HARMONIC SOURCE IDENTIFICATION SYSTEM

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor in Electrical Engineering with Honors

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YEAR 2020/2021

“I hereby declare that I have read through this report entitle “Harmonic Source Identification System” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering with Honours

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I declare that this report entitle “Harmonic Source Identification System” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Harmonic source detection becomes important in an interconnected power system in a deregulated power situation. In electrical systems, harmonics cause current and voltage to be warped and vary from sinusoidal waveforms. Nonlinear loads connected to the distribution system create harmonic currents, which are the result of nonlinear loads converting AC line voltage to DC. Nonlinear electronic switching devices, such as variable frequency drives (VFDs), computer power supplies, and energy-efficient lighting, introduce harmonics into the electrical system. One of the most significant effects of power system harmonics is an increase in system current. This is especially true for the third harmonic, which generates a significant rise in the zero sequence current and, as a result, an increase in the neutral conductor current. This paper gives a thorough examination of the system developed using Matlab R2020a Simulink and Matlab R2020a GUI and the Impedance Spectrum approach, as well as their main advantages and disadvantages. With accuracy as the primary criterion, it is stated that harmonic source determination and harmonic estimation are better suited to Impedance Spectrum methods using harmonic state estimation. Correct harmonic source identification methods are crucial in a deregulating environment when there is insufficient information on the topology of the power system, therefore research in this area is very important.

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ABSTRAK

Dalam senario penyahkawalseliaan kuasa, pengesanan sumber harmonik dianggap penting dalam sistem kuasa yang saling berkaitan. Kehadiran harmonik dalam sistem elektrik bermaksud arus dan voltan diputarbelitkan dan menyimpang dari bentuk gelombang sinusoidal. Arus harmonik disebabkan oleh beban tak linear yang disambungkan ke sistem pengedaran yang berpunca daripada beban tak linear yang menukar voltan saluran AC ke DC. Harmonik mengalir ke sistem elektrik kerana alat pensuisan elektronik bukan linier, seperti pemacu frekuensi berubah-ubah (VFD), bekalan kuasa komputer dan pencahayaan yang menjimatkan tenaga. Salah satu kesan utama harmonik sistem kuasa adalah meningkatkan arus dalam sistem. Ini terutama berlaku untuk harmonik ketiga, yang menyebabkan kenaikan mendadak arus urutan sifar, dan oleh itu meningkatkan arus pada konduktor neutral. Makalah ini memberikan tinjauan terperinci mengenai sistem yang dikembangkan berdasarkan Matlab R2020a Simulink dan Matlab R2020a GUI yang menggunakan teknik Impedance Spectrum dengan kelebihan dan kekurangan utama mereka. Dengan ketepatan sebagai kriteria utama, dapat disimpulkan bahawa kaedah Impedance Spectrum yang menggunakan anggaran keadaan harmonik lebih sesuai untuk penentuan sumber harmonik dan anggaran harmonik daripadanya. Namun, dalam lingkungan deregulasi tanpa maklumat yang cukup mengenai topologi sistem kuasa, kaedah pengenalpastian sumber harmonik yang betul sangat penting dan penyelidikan dalam hal ini sangat penting.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Harmonic distortion is a significant challenge today when it comes to maintaining power quality. Analyzing control flags and determining different distortions is really simple. Some harmonics in power signals are harmful to sensitive gear and result in power loss. It's crucial to find such distortion and use several consonant mitigation approaches to encourage a clean/pure flag for safe operation of the linked equipment and to reduce Control misery. Harmonics are currents or voltages with frequencies that are multiples of the elemental control recurrence frequency, which is 50 or 60 Hz (50Hz for European control and 60Hz for American control). If the basic control recurrence is 50 Hz, the second consonant is 100 Hz, the third consonant is 150 Hz, and so on. The most typical run of frequencies detected in electrical transportation systems is from the third to the twenty-fifth. Overheated transformers, unbalanced conductors, and other electrical distribution are all side effects of harmonic difficulties [1].

