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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A DIAGNOSTIC OF HARMONIC SOURCE SIGNATURE RECOGNITION IN POWER DISTRIBUTION SYSTEM BY USING PERIODOGRAM

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

by

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ABSTRAK

Pengedaran voltan kepada para pengguna yang berpandukan had tertentu seperti yang dinyatakan dalam kod grid kebangsaan atau piawaian adalah kewajipan pengendali rangkaian. Kebiasaanya, kualiti elektrik yang dihasilkan oleh utiliti di loji janakuasa konvensional adalah dalam keadaan ang memuaskan tetapi apabila ia mencapai pada terminal pelanggan, elektrik tidak lagi sempurna oleh kerana gangguan dalam rangkaian pengedaran, penghantaran atau mana-mana kawasan lain. Salah satu isu utama yang berkaitan dengan sistem kuasa atau kualiti kuasa adalah gangguan harmonik yang mampu mengubah bentuk gelombang sinusoidal dari gelombang sinus yang licin ke bentuk gelombang yang terganggu yang membawa kepada peningkatan pembentukan arus, peningkatan voltan per unit rintangan wayar neutral dan pemusnahan peralatan dan konduktor akibat kewujudan lebihan arus elektrik. Pengenalpastian sumber harmonik sangat penting bagi pengawasan kualiti kuasa, terutamanya apabila masalah harmonik berlaku dalam sistem. Dalam kajian ini, kaedah yang diperkenalkan oleh Pyzalski dan Wilkosz akan digunapakai bagi mengenal pasti lokasi sumber harmonik daripada PCC. Akibatnya, lokasi pelbagai sumber harmonik diiktiraf.

ABSTRACT

Distributing a voltage to the user that ought to stay in a specific limit as stated in the standard or national grid code is the obligation of the network operator. Normally, the quality of electricity generated by the utility in a conventional power plant is excellence but when it reaches the customer's terminal, the electricity may not perfectly shaped because of the disturbances in distribution networks, transmission or any other regions. One of the main issues related to power system or power quality is harmonic disturbance which is extremely altering the shape of the sinusoidal waveform from a smooth sine wave to a distorted waveform which lead to the increment of current formation, rise of voltage per unit resistance in the neutral wire and destruction of equipment and conductors due to overheating. The recognition of harmonic source is highly crucial for power quality supervision, especially when a harmonic problem takes place in a system. In this research, the method introduced by Pyzalski and Wilkosz will be used for the identification of harmonic sources location at PCC. As a result, the location of multiple harmonic sources are recognized.

DEDICATION

To my beloved parents,
Norsham Shina M.Yunus and Shamsuri Shamsudin.

To my helpful supervisor and co-supervisor,
Sir Mustafa Manap and Sir Hatta Jopri.

To my lunatic FYP team,
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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AC	-	Alternative current
DC	-	Direct current
ESD	-	Electrostatic discharge phenomena
FFT	-	Fast Fourier Transform
HVDC	-	High Voltage Direct Current
IEEE	-	Institute of Electrical and Electronics Engineer
MATLAB	-	Matrix Laboratory
NEMP	-	Nuclear electromagnetic pulse
PCC	-	Point of Common Coupling
PU	-	Per unit
RMS	-	Root mean square
THD	-	Total harmonic distortion
UTeM	-	Universiti Teknikal Malaysia Melaka
VSD	-	Variable Speed Drives

CHAPTER 1
INTRODUCTION

1.0 Project Background

A simulation of two modelling network are diagnosed based on four cases. The first modelling network is a circuit of non-harmonic producing load with non-harmonic producing load while the second modelling network is a combination of three other cases which is non-harmonic producing load with harmonic producing load, harmonic producing load with non-harmonic producing load and harmonic producing load with harmonic producing load. The main goal that is going to be achieved in this reseach is to identify the location of multiple harmonic sources. All the measurements are taken at the point of common coupling (PCC) which is located in the power system between customer and supplier. Frequency, current, impedance, resistance, power and voltage are some of the crucial parameters used in this research in order to meet the objective.

