E-LEARNING: HARMONIC ANALYSIS OF POWER ELECTRONIC

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HARMONIC ANALYSIS OF POWER ELECTRONIC

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A report submitted in partial fulfillment of the requirements for the degree of Industrial Power (BEKP)

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I declare that this report entitle Harmonic Analysis of Power Electronic 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.

Signature : .....

Name : .....

Date : .....

“ I hereby declare that I have read through this report entitle Harmonic Analysis of Power Electronic and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)”

Signature : .....

Name : .....

Date : .....

To my beloved mother and father

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ABSTRACT

This project is focus in the creating e-learning tools of a Harmonics of Power Electronics. E-learning is a type of education in interactive way by using the computer as a medium of learning. E-learning is used interchangeably in a wide variety of contexts. Harmonics is the form of the frequencies that is integer multiple of the fundamental frequency. To analyze harmonics, Fourier series is applied. Fourier series is the decomposition of a function in terms of sinusoidal functions (called basis functions) of different frequencies that can be recombined to obtain the original function. In other word, Fourier series is a made up of infinite sum of sines and cosines with frequencies that are multiple of the fundamental frequency. There are four types of harmonics wave in this tool that is sines wave, square wave, triangular wave and sawtooth wave. This project has simulation of harmonics to help student in better understanding of harmonics and Fourier series. The simulations are is the forming of triangle wave, square wave and sawtooth wave from basic sine wave. This tool also included with even and odd function simulation. Exercises are provided for student to test their understanding the basic concept of harmonics.

ABSTRAK

Projek ini memfokuskan kepada penghasilan *e-learning* mengenai *Harmonic Analysis in Power Electronic*. *E-learning* adalah satu cara pembelajaran yang menarik dan menggunakan computer sebagai medium penyampaian. Harmonik adalah bentuk frekuensi-frekuensi iaitu integer berbilang bagi frekuensi asas. Ia mengaplikasikan siri Fourier. Siri Fourier adalah penguraian satu fungsi bentuk sinusoid (dipanggil fungsi asas) frekuensi-frekuensi berbeza yang boleh digabungkan untuk mendapatkan fungsi asal. Dalam perkataan lain, siri Fourier adalah jumlah hasil tambah infiniti fungsi-fungsi sinus dan kosinus dengan frekuensi-frekuensi yang merupakan gandaan bagi frekuensi asas. Terdapat empat jenis gelombang dalam harmonik iaitu gelombang sinus, gelombang segiempat, gelombang segi tiga dan gelombang gigi gergaji. Projek ini mempunyai simulasi tentang harmonik untuk membantu pelajar dalam pemahaman lebih baik bagi ilmu harmonik dan siri Fourier. Simulasi-simulasi adalah pembentukan gelombang segi tiga, gelombang segiempat dan gelombang gigi gergaji daripada gelombang asas sinus. Terdapat juga simulasi untuk fungsi genap dan ganjil. Latihan disediakan untuk pelajar untuk menguji pemahaman mereka konsep asas ilmu harmonik.

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CHAPTER 1

INTRODUCTION

1.1 Background

This project is based on design an e-learning tool about Harmonic analysis to help student in their study. E-learning is a type of education in interactive way by using the computer as a medium of learning. E-learning is used interchangeably in a wide variety of contexts. This project also helping the lecturer to assist their student understands the topic.

1.2 Problem Statement

Nowadays, student have problem in understanding about harmonics because they can't see the basic operation of some form of the harmonic. Student always confused in understanding about harmonic because it involves equation, calculation and analysis. Some student much prefers to reviews the topic at home in order to understand the topic. In class, some students are losing their focus in the lecture that resulting less understanding about the topic.

1.3 Objective

The objective of this project are:

1. To create an interactive method in learning Harmonic Analysis.
2. To create an e-learning tool that can be access at any places and anytime with computer.
3. To visualize simulation of harmonic analysis in process of learning to give student better understanding.

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1.4 Scope

This e-learning project are about harmonic analysis. To analyze the harmonic of certain wave, we need to understand about the Fourier series. Each waveform have different analysis in order to get the

In this project, there are four types wave that will teach in this tool. The waves are sines wave, square wave, sawtooth wave and triangle wave. The sine wave is the basic function employed in harmonic analysis. The square wave is a periodic waveform consisting instantaneous transitions between two levels. The sawtooth waveform is a repeating waveform that rises from zero to a maximum value linearly drop back to zero and repeat. It is named a sawtooth based on its resemblance to the teeth on the blade of a saw. The triangular wave is waveform that resembles the triangle shape.

Fourier series is applied in this tool to analyzing wave shape. A Fourier series is an expansion of a periodic function *f(x)* in terms of an infinite sum of sines and cosines. This tool also provided with the note of Total Harmonic Distortion (THD). Total Harmonic distortion of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.

