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Simulation of three Phase Induction Motor with Resonant Switched Boost Converter

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***Abstract*— The day by day consumption of power and increase in oil price has demanded the scientists to do more research on renewable and green energy sources, usually the solar arrays and fuel cells. If an efficient converter is used to convert the power from the renewable energy sources. It will be a very useful solution for industries to drive there various machines using these converter. In this paper three phase induction motor is fed with resonant switched boost converter. An efficient two inductor boost converter is used, which converts low input voltage to high output voltage. In the two main switches soft switching method is applied to increase the overall power conversion efficiency. Simulation of the proposed model was done in MATLAB/SIMULINK.**

Keywords*— INDUCTION motor,Zero Current switching, Zero Voltage switching.

I. INTRODUCTION

Induction motors are used in almost all industries. Where the rotating magnetic field of the stator cuts the stationary rotor conductors, an emf is induced and this is called principal of induction. Induction motor works on this principal. Induction motor has a significant place in industrial drive application. Almost every industries uses AC power, whereas the ac power is used in distribution, generation and transmission. Earlier, for the speed control applications DC motors are used rather than induction motors because speed control of motor was difficult. Due to the advance in power electronics and semi-conductor switches the speed control of induction motor are possible, mostly variable frequency drive (VFD) are used in industries. The advantage of using these methods are we can save energy as well as the life of the motor.

One of the diminishing factor of the electrical field is that the demand of electrical power is increasing each day. The gadget oriented and luxurious life led by the society has resulted in high usage of electrical power, where the generation of the power and demand of the power are not in proportion. So we need to find other solution to meet up with the demand. If an efficient converter is linked with renewable energy sources like solar cells, wind mill etc. We can drive various machines in industries with these converters. Which will be more effective and energy saving.

In this paper, resonant switched boost converter is fed with three phase induction motor. Interleaved operation of a two inductor boost converter is explained and simulated using MATLAB/SIMULINK.

II. PROPOSED CONTROL SCHEME.

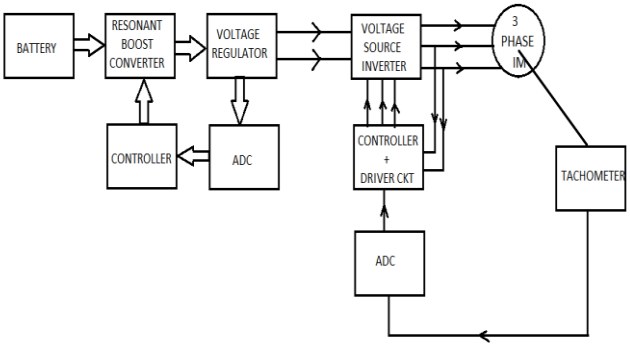

Fig.1 Block diagram of the proposed scheme

Figure 1 shows the proposed scheme of a three phase induction motor fed with resonant switched boost converter. Motor is driven through a battery, a DC-DC converter (resonant boost converter), a voltage regulator to maintain the desired voltage, a voltage source inverter through which three phase induction motor is fed, Tachometer to sense the speed of the motor, two ADC to convert analogue signal to digital signals and two controllers. One controller is used to control the duty cycle of the mosfet switches in the resonant boost converter, while the other is used for switching the gate signal of the desired switch of the voltage source inverter.

A. Resonant Boost converter

The figure 2 shows the two inductor resonant switched boost converter. In the input side there are two inductors L_1 and L_2 and the two main switches S_1 and S_2. These two switches produces interleaved boost operation. Inductor L_1 and L_2 divides the input current thus it can reduces the I^2R conduction losses greatly. The other part of the circuit are resonant inductor L_r, one bi-directional switch S_A, Two auxillary diodes D_{A1} and D_{A2} and a voltage doubler circuit. Doubler circuit consist of two rectifier diodes D_1 and D_2, two capacitor C_1 and C_2 and resistor R.

