



iJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 Issue: VII Month of publication: July 2020

DOI: <https://doi.org/10.22214/ijraset.2020.30696>

www.ijraset.com

Call:  08813907089

E-mail ID: ijraset@gmail.com

Modeling of Lithium Ion Battery using OpenModelica

B Bhargavi¹, D R Pavithra²

^{1,2}Electronics and Communication Department, JSS Science and Technology University

Abstract: Modeling and simulation have multiple applications in the automotive industry such as the design of systems or the re-design of existing systems. Currently, automakers are turning to modeling and simulation to speed up the design process and achieve more successful approaches. The main objective of this project is to design the virtual electrochemical lithium battery that has similar properties as real batteries. The properties considered are SOC, OCV, Capacity, Temperature dependence of battery.

Keywords: Lithium ion battery, electrochemical cell, SOC, OCV, Capacity, Temperature.

I. INTRODUCTION

The smallest individual electrochemical unit is a cell which delivers a voltage depending on the combination of chemicals and compounds used in making of the cell. Primary cells are single-use cells whereas secondary cells are known as rechargeable cells. The most commonly used batteries in hybrid electric vehicle is lithium ion batteries. As li-ion batteries are able to be recharged hundreds of times and are more stable. It has higher energy density, voltage capacity and lower self-discharge rate which is advantageous over rechargeable batteries. Hence, better power efficiency as a single cell tend to have longer charge retention than other battery.

II. PROPOSED ALGORITHM

An electrochemical cell is a device that can generate electrical energy from the chemical reactions occurring in it, or use the electrical energy supplied to it to facilitate chemical reactions in it. These devices are competent to convert chemical energy into electrical energy, or vice versa.

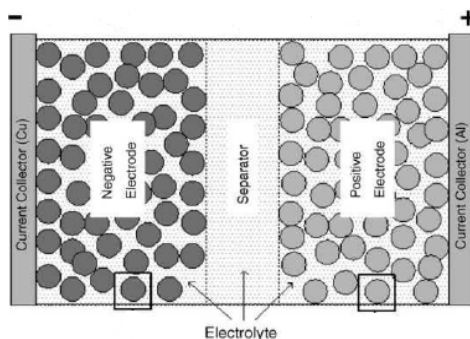
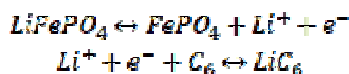


Figure 1. Electrochemical cell

On the basis of such considerations, the Lithium Iron Phosphate (LiFePO₄ or LFP) battery model is created based on the electrochemical cell. The model as shown in Figure 2 is created in the modeling perspective window by dragging and dropping of the required components and connecting them accordingly. It contains three solutions anode, cathode and electrolyte.

The redox reaction used for the designed battery is as follows:



Where Anode is C₆ (graphitic carbon), Cathode is LiFePO₄, Electrolyte is LiPF₆. The substances are defined as record which consists of thermal quantizes such as enthalpy, Gibbs free energy and vacancy electron. After substances are defined it is connected based on the chemical equation and array of stoichiometric coefficients in reaction. These batteries can be connected to any electrical circuit that allows to understand discharging, charging OCV, Capacity and SOC characteristic curves.

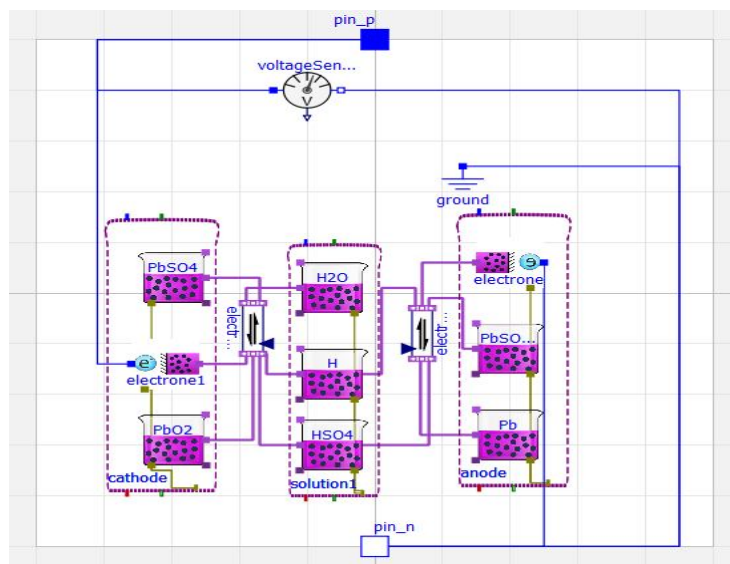


Figure 2. Lithium Iron Phosphate (LiFePO_4 or LFP) battery model

Further it is reduced to a component with a positive pin, negative pin and temperature port. The temperature port is connected to the temperature sensor. By making use of this component the temperature dependence of the battery is easily determined.

