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Harmonic filter design for induction motor / Mohd Jamal Abu.

HARMONIC FILTER DESIGN FOR INDUCTION MOTOR

MOHD JAMAL BIN ABU

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HARMONIC FILTER DESIGN FOR INDUCTION MOTOR

MOHD JAMAL BIN ABU

This Report Is Submitted In Partial Fulfillment of Requirement for the Degree of Bachelor in Electrical Engineering (Industry Power)

Fakulti Kejuruteraan Elektrik
Kolej Universiti Teknikal Kebangsaan Malaysia

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"I am accepting that have been read this work of report. In my opinion this report is suppose in the scope and quality for purpose to award the Degree of Bachelor in Electric Engineering (Industry Power)."

Signature : ....
Supervisor Name : .....JURIFA MAT LAZI.....
Date : .....23/11/05.....

JURIFA BT. MAT LAZI
Pensyarah
Fakulti Kejuruteraan Elektrik
Kolej Universiti Teknikal Kebangsaan Malaysia

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" I admit this report is producing by me except the summary and extraction for each I have been clearly presented."

Signature : ....

Writer Name : Mohd. Jamal bin Abu

Date : 21st November 2005

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Thank you Allah for my beloved mother and father, my family,
all my teachers and friends.

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ABSTRACT

This project is about to design harmonic filter for induction motor and do the simulation using PS CAD software. Harmonic is produced by unbalance load in power system. The sources of harmonics are equipments like computers, adjustable speed motors, electronic apparatus, battery charger and welding machine. When harmonics happen, its cause overload in neutral cable, overheated in motors and transformers, fuse may blow, circuit breakers always close/disclose, damage power factor capacitor banks, equipment failure and increasing the demand of KVA. To reduce this harmonic effect, effective filter system is required most. Types of filter used are band pass filter that filtering low harmonic order such as 3rd, 5th, 7th and etc, and also high pass filter that filtering high order harmonic and cover wide range of frequencies. Today, there are two common filter uses; passive filter and active filter. Passive filter consists of passive element like resistor, inductor and capacitor. Common type use is shunt filter that much cheaper than series filter. Active filter is functional by controlling current and voltage sources. The harmonic in induction motor will cause noise, vibration, overheated and shorten motors life operation. In my design simulation, I only choose 3 types of passive filter that are band pass, high pass and series filter.

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ABSTRAK

Projek ini adalah berkenaan merekabentuk penapis harmonik bagi motor aruhan dan melakukan simulasi menggunakan perisian PS CAD. Harmonik terhasil dari beban tidak seimbang dalam sistem kuasa. Sumber–sumber harmonik adalah seperti dari peralatan komputer, peranti kelajuan boleh laras, perkakasan elektonik dan pengecas bateri serta alatan kimpalan. Harmonik menyebabkan beberapa perkara seperti lebihan arus beban pada kabel neutral, lebihan haba pada motor dan alat ubah, fius terbakar serta pemutus litar sentiasa terpelantik, kerosakan pada kapasitor faktor kuasa, kegagalan fungsi perkakasan dan meningkatkan kadar permintaan KVA. Bagi mengurangkan kesan-kesan harmonik tersebut, satu sistem penapis yang efektif diperlukan. Jenis-jenis yang digunakan adalah seperti penapis *band-pass* yang menapis harmonik-harmonik rendah seperti harmonik ke-3, ke-5, ke-7 dan sebagainya dan penapis *high-pass* yang menapis harmonik-harmonik tinggi dan merangkumi julat frekuensi yang besar. Terdapat dua jenis penapis iaitu penapis pasif yang biasa digunakan dan penapis aktif. Penapis pasif biasanya terdiri dari gabungan perintang, kapasitor dan induktor. Jenis yang biasa digunakan pula ialah penapis shunt yang lebih murah berbanding penapis sesiri yang lebih mahal. Penapis aktif pula berfungsi mengawal sumber arus dan voltan. Kesan harmonik pada motor aruhan diantaranya ialah memendekkan jangka hayat motor, motor berbunyi bising dan bergetar serta sentiasa dalam keadaan panas. Dalam projek ini, saya hanya membuat simulasi menggunakan 3 jenis penapis pasif iaitu penapis *band pass*, *high pass* dan sesiri.

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CONTENT

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LIST OF TABLE

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LIST OF FIGURE

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LIST OF APPENDIX

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CHAPTER 1

INTRODUCTION

Projek Sarjana Muda (PSM) is one of knowledge research that related to student's discipline. This task should be completed by the student before they can finish their bachelor study in the university. The project has been divided into three categories, design project, software development and case study.

i. Design project should be base on certain design and finally could end with product or design.
ii. Software development project should concentrate on the computer software that relates to student's discipline their selves.
iii. The case study project is more on study research on certain case or topic.