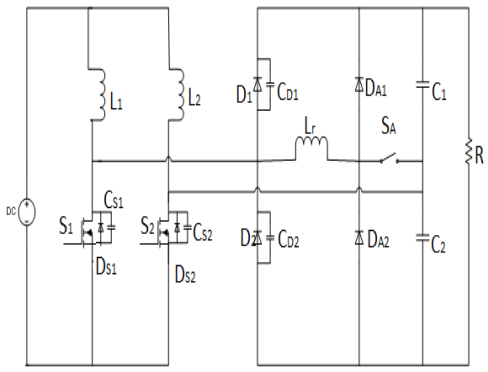

Figure 2. Two inductor resonant switched boost converter

The resonant inductor L_r, bi-directional switch S_A and two auxiliary diodes D_{A1} and D_{A2} which helps in zero voltage turn off switches and to abort the reverse recovery losses in the rectifying diodes. L_r is used for the resonance process it will be linked with the capacitor across the mosfet drain-source switch as well as the other capacitors. When the resonance is created by switching the bi-directional switch S_A the resonant inductor L_r charges. Once the inductor gets charged the resonance is created and it discharge the drain source capacitance of the switch. During turn off, it limits the change in anti-parallel diode D_{S1} and D_{S2} current across the mosfet switch in respective operation.

Bi-directional switch S_A gate signals are switched with constant duty ratio before the two main switches are switched. In order it generates a resonance process and creates a zero voltage switching as well as zero current switching under some desired conditions.

- L_r = resonant inductor
- $C_r = C_{S1} + C_{D1} + C_{D2}$, when switch S_2 is ON or else
- $C_r = C_{S2} + C_{D1} + C_{D2}$, when switch S_1 is ON.

B. Induction motor drive

To control a three phase induction motor, one needs a three phase inverter with dc link, driving circuits and a controller to control the inverter switches by space vector modulation techniques.

A tachometer is used to sense the speed of the induction motor. For speed control application, tachometer gives the signal to the analog to digital converter where it converts the value to the controller circuit. Gating signal to the inverter switches are provided by the controller which depends on the speed required. Here in this model speed is varied by changing the frequency.

III. SIMULATION

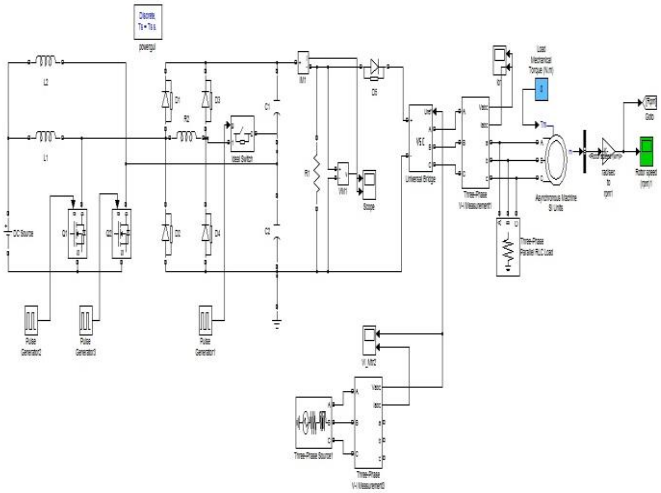

Figure 3. Simulation diagram of three phase induction motor with resonant boost converter

Figure 3 shows the two inductor resonant boost converter fed induction motor drive. It was observed that smooth speed control was possible. Stepping up of low input voltage to high input voltage is obtained by the converter. The output voltage of 93V is obtained for the input voltage of 24V. The output current of the converter is 2.5A.

