INVESTIGATION OF HARMONICS EFFECTS IN POWER SYSTEMS AND MITIGATION TECHNIQUES

A dissertation submitted to the
Department of Electrical Engineering, University of Moratuwa
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By
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Abstract

The Electrical power industry is one of the fastest growing industries in the world today. Nowadays electricity consumers are very much concerned of the quality of the supply they receive, due to increased use of sophisticated equipment in their day-to-day activities. Nature of electrical power is such that it can neither be conveniently stored in quantity nor be subjected to quality assurance checks before it is used. As such, study on Power Quality issues in power systems has become one of the most important areas in Electrical Engineering.

Among many power quality problems that prevail in power systems, Harmonic distortion continues to cause more and more problems in electrical installations due to proliferation of high power semi conductor devices and power electronics in industrial processes, and microelectronics processors in a wide range of equipment's.

This study investigates the effect of harmonic distortion in the power system and its components. Harmonic current measurements are carried out at number of different consumer installations to determine the harmonic distortion levels and contribution of harmonic distortion to their present problems. Furthermore, harmonic measurements are also carried out on some common non-linear loads and measured harmonic spectrums are compared with theoretical results.

The various harmonic mitigation techniques employed in the power system are studied, concentrating on active filters, because it has become the popular choice of many harmonic mitigation equipment manufacturers today. The different active filter control strategies are also studied and their performances are compared with real life applications. A computer model of a shunt active filter is developed and simulated in the MATLAB/SIMULINK environment.

It is concluded that the harmonic distortion level at most of the installations are well beyond the accepted international standards and the effects of harmonic distortion are investigated neither by the utility nor by the consumers. Now it is the best time to impose appropriate regulations to limit harmonic emission by individual consumers, which would be beneficial to the utility as well as to the electricity consumers.

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.

N.H.D. Wanigaratne
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LIST OF ABBREVIATIONS AND PRINCIPLE SYMBOLS

ABBREVIATIONS

AC	- Alternating Current
ANSI	- American National Standard Institute
ASD	- Adjustable Speed Drive
CEB	- Ceylon Electricity Board
CFL	- Compact Fluorescent Lamp
DC	- Direct Current
FFT	- Fast Fourier Transform
HV	- High Voltage
IEC	- International Electromechanical Commission
IEEE	- Institute of Electrical and Electronics Engineers
IFFT	- Inverse Fast Fourier Transform
IGBT	- Insulated-Gate Bipolar Transistor
IHD	- Individual Harmonic Distortion
IL	- Maximum Demand Load Current
IRPT	- Instantaneous Reactive Power Theory
ISC	- Maximum Short Circuit Current
LECO	- Lanka Electricity COmpany
LV	- Low Voltage
MCB	- Miniature Circuit Breaker
MV	- Medium Voltage
PCC	- Point of Common Coupling
PWM	- Pulse Width Modulation
RCCB	- Residual Current Circuit Breakers
RMS	- Route Mean Square
SMPS	- Switch Mode Power Supplies
SRF	- Synchronous Reference Frame
TDD	- Total Demand Distortion
THDI	- Total Harmonic Distortion-current

THDV - Total Harmonic Distortion-voltage

UPS - Un-interruptible Power Supply

VSI - Voltage Source Inverter

PRINCIPLE SYMBOLS

A - Ampere

F_p - power factor

$F_{p\,tot}$ - True power factor

$F_{p\,disp}$ - Displacement power factor

$F_{p\,dist}$ - Distortion power factor

I - Current

H -Henry

V - Voltage

P - Active power

f - frequency

f_0 - cut-off frequency

f_1 - fundamental frequency

h - Harmonic number

kVA - kilo volt ampere

kV - kilo volt

kW - kilo watt

ω - Angular velocity

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