

# ACTIVE CURRENT SHAPING FOR BETTER UTILITY INTERFACE

A dissertation submitted to the  
Department of Electrical Engineering, University of Moratuwa  
in partial fulfillment of the requirements for the  
degree of Master of Science

by

**MATHARAGE HASATH CHANDIKA PERERA**

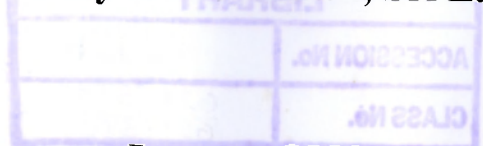


University of Moratuwa, Sri Lanka  
Electronic Theses & Dissertations  
www.lib.mrt.ac.lk

LIBRARY  
UNIVERSITY OF MORATUWA, SRI LANKA  
MORATUWA

Supervised by: Dr. J. P. Karunadasa

Department of Electrical Engineering  
University of Moratuwa, Sri Lanka



January 2009



92970

92970  
621.3 "09"  
621.3(043)  
TH

## DECLARATION

The work submitted in this dissertation is the result of my own investigation, except where otherwise stated.

It has not already been accepted for any degree, and is also not being concurrently submitted for any other degree.

***UOM Verified Signature***

M.H. Chandika Perera



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

I endorse the declaration by the candidate.

***UOM Verified Signature***

Dr. J.P. Karunadasa

# CONTENTS

Dedication .....	i
Abstract .....	v
Acknowledgement .....	vii
List of Figures .....	viii
List of Tables .....	ix

## CHAPTER I

### INTRODUCTION

1.1.Power system harmonics & effects of harmonics.....	1
1.2.Measures of harmonics.....	3
1.3.Importance of harmonic mitigation.....	3
1.4.Methods of harmonic mitigation .....	4
1.5.Active Power Filters .....	6
1.6.Objectives .....	8
1.7.Thesis Organization .....	8



University of Moratuwa, Sri Lanka  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

## CHAPTER 2

### MATERIALS AND METHODS

2.1.Acquisition of voltage and current signals of the power appliance	
2.1.1.Sample load .....	9
2.1.2.Data acquisition card .....	10
2.1.3.Hardware circuit .....	11
2.1.4.Acquisition of voltage and current signals by MATLAB.....	12
2.1.5.MATLAB Data acquisition tool box .....	13
2.2.Analysis of acquired signals using MATLAB .....	15
2.3.Determination of the appropriate filter current .....	18

2.4. Simulation to implement active power filter	
2.4.1. Circuit arrangement of the simulation .....	19
2.4.2. Simulation to obtain circuit parameters .....	21
2.5. Validation of the acquired circuit parameters .....	23

## CHAPTER 3

### RESULTS

3.1. Electrical parameters of the load	
3.1.1. Voltage signal of the sample load .....	24
3.1.2. Current signal of the sample load .....	25
3.1.3. Electrical parameters of the sample load .....	26
3.2. Required current from the filter	
3.2.1. Current of the capacitor charger .....	26
3.2.2. Filter current with capacitor charger .....	27
3.3. Simulation results	
3.3.1. Selection of the inductor .....	28
3.3.2. Selection of the step up transformer .....	31
3.3.3. Selection of the switching frequency .....	33
3.4. Validation	
3.4.1. Validation for load variations .....	36
3.4.2. Validation for supply voltage variations .....	39

CHAPTER 4

DISCUSSION..... 41

References47

Annex-1..... 48

Annex-2..... 49

Annex-3..... 50



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)



## ABSTRACT

Increased use of nonlinear electrical loads injects harmonic currents to power systems. High levels of power system harmonics create voltage distortion and enlarge power quality problems. Harmonics result in poor power factor, lower efficiency and interference to adjacent communication systems. The harmonic currents flow into the utility supply lines produces extra losses. An active power filter uses a switching inverter to produce harmonic compensating currents.

