Simulation and Analysis of Parallel Resonant DC Link Inverter
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Abstract— parallel resonant dc link that provides soft switching and pulse width modulated inverter is presented. The new PRDCL ensures zero crossing of time period.

Key words: Soft switching, Parallel resonant dc link inverter, PWM.

I. INTRODUCTION

Induction motors with squirrel-cage rotors are found in numerous industrial applications because of their low cost and rugged construction. When induction motors are operated directly from the line voltage, they run at a nearly constant speed, determined by the line voltage frequency and the number of poles in the machine.

Power conversion is required to effectively and efficiently control motors of all kind. Performance of the overall system is greatly dependent on the appropriate conversion and power to the motor. For example, a system could utilize the most efficient motor and still operate very inefficiently if the motor is not driven properly. Significant improvement can be made in the efficiency; power density and reliability of present motor drives by using new topologies operates at higher switching speeds and employ new control strategies that lead to enhance the performance.

Resonant inverter is the generic name for a type of high frequency switching topology used in many of Spellman’s supplies. Resonant switching topologies are the next generation of power conversion circuits, when compared to traditional pulse width modulation (PWM) topologies. Resonant-based supplies are more efficient than their PWM counterparts. This is due to the zero current and/or zero voltage transistors switching that is inherent in a resonant supplies design. This feature also provides an additional benefit of eliminating undesirable electromagnetic radiation normally associated with switching supplies.

II. PROBLEM IDENTIFICATION

Usually electric vehicles utilize hard switching inverters (HSI) to drive their motors. The attractiveness of the hard switching inverter stems from its circuit simplicity and rugged control schemes. However, this type of inverter suffers from high switching losses, high switching stresses, and EMI (electromagnetic interference) problems. To solve these problems, soft switching resonant dc link inverters have been proposed. In a Resonant DC link inverter, the dc bus is controlled to oscillate at a high frequency so that the bus voltage goes through periodic zero crossings, thus setting up zero voltage switching conditions for all devices across the bus. The resonant dc link inverter has been shown to be a viable topology to realize high performance and high power density ac drives.

III. SOFT SWITCHING

Traditional hard-switching inverters presented several problems during switching. During turn-on, the device current rises from zero to the load current with additional diode reverse recovery and stray capacitor charging and discharging currents on top of the load current. Typically, a current spike will occur, and the peak device power consumption is extremely high. During turn-off, the device voltage rises. Due to the leakage inductance intheloop, avoltage over shoot caused by Ldi/dt will occur, and the device voltage will exceed the dc bus voltage. This voltage over shoot can be reduced by a good circuit layout and high frequency DC bus capacitors. The turn-off loss varies among different types of devices depending upon the turn-off delay and current fall time. The Power MOSFET consumes least turn-off loss. The insulated gate bipolar transistor (IGBT) turn-off loss also varies among different manufacturing processes and its associated minority carrier lifetime killing. Some ultrastaf ICTs may have low turn-off loss, lose to that of power MOSFETs. The bipolar junction transistors (BJT), in general, have long turn-off delay time and consequently, high switching losses. Another switching problem is the voltage rise and fallrate, di/dt. During turn-on, the voltage falls to zero when the opposite switch turns off. During turn-off, the voltage rises to the dc bus voltage with an overshoot.

IV. SOFT SWITCHING DC AC CONVERTERS

The development of soft-switching inverters for ac motors (including induction motors, P Motorless motors and PM hybrid motors) becomes a research direction in power electronics. Figure 1 shows a milestone of soft-switching inverters, namely the three-phase voltage-fed resonant dc link (RDCL) inverter developed in 1989 [Divan, 1989].

![Fig. 1: Three-phase voltage-fed RDCL inverter](image)

Subsequently, many improved soft-switching topologies have been proposed, such as:

1) Series resonant dc link (SRDCL),
2) Parallel resonant dc link (PRDCL),
3) Quasi-resonant dc link (QRDCL),
4) Resonant transition auxiliary resonant commutated pole (ARCP),
5) Auxiliary resonant snubber (ARS) inverter.
V. PROPOSED SCHEME:

A. Block diagram

Figure 2. shows the block diagram for Parallel Resonant DC Link inverter. As shown in figure DC supply is given to the DC links which constitute an inductor and capacitor in parallel. The output of DC link is given to the three phase PWM VSI. The switching losses in a PWM inverter is avoided by connecting a resonant circuit in between the DC input voltage and the PWM inverter. The output of PWM inverter is given to the three phase induction motor. Control circuit for DC link and three phases PWM VSI are connected.

VI. OPERATING PRINCIPLE

This topology involves placing a simple L-C resonant circuit between the DC bus and a conventional inverter. The PRDCL Inverter operates in the following manners. A DC voltage is applied to a parallel L-C resonant circuit with a switch S across the capacitor. By closing switch, the inductor is charged. When inductor is charged to a sufficient level switch is opened and the resonant bus voltage oscillates and returns to zero. The resonant switch is closed every time the resonant bus voltage returns to zero. At this time the power switching devices in the inverter bridge are turned on or off ensuring a zero voltage transition.

VII. SIMULATION

Simulation of Parallel Resonant DC Link Inverter with R load is prepared by MATLAB 2010a as shown in fig.4. Scopes are connected to measure three phase output line voltage $V_L$, Phase voltage $V_p$ and output current $I_o$. Figure 5.2 shows a simulation result of three phase output line voltage $V_L$, Phase voltage $V_p$ and output current $I_o$ with R load.

VIII. RESULTS

Simulation of Parallel Resonant DC Link Inverter with RL load is prepared by MATLAB 2010a as shown in figure 5.5. Scopes are connected to measure three phase output line voltage $V_L$, Phase voltage $V_p$ and output current $I_o$. Figure 5.6 shows a simulation result of three phase output line voltage $V_L$, Phase voltage $V_p$ and output current $I_o$ with RL load.
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IX. HARDWARE

Fig. 9: Hardware Setup

Fig. 10: Control Circuit

IX. HARDWARE

Fig. 8: Results

Fig 11 Dc Link and Supply circuit

X. PARAMETERS USED IN HARDWARE

- Input voltage :- 230 V AC
- Inductor :- 45 milihenry
- Capacitor :- 0.8 microfarad
- DC link frequency :- 20Khz
- Switching frequency :- 5Khz
- Ratings of Motor:-3 phase,230 volt,1.3 Amp,0.25 hp.
- Microcontroller :- 89C51
- Transformer :- 230/24 volts,5 Amp and 230/24 volts, 1.5 Amp

XI. CONCLUSION

In this project report, PRDCL circuit is presented. This circuit provides zero crossings on the DC link to implement the SS and PWM operation of the inverters. The new circuit combines the most desirable features and overcomes most drawbacks of other circuits using only one auxiliary switch. Subsequently, all semiconductor devices in the circuit operate under SS, the circuit can successfully operate under various load conditions.

A resonant DC link inverter driving a 0.18kW induction motor for an electric vehicle application has been developed. Inverter operation with an 110V DC supply at a link frequency of approximately 20 KHz has been successfully demonstrated. It has been experimentally checked that the resonant DC link inverter is capable of bi-directional power flow. Inverter tests have shown that the resonant DC link inverter has the advantages of low losses, allow dv/dt, low acoustic noise, a high switching frequency, and snubber less operation. Therefore, the resonant DC link inverter has a promising application to electric vehicle propulsion.

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REFERENCES