Harmonic distortion is defined as separate recurrence periodic components overlaid on the waveform with the highest recurrence. Existing harmonics in control systems are often odd numbers differing from the control recurrence. Most common harmonics can be differentiated as the 3rd, 5th, 9th, 7th, 11th, and 13th orders. In addition to these usual harmonics, flag components that are not integer multiples of the fundamental are possible. Inter-harmonics are a type of component that is commonly encountered while dealing with non-periodic signals. Due to the rising use of non-linear loads, a rapid increase in harmonic voltages and streams injected into control systems has been observed in recent years.

Control quality events are assessed by looking at and examining control line waveforms. To screen the control quality, it's critical to measure voltage, current, recurrence, harmonic distortion, and waveform. The purpose of using control quality observing is to find the source of the events that occur. For viewing control quality in real time, a few of the connected observing systems include an information acquisition board or a DSP processor [3]. Control quality handling inspection and analysis are quite important in order to overcome and improve.

Voltage flag in RMS value (voltage and current), and recurrence are the characteristics that define the control quality (Hz). The categorization test is written in Matlab R2020a using based computer code. On the other hand, this monitoring system confirms that the advertised control's quality is within pre-specified benchmarks and investigates and records information or data for problem-solving. Existing control quality monitoring has to improve in terms of capability, efficiency, consistency, and precision [2].

This extension outlines a strategy for enhancing the quality monitoring system for real-time control. The system has the ability to filter record and analyse data from the control line. The voltage (rms), current (rms), frequency, reactive power, apparent power, and power factor are all being measured. The data will be effectively recorded and stored. The control line system's exhibitions can be viewed online..

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1.2 Problem Statement

Control quality has become a major concern as the number of loads sensitive to unsettling influences has grown, as has the need to make money. Computers, broadcast transmissions, and electronic prepare controls are just a few of the modern devices that are being increasingly introduced into advertising. In comparison to the most experienced equipment, all of these cutting-edge innovations necessitate a constant control supply in order to achieve perfect unwavering quality. In a functional plant, even little disruptions in a control line might result in losses of millions of dollars.

Power-quality awareness has dramatically improved over the last 20 years, with a report from Commerce Week (1991) stating that spikes, droops, and outages cost the US country US$26 billion in downtime [6]. Lost time, lost generation, lost deals, conveyance delays, and harmed generating equipment all contribute to the toll. As a result, it may be necessary to obtain it and take steps to address quality issues.

The control quality events will have an impact on a variety of organisations, perhaps disrupting manufacturing plans, resulting in hardware dissatisfaction and financial losses. Until recently, users merely used power and were unaware of the voltage and current embedded in the loads. The perusing is done physically and the measurements are collected with a multimeter. This will result in a misreading of the readings. Aside from that, the electronics used in advertising these days can only capture and publish data. The information cannot be efficiently screened and stored as it grows. At that time, the client is unable to monitor the control line system's operation. The current developments are both unappealing to customers and expensive.

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1.3 Project Objectives

The objectives of this paper are:

1. To create real time harmonics monitoring system that can detect and show power line parameters such as voltage (V), current (I), frequency (Hz), and Total Harmonic Distortion (THD) on the computer in real time.

2. To classify signals such as normal or interrupted by harmonics.

3. To detect the real time power system's problems by analyzing and verifying the performance of the monitoring system.

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1.4 Project Scope

This project executes the utilizing of MatLab R2020a Simulink and GUI program on computer. The scope consists of:

1. This system utilizes the MatLab R2020a Simulink and MatLab R2020a GUI software.
2. This project can measure voltage (rms), current (rms), frequency and Total harmonic Distortion (THD).
3. Voltage and current signals are measured between 0 to 350 Vrms and 0 to 10 ampere for signal phase power line.

Due to its limitation, the scope of this project does not include measuring the voltage and current in a three phase and high power line.

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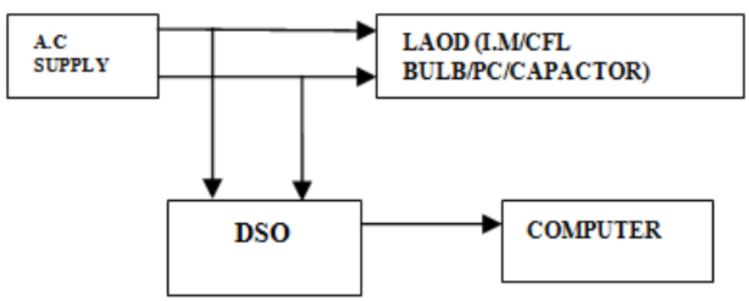

