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POWER FACTOR CORRECTED ZETA CONVETER WITH IMPROVED POWER QUALITY SWITCHED MODE POWER SUPPLY

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Abstract: Multiple-output Switched Mode Power Supplies (SMPSs) for personal computers (PCs) normally depict extremely bad power quality indices at the utility interface such as total harmonic distortion of the input current being more than 80%, power factor being lower than 0.5 and output voltage regulation being very poor. They violate the limits of harmonic emissions set by international power quality standards. In this paper, a non isolated power factor corrected (PFC) converter is being proposed to be used at the front end to improve the power quality of an SMPS for a PC. The front-end converter is able to reduce the 100-Hz ripple in its output that is being fed to the second stage isolated converter. The performance of the front-end Zeta converter is evaluated in three different operating conditions to select the best operating condition for the proposed SMPS system. The performance of the proposed SMPS is simulated and a laboratory prototype is developed to validate its performance. Test results are found to be in line with the simulated performance under varying input voltages and loading conditions and all the results demonstrate its enhancedperformance.

Index Terms— SMPS, Point of Common Coupling & Continuous Conduction Mode

1. INTRODUTION

In the present era, personal computers (PCs) have become apart of our day-to-day activities from business toeducation to infotainment. Switched Mode Power Supply (SMPS) is an integral part of the computer that converts ac to multiple numbers of suitable dc voltages to impart power to different parts of the PC. It contains a diode bridge rectifier (DBR) with a capacitor filter followed by an isolated dc-dc converter to achieve multiple dc output voltages ofdifferent ratings. The uncontrolled charging and discharging of the capacitor result in a highly distorted, high crest factor, periodically dense input current at the single phase ac mains; this violates the limits of international power quality (PQ) standards . the neutral current in the distribution system increases if these PCs are used in large numbers which creates serious problems like overloading the neutral conductor, noise, de-rating of the transformer, and voltage distortion .To end these problems, improved PQSMPSs

that are capable of drawing a sinusoidal input current at unity power factor (UPF) and yielding stiffly regulated output voltages,are extensively being researched. Employing various power factor corrected

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(PFC) single- stage and two-stage converters effect a perceivable PQ improvement in these SMPS.PQ improvement is visible in the form of low total harmonic distortion (THD) in the ac mains current and power factor being close to unity at the point of common coupling (PCC).This is achieved even under varying loads and supply voltage conditions. In a single-stage SMPS, ac supply is connected to a DBR whose output is processed by a multi-output PFC isolated dc-dc converter for obtaining dc voltages. The reliability of this single-stage SMPS is good. however, the output capacitors usedare of very high value to reduce the 100 Hz ripple content. So, the rating of any single-stage SMPS is limited to about 200W to avoid prohibitively high capacitance value. For medium power ratings, two-stage SMPS is a commonly accepted solution in the SMPS market for PCs. The first stage is meant for improving the power quality at the PCC and for providing regulated dc output voltage to the isolated (second)stage. The selection of operating mode of the front-end converter may be in Discontinuous Conduction Mode (DCM) if the cost is a major consideration; if not, Continuous Conduction Mode (CCM) is adopted that reduces device stresses, despite the fact that CCM uses two voltage and one current sensors which naturally makes it costlier. Therefore, a DCM operation of the front-end PFC converter is preferred in PCs where only one voltage sensor is needed for sensing and control. A boost converter is a common choice as a PFC in various industrial applications. However, it cannot be used if a wide range of ac mains voltage is to be taken care of. Similarly, due to limited output voltage range buck converters are not preferred for computer power supply.Nonisolatedbuckboost PFC converter configurations are the best suited for maintaining a constant dc output voltage irrespective of wide variations in ac supply voltages. Different buck-boost converters configurations and their application to SMPS are reported in the literature. A conventional buck-boost converter has a low component count. However, the output current is pulsating in nature which increases the ripple in voltage. The buck-boost Cuk converter is not preferred due to the polarity of the output being reversed which gives rise to various design issues. SEPIC also depicts a pulsating output current. As the output stage of the power supply is very sensitive, this pulsating current is not desirable. The flyback converter suffers from leakage inductance problem which imposes a limit on its rating. To eliminate these issues, a Zeta PFC converter is employed as a PFC converter in many research papers. It provides a continuous output current with a low ripple output voltage along with a high level performance which is highly recommendable for PCs. The dynamic modeling of the Zeta converter is carried out using state space averaging technique in. The suppression of lower order harmonic content leadsto reduction in EMI of a PFC ac-dc converter operating in DCM . This paper introduces a design, analysis, simulation and improvement of power factor (PF) multiple output Switched Mode Power Supply (SMPS) using a bridgeless non buck-boost DC- DC converter is used as the first stage. The first stage buck-boost converter is designed in Discontinuous Conduction Mode(DCM) for inherent power factor correction (PFC). Comparing with conventional topologies the proposed topology reduces conduction losses and improves power quality. Both simulation and experimental results demonstrate the improved performance of the proposed SMPS. This paper reports the converter topologies which are employed for better Power Factor Correction at the input side. The Power Factor Correction is an important factor when considering the Power Quality. Based on the converter topologies, the Bridgeless converters are preferred in order to reduce the number of switching devices, losses associated with it and improve the Power Quality further more. This paper investigates about the Power Factor performances and conduction losses of the Bridgeless Power Factor Corrector Converters which see through the benefits and limitations by analyzing the Bridgeless Buck-Boost Converter, Bridgeless SEPIC converter and Bridgeless CUK

