# DEVELOPMENT OF A COMPREHENSIVE ELECTRO-THERMAL BATTERY MODEL FOR ENERGY MANAGEMENT IN MICROGRID SYSTEMS

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Degree of Master of Science by Research

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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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**ABSTRACT**

Energy storage systems are frequently used to buffer the difference between intermittent renewable generations and energy demand in microgrids. Different energy storage options are possible but the battery energy storage is in high demand in due to its advantages such as relatively fast response, less environmental impact, and diversity of technology and ability of recycling, over the alternative options such as ultra-capacitors, pump storage and flywheels. But the operation of a Battery Energy Storage System (BESS) is affected by dynamics of charging/discharging current, internal temperature build up, extreme reaches of SOC level etc. Therefore a battery model that can represent dynamic and static load changes, thermal response and SOC is important to monitor and control the BESS for a longer life time, enhancing sustainability and reliability of the microgrid.

This thesis describes the development of a comprehensive electro-thermal model for li-ion batteries that can be used to investigate dynamic and static performances of a microgrid under real time operating conditions. The battery-model has the ability to self-update its parameters with the variation of core-temperature, and also to accommodate inherent hysteresis present on parameters between charging and discharging events. The developed model is presented as a block in MATLAB/Simulink for easier use by others. In parallel with that, the details of the development of a complete simulation platform of a microgrid is also described, which includes battery charging and discharging converter systems, bi-directional grid-end AC/DC converter system, wind energy input, solar PV energy input, load and closed loop control associated with converter systems. The battery model is simulated within the microgrid platform with a chosen energy management criteria. The results of the simulation are also presented and discussed.

*Keywords— Battery Energy Storage System; Dynamic modelling; Electro-thermal model; Energy Management System; Equivalent Circuit Models; Microgrids; State of Charge; Thermal behavior*

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**LIST OF ABBREVIATIONS**

ESS : Energy Storage System

DG : Distributed Generation

BESS : Battery Energy Storage System

SOC : State Of Charge

ECM : Equivalent Circuit Model

BMS : Battery Management System

EMS : Energy management

PNGV : Partnership for a New Generation Vehicle