ABSTRACT

Power quality is among the main things that is emphasized and is taken into consideration by utilities in order to meet the demands of their customer. At each passing day this issue has becoming more serious and at the same time the user's demand on power quality also gets more critical. Thus it is essential to establish a power quality monitoring system to detect power quality disturbance. Several research studies regarding the power quality have been done before and their aims frequently concentrated on the collection of raw data for a further analysis, so the impacts of various disturbances can be investigated. This study presents the identification of voltage disturbance based on mathematical method of Wavelet Transform and Fast Fourier Transform (FFT). A simple program is developed based on these two methods using MATLAB 7.8 software. The recorded data used is taken from 22kv and 33kv TNB Distribution System in Skudai and focused on three major voltage disturbances which are voltage sag, voltage swell and voltage harmonic. Wavelet Transform and FFT will extract and localized the features of voltage disturbance occur in the recorded data. The recorded data contains voltage sag, voltage swell and harmonic is analyzed using FFT to extract its magnitude and frequency components of the disturbance. To locate the start time, end time, duration and magnitude of the voltage disturbance occur on the recorded data, the Wavelet Transform algorithm is applied. At the end of the study, a comparative analysis of the recorded data between Wavelet Transform and FFT methods used is reported to highlight the strength and weakness of each method. Besides that, the comparative analysis is done within these two methods to select the best and effective method to localize and extract the voltage disturbance.

ABSTRAK

Kualiti tenaga adalah antara perkara-perkara utama yang ditekankan dan diambil kira oleh utiliti untuk memenuhi tuntutan pelanggan-pelanggan mereka. Semakin hari isu ini telah menjadi lebih serius dan pada masa yang sama permintaan pengguna pada kualiti tenaga juga menjadi lebih kritikal. Maka adalah penting bagi mewujudkan sistem pengawasan kualiti kuasa bagi mengesan gangguan kualiti tenaga. Beberapa kajian penyelidikan mengenai kualiti tenaga pernah dilakukan dan tujuan mereka seringkali tertumpu pada koleksi data mentah untuk satu analisis lanjut, jadi impak bagi pelbagai gangguan dapat dikenalpasti. Kajian ini membentangkan identifikasi gangguan voltan berdasarkan kaedah matematik *Wavelet Transform* dan *Fast Fourier Transform (FFT).* Satu pengaturcaraan mudah dibangunkan berasaskan dua kaedah matematik ini menggunakan perisian MATLAB 7.8. Data terakam yang digunakan bagi projek ini diambil daripada 22kv dan 33kv Sistem Pengagihan TNB di Skudai dan fokus kepada tiga jenis gangguan voltan utama yang mana adalah voltan lendut, voltan kembang dan voltan selaras. *Wavelet Transform* dan *FFT* akan mengekstrak dan mengesan dengan tepat ciri-ciri gangguan voltan yang terdapat dalam data yang dirakam. Data terakam yang mengandungi voltan lendut, voltan kembang dan voltan selaras dianalisis menggunakan FFT bagi mengekstrak magnitud dan komponen frekuensi gangguan. Untuk mengesan masa mula, masa tamat, tempoh dan magnitud gangguan voltan yang berlaku pada data yang dirakam, kaedah *Wavelet Transform* digunakan. Di akhir kajian ini, satu analisis perbandingan antara kaedah *Wavelet Transform* and *FFT* yang digunakan bagi menganalisi data yang dirakam adalah dilaporkan bagi menekankan kekuatan dan kelemahan setiap kaedah. Selain itu, analisis perbandingan juga dibuat dalam lingkungan dua kaedah yang digunakan bagi memilih kaedah yang efektif dan terbaik dalam mengesan dan mengekstrak gangguan voltan dengan lebih tepat.

CHAPTER I

INTRODUCTION

1.1 Introduction

Power quality is among the main things that is emphasized and is taken into consideration by utilities in order to meet the demands of their customer. At each passing day this issue becoming more serious and at the same time the user's demand on power quality also gets more critical. Thus it is essential to establish a power quality monitoring system to detect power quality disturbance [1]. Power quality can be described as any power problem that manifested in voltage current or frequency deviation that result in failure of customer equipment [3].

