"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of bachelor of Electrical Engineering (Industrial Power)".

Sign : ....

Name of Supervisor : GAN CHIN KIM

Date : 21 NOVEMBER 2005

EQUIPMENT SENSITVITY STUDY DURING POWER QUALITY EVENT

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"I hereby verify that this paper work is done on my own except for the references I made which I stated the source clearly on the specified section"

Sign : ....

Name : MOHD IDZWAN BIN MOKHTAR

Date : 19 NOVEMBER 2005

For my beloved father and mother.

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Syukur Alhamdulillah, thank God because I completed my PSM project and finishd my report before my due date.First of all, I want to thank my parents, Haji Mokhtar Bin Mokhtar and Hajjah Rahmah Binti Kassim, also for my brothers and sisters because being understanding. Special thank to my Supervisor, Mr. Gan Chin Kim, which help me in my project and give me motivation when doing this project. I really appreciate it. Also to my friends, Shamshul, Hafis, Sharifah, Zuraidah and all 4BEKP2, thanks for being my friend. Thank you very much.

ABSTRACT

Power quality waveform events such as voltage sags, swells, transients, flickers, harmonics and others, may cause sensitive loads trip or mis-operation of the specific power quality event on the equipment. In general, the more sophisticated equipment is the more sensitive it is to variations in power quality. The control system of the drive has a great impact on the behavior of the drive during the sag and after recovery. The trip point settings of many drives can by field-adjusted and greatly improve many nuisance trips resulting from minor voltage sags. AC motor drive among the most power electronics- base industrial equipment, and have 3 stages topology; diode rectifier, dc link or bus (filtering) and PWM inverter. The AC drive have some energy storage in the DC link capacitor and most use passive diodes on the 'the front end'. The ac drive can be made somewhat tolerant to voltage sags, but most drive is rather sensitive. Voltage depressions caused by faults on the system affect the performance of induction motors, in terms of the production of both transient currents and transient torques. It is often desirable to minimize the effect of the voltage sags on both the induction motor and more importantly on the process where the motor is used.

ABSTRAK

Gelombang Qualiti Kuasa seperti voltan kelonggaran, gelombang besar, kesementaraan, kerdipan, harmonik dan lain-lain lagi, boleh menyebabkan beban sensitif trip atau operasi terganggu daripada spesifik Qualiti Kuasa kepada peralatan. Secara umum, lebih sofistikated peralatan itu, lebih sensitif ia kepada variasi Qualiti Kuasa. Pembawa sistem kuasa mempunyai impak yang besar kepada perjalanan drive semasa kelonggaran dan selepas pemulihan. Titik keadaan trip dari banyak pembawa boleh dilakukan dengan pengubahsuaian bidang dan memperbaiki gangguan keputusan trip daripada voltan kelonggaran minor. Pembawa AC motor ialah antara banyak asas Kuasa Elektronik peralatan industri dan mempunyai 3 peringkat topologi; diod pembetulan, penghubung DC dan pembalik PWM. Pembawa AC motor mempunyai tenaga simpanan dalan kapasitor penghubung DC dan kebanyakan menggunakan diod pasif pada penamat hadapan. Pembawa AC boleh dibuat toleransi dengan voltan kelonggaran tetapi kebanyakan pembawa lebih sensitif. Kemerosotan voltan yang disebabkan oleh kegagalan pada sistem mengakibatkan prestasi motor induksi pada sudut produksi kedua-dua arus kesementaraan dan kesementaraan tenaga putaran. Ia selalu diperlukan untuk mengurangkan kesan voltan kelonggaran kepada motor induksi dan lebih penting lagi kepada proses dimana motor itu digunakan.