In this e-learning tool, it provides notes about the four wave shape of harmonic. This tool also provides with example to help user understanding the topics. This tool also provide tutorial/exercise to test user knowledge about topic. Some simulation/animation will help user the visualization of harmonic.

Software that use in completing this project is Macromedia Flash 8. Flash 8 is a multimedia platform for adding animation and interactivity to web pages. Flash is commonly used to create animation, advertisements, and various web page components, to integrate video into web pages, and more recently, to develop rich Internet applications. It is appropriate software to use to create an e-learning tool.

CHAPTER 2

LITERATURE REVIEW

2.1 Previous Study

When studying a certain power electronic circuit, the first question of the student is always for the different current paths in dependency of the switching states and certain impressed currents and voltages. With traditional teaching the current paths are drawn using different colors into some figures of the power circuit, or the teacher presents slide-shows in the classroom. Here the approach of interactive animations is used. Different visualization principles for explaining power electronic circuits. To illustrate the ideas mentioned above an example is shown here. The square wave generation principle shown in Figure 2.1 is a basic switching strategy used for high power converters. The continuously running animation was replaced by a static one where the cursor (orange vertical line in the time diagram) that can be shifted in time by the lecturer. This solution gives a possibility to explain circuit behavior given by switching states of the power semiconductor devices in the required time instant. The chain circuit represents a straightforward approach to the realization of a multi-level converter for use in high power applications without the need for magnetic combining circuitry and complex transformer arrangement. The main advantage of this approach is the well-defined operating environment for each three-level pole within a substantially isolated H bridge circuit. Figure 2.1 shows the single-phase structure of an m-level cascade inverter.

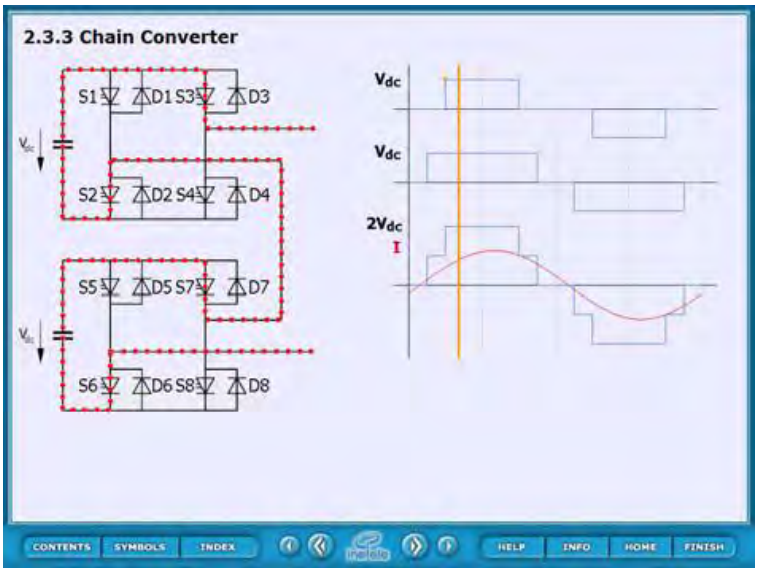

Figure 2.1: A single-phase structure of an m-level cascade inverter

2.2 Definition of E-learning

E-learning is a type of education in interactive way by using the computer as a medium of learning. E-learning is used interchangeably in a wide variety of contexts. In the USA, it is defined as a planned teaching/learning experience that uses a wide spectrum of technologies, mainly Internet or computer-based, to reach learners at a distance.

Lately in most Universities, e-learning is used to define a specific mode to attend a course or programs of study where the students rarely, if ever, attend face-to-face for on-campus access to educational facilities, because they study on-line.

Other definition of e-learning is:

"The delivery of a learning, training or education program by electronic means. E-learning involves the use of a computer or electronic device (e.g. a mobile phone) in some way to provide training, educational or learning material". (Derek Stockley 2003)

E-learning can involve a greater variety of equipment than online training or education, for as the name implies, "online" involves using the Internet or an Intranet. CD-ROM and DVD can be used to provide learning materials. Distance education provided the base for e-learning's

development. E-learning can be "on demand". It overcomes timing, attendance and travel difficulties. E-learning is designed to make the study more efficient and easy to understand for student. The objective of e-learning is to create an interactive way of learning the subject and to make student for better understanding

2.3 History of E-learning

Firstly developed in US by Rath and Anderson that work at IBM in 1958. At first, this program is use to teaching in arithmetic system. Dr. Don Britzer from Illinois University introduced concept of learning with the computer that named Illiac 1. His splendid contribution is introducing authorized language concept.