Most of researches and studies have been conducted before normally use various methods to detect and classify the power quality occurs. Some of the methods used in previous research are S-Transform, Wavelet Transform, Neural Network, Data Mining, Fourier Transform, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Fuzzy Logic, the combination of them and others. Most of the methods mentioned above monitored power quality disturbance by changing from one time domain to other mathematical domain which provide more detail analysis [2].

This project presents the identification of voltage disturbance based on mathematical method of Wavelet Transform and Fast Fourier Transform (FFT). A simple program is developed based on these two methods using MATLAB 7.8 software. The data of voltage disturbance used is limited into voltage sag, voltage swell and harmonic. FFT is the extension of the Discrete Fourier Transform (DFT). To locate the start time, end time and magnitude of the voltage disturbance occur on the recorded data, the Wavelet Transform is applied.

For the project, the recorded data of voltage disturbance used in the software development is taken from 22kv and 33kv TNB Distribution System in Skudai. At the end of the project a comparative analysis of the recorded data between Wavelet Transform and FFT methods used will be reported to highlight the strength and weakness of each method.

1.2 Objectives of Project

The major objective of this project is to extract and localizes voltage disturbance in Distribution System using FFT and Wavelet Transform. There are several measurable objectives to be achieved at the end of this project which are:

1. To analyze voltage sag, voltage swell and harmonic based on given data using FFT and Wavelet Transform.
2. To develop a simple program that can extract and localize the voltage disturbance accurately and efficiently.
3. To analyze the performance of FFT and Wavelet Transform in analyzing voltage disturbance.
4. To investigate the different between FFT and Wavelet Transform for voltage disturbance diagnosis.

1.3 Background of Study

Power quality can be defined based on the views of utilities, equipment manufacturers and customer. Utilities treat power quality from the system reliability point of view. Equipment manufacturer considers power quality as the level of power supply allowing for proper operation of their equipment while for customer consider a good power quality is ensures the continuous running of processes, operation and business [3].

There are a several methods and also the combination of them for power quality monitoring and identification used in previous researches. Wavelet transform is a mathematical tool that provides an automatic detection of power quality disturbance waveforms [9]. Another method frequently use is FFT which is the extension of DFT. Besides that for voltage disturbance detection, there also a method that applied Neural Network and Fuzzy Logic but this method comes with disadvantage which it has a complex calculation and also require lots of data for training and learning process.

1.4 Problem Statement

In order to improve power quality problem, the detection of power quality disturbance must be carried out. It is the fact that power quality disturbance varies in a wide range of time and frequency which make automatic detection of power quality problem often difficult to diagnose [6].

1.5 Project Scopes and Limitations

Power quality has a wide definition, sources and methods used to overcome the problem. For this project, the scope is limited into five parts as mention below:

1. The classification of voltage disturbance methods used in this project only focuses on FFT and Wavelet Transform.
2. Types of voltage disturbance used in the analysis are limited to voltage sag, voltage swell, and voltage harmonic.
3. The data of the voltage disturbance is analyzed using RPM Power Analysis software.
4. Identification or simulation of voltage disturbance using MATLAB7.8 software.
5. The data of voltage disturbance used in the simulation is taken from 22kv and 33kv TNB Distribution system in Skudai.

This report is organized in five chapters. Chapter I provides an overview of the project which include introduction, objective, project background, problem statement also scopes and limitation. Chapter II gives a brief explanation about the previous researches. Chapter III explains the methodologies that are implemented in the project. Chapter IV presents the results and analysis and Chapter V consists of conclusion of the project and future recommendation.

CHAPTER II

LITERATURE REVIEW

2.1 Power Quality

Power quality may be associated with reliability by electric utilities. However, equipment manufacturers can interpret it differently, by referring it to those characteristics of power supply that enable the equipment to work properly. This day, the effects of power quality are rather costly so there is a need of power quality monitoring system can able to detect and localized the disturbance occur. Common types of disturbance occur in power system are voltage sag, voltage swell, momentary interruption, transient, voltage unbalance, harmonic and voltage fluctuations.

