Power Quality Improvement Using UPQC for Wind Farm Generation System

Bandaru Murali Mohan

Abstract: *Comparing with single-phase TM boost converter, both the input and output current ripple of the proposed push-pull quasi-resonant boost converter can be reduced if the equivalent inductance of the coupled inductor equals the inductance of single-phase TM boost converter. Therefore, both the PF value and the power density are increased. In addition to the equal distributions of the input current and output current, the proposed topology with a cut-in-half duty cycle can reduce the conduction losses of the switches and both the turns and diameters of the inductor windings.It also maintains the advantages of a TM boost converter, such as QR valley switching on the switch and zero-current switching (ZCS) of the output diode, to reduce the switching losses and improve the conversion efficiency.*

Keyword:*Boost inductor, power factor corrector, push pull topology, Quasi resonant (QR) converter, Zero current switching.*

I. INTRODUCTION

The quasi resonant converter evincing high efficiency is able to control output voltage to a large extent. Due to the inductive character of the load the switching losses are also limited with the help of pulse width modulation through changing the width of pulses in order to control the output voltage, the converters are managebely controlled. System oscillating at a particular frequency with large amplitude is called resonance. The electrical resonance occurs when the impedance is at minimum. The boost converter is a step up power stage non-isolated power stage topology as here the required output is always higher than the input voltage. For a non-pulsating and continuous input current the output diode conducts only for a portion of the switching cycle. The power factor correction is simply defined as the ratio of real power to apparent power. In AC to DC power conversion system of the switching mode the power factor correction technique is used. The basic principle of Turning on the power device for attaining zero current switching (ZCS) is achieved through the transition mode, hence here the coupled inductor is used. Among the three operating modes of a boost power factor corrector which are the transition mode(TM) continuous conduction mode (CCM) and the discontinuous conduction mode (DCM), the transition mode is the best mode for PFC as in this mode the inductance is neither higher nor lower, it has moderate inductance, the turn on losses are reduced due to the quasi-resonant valley switching of the switch which is an added advantage of the transition mode of boost power factor correctorThe rating of power is increased also the total harmonic distortion(THD) can be reduced both of the output capacitance and the input current. This paper proposes two interleaved TM boost PFC of the push pull boost power factor corrector along with the coupled inductor which is coupled to a single magnetic core.

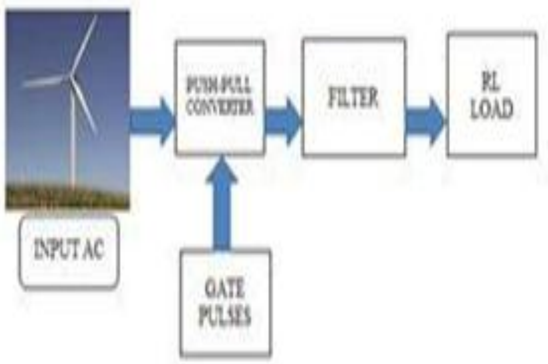

Fig.1. Block Diagram of Proposed Circuit

The power capability is promoted till the higher power level applications as the output power is shared between the two identical modules. This interleaved actions or operations of the push pull converter doubles the core operating frequency of the switching frequency along with the reduction of circuit volume and the cost hereby increasing the power density and the power factor value and improving conversion efficiency.

II. PUSH PULL CONVERTER

The push pull converter with an AC voltage here drives the high frequency tranformer. The push pull

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term generally invoves the bidirectional exitation of the tranformer causing to function the transformer with AC power and produce a voltage on its output side. The two switch topology is the topology used for push pull converter with a split primary is winding. In order to filter the switching noise the capacitors are connected at its output side, where the output is rectified and sent to the load. The operation of a push pull converter is regarded as two single switch forward converter running out of phase. The biggest advantage is that push pull converter does not require an isolated power supply to drive FET'S. Working in both the quadrant makes the transformer run and gets resetted at every cycle. One of the main advantages of the push pull converter is that peak current sensing is done so that the core does not drift into saturation and also it is low cost.