The major objective of this project was to eliminate effects of harmonics and to improve power factor of a typical nonlinear load. Attempts were made to apply active power filters for current shaping of a specific load, contrary to its common applications of applying at the point of common coupling.

The National Instruments USB-6008 multifunction data acquisition (DAQ) module was used to acquire data from the sample load viz. the computer power supply. A potential divider was incorporated to the circuit to acquire voltage signal. Current signal was acquired using a series resistor.

Filter current was implemented by switching an inductor using four insulated gate bipolar transistors (IGBT) arranged in H bridge configuration. The simulation circuit was implemented using MATLAB Simulink software tool. Inductance of the switching inductor, voltage of the step up transformer and the switching frequency of the system were obtained by simulation. Subsequently the above circuit parameters were validated for variable loads using total harmonic distortion as the discerning criterion.

It was possible to reduce THD of the current wave of computer power supply from 107% to 12%. Power factor was improved from 0.66 to unity. By increasing the power factor to unity, the current flow can be reduced by approximately 34%. The observations made herein are applicable for harmonic elimination in nonlinear loads in general with necessary modifications.



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

## ACKNOWLEDGEMENT

I am greatly indebted to my supervisor Dr. J.P. Karunadasa, Head of Department, Department of Electrical Engineering, University of Moratuwa, Moratuwa for his ever present words of wisdom. Department of Electrical Engineering, and the Department of Mechanical engineering of the University of Moratuwa, Moratuwa for providing me this immensely valuable opportunity to carry out a postgraduate project with all the facilities and guidance in a pleasant environment.

I wish to record my gratitude to the laboratory staff the Department of Electrical Engineering, University of Moratuwa, Moratuwa for the technical support in carrying out my research work. Further to the staff of the Regional support Center (Southern/Uva) of National Water supply and Drainage Board, Matara for their support.

Finally, I should thank many individuals, friends and colleagues who have not been mentioned here personally in making this educational process a success. May be I could not have made it without your supports.



## LIST OF FIGURES

- Figure 1.1: Typical arrangement of a passive filter
- Figure 1.2: Compensation characteristics of a parallel active power filter
- Figure 2.1: Hardware circuit to obtain voltage and current signals
- Figure 2.2: Schematic representation of the data acquisition using MATLAB
- Figure 2.3: MATLAB commands used for data acquisition
- Figure 2.4: MATLAB commands used for waveform analysis
- Figure 2.5: Circuit diagram of the parallel active filter
- Figure 2.6: Simulation circuit
- Figure 3.1: Voltage signal of the sample load
- Figure 3.2: Current signal of the sample load
- Figure 3.3: Current wave of the capacitor charger
- Figure 3.4: Current waveform required from the parallel active filter
- Figure 3.5: Waveform obtained for inductance of 10mH, step up voltage of 350V and switching frequency of 100kHz
- Figure 3.5: Waveform obtained for inductance of 10mH, step up voltage of 350V and switching frequency of 100kHz
- Figure 3.6: Waveform obtained for inductance of 50mH, step up voltage of 300V and switching frequency of 50kHz
- Figure 3.7: Waveform obtained for inductance of 50mH, step up voltage of 350V and switching frequency of 10kHz
- Figure 3.8: Resultant total current observed under inductance of 50mH, step up voltage of 350V and switching frequency of 100kHz
- Figure 3.9: Resultant total current observed under 50% load under selected circuit parameters
- Figure 3.10: Resultant total current observed under 160% load under selected circuit parameters
- Figure 3.11: Resultant total current observed under 90% of supply voltage under selected circuit parameters
- Figure 3.12: Resultant total current observed under 110% of supply voltage under selected circuit parameters

## LIST OF TABLES

- Table 2.1: The input range and the relevant level of accuracy
- Table 3.1: Electrical parameters of the sample load
- Table 3.2: Total harmonic distortion variation with the inductance
- Table 3.3: Total harmonic distortion variation with the step up transformer voltage
- Table 3.4: Total harmonic distortion variation with switching frequency
- Table 3.5: Total Harmonic Distortion variation for different load variation



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)