# LOAD MODELLING AND SIMULATION OF INDUSTRIAL AND RESIDENTIAL LOAD FOR HARMONIC ANALYSIS

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*To my beloved mother, wife, daughters and son*

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# ABSTRACT

Power Quality (PQ) is a phrase normally uses to describe all aspects of events in electrical system that deviates from normal system operations. Issues regarding PQ are growing concern especially towards power utilities. The increasing numbers of sophisticated electronics equipment like high efficiency variable speed drive (VSD) and power electronic appliances in the market producing harmonics current to the network system. Harmonics current can be transmitted from one facility through the others utilities equipment to neighbouring businesses through shared networks system. Harmonics current can cause harmful effects at the main equipment on network system and will cause problems such as overheated transformers, conductors, neutral wires, nuisance breaker trips, and voltage distortion all leading to equipment malfunction or fail which translates to loss of money to power utilities and consumers. The objective of this thesis model the nonlinear based on actual load to determine the level of harmonics produce by nonlinear loads. Other than that, objective of this thesis to investigate the current harmonics produce by residential and industrial load. The loads are connected to network system based on IEEE-13 bus distribution and small scale system to determine the current harmonics characteristic in network system for residential and industrial building.The main objective of this thesis to apply the mitigation technique to reduce current harmonics by using active and passive filter. Active filter will be using STATCOM as mitigation technique. The data will be tabulate for comparison and analysis. The results current harmonic level in network system will be reduce due to mitigation techniques apply in the system.

# ABSTRAK

Kualiti Kuasa (PQ) adalah frasa yang biasanya digunakan untuk menggambarkan semua aspek peristiwa dalam system elektrik yang menyimpang daripada operasi sistem normal. Isu-isu mengenai PQ semakin membimbangkan terutamanya terhadap pihak pembekal kuasa. Peningkatan mendadak peralatan elektronik canggih seperti kecekapan tinggi memandu laju boleh ubah (VSD) dan peralatan elektronik kuasa dalam pasaran menghasilkan harmonik arus kepada system rangkaian elektrik. Harmonik arus boleh dihantar dari satu tempat melalui peralatan lain utility dan perniagaan yang lain melalui system rangkaian yang dikongsi.Harmonik arus boleh meyebabkan kesan berbahaya pada peralatan utama pada system rangkaian pengagihan elektrik dan boleh menyebabkan masalah seperti alat pengubah menjadi terlalu panas, konduktor, wayar neutral, perjalanan pemutus kacau ganggu, dan ganguan voltan, ini semua akan membawa kepada kerosakan peralatan atau gagal yang diterjemahkan kepada kehilangan kerugian kepada pihak pembekal tenaga dan pengguna. Beban akan direka bentuk berdasarkan kepada beban sebenar untuk menentukan tahap harmonik yang dihasilkan oleh peralatan. Beban disambungkan kepada system rangkaian berdasarkan IEEE-13 sistem pengagihan dan system skala kecil.Harmonik arus akan di ukur didalam system rangkaian yang menentukan dengan menggunakan perisian PSCAD / EMTDC dan akan mengurangkan dengan menggunakan penapis aktif dan pasif. Data ini akan menjadi menjadualkan untuk perbandingan dan analisis.

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| | | |
|---|---|---|
| PQ | - | Power Quality |
| VSD | - | Variable Speed Drive |
| IEEE | - | Institute of Electrical and Electronics Engineers |
| kV | - | kilovolt |
| PCC | - | Point Common Coupling |
| APF | - | Active Filter |
| PF | - | Passive Filter |
| MW | - | mega watt |
| MVA | - | mega volt ampere |
| MVar | - | mega volt ampere reactive |
| DC | - | Direct Current |
| p.u | - | per unit |
| THD | - | Total Harmonic Distortion |
| rms | - | root mean square |
| TDD | - | Total Demand Distortion |
| Xc | - | Capacitance Reactance |
| VSC | - | Voltage Source Converter |
| PFCC | - | Power Factor Capacitor Correction |

## LIST OF SYMBOLS

| | | |
|---|---|---|
| C | - | Capacitance |
| f | - | Frequency |
| F | - | Farad |
| Ω | - | Ohms |
| R | - | Resistance |
| $R^2$ | - | coefficient of determination |
| S | - | Siemens |
| X | - | Reactance |
| L | - | Inductance |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the Study

Electronics equipment or machinebecame the most important equipment to reduce or expeditethe work. This current phenomenon was increasing the numbers of sophisticated electronics equipment's through the innovation by design engineer. The most important of innovation has been discover like high efficiency variable speed drive (VSD) and power electronic controller which is has been used widely in electronics equipment's. However, this innovation was create the electromagnetic interference has heightened interest in power quality (PQ).PQa phrase normally uses to describe all aspects of events in electrical system that deviates from normal system operations. PQ is the most important characteristic explain for many types of power system disturbances such as harmonic distortion, transient voltage variations, voltage flicker and etc. Nowadays, PQ relate to harmonics has been getting more and more get attention from many researches. Many researcher focus the investigation the effect of network system performance of industrial equipment. PQ problems occur when the 50 or 60 Hertz sine wave alternating-voltage power sources is distorted. Industrial or residential have using power electronics circuit in the equipments will produce the harmonics and will affect the network system. This will cause the malfunction or overheated on the equipment.

