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Name of Candidate: MAASPALIZA BINT AZRI (I.C/Passport No: 770618-04-5114)

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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*.

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## LIST OF SYMBOLS

$V_{ab}$	Inverter output voltage
$V_{grid}$	Grid voltage
$C_{pv}$	Parasitic capacitance
$\eta_{mppt}$	Efficiency of MPP tracker
$\eta_{conv}$	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
$\omega_{grid}$	Grid frequency in (rad/sec)
$V_c$	Rated input DC-link capacitor voltage
$\Delta u_c$	Ripple voltage of DC-link capacitor
$\Delta I_{Lripple, max}$	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