Active Power Factor Correction for AC-DC Converter with PWM Inverter for UPS System

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Abstract—Power factor and harmonics are very important in power system. Low power factor and high THD affects the system efficiency, to improve this with the help of advanced power electronics devices, different PFC topologies are implemented for the ups system. Pf is improved by auxiliary winding of the fly back converter, dc-dc converter is operated in high switching frequency input current conduction angle is increased and the harmonics is reduced. In this paper low THD high efficiency, high power factor, less size are achieved. The developed topology is simulated in MATLAB/Simulink 2013 software and results are obtained.

Keywords: PWM inverter, Battery, UPS, PFC, AC DC converter

I. INTRODUCTION

Ups is a backup protection for the loads, when the input supply fails to provide the load, battery feeds the load. ups plays very important role in the areas of telecommunication, hospitals, residential , educational organizations. No interruptions in the power supply the main advantage of ups. It is classified as (1) static and (2) rotary ups.

Static ups: controlled by the operator or crew.

Rotary ups: controlled by the machine’s.

Static ups classification
- Off line
- Stand by
- Line interactive
- On line
- Delta conversion.

A. On line ups:

In this on line ups ac power supply is fed continuously to the battery and the load. Battery is continuously charged, when the input supply fails, the battery supply to the load. Fig 1 shows online ups, it mainly provides protection for sag, swell, over voltage, frequency variation etc. in this three operating modes are there

1) Normal Mode:
In this battery and load continuously ac supply is fed.

2) Battery operating mode:
In this battery discharges through the single phase full bridge inverter to the load

3) By pass mode:
In this when the maintenance is required ac supply is directly fed to the load.

Fig. 1: On Line Ups

When the supply is turned on initially it is given to the ac dc converter, in this ac to dc converter diode bridge rectifier is used the dc output contains many ripples and this is the causes for low power factor, so in this PFC circuit is added the dc supply is fed to the dc-dc fly back converter. The dc supply charges the battery and the dc supply is converted in to ac with the single phase full bridge PWM inverter to the load. The controller used in this is pi controller.

II. POWER FACTOR CORRECTION FOR SINGLE PHASE AC DC CONVERTER

Power factor is a measure of how much efficiently power has been consumed. Diode bridge rectifier is used to convert ac dc supply; dc supply consists of high in ripple content and harmonics.

Fig. 2: Ac Dc Converter

The existing system consist of two stage power factor correction in this two controllers are required to control the pfc and dc supply, cost is very high and requires large space even though the efficiency is high. To overcome this different topologies for single stage power factor correction has developed, the advantage of single stage is only one controller is required to correct power factor and for dc-dc converter and requires less space ,less cost , only one MOSFET switch is required to control it.

Fig. 3: Single Stage Pfc
This single stage pfc circuit operates in dcm mode, this will give low THD

III. PFC CIRCUIT OPERATION

In the proposed circuit ac supply is given to the diode bridge rectifier it converter ac dc supply to reduce the ripple pfc cell and dc-dc cell is used, it consist of Lb boost inductor bulk capacitor Ca bulk capacitor and L3 auxiliary winding. Cb provides intermediate dc bus voltage, discontinuous input for the fly back converter, the transformer used is of 3 winding.

Dc converter operates at high frequency pulsating source, capacitors are assumed to be high so that voltage would be constant.

Assuming all power electronics devices are ideal, operation is analyzed with dcm mode, the operation is explained in four stages, current across LB, IM and output diode are zero at the beginning of each switching period, average capacitor voltage Vca greater than the average input voltage, turns ratio of transformer is N1/N3 ≥ 2 and Lb < Lm, operation is analyzed in steady state.

A. Stage1:0-11:

Switch is turned on at zero instant both the diodes are zero, Vcb discharges through the Lm which causes Lm increases current across Lm is

\[ i_m = \frac{V_{CB}}{L_m} (t_o - t_1). \]

As the diode is off boost inductor charges through supply voltage current across this increases from zero it is known that PFC cell operates in dcm mode. Inductor current Lb is equal to –I3 capacitor Ca charges, Do is turned off output capacitor discharges through the load. Current across

\[ i_{LB} = \frac{[V_{IN} + (N_1/N_3)V_{CB} - V_{CA}]}{L_B} (t_o - t_1) \]

B. Stage 2: 11-12:

Switch is turned off both the diodes are turned on, due to the energy stored in the magnetizing inductance Lm it discharges, fly back transformer through the secondary winding feeds through the load. ILB linearly goes to zero. Capacitor Ca discharges to dc bis capacitor Cb; Current across auxiliary winding changes its direction

C. Stage 3:12-13:

Current across Lb reaches to zero, capacitor Ca completely discharges to the dc bus capacitor Cb, magnetizing inductor Lm de-energizing all its stored energy to the load and current Im and I2 reaches to zero level because it operates in DCM.

D. Stage 4: 13-14:

Magnetizing inductance and current across the output diode reaches to zero, D1 in forward bias capacitor Ca still releases energy. This stage ends when Ca completely discharge.
IV. PWM INVERTER

Inverters are mainly used for conversion of DC to AC supply. It is classified as (a) Single phase (b) Three phase. Single phase inverters: (1) Half bridge. (2) Full bridge.

A. Single Phase Full Bridge Inverter:

To achieve both positive and negative half cycles of AC power supply this inverter is used, it mainly consist of a battery or a dc voltage source and MOSFET or IGBT switches.

Battery: It stores and discharges the DC power supply. It can be configured in series or parallel connection; different types of batteries are available depending on the requirement or applications.

B. PWM (Pulse Width Modulation):

Most of the inverters uses PWM technique for the operation of switches, in this it compares reference signal with a triangular signal, the obtained output is a quasi square wave, to make it as a pure sine wave L C filters are used.

C. Operation of Single Phase Full Bridge Inverter:

When dc supply is connected across the, switches Q1 and Q4 turns on, through the load for one half cycle (0-180) for then next half cycle i.e (180-360) switches Q2 and Q3 turns on.
C. Complete Simulation of the Topology:

VI. EXPERIMENTAL VERIFICATION

This simulated circuit has been implemented in hardware, the hardware mainly consist of diode bridge rectifier, boost induction, bulk capacitor, fly back transformer, intermediate dc bus voltage capacitor, battery, inverter, step down transformers for the driver circuit and micro controller.

VII. FUTURE SCOPE

Multi input can be operated of the ups system i.e. solar PV cell, Wind turbine can be fed to the battery when ac supply does not provide the load. Soft switching can be used for inverter to reduce switching loss and stress.

VIII. CONCLUSION

In this paper power factor is improved and harmonics is reduced with the proposed topology, efficiency is increases and require very less space for single stage PFC circuit. PI controller is used for the closed loop operation.

REFERENCES


