Chapter 4

PROPOSAL & IMPLEMENTATION OF MODIFIED QUASI-RESONANT CONVERTER

4.1 Introduction

As seen in Figure 3-9 the quasi resonant converter requires a Capacitor to provide the path of return current. In Mode-III after t4, the energy sent by the capacitor and stored in the inductor is converted to DC-LINK as the D1 diode is forward biased. During this period the current flows through filter capacitor.

A new approach to quasi resonant converter is proposed in following section so as to remove filter capacitor.

4.2 Modified Quasi Resonant Converter

The following Figure 4-1 features a block diagram of a modified quasi-resonant converter.

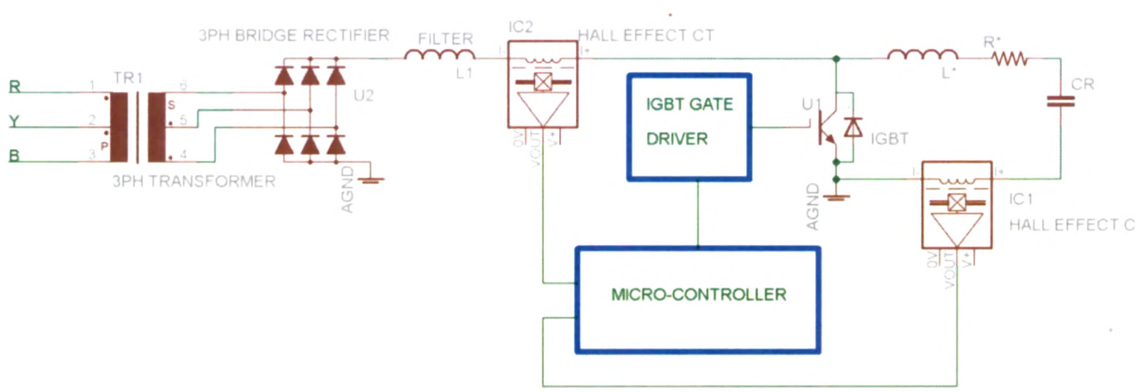

Figure 4-1 Power Circuit of Modified Quasi-resonant Converter

The total system block is comprised of main power circuit, dc-link & tank current detection circuit and microcontroller as shown in Figure 4-1. The basic operating concept of modified quasi-resonant circuit is similar to that of quasi-resonant converter in the fact that heat energy is generated. However, the methods of controlling the gate in the switching circuit are totally different.

Major functions of each block are as follows.

4.2.1 Main power circuit

The main power circuit features a quasi-resonant converter consisting of the IGBT and a diode connected to it in parallel the circuit executes high frequency switching. By turning off the IGBT while the diode is in turn-on it is possible to do a turn-off switching with the voltage and current remaining at zero. The resonant circuit is composed of equivalent inductance (L*), equivalent resistance (R*) and resonant capacitance (CR).

4.2.2 Operating Concept

Figure 4-2 illustrates an equivalent of the main power circuit. When D1, connected to the S1 switching circuit, is turn-on a zero voltage turn-off switching is available as Vce of the circuit becomes zero.

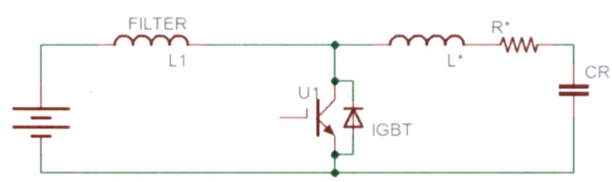

Figure 4-2 Equivalent Circuit

Figure 4-3 shows the waveforms of each block of the main power circuit in a cycle. In the initial stage U1 is off. And CR is charged fully by the current flowing through L1, L* and R*. Following are the four modes available.

