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Simulation and Experimental Verification of Single Phase Unity Power Factor PWM Boost Rectifier with Improved Voltage Profile: A Review

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Abstract - PWM Rectifier is widely been used in communication, computers and industrial. One of the leading issues in line-frequency operated power converter design is how to consume power from the grid but not to return it. The Unity Power Factor (UPF) PWM has become an important design issue as a consequence of recent legislation. Central Electricity Regulatory Commission (CERC) legislation restricts the harmonic content of power supplies. One of them is international standards known as IEC61000–3–2. The advantages of UPF are more than legislative compliance. The advantages include greater efficiency, larger power density and improved power quality result in economic benefits to the electricity service provider. The goal of this dissertation is to develop a unity power factor rectifier. The motivation in developing this product was to develop a regulated power supply capable of producing power with low level of harmonic current distortion. This research involves the design of a 500W Unity Power Factor Rectifier. The converter operates at an input voltage of 100VAC and regulated output at 150VDC. This allows the converter to operate directly from a residential mains outlet. To obtain the output at low level voltage, a second-stage DC to DC converter is added. The prototypes were fully tested at different parameters to test its capabilities.

Key Words: Keywords – Switched Mode Power Supply, Unity Power Factor, Pulse Width Modulation, Total Harmonic Distortion

1. INTRODUCTION

In the present situation, the evolution of growing in computers, laptops, uninterrupted power supplies, telecom and biomedical equipment has become overpowering. Hence, the utilization of such equipment results high power consumption and small power density which provided a large market to Distributed Power System (DPS). Power conditioning; typically, rectification is essential usually for electronics equipment. Rectifier behaves as nonlinear load producing non-sinusoidal line current due to the nonlinear input characteristic. The steady growth of use of electronics equipment is become a significant problem as per the line current harmonic is concerned. Their adversative effects on the power system are acknowledged healthy. Hence fore, in three-phase systems, the neutral current magnitude increases and becomes the cause of overheating of transformers and induction motors, as well as the dreadful conditions of system voltage waveforms. There are numbers of international standards to limit the harmonic content, caused due to the line currents of equipment coupled to electricity distribution networks. Accordingly, a reduction in line current harmonics, or Power Factor Correction – PFC is vital. This idea is the inspiration to this research effort. The objective is to improve the power factor nearly unity with minimum Total Harmonic Distortion (THD).

There are two types of PFC's.

1) Passive PFC,
2) Active PFC.

For this dissertation work small EMI (LC) passive PFC and Boost Converter active PFC are presented with suitable switching control. Different conventional and nonlinear control schemes are analysed for the switching of Boost PFC Converter, which is the key to obtain power factor nearly to unity with least percentage of THD. There are some major conventional control techniques that are implemented for the dissertation work, which are;

1) Peak Current Control
2) Average Current Control
3) PI Control.

Also, for improved dynamic response and large stability range at high frequency the nonlinear controllers;

1) Dynamic Evolution Controller and
2) Sliding Mode Controller are applied.

For each case the input power factor is closed to unity and the line current waveform is observed as sinusoidal with THD percentage is in the tolerate limit.

2. LITERATURE REVIEW

The various literature associated to 'Simulation and Experimental Verification of Single Phase Unity Power Factor PWM Boost Rectifier with Improved Voltage Profile' has been surveyed in various IEEE transactions, journals, Conference papers and websites and also, their relationship with present research work.

Hitesh B Hatnapure [2017]: The main consideration of this project is to control the performance of PWM based UPFC on the bases of harmonics reduction. The proposed work is validated by using MATLAB software.

William de Jesus Kremes [2016]: This paper presents the analysis of a single-phase bridgeless SEPIC rectifier operating in discontinuous conduction mode with two

different modulation techniques. The rectifier operates with high power factor and output voltage control.

Abdelouahed Touhami [2015]: This paper proposes the Unified Power Flow Controller (UPFC) as a strong candidate to provide a full dynamic control of Power transmission operating parameters: voltages, line impedance, and phase angle under normal and fault conditions.

Geethu S Raj [2015]: In this paper Performance of a p-q theory based SAPF is analysed. Then a new improved control with p-q theory is used to improve the performance of SAPF during non-ideal grid voltage conditions and the results are compared.

Thomas Friedli [2014]: In this paper essence of Three-Phase PFC Rectifier Systems is dedicated to a comparative evaluation of four active three-phase PFC rectifiers that are of interest for industrial application: the active six-switch boost-type PFC rectifier, the VIENNA Rectifier, the active six-switch buck-type PFC rectifier, and the SWISS Rectifier.

Hassan Youness [2014]: This paper presents different multiprocessor implementations of the proportional-integral-derivative (PID) controller using two technologies: field programmable gate array (FPGA)-based multiprocessor system-on-chip and multicore microcontrollers (MCUs).

Gabriel Tibola [2013]: This paper assists the energy management and power quality issues related to electric transportation and focuses on improving electric vehicles loads connection to the grid. The control strategy is designed to prevent current harmonic distortions of non-linear loads to flow into the utility and corrects the power factor of this later.

Mohammad Mahdavi [2011]: In this paper, a new bridgeless single-ended primary inductance converter power-factor-correction rectifier is introduced. The proposed circuit provides lower conduction losses with reduced components simultaneously.

Yao Shu-Jun [2011]: This Paper Presents Unified Power Flow Controller circuit, give a simple analysis about the principle of power flow control of UPFC, and a detailed simulation model of UPFC considering the charging dynamics of its DC link capacitor is provided.

Priscila Facco de Melo [2010]: This paper proposes a high-power-factor rectifier suitable for universal line base on a modified version of the single-ended primary inductance converter (SEPIC).

M.K Yoong [2010]: In this paper regenerative mode of the motor act as a generator, it transfers the kinetic to electrical energy to restore the batteries or capacitors. Meanwhile, the brake controller monitors the speed of the wheels and calculates the torque required plus the excessive energy from the rotational force that can be converted into electricity and fed back into the batteries during regenerative mode.

3. PROPOSED METHODOLOGY

The following methodology is carried out in two stages via analysis and experimental. The analysis starts with a literature studies which are related to the thesis topic. A completed studies and investigations were carried out on the characteristic of nonlinear loads, voltage and current distortion, total harmonic distortion, power factor and active power. In the literature survey, various topologies have been evaluated which might be able to fulfill the design specifications. Based on the literature survey, two stages topology were selected for further evaluation. The first stage is the Boost converter and the second stage is the Fly back converter. After a comparison of various topologies, this Boost-Fly back topology benefits in terms of their current waveform, cost and device rating, power rating and maximum power factor achievable. To obtain unity power factor, all the odd harmonics in the input current should be eliminated as well as not producing any displacement angle between input voltage, V_{in} and input current, I_{in} meaning that the value of distortion factor and displacement power factor is equal to unity. To generate odd current harmonics represents the characteristic of a nonlinear loads, a single-phase full-bridge rectifier containing diodes was used during the experiment. A computer power supply was also used as one of the sample for nonlinear loads.

4. CONCLUSION

A new single stage power factor correction ACDC converter has been studied and analysed for operation in both continuous and discontinuous current modes. The features of the proposed converter topology confirmed by design, simulation and experimental results can be summarized by the independent and high frequency operation of the load inverter allows the design of control loops with wide band width.

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