UNIVERSITI PUTRA MALAYSIA

UNIFIED NEURAL NETWORK CONTROLLER OF SERIES ACTIVE POWER FILTER FOR POWER QUALITY PROBLEMS MITIGATION

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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August 2013

Chairman : Mohd Amran Mohd Radzi, PhD

Faculty : Engineering

This thesis presents the design, development and analysis of series active power filter (APF) with a novel control technique. The series APF developed in this work is applied at a point of common coupling (PCC) to compensate voltage harmonic and source-end disturbances of the grid supply voltage. To solve the mentioned power quality issues, the architecture of the series APF controller is developed to assess and extract voltage harmonic, sag, swell and interruption conditions. The proposed unified controller is responsible to generate proper switching signals for dynamic compensation of voltage harmonic, sag, swell and interruption and formed of two main parts. The first and core unit of the controller utilizes adaptive neural network algorithm to extract fundamental component of the supply voltage and detach the present voltage harmonic. The adaptive neural network unit uses Adaline structure for faster extraction of present distortions at the supply voltage. The amplitude value of the fundamental component is measured and saved by the second unit called peak detector. Furthermore, it is unified with a phase-locked loop (PLL) based reference generator unit to generate proper compensation signal for present faults at voltage

supply fundamental signal caused by source-end disturbances. In order to enhance the response time of series APF, two of the most well known learning algorithms are investigated in this work. First, Widrow-Hoff algorithm is examined and its constant learning rate is modified by adding an adaptive learning rule to change the learning rate value. This modification demonstrates a significant contribution in performance of the series APF in terms of speed and accuracy. However, in the second investigation neural network unit utilized Levenberg-Marquardt algorithm as the harmonic extractor, since it is faster and more accurate than adaptive Widrow-Hoff especially during fundamental signal variation caused by source-end disturbances. The controller uses extracted distortion signal to generate the proper reference signal. The compensator unit receives reference signal to operate the pulse width modulation (PWM) based voltage source inverter to generate the replica of the voltage harmonic, sag, swell and interruption to inject them into the system for compensation. The implementation of the proposed APF could maintain the utility supply voltage at the point of common coupling in a distribution network at almost sinusoidal and should minimize the total harmonic distortion (THD) levels in the network. The proposed extraction techniques and inverter control scheme of series APF topology was investigated to examine the functionality of the system under different disturbance conditions. The obtained simulation results illustrate the capability of the series APF with the proposed unified controller in mitigating of voltage harmonic and compensating of voltage sag, swell and interruption during variety of voltage quality problems occurrence at the PCC.

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

PENGAWAL RANGKAIAN NEURAL BERSATU BAGI PENAPIS KUASA AKTIF SESIRI UNTUK PENGURANGAN MASALAH KUALITI KUASA

Oleh

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Ogos 2013

Pengerusi : Mohd Amran Mohd Radzi, PhD

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Tesis ini membentangkan reka bentuk, pembangunan dan analisis penapis kuasa aktif sesiri dengan teknik kawalan baru. Penapis kuasa aktif sesiri yang dicadangkan digunakan pada satu titik gandingan sepunya untuk memampas voltan harmonik dan gangguan sumber akhir voltan bekalan grid. Bagi menyelesaikan isu-isu kualiti kuasa yang dinyatakan, seni bina pengawal penapis kuasa aktif sesiri dibangunkan untuk menilai dan mengekstrak voltan harmonik, lendut, ampul dan keadaan sampukan. Pengawal bersatu yang dicadangkan bertanggungjawab untuk menjana isyarat pensuisan yang sepatutnya untuk pampasan dinamik voltan harmonik, lendut, ampul dan sampukan, dan dibentuk oleh dua unit utama. Unit pertama dan teras pengawal menggunakan algoritma rangkaian neural suai untuk mengekstrak komponen asas voltan bekalan dan menanggalkan kehadiran voltan harmonik yang hadir. Unit rangkaian neural suai menggunakan struktur *Adaline* untuk pengeluaran lebih cepat gangguan yang hadir pada voltan bekalan. Nilai amplitud komponen asas diukur dan disimpan oleh unit kedua dipanggil pengesan puncak. Tambahan pula, unit ini disatukan dengan unit penjana rujukan berasaskan gelung terkunci fasa untuk

menghasilkan isyarat pampasan yang sepatutnya bagi kerosakan semasa pada isyarat asas bekalan voltan yang disebabkan oleh gangguan sumber akhir. Dalam usaha untuk meningkatkan masa tindak balas penapis kuasa aktif sesiri, dua daripada algoritma pembelajaran yang paling terkenal disiasat dalam kerja ini. Pertama, algoritma *Widrow-Hoff* diperiksa dan kadar pembelajaran malarnya diubah suai dengan menambah peraturan pembelajaran suai untuk mengubah nilai kadar pembelajaran. Pengubahsuaian ini menunjukkan sumbangan yang ketara dalam prestasi penapis kuasa aktif sesiri daripada segi kelajuan dan ketepatan. Walau bagaimanapun, dalam penyiasatan kedua, unit rangkaian neural menggunakan algoritma *Levenberg-Marquardt* sebagai pengekstrak harmonik, kerana unit ini adalah lebih cepat dan lebih tepat daripada Widrow-Hoff suai terutama semasa perubahan isyarat asas yang disebabkan oleh gangguan sumber akhir. Pengawal menggunakan isyarat herotan terekstrak untuk menjana isyarat rujukan yang sepatutnya. Unit pemampas menerima isyarat rujukan untuk mengendalikan pemodulatan lebar denyut berasaskan penyongsang bersumberkan voltan untuk menghasilkan replika voltan harmonik, lendut, ampul dan sampukan untuk menyuntik semuamya ke dalam sistem bagi pampasan. Pelaksanaan penapis kuasa aktif yang dicadangkan boleh mengekalkan voltan bekalan kegunaan di titik gandingan sepunya dalam rangkaian pengedaran pada bentuk hampir sinus dan seharusnya meminimumkan tahap jumlah herotan harmonik dalam rangkaian. Teknik-teknik pengestrakan yang dicadangkan dan skim kawalan penyongsang bagi topologi penapis kuasa aktif sesiri telah disiasat untuk memeriksa kebarangkapan sistem dalam keadaan gangguan yang berbeza. Keputusan simulasi yang diperolehi menggambarkan keupayaan penapis kuasa aktif sesiri yang dicadangkan dalam mengurangkan voltan harmonik dan pampasan daripada lendut, ampul dan sampukan

voltan dalam pelbagai perubahan parameter sumber elektrik di titik terganding sepunya.

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I certify that a Thesis Examination Committee has met on 30th August 2013 to conduct the final examination of Behzad Ghazanfarpour Khoulenjani on his thesis entitled "Unified Neural Network Controller of Series Active Power Filter for Power Quality Problems 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 Master of Science.

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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 Master of Science. The members of the Supervisory Committee were as follows:

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