

SIMULATION OF SPACE CHARGE IN ELECTRIC DOUBLE LAYER CAPACITOR

ARIF FARHAN BIN ABDUL RAHMAN

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This thesis is dedicated to, The sake of Allah, my Creator and my Master, My great teacher and messenger, Mohammed (May Allah bless and grant him), who taught us the purpose of life, My great mother, who never stop giving of her in countless ways, My dearest friends, who leads me through the valley of darkness with light of hope and support, My beloved brothers, who encourage and support me.

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ABSTRACT

Electric double layer capacitor (EDLC) is one of the super capacitors families. Due to its high power density compared to lithium battery, EDLC has been widely applied in much modern application such as in electric or hybrid cars and aircraft emergency doors. During its operation, charges are being stored electrostatically onto an interface layer between its active electrode and electrolyte, resulting fast charging-discharging and long-life energy storage device. Charge behavior inside an EDLC can be well-studied based on ac impedance and space charge measurement. Nonetheless, the numbers of scientific researches dealing with the space charge measurement on EDLC are very limited in the past decade. This research project aims to investigate the space charge behavior in EDLC using Quickfield software. The charge and potential distribution within an EDLC were simulated and analyzed in this project.

ABSTRAK

“Electric double layer capacitor” (EDLC) merupakan salah satu keluarga supercapacitors. Oleh kerana ketumpatan kuasa yang tinggi berbanding dengan bateri litium, EDLC telah digunakan dengan meluas dalam pelbagai aplikasi moden seperti kereta elektrik atau hibrid dan pintu kecemasan pesawat. Semasa operasi, cas disimpan sebagai elektrostatik ke lapisan antara elektrod aktif dan elektrolit, menyebabkan pengecasan dan pelepasan cas lebih cepat, dan jangka hayat peranti bagi menyimpan tenaga lebih panjang. Tingkah laku Cas dalam EDLC boleh juga dikaji berasaskan pada “ac impedans” dan pengukuran “space charge”. Namun begitu, jumlah kajian saintifik berurusan dengan pengukuran “space charge” pada EDLC sangat terhad dalam dekad yang lalu. Projek penyelidikan ini bertujuan untuk menyiasat tingkah laku “space charge” dalam EDLC dgn menggunakan perisian Quickfield. Cas dan perbezaan keupayaan di dalam EDLC juga disimulasi dan dianalisis di dalam projek ini.

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LIST OF ABBREVIATIONS

| | | |
|---------------|---|-------------------------------------|
| EDLC | - | Electrical Double Layer Capacitance |
| μm | - | Micro Meter |
| mm | - | Milimeter |
| DC | - | Direct Current |
| PEA | - | Pulsed Electro-Acoustic |
| diff | - | Different |
| SSA | - | Specific Surface Area |
| CG | - | Gravimetric Capacitance |
| ε | - | Constant Dielectric |

LIST OF SYMBOLS

| | | |
|------------|---|-------------------------------|
| V | - | Voltage |
| Q | - | Charge |
| C | - | Coulomb |
| d | - | Distance/Thickness |
| Φ_L | - | Inner Potential at The Liquid |
| X | - | Position |
| ΔG | - | Energy Density |
| C_v | - | Volumetric Capacitance |

CHAPTER 1

Introduction

1.0 Project Overview

Electric double layer capacitor (EDLC) is one of the super capacitors families. Due to its high power density compared to lithium battery, EDLC has been widely applied in many modern applications such as in electric or hybrid cars and aircraft emergency doors. During its operation, charges are being stored electrostatically onto an interface layer between its active electrode and electrolyte, resulting in fast charging-discharging and long-life energy storage device. Charge behavior inside an EDLC can be

well-studied based on ac impedance and space charge measurement. Nonetheless, the numbers of scientific researches dealing with the space charge measurement on EDLC are very limited in the past decade. This research project aims to investigate the space charge behavior in EDLC. In addition, this project also showed the measurement of charge and potential different through the EDLC. Quickfield was used for simulation process to get charge and potential different result. Last but not least, the result of simulation was not limit to using quickfield only, the other software also be used for analysis propose such as excel Microsoft office.

1.1 Background of Study

Electric double layer capacitor (EDLC) is one of the super capacitors families. Due to its high power density compared to lithium battery, EDLC has been widely use nowadays. Advantage of EDLC is EDLC resulting fast charging and discharging. This project aims to investigate the space charge behavior in EDLC. Quickfield was used for simulation the EDLC. In addition, this software also will show the result for charge and potential different on EDLC. Charge behavior inside an EDLC can be well-studied based on result space charge measurement. EDLC was chosen 5 layers that consist of 2 layers for aluminum, 2 layers for carbon electrolyte and 1 layer of separator. In addition, the number of scientific researches dealing with the space charge measurement on EDLC is very limited in the past decade.

1.2 Problem Statement

EDLC is still new in Malaysia. Moreover, the number of scientific researches dealing with the space charge measurement on EDLC is very limited in the past decade. This study are needed to be done for improving the behavior for EDLC, in future maybe form this study the effect of space charge can reduce some of part in EDLC which is dimension of EDLC, size of EDLC and EDLC capacity.

1.3 Objective

The aim of the project is to simulate and investigate space charge behavior, charge and potential distribution in electrical double layer capacitor (EDLC) using quick field software. Besides that, this project involves result analysis of measurement of potential different and charge with various thickness of EDLC also with various material for EDLC.

1.4 Project Scope

This project focuses on space charge behavior of EDLC. Cover on related space charge in EDLC. The circuit simulation was done by using Quickfield. The EDLC was chose to be 5 layers instead of 7 layer, and have 2.5 DC supply. The material used in EDLC was Aluminum, carbon electrolyte, and cellulose for separator. The permittivity was refered to other journal for analysis propose.

1.5 Organization of Report

This project was draft and planned properly from the starting until the end of the project. The project is 100 percent researching on space charge performance in EDLC. In addition, the using of software is to compute the behavior of space charge on EDLC. This report will consist of five main chapters; Introduction, Literature Review, Methodology, Simulation and Analysis, and Discussion.

In ***Chapter 1: Introduction***, discusses the project in collectively. This chapter explains the key aspect of the research work such as project overview, background of study, objectives of the project, scope of the project, and problem statement.

Chapter 2: Literature Review, explains about EDLC and it operation. Moreover the space charge concept and space charge measurement. This report will give description for characteristic for EDLC and it advantages EDLC instead of batteries.

Chapter 3: Methodology, explains on how this project will complete. Besides that, it had shown the process to complete this project by using flow chart. The process and work program for this report also shown in this chapter.

Chapter 4: Result and Analysis, shows the procedure to complete the project, from the obtaining data until the simulation that has been done by using quickfield and excel.

Chapter 5: Conclusion and Future Work, concludes this project based on result that has been got from simulation and study. In addition, this chapter includes idea for future work to be done.

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