A PASSIVE DAMPING NETWORK FOR SINGLE PHASE MATRIX CONVERTER OPERATING AS A RECTIFIER

PUTERI NOR ASHIKIN BINTI MEGAT YUNUS

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This is special dedicated to my beloved mother Suibah binti Alang Kassim , my father Megat Yunus bin Megat Ibrahim and my family for their continuous love and prayers , also to all my friends for their patient , kindness and cooperation . I wish to thanks all of you for your support
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ABSTRACT

This report presents the study of a Single Phase Matrix Converter (SPMC) operated as an AC-DC controlled rectifier driving the linear and non-linear load (constant power load). SPMC used the multiple PWM technique as its basic switching operation for synthesizing the required output. Modeling and analysis of CPL and passive damping network were conducted in detailed before been implemented in the SPMC system. The usage of LC filter at the DC side of the rectifier to generate smooth DC output creates non sinusoidal input current input containing a lot of harmonics. Passive damping network at the DC side was introduced to compensate this problem, however the system performances becomes worse if non-linear load such as constant power load is connected. The combination of modified input LC filter at the input side with the passive damping network at the DC side seems produced very good results. SPMC works well with this arrangement. A complete set of simulation results using MATLAB/Simulink to validate the analysis and design approach of SPWM were given.

ABSTRAK

Laporan ini mengemukakan kajian mengenai Penukar Matrik Satu Fasa (SPMC*)* berfungsi sebagai penerus terkawal AU-AT dalam memacu beban linear dan beban tidak linear (CPL). Bagi operasi asas, teknik gandaan Permodulatan Denyut Lebar (PWM) telah digunakan sebagai teknik pengsuisan dalam mensintesiskan keluaran yang diperlukan. Permodelan dan analisis terhadap beban tidak linear (CPL) dan rangkaian redaman pasif telah dilakukan sebelum diimplementasikan ke dalam sistem SPMC. Penggunaan penapis LC pada bahagian AT penerus dalam menjana voltan keluaran AT yang lebih licin telah menghasilkan sumber arus yang tidak sinus serta mengandungi lambakan harmonik. Rangkaian redaman pasif pada bahagian AT telah digunakan untuk mengatasi masalah ini. Walaubagaimanapun, prestasi SPMC menjadi bertambah buruk apabila beban tidak linear disambungkan. Penggunaan gabungan penapis LC yang telah diubah suai pada bahagian kemasukan bersama rangkaian redaman pasif pada bahagian keluaran AT telah menghasilkan keputusan yang sangat baik. SPMC berjalan lancar bersama susunan ini. Keputusan simulasi yang lengkap menggunakan Matlab/Simulink telah dihasilkan bagi mengesahkan keberkesanan analisa dan reka bentuk SPMC.

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LIST OF ABBREVIATIONS

AC	-	Alternating Current
DC	-	Direct Current
AT	-	Arus Terus
AU	-	Arus Ulang Alik
MC	-	Matrix Converter
SPMC	-	Single Phase Matrix Converter
IGBT	-	Insulated Gate Bipolar transistor
PWM	-	Pulse Width Modulation
BJT	-	Bipolar Junction Transistors
SCR	-	Silicon-Controlled Rectifier
MOSFET	-	Metal-Oxide Semiconductor Field Effect Transistors
THD	-	Total Harmonic Distortion
V	-	Voltage
A	-	Ampere
S 1a	-	Switch 1a
S 1b	-	Switch 1b
S 2a	-	Switch 2a
S 2b	-	Switch 2b
S 3a	-	Switch 3a
S 3b	-	Switch 3b
S 4a	-	Switch 4a
S 4b	-	Switch 4b

CHAPTER 1

INTRODUCTION

1.1 Introduction

Power electronics circuits convert electric power from one form to another form by using electronic devices. Power electronic circuits function by using semiconductor devices as switches, thereby controlling or modifying a voltage or current. Applications of power electronics range from high power conversion equipment, such as dc transmission and to low power such as power supply for notebook computers [1]. One of the new applications is an advanced circuit topology known as Matrix Converter (MC).

