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MODELING FOR REDUCTION OF HARMONICS USING INVERTERS IN SMART GRID SYSTEM

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MODELING FOR REDUCTION OF HARMONICS USING INVERTERS IN SMART GRID SYSTEM

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DECLARATION

I declare this dissertation entitled "modeling for reduction of harmonics using inverters in smart grid system" is the result of my own research except as cited in the reference. The dissertation has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : ....

Name : ALI KAREEM SAEED

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APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion, this dissertation/report is sufficient in terms of scope and quality as a partial fulfillment of Master of Electrical Engineering (Industrial Power).

Signature : ....

Supervisor Name : Prof. Dr. Mohammad Rom Bin Tamjis

Date : 23. 06. 2016

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DEDICATION

Almighty Allah who blessed me with a lot of graces.

I dedicated this dissertation:

To the spirit of my father

To my beloved mother

To my wife "Zahraa Ali"

To my Daughter "Fatema" and my sisters and brothers for their love and encouragement.

ABSTRACT

The rapid growth of grid-connected PV generation resulting in the total harmonic distortions (THD) due to use of PV inverters is becoming a major concern. The output voltage of the inverter is a square or a nearly sinusoidal waveform, therefore, the output voltage contain the harmonic. Harmonic contents depend on the type and typology of the inverter. Use of multilevel inverter helps to solve this problem. Several converter topologies have been used in low-voltage applications; most of the topologies are not suitable in medium-voltage applications. CHB-MLI based on OHSW-SHE is a preferred choice to solve this problem. In this inverter, the THD depends on the switching angles and modulation index. The number of levels which can be synthesized in line voltage depends on MI since the RMS line voltage depends on these number of levels. In this research, Newton Raphson iterative method is implemented for the computation of the optimal switching angles and total harmonic distortion (THD) in 5,7,9,11 and 13-level inverter. The switching angles are calculated offline to eliminate lower order harmonics that are more harmful and difficult to remove without filter while the fundamental output voltage is obtained as desired. The simulation modeling for the single phase and the three-phase for 5,7,9,11 and 13-level CHB-MLI is done by using MATLAB Simulink . The THD for phase voltage and line voltage for three-phase output inverter is obtained from the simulation for various values of Modeling Index (MI). Computational THDs are validated with MATLAB simulations, and both results are in close agreement. In addition, the values of (MI) which achieve the maximum level in line to line voltage is also computed. In CHB-MLI, number of IGBT is proportional directly to number of level. One of the important features for CHB-MLI is the ability for this type to get a high AC voltage based on cascaded DC source. In addition, SHE technique helps to eliminate the lower order harmonics in the output voltage. This reduction in the THD value for the output voltage is below the limitation set in IEEE-519 without filtering system. Thus, it is necessary to investigate the ability to produce 11kv transformer less inverter to eliminate a bulk transformer in PV farm. Parameter identification is a vital part of the medium-voltage inverter design process. In this project, suitable IGBTs for 5, 7, 9, 11, and 13 level 11kV-voltage CHB-MLI for renewable generation systems (PV) is selected accordingly. The availability of IGBT modules in the market is considered in the selection process. The result shows the line voltage THD for 13-level is below the limitation set in IEEE-519 without filtering system. In addition, the IGBTs for 13 level 11kV CHB-MLI inverter are costed a minimum total price of IGBTs when compared with IGBTs price for 5, 7, 9, and 11level. This means in transformer less CHB-MLI type, the 13-level is more suitable for 11 kV medium application. However, this research is limited to harmonic reduction only using CHB-MLI based on OHSW-SHE, not including filter system. Also, the elimination of harmonic is done by calculating the optimum switching angles by using equal SDCS.