Modern distribution system, harmonic produced by the modern home appliance such as compact fluorescent light, LCD TVs, personal computers and others electronics equipment. Nonlinear loads became to be prime sources of harmonics distortions in networks system. Harmonics current produced by non-linear loads are injected back into power distribution system through the points of common coupling (PCC) [1].Consequently, the harmonic problems were identified and treated by installing passive harmonic filters at the Point of Common Coupling (PCC) of the major distorting loads so that the filter effectiveness was easily accessed and verified [29],[30][31].Although each of the devices is not individually a large source of harmonics, the collective effect is so noticeable that the excessive waveform distortions in urban distribution systems are becoming increasingly dominated by the harmonics of residential loads [26][27].Figures 1.1 describes the load connected to a sinusoidal voltage the devices create non-sinusoidal current [4]. Current also carry the higher frequencies and distorted the sinusoidal waveform.

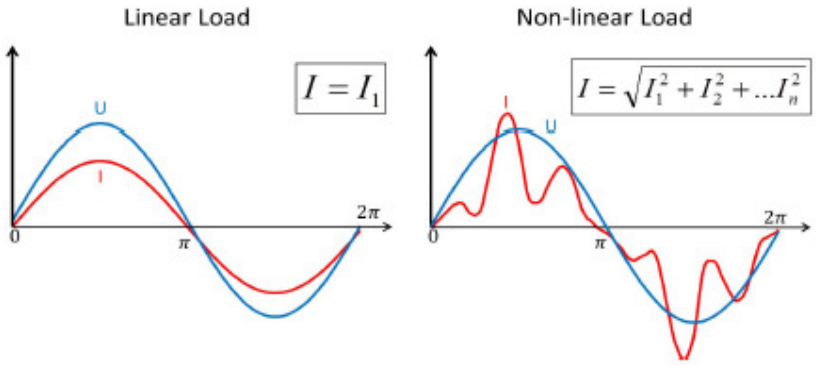


**Figure 1.1** comparison between linear and a nonlinear load in time domain

Harmonics filter has been designed to reduce or eliminate the harmonics in the system. Harmonics distortions in power distribution system can be eliminate be suppressed using two approached namely passive and active filter [1]. Passive

filtering (PF) is the simplest conventional solution to mitigate the harmonic distortion [2]. Although simple, the use passive elements do not always respond correctly to dynamics of the power distribution systems [3].Active filters (APF) is newest technology for mitigation harmonic in distribution system. APF performances are independent on the power distribution system properties [3].Some of these solutions offer guaranteed results and have no adverse effect on the power system, while the performance of others is largely dependent on system conditions.[20] Operation analysis and technical appraisal of these solutions are studied [21].

## 1.2 Problem Statement

Current harmonics can causes transformers, motor and others equipment became malfunction and power electrical network to became unstable which translate to losses of money. Current harmonics is creating by electronics equipment, variable speed drive (VSD) and power electronics controller. These types of electronic equipment will cause distorted waveforms that contains harmonic, thus affecting the power quality in electrical system. The filter is essential to be installed to filter current harmonic occurs in the network system.

This proposed method will able to reduce or eliminate of current harmonic at low voltage for residential and industry building.

## 1.3 Objectives of the Study

The objectives of this study are:

- To model and simulate the harmonic produced by nonlinear load for residential and industrial building.
- To investigate the harmonic impact from residential and industrial load.
- To mitigate the harmonic current in distribution system by using passive and active filter method.

## 1.4 Scopes of the Study

The scopes of this study are:

- Analysis will focus on residential and industrial building.
- Load modelling will be focus on television, CPU and desktop, lift, CFL Lamp and Adjustable Variable Speed (ASD).
- Mitigation method will be focus on passive and active filter and simulate by using PSCAD software.
- Current harmonics characteristic will be monitor on the low voltage system for residential and industrial building.

## 1.5 Project Report Outline

This project report consists of five main chapters which are introduction, literature review, methodology, results and discussion and conclusion.

Chapter 1 of this project report will be focused on the general briefing about harmonics, load modelling methods, total harmonics distortion and mitigation techniques. This chapter also explains the objectives, scopes of the project, problem statements and project report outline.

Chapter 2 will be more on the discussion about literature review on the harmonics, load modelling methods, total harmonics distortion and mitigation techniques. This chapter also discusses on the related works on current harmonics mitigations technique.

Chapter 3 is the methodology for this project. In this chapter, the method proposed will be explained in further details on how to model and simulate the test systems using software. This chapter also discusses on the development of load modelling using software.

Chapter 4 will be focussing on the results obtained in the chapter 3. The results will be analysed using appropriate tools. The analysis comprises of load modelling, current harmonics spectrum, total harmonics distortion (THDi), performances of mitigation techniques.

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