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converter. The resultant voltage is fed to the BLDC motor which is rapidly replacing the Induction motor for its better operating characteristics. These strategies are being analyzed using the MATLAB/Simulink software and the results are verified through the experimental analysis. The converter choice is preferred through the performance characteristics and Power Factor Correction at the supply. The Power Factor obtained should be within the acceptable limits under IEC 61000-3-2 standards.

2. CONVERTERSYSTEM

A zeta converter is an electronic circuit which converts a source of direct current (DC)from one voltage level to another. It is a Switched DC - DC converter which provides a regulated and stepped up output voltage. It is widely applied to maximize the energy harvest for photovoltaic

systems and for wind turbines, hence they are called power optimizers. In this paper, ZETA converter is designed controlled using a PI controller and the corresponding output response is simulated using MATLAB software. Also the response of ZETA converter when it is subjected to line and load variations is simulated. The benefits of the ZETA converter over the SEPIC converter include lower output-voltage ripple and easier compensation. The ZETA converter topology provides a positive output voltage from an input voltage that varies above and below the output voltage. The ZETA converter needs two inductors and a series capacitor, sometimes called a flying capacitor. Unlike the SEPIC converter, which is configured with a standard boost converter, the ZETA converter is configured from a buck controller that drives a high-side PMOSFET. The ZETA converter is another option for regulating an unregulated input-power supply, like a low-cost wall wart. To minimize board space, a coupled inductor can be used. The proposed drive system is designed for zeta converter as PFC converter fed SMPS operating in . The output inductor value is selected such that the current remainsdiscontinuous is a single switchingcycle.

3. DESCRIPTION

The ZETA converter topology provides a positive output voltage from an input voltage that varies above and below the output voltage. The ZETA converter needs two inductors and a series capacitor, sometimes called a flying capacitor. Unlike the SEPIC converter, which is configured with a standard boost converter, the ZETA converter is configured from a buck controller that drives a high-side PMOSFET. The ZETA converter is another option for regulating an unregulated input-power supply, like a low- cost wall wart. To minimize board space, a coupledinductor can be used. Similar to the SEPIC DC/DC converter topology, the ZETA converter topology provides a positive output voltage from an input voltage that varies above and below the output voltage. The ZETA converter also needs two inductors and a series capacitor, sometimes called a flyingcapacitor.UnliketheSEPICconverter,whichis

configured with a standard boost converter, the ZETA converter is configured from a buck controller that drives a high-side PMOS FET. The ZETA converter is another option for regulating an unregulated input-power supply, like a low-cost wall wart. This article explains how to design a ZETA converter running in continuous-conduction mode (CCM) with a coupled inductor**.** When the switch S is "on", and the diode D is "off". This region takes the time from 0 to d1 TS seconds. The inductor Lm stores the energy received from the rectifier. The capacitor C1 supplies energy to the load (R) via the inductor Lo, and the capacitor Co the currents through the inductors Lm and Lo increase linearly,whilenocurrentflowsthroughthediode.Whenthe switch S is "off", and the diode D is "on". This region begins at the time d1 Ts seconds, and ends by d2 Ts seconds. The diode D is forward biased due to the voltage across the inductor Lm has reversed polarity, while the currents ILm and ILo decrease linearly.

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The stored energy in the inductor Lm is transferred to the capacitor C1. The load R receives energy from the inductor Lo. Hence, the currentiD=iC1+iLo.