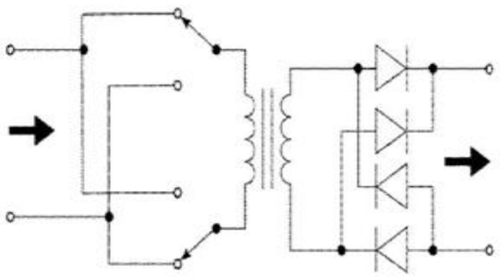

Fig 2. A General Push Pull Circuit

In order to design the power factor corrector there are some few specifications which are required such as output voltage, output current, output power and also the main factor which is the efficiency.The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit and is a dimentionless number between -1 and 1.The devices for correction of the power factor may be at a central substation, spread out over a distribution system, or built into power-consuming equipment.In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred.Power factor correction may be applied by an electric power transmission .In a proposed circuit of 200 WATTS power both the experimental and simulation results are carried out. Here in the AC input of the block diagram wind turbine in used as the input. Since it is an AC source wind turbine is directly connected to the push pull converter.

III. PROPOSED COVERTER OPERATING PRINCIPLES

In the following diagram of the proposed topology there are two modules present which are module A and module B , both these modules connected to a common output capacitor Co. Individually both the modules are connected to their respective switches, inductor's and windings. Module A is composed of inductor La, switch Saand inductor La with diode Da. Here the inductor La is wounded to the magnetic core of the transformer. Similarly module B is also composed of inductor Lb, switch Sband inductor Lb with diode Db. Here the inductor Lb is also wounded to the magnetic core of the transformer as that of the inductor La. Operating in the constant on-time and variable operating frequencies this proposed power factor converter is operated in the transition mode of it.

The advantages of this proposed system when compared to its conventional circuit is that here in the proposed system the input and the output current ripples are low where as in the conventional system both the input and output current ripples are high. Another advantage is also that conventional circuit has low efficiency whereas proposed has high efficiency. In the proposed circuit the transformer turns ratio is reduced but in conventional circuit is it is high.

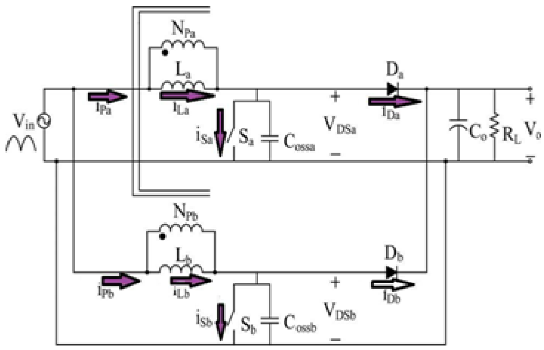

Fig.3. Proposed Circuit Diagram

Following few points are considered important for the operating principles.

1.Since the two windings NPa and NPb are identical there is no leakage inductance, as the two inductors Laand Lb are perfectly coupled.

2.For the conducting switches S_a and S_b, the resistance is intially zero, D is the dutycycle of the conduction period and the switching time interval is TS hence DTS is the period of conduction of the switches.

3.Forward voltage which is lso the initial voltage of the two diodes connected to the proposed circuit $D_a$and D_b. are zero ideally.