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CHAPTER 1

1.0 INTRODUCTION

Power quality waveform events such as voltage sags, swells, transients, flickers, harmonics and others, may cause sensitive loads trip or mis-operation of the specific power quality event on the equipment. So it is important to evaluate the effects of the specific power quality event on the equipment. In general, the more sophisticated equipment is the more sensitive it is to variations in power quality. Voltage sags are one of the most concerned power quality events in the modern power system as they often load to tripping or mis-operation of the customer equipment.

Among the various kind of power quality disturbance, voltage sags a particularly troublesome since they occur rather randomly and are difficult to predict. Voltage sags may often cause trips or mis-operation for industrial equipment. Voltage depressions caused by faults on the system affect the performance of induction motors, in terms of the production of both transient currents and transient torques.

It is often desirable to minimize the effect of the voltage sags on both the induction motor and more importantly on the process where the motor is used.

1.1 OBJECTIVE

This project presents a simulation method for performing equipment sensitivity study during power quality events. Power quality waveform events such as voltage sags, swells, transients, etc. may cause sensitive loads to trip or mis-operate. For better coordination between the system and the equipment, it is necessary that the effects of specific events on the equipment behavior be thoroughly evaluated.

Voltages unbalance and phase angle shifts cause large unbalanced source currents to, excessive voltage ripple in the dc-link, and reduced dc-link average voltage. The response of the motor and drive to these varies considerably. Experimental results clearly show the load dependent behavior of a typical drive.

The ability of the drive to ride-through voltage sag is dependent upon the energy storage capacity of the dc-link capacitor, the speed and inertia of the load, the power consumed by the load, and the trip point settings of the drive. The control system of the drive has a great impact on the behavior of the drive during the sag and after recovery. The trip point settings of many drives can by field-adjusted and greatly improve many nuisance trips resulting from minor voltage sags.

This project will focus on the effect of voltage sags on the induction motor connected to ac motor drive case. This case study will focus on induction motor drive model, converter model, and speed motor model on matlab simulation. The outcome of the project is matlab simulation software project.

The expected result is from the simulation:

- The waveform of voltage sags to equipment.
- The Analysis for this project.

1.2 SYSTEM DESCRIPTIONS

The simulation is developed using Matlab Simulink software. Sags generator was modulated from 3-phase programmable Voltage and induction machine was modulated from asynchronous machine. Variable Speed Drive, VSD was built from 2 universal blocks AC-DC-AC converter consist of Diode rectifier and IGBT inverter through a DC link. IGBT inverter is controlled with PI regulator in order to maintain 1 p.u. voltage at load terminals. To generate the Inverter, PWM pulse generator is used to give impulse to IGBT inverter.

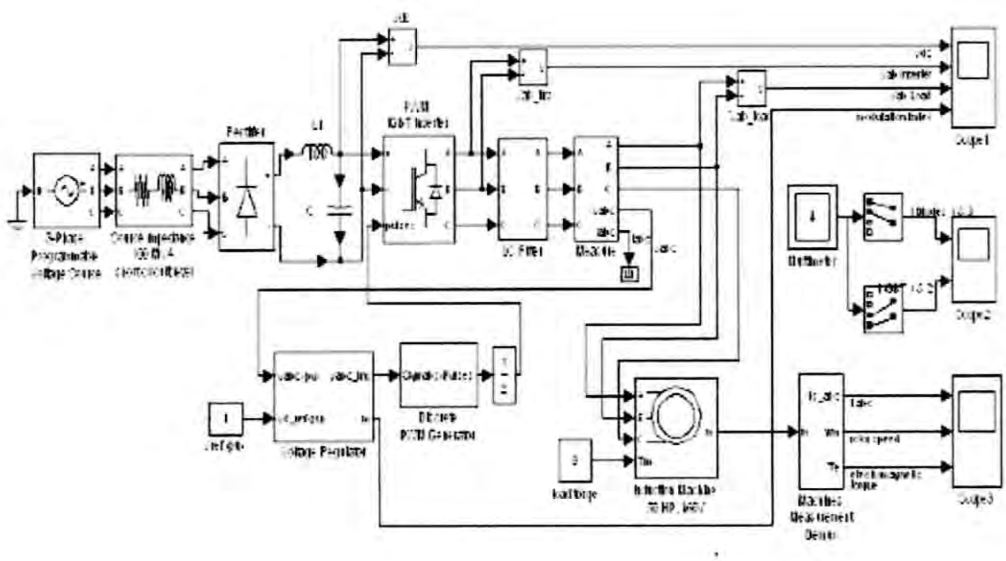


Figure 1.0 Overall Matlab Simulink system for this project.