ABSTRAK

Pembangunan pesat penjanaan PV kesambung grid yang berkaitan menyebabkan jumlah herotan harmonik (THD) dihasilkan daripada "inverter" PV menjadi perhatian utama, kerana ia mempunyai kesan buruk kepada grid pintar. Penggunaan inverter bertingkat dapat membantu untuk menyelesaikan masalah ini. Beberapa topologi penukar telah digunakan dalam aplikasi voltan rendah; kebanyakan topologi tidak sesuai dalam aplikasi voltan sederhana. CHB-MLI berdasarkan OHSW-SHE adalah pilihan terbaik untuk menyelesaikan masalah ini, dalam inverter ini THD bergantung kepada sudut pensuisan dan indeks modulasi. Bilangan tahap yang boleh disintesis dalam voltan talian bergantung kepada MI disebabkan voltan RMS talian bergantung kepada bilangan peringkat. Dalam kaedah ini, Newton Raphson dilaksanakan untuk pengiraan sudut pensuisan optimum dan jumlah herotan harmonik (THD) dalam 5,7,9,11 dan 13 peringkat inverter. Sudut pensuisan dikira "offline" untuk menghapuskan harmonik bagi lebih rendah yang lebih berbahaya dan sukar untuk membuang dengan penapis manakala voltan output asas diperolehi seperti yang dikehendaki. Pemodelan simulasi untuk fasa tunggal dan tiga fasa bagi 5,7,9,11 dan 13 peringkat CHB-MLI dilakukan dengan menggunakan MATLAB Simulink. The THD voltan fasa dan voltan talian tiga fasa "output inverter" adalah didapatkan dari simulasi untuk pelbagai nilai Indeks Model (MI). "THDs Computational" disahkan dengan simulasi MATLAB, dan kedua-dua keputusan adalah selaras. Di samping itu nilai-nilai (MI) yang mencapai tahap maksimum dalam talian ke talian voltan juga dikira. Dalam bilangan CHB-MLI daripada IGBT berkadar terus dengan beberapa tahap. Salah satu ciri yang penting bagi CHB-MLI adalah keupayaan untuk jenis ini untuk mendapatkan voltan AC tinggi berasaskan sumber DC tandem Di samping itu, teknik SHE membantu untuk menghapuskan harmonik bagi lebih rendah voltan output. Pengurangan dalam nilai THD untuk voltan keluaran adalah di bawah had yang ditetapkan dalam IEEE-519 tanpa sistem penapisan. Ini menggalakkan untuk menyiasat dalam keupayaan untuk menghasilkan 11kV " inverter tanpa alatubah"untuk menghapuskan alatubah pukal di ladang PV. Pengecaman parameter adalah sebahagian penting daripada proses rekabentuk "inverter" voltan sederhana. Dalam projek ini, IGBT yang sesuai merangka tahap 5, 7, 9, 11, dan 13, 11kV voltan CHB-MLI untuk sistem penjanaan tenaga boleh diperbaharui (PV) dilaksanakan. Dengan adanya modul IGBT di pasaran adalah dipertimbangkan dalam proses memilih yang terbaik.

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LIST OF ABBREVIATIONS

Abbreviations	Description
AC	Alternating Current
CHB	Cascaded H-Bridge
DC	Direct Current
FACTS	Flexible AC Transmission Systems
FC	Flying Capacitor
FFT	Fast Fourier Transform
GTO	Gate Turn Off
HVDC	High Voltage DC
IGBT	Insulated Gate Bipolar Transistor
IPD	In Phase Disposition PWM
LS	Level Shifted PWM
MLI	Multilevel Inverter
MPPT	Maximum Power Point Tracker
NPC	Neutral Point Clamped Inverter
OHSW	Optimized Harmonic Stepped Waveform
PCC	Point of Common Coupling
POD	Phase Opposition Disposition
PS	Phase Shifted PWM
SHE	Selective Harmonic Elimination

SPWM	Sinusoidal Pulse Width Modulation
SVM	Space Vector Modulation
THD	Total Harmonic Distortion

LIST OF PUBLICATIONS

A. K. Saeed, R.T., Mohamad, M.R., Ab Ghani, 2015. "Framework Of Harmonics Mitigation Modelling For Renewable Energy Source Connected To The Grid". *Paper Accepted for International Journal of Applied Engineering Research*, Paper Code: 40224.

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CHPATER 1

INTRODUCTION

1.1 Research Background

The model of the power grid is usually considered to have distinct parts usually, generation plants, transmission lines, distribution system and distribution generation. The traditional view of generation plants in the power grid has been large generator stations that are located outside of cities. Transmission lines carry large amounts of power and form the backbone of the grid connecting large generation stations and major load centers. Distribution systems, on the other hand, contain smaller lines and transmit smaller amounts of power. They are generally placed in residential areas and carry power to individual homes and businesses.

These days the demand for electrical energy is increasing to meet the load expansion in the electrical power system. The load expansion leads to transfer of bigger amount of power from generation stations to load centers to meet this new additional load. The transmission lines in old electrical grid are not able to carry this additional power. Therefore another type of generation called distributed generation (DG) is regarded for customers to cope with this problem. The distributed generations decrease the power losses in the grid due to decreasing in current flow. One of this DG is renewable energy source (photovoltaic) (Anees, 2012).