AN IMPROVEMENT OF VOLTAGE QUALITY IN LOW VOLTAGE DISTRIBUTION SYSTEM USING DYNAMIC VOLTAGE RESTORER

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DEDICATION

To my beloved mother Hajiya Yagana Abba Lawan,
My father Alhaji Lawan Mai Bukar,
And to the entire member of my family

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ABSTRACT

With the increased use of semiconductor devices (switched mode power supply) and ICT (information communication technology) equipment in homes, offices and the industry, power quality (PQ) is gaining significant interest to both the electric utility and the industry. The absence of power quality causes enormous economic losses all over the world; it is estimated that PQ problems cost commerce and industry about 100 billion Euros per annum in the European Union. One of the most and undesirable PQ phenomenon are voltage sags, which puts sensitive loads under risk. This project is therefore, aimed at mitigation of power quality problems such as voltage sag, voltage swell, interruption and harmonic at low voltage distribution system, using a versatile custom power device that is capable of mitigating various types of PQ disturbances called dynamic voltage restorer (DVR). Implementations of DVR have been proposed at both a medium and low voltage levels to protect sensitive loads from power quality problems. The proposed system is designed using Matlab/Simulink SimPower System Tools Box. The proposed DVR system comprises of line filter, voltage injection transformer, voltage source inverter, bypass switch and energy storage device from which the power necessary for compensation can be obtained during PQ disturbance. Simulation results verified the capability of the proposed DVR system in mitigating the power quality problems in a low-voltage distribution system.

ABSTRAK

Dengan peningkatan penggunaan peranti semikonduktor (mod suis bekalan kuasa) dan ICT (teknologi maklumat dan komunikasi) peralatan di rumah, pejabat dan industri, kualiti kuasa (KK) semakin mendapat faedah yang besar kepada kedua-dua utiliti elektrik dan industri. Ketiadaan kualiti kuasa menyebabkan kerugian ekonomi yang sangat besar di seluruh dunia; adalah dianggarkan bahawa kos masalah KK perdagangan dan industri kira-kira 100 bilion Euro setahun di Kesatuan Eropah. Salah satu fenomena KK paling dan yang tidak diingini adalah voltan lendut, yang meletakkan beban yang sensitif di bawah risiko. Projek ini adalah bertujuan untuk mengurangkan masalah kualiti kuasa seperti voltan lendut, voltan ampul, gangguan dan harmonik pada sistem pengagihan voltan rendah, menggunakan peranti kuasa serba boleh yang berupaya mengurangkan pelbagai jenis gangguan KK yang dipanggil pemulih voltan dinamik (DVR). Perlaksanaan DVR telah dicadangkan di kedua-dua peringkat medium dan voltan rendah untuk melindungi beban-beban sensitif dari masalah kualiti kuasa. Sistem yang dicadangkan direka menggunakan Matlab / Simulink SimPower Tools Sistem Box. Sistem DVR yang dicadangkan terdiri daripada penapis talian, voltan suntikan pengubah, voltan sumber penyongsang, suis pintasan dan peranti penyimpanan tenaga yang membekalkan kuasa bagi pampasan semasa gangguan KK. Keputusan simulasi mengesahkan keupayaan sistem DVR yang dicadangkan dalam menangani masalah kualiti kuasa di dalam sistem pengagihan voltan rendah.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Sensitive loads such as factory automations equipments, hospital equipments, ICT (information communication technology) equipments and semiconductor devices like SMPS (switched mode power supply) are vulnerable to power supply disturbances. Consequently, the demand for a supreme high power quality and voltage stability becomes an issues nowadays [1]. Absence of PQ causes enormous economic losses all over the world, it is estimated that PQ problems cost commerce and industry about 100billion Euros per annum in the European Union [2]. Today, both the utilities and the end users of electrical power are becoming increasingly concerned about the quality of power supplied and consumed. Generally, PQ problems can solve in two perspectives. First is to ensure that process equipment's are less tolerant disturbances that are likely to occur, that is letting the devices or process equipment to ride through PQ disturbance [3] or secondly is the use of custom power devices to mitigate the PQ disturbances.