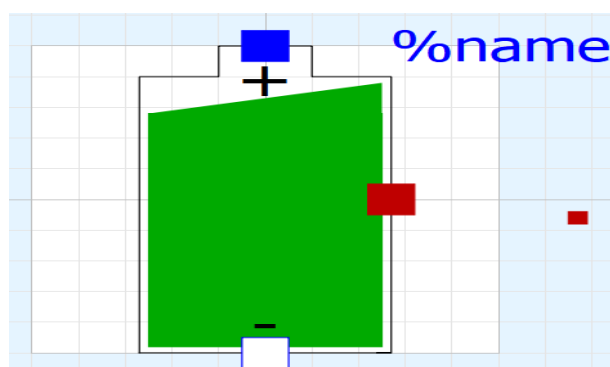
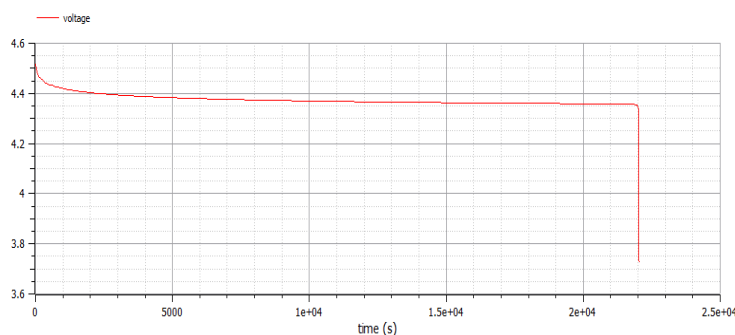


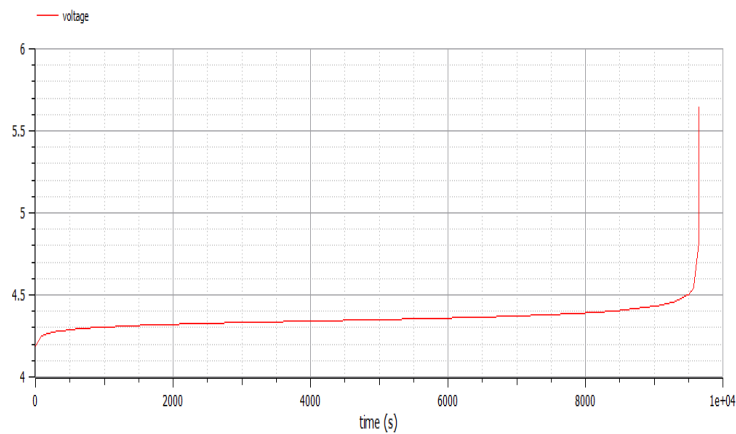
Figure 3. Component

III. EXPERIMENT AND RESULTS

The battery is tested by connecting to an external load or source based on the requirement whether to charge or discharge. OpenModelica 1.14 software platform is used to create and perform the experiment on battery. OpenModelica based on the Modelica modeling language is a free and open source platform widely used in optimizing, simulating, modeling and analyzing complex dynamic systems. A non-profit, non-governmental organization known as Open Source Modelica Consortium develops this software actively.

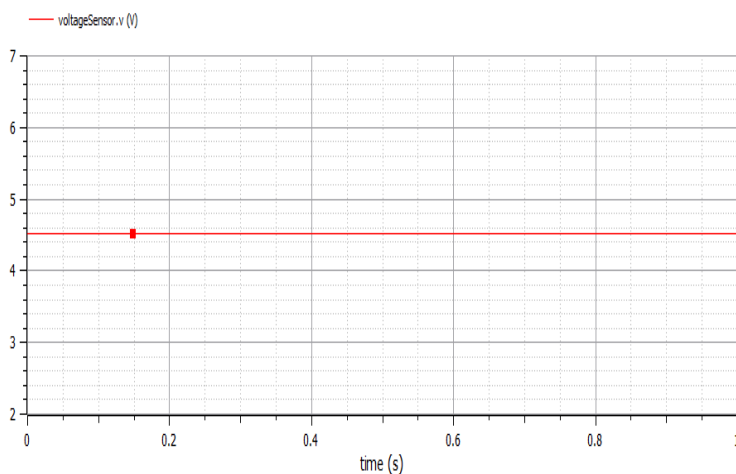


(a)