2.1.1 Voltage Sag

Many types of electronic equipment are sensitive to voltage sags, including variable speed drive controls, motor starter contactors, robotics, programmable logic controllers, controller power supplies, and control relays. Much of this equipment is

used in applications that are critical to an overall process, which can lead to very expensive downtime when voltage sags occur. Voltage sag (refer Figure 2.1) is a temporary voltage drop. Common source of voltage sag is the change of load, for example start up of large load at neighboring utilities. Other common causes of external voltage sags are lightning, storms, animals and others.

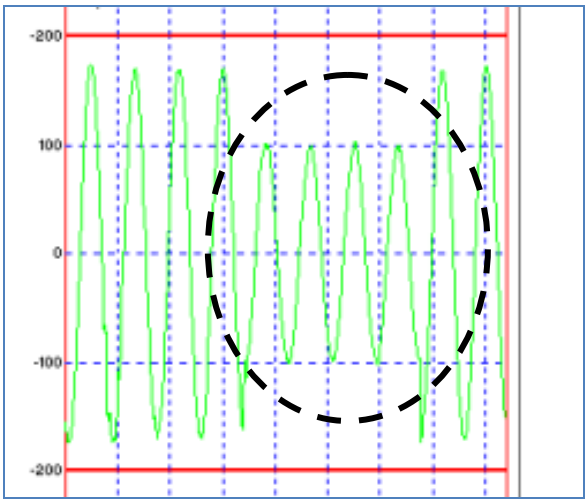


Figure 2.1: Voltage sag

2.1.2 Voltage Swell

Voltage swell in Figure 2.2 is the reverse form of a sag which having the increasing of voltage. Common source of voltage swell is sudden large load reduction or fault occurs. Although voltage swells occur less frequently than sags, even relatively minor swells can damage equipment. Therefore, they require immediate attention.

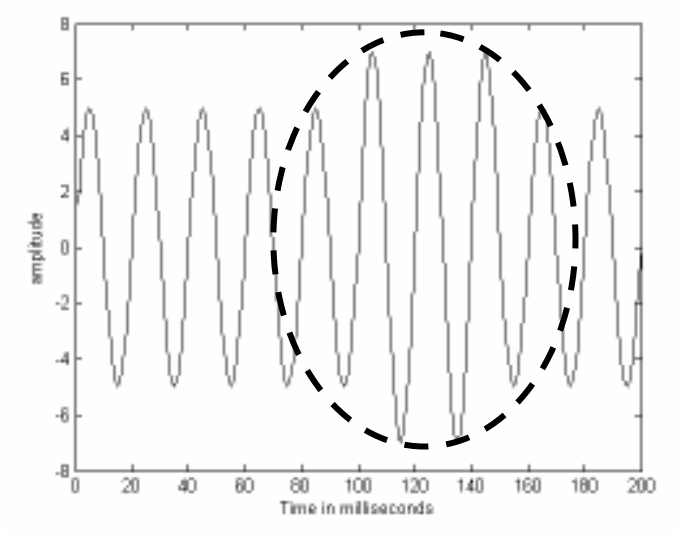


Figure 2.2: Voltage Swell

2.1.3 Harmonic

Harmonic in Figure 2.3 is a component frequency of the signal that is an integer multiple of the fundamental frequency. Most current distortion is generated by electronic loads, also called non-linear loads. Current distortion also may cause transformers to overheat and fail even though they are not fully loaded.

