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An improved Power factor of ZVS based Quasi-resonant Converter Driven DC Motor

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Abstract

Power factor improvement takes a vital part in industrial drives and in this we analyzed improvement in power factor for the converter driven DC motor using Quasi resonant Zero voltage switching (ZVS)[1]. With rectifier gives poor efficiency, hence the input rectifier is removed which helps for improving efficiency, especially at low input voltages. We have come across several with and without bridge rectifier PFC circuits [2], but the proposed new converter attains ZVS in a very largeworking range with a greatest advantage of reduced switching losses and some other benefits.

Keywords: Zero voltage Switching (ZVS), Power factor correction (PFC), two Inductor with capacitor (LLC).

Introduction

In a recent days, Power electronic devices dominates in industries and also in domestic home appliances. Almost every consumer electronic product has a commonality; it needs a power supply to generate an isolated output voltage in the extra-low voltage range. With respect to large number of devices connected to the public low voltage mains, the harmonic currents are limited in standards to ensure an acceptable mains voltage quality [3] & [4]. Today, most switched-mode power supplies (SMPS) contains various conversion stages in series. If it has to perform in a specified standard, it is required for the improvement of power factor like (PFC) [5]. We observed that the PN junction power semiconductor device will produce large conduction loss at the entry stage of rectifier of a classic boost PFC stage, without bridge rectifier,improvement of power factor like (PFC) converters are used to achieve higher conversion efficiency. The improvement of power factor like (PFC) stage supplies an intermediate voltage bus with a typical voltage around 400 V. In many applications this high voltage is reduced to a lower output voltage with isolation based on an additional DC/DC converter stage. A typical power supply with a two stage approach. This AC/DC-converter contains a bridgeless dual boost PFC rectifier, come after a resonant LLC DC/DC-converter [6] and has already been optimized for a higher total conversion efficiency by using a bridgeless improvising power factor like (PFC) stage [7] with less conduction losses and an efficient soft switching LLC resonant converter. To further increase efficiency and decrease number of devices used and control the complexity, a single-stage converter concept could be used in a modern AC/DC switched-mode power supplies (SMPS) [8]. Single-stage converters achieve rectification, improvising power factor (PFC) and isolation is at only single converter stage. This mono stage converter topology operates directly on the mains without a PN Junction power semiconductor device in front. The "True Bridgeless PFC Converter" is basically a boost type converter.

1. *Conventional topology of Bridgeless PFC Converter*

We know the "Totem-Pole Bridgeless Boost PFC" as its improvement of power factor like (PFC) stages are often followed by an isolated asdirect current to its variable direct current converter with a transformer to achieve an isolated output with a lower output voltage. Here the conventional bridgeless improvement of power factor like (PFC) [1] Converter is basically a boostConverter, nevertheless a converter soft start with completely drained out capacitor isTechnically possible tends to easily operate this converter and here the characteristics[8] &[9] shown in Fig:1 as "True Bridgeless PFC Converter"

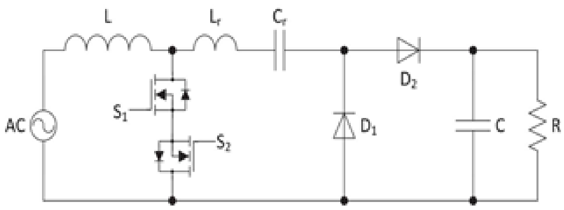

Fig: 1 "True Bridge PFC Converter"

There will be a chance of creating issues with a high resonant current amplitude or with inductor current freewheeling and another problem exists under operating condition is the current commutation from the switch path to the resonant network during the switch turns off. The resonant inductor of the resonant network can't carrythe input inductor current immediately [10] & [12]. Which leads to an abnormal voltage across the switch during turn off. Here modeled by two anti-serial MOSFETs $s_1$and $s_2$and a resonant $L_r - C_r$network. Theresonant frequency $f_r$of this $L_r - C_r$network is chosen so that the resonating can completelyoccur during the ON-time t_{on} of the switches$s_1$and s_2. The following equations will be applied,where $f_{sw}$is the converter switching frequency:

$$f_{r=1}/_{2\pi\sqrt{L_r}C_r} > \frac{1}{2} f_{sw}$$

2. *Resonant Current at Converter Start-up.*

The capacitor at the other end is completely drained out at start-up time. The potential difference between the resonant capacitor is equal to the applied voltage (Fig. 2). If the Power Device 'S' tends to close high circular resonant current flows. This high current will stress the semiconductors and could saturate the resonant inductor, which is typically designed to carry only the normal operation current.

