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Analysis and Design of Single Phase Power Factor Correction using DC-DC SEPIC Converter with Bang-Bang and PSO based Fixed PWM Techniques

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Abstract— This paper presents the design and analysis of single phase Power factor correction (PFC) using DC-DC Single Ended Primary Inductance converter (SEPIC).The proposed system applies cascade approach where outer loop is implemented with Particle Swarm Optimization (PSO) tuned PI controller to synchronize the output voltage with reference voltage and inner current loop is controlled by Bang-Bang/PSO based Fixed PWM control techniques .The performance characteristics of these two approaches are analyzed by simulation results . The PSO based Control strategy yields an advantages of unity power factor (UPF) ,low percent THD(%THD), well synchronized output voltage for the variations in the line and load. It also provides efficient tracking of reference voltage compared to Bang-Bang control.

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Keywords: Power Factor Correction; Particle Swarm Optimization; Bang-Bang control; Fixed PWM technique; %THD

1.INTRODUCTION

In distributed power system, battery charging and LED applications ,a line current with large amount of pulsations is drawn from a diode full bridge rectifier. It becomes the major cause for harmonic polluted line current which in turn results deteriorated efficiency, low Power factor and increase in % THD. Some international organizations such as IEC and IEEE have defined some acceptable limits for harmonics in line current through some standards like IEC 61000-3-2 and IEEE 519 respectively [1] which has made to concentrate more on the development of PFC circuits. In order to enhance the Power factor close to unity and reduce the percentage of THD several types of Passive and Active Power factor correction schemes have been developed. Passive power factor

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correction schemes are not suitable as it is found to be expensive method due to the application of bulky components in the circuit and they can be tuned for one particular frequency. Hence, on the other hand, an adaptive PFC technique known as Active Power Factor Correction(APFC) is employed. In APFC, DC-DC Converter can be made to emulate as a resistor by operating it in high switching frequency. Moreover, the size of the reactive elements also gets reduced when operating at high switching frequency .This feature makes it to be suitable for PFC Applications. Different circuit topologies and control methods have been developed for PFC. The comparison of various DC-DC Converters such as Buck, Boost, buck-boost, Cuk, and SEPIC used for the implementation of Single-phase PFC circuits are analyzed with their merits and demerits proposed by various authors .The Buck converter based PFC described in [2] has an advantage of presence of lower content of ripples in the output voltage, but the disadvantage is the output voltage is always lesser than the input voltage. Another PFC method using boost converter is proposed in [3] which has an advantage of elimination of input filter but the disadvantages are buck operation cannot be achieved and it has more ripple content in the output voltage. PFC scheme based on buck-boost presented in [4] has the demerits of requirement of input and output filters and output voltage is inverted. The performance of fourth DC-DC Converter known as cuk converter for PFC is proposed in [5].It offers an advantage that it can either increase or decrease the output voltage but it provides the output voltage with polarity inversion. To overcome the demerits of above mentioned DC-DC converters, DC-DC SEPIC converter is chosen for PFC [6,7].It yields some major advantages like (i) both the buck and boost operations can be performed (ii) an isolation is provided between source and control side by means of the coupling capacitor. (iii)Output voltage does not have polarity inversion. It has high power density and fast transient response, when compared to other Switching converters. Although with the invent of advanced controllers for PFC, PI controller still plays a prominent role due to its rapid response for variations in load, set point and line variations. Thus it necessitates the need for better tuning method to find the Co-efficients of PI controller. Various soft computing methods such as Genetic algorithm ,Ant colony optimization ,Particle swarm optimization and Fuzzy controllers are used for the tuning of PI controller which are reported in [8-10] . Here PSO is chosen due its easier steps to arrive at the solution with fast convergence rate .Thus it is proposed to construct DC-DC SEPIC converter for PFC using PSO tuned PI controller along with Bang-Bang and Fixed Frequency PWM current controllers individually in order to analyse the performance of two techniques using MATLAB based simulation Studies.

2.POWER FACTOR CORRECTION

2.1 Power factor correction using DC-DC SEPIC converter

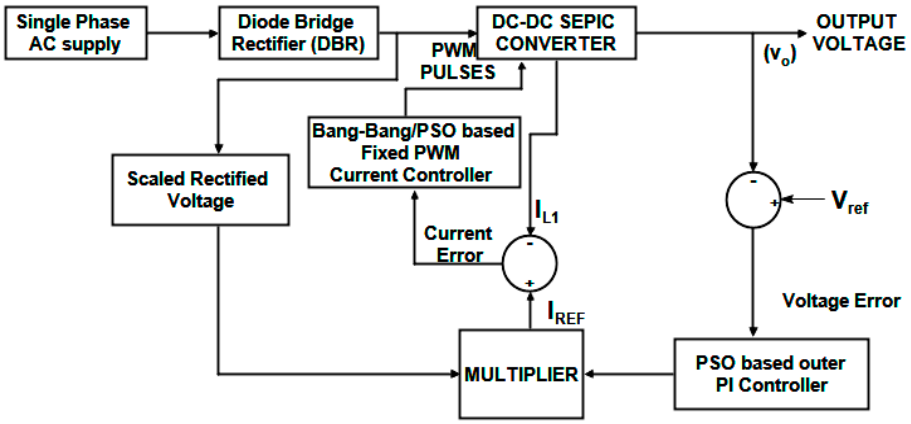

Fig.1 Proposed PFC scheme

Fig.1 shows the PFC scheme using DC-DC SEPIC converter.PFC using cascade approach has two loops, one is outer loop for controlling the output voltage and inner current loop for current control. The outer PI controller plays a major role of extracting reference current for an inner current loop. Hence it becomes necessary to apply the appropriate tuning method such as PSO to find the PI controller co-efficients. The generated reference current is then compared with an input inductor current. This current error signal is applied to Bang-Bang and PSO based