POWER QUALITY IMPROVEMENT USING UNIFED POWER QUALITY CONDITIONER (UPQC)

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DEDICATION

This project report is dedicated to my parents and my fellow family.

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ABSTRACT

The purpose of this project is to evaluate the effectiveness of control strategy of Unified Power Quality Conditioner (UPQC) in order to improve power quality problem in distribution system specifically harmonics distortion. The performance of UPQC system controlled by Fuzzy Logic Controller (FLC) is compared by Proportional Integral (PI) controller. The control strategy depends on d-q transformation both shunt active filter and series active filter, phase-locked loop synchronization and constant dc-link voltage. The capability and performance of FLC and PI controller under non-linear load is demonstrated using test models built in Matlab / Simulink software. Simulation result is depicts the reliability of Fuzzy Logic Controller in reducing harmonics distortion in comparison with PI controller. The equipment is designed to have potential in reducing total harmonic distortion to values within the prescribed criteria set by IEEE standards.

ABSTRAK

Projek ini dilaksanakan bertujuan untuk menilai tahap kecekapan kaedah kawalan yang digunapakai oleh Penyesuai Kualiti Kuasa Disatukan (UPQC) dalam menangani masalah Kualiti Kuasa pada sistem agihan terutamanya gangguan daripada harmonik. Keupayaan UPQC yang dikawal oleh Pengawal jenis Logik Kabur (FLC) dibandingkan dengan Pengawal jenis Pengamiran Kadaran (PI). Strategi kawalan adalah bergantung kepada kaedah transformasi d-q yang diaplikasikan untuk kedua-dua jenis penapis iaitu Penapis Aktif secara Sesiri dan Penapis Aktif Selari, kesinambungan Gelung Terkunci Fasa, dan voltan pautan dc yang tetap serta malar. Kebolehupayaan serta prestasi pengawal FLC dan PI apabila disambungkan dengan beban tidak linear adalah dinilai dan diukur dengan menggunakan model litar ujian yang direkabentuk melalui perisian Matlab / Simulink. Keputusan simulasi menunjukkan kebolehupayaan Pengawal jenis Logik Kabur yang lebih berpotensi mengurangkan gangguan harmonik jika dibandingkan dengan pengawal jenis PI. Peranti yang dicadangkan berkeupayaan untuk mengurangkan keseluruhan gangguan harmonik kepada sistem kuasa berdasarkan nilai bacaan yang dibenarkan oleh ketetapan piawaian IEEE.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABREVIATIONS

APF	-	Active Power Filter
ANN	-	Artifial Neural Network
CPD	-	Custom Power Devices
CSI	-	Current Source Inverter
d	-	Direct or real
d-q-0	-	Transformation direct-quadrature-zero transformation
DC	-	Direct Current
DSTATCOM	-	Distribution Static Compensator
DVR	-	Dynamic Voltage Restorer
FFT	-	Fast Fourier Transform
FLC	-	Fuzzy Logic Controller
FOC-IM	-	Field-Oriented Control Induction Motor
IEEE	-	Institute of Electrical and Electronic Engineers
IEC	-	International Electrotechnical Commision
IGBT	-	Insulated Gate Bipolar Transistor
K	-	Gain
Ki	-	Integral
Kp	-	Proportional
LPF	-	Low Pass Filter
NB	-	Negative Big
NS	-	Negative Small
PCC	-	Point Common Coupling

PI	-	Proportional Integral
PLL	-	Phase Locked Loop
PB	-	Positive Big
PQ	-	Power Quality
PS	-	Positive Small
PV	-	Photo-Voltaic
PWM	-	Pulse Width Modulation
Ref	-	Reference
SLG	-	Single Line-to-Ground Fault
THD	-	Total Harmonic Distortion
UPQC	-	Unified Power Quality Conditioner
VSI	-	Voltage Source Inverter

LIST OF SYMBOLS

A	-	Ampere
ce	-	Change in error
e	-	error
I_L	-	Load Current
kV	-	kiloVolt
kW	-	kiloWatt
L	-	Inductor
V_L	-	Load Voltage
V_S	-	Source Voltage
X	-	Inductance
X/R	-	Ratio of total inductive reactance to its total resistance
Y	-	Star
Z	-	Impedance
Δ	-	Delta
μ	-	Micro
π	-	Pi
ω	-	Omega

