UNIVERSITI PUTRA MALAYSIA

SIMULATION AND CONSTRUCTION OF VOLTAGE SAG CORRECTOR

DANIEL ROHI

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfillment of Requirements for the Degree of Master of Science

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DEDICATION

Give thanks to the Lord, for He is good
His love endures forever (Psalm 136:1)

This report is dedicated to
my lovely mother Maria Rohi Padji for her praying.
my lovely wife Eva Juliana, for her patience and
understanding during the preparation of this project, and to
my sweet heart Zefanya I.Angelista

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SIMULATION AND CONSTRUCTION OF A VOLTAGE SAG CORRECTOR

By

DANIEL ROHI

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Chairman : Nasrullah Khan, Ph.D

Faculty : Engineering

Electrical power quality has been the most important issue in recent years. Research has shown that nearly 92% of the electrical power quality problems were associated with voltage sags. Voltage sag is a short duration reduction in rms voltage caused by short circuit faults, switching operations, impact over loading, or starting of large motors. To mitigate voltage sag problems are to have a cautious maintenance and control to the supply, transmissions and the distribution to prevent damages. User can find the underlying cause of voltage sag by installing devices that can minimize voltage sag. Electro-magnetic contactor is one of the devices that is sensitive to voltage sag. Data shows that contactor, which is widely used for controlling motor, cannot work properly when there are 50% rms voltage reduction for a period longer than one cycle. This project will describe a type of voltage sag corrector (VSC) device that is especially use to minimize voltage sag impact at the contactor. The VSC device is used for contactor that uses 120V AC. To give enough magnetic power to the contactor, AC voltage that is stable is used until

there is a match with DC voltage. When there is 120 V AC input, it will be converted by the rectifier to DC voltage with a value of 170 V. Furthermore, 170 V DC will be reduce to 12 V DC by the chopper circuit. The chopper circuit is driven by the output signal or duty cycle of the control circuit. The duty cycle depends on the occurring voltage sag magnitude. The duty cycle will increase proportional with voltage sag. The software Orcad PSpice version 9.1 is effective to make simulations of the VSC circuit. The experimental result shows that the VSC is effective to mitigate voltage sag for contactor ride-through.

Abstrak tesis yang dikemukakan kepada Senat University Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

SIMULASI DAN PEMBINAAN PEMBAIKI VOLTAN LENDUTAN

Oleh

DANIEL ROHI

Februari 2002

Pengerusi : Nasrullah Khan, Ph.D

Fakulti : Kejuruteraan

Kualiti kuasa elektrik telah menjadi isu yang sangat penting pada masa kini. Penyelidikan menunjukkan hampir sembilan puluh dua peratus dari masalah kualiti kuasa elektrik memiliki kaitan dengan masalah voltan lendutan. Voltan lendutan adalah kejadian singkat penurunan nilai voltan yang disebabkan oleh litar pintas, kelebihan beban, operasi dari suis dan penggerak motor besar. Mengatasi masalah voltan lendutan dapat dilakukan dengan mengadakan pemeliharaan dan kawalan yang cermat pada penjana, sistem penyaluran dan sistem pengagihan. Selain itu pengguna dapat mengatasi dengan memasang peralatan yang dapat mengurangkan lendutan voltan. Sesentuh adalah salah satu peralatan yang peka terhadap lendutan voltan. Data menunjukan sesentuh yang kebanyakan digunakan untuk kawalan motor tidak dapat bekerja dengan sempurna apabila terjadi voltan lendutan sebesar lima puluh peratus dalam jangka masa lebih besar dari satu kitaran. Projek ini akan menguraikan penggunaan dari peralatan pembaiki voltan lendutan yang khas untuk mengurangi pengaruh voltag lendutan pada sesentuh. Peralatan pembaiki voltan lendutan ini dipakai untuk sesentuh jenis 120 V AC. Untuk memberikan kuasa

penggunaan dari peralatan pembaiki voltan lendutan yang khas untuk mengurangi pengaruh voltag lendutan pada sesentuh. Peralatan pembaiki voltan lendutan ini dipakai untuk sesentuh jenis 120 V AC. Untuk memberikan kuasa magnet pada belitan sesentuh, diperlukan nilai voltan yang tetap sehingga dapat digunakan voltan arus terus yang setara dengan voltan arus ulang alik. Masukan 120 V AC akan diubah oleh penerus menjadi 170 V DC. Selanjutnya 170 V DC akan diturunkan menjadi 12 V DC oleh litar pemangkas. Litar pemangkas ini di pandu oleh isyarat atau gelombang kerja yang dihasilkan oleh litar kawalan. Gelombang kerja tergantung pada voltan lendutan yang terjadi. Apabila terjadi voltan lendutan maka gelombang kerja akan berubah secara berkadaran sehingga sesentuh tetap bekerja dengan sempurna. Perisian Orcad PSpice versi 9.1 sangat berguna untuk membuat simulasi pada litar pembaiki voltan lendutan. Selain itu, ujikaji litar pembaik voltan lendutan berkesan untuk mengurangi pengaruh voltan lendutan pada sesentuh.

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LIST OF ABBREVIATIONS

AC	Alternating Current
ASDs	Adjustable Speed Motor Drives
CBEMA	Computer Business Equipment Association
CVTs	Ferro-resonant, Constant Voltage Transformer.
DC	Direct Current
DPQ	Distribution Power Quality
EMP	Electromagnetic Pulse
EPRI	Electric Power Research Institute
HEMP	High Altitude Electromagnetic Pulse
HID	High-Intensity Discharge
ITI	Technology Industry Council
M-G Sets	Motor Generator Sets.
PCC	Point-of- Common Coupling
PLC's	Programmable Logic Controllers
RMS	Root Mean Square
SLGF	Single Line Ground Fault
SSDs	Super conducting Storage Devices
UPS	Uninterruptible Power Supply
VSC	Voltage Sag Corrector

CHAPTER 1

POWER QUALITY PROBLEMS

1.1 Introduction

The problem of electric power system has become complex now. It is not just a question of how to generate electrical power and the means of transferring this power. but also about how to maintain the voltage and frequency within certain level suitable for consumer equipment. All the process that was described above must follow several criteria such as reliability, economic viability and quality.