4. SWITCH MODE POWERSUPPLY

Switch mode power supplies (SMPSs) are used in a range of applications as an efficient and effective source of power. This is in major part to their efficiency. For anybody still working on a desktop, look for the fan output in the central processing units (CPU). That‟s where the SMPS is. SMPS offers advantages in terms of size, weight, cost, efficiency and overall performance. These have become an accepted part of electronics gadgets. Basically it is a device in which energy conversion and regulation is provided by power semiconductors that are continuously switching "on" and "off" with high frequency.A number of different design types are used. Where the input is the AC mains (line) supply the AC is rectified and smoothed by a reservoir capacitor before being processed by what is in effect a DC to DC converter, to produce a regulated DC output at the required level. Hence a SMPS can be used as an AC to DC converter, for use in many mains powered circuits, or DC to DC, either stepping the DC voltage up or down as required, in battery powered systems. The output rectification and filter are isolated from the High Frequency switching section by a high frequency transformer, and voltage control feedback is via an opto isolator. The control circuit block is typical of specialist ICs containing the high frequency oscillator, pulse width modulation, voltage and current control and output shut down sections. Whatever the purpose of a SMPS, a common feature (after conversion of AC to DC if required) is the use of a high frequency square wave to drive an electronic power switchingcircuit.

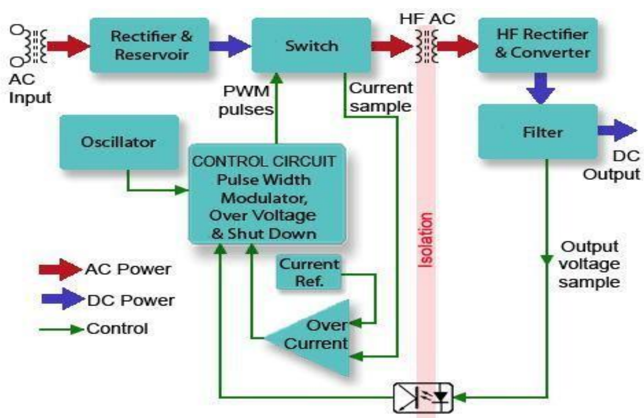

Fig 1

Whatever the purpose of a SMPS, a common feature (after conversion of AC to DC if required) is the use of a high frequency square wave to drive an electronic power switching circuit. This circuit is used to convert the DC supply into high frequency, high current AC, which by various means, depending on the design of the circuit, is reconverted into a regulated DC output. The reason for this double conversion process is that, by changing the DC or mains frequency AC to a high frequency AC, the components, such as transformers, inductors and capacitors, needed for conversion back to a regulated DC supply, can be much smaller and cheaper than those needed to do the same job at mains (line) frequency. This type of SMPS has an AC i/p and it is converted into DC by using rectifier & filter. This unregulated DC voltage is fed to the PFC circuits as it

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is affected. This is because around the voltage peaks, the rectifier draws short current pulses having significantly high-frequency energy that affectsthe

power factor to reduce. It is almost related to the above discussed converter, but in the place of DC power supply, here we have used AC i/p. So, the mixture of the rectifier &filter, this block diagram is used for converting the AC to DC and the switching operation is done by using a power MOSFET amplifier. The MOSFET transistor consumes low on-resistance & can resist high currents. The frequency of the switching is selected such that it must be kept low to normal human beings (above 20KHz) and action of switching is controlled by a feedback using the PWM oscillator. Again, this AC voltage is fed to the o/p of the transformer shown in the above figure to step up or step down the levels of voltage. Then, this transformer‟s o/p is rectified & smoothed by using the o/p filter and a rectifier. The o/p voltage is controlled by a feedback circuit by likening it with the referencevoltage.

5. DESCRIPTION

The exisiting system is a boost converter is sometimes called a step-up converter since it "steps up" the source voltage. A boost converter is a DC-DC power converter steps up voltage (while stepping down current) fromits input (supply) to its output (load). It is a class of Switched Mode Power Supply (SMPS) containing at least two semiconductors (a diode and a transisor) and at least on eenergy storage element, a capacitor, inductor or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter).The switch is typically a MOSFET, IGBT or BJT. An AC-DC Zeta converter topology is used for providing regulated DC voltage to feed the voltage source inverter (VSI) employed in the direct torque controlled PMSM drive. The proposed converter provides improved power quality in terms of low total harmonic distortion (THD), reduced crest factor (CF) of the AC supply current, high power factor of the AC mains and regulated output DCvoltage.

6. WORKING

A Zeta PFC converter is still unexplored for the development of computer SMPSs that are capable of drawing a purely sinusoidal current with unity PF, offering

low rippled output which is the prime requirement of PCs. A ZETA Converter is a non isolated power factor corrected (PFC) converter is being proposed to improve the power quality of an SMPS for a PC. It allows a regulated output voltage with only one power processing stage. Analysis of ZETA Converter operating in discontinuous conduction mode for power factor correction. All other converters corrects the power factor with intrinsic limitations except ZETA Converter. In thyristor driver circuits, appropriate control signals are used to generate gate current pulses in order to trigger the thyristor. A transformer often isolates the control circuit from the high voltages of the power circuit. .Principle of a thyristor driver circuit. The firing pulses are repeated several times in order to ensure that the pulses exceed the thyristor's latching current. The latching current is the minimum gate current required to trigger the thyristor. MOSFET and IGBT Driver Circuits IGBT and MOSFET drivers are very similar in that both components are controlled by voltage (charging the gate capacitor). The insulation between the gate and the emitter is made of thin silicon oxide. A maximum voltage of 20V to 25V must never be exceeded in order to ensure that the oxide layers remain intact. Functions of Typical Driver Circuits The diagram below shows an example of an IGBT half-bridge driver circuit.