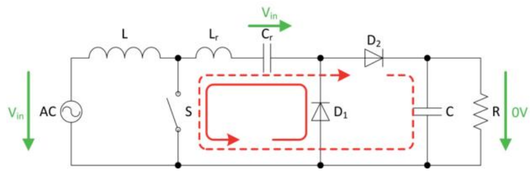

Fig:2 Start-up phase with high resonant currents.

3. *Resonant current cut off*

The oscillating cannot occur completely during ON-time. The sinusoidalresonant current $i_r$is cut off before it reaches zero again [11]. The switch is now open, but theresonant inductor still wants to force the current $i_r$in the same direction. Anappropriate freewheeling path is not there, which is shown in Fig. 4. This results in an overvoltage acrossthe switch s if no additional measures are taken.

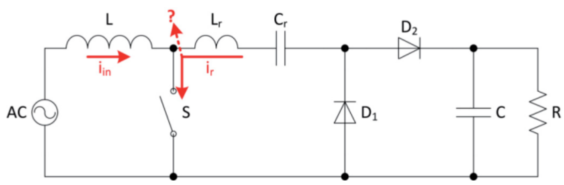

Fig:3 Absence of freewheeling path during resonant current cut off.

4. *Bridgeless Power Factor Correction*

An unity power factor at the source end can be possibly be obtain by using buck-boost converter made to work in discontinuous inductor current. The performance of the PFC Buck - Boost converter [1] & [16] is further categorized into two parts which works in both the half cycles of the supply voltage and during complete each half cycle. There are three different cycles of operation for the supply voltage.

Efficiency and cost important role in the development of low-power motor drives particularly targeting household applications such as fans, water pumps, blowers, mixers, etc [13]. The use of the DC motor in these applications is becoming very common due to features of improved efficiency [14], withmaximum flux density per unit volume, low maintenance requirements, and low magnetic interference problem.

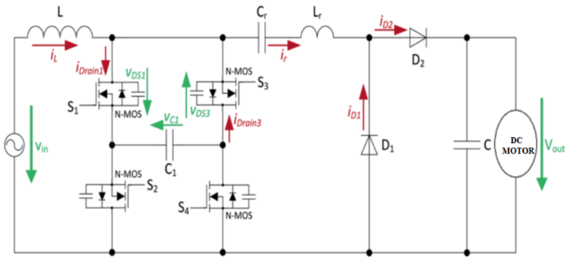

Fig:4 Circuit Diagram of the proposed converter

Fig.4. shows the connectionmodel of the converter with motor load. The above mentioned application dominate by DC motor for the following advantages as of improved efficiency, maximum flux density per unit volume, low maintenance requirements, and low magnetic disturbance or interference problem

5. Discussion on the Simulation Results

Circuit diagram of the overall simulation is shown in Fig5 .1.Input voltage and current waveform of the converter is shown in Fig 5.2. Generated pulse for the converter switches shown in Fig 5.3. Output voltage waveform of the converter was shown in Fig 5.4.

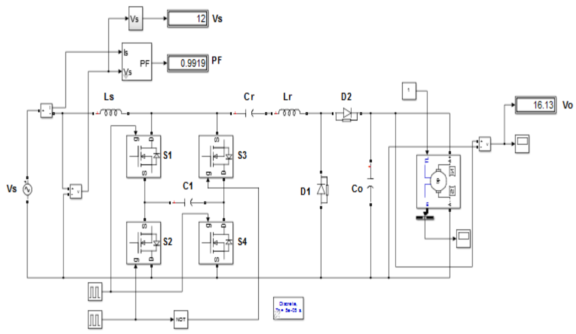

Fig.5.1. Circuit diagram of the overall simulation

And Fig 5.1.1 shows about the motor parameters and we just worked out with different torque value for obtaining the better power factor nearly for unity.

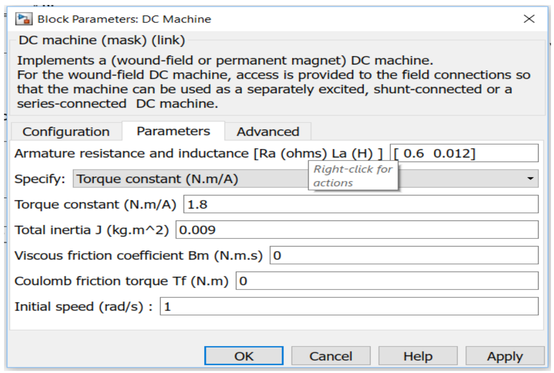

Fig.5.1.1 DC Motor parameters

Where the parameter of DC motor is given as Ra= 0.6Ω, La = 0.012H and Torque = 1.8N.m/A.