Figure 1.0: Block diagram of the project

1.5 Report Structure

This report has been divided into five chapters. All the parts contain all the information about the development of the project which includes introduction, literature review, methodology, results and conclusion. For the first chapter, it consists the motivation, problem statement, objectives, scopes of the project and also methodology which will be used in order to complete the project. Next, the literature review parts have a quick overview of the power quality events. Methodology part explained the details of the project, such as modeling, making plans as well as how the project will be tested. In chapter four which proves that the project either produced the desired result or was not based on the methodology proposed earlier. In my report, this project will show the prediction result. The last chapter concludes the summarization of the result of the project and will include the suggestion for the improvisation the project.

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CHAPTER 2

LITERITURE REVIEW

2.1 Introduction

A literature review is a collection of articles that examines people's ideas and perceptions of real-time power quality systems. The power quality events, power quality estimation, and power quality monitoring are all covered in this chapter.

2.2 Power Quality

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Due to visit recurrence of the concerns, there is a need to raise awareness among power clients about power quality occasions [1]. In addition, a control quality measuring system is required to execute a quick estimating system and dependable power quality testing. Undervoltage, overvoltage, interruption, interharmonic, harmonics, notching, and transient are all examples of power quality signals. Electromagnetic wonders are divided into a few groups, as illustrated in Table 2.1, by the International Electrotechnical Commission (IEC).

Table 2.1: Categories and Typical Characteristic of Power System Electromagnetic phenomena

Categories	Typical spectral content	Typical duration	Typical voltage magnitude
1.0 Transients			
1.1 Impulsive			
1.1 Impulsive	5 ns rise	< 50 ns	
1.2 Nanosecond	1 ms rise	50 ns-1 ms	
1.3 Millisecond	0.1 ms rise	> 1 ms	
1.2 Oscillatory			
1.2.1 Low frequency	< 5 kHz	0.3-50 ms	0-4 pu
1.2.2 Medium frequency	5-500 kHz	20 ms	0-8 pu
1.2.3 High frequency	0.5-5 MHz	5 ms	0-4 pu
2.0 Short duration variations			
2.1 Instantaneous			
2.1.1 Sag		0.5-30 cycles	0.1-0.9 pu
2.1.2 Swell		0.5-30 cycles	1.1-1.8 pu
2.2 Momentary			
2.2.1 Interruption		0.5 cycles -3 s	< 0.1 pu
2.2.2 Sag		30 cycles-3 s	0.1-0.9 pu
2.2.3 Swell		30 cycles-3 s	1.1-1.4 pu
2.3 Temporary			
2.3.1 Interruption		3 s-1 min	< 0.1 pu
2.3.2 Sag		3 s-1 min	0.1-0.9 pu
2.3.3 Swell		3 s-1 min	1.1-1.2 pu
3.0 Long duration variations			
3.1 Interruption, sustained		> 1 min	0.0 pu
3.2 Undervoltages		> 1 min	0.8-0.9 pu
3.3 Overvoltages		> 1 min	1.1-1.2 pu
4.0 Voltage imbalance		steady state	0.5-2%
5.0 Waveform distortion			
5.1 DC offset		steady state	0-0.1%
5.2 Harmonics	0-100th H	steady state	0-20%
5.3 Interharmonics	0-6 kHz	steady state	0-2%
5.4 Notching		steady state	
5.5 Noise	broad-band	steady state	0-1%
6.0 Voltage fluctuations	< 25 Hz	Intermittent	0.1-7%
7.0 Power frequency variations		< 10 s	

The term "power quality" refers to a group of electromagnetic phenomena that discriminate voltages and currents over time and space. The most frequent method of determining power quality is to look at voltage and current waveforms and see if they are recognized [5].

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The monitoring system can classify power quality events, identify existing problem resolutions, and predict future issues. Aside from that, power quality monitoring can be used to prepare the transformation of analogue voltages and currents inside the control system to sampled computerized values. When quality events are identified, they are categorized into known waveforms for data collection and analysis. The information gathered and analyzed can aid in discovering the causes of the problems as well as potential solutions.

