VOLTAGE SAGS IN DISTRIBUTION SYSTEM

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MAY 2007

"I hereby declare that I have read through this report and found that it is sufficient in terms of scope and quality to be awarded of the Degree of Bachelor in Electrical Engineering (Industrial Power)"

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VOLTAGE SAGS IN DISTRIBUTION SYSTEM USING PSCAD SOFTWARE

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"I hereby declared that this report is a result of my own work except for the Excerpts that have been cited clearly in the references."

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To My Beloved Parents, friends, Zulkifli and Ila

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ABSTRACT

The purpose of this project is try to analyze and identify voltage sags problem in power quality especially in a distribution system. There are a lot of power quality problems occurred in a reality such as harmonic distortion, voltage swell and etc. In this project, it focused on voltage sags where we will identify briefly what is voltage sags in power quality problems. Voltage sags also known as voltage dips can define as a sudden reduction of the voltage at a point in the electrical system followed by a voltage recovery after a short period of time. Voltage sags in a large distribution system occurs by fault or load behavior. If there is a fault, any clearing of the faults provided interruptions and produce voltage sags. Voltage sags are a remarkable source of economic losses. PSCAD software will be used to determine voltage sags in a distribution system. To run the simulation, all the factors that caused the voltage sags have to be identified. During simulation, the location, type of fault, faults clearing time and electrical configuration will be analyze. Through out this simulation, voltages sags problems can be solve and mitigate as well earn fewer losses especially in distribution system.

ABSTRAK

Tujuan projek ini adalah untuk cuba menganalisis dan mengenal pasti kejatuhan voltan di dalam masalah kualiti kuasa terutama sekali dalam satu sistem pengagihan. Terdapat banyak masalah di dalam kualiti kuasa berlaku dalam satu realiti seperti herotan harmonik, voltan kembang dan dan sebagainya. Dalam projek ini, ia tertumpu pada kejatuhan voltan di mana kita akan mengenalpasti dengan secara ringkas apakah kejatuhan voltan dalam masalah kualiti kuasa. Kejatuhan voltan juga dikenali sebagai voltan pusuan boleh ditakrifkan sebagai suatu pengurangan voltan yang mengejut pada satu masa dalam sistem elektrik diikuti oleh satu voltan pemulihan selepas satu tempoh masa yang pendek. Kejatuhan voltan dalam satu sistem pengagihan yang besar berlaku sebelum kegagalan atau bergantung kepada jenis beban. Jika terdapat satu kegagalan, setiap pembetulan kegagalan menyediakan gangguan dan menghasilkan kejatuhan voltan. Kejatuhan voltan adalah suatu sumber yang luar biasa dan melibatkan kerugian di dalam ekonomi. Perisian PSCAD akan digunakan untuk menentukan kejatuhan voltan di dalam satu sistem pengagihan besar. Untuk melakukan simulasi, semua faktor-faktor yang menyebabkan kejatuhan voltan akan dikenal pasti. Semasa simulasi, lokasi, kegagalan jenis apa, masa membaik pulih kegagalan dan konfigurasi elektrik akan dianalisis. Melalui simulasi ini, masalah-masalah kejatuhan voltan boleh diselesaikan dan juga dapat lebih mengurangkan kerugian.

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CHAPTER I

INTRODUCTION

1.0 Introduction

In this chapter, it covers on analyzing and identifying voltage sags problem in power quality especially in a distribution system. From that, the conclusion will be produced based of the problem. There are a lot of power quality problems occurred in reality such as harmonic distortion, voltage swell and etc.

In this project, it focused on what is voltage sags in power quality problems. The objectives and scope of the project are also will be explained. They were very important towards this project because it will guide the whole process and give us first impressions about the project. It helps us to understand more about this project. In this project, I will use PSCAD software to simulate the voltage sags. The software comes with perfect analytical and friendly environment, and can provide good results, so I can manage to make knowledge research to solve the problem [1].

1.1 Project Objectives

There are a few objectives that should be managed to complete this project. First, I have to identify briefly what is voltage sags in power quality problem. It is the definition of voltage sags that we know is very important to be determined. Voltage sags in distribution system need to be identified.

Secondly, I have to determine the load behavior of the voltage sags. The loads that will be study in this project are three phase to ground fault and single phase to ground fault. Beside of that, I have to verify the characteristics of voltage sags. It is important to be understood because from that we can know the step that can be taken to reduce or prevent the problem from occur continuously. The voltage sags is studied due to its dept and duration from it characteristics.

Furthermore, I have to verify the influences and consequences of voltage sags. Voltage sags gives many bad influences to electrical component and equipment, especially to the sensitive electronic equipment such as electronics and controller devices, computers, medical equipments, contactor and Programmable Logic Controller (PLC). These equipments and devices are more subject to break up if voltage sags occurred. Monitoring and controlling is needed to prevent or reduce the losses.