7. SIMULATION ANALYSIS ANDRESULT

In this chapter the objective of the project is implemented through modelling of zeta converter in MATLAB

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simulink. The necessary simulation diagram and output waveform are detailed.

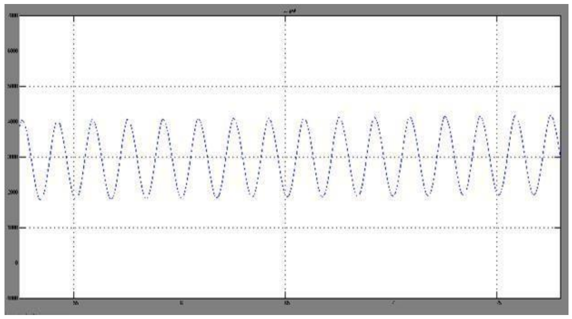

Fig 2

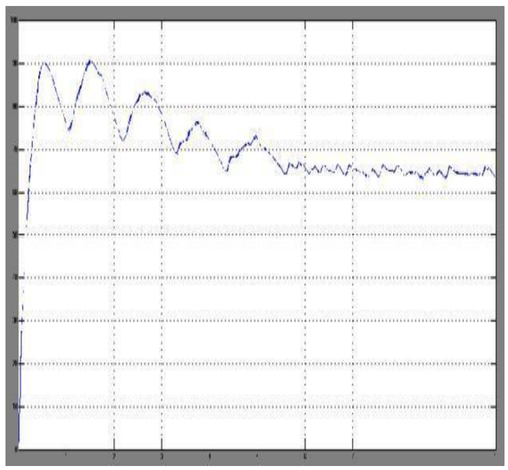

Fig 3

This N channel enchancement mode silicon gate powerfield effect transistor is an advanced power MOSFET designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation. An opto coupler is an electronic component that inter connects two separate electric circuit by means of light sensitive opticalinterface.

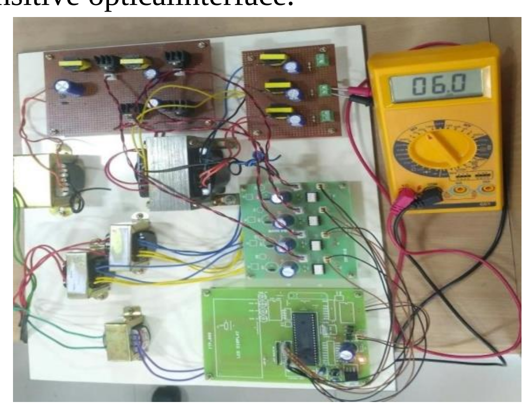

Fig 4

The first pin is the master clear pin of this IC. It resets the microcontroller and is active low, meaning that it should constantly be given a voltage of 5V and if 0 V are given then the controller is reset. Resetting the controller will bringitbacktothefirstlineoftheprogramthathasbeen burned into the IC.A push button and a resistor isconnected

to the pin. The pin is already being supplied by constant 5V. When we want to reset the ICwe just have to push the button which will bring the MCLR pin to 0 potential thereby resetting the controller.PIN 2: RA0/AN0: PORTA consists of 6 pins, from pin 2 to pin 7, all of these are bidirectional input/output pins. Pin 2 is the first pin of this port. This pin can also be used as an analog pin AN0. It is built in analog to digitalconverter.
PIN 3: RA1/AN1 :This can be the analog input 1.

PIN 4: RA2/AN2/Vref- :It can also act as the analog input2 Or negative analog reference voltage can be given to it.

8. CONCLUSION

A DCM operated front-end PFC converter cascaded with a multiple output isolated converter has been used for the design of an SMPS for PCs. It has been designed, modeled, simulated and developed for input power quality improvement and output voltage regulation. All the dc

9. REFERENCE

output voltages are regulated by controlling only one output voltage. Three different modes of operation of the front-end converter have been carried out in simulation to select the best possible operation especially based on device stresses. Finally, the best suited mode of operation for the front-end converter has been implemented in an experimental prototype. Test results obtained from the prototype conform to the ones obtained via simulations. From the recorded test results, it is evident that the proposed power supply is able to mitigate power quality problems that are present in the conventional SMPS systems. Based on these results, it is concluded that the proposed SMPS configuration in PCs is expected to yield improved THD of ac mains current.

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