1.1 Problem Statement

Poor power quality is becoming a crucial concern to the supplier, industries and users. The increasing energy rate and the development of disturbances are contributed due to low quality of power supply which is because of the increasingly sensitive component used. Ironically, it is often the equipment itself that forms the disturbances. Electronic and power electronic equipment have become much more sensitive compared to 1 or 2 decades ago. High consumption of converter-driven components lead to a huge evolution of voltage disruption, even though the equipment has not reach to a stage where it becomes old and sensitive. There are tons of power quality conflicts in our surrounding which some of them are harmonics, network unbalance, reactive power, flicker, voltage variations such as dips, sags, swells, brown-outs, transients like fast disturbance and oscillations such as resonances.

One of the major effects of harmonics is the increament of current formation in the system. Harmonic number three is particularly the cause of it which lead to the creation of high-pitched growth in zero sequence current. This circumstance leads to the rise of voltage per unit resistance in the neutral wire.

The heating consequences of harmonic currents can cause destruction of equipment and conductors. The results can be unpredictable legal and financial ramifications. Harmonic currents and voltage distortion are becoming the most severe and complex electrical challenge for the electrical industry. The problems associated with nonlinear loads were once limited to isolated devices and computer rooms, but now the problem can appear throughout the building and utility system.

Harmonics really affect us all, from the secretary operating a computer, the electrician trouble shooting equipment failure, the electrical contractor having to absorb the cost of equipment replacement, the inspector who needs to investigate the cause of electric fires, to the facilities management interested in effective and efficient equipment operation and the avoidance of down time. Therefore, harmonic issue gives impact to architects, engineers, designers, property managers, building maintenance personnel, suppliers, equipment manufactures, and industry.

Despite the standardised limits for each harmonic, there are users who do not follow and respect these limits. The power suppliers would like to have the ability in detecting all of the consumers who contaminate the grid. Therefore, a number of experts deal with the problem in computing and locating the non-linear loads.

1.2 Objectives

To identify the location of multiple harmonic sources

1.3 Work Scope

The project scope is very crucial in order to support the development and process of this project. Listed below are the scope descriptions for this project:

i. Analysing harmonic signals and spectrums using periodogram technique.
ii. Determining the total harmonic distortion to measure harmonic content of each modelling circuit.
iii. Diagnosing the harmonic source by the comparison of harmonic impedance and the fundamental impedance by simulating modeling circuit utilizing MATLAB software.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

Delivering sufficient electricity to serve a facility's load at the grade of power quality needed and offering for enough power during curtailment or other emergency conditions are a reliable power supply in order to ensure the safety of personnel and protection of critical processes and equipment. Power disturbances are still occurring even though today's utilities use advanced hardware and software at the substations and on their distribution systems. The increasing application of electronic equipment that can cause electromagnetic disturbances which can be sensitive to these phenomena has heightened the consideration in power quality in recently. One of the main reasons different categories of electromagnetic phenomena is developed because there is different kind of ways to mitigate power quality problems based on the particular variation that is of concern. There are also different requirements for characterizing the phenomena using measurements. It is crucial to be able to categorize events and electromagnetic occurrence in order to mitigate power quality impediments for analysis purposes. (Committee, Power and Society, 2009)

2.1 Power Quality

The term of power quality denotes to an extensive variety of electromagnetic occurrences that characterize the current and voltage at a given location and time on the power system. (Committee, Power and Society, 2009) Power quality symbolizes a set of electric measures that describes the power supply of a user and its capability to function at a satisfy level in its electromagnetic environment without introducing ny uncompromised electromagnetic disturbances. (Barbulescu *et al.*, 2013) ;egulators have to make sure that the customers would get the electricity that can be epended on and owns a great level of power quality since electricity is considered s a commercial product that ought to satisfy proper quality requirements. Therefore, ll the consumer or user would work safely and use it satisfactorily. (Bhattacharyya, 1yrzik and Kling, 2007)

2.1.1 Power Quality Disturbances

In the last two decades, the urge for good quality of the power supply from the customers have increased as they use an increasing number of sophisticated and sensitive equipment such as power electronic devices, computers and variable speed drives (VSD). Typical power quality complaints arise from the customer side when the functioning of the customer's sensitive devices is affected and this leads to data loss, physical damage of sensitive devices, complete loss of the power supply, corruption or data damage, flickering of computer screens. (Bhattacharyya, Myrzik and Kling, 2007)

Power quality disturbances can be categorized into two classes which are continuous or variation type and discrete or event type. Continuous type disturbances are presenting every cycle and typically include voltage variations, unbalance, flicker and harmonics. The discrete type disturbances appear as isolated and independent events and mainly include voltage dips (sags), swells and oscillatory or impulsive transients. The classifications and attributes of power system electromagnetic occurrence is shown in the Table 2.0 below.