1.2.1 3-Phase Programmable Voltage Source

To implement a three-phase source signal with programmable time variation of amplitude.

Description - Use this block to generate a three-phase sinusoidal signal with time-varying parameters. Can program the time variation for the amplitude, phase, or frequency of the fundamental component of the source. The 3-Phase Programmable Source block can be used to control the voltage of three Controlled Voltage Source blocks or the current of three Controlled Current Source blocks.

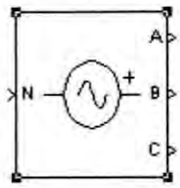


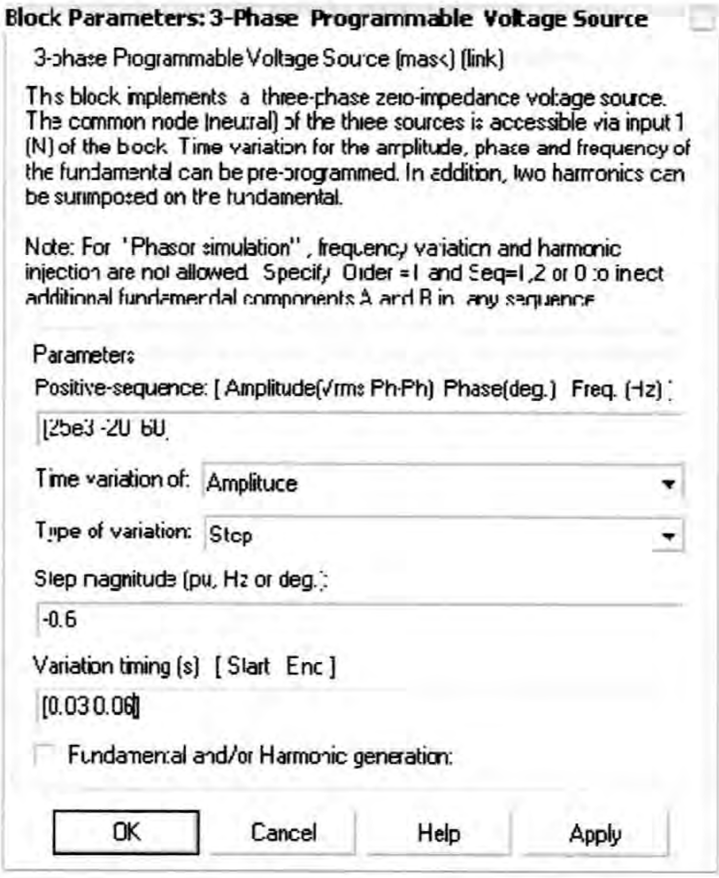
Figure 1.1 3-phase programmable voltage source block

Time variation of - Specify the parameter for which you want to program the time variation. Select none if don't want to program the time variation of the source parameters. Select Amplitude if want to program the time variation of the amplitude. Select Phase if want to program the time variation of the phase. Select Frequency if want to program the time variation of the frequency. Note that the time variation applies on the three phases of the source.

Type of variation - Specify the type of variation that is applied on the parameter specified by the Time variation of parameter. Select Step to program a step variation. Select Ramp to program a ramp variation. Select Modulation to program a modulated variation.

Step magnitude - Specify the amplitude of the step change. This parameter is only visible if the Type of Variation parameter is set to Step.