Reliability is associated with protection system, and it consists of two elements: dependability and security. Dependability is the certainty of correct operations in response to system trouble, whereas security is the ability of the system to avoid missed operations or to be without faults. The economic viability tells about producing good electrical power with reasonable cost. The final criterion is quality. which is related to the effects of electrical power supply instability on consumer equipment [1].

The instability of power supply can be caused by disturbances at utility or by consumers of the supply, which affects the load. This, in turn, will affect other equipment especially those that are sensitive to this instability. This equipment, or load, cannot function properly, because of the low quality of the power supply. Furthermore, if the consumer uses non-linear equipment, it can introduce harmonic

distortion on the supply. Based on these phenomena, power quality problem can be defined as: Any power problem manifested in the voltage, current, or frequency deviation that results in failure or miss operation of customer equipment. In short, power quality problem can be identify as voltage quality [2].

This definition is one of the many definitions of power quality. The experiences of many people have resulted in its numerous definitions. However, most people agree and have the same perception about the phenomena of power quality. They have, for example, agreed on the possible causes of power quality problems that can generally be classified as one of the following phenomena: Transients under voltage or voltage sag, transients over voltage or voltage swell, momentary interruptions, transient, harmonics distortion and electrical noise.

The problem of power quality has become an important issue. This is due to several reasons: The first is, customers, especially in industries, use equipment that is sensitive to changes in power supply, caused by power instability. For example, large industries now use many equipment that are load sensitive, such as in design processes, in which Adjustable-Speed drives (ASDs) for speed control remotely communicate with Programmable Logic Controller (PLC) to monitor and control many aspects of processes behavior, and contactors. The equipment, and hence the process, does not function properly in the event of an electrical power problem, that can create voltages changes especially voltage sag.

The second reason is related to economics. In this case, if a production process is disrupted by the poor quality of power supply, the company involved will suffer

economic lost. Therefore, the effect of poor power quality. especially that of voltage sag is also an economic one. Companies must spend money to mitigate it. The economic impact is on both the utility companies and consumers. Another basis for action is the integration of processes. Integrated processes mean that the failure of any component will result in the failure of the whole. a very serious consequence indeed [2].

Surveys have shown that voltage sags are considered as the dominant factor affecting power quality. Productivity loss due to deep voltage sags and brief power interruptions has been called "the most important concern affecting most industries and customers", costing billions of dollar every year in the United State alone [3].

Electrotek Concepts, in a study sponsored by the Electric Power Research Institute (EPRI), and in collaboration with 24 utilities. evaluated power quality disturbances over a period of 27 months from 1993 to 1995. Approximately 300 power quality monitors were installed in locations across the US. resulting in over 6 million power quality events being recorded. The cumulative data from the "Distribution Power Quality (DPQ) study" indicates that 92% of all events correspond to voltage sags down to 40-50 % of nominal line voltage, and that most of these events last for less than 2 seconds [4].

In Malaysia, the problem of voltage sag has become important, as the country has set its sight on becoming a developed country by the year 2020. The incidence of voltage sags in Malaysia is on the average, high, because the country has a very high rate of thunder (lighting) /day of more than 200. Many research results indicate that

the main cause of voltage sag is due to single line ground fault (slgf). For example, on the utility side, 75% of the voltage sag is due to single line ground fault. 19% and 6% are due to two and three phase faults respectively. On the consumer side, one industry data shows that there are 1.06 disturbances per month of which voltage sags make up about 1.01 or 97% of the disturbances [5].

In short, power quality is becoming an important concern in distribution systems and industrial plants. It is expected that these concerns will be even more prevalent in a deregulated power systems environment, where electricity may be available at different rates and with various power quality features. A supply of high quality and availability is essential for the operation of modern plants in which the use of computers and other sensitive electronic equipment is widespread [6].

Solving power quality problems especially on voltage sags can be done on either the utility side or on the consumer side. On the consumer side, the best solution is to protect the entry facility from voltage sag with a device such as a dynamic voltage restorer or in other cases, it is more economical to identify particularly susceptible components and protect them alone. Many facilities have motors controlled by contactors. While motors often have enough inertia to ride through power line disturbances, contactors have been shown to be particularly susceptible to voltage sags. One manufacturer has provided data that indicates their line of motor contactors will drop out at 50% voltage if the condition lasts for longer than one cycle [7].

1.2 Aims and Objectives

The aim of this project is to develop a device to address the problem of voltage sag especially to facilitate a contactor ride through. To achieve this objective, the following works were carried out.

1. Simulation of a voltage sag corrector circuit using PSpice software program.
2. Construction of a voltage sag corrector circuit to demonstrate the operation of the contactor during voltage sag.

1.3. Thesis Layout

This thesis is divided into five chapters. Chapter 1 gives an overview of power quality problems and the scope of work in this thesis. Chapter 2 reviews literature on voltage sag problems, causes of voltage sag, characteristics of voltage sag, and the relationship between voltage sag and sensitive equipment. Chapter 3 describes the workings of a contactor and the voltage sag corrector circuit, and the experiment conducted with it. Chapter 4 discuses the results of the circuit simulation and experiment. Finally, chapter 5 presents the conclusion and suggestions for further development of voltage sag corrector circuit.