DESIGNING OF A GRID TIE INVERTER FOR COMMERCIAL AND HOUSEHOLD SOLAR POWER INSTALLATIONS BASED ON A SOLID-STATE TRANSFORMER TOPOLOGY

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Degree of Master of Science

Department of Electrical Engineering

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Thesis/Dissertation submitted in partial fulfillment of the requirements for the degree Master of Science

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Declaration

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the Masters Dissertation under my supervision.

…… ……

Signature of the supervisor: Date

(Dr L.N.W Arachchige)

…… ……

Signature of the supervisor: Date

(Dr H.M.Wijekoon)

Abstract

Solar PV installations have gained a rapid popularity in Sri Lanka due to the reduction of PV panel costs and government incentives to promote renewable energy. The presence of these PV inverters has introduced power quality problems at the LV grid, mainly due to the injection of harmonics and DC currents.

The objective of this thesis is to study the power quality issues of the existing transformerless inverters and propose a solar PV inverter configuration based on a solid-state transformer (SST) topology. Upon recognizing the drawbacks of the existing configurations, three inverter configurations were developed based on the dual active bridge (DAB) and Tri active bridge (TAB) configurations utilized in the solid-state transformer.

Two configurations for the DAB based inverter are presented. Mathematical modelling of the TAB converter is presented with its associated converter currents and voltages. Based on the mathematical model, controllers were derived to maintain the DC bus voltages and the power flow of the TAB. Output filter designs, MPPT algorithm selection, power flow controllers and PV array selection procedures are presented along with the inverter configurations.

The developed systems were simulated and compared with the transformerless system in the MATLAB Simulink platform to assess their improvements. The load side harmonic isolation capabilities and the fault current limiting capabilities of the DAB and TAB based PV inverter systems are presented. The TAB and transformerless systems were also simulated with the presence of grid voltage harmonics. In all the cases tested, the TAB based system provides excellent power quality and fault current limiting capabilities over the transformerless system.

Dedication

Dedicated to my loving parents, wife and daughter

Acknowledgement

My sincere gratitude goes to my supervisors, Dr H.M. Wijekoon (Chief Engineer-Transmission Planning, Ceylon Electricity Board) and Dr Lidula Widanagama Arachchige (Senior Lecturer, University of Moratuwa) for continuously encouraging and guiding me throughout this research. If not for their continued guidance and inspiration, none of this would have been possible.

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List of Abbreviations

AAC	All aluminum conductor
CEB	Ceylon Electricity Board
DAB	Dual active bridge
HF	High frequency
IGBT	Insulated gate bipolar junction transistor
KCL	Kirchhoff's current law
KVL	Kirchhoff's voltage law
LECO	Lanka Electricity Company
MOSFET	Metal oxide field effect transistor
MPP	Maximum power point
MPPT	Maximum power point tracking
P&O	Perturb and observe
PCC	Point of common coupling
PI	Proportional integral
PSM	Phase shift modulation
PV	Photovoltaic
PWM	Pulse with modulation
RMS	Root mean square
SST	Solid state transformer
SVM	Space vector modulation
TAB	Tri active bridge
TDD	Total demand distortion
THD	Total harmonic distortion