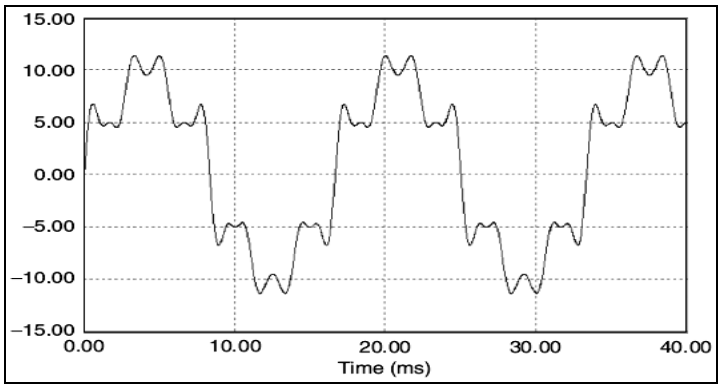


Figure 2.3: Harmonic

2.2 Previous Research

There are a numbers of research work have been done before in order to determine the most automatically and effectively way to identify and classify the voltage disturbance on electrical system. The first stage of the project is information gathering. The information gathered for the project is based on the theory and also the previous research work that have been done before. The project includes a few of previous research on power quality or voltage disturbance identification using various methods as mention above as a reference and guide.

A.P Memon and T.R Mohamad proposed an approach technique for detection of power quality disturbances by time and frequency analysis with Wavelet Transform. The Wavelet Transform represents signal as a sum of wavelets at different locations and scales and this method can be accomplished in three ways which are Continuous Wavelet Transform (CWT), Wavelet Series (WS) and Discrete Wavelet Transform (DWT).

Besides only using Wavelet Transform, there is also a method which applied the combination of Wavelet Transform and T.A Hoang come out with this idea on their paper. This paper proposes to make use the advantage of FT which is best for the analysis of steady periodic signal. CWT is very accurate in determining the features and location of discontinuities in signals.

R. Montano use Wavelet Transform and FFT in order to characterize and classify the fault. Based on this research, it shows that the use of Wavelet Transform and FFT possible to categorize, detect the time when the fault occur and also describe the frequency components of signal.

Besides that Wavelet Transform also is better for analyzing power quality signal which uses variable window length. For automatic classification, the feed forward Neural Network is used but the network needs to be trained with the input parameter. Zhu present a new hierarchical identification method of power quality disturbance involving the combination of dq conversion, Wavelet Transform and FFT. However when duration is less than 1ms, oscillation is easily taken for transient pulse.

Ali Dastfan and A. Shantiaee Zadeh [20] present a method in intelligent monitoring power. Besides that S- Transform also performs multiresolution analysis on the signal because the width of its window varies inversely with the frequency which results high time resolution at high frequency and high frequency resolution at low frequency.

2.3 MATLAB

MATLAB 7.8 used in this project in order to detect and localized the voltage sag, swell and harmonic. Using this software, the simulation process is done and the outcomes are represented in graphs. The simulation using M-file is implemented where this MATLAB function able to run the program efficiently. MATLAB functions with an M-file source are just like any other functions coded with MATLAB. When one of these M-file functions is called, MATLAB parses and executes each line of code in the M-file. It saves the parsed version of the function in memory, eliminating parsing time on any further calls to this function.

CHAPTER III

METHODOLOGY

3.1 Introduction

In this chapter, the methodology of the project only focuses on software development as shown in Figure 3.1. This project develops a program that is able to detect and extract features of voltage disturbance of recorded data. The data of voltage disturbance used in the project is taken from 22kv and 33kv TNB Distribution System in Skudai. The data of voltage disturbance extracted in this project is limited into voltage sag, voltage swell and harmonic.

Based on Figure 3.1, the project starts with the software development using MATLAB 7.8 and the output extracted from the voltage disturbance signal is analyzed in order to find out the effectiveness of the two methods used to localize and extract the voltage disturbance signal. Then the same data is analyzed using Wavelet Transform to extract and locate with time for each disturbance occurs. The flowchart for the whole project is shown in Figure 3.2. At the end of the project, the analysis and comparison is made between these two mathematical methods used in order to determine the best and effective method to extract and locate the voltage disturbance. This chapter will be divided into few portions that will explain detail

about the voltage disturbance signal used in software development, FFT, Wavelet Transform, MATLAB 7.8 and also types of analysis performed.