IV. OPERATION MODES IN QUASI RESONANTCONVERTER

The operating modes of the proposed topology are analyzed as follows

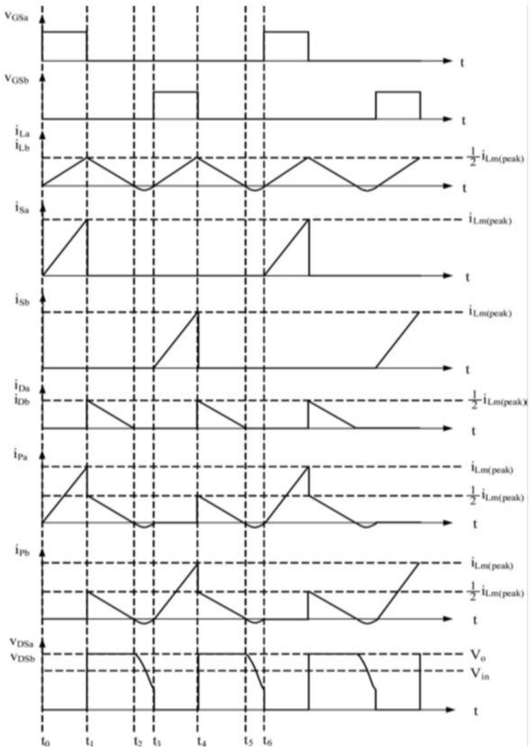

Fig.3. key Waveforms Of proposed topplogy

Operating Mode 1: $t_0 < t < t_1$

Operating Mode 2: $t_1 < t < t_2$

Operating Mode 3: $t_2 < t < t_3$

Mode 1: Conduction period between t_0 to t_1

From the following figure Fig.4. it is inferred that initially module A is in the operating condition where switch S_a is conducting. The input voltage is V_{in} hence when this input voltage flows in the circuit the diodes D_a and D_b gets reversed biased, with a gradual increase in the inductor current i_{La}. The input voltage V_{in} flows through the winding N_{pa}. Whereas on the other side in module B, same input voltage V_{in} flows through the winding N_{pb}. There is same voltage flowing through both the windings N_{pa} and N_{pb} are coupled to the same magnetic core. The coupling effect makes the inductor current i_{Lb} which gradually increases flows through winding N_{pa} also, Co is the common output capacitor, from where the load is supplied energy.

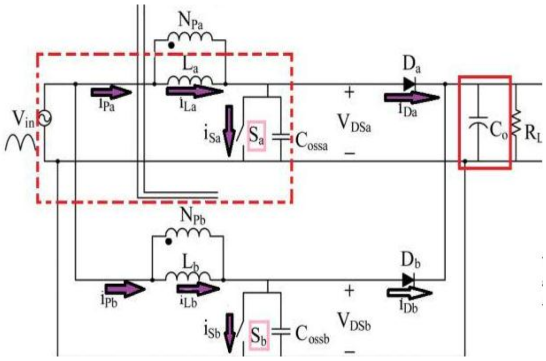

Fig. 4. Mode 1 Conduction Path

Mode 2: Conduction period between t_1 to t_2

In this mode both the switches Sa of module A and switch S_b of module B are turned off, the load receives the stored energy from the inductor L_a and the common capacitor C_o. both the windings Npa and N_{pb} have same voltage (V_o-V_{in}). There is a linear decrease in both the currents i_{La} and i_{Lb}.

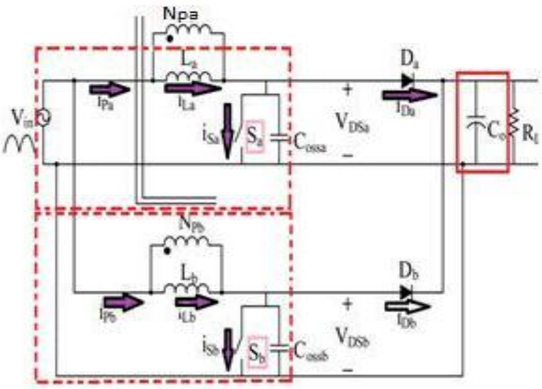

Fig. 5. Mode 2 Conduction Path

Mode 3: Conduction period between t_2 to t_3

In this mode, the Zero Current Switching technique (ZCS) is used for the turning off of the diode D_a, the current i_{Lb} reduced to Zero as ZCS is used to turn off diode D_b. Through the quasi resonant valley switching switch S_b is turned on. In this mode only both the capacitors C_{ossa} and C_{ossb} starts to resonate.

