic loss, volume and in operation region of the system. [8][9]

4.3 Conclusion

In this paper, DC-AC, a single phase resonant converter was proposed using basic square wave converter, and built from simple components and increases the efficiency of the circuit. Its control circuit is fundamental considering other resonant converter control circuits and has the ability to work in different frequencies. In this case fixed frequency was utilized.

In this paper, DC-AC, a single phase resonant converter was proposed utilizing soft switching, and worked from straightforward segments and expands the productivity of the circuit. Resonant converter is vastly used in induction heating process for reducing switching loss & converter size. Snubber circuit was introduced in this thesis to emphasize that it can lessen the voltage stress. In this full working procedure, the topology was to implement soft switching in both series- parallel resonant converter through half bridge full bridge rectification for reducing switching losses. The proposed idea was proven through Schematics simulation.

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