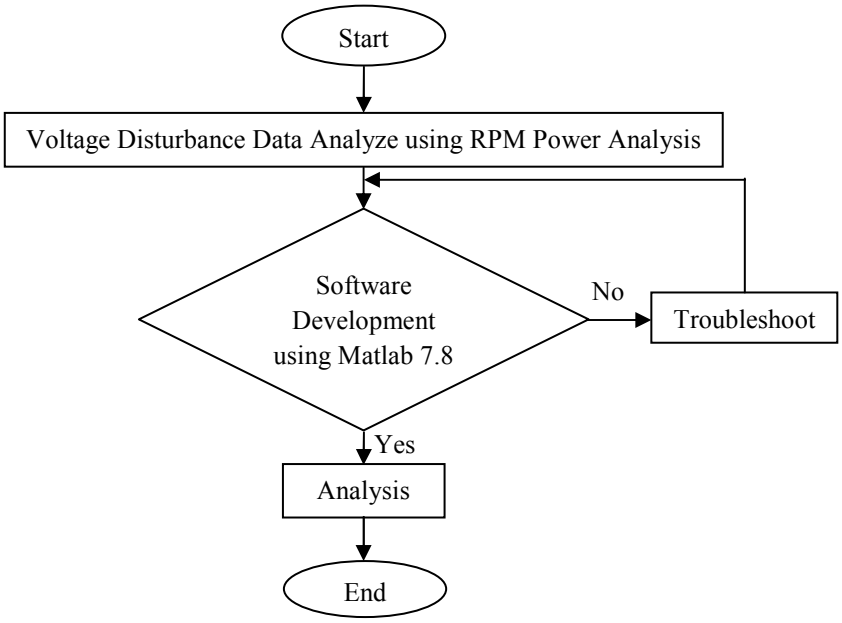


Figure 3.1: Flowchart of project

3.2 Data Analyzing Using RPM Power Analysis Software

The data of voltage disturbance used in this project is obtained from 22kv and 33kv TNB Distribution system in Skudai. The data of voltage sag, voltage swell and harmonic is then analyzed using RPM Power Analysis software as shown in Figure 3.3.

