# Design and Implementation of a Multi-port Power Converter topology for DC Nano-grid

Pasan Nawodaka Gunawardena

(178005A)

Degree of Master of Philosophy

Department of Electronic and Telecommunication Engineering

University of Moratuwa
Sri Lanka

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Loku Hettige Pasan Nawodaka Gunawardena

(178005A)

Thesis submitted in partial fulfillment of the requirements for the degree Master of Philosophy

Department of Electronic and Telecommunication Engineering

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## Declaration

I declare that this is my own work, and this thesis 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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DR. M.D.R.Nayanasiri

## Abstract

This thesis presents a novel multi-port power converter topology for DC nano-grid applications. The proposed topology integrates energy sources, loads and energy storing elements using DC-link and magnetic coupling using a single converter. As a result, it has fewer component counts and conversion stages than the individual converters for each element in the nano-grid, which paves the way for a more efficient system.

The first part of this thesis presents a PV converter topology designed and developed in the laboratory. This circuit topology integrates two PV modules and boosts the input voltage into a 120V DC voltage level. However, switching loss of the converter is significant due to the hard-switching operation. Therefore, switching control strategy of the converter has been modified to minimize switching losses with the assistance of the existing parasitic elements. The operation of the power converter with the proposed switching control strategy is mathematically analyzed and verified using simulation results. The design is further validated using the experimental results obtained using a 250 W hardware prototype.

Moreover, a bi-directional high step-up/down converter is designed and developed to integrate an energy storing element into the system. The bi-directional converter step downs 120 V DC link voltage to an extremely low voltage (10-16 V DC) to charge a Li-ion battery pack. When the solar power is not available, the proposed converter discharges the Li-ion battery to regulate the 120 V DC link. The operation of the battery interfacing converter is validated and verified using both simulation and experimental results.

The conclusions and suggestions for the further development have been presented at the end of this thesis.



***Index terms***— Bi-directional power converters, DC-DC converters, high step-up/down converters, multi-port power converters, renewable sources, soft-switching.

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## List of Abbreviations

| Abbreviation | Description |
|---|---|
| AC | Alternating Current |
| BMS | Battery Management System |
| CC | Constant Current |
| CCM | Continuous Conduction Mode |
| CV | Constant Voltage |
| DC | Direct Current |
| DCM | Discontinuous Conduction Mode |
| EMI | Electro-Magnetic Interference |
| HF | High Frequency |
| IEC | International Electrotechnical Commission |
| LED | Light Emitting Diode |
| LC circuit | Inductor Capacitor circuit |
| MIMO | Multiple Input Multiple Output |
| MISO | Multiple Input Single Output |
| MPPT | Maximum Power Point Tracking |
| PCB | Printed Circuit Board |
| PV | Photovoltaic |
| PWM | Pulse Width Modulation |
| RCD | Resistor Capacitor Diode |
| RMS | Root mean Square |
| SIMO | Single Input Multiple Output |
| SISO | Single Input Single Output |
| SoC | State of Charge |
| SRC | Series Resonant Converter |
| SWT | Small Wind Turbine |
| ZCS | Zero Current Switching |
| ZVS | Zero Voltage Switching |