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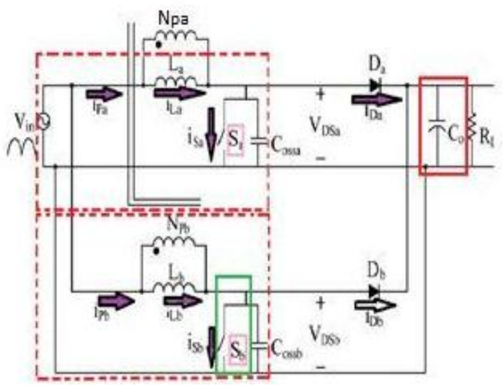

Fig. 6. Mode 3 Conduction Path

IV. RESULTS & DISCUSSIONS

Given below are the graphs relating to the input and output current and voltage of the proposed technique :

1) Line voltage: V_{in} rms = 90 Vac-264 V_{ac}
2) Output dc voltage: V_o= upto380 V_{dc};
3) Rated output power: Po (rated) = 200 W;
4) Maximum duty cycle: D_{max} = 0.35;
5) Minimum switching frequency: f_s(min) = 40 kHz;
6) Maximum switching frequency:f_s(max) = 110 kHz;
7) Conversion efficiency: η = above 94%
8) Winding turns: NP_a = 25, NP_b = 25;
9) Inductances: L_a = L_b= 320 μH;
10) Switches Sa and Sb: Infineon 11N60C3
11) Capacitors: C_{in}=1μF
C_{out}=220μF
C_{ossa}=C_{ossb}=38pF
12) Resistors: R_s=5mOhm

RESULTS:

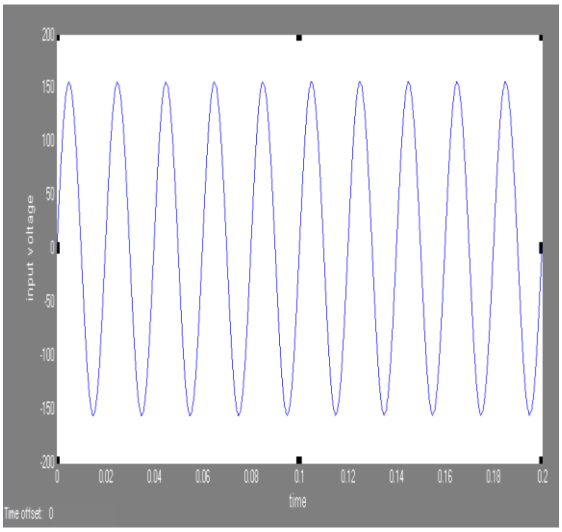

Fig 7 input voltage

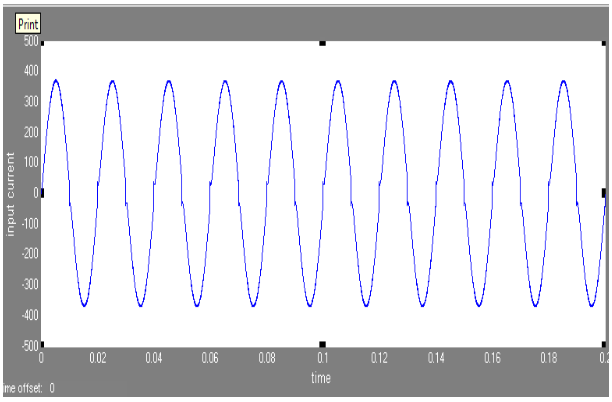

Fig 3.16.2 input current

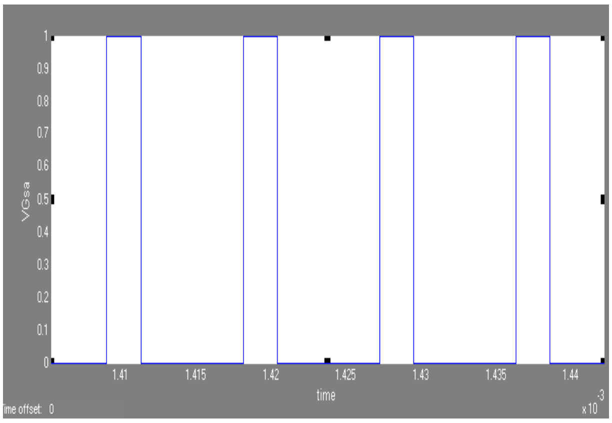

Fig 8 triggering pulses (VG_{sa})