The last of the objective is to simulate the voltage sags in a large distribution system using PSCAD software. Due to the objective, I have to study how to manage the software and study how to generate my own circuit according to a large distribution system or faults happened. In this project, I also explain the reasons I used the PSCAD software in this project.

1.2 Project Scopes

This project is trying to analyze and identify voltage sags in distribution system. Fault in distribution system create the voltage sags. After that, the voltage sags was simulated by using PSCAD software. The data provided by simulation will be studied and understand clearly. All the aspects such as factors that caused, load behavior, characteristics, influences, consequences and the expected results, will be observed and explained briefly, so at the end of this, discussion and conclusion of the problem can be produced.

1.3 Problem Statements

Voltage sags are one of the most major concerns in power quality problem. Power quality is the physical characteristics of the electric supply provided under normal operating conditions that do not interrupt or disturb the consumer's process. Power quality is a term used to direct the entire scope of interaction among electrical suppliers, the environment, the systems and products energized, and the users or customers. It is more than the delivery of "clean" electric power that complies with industry standards. It involves the maintainability of that power, the design, selection, and the installation of every piece of hardware and software in the electrical energy system. Stretching from the generation plant to the utility customer, power quality is a measure of how the elements affect the system as a whole.

Many researches have been made on voltage sags characteristics in industrial, commercial and residential. The consequences of voltage sags caused the cost of economical losses, production losses, highly maintenance system, plant breakdown and etc. Voltage sags also caused more problems in interruptions than disturbances in distribution system. Some of the equipments used in distribution system are very sensitive to the voltage sags.

For this project, a distribution system will be analyzed and modulated based to the voltage sags. The most common causes of voltage sags are fault. The location of faults, type of faults, fault clearing time and electrical configuration will affect the voltage sags.

1.4 Literature Review

There are a few literature reviews that have been made according to the voltage sags in power quality system. The thesis by Pirjo Heine, Member, IEEE and Matti Lehtonen which is "Voltage Sag Distributions Caused by Power System Faults" studied about the caused of voltage sags. Voltage sags caused by faults at different voltage levels and experienced by low-voltage customers were established for four different power system areas. The shares of different fault type at each voltage level and the sag propagation throughout the power system were taken into account. The results show that the origin of sags in urban and rural areas tends to be different [1].

Voltage sags can generally be characterized by sag magnitude, duration and frequency. Network impedances determine the sag magnitude. When considering sags caused by faults, the protection practices specify the sag duration and the fault frequencies determine the number of voltage sags.

A sag distribution can be determined for each low voltage customer, categorized in terms of the part of the network in which the fault occurs:

1) Transmission and sub transmission systems
2) Local medium distribution systems
3) Adjacent medium voltage distribution systems
4) Local low voltage distribution systems
5) Adjacent low voltage distribution systems

From the literature reviews that have been discovered, several conclusions can be made:

1) A power system fault is a typical cause of voltage sag.
2) Faults occur in transmission (EHV), subtransmission (HV), medium voltage (MV) and low voltage (LV) systems and sags propagate throughout the power system.
3) In low voltage networks, different fault types cause sags with different characteristics. The fault frequencies of each fault type should be determined. The faults occur at all voltage levels. The fault type, earthing practices and transformer connections determine which voltages are of interest when considering sags.
4) When an earth fault occurs in a transmission system, one phase voltage is sagged and the neutral point voltage will rise.

The thesis by I. Rendroyoko, R.E. Morrison and Peter K.C. Wong which is "Load Influence on Voltage Dip Characteristics)" studied about the load influence on voltage dip characteristics. Voltage dips are short duration reductions in rms voltage. They are mainly caused by short circuits. Voltage dips are one of the most troublesome power quality problems due to the interference they cause to several types of equipment. The objective of this study in concerning voltage dip problems is the influence of loads on voltage dip characteristics [5].

Voltage dips which occur on a system with no rotating machines result in a rectangular profile dip. The voltage directly drops to a particular level during fault. After the fault is cleared, the voltage returns to the level present before the fault occurred. A different phenomenon can be found in a system with rotating machine loads. When a fault occurs, the voltage does not directly drop to its minimum level but it decays until reaching a steady condition before the fault is cleared. At that time, the voltage does not directly return, but recovers slowly until reaching its original level. From these two results, it can be declared that the load influences the voltage dip characteristization.