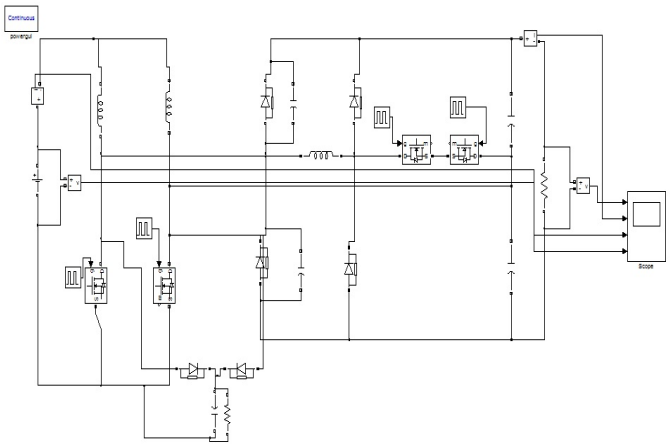

Figure 4. Simulation circuit of the converter

The figure 4 shows the simulation circuit of resonant boost converter alone. To prevent a voltage stress at turn-off an extra RCD snubber circuit is added across the main switch.

IV. RESULTS.

Here converter input output voltages and currents waveforms as well as the whole system waveforms are given below.

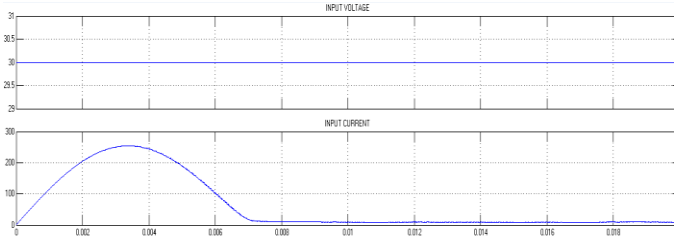

Figure 5. Input voltage and current waveforms of converter

Figure 5 shows the waveforms of the converter, these waveforms represents to the simulation circuit shown in the figure 4 which is resonant boost converter alone. Waveform in figure 5 shows an input voltage of 30V and input current of 10A. we get an output voltage of 300V and 0.8A current which is shown in figure 6. So stepping up of low voltage to high voltage is obtained by this converter.

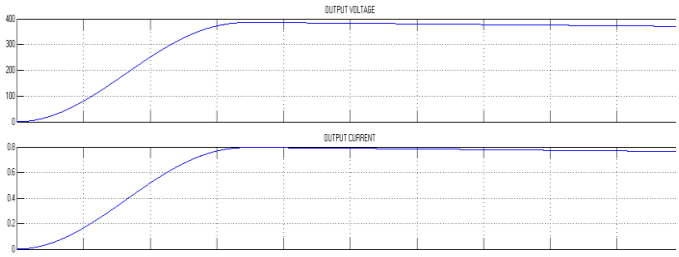

Figure 6. Output voltage and current waveforms of the converter

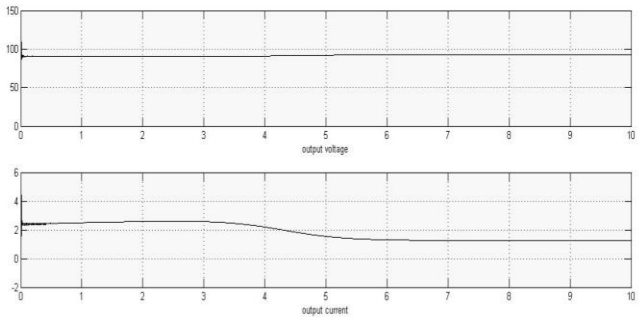

Figure 7. Output voltage and current waveforms of resonant boost converter

In the figure 7 it shows the simulated waveforms of the resonant boost converter, where the simulated circuit diagram is shown in the figure 3. Here in the waveform it shows converter output voltage is 93V, whereas converter output current is 2.5A. This resonant boost converter is fed to the induction motor.

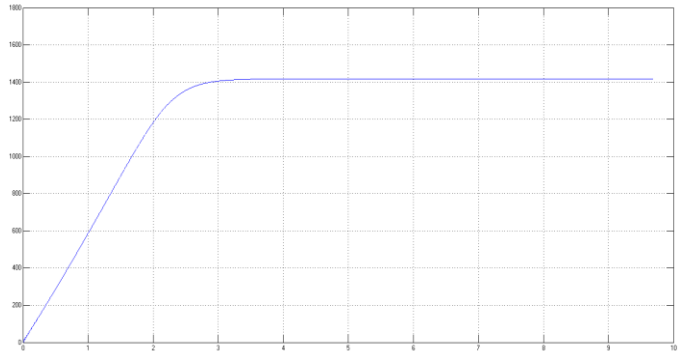

Figure 8. Speed of motor at 1440 rpm

Figure 8 shows the speed curve of the motor at 1440 rpm when a frequency of 50 Hz is applied.