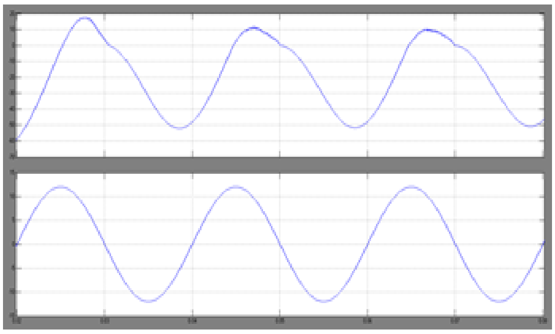

Fig.5.2. Input voltage and current waveform of the converter.

Here Fig:5.2 show the Voltage and current Waveforms of Input given to Converter driven DC Motor. Where the Power and the Power factor will be measured at the source end. To maintain the improved power factor at the source end the Bridge-less converter is controlled by pulse generator Fig:5.3 shows the Pulse input to the switching of converters.

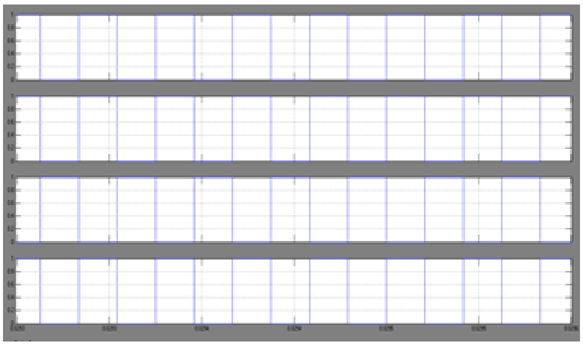

Fig5.3 Generated pulse for the converter switches.

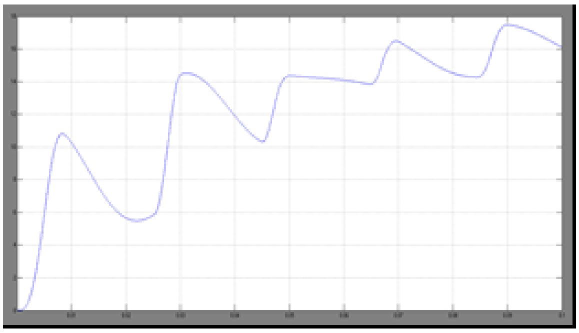

Fig.5.4 output voltage waveform of the converter.

The above Fig:5.4 shows the output voltage at DC Motor terminal and the Fig: 5.5 shows the improved power factor and stabilized at 0.95 to 0.97 which is ~1 (i.e)Unity power factor such that the performance of a DC motor also improvised irrespective of the change in load.

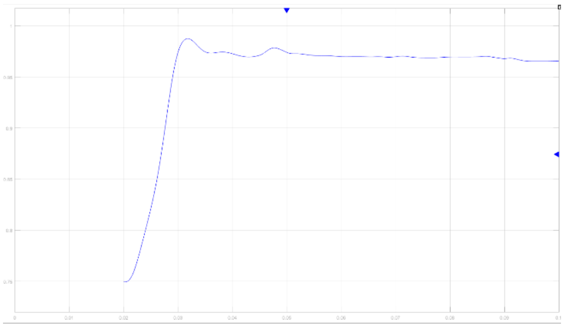

Fig.5.5. Improved Power Factor

In this given converter has entirely differfrom a conventional boost, buck or buck-boost topologies. The voltage gain achieved can be smaller or greater than unity and depends also on the input inductor currenti_L, To get the same voltage gain with higher input current or higher load, the Firing angle is to be changed and on time T_{on} has to be increased. The duty cycle is defined as the percentage of the switching period T_{sw} in which the ON-signal to the MOSFETs s_1 or s_2 is applied.

6. Conclusion

In this project, a new bridgeless, quasi-resonant ZVS switching, buck-boost PFC topology was presented. The circuit may also be extended to an isolated converter if a transformer is inserted. The inrush-current is negligible and a fast converter soft-start is possible without additional component stress. Furthermore the converter has no abnormal voltage across the semiconductor switches and offer zero voltages switching (ZVS) to reduce the switching losses.

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