By the end of this project, student should come with solution of the problem. I have been chosen the software development project focus in simulation environment and my project title is "Harmonic Filter Design for Induction Motor". This project will focus on simulation a few type of filters using PS CAD.

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1.1 Objective

The objective of my project is to design harmonic filter for induction motor using PS CAD software. Besides that, I would simulate an inverter in order to adjust the speed drive of induction motor. I also want to find the most suitable filter design to eliminate harmonic produce by adjustable speed drive.

1.2 Scope

The project scope is to familiar with PS CAD software environment and using it to simulate filter design of induction motor. Other scope is to reduce harmonic order contents like 3rd, 5th, 7th and etc. I also need to know more about which filter is effective in order to filter harmonic.

1.3 Problem Statement

Now more and more induction motors are used in the utility system. That is because the induction motor is rugged, reliable, and single-fed machine, it can directly absorb the reactive power from the utility, and needn't additional magnetic field provider. In order to control the speed of induction motor, many methods have been developed. The most popular way is to use the Adjustable Speed Drive (ASD), usually it is an AC inverter. With this device, we can get two advantages: one is that we can get a low start current; the other is that we can change the motor speed conveniently by controlling the output frequency of the ASD.

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But at the same time, AC inverter can also causes harmonics in utility and becomes the harmonic source in utility system. These harmonics will reduce the power factor and, if seriously enough, it will destroy the motor in this system.

The effects of harmonic in induction motor are noise vibration, shaft deflection, overheating, excessive losses, harmonic torques, oscillation, low efficiency and shorten induction motor life operation.

Because of these problems, the harmonic filters must have to be design by considering all of those factors

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CHAPTER 2

LITERATURE REVIEWS

These chapters are all about theories of the project. Most of these are from references source.

2.1 Harmonic

There has been much discussion and interest in recent years on the subject of power quality. More and more frequently, industrial plants are finding they have to deal with the problem of "dirty" power. "Dirty power" is a slang expression used to describe a variety of voltage and current contaminations.

Harmonic distortion is a specific type of dirty power that is usually associated with an industrial plant's increased use of adjustable speed drives, power supplies and other devices. Harmonic distortion can also be generated by a variety of non-linear electrical devices.

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The term harmonics commonly refers to a distortion of the normally smooth utility power. Harmonics are actually higher frequency voltages and currents, and when added to the utility power, produce a distortion of the normal voltage or current waveform. Usually, harmonic distortion must be present continuously to have an adverse effect on the power system.

Technically, a harmonic is a component of a periodic wave having a frequency that is an integral multiple of the fundamental power line frequency of 50 Hz (in Malaysia). The easiest way to explain this is with the following diagram:

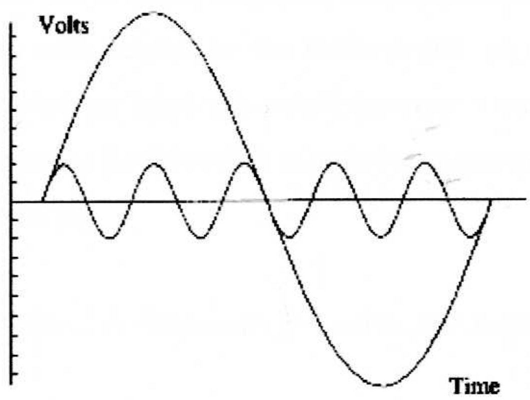

Figure 2.1: Normal sine curve and harmonic

In Figure 2.1, we see two curves; a normal large sine curve, representing a "clean" power current; and a smaller curve, representing a harmonic.

This harmonic curve represents a "fifth order" harmonic, meaning it is 5 x 50 Hz.

In Figure 2.2, we see what the power current looks like when the two curves are combined.

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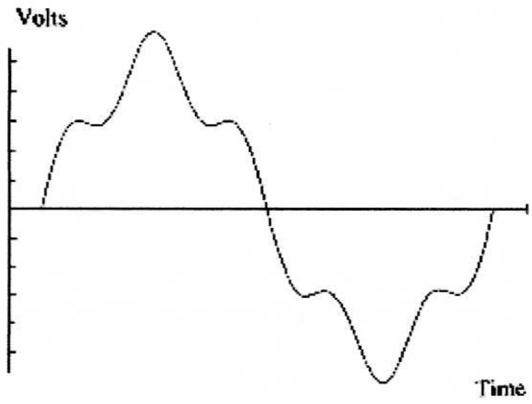

Figure 2.2: Harmonic curve

Each harmonic has a name, frequency and sequence. The sequence refers to the phase or rotation with respect to the fundamental. In an induction motor, for instance, a positive sequence harmonic would generate a magnetic field that rotated in the same direction as the fundamental. A negative sequence harmonic would rotate in the reverse direction. [6]

Table 2.1: Harmonic, frequency and sequence

Harmonic	**Frequency**	**Sequence**
1st	50	+
2nd	100	-
3rd	150	0
4th	200	+
5th	250	-
6th	300	0
7th	350	+
8th	400	-
9th	450	0

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Zero sequence harmonics are called "Triplens." These are odd multiples of the 3rd, such as 3rd, 9th, 15th, 21st, etc.

