HARMONIC MITIGATION IN DISTRIBUTION NETWORK RESULTED FROM NON-LINEAR LOAD AND PHOTOVOLTAIC USING ACTIVE FILTER

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DEDICATION

This project report is dedicated to my beloved father and mother, Che Ishak Bin Che Soh and Siti Sharifah Binti Awang, my husband, Muhammad Dosukey Bin Johari and my sons whom support me, physically, mentally and emotionally, throughout my Master's study.

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ABSTRACT

An electrical power system consists of generators, transmission and the distribution network. These networks will deliver power to varying the linear and non-linear loads for consumers. Usually nonlinear electrical devices cause the harmonics distortion of the output sine waveforms of source voltages and currents. Besides, the penetration of Photovoltaic (PV) into distribution increases the harmonics distortion. The equipment of electronic devices will overheat and cause malfunction if it is connected to electrical power system. Removing the harmonic pollution is crucial but it is not an easy task. Therefore, the purpose of this project is to mitigate the harmonic which is generated by Photovoltaic (PV) and nonlinear load using Shunt Active Power Filter (SAPF). This project is designed and simulated by using MATLAB Simulink software as a simulation tool. The analysis of harmonics are carried out using Fast Fourier Transform (FFT) to evaluate the Total Harmonic Distortion (THD) of the nonlinear load and Photovoltaic (PV) with filter and without filter. The results shows that the harmonic distortion is reduced by using the proposed filtering method.

ABSTRAK

Sistem elektrik kuasa terdiri daripada penjana, penghantaran dan rangkaian pengedaran. Rangkaian ini akan memberikan kuasa untuk menvariasikan beban linear dan beban bukan linear untuk pengguna. Peralatan elektrik yang bukan linear biasanya akan menyebabkan pencemaran harmonik kepada gelombang sin keluaran voltan sumber dan arus. Selain itu, penambahan Photovoltaic (PV) pada pengedaran akan meningkatkan pencemaran harmonik. Peralatan elektronik akan menjadi panas dan mengalami kerosakan jika ia disambungkan ke sistem elektrik. Menghilangkan pencemaran harmonik sangat penting tetapi ia bukan suatu tugas yang mudah. Oleh itu, projek ini adalah bertujuan untuk mengurangkan harmonik yang dihasilkan oleh PV dan beban tidak linear dengan menggunakan Shunt Active Power Filter (SAPF). Projek ini akan direka dan disimulasikan dengan menggunakan perisian MATLAB Simulink sebagai alat simulasi. Analisis harmonik akan dilakukan dengan menggunakan Fast Fourier Transform (FFT) untuk menilai harmonik beban tak linear dan PV dengan menggunakan SAPF dan tanpa SAPF. Keputusan menunjukkan bahawa pencemaran harmonik dapat dikurangkan dengan menggunakan kaedah penapisan yang telah dicadangkan.

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LIST OF ABBREVIATIONS

PV	-	Photovoltaic
DG	-	Distributed Generation
PCC	-	Point Common Coupling
APF	-	Active Power Filter
THD	-	Total Harmonic Distortion
FFT	-	Fast Fourier Transform
HVDC	-	High Voltage Direct Current
THDv	-	Total Harmonic Distortion for Voltage
THDi	-	Total Harmonic Distortion for Current
FLC	-	Fuzzy Logic Circuit
PI	-	Proportional-Integral
VSI	-	Voltage Source Inverter
AC	-	Alternating Current
DC	-	Direct Current
Vs	-	Voltage Source
SAPF	-	Shunt Active Power Filter
MPPT	-	Maximum Power Point Tracking
Std	-	Standard
HB	-	Hysteresis Band
STC	-	Standard Test Condition
CC-VSI	-	Current Controlled Voltage Source
IGBT	-	Insulated Gate Bipolar Transistor
3ph	-	Three Phase
p-q	-	Reactive Power

LIST OF SYMBOLS

Ω	-	Ohm
R	-	Resistor
L	-	Inductor
C	-	Capacitor
I	-	Current
3ϕ	-	Three phase
α	-	Alpha
β	-	Beta

CHAPTER 1

INTRODUCTION

1.1 Project Background

These days, power quality in electrical energy is getting more increasingly importance in electrical global. Power quality is referred to maintain the sinusoidal wave from supply. The waveform is pure and free from the distortion [1].