Table 2.0: Classifications and Attributes of Power System Electromagnetic Occurrence

Classifications	Typical spectral content	Typical duration	Typical voltage magnitude
Transients:			
1. Impulsive			
a) Nanosecond	5 ns rise	<50 ns	
b) Microsecond	1 µs rise	50 ns – 1 ms	
c) Millisecond	0.1 ms rise	>1 ms	
2. Oscillatory			
a) Low frequency	< 5 kHz	0.3 – 50 ms	0 – 4 pu[a]
b) Medium frequency	5 – 500 kHz	20 µs	0 – 8 pu
c) High frequency	0.5 – 5 MHz	5 µs	0 – 4 pu
Short duration root-mean-square (RMS) variation:			
1. Instantaneous			
a) Sag		0.5 – 30 cycles	0.1 – 0.9 pu
b) Swell		0.5 – 30 cycles	1.1 – 1.8 pu
2. Momentary			
a) Interruption		0.5 cycles – 3 s	< 0.1 pu
b) Sag		30 cycles – 3 s	0.1 – 0.9 pu
c) Swell		20 cycles – 3 s	1.1 – 1.4 pu
3. Temporary			
a) Interruption		>3s – 1 min	< 0.1 pu

b) Sag c) Swell		>3s – 1 min >3s – 1 min	0.1 – 0.9 pu 1.1 – 1.2 pu
Long duration RMS variation: 1. Interruption 2. Undervoltages 3. Overvoltages 4. Current overload		 > 1 min > 1 min > 1 min > 1 min	 0.0 pu 0.8 – 0.9 pu 1.1 – 1.2 pu
Imbalance: 1. Voltage 2. Current		 Steady state Steady state	 0.5 – 2 % 1.0 – 30 %
Waveform distortion: 1. DC offset 2. Harmonics 3. Interharmonics 4. Notching 5. Noise	 0 – 9 kHz 0 – 9 kHz Broadband	 Steady state Steady state Steady state Steady state Steady state	 0 – 0.1 % 0 – 20 % 0 – 2 % 0 – 1 %
Voltage fluctuations	< 25 Hz	Intermittent	0.1 – 7 % 0.2 – 2 P_{st} [b]
Power frequency variations		< 10 s	± 0.10 Hz

[a] Per unit (pu) is measureless. The value of 1.0 pu denotes 100%. 1.0 pu is the usual state that is frequently be considered. The base of rms variations is taken from nominal rms value while the base of transients is the nominal maximum value.

[b] Flicker severity index, P_{st}.

2.1.2 Power Quality Effects

The electricity service quality is matter to the user and the customers are very alert of it recently. Distributing a voltage to the user that ought to stay in a specific limit as stated in the standard or national grid code is the obligation of the network operator. Normally, the quality of electricity generated by the utility in a conventional power plant is excellence but when it reaches the customer's terminal, the electricity may not perfectly shaped because of the disturbances in distribution networks, transmission or any other regions. Moreover, the electrical equipment has become extra complex in terms of their purposes or functionalities and the interaction with any other equipment presented in the network. Therefore, it is becoming an increasing problem for the utility to sustain good voltage quality because of the interactions of the customer's loads with the network.

The electrical component's consequences upon bad power quality and the electrical stress intensity that can be tolerated before it fails in operation are different based on the types of sensitive equipment used. Nature, the age of the part, occurrence frequency, magnitude and period of power quality incident, sensitivity of the component to the event and the area of the equipment within the user's installations are the main aspects that define the tolerances of the component. Operational difficulty towards the user or customer and losses of financial are the cause of power source loss. The charge of energy supplied is lesser than the energy charge that is not delivered because of the interruption which is observed in industrial production unit. An outage that is happening for a nick of time might lead to the loss of manufacture from seconds to minutes and minutes to hours

An interference or interruption event for a few seconds may strike to the loss of production for minutes and from minutes, it might lead to hours of nuisance. This is because the whole procedure needs to be start all over again. Some of the electromagnetic disturbances are summarize by its group below in Table 2.1. (Bhattacharyya, Myrzik and Kling, 2007)