Table 1.0 Block parameter for 3-phase programmable voltage source



1.2.2 Universal Bridge

To implement a universal three-phase bridge converter with selectable configuration and power switch type. The Universal Bridge block implements a universal three-phase power converter that consists of six power switches connected as a bridge. The types of power switch and converter configuration are selectable from the dialog box.

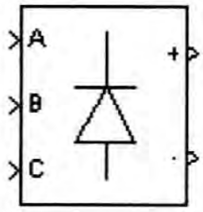


Figure 1.2 Diode bridge block

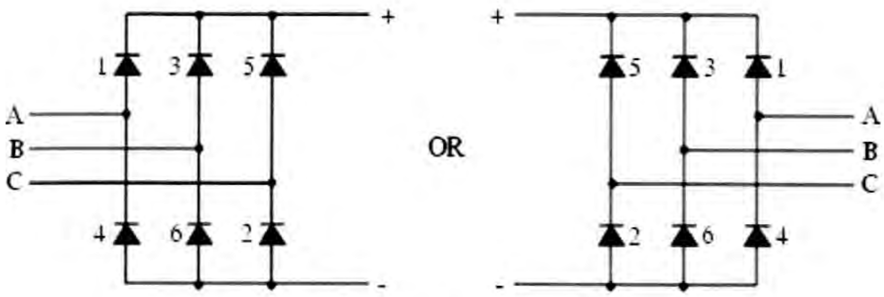
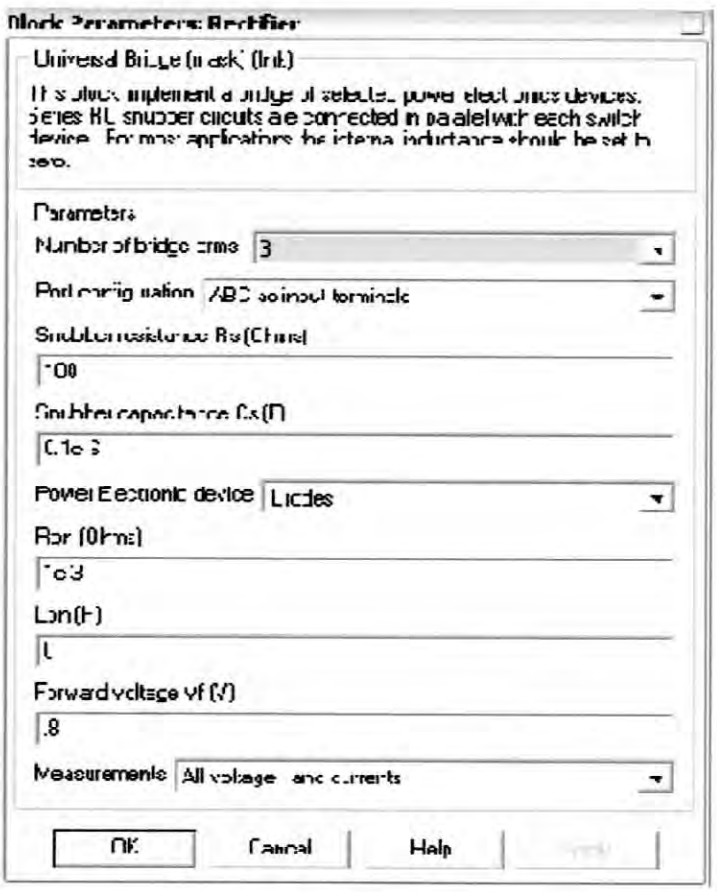


Figure 1.3 Diode bridges schematics

Table 1.1 Parameters of Rectifier.



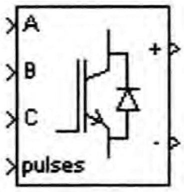


Figure 1.4 IGBT diode bridge block.