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Power Quality (PQ) problem in power distribution system namely harmonics, voltage sags and swells are the major concern with increased usage of sensitive load connected to power system line as well as integration of renewable energy source such as solar energy and wind power to the grid. System experienced disturbance in grid voltage such as increased value from nominal source voltage due to intermittent nature of renewable energy (RE) source. The disturbance occurs when rising amount of RE generation and connected demands of loads is decreased. (Devassy S. and Singh. B, 2012). Interruption and disturbances in power supply affect all type of consumer including domestic, commercial and in particularly industrial customers. Impact on financial losses is main factor to control for industry player. In the recent years, people awareness towards power quality improvement have actuate the evolving of power system. Customers demands the reliability of delivered power from utility as smooth as supply power from source system.

Institute of Electrical and Electronics Engineers (IEEE) defined Power Quality (PQ) as “the concept of powering and grounding sensitive electronic equipment in a manner suitable to the operation of equipment”. In other words, it defines as “the ability of electrical equipment to operate in satisfactory manner, given proper care and maintenance and without adversely affecting the operation of other electrical equipment connected to the system.” (T.Gonen,2014). This experiences to the possibility of disturbance in sinusoidal waveform deviation of power system supply voltage or load current quality. The common issue related to PQ in power system are current and voltage harmonic. Impact of these issue encounter large amount of financial loss. Numerous research article discloses that sensitive loads experience stern impact of harmonic distortions is at the feeder of Point of Common Coupling (PCC).

In order to improve harmonics profile in the distribution system, Custom Power Devices (CPD) are introduce as customized solution to PQ issues. Enhancement of reliable power quality deliver to customers is achieved by application of CPD. It works due to capability of electronic power converters and fast adaptation of control adjustment for the electrical system.

UPQC is more advanced type of CPD combining two Active Power Filters (APFs). This device is the best CPD in dealing with distortion of load current as well as supply voltage. UPQC has advantages by providing the reactive power which required by load demands to ensure that voltage and current supply both operate in similar phase. Hence, installation of additional equipment to correct measurement of power factor is not required (P.Ram Kishore et.al, 2012). The device is adaptable to deliver its function on compensate the load and control the voltage system simultaneously

1.2 Problem Statement

The effectiveness and performance for UPQC when dealing with power quality problem is depends on reliability of different control strategies. The distortion can be eliminated by using proper control strategies and filters in both series and shunt inverter of UPQC

The capability of different type of control strategy had presented from various number of previous literature and publication. A Proportional Integral (PI) is commonly used as control strategy for power enhancement by reducing the distortion in the output power. At the same time, application of Fuzzy Logic Control (FLC) has increased in past few years because it neither needs of complex mathematical formulae nor quick processors to react. Despite of that, this method requires minimum storage of data because the function is duly on knowledge base including Membership Functions (MF's) and rules.

An operation of FLC generally based on the required number of linguistic variables. Increased number of linguistic variables resulted to increasing computational time and large number of memory space requirement. It is happened because to ensure FLC working in most efficient, large computation time is requires by the device to process each step time in order to obtained the suitable control value to the system for implement. Thus, a reduce number of large fuzzy rule base is introduced to applied in the system.

1.3 Objectives of the Project

The objectives of this project are stated as follows:

i. To study power quality problem especially harmonic distortion in the distribution system with presence of non-linear loads.

ii. To develop simulation models of UPQC controller which can be use in distribution system subject to suppress harmonics

iii. To evaluate and analyse the performance between different types of controller of UPQC (PI and Fuzzy Logic) in compliance with IEEE 519-1159 standards.

1.4 Scope of the Project

The scopes of this project are shown below:

i. Identify harmonics effect at grid line when non-linear load is connected to distribution network comprising 11kV feeder

ii. Modelling two (2) type of controller (PI and Fuzzy Logic) and evaluation of its performance is carried out using MATLAB-Simulink software. In this work, FLC with 25 rules is applied to reduce computation effort and shorten the period of processing time.

iii. Analyzing the performance of the proposed model of UPQC by testing under Single Line-to-Ground Fault

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