The other thesis by Math Bollen which is "Voltage Dips a major Power Quality Issue" studied about the needed of care about power quality [6]. It was because:

1) Equipment has become more sensitive.
2) Equipment causes voltage disturbances
3) Need for standardization and performance criteria
4) Utilities want to deliver a good product
5) The supply has become too good
6) The power quality can be measured

The last thesis by P Heine, Member, IEEE, M. Lehtonen and E.Lakervi, Senior Member, IEEE which is "Voltage Sag Analysis Taken into Account in Distribution Network Design" studied about voltage sags that occur in distribution of Rural and Urban companies. The thesis also discussed about the effects of network characteristics on sag distribution caused by faults on the neighbouring MV feeders of the sag sensitive customer [2].

Urban areas have typically higher loading, more looped and stronger transmission system and larger transformer at HV/MV substation. Stronger source and larger transformers create higher remaining voltage during sag. Urban networks also consist typically of underground cables having larger cross sections than rural overhead line networks. Larger cross section means smaller line impedance and thus lower remaining voltage during the sag. The lower fault frequency of underground cables means less faults and sags.

The objective of the thesis is to minimize the impact of interruptions to customers. Underground cable networks seem to be superior compared to overhead line networks because of their lower fault frequency. When having sag sensitive customers in mixed underground cable and overhead line networks the way of thinking is no more straightforward. The aim of decreasing interruptions and voltage sags can bring competing aspects to network design.

Underground cable networks have compared to overhead line networks:

1) Lower fault frequency
2) Larger cross sections. Larger cross sections mean lower remaining voltage during a sag. In addition the area of vulnerability is wider in underground cable networks.

1.5 Project Methodology

To accomplish this project, there are three parts of work planning that have to be done completely. The first part is to search for information about voltage sags. The factors that caused the problem, load behavior, characteristics, influences and consequences and the expected results of the voltage sags is being determined and identified.

The second part is gathering data and measurement according to the voltage sags that occurred by faults in distribution system. It is based on the literature reviews that have been studied.

The last part is to evaluate and analysis voltage sags by simulating the distribution system by using PSCAD software. The large distribution system includes of generators, substation, transformer, switchgear, feeder pillar and load.

CHAPTER II

VOLTAGE SAGS

2.0 Introduction

In this chapter, the definition of voltage sags which is one of the power quality problems will be discussed. We will also discussed the characteristics of voltage sags and its role in contribute the problem in electrical system. Furthermore, the factors that caused voltage sags and its effect in distribution system and electrical system will be determined and analyzed.

2.1 Definition of Voltage Sags

Power quality problems generally appear in the form of voltage sags, transients and harmonics. From these three categories of power quality problems, voltage sags contribute the most disturbances experienced by industrial customers. Voltage sags or also known as voltage dips generally refers to instantaneous short duration voltage variations, which the typical duration of voltage sags is between 0.5 to 30 cycles with typical magnitude of 0.1-0.9 per unit [4]. According to IEEE standard 1159-1995, voltage sag is define as a decrease to between 0.1 and 0.9 p.u. in root mean square (rms) voltage at the power frequency for durations of 0.5 cycle to 1 min [1].

The term sag has been used in the power quality community for many years to describe a specific type of power quality disturbance known as a short duration voltage decrease. Clearly, the notion is directly borrowed from the literal definition of the word sag. The IEC definition for this phenomenon is dip. The two terms are considered interchangeable, with sag being preferred in the United States power quality community. Previously, the duration of sag events has not been clearly defined. Typical sag durations defined in some publications range from two milliseconds (about one-eighth of a cycle) to a couple of minutes. Undervoltages that last less than one-half cycle cannot be characterized effectively as a change in the rms value of the fundamental frequency value. Therefore, these events are considered transients [1]. Undervoltages that last longer than one minute can typically be controlled with voltage regulation equipment and may be associated with a wide variety of causes other than system faults [2].

Sag durations are subdivided here into three categories. It is instantaneous, momentary and temporary, coinciding with the three categories of interruptions and swells. These durations are intended to correlate with typical protective device operation times as well as with duration divisions recommended by international technical organizations.

Voltage dip is defined by NEMA MG1-16.48 as the maximum voltage deviation from rated generator output voltage. These dips are caused by inrush currents at motor start-up or by heavy block loads which slow engine speed and lower excitation to the main field. As the cause and remedy for instantaneous voltage dips differ from those due to block loads, they are measured and analyzed separately. The maximum dip due to motor inrush current occurs within five cycles and can only be measured with an oscilloscope, due to its instantaneous nature. Dip due to heavy block loads which slow engine speed can be measured by mechanical recorders. Thirty percent instantaneous voltage dip is regarded as the standard throughout most of the gen set industry, depending on what equipment is already on line. Commercially acceptable recovery time is usually two or three seconds, or at maximum, 15 seconds, depending on the load.