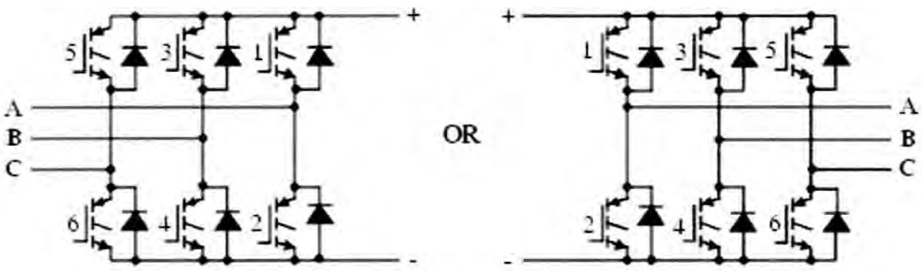
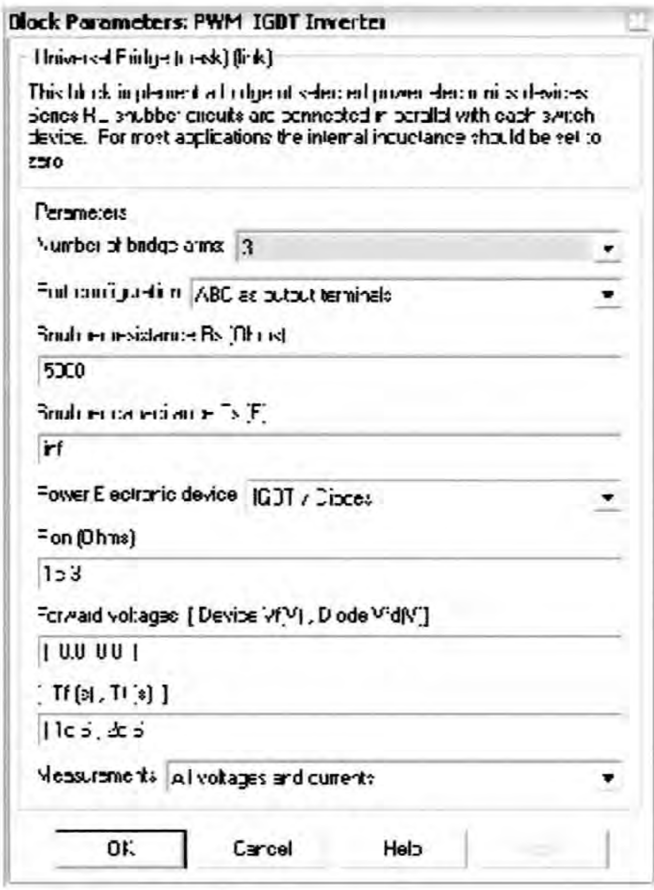


Figure 1.5 IGBT diode bridges schematics.

Table 1.2 Parameters of IGBT-diode Inverter.


Block Parameters: PWM IGBT Inverter

Universal Bridge (mask) (link)

This block implement a bridge of selected power electronics devices. Series RC snubber circuits are connected in parallel with each switch device. For most applications the internal inductance should be set to zero

Parameters

Number of bridge arms: 3

Port configuration: ABC as output terminals

Snubber resistance Rs (Ohms)

5000

Snubber capacitance Cs (F)

inf

Power Electronic device: IGBT / Diodes

Ron (Ohms)

1e-3

Forward voltages [Device Vf(V) , Diode Vfd(V)]

[0.0 0.0]

[Tf (s) , Tt (s)]

[1e-5 , 2e-5]

Measurements: All voltages and currents

OK Cancel Help

1.2.3 Induction Machines.

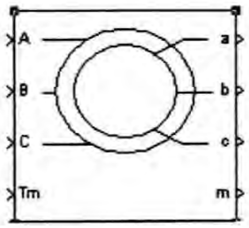


Figure 1.6 Asynchronous machine block

The induction motor is represented by the Asynchronous Machine block, which models both electric and mechanical dynamics. The control system, including current and speed regulators, is built using Simulink blocks. The interface between electrical and control systems is managed by blocks of the Measurements library.