2.3 Power Quality Events

These are several common power quality in power line system, it is normally divided into 5 categories. They are [7]:

i. Transient
ii. Waveform Distortion
iii. Short Duration Voltage Variations
iv. Long Duration Voltage Variations
v. Interruptions

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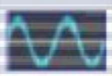
Table 2.2: Categories and Typical Characteristics of Power Quality Signal

Temporary Interruption		Planned or accidental total loss of utility power in a localized area of the community. Seconds to minutes	Equipment shutdown, loss of work and data, file and hard disk and operating system (OS) corruption, loss of fiber optic, T1 and ISDN connections.	Off-line - Yes Line-interactive - Yes On-line - Yes
Long-Term Interruption		Planned or accidental total loss of utility power in a localized area of the community. Minutes to hours	Equipment shutdown, loss of work and data, file and hard disk and OS corruption, loss of fiber optic, T1 and ISDN connections	Off-line - No Line-interactive – 95% No On-line - Yes
Momentary Interruption		Very short planned or accidental power loss. Milliseconds to seconds	Computer hangs, computer and network equipment reboots or hangs, loss of work and data, file and hard disk and OS corruption	Off-line - Maybe Line-interactive - Maybe On-line - Yes
Sag or Under Voltage		A decrease in utility voltage Sags – Milliseconds to a few seconds • Under-voltage – Longer than a few seconds	Shrinking display screens, equipment hang or reset, equipment power supply damage. Computer hangs, computer and network equipment reboots or hangs, loss of work and data, file and hard disk and OS corruption	Off-line - No Line-interactive - Yes On-line - Yes
Swell or Over Voltage		An increase in Utility voltage Swell – Milliseconds to a few seconds • Over-voltage – Longer than a few seconds	Permanent equipment damage, Computer hangs, computer and network equipment reboots or hangs, loss of work and data, file and hard disk and OS corruption.	Off-line - No Line-interactive - Yes On-line - Yes
Transient, Impulse or Spike		A sudden change in voltage up to several hundred to thousands of volts Microseconds	Network Errors, Burned or damaged equipment and circuitry, Computer hangs, computer and network equipment reboots or hangs, loss of work and data, file and hard disk and OS corruption	Off-line - Yes Line-interactive - Yes On-line – Yes, Higher level of protection
Notch		A disturbance of opposite polarity from the waveform Microseconds	Slow LAN due to excessive errors, audible noise in telephone and audio equipment	Off-line - No Line-interactive - No On-line - Yes
Noise		An unwanted electrical signal of high frequency from other equipment Sporadic	Slow LAN due to excessive errors, audible noise in telephone and audio equipment. Equipment hangs.	Off-line - No Line-interactive - No On-line - Yes
Harmonic Distortion		An alteration of the pure sinewave (sinewave distortion), due to non-linear loads such as computer switching [illegible]	Causes motors, transformers and wiring to overheat, lowers operating efficiency of office equipment.	Off-line - No Line-interactive - No On-line - Yes

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2.3.1 Transients

A transient in power quality is used to describe an unfavourable but brief event. When most control engineers hear the word transient, the first thing that springs to mind is the idea of a damped oscillatory temporal due to RLC arrangement. A transitory, in a larger sense, means "that fraction of a change in a variable that evaporates between transitions from one consistent state working condition to another." Transients can be divided into two types: impulsive transients and oscillatory transients.

2.3.1.1 Impulsive Transient

An incredibly rapid shift within the steady-state condition of voltage, current, or both, that is unidirectional in polarity either positive or negative, is referred to as an impulsive transient. Lightning is the most prevalent source of impulsive transient. Lightning strikes can produce peak currents of over 200 kA with a duration of 10/350 micro seconds. The frequency range is greater than 5kHz, which falls within the tall frequency category. The duration of an impulsive transient ranges from 30 to 200 micro seconds, and it most commonly happens along utility lines. An impulsive transient can cause transformer failures, arrester failures, and client hardware damage. The waveform of an incautious transient is shown in Figure 2.1.

Figure 2.1: Impulsive Transient

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2.3.1.2 Oscillatory Transient

An oscillatory transient within the steady-state condition of voltage, current, or both that includes positive and negative extreme values is known as an oscillatory transient. Prevalence frequency, duration, and magnitude are all depicted. Low, medium, and high frequency are the three subclasses.