MODELING, SIMULATION AND DESIGN OF AN IMPROVED HIGH POWER FACTOR BRIDGELESS SEPIC CONVERTER

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ABSTRACT

Switch Mode Power Supply (SMPS) designs are normally have a power quality issues due to the harmonic distortion produce in the system. Therefore it is essential to incorporate a power factor correction (PFC) circuit in SMPS design. Although, the boost converter is more popular to use with PFC circuit, SEPIC converter can produce an input current with lower ripple value. However, since it involved with 4 energy storage component, a bridgeless SEPIC converter were used as the bridgeless circuit reduce the component conducted in ech switching cycle compared to conventional SEPIC. Therefore this thesis focuses on designing the bridgeless PFC SEPIC converter that operate in CCM with two types of controller. The controllers are Average Current Control Mode and Peak Current Control Mode. Simulation of the bridgeless SEPIC PFC circuit were done using MATLAB Simulink software. The results show that the Average Current Mode Control produce high power factor with low harmonic distortion compared to Peak Current Mode Control. At the end of this thesis, a suitable recommendation and suggestion were made to improve the project design.

ABSTRAK

Rekaan Suis Mod Bekalan Kuasa (SMPS) biasanya mempunyai isu dalam membekalkan kuasa yg berkualiti kerana ia sering menghasilkan herotan harmonik di dalam sistem. Oleh itu, adalh penting untuk mengaplikasikan litar pembetulan faktor kuasa (PFC) di dalam rekaan SMPS. Walaupun penukar Boost adalah lebih popular dalam proses mengimplemtasikan litar PFC, namun penukar SEPIC boleh menghasilkan arus input dengan nilai riak yang lebih rendah. Walaubagaimanapun, oleh kerana penukar SEPIC terdiri daripada 4 komponen pemyimpan tenaga, penukar SEPIC tanpa jambatan telah digunakan kerana didalam setiap kitaran litar, komponen yg digunakan adalah lebih sedikit. Dengan itu, tesis ini tertumpu kepada merekabentuk penukar PFC SEPIC tanpa jambatan yg beroperasi dalam keadaan arus berterusan (SSM) dengan due jenis pengawal litar. Jenis-jenis pengawal litar adalah kawalan secara purata dan kawalan secara puncak. Simulasi litar SEPIC PFC tanpa jambatan telah dijalankan mengggunakan perisian MATLAB Simulink. Hasil kajian menunjukkan bahawa faktor kuasa yang tinggi hasil daripada penggunaan kawalan secara purata dengan herotan harmonik yang rendah.

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LIST OF ABBREVIATIONS

AC	-	Asychrounous Current
DC	-	Direct Current
PFC	-	Power Factor Correction
SMPS	-	Switch Mode Power Supplies
SEPIC	-	Single-Ended Primary Inductor Converter
CCM	-	Continuous Conduction Mode
MDB	-	Multiplication And Dividing Block
PF	-	Power Factor
THD	-	Total Harmonic Distortion
DF	-	Distortion Power Factor
PWM	-	Pulse Width Modulation

LIST OF SYMBOLS

V_L	-	Voltage across inductor
V_{CS}	-	Voltage across series capacitor
V_{CO}	-	Voltage across capacitor output
S	-	Switch
Q	-	Power Switch
D	-	duty ratio
L	-	inductance
C	-	capacitance
R	-	load
D	-	diode

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CHAPTER 1

INTRODUCTION

1.1 Introduction and Background

Nowadays, the input of power supplies often to be an AC sources, and therefore the use of full wave rectifier is very important to convert the AC input to a DC output since many of electronic equipment use DC voltage as a power supplies. With the extensive use of electrical and electronic equipment, there is a large demand for a power supplies that draw current with low harmonic content and also have high power factor value [1].

Thus, it can be said that the AC mains utility supply is supposed to be free from high voltage spikes and harmonics. However with the use of rectifier, the resulting input current is highly non-sinusoidal which produce a high value of total harmonic distortion which leads to a disturbance that can have a bad impact on electrical and electronic circuit [2].

The large value of total harmonic distortion can be mitigated using power factor correction (PFC) circuit. There are two types of power factor correction circuits, which are active PFC and passive PFC [3]. Passive PFC consists of reactive elements that will correct output impedance at a given frequency [3]. Thus, it will only mitigate at one specific frequency and if the disturbance occurs out of the expected range, the harmonic distortion will not be corrected [3]. Differ from passive PFC, the active PFC circuit have been designed to detects the actual output impedance of the circuit and dynamically re-adjust the power factor [3]. As a result, the active PFC can mitigate the harmonic better than the passive PFC circuit.

Therefore, the active PFC circuits are preferable compared to the passive PFC circuit. Most active PFC circuit consists of a front-end full bridge rectifier followed with a DC to DC converter. Apart from that since the full bridge rectifier contribute to a high value of conduction losses, therefore the efficiency value is decrease. Hence, there are lots of effort to design and control the bridgeless power factor correction circuit in order to cater this issue. Thus, the bridgeless PFC circuit will be studied in this project and discussed in this thesis.

1.2 Problem Statements

Switch Mode Power Supplies (SMPS) is an electronic device that is widely use to convert electrical power. However it have harmonic distortions produce by main switch and leads to a disturbance. For this reason, it is desirable to design an SMPS with a unity power factor. In order to solve this problem, a power factor correction circuit is incorporated in the converter system.

There are several well-known topologies for PFC converter such as buck, boost and buck-boost converter. However a SEPIC converter is less popular topology for PFC converter design due to the complex control part where it reaches the 4th order [4].

In spite of that, the PFC SEPIC converter offer an advantage compared to 2nd order converter which it have two inductors on the same wound [4]. Consequently, it has a lower input current ripple compared to other converter topology. Thus, the bridgeless SEPIC PFC converter with a closed-loop control will be studied in this project to observe the total harmonic produce by SEPIC PFC circuit [5].

1.3 Objectives of Project

There are two objectives in this project, which are as follow:

1. To study and design bridgeless SEPIC power factor circuit (PFC) converter with a close loop controller in Continuous Conduction Mode (CCM).

2. To compare the performance of controller by using two methods which are the average mode control method and peak mode control method.

1.4 Scope of Project

The scopes for this project are as follows:

1. Study on the conventional and bridgeless SEPIC PFC converter.

2. Understand the performance of controller especially the current mode control

3. Design the closed loop compensator such that the converter operates within the desired operating condition using Matlab/Simulink.

4. Identify the effect and performance of bridgeless SEPIC PFC converter with two commonly used current control method.

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