In 1972, US government spent US$ 10,000,000 trough American National Science Foundation (ANSF) to create learning system based on computer. Two system are create that is Programmed Logic for Automatic Teaching Operation (PLATO) and Timeshared Interactive Computer-Controlled Information Television (TICCIT). Late 1960, IBM developed two software coursewriter-III and coursewriter IIS.

2.4 Advantages of E-learning

Advantages of e-learning are it is an interactive way of learning, it can be access where there are computers. Also, e-learning can help user to understand more about their topic of learning. The animation/simulation will help student to visualize the topics. Other than that, other than that, learner may have the option to select learning materials that meet their level of knowledge and interest. Also, self-paced learning modules allows user to work at their own pace.

2.5 Disadvantages of E-learning

The disadvantages of e-learning are if there are confusing topics, it is hard top explain because there are no lecturer/instructor to explain the confusion. Also, unmotivated learners or those with poor study habits may fall behind. Other than that, students may feel isolated or miss social interaction and some courses such as traditional hands-on courses can be difficult to simulate.

2.6 INTRODUCTION TO HARMONICS ANALYSIS

2.6.1 Definition

Harmonic analysis is the branch of mathematics that studies the representation of functions or signals as the superposition of basic waves. The basic waves are called "harmonics"(in physics), hence the name "harmonic analysis," but the name "harmonic" in this context is generalized beyond its original meaning of integer frequency multiples. In the past two centuries, it has become a vast subject with applications in areas as diverse as signal processing, quantum mechanics, and neuroscience.

Study of harmonics requires understanding of wave shapes. **Fourier series** is a tool to analyze wave shapes. Fourier series is the decomposition of a function in terms of sinusoidal functions (called basis functions) of different frequencies that can be recombined to obtain the original function. Fourier series is a made up of infinite sum of sines and cosines with frequencies that are multiple of the fundamental frequency. The definition of periodic function is that $f(x)$denotes a function of the real variable *x*. This function is usually taken to be periodic, of period T, which is to say that

$$f(x) = f(x+T) \tag{2.1}$$

We start by assuming that the trigonometric series converges and has a continuous function *f(x)* as its sum on the interval [-π, π], that is,

$$f(x) = a_0 + \sum_{n=1}^{\infty} (a_n \cos nx + b_n \sin nx) \qquad -\pi \le x \le \pi \tag{2.2}$$

$$a_0 = \frac{1}{2\pi}\int_{-\pi}^{\pi} f(x)\,dx \tag{2.3}$$

$$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)cosnxdx \tag{2.4}$$

$$b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\sin nx\,dx \qquad (2.5)$$

2.6.2 Odd and Even function

Odd function is a function *f(x)* is said to be odd when *f(-x)* = - *f(x)*. Geometrically, the graph of an odd function has rotational symmetry with respect to the origin, meaning that its graph remains unchanged after rotation of 180 degrees about the origin. Figure 2.2 show that odd function has rotational symmetry with respect to the origin.

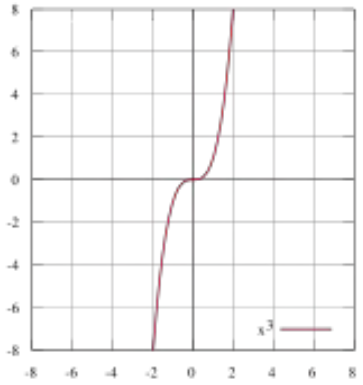

Figure 2.2: Odd function, $f(x) = x^3$

Even function is a function *f(x)* is said to be even when *f(x)* = *f(-x)*. Geometrically, the graph of an even function is symmetric with respect to the *y*-axis, meaning that its graph remains unchanged after reflection about the *y*-axis. Figure 2.3 show that even function is symmetric with respect to the *y*-axis.

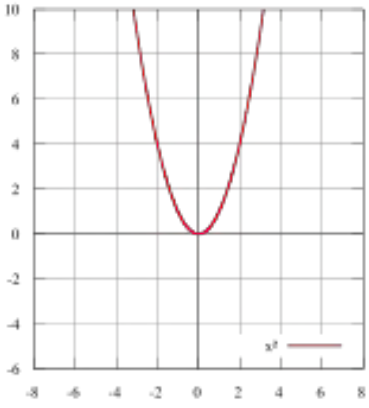

Figure 2.3: Even function, $f(x) = x^2$

2.6.3 Fourier series of Sine wave.

For sine wave, *f(x)* is an odd function, then a_n=0, the Fourier series collapses to equation below. Figure 2.4 shows the shape of sine wave.

