

**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

Department of Electrical 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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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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TABLE OF CONTENT

DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
CONTENTS	vi
LIST OF FIGURES	ix
LIST OF TABLES	xi
LIST OF ABBREVIATIONS	xii
1. INTRODUCTION	1
1.1. Problem Statement.....	1
1.2. Project Objectives and Scope	2
1.3. Energy Storage Techniques	3
1.3.1 Battery Energy Storage Systems (BESS) and lithium-ion batteries.....	4
1.3.2 Lithium-ion battery technology.....	5
1.4. Battery dynamic modelling	8
1.5. Energy Management System (EMS)	9
1.6. Thesis Outline	9
2. Dynamic Modelling of battery cell.....	10
2.1. Electrochemical models	11
2.2. Equivalent Circuit models (ECM).....	12
2.2.1. Rint model.....	12
2.2.2. RC model	13
2.2.3. PNGV model	14
2.2.4. First Order RC ECM	15
2.2.5. The second order RC ECM	15
2.3. Estimation method of battery State Of Charge (SOC)	16
2.3.1. Direct method	15
2.3.1.1. OCV method.....	19
2.3.1.2. Terminal voltage method	18
2.3.1.3. Impedance method	18
2.3.1.4. Impedance spectroscopy method	18
2.3.2. Book – keeping methods	19
2.3.2.1. Coulomb Counting method	19
2.3.3. Indirect measurement	20
2.3.3.1. Neural network method	20
2.3.3.2. Kalman filter	22

2.3.3.3.	Extended Kalman filter	23
2.3.3.4.	Unscented Kalman filter	24
2.3.3.5.	Fuzzy logic	25
2.3.3.6.	Support Vector machines	26
2.3.3.7.	Particle filter algorithm	26
2.3.4.	Analyze of SOC estimation method	25
2.3.4.1.	Qualitative analysis	27
2.3.4.2.	Quantitative analysis	29
3.	Thermal behavior of cylindrical batteries	31
3.1.	Impact of temperature on lithium-ion batteries	32
3.2.	Battery Management System	32
3.2.1.	Management of battery charging/discharging current and voltage	33
3.2.2.	Heat Management and Operating temperature control	33
4.	The proposed comprehensive Electro-thermal battery model	34
4.1.	Overview of the proposed model	34
4.2.	The Electrical model (Second Order RC ECM)	36
4.3.	Two –state thermal model	37
4.4.	Combining of electrical model and thermal model	39
4.5.	MATLAB/Simulink structure to represent battery as a circuit element	42
4.5.1.	SOC calculation method	43
4.5.2.	OCV calculation method	44
4.5.3.	ECM calculation method	45
4.5.4.	Terminal voltage calculation	46
4.5.5.	Heat generation calculation	47
4.5.6.	Temperature calculation	48
4.5.7.	Considerations of the developed model	49
5.	Testing of the proposed battery model	50
5.1.	Microgrid layout	50
5.2.	Energy Management Criteria	51
5.2.1.	Energy Management Algorithm	52
5.2.2.	Battery System	53
5.2.3.	Grid-End Bidirectional Converter	54
5.2.4.	Modelling of renewables and loads	56
6.	Simulation results	58
6.1.	Battery data	55
6.1.1.	Variation of resistance (R_s, R_1, R_2) values with SOC and core temperature. 58	

6.1.2.	Variation of resistance (C_1, C_2) values with SOC and core temperature ...	59
6.1.3.	Variation of resistance OCV values with SOC and core temperature	61
6.2.	Battery response (electro-thermal dynamics)	61
7.	Conclusion and future work	66
7.1.	Conclusion	66
7.2.	Future work	67
	REFERENCES	69
	APPENDICES	77
	[Appendix – A:	77
	[Appendix – B:	83

LIST OF FIGURES

Figure 1.1: Scope of Research

Figure 2.1: Classification of battery models

Figure 2.2: Rint model

Figure 2.3 RC model

Figure 2.4: PNGV model

Figure 2.5: First Order RC ECM

Figure 2.6: Predicting model of SOC based on neural network method

Figure 2.7: Kalman filter Process

Figure 4.1: Overview of the proposed battery model

Figure 4.2: Battery model (mask)

Figure 4.3: Coupling of electrical model and thermal model

Figure 4.4: The second order RC ECM

Figure 4.5: Two-state thermal model

Figure 4.6: Cylindrical single cell radial lumped thermal model

Figure 4.7: Combining of electrical model and thermal model

Figure 4.8: Details of ECM parameters identification process

Figure 4.9: Look-up table for ECM parameters at different SOC and T_C

Figure 4.10: The proposed MATLAB/Simulink model as a circuit element

Figure 4.11: SOC calculation

Figure 4.12: OCV calculation

Figure 4.13: Capacitances (C_1, C_2) calculation

Figure 4.14: Resistance (R_s) calculation

Figure 4.15: Resistances (R_1, R_2) calculation

Figure 4.16: Terminal Voltage(V_t) calculation

Figure 4.17: Heat calculation

Figure 4.18: Temperature (T_c, T_s) calculation

Figure 5.1: The configuration of the proposed battery test system

Figure 5.2: Battery Management Algorithm

Figure 5.3: Battery System

Figure 5.4: Hysteresis Current Controller

Figure 5.5: Grid-end bidirectional converter

Figure 5.6: Wind model

Figure 5.7: Solar model

Figure 5.8: Load model

Figure 6.1: Renewable Energy Profile

Figure 6.2: DC bus voltage

Figure 6.3: Simulation results (i)

Figure 6.4: Simulation results (ii)

Figure 6.5: variation of R_1 with SOC and T_c

Figure 6.6: variation of R_2 with SOC and T_c

Figure 6.7: variation of R_s with SOC and T_c

Figure 6.8: variation of C_1 with SOC and T_c

Figure 6.9: variation of C_2 with SOC and T_c

Figure 6.10: variation of OCV with SOC and T_c

Figure 7.1: Battery test bench

LIST OF TABLES

Table 1.1. Characteristics of Energy Storage Systems

Table 1.2. Different battery Chemistries

Table 1.3. Advantages and disadvantages of lithium-ion batteries

Table 1.4. Components of different lithium-ion battery characteristics

Table 1.5. Characteristics of different lithium-ion battery chemistries

Table 0.1. Research gap

Table 3.1. Impact of temperature on lithium-ion batteries

Table 4.1. Thermal model parameters

Table 4.2. Sub-models of the proposed battery model

Table 4.3. Thermal parameterization of battery pack

Table 5.1. The system characteristics

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