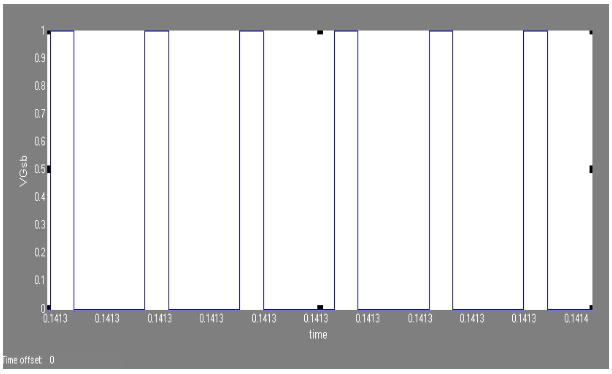

Fig 9 triggering pulses (VG_{sb})

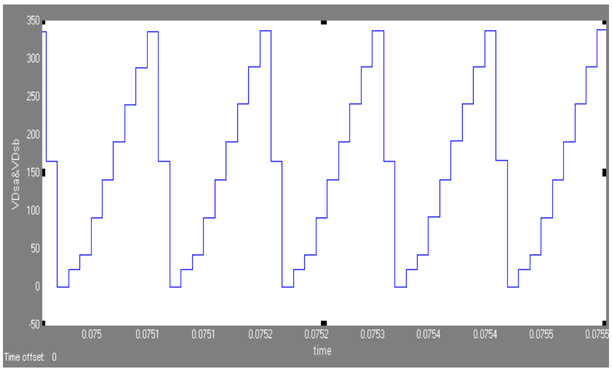

Fig 10 Diode Voltages (VD_{sa}&VD_{sb})

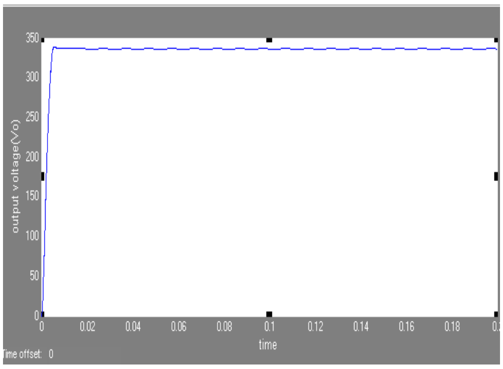

Fig 11 output voltage (V_o)

I/P Current Distortion

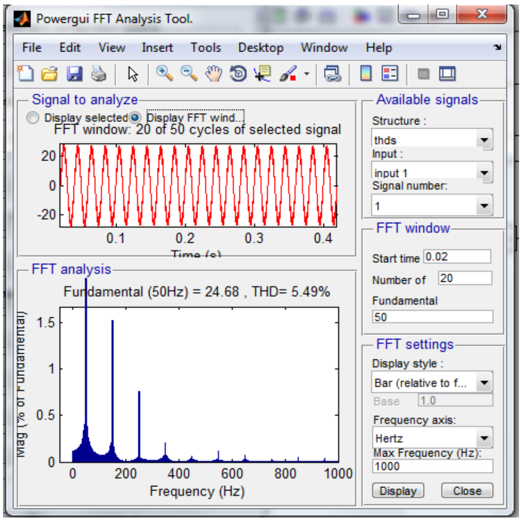

Fig 12 I/P Current Distortion

V. CONCLUSION

The design of proposed push-pull quasi resonant boost power factor corrector is shown here. The advantages of push pull quasi resonant boost power factor corrector when compared to its conventional circuit is that the efficiency of the conventional circuit is 31.25% whereas that of push pull converter is98%. In this paper it is also presented that the diameters of the windings are reduced due to the cut-in-half duty cycle. Using the ZCS technique and the quasi resonant valley switching formed due to the resonant circuit the switching losses are reduced. The push pull quasi resonant converter acquires highest power density along with reduced copper loss and conduction loss. Due to these important features of push pull converter it is being used in wide variety of applications such as electronic ballast, railway traction drives and battery charger.

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