$$f(x) = \sum_{n=1}^{\infty} b_n \sin(nx) \tag{2.6}$$

$$b_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \sin nx \, dx \tag{2.7}$$

$$b_n = \frac{2}{\pi} \int_{0}^{\pi} f(x) \sin(nx) dx \tag{2.8}$$

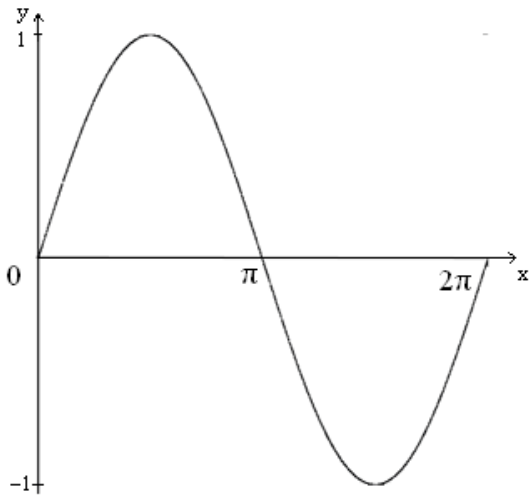

Figure 2.4: Sine Waveform

2.6.4 Fourier series of Square Wave

Square wave is waveform that shape like the square. This example will help user understand the square wave. Figure 2.5 shows the shape of square wave.

$$f(x) = \begin{cases} 1 & ,-\pi \le x < 0 \\ -1 & ,0 \le x < \pi \end{cases} \text{ and } f(x+2\pi) = f(x) \tag{2.9}$$

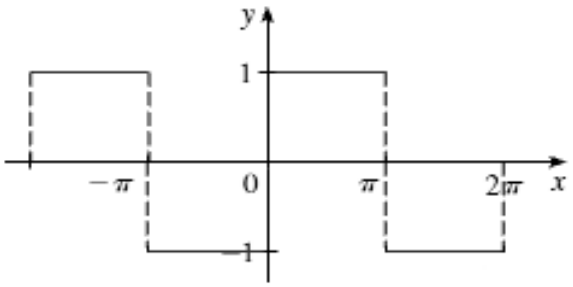

Figure 2.5: Square waveform

For a_0,

$$a_0 = \frac{1}{2\pi}\int_{-\pi}^{\pi} f(x)dx \tag{2.10}$$

$$a_0 = \frac{1}{2\pi}\left[\int_{-\pi}^{0} -1dx + \int_{0}^{\pi} 1dx\right] = \frac{1}{2\pi}[-\pi + \pi] = 0$$

For $n \geq 1$,

$$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)cosnxdx \tag{2.11}$$

$$a_n = \frac{1}{\pi}\left[\int_{-\pi}^{0} -cosnxdx + \int_{0}^{\pi} cosnxdx\right] = \left[\frac{1}{\pi}\left[\frac{-\sin nx}{n}\right]_{-\pi}^{0} + \frac{1}{\pi}\left[\frac{\sin nx}{n}\right]_{0}^{\pi}\right]$$

$$= \frac{1}{n\pi}[-\sin 0 + \sin n(-\pi)] + \frac{1}{n\pi}[\sin n\pi + \sin 0] = 0$$

$$b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\sin nx\, dx \tag{2.12}$$

$$b_n = \frac{1}{\pi}\left[\int_{-\pi}^{0} -\sin nxdx + \int_{0}^{\pi} \sin nx\, dx\right] = \left[\frac{1}{\pi}\left[\frac{\cos nx}{n}\right]_{-\pi}^{0} + \frac{1}{\pi}\left[\frac{\cos nx}{n}\right]_{0}^{\pi}\right]$$

$$= \frac{1}{n\pi}[1 - \cos n(-\pi)] + \frac{1}{n\pi}[\cos n(\pi) - \cos 0]$$

$$n = even, \cos n\pi = 1 \;\&\; n = odd, \cos n\pi = -1$$

$$b_n = \begin{cases} 0\,, if\ n = even \\ \dfrac{4}{n\pi}, if\ n = odd \end{cases}$$

So, when value of *n* is odd

$$f_n(x) = \frac{4}{\pi}\sin x + \frac{4}{3\pi}\sin 3x + \cdots + \frac{4}{n\pi}\sin nx \qquad (2.13)$$

2.6.5 Fourier series of Triangular Wave.

If a function has period other than 2π, we can find its Fourier series by making a change of variable. Suppose *f(x)* has period 2*L*, that is *f(x+2L) =f(x)* for all x. If we let $t = \frac{\pi x}{L}$ and

$$g(t) = f(x) = f\left(\frac{Lt}{\pi}\right) \qquad (2.14)$$

Then, as you can verify, *g* has period 2π and $x=\pm L$ corresponds to $t=\pm\pi$. The Fourier series of *g* is

$$a_0 + \sum_{n=1}^{\infty}(a_n \cos nt + b_n \sin nt) \qquad (2.15)$$

$$a_0 = \frac{1}{2\pi}\int_{-\pi}^{\pi} g(t)\,dt \qquad (2.16)$$

$$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} g(t)\cos nt\,dt \qquad (2.17)$$