In small quantities, harmonics are of little concern. However, too many non-linear loads can lead to significant power quality problems. Often the most reliable, low-cost solution is realized with the use of harmonic filters.

While there are several products available on the market designed to deal with harmonics, each requires careful analysis to ensure proper application. Both passive and active harmonic filters can be applied in specific situations. Passive harmonic filters are the most common and are always custom-designed for the application or site. Active harmonic filters are a relatively new technology that will gain market share quickly as their initial cost becomes competitive with the passive variety.

2.2 Induction Motor

Induction motors are the simplest and most rugged machine of all electric motors. There are only two main components: the stator and the rotor. The rotor is built from a number of conducting bars running parallel to the axis of the motor and two conducting rings at the ends.

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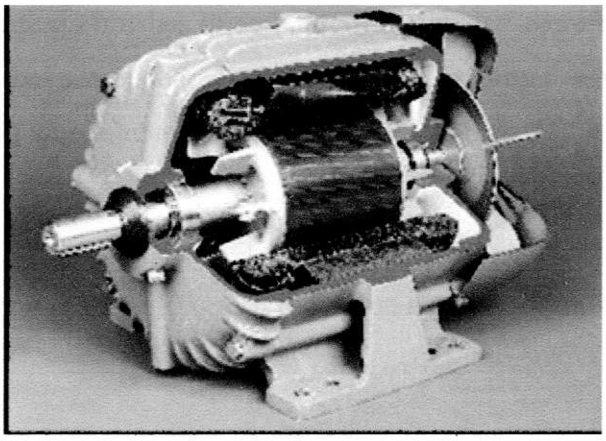

Figure 2.3: Induction motor

Figure 2.4 below shows an example of the stator bars and the two rings of a squirrel cage induction motor. The stator contains a pattern of copper coils arranged in windings. As alternating current is passing through the windings, a moving magnetic field is form near the stator which induces a current in the rotor, and creating its own magnetic field.

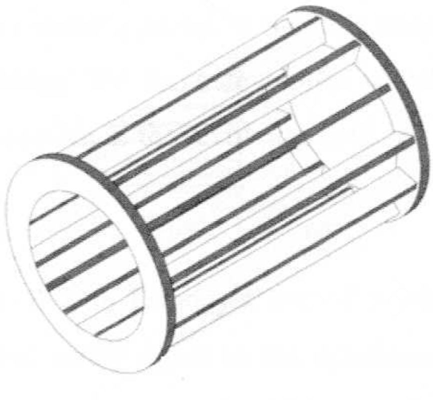

Figure 2.4: Stator Bars of a Squirrel Cage Induction Motor

An induction motor constitute of the following:

It is a single-fed motor which means that it does not require a commutator, slip-rings, or brushes.

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Since there are no brushes in an induction motor, it therefore operates at high efficiency. It has the same characteristic as a transformer where the secondary winding is energized when the machine rotates.

The synchronous speed N_S of an induction motor is defined as:

$$N_S = \frac{120f}{P} \quad (2.0)$$

f Is the frequency of the current in the stator winding and P is the number of poles. And the Motor Speed = Synchronous Speed –Motor Slip.

The revolving field induces electromotive force (EMF) in the rotor winding. Since the rotor winding forms a closed loop, the induced EMF in each coil gives rise to an induced current in that coil. When a current-carrying coil is immersed in a magnetic field, it experiences a force (or torque) that tends to rotate it. The torque thus developed is called the starting torque. If the load torque is less than the starting torque, the rotor starts rotating. The force developed and the thereby the rotation of the rotor are in the same direction as the revolving field.

This is in accordance with Faraday's law of induction. Under no load, the rotor soon achieves a speed nearly equal to the synchronous speed. However, the rotor can never rotate at the synchronous speed because the rotor coils would appear stationary with respect to the revolving field and there would be no induced EMF in them. In the absence of an induced EMF in the rotor coils, there would be no current in the rotor conductors and consequently no force would be experienced by them. In the absence of a force, the rotor would tend to slow down. As soon as the rotor slows down, the induction process takes over again. In summary, the rotor receives its power by induction only when there is a relative motion between the rotor speed and the revolving field. Since the rotor rotates at a speed lower than the synchronous

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