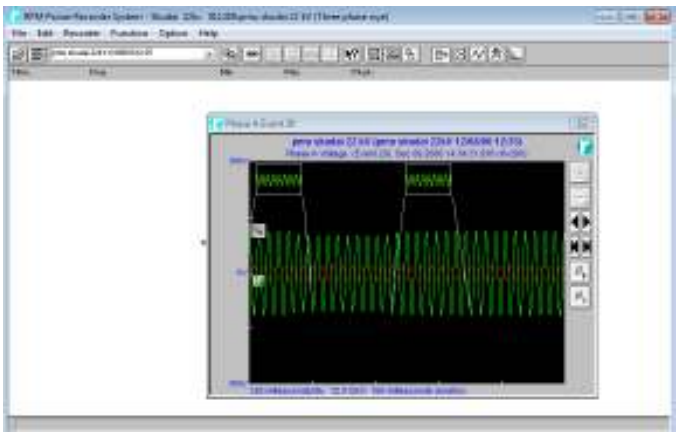
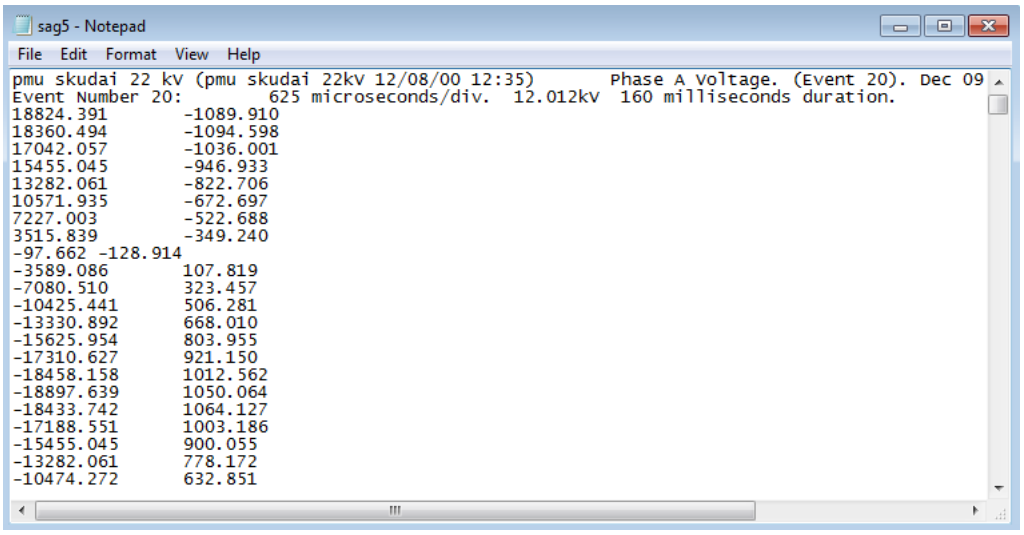
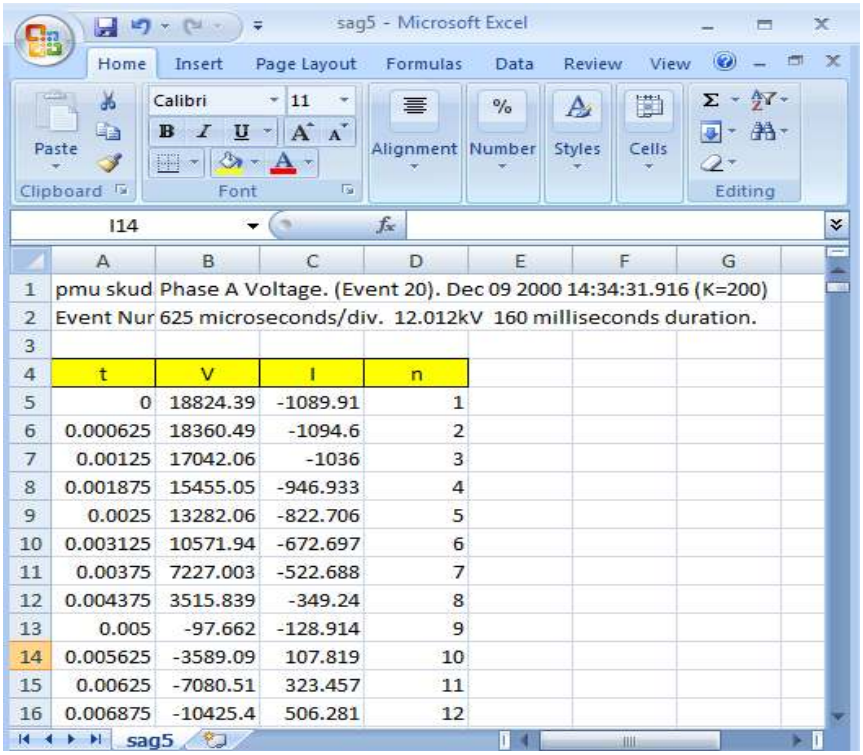


Figure 3.3: RPM Power Analysis software



(a)

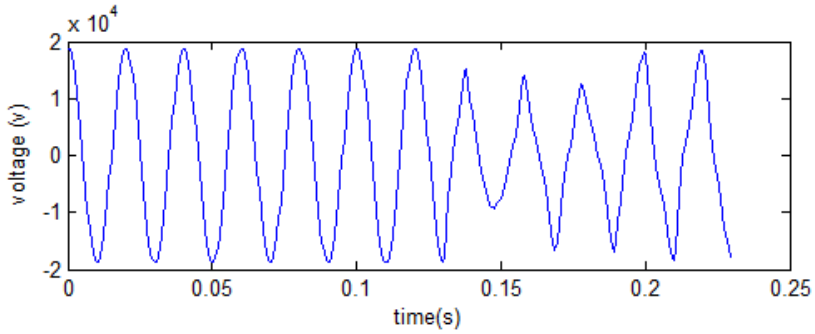


(b)