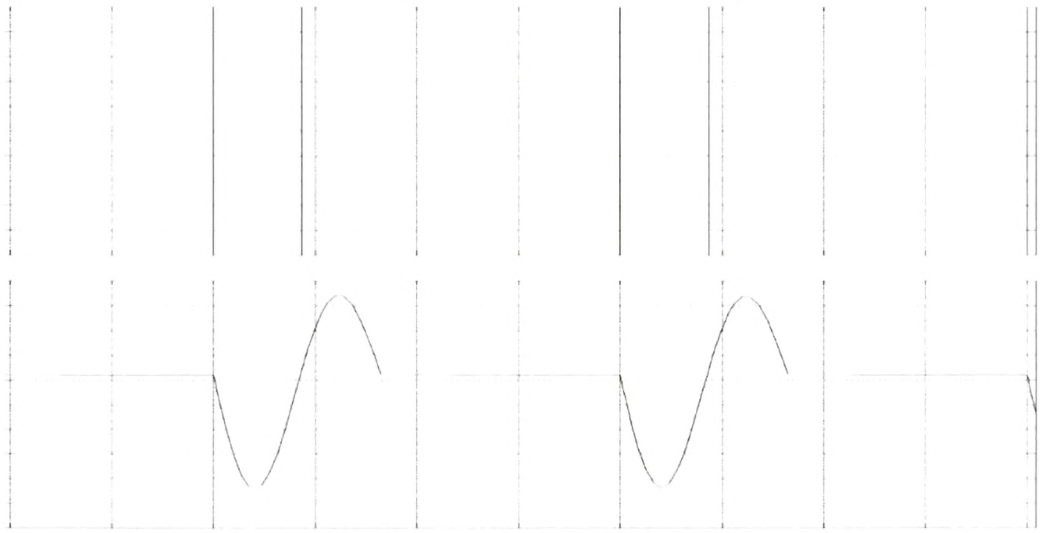

Figure 4-3 Waveforms of Main Power Circuit

MODE I:

At time t0 the switching circuit is turned on. In this process, a turn-on switching loss occurs. At this point the capacitor starts discharging the energy to the inductor through switching circuit. Thus the current increases in the negative direction. The current reaches to its maximum value when the capacitor is discharged.

MODE II:

At this point, the energy stored in the inductor begins to be transferred to the capacitor. So the current starts decreasing in negative direction. Once the capacitor is fully charged in negative direction the current becomes zero. This is also the point when the transfer of the energy stored in the inductor to the capacitor is completed.

MODE III:

After this point, the capacitor starts discharging the energy to the inductor, which causes the current flowing in the positive direction through the diode. At this point as the resonant current is flowing through freewheeling diode the voltage & current in the switching device is zero, and can be switched off to have zero turn-off switching loss. The current reaches to maximum when the discharge is completed.

MODE IV:

After this point, the energy stored in the inductor begins to be transferred to the capacitor so that current starts decreasing in positive direction. The current becomes zero when the energy transfer is completed. At this point or later the switching circuit can be turned on, returning to MODE I.

The frequency of operation can be varied depending upon required power by increasing/decreasing the turn-on instant of switching circuit.

4.3 Simulation of Modified Quasi-resonant Converter

Simulation results were performed using Simulink block as shown in Figure 4-4. To limit the stresses in switching device to 600V & to isolate the main supply the 3-ph ac is stepped down using a 3-ph step down transformer from 415V to 140V. This is further rectified using a 3-ph rectifier and smoothened using an inductor. As there is no return path required for current the filter capacitor is not required. The resonant circuit is composed of resonant inductance (Lr) and resonant capacitance (Cr). Simulation result of the inductor current is shown in Figure 4-5. Figure 4-6 shows the simulation result of current through IGBT. And that of dc-link voltage is shown in Figure 4-7. The DC-link voltage of 200V is applied to the input of the converter.