In the digitalization revolution, the power quality and power supply are major issue in power system. To resolve this problem, the Distribution Generation (DG) is connected to the grid to generate the power. The photovoltaic (PV) generation is one of the popular DG because it has the more productive and generate the no pollution energy [2] .

Basically, the harmonic distortion in the distribution network is the root effect of power quality issues. The definition of the harmonics is a sinusoidal part of the quantity having a frequency that is the integral multiple of the fundamental frequency [3]. Several non-linear loads, such as fluorescent light, arc furnaces, rectifiers, etc., produce this harmonic [4]. In addition, the connection distribution network also become the other power quality issues. These issues are voltage sell, voltage swell, oscillations in network others [5][6].

Increasing the current harmonic in the system that exceeds the limit defined in the IEEE 519 standard can affect the voltage of the system and cause problems with the operation of the system, such as overheating, control system failure, and the behaviour of the safety device connected to the system. Harmonic is not a concern until they have reached the normal limit.

To mitigate issues caused by harmonics distortion, some filter components are used inside the system. The passive filters were the most common method is used to remove the harmonic distortion which ease of operation and the costing is cheaper. However, the passive filters have a few issues such as large size, the impedance of the source affects the filtering characteristic, resonance, etc [4] [7].

1.2 Problem Statement

The implementation of non-linear loads and DG based on PV produces harmonic current and increases the degradation of device voltage and waveforms of current. Therefore, harmonic in network need to be reduced. Passive filter was commonly used. However, passive filters have serious drawbacks likes their failure to compensate for spontaneous harmonic current variance, built for a particular frequency only and the risk of the Point Common Coupling (PCC) resonance, issues with tuning, and overloads of filters.

In this project, the Shunt Active Power Filters (SAPF) is used as the filtering method to overcome these issues. The SAPF was used to compensate the utility line current waveform. Besides, the SAPF can reduced the damping, reduced the voltage-flicker, providing isolation and others [4]. Besides, the APF can be used the p-q method as the current control strategy, which was to removing the harmonic from power system.

1.3 Objectives

The main purpose of this project is to decrease harmonic distortion. Therefore, the objectives of this project are:

(a) To analyze the impact of non-linear load and PV on the distribution network harmonic.

(b) To mitigate harmonic in the distribution network using SAPF.

(c) To evaluate the implementation of SAPF on different conditions of distribution network.

1.4 Scope of Work

The aim of the project is to mitigate harmonic in the distribution network with the present non-linear load and PV as the DG. The scope of this project as shown below:

(a) IEEE 15-bus distribution system is used as the distribution network. The system is fed from a utility supply at 11 kV at bus 1.

(b) The 100 kW PV system is connected as DG and the size is assumed optimal.

(c) The 100 kW, 250 kW and 400 kW PV system are carried out as the multiple PV to evaluate the THD.

(d) MATLAB Simulink is used as a platform for the simulation tool in this project.

Waveform and FFT analysis are measured at PCC.

1.5 Significant of Contribution

This project used the Shunt Active Power Filter to mitigate the harmonic for linear and non-linear load (with and without PV). Besides, the different number of non-linear load and PVs also carried out in this project.

1.6 Organization of Report

In general, this project report consists mainly of five chapters, which are Introduction, Literature Review, Methodology, Result and Discussion and Conclusion of the project.

In chapter 1, this report is explained the main aspect of the research work such as project background, problem statement, objectives, scope of work and the organization of report for this project.

Chapter 2 is discussed about literature review that associate with this project. The sources of the information had been obtained from books, journals, research papers and thesis.

Chapter 3 is discussed the methodology used in this project. It is explained clearly and details about how this project was carried out. Besides, this chapter is reviewed about the designation of method.

Chapter 4 is showed the simulation of analysis and results of the project and brief discussion on the results obtained.

Chapter 5 is the conclusion of the whole project and future works suggestion based on the finding of the results is conducted.

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