The MC circuit topology was first proposed by Gyugyi [2] in 1976 and offers many advantages such as the ability to regenerate energy back to the utility, sinusoidal input and output current and controllable input current displacement factor [3]. Besides, it has the potential of affording an "all silicon" solution for AC-AC conversion, removing the need for reactive energy storage components used in conventional rectifier-inverter based system. Obviously published studies mainly dealt with three-phase circuit topologies [4-6]. The Single-phase matrix converter (SPMC) was first realized by Zuckerberger [7].

Switching strategy for the four quadrant switches is the most important things of matrix converter since it will result in the input source being converted to the desired

output through matrix convertion. PWM was used as the switching technique for the four-quadrant switches. Applying the switching strategy and switching technique will produce the desired output that is synthesized from the input source of the matrix converter.

There are four types of matrix converter, which relates to the type of power conversion; DC-AC, AC-DC, DC-DC and AC-AC. Since matrix converter was originally introduced, it has received considerable attention because it offers many advantages as described above. The size of the converter is also reduced since there are no large reactive components for energy storage [8].

1.2 Converter Classification

The objective of power electronics circuit is to match the voltage and current requirements of the load to the source. Power electronics circuit convert one type or level of a voltage or current waveform to another, and are hence called *converters*. Converters are classified by the relationship between input and output [1]. The following are various types of converters that are frequently used to control electric machines.

i. **AC input to DC output**

The AC-DC converter produces a DC output from an AC input. Average power is transferred from an AC source to a DC load. The AC-DC converter is specially classified as a *rectifier*. It is used primarily to control the speed of dc motors.

ii. **DC input to AC output**

The DC-AC converter is specially classified as an *inverter*. An inverter converts a fixed voltage dc to a fixed (or variable) voltage ac

with variable frequency. It can be used to control the speed of ac motors.

iii. **DC input to DC output**

The DC-DC converter is useful when a load requires a specified (often regulated) DC voltage or current but the source at is at different or unregulated DC value. It is primarily to control the speed of dc motors.

iv. **AC input to AC output**

The AC-AC converter may be used to change the voltage level and/or frequency of an AC signal. It can be used to control the speed of an induction motor.

1.3 Objectives

The main objective of this project is to design and operate SPMC topology as a controlled rectifier which able to convert AC input signal to DC output signal. Besides, the performances of the SPMC topology when operating as a controlled rectifier driving the constant power load (CPL) will also be studied and analyzed, with the help of a passive damping.

1.4 Scope of Project

In order to achieve the objectives that have been stated, there are scopes that will be covered. Apart from converting AC input to DC output signal, the investigation also will be focused on the introduction of Passive Damping network at DC side to improve the total harmonic distortion (THD). The effects on THD over the variation of switching frequency will also be observed. After the entire element has been determined, the performance of SPMC driving a CPL will be examined.

The model of CPL was built and detailed performance of its instability characteristic is studied at different CPL power level. The performance on SPMC in term of current THD and output voltage at variable selected frequency and CPL power level also is studied. Lastly the effect on connecting a LC passive filter at the input side was observed. The investigation on the rectifier performances will be carried out using the Matlab Simulink software.

1.5 Thesis Organization

The structure of this thesis was carefully planned to give a clear explanation of the overall project. This thesis divided into seven chapters. Chapter 1 briefly explains the introduction of Matrix Converter with other types of converters. The basic theory of converters is also discussed. Chapter 2 describes the overview of a Single Phase Matrix Converter (SPMC). Chapter 3 describes more clearly the switching strategy that involve in the SPMC.

In Chapter 4, the instability effect due to source-load interaction and its analysis, as well as passive damping method are explained. Chapter 5 will discusses on the characteristic of the constant power load (CPL). In Chapter 6 brief explanations on a modelling of overall circuit and its simulations are covered. This chapter discussed on the whole system that was produced.

In chapter 7, the results obtained from the Modelling and Simulation part being compared to proceed for the conclusion and the recommended for future project was given.