The motor used in this case study is a 50 HP, 460 V, four-pole, 60 Hz motor having the following parameters: Rs = 0.087Ω , Lls = 0.8 mH, Lm = 34.7 mH, Rr = 0.228 Ω, Llr = 0.8 mH.

Where:

Rs = stator resistance.

L1s = stator inductance.

Lm = mutual inductance.

Rr = rotor resistance.

L1r = rotor inductance.

Table 1.3 Parameters of induction machine.

Parameters

Rotor type: Wound

Reference frame: Stationary

Nom. power,L-L volt. and freq. [Pn(VA),Vn(Vrms),fn(Hz)]:

[50*746, 460, 60]

Stator [Rs,Lls] (pu):

[0.087,0.8e-3]

Rotor [Rr',Llr'] (pu):

[0.228,0.8e-3]

Mutual inductance Lm (pu):

34.7e-3

Inertia constant,friction factor and pairs of poles [H(s) F(pu) p()]:

[1.662,0.1,2]

Initial conditions (read the details in the description above)

[1,0 0,0,0 0,0,0]

CHAPTER 2

2.0 BACKGROUND STUDY

2.1 Power Quality

Power quality is related to the compatibility between the power supply source (voltage, current and frequency) and the equipment served. When there are electrical disturbances, the equipment might not be able to operate normally if the equipment has not been specified to cater for such supply conditions.

Power quality waveform events such as voltage sags, swells, transients, etc. may cause sensitive loads to trip or mis-operate. For better coordination between the system and the equipment, it is necessary that the effects of specific events on the equipment behavior be thoroughly evaluated.

Power quality is an issue that is becoming increasingly important *to* electricity consumers at all levels of usage. Sensitive equipment and non-linear loads are now more commonplace in both the Industrial/commercial sectors and the domes tic environment. Because of this a heightened awareness of power quality is developing amongst electricity users. Occurrences affecting the electricity supply that were once considered acceptable by electricity companies and users are now often considered a problem *to* the users of everyday equipment.

The term 'power quality' has come into the vocabulary of many industrial and commercial electricity end-users in recent years. Previously equipment was generally simpler and therefore more robust and insensitive to minor variations in supply voltage. Voltage fluctuations corning from the public supply network were therefore not even noticed. Now equipment is used which depends on a higher level of power quality and consumers expect disruption-free operation.

In a recent presentation given by a representative of OFGEM on the subject of power quality, the stance of the UK regulator concerning where the responsibility for power quality lies was made clear. 'It is for the end-user to protect sensitive loads from power quality disturbances/disturbing loads by installing protection equipment'. A wide diversity of solutions to power quality problems is available to both the distribution network operator and the end-user. More sophisticated monitoring equipment is readily affordable to end-users, who empower themselves with information related to the level of power quality they receive. The following paragraphs introduce the main definitions of power quality measurable quantities or occurrences:

- A voltage dip is a reduction in the RMS voltage in the range of 0.1 to 0.9 pu. (Retained) for duration greater than hall a mains cycle and less than 1 minute. Often referred to as'sag'. Caused by faults, increased load demand and transitional events such as large motor starting.

- A voltage swell is an increase in the RMS voltage in the range of 1.1 to 1.8 p.u. for duration greater than half a mains cycle and less than 1 minute. Caused by system faults, load switching and capacitor switching.

- A transient is an undesirable momentary deviation of the supply voltage or load current. Transients are generally classified into two categories: impulsive and oscillatory (Fig 2.0).