Figure 3.4: Data analyzed from RPM Power Analyzer in (a)**.txt format (b) Data converted into **.xls format

3.3 Data Collection

For the project there are several data of voltage disturbance considered for analysis. The data is categorized into voltage sag, voltage swell and harmonic and loaded into the program constructed using MATLAB 7.8



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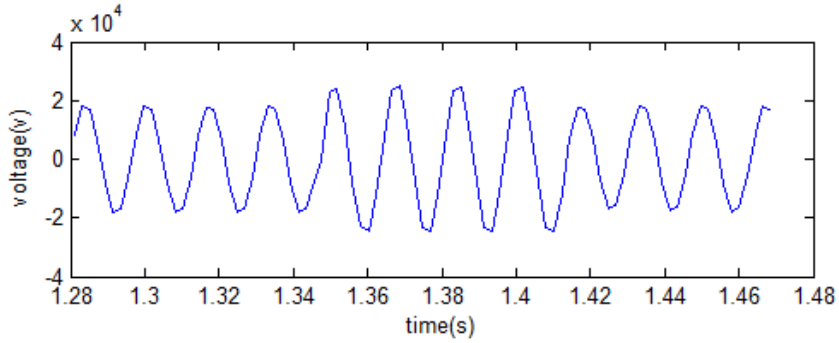

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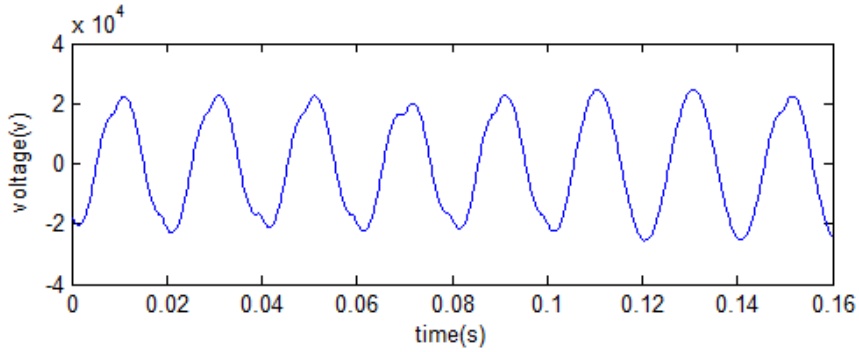


(c)

Figure 3.5: Sample data used in the project (a) Voltage Sag (b) Voltage Swell (c) Harmonic

3.4 Fast Fourier Transform (FFT) Algorithm

FFT is an innovation that made the digital analysis is more practical. Nowadays, this method is used extensively in signal processing application such as communications, broadcasting, entertainment and many other areas. Based on the study, the most common and familiar FFTs are 'radix 2', however other radices are sometimes can be used depend on situation.

3.4.1 Discrete Fourier Transform (DFT)

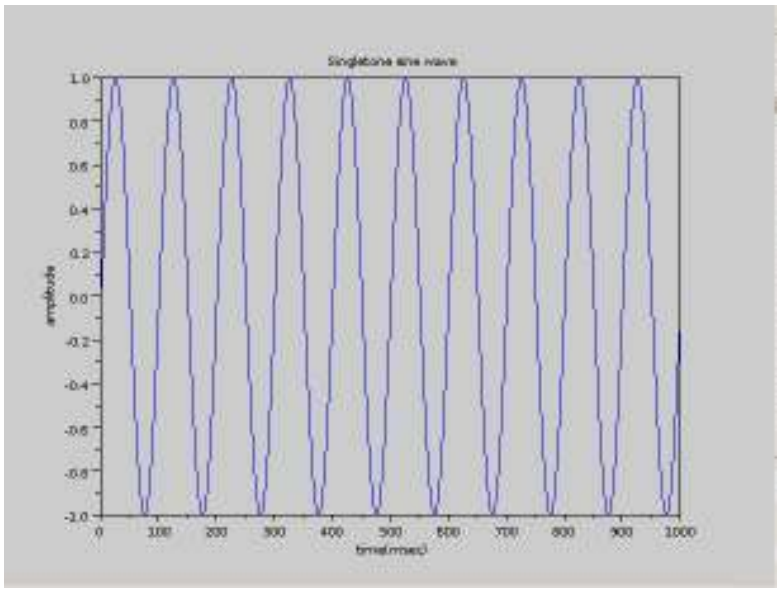
DFT is the extension of the Fourier Transform. This method decomposes a sequence of values into components of different frequencies. Besides that DFT also describe the signal which originally in time domain into frequency domain\