Numerous of custom power devices (CUPS) are commercially available these days for the purpose of solving PQ disturbances. This include uninterruptible power supplies (UPS), static var compensator (SVC), active power filters (APF), distribution static synchronous compensators (DSTATCOM), thyristor switched

capacitors (TSC), battery energy storage systems (BESS), dynamic voltage restorers (DVR), solid state circuit breaker (SSCB), surge arrestors (SA), solid state transfer switches (SSTS), super conducting magnetic energy storage system (SMES), static electronic tap changers (SETC), distribution series capacitors and power factor corrector (PFC).

Research in field of PQ indicates that dynamic voltage restorer (DVR), which is classified as CUstom Power System (CUPS) have been successfully employed to solve PQ problems, especially voltage dips and swells [4] and existing research literature reveals that a DVR is considered as a suitable, economically and effective device to compensate the voltage disturbances [5]. Beside swell and sag compensation in [6-9], DVR has been successfully used to compensate harmonic [10-12] and also to limit down streams fault current [13].

The DVR has lower losses and cost effective. But still it has the disadvantage of not able to compensate interruptions and it is difficult to protect it [14]. The installation of DVR technology is still seldom in the power system network and virtual only few can be found around the world. In [15-22] viable products and projects regarding the DVR technology have been testified and but still the projects provide inadequate information on the design and control aspects.

DVR technology is still not developed and many areas regarding its control and designs are still at study level. In [23-25] DVR design is discussed and treated with emphasis on the sizing of current, voltage and power and ratings, also in [26] the structure of DVR have been treated and in [47] the design considerations for DVR line filter is addressed

In addition, the DVR as a series connected device is difficult to protect from interference with existing protection devices in the occurrence of a short circuit. In this project, dynamic voltage would be designed and implemented with emphasis on mitigating voltage sags, swells, harmonics and voltage unbalances mitigation.

1.2 Problem Statement

Power quality is a very important issue due to its impact on electricity supplier and the consumer equipment's, especially the sensitive loads. Power quality problems can cause tripping of sensitive loads and this sometimes leads to huge economic losses. To solve this problem, several CPD have been used in the past. Among the several CPD, DVR provides a single solution in mitigating different PQ disturbances such as voltage swell, dip, unbalanced and harmonics and voltage etc.

1.3 Objectives of the study

The aims of this study are as follows:

i. To design a three phase network system for power quality analysis
ii. To design a controller that would drive the DVR appropriately during normal and abnormal conditions.
iii. To design a dynamic voltage restorer (DVR) and incorporate with a three phase network designed so as to mitigate different types of power quality problems for different events.

1.4 Scope of the Study

The scope and limitations are as follows. Mitigation of Power Quality Problems using dynamic voltage restorer, it is also limited to voltage sag, harmonics, voltage unbalances and swell mitigation. The topology of the DVR is limited to DVR topology with DC storage. The implementation of the control schemes is limited to MATLAB/Simulink environment.

1.5 Significances of the study

Mitigation of power quality problems is highly essential, as ICT equipment in homes and offices, automated production plants and other commercial activities demand for a high supreme and reliable power supply. Also on the other hand commercializing and deregulating of the power sectors has made power quality as one of the most important parameters of interest to get a higher price per kilowatt, to raise the earnings and share of the market.

1.6 Report Outline

This project write up is divided into six chapters. In Chapter 1 introduce the reader an overview of the research study is presented. It introduces the dynamic voltage restorer as a powerful custom power devices for mitigating power quality disturbances, its advantages and disadvantages over other custom power device is also discussed. Thereafter the problem statement, objectives, scope of the study and significances of the study are presented.

In chapter 2, a general overview of power quality is discussed, which include the definition of power quality, the need for quality power, power quality problems, causes of power quality problems, power quality solutions and lastly power quality solving procedures. Also included in this chapter is a general overview of the DVR, which include its power circuit of DVR, DVR operating principle, DVR load voltage controllers and literature review of topologies developed for DVR by different researches are described.

In Chapter 3, the designed and implementation of the DVR system is presented. Also included is this chapter is the control strategy and methods used.

In chapter 4, the Results obtained are comprehensively displayed and discussed in detail.

Finally, chapters 5 concludes the work and gives some valuable recommendation.

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