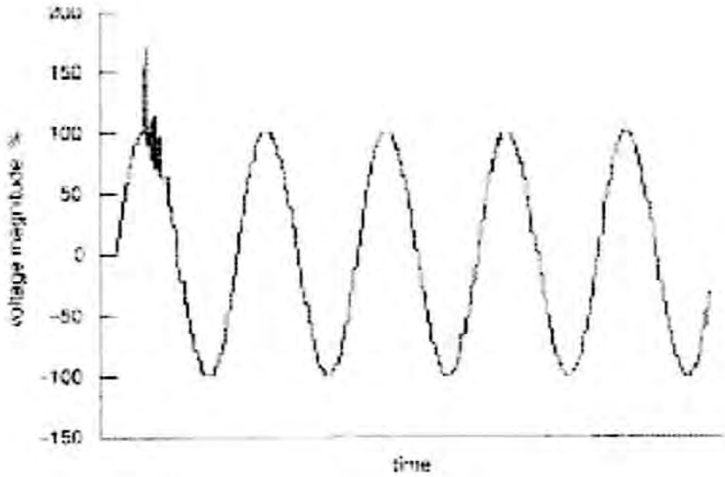


Figure 2.0 Impulsive and oscillatory

- Harmonics are periodic sinusoidal distortions of the supply voltage or load current caused by non-linear loads. Harmonics are measured in integer multiples of the fundamental supply frequency. Using Fourier series analysis the individual frequency components of the distorted waveform can be described in terms of the harmonic order, magnitude and phase of each component (Fig. 2.1). Paul Wright's article (p.87) considers the limitation of low-frequency effects generated by mains connected appliances.

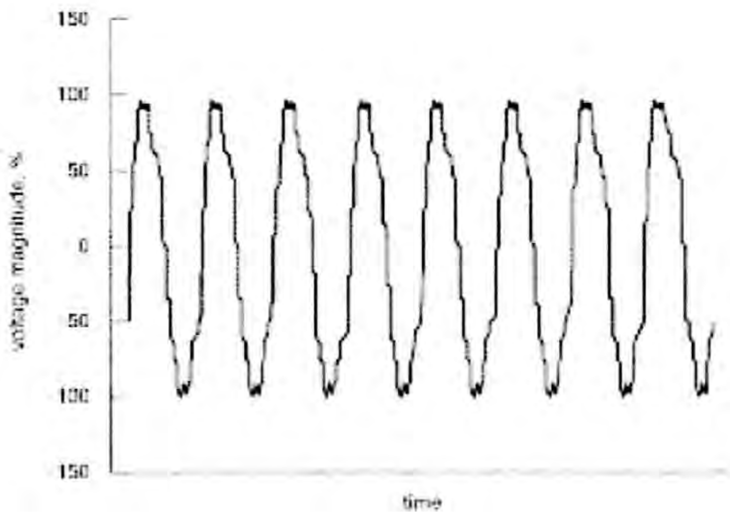


Figure 2.1 the harmonic order, magnitude and phase of each component

- Distorted voltage or current waveforms containing periodic distortions of a sinusoidal nature that are not integer multiples of the fu1idamental supply frequency are inter-harmonics.

- Flicker is a term used to describe the visual effect of smal1 voltage variations on electrical lighting equipment (particularly tungsten filament lamps). The frequency range of disturbances affecting lighting appliances, which are detectable by the human eye, is 1 – 30 Hz.

- Voltage imbalance is defined as a deviation in the magnitude and/or phase of one or more of the phases, of a three-phase supply, with respect to the magnitude of the other phases and the normal phase angle (120°).

- Frequency deviation is a variation in frequency from the nominal supply frequency above/below a predetermined level, normally ±0.1%.

- A transient interruption is defined as a reduction in the supply voltage, or load current, to a level less than 0.1 p.u. for a time of not more than 1 minute. Interruptions can be caused by system faults, system equipment failures or control and protection malfunctions. Interruptions are considered to be measurable events coining under the field of 'quality of supply'.

- An outage is defined as an interruption that has duration lasting in excess of one minute. A simple statistical model is introduced which will provide estimates of the probability of exceeding a pre-specific number of interruptions per annum.