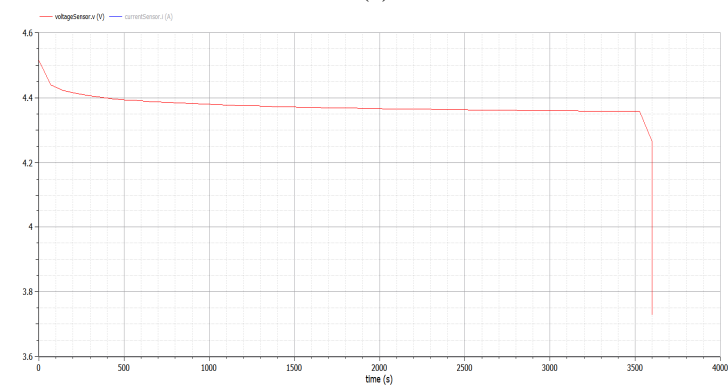


(b)

Figure 4. (a) Discharging the battery with 1 ohm resistor (b) Charging the battery with 10 amps of current source



(a)



(b)

Figure 5. (a) OCV of 4.5 volts (b) SOC using coulomb counting method with respect to time

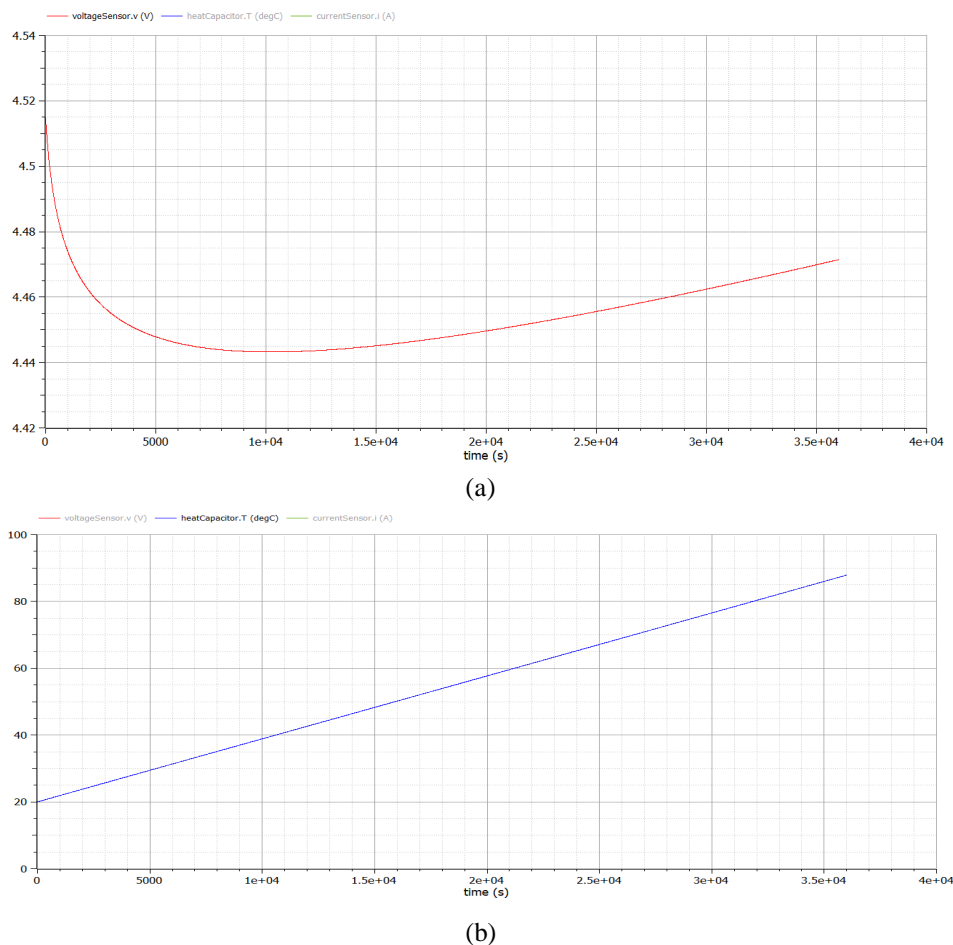


Figure 6. (a) Voltage raising graph (b) Temperature raising graph

The load of 10 ohm is connected to the battery is discharging, hence the voltage is decreasing to 4.47v from 4.52v. Temperature plays a crucial role in determining the chemical reaction speed, the resistance of the semiconductor, and the band gap. From -20°C ~ 60°C , Thermal energy tends to increase the reaction speed of the chemical processes (i