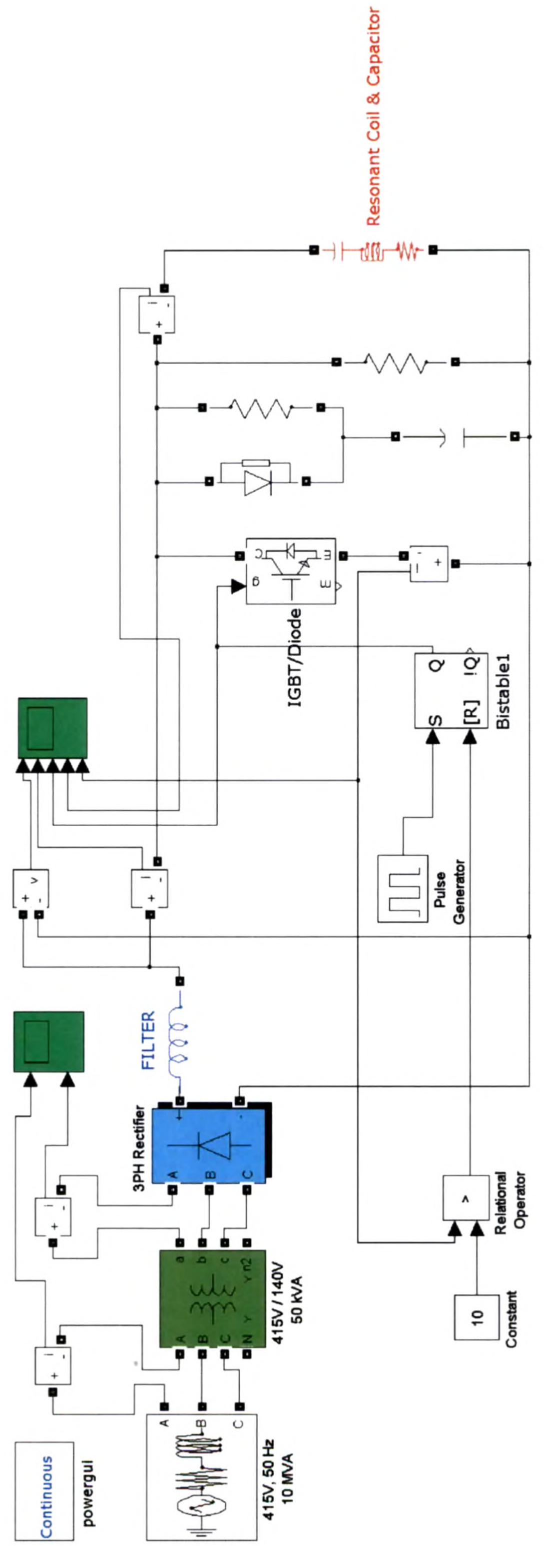

Figure 4-4 Simulink Block of Quasi-resonant converter

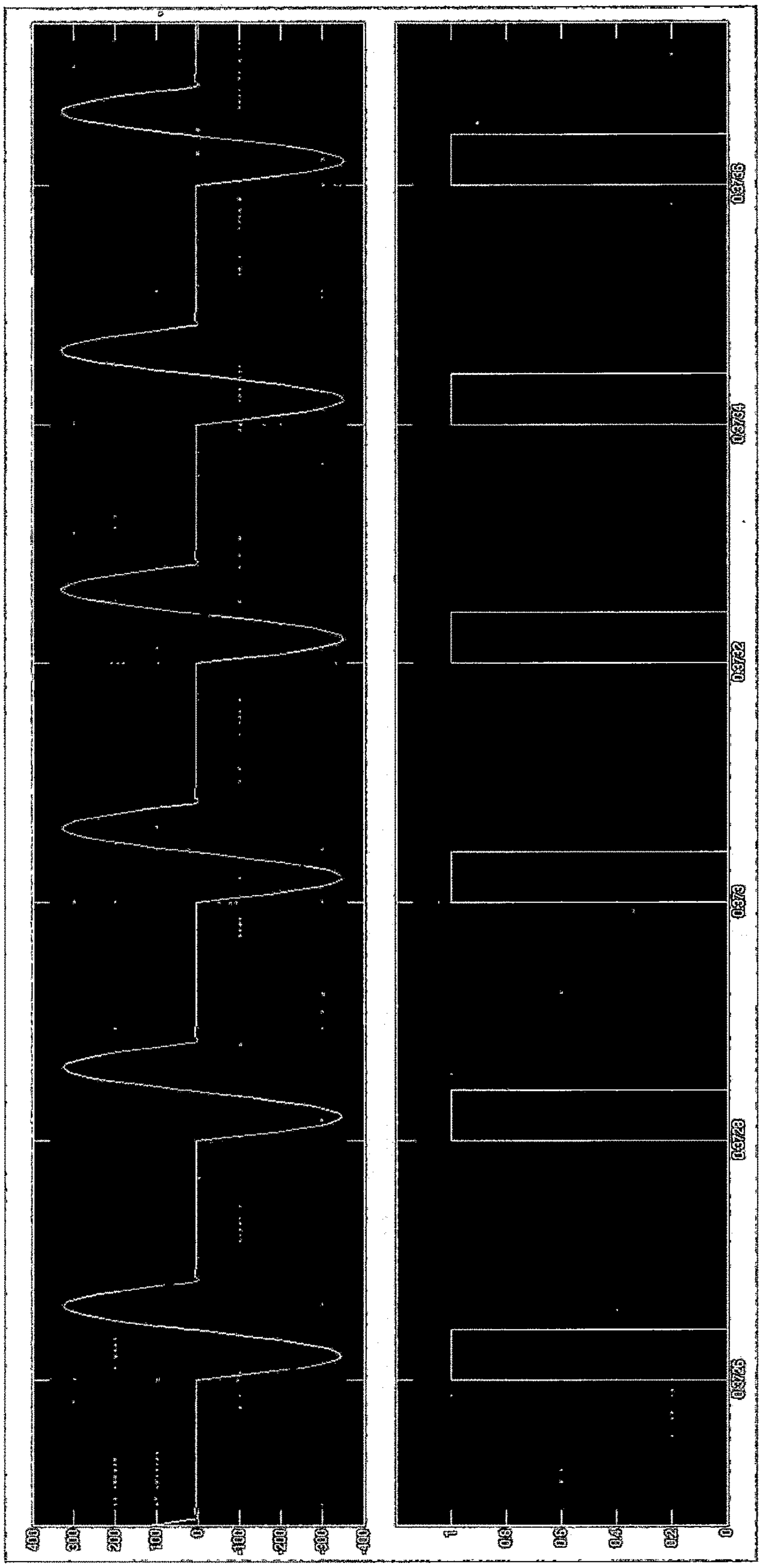

Figure 4-5 Simulation Result of Inductor Current

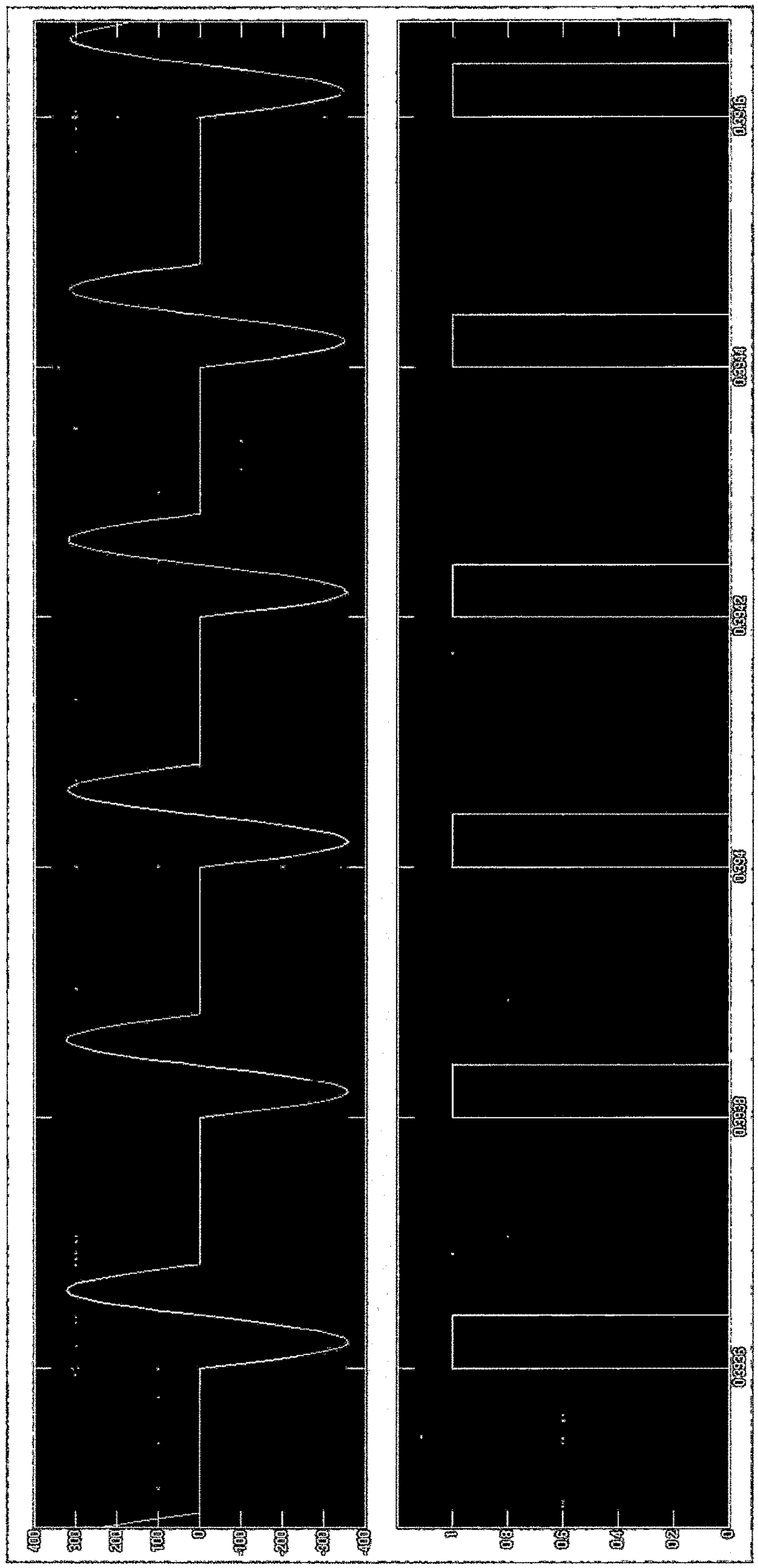

Figure 4-6 Simulation Result of IGBT Current

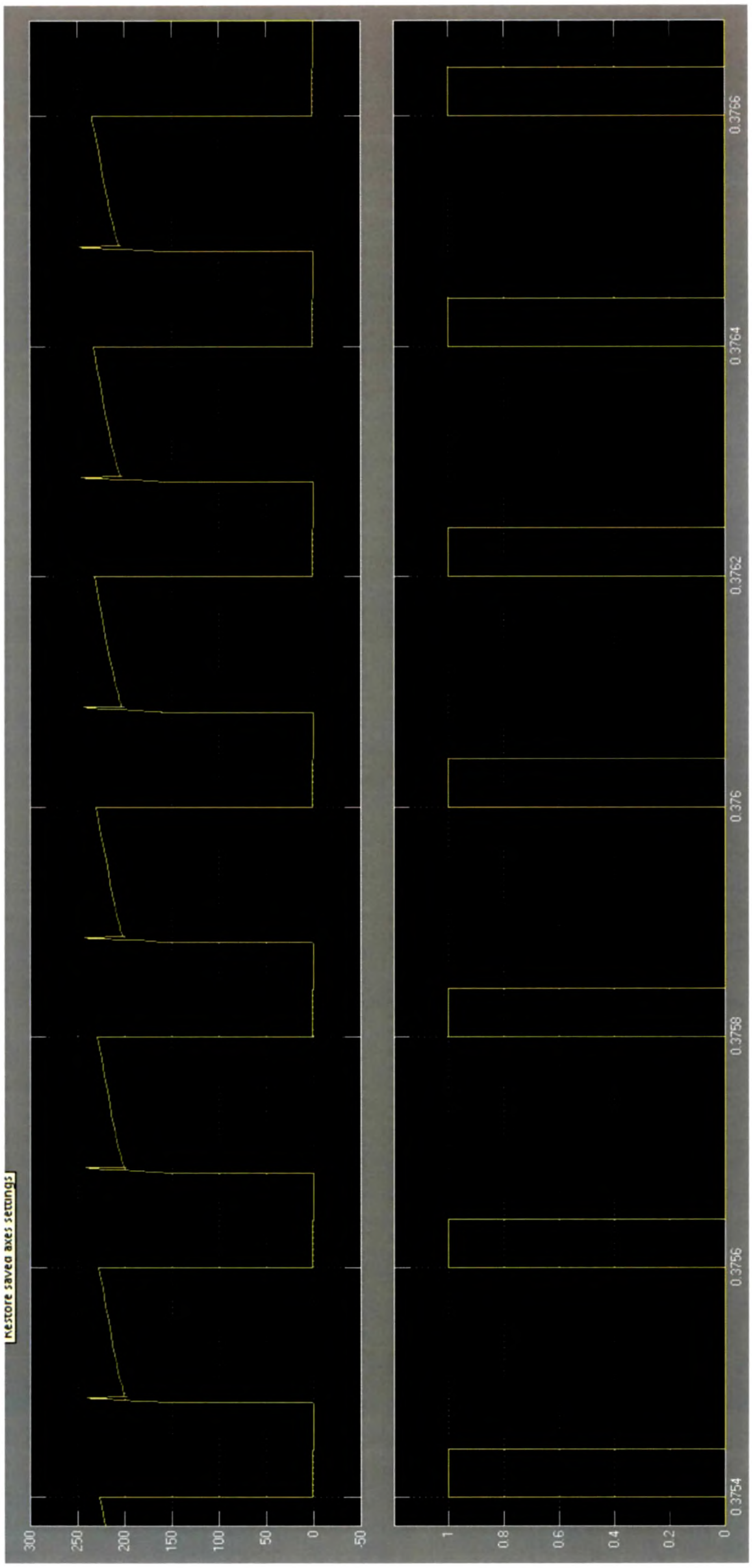

Figure 4-7 Simulation Result of voltage across IGBT

4.4 Summary

This chapter has presented analysis, modeling and simulation of the modified Quasi-resonant converter. The main findings of this chapter reveals following:

1. The modified quasi resonant converter is low cost as the filter capacitor is eliminated as compared to quasi resonant converter. This new scheme also requires one switching device which maintains the advantage of a relatively smaller design for the heat sink and PCB.
2. This new scheme is more advantageous as the positive & negative current flows through the same resonant path resulting into a pure sine wave of current.
3. This system has advantages like low switching losses, reduced stress and increased power density.
4. The variation in power can easily be obtained by changing the operating frequency of IGBT gate pulses.
5. The simulation results are in line with the predictions.