UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF D-STATCOM FOR VOLTAGE SAG MITIGATION

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DEVELOPMENT OF D-STATCOM FOR VOLTAGE SAG MITIGATION

By

HENDRI BIN MASDI

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

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DEDICATION

I would like to dedicate this project to my beloved family, all my supervisors and lecturers in the Department of Electrical and Electronic Engineering, friends, and society. Their guidance and relentless support have been a great inspiration to the realization of this project.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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Chairman: Professor Norman Mariun, PhD, P.Eng., FIEM, SMIEEE.

Faculty: Engineering

The increased awareness in power quality issues has brought tremendous changes and improvements in power system delivery. Various circuit topologies and control techniques have been developed aimed at mitigating power quality disturbances.

Custom Power (CP) concept is one of technological responses to the poor power quality presently surfacing in factories, offices and homes. It is dedicated to maintaining and improving the quality and reliability of distribution level power and to protecting customers against disturbances generated by other users in the network. CP family includes power electronics based devices such as Distribution Static Compensator (D-STATCOM), Dynamic Voltage Restorer (DVR), Solid State Fault Current Limiter (SSFCL), Active Power Filter (APF) and Solid State Transfer Switch (SSTS). The CP concept is the customer's solution by the utilities sector.

In this research work, the focus will be on one of the CP family, that is, the D-STATCOM. The D-STATCOM, which consists of a IGBT-based voltage source inverter, uses advanced power electronics to provide voltage stabilization, power factor correction, harmonic control and a host of other power quality solutions for both utility and industrial applications.

This thesis describes the configuration, design and control of the 12-pulse D-STATCOM. Its simulation works are done by using PSCAD/EMTDC version 4.2.0 software, developed by Manitoba HVDC Research Center, Canada. The designed D-STATCOM is connected in shunt to an 11 kV test distribution system. Simulations have been carried out to illustrate the effectiveness of the D-STATCOM in mitigating voltage sags and voltage unbalance as well as eliminating harmonics. The results obtained from the simulations and the experimental measurement clearly showed that the designed D-STATCOM is capable in mitigating voltage sags and voltage unbalance. Furthermore, by connecting passive filters in shunt at the primary side of the step-down transformer reduces the harmonics generated by the D-STATCOM.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMBANGUNAN PEMAMPAS STATIK (D-STATCOM) UNTUK MENGURANGKAN LENDUT VOLTAN

Oleh

HENDRI MASDI

June 2011

Pengerusi: Profesor Norman Mariun, PhD, P.Eng., FIEM, SMIEEE.

Fakulti: Kejuruteraan

Peningkatan kesedaran dalam isu kualiti kuasa telah membawa banyak perubahan dan evolusi dalam penghantaran sistem kuasa. Topologi dan teknik kawalan yang berbagai telah direka untuk menangani masalah kualiti kuasa. Konsep Kuasa Langganan adalah merupakan salah satu teknologi yang boleh menangani masalah kualiti kuasa yang rendah yang sering dialami di kilang-kilang, pejabat, dan kawasan perumahan. Kuasa Langganan adalah bertujuan untuk mengekal dan meningkatkan kualiti kuasa dan untuk melindungi pelanggan daripada gangguan yang dijana oleh pengguna sendiri. Keluarga peranti-peranti Kuasa Langganan adalah termasuk Pemampas Statik (D-STATCOM), Pemulih Voltan Dinamik (DVR), Penghad Arus Kerosakan Pepejal (SSFCL), Penapis Kuasa Aktif (APF) dan

Suis Pemindah Keadaan Pepejal (SSTS). Konsep Kuasa Langganan adalah penyelesaian bagi masalah pelanggan daripada sektor pembekal.

Dalam kajian ini, fokus akan diberikan kepada satu daripada peranti Kuasa Langganan iaitu, D-STATCOM. Ianya menggunakan peranti elektronik kuasa untuk menstabilkan voltan, mengurangkan kerlipan, membetulkan faktor kuasa dan kawalan harmonik. Tesis ini menerangkan konfigurasi, reka bentuk dan kawalan D-STATCOM 12-denyut. Simulasi untuk D-STATCOM akan dijalankan dengan menggunakan program PSCAD/EMTDC versi 4.2.0 yang direka oleh Manitoba HVDC Research Center, Kanada. D-STATCOM yang telah direkabentuk akan disambungkan secara selari dengan sistem agihan 11 kV. Selanjutnya rekabentuk D-STATCOM sebenarnya dibuat dan penggunaan penggujian dilaksanakan di makmal untuk mendapatkan hasil pengamatan yang kemudian dibandingkan dengan simulasi PSCAD/EMTDC yang telah dijalankan.

Hasil simulasi rekabentuk D-STATCOM dan hasil pengamatan yang telah dijalankan menggambarkan D-STATCOM efektif dalam menangani masalah voltan lendut dan voltan tidak stabil serta mengurangkan harmonik. Keputusan yang diperolehi secara terang menunjukkan D-STATCOM yang direkabentuk berkebolehan dalam menangani masalah voltan lendut dan voltan tidak stabil dan sangat berguna untuk kajian kualiti kuasa selanjutnya dalam sistem agihan. Seterusnya, perhitungan yang tepat dan benar dapat dilakukan menyambung penapis pasif pada bahagian pengubah utama (primer transformer) telah mengurangkan harmonik yang dijana oleh D-STATCOM.

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I certify that a Thesis Examination Committee has met on the 13rd Jun 2011 to conduct the final examination of Hendri Bin Masdi on his thesis entitled "Development Of D-Statcom For Voltage Sag Mitigation" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

HENDRI BIN MASDI

Date: 13rd Jun 2011

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