

**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

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University of Moratuwa

Sri Lanka

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

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Date:

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

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Signature of the supervisor:

(Dr L.N.W Arachchige)

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Date

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(Dr H.M.Wijekoon)

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Date

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

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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 |