UNIVERSITI MALAYA

ORIGINAL LITERARY WORK DECLARATION

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Registration/Matric No: KHA 090044

Name of Degree: DOCTOR OF PHILOSOPHY

Title of Project Paper/Research Report/Dissertation/Thesis ("this Work"):

COMPARISON OF SINGLE-PHASE TRANSFORMERLESS PHOTOVOLTAIC GRID-CONNECTED INVERTER TOPOLOGIES WITH HIGH EFFICIENCY AND LOW GROUND LEAKAGE CURRENT

Field of Study: POWER ELECTRONICS

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Abstract

When a transformer is taken out of a photovoltaic (PV) inverter system, the efficiency of the whole system can be improved. Unfortunately, the additional ground leakage current appears and needs to be considered. The problem of ground leakage current is that it poses an electrical hazard to anyone touching the photovoltaic (PV) array's surface. For safety issues, the ground leakage current should be less than 300 mA, which follows the VDE-0126-1-1 German standard. To minimize the ground leakage current in the transformerless PV grid connected inverter system, the proposed inverter topologies (SC-HB inverter, bipolar H-Bridge inverter with CD-Boost converter, modified unipolar H-Bridge inverter with CD-Boost converter and modified unipolar H-Bridge inverter with modified boost converter) are analyzed, verified and compared in this thesis. In order to analyze the effect of unbalanced filter inductance on the transformerless bipolar H-Bridge inverter topology, the matching ratio of inductance (L_r = L_{f1}/L_{f1n} and L_{f2}/L_{f2n}) is investigated. In addition, the effect of parasitic capacitance value on the transformerless bipolar H-Bridge inverter topology is studied. The effect of modulation techniques using bipolar SPWM and unipolar SPWM on the transformerless H-Bridge inverter topology is compared and analyzed in terms of common-mode voltage and ground leakage current. TMS320F2812 is used as a controller to generate the PWM control signal, maximum power point tracking (MPPT) based on power balance and Proportional-Integral (PI) controller. PSIM 9.0 simulation software is used to design the proposed transformerless inverter topologies. Simulation and experimental results verified the proposed inverter's feasibility in addressing issues of transformerless DC/AC converters in grid-connected PV systems.

Abstrak

Apabila pengubah diambil daripada sistem *photovoltaic* (*PV*) penyongsang, kecekapan keseluruhan sistem boleh diperbaiki. Malangnya, tambahan arus kebocoran bumi akan muncul dan perlu dipertimbangkan. Masalah kebocoran arus bumi ialah ia menimbulkan bahaya elektrik kepada sesiapa menyentuh permukaan *photovoltaic* (*PV*) array. Untuk isu-isu keselamatan, kebocoran arus bumi hendaklah tidak kurang daripada 300 mA, yang mengikuti VDE-0126-1-1 standard Jerman. Untuk mengurangkan arus bocor bumi di grid yang berkaitan sistem penyongsang pengubah PV, topologi-topologi penyongsang dicadangkan (penyongsang *SC-HB*, penyongsang *bipolar H-Bridge* dengan penukar *CD-Boost*, penyongsang *modified unipolar H-Bridge* dengan penukar *CD-Boost* dan penyongsang *modified unipolar H-Bridge* dengan penukar *modified boost*) dianalisis dan disahkan di dalam tesis ini. Untuk menganalisis kesan tidak seimbang penapis kearuhan pada pengubah bipolar H-Bridge penyongsang topologi, nisbah kearuhan (L_r = L_{f1}/L_{f1n} dan L_{f2}/L_{f2n}) disiasat. Juga, kesan nilai kapasitan parasit pada pengubah *bipolar H-Bridge* penyongsang topologi dikaji. Kesan teknik modulasi (*SPWM bipolar* dan *SPWM unipolar*) pada pengubah *H-Bridge* penyongsang topologi dibandingkan dan dianalisis dari segi *common-mode* voltan dan arus bumi bocor. TMS320F2812 digunakan sebagai pengawal untuk menjana isyarat lebar denyut modulasi, maksimum pengesanan titik kuasa berdasarkan pembahagian kuasa dan kawalan Berkadar-Integral. Perisian simulasi PSIM 9.0 digunakan untuk merekabentuk topologi-topologi penyongsang pengubah yang dicadangkan. Keputusan simulasi dan ujikaji mengesahkan bahawa cadangan penyongsang memenuhi isu-isu yang berkaitan dengan penukar Arus Terus/Arus Ulang-Alik (AT/AU) di dalam sistem penyambungan *PV* ke *grid*.

ACKNOWLEDGEMENT

In the name of Allah, the most Gracious and most Compassionate.

I would like to thank Allah The Almighty for blessing and giving me strength to accomplish this thesis. Special thanks to my supervisor, **Prof. Dr. Nasrudin Abd. Rahim** for his invaluable support, encouragement, supervision and useful suggestions throughout this project. His moral support and continuous guidance enabled me to go through the tough route to complete this project successfully.

I acknowledge my sincere indebtedness and gratitude to my beloved husband, Nazarul Abidin Ismail, my sons, Aizuddin NasrulHaq, Ahmad Naqiuddin and Aaqil Najmuddin for his love, support and sacrifice throughout my toughest time in my life. My deepest gratitude for my friends for consistently encouraged me and keep my heart strong in accomplish this PhD study. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Finally, I acknowledge my greatest thanks to University of Malaya and Universiti Teknikal Malaysia Melaka (UTeM) for all support given to complete this project.

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LIST OF SYMBOLS

V_{ab}	Inverter output voltage
V_{grid}	Grid voltage
C_{pv}	Parasitic capacitance
η_{mppt}	Efficiency of MPP tracker
η_{conv}	Efficiency of conversion
V_A	Array voltage
I_A	Array current
N_1, N_2	Primary winding turn ratio, Secondary winding turn ratio
I_g	Ground-leakage current
I_{grid}	Grid current
V_{cmm}	Common-mode voltage
C_b, C_{dc}	DC-link capacitors
P_{pv}	Rated power of PV module
ω_{grid}	Grid frequency in (rad/sec)
V_c	Rated input DC-link capacitor voltage
Δu_c	Ripple voltage of DC-link capacitor
$\Delta_{ILripple,\ max}$	Maximum Ripple Current
V_{pv}	Photovoltaic voltage
V_i	Input voltage
V_{dc}	Output DC-DC converter and input inverter voltage
V_{inv}	Output inverter voltage
V_{rms}	Root mean square voltage
P_{ac}	AC output power
P_{dc}	DC output power