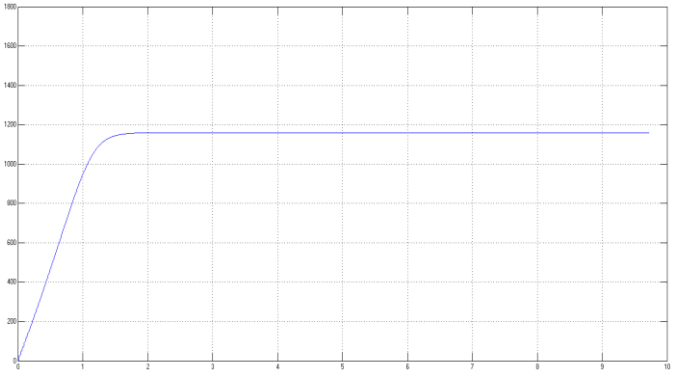

Figure 9. Speed of motor at 1150 rpm

Figure 9 shows the speed curve of motor. When a frequency of 40 Hz is applied we got a speed of 1150 rpm.

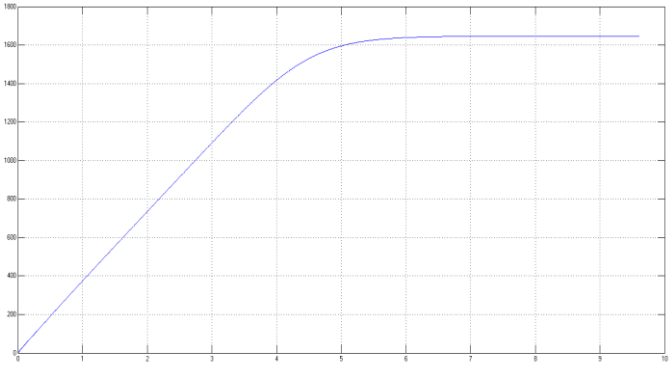

Figure 10. Speed of motor at 1660 rpm

Figure 10 shows the speed curve of the motor running at 1660 rpm when a frequency of 60 Hz is applied

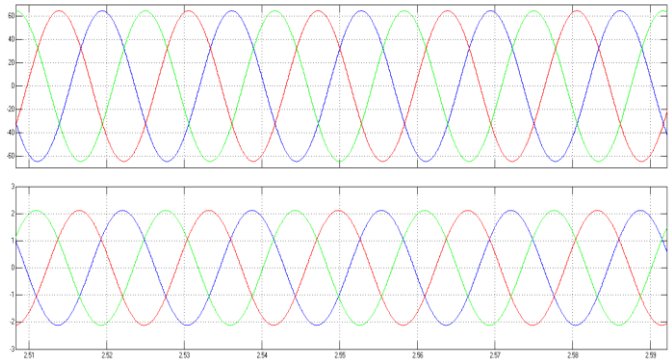

Figure 11. output waveform of voltage source inverter

Figure 11 shows the output waveform of the voltage source inverter. It shows phase to phase voltage of 60V as well as the current of 2A.

V. CONCLUSION

The speed of the induction motor fed by a resonant boost converter is controlled. Model is simulated using MATLAB/SIMULINK and waveforms are verified through simulation. So it can be concluded that by using a two inductor resonant boost dc-dc converter is an effective solution for high step up applications. Where the two main switches operates at zero voltage switching and zero

current switching, so the switching loss and diode reverse recovery losses are reduced. Furthermore reduced size and simple implementation are possible due to single resonant inductor, the interleaved operation of the two main switches reduces the input current as well. So the overall power conversion efficiency of the converter is increased. This converter can be used in renewable energy plants, so that industries can benefits largely by producing pollution free green power generation.

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