3.4.2 Fast Fourier Transform (FFT) versus Discrete Fourier Transform (DFT)

FFT successfully decompose the N-point computation into computations of smaller size DFT [3].

3.4.3 Spectrum Analysis (Frequency Spectrum)

The goal of spectrum analysis is to determine the frequency content of signal. Spectrum analysis can also be represented as the frequency spectrum. The frequency spectrum is a function in the frequency domain, which means that we can examine the long-term behaviour of fast and slow oscillations.



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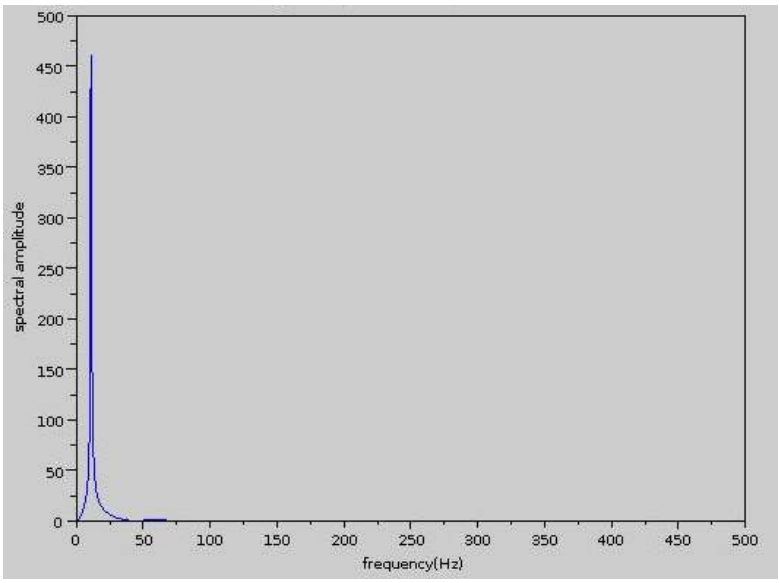

(b)

Figure 3.6: Spectrum Analysis (a) The input signal of sine wave (b) The frequency spectrum

3.4.4 Computation Using Fast Fourier Transform (FFT)

The FFT returns a two-sided spectrum in complex form or in real and imaginary part.

3.4.5 Flowchart of Fast Fourier Transform (FFT) method

Figure 3.7 shows the flowchart for programming development using Fast Fourier Transform (FFT).

3.5 Wavelet Transform Algorithm

Wavelet Transform is mathematical tools that transform from one domain to another domain. In Wavelet Transform, the original domain which is in time domain is transformed into time-scaled domain [18]. The main advantage of Wavelet Transform is in identification of the occurrence and duration of the disturbances.

3.5.1 Discrete Wavelet Transform (DWT)

DWT evaluation has two stages. First stage referred to wavelet coefficient determination where the coefficient represents the given signal in the wavelet domain.

3.5.2 Daubechies

Daubechies Wavelet Transform is a very accurate Wavelet Transform for analyzing power quality disturbances [1]. The names of the Daubechies family wavelets are written as DbN where N is the order and Db the ‘surname’ of the wavelet [9].

3.5.3 Flowchart of Wavelet Transform Method

Figure 3.9 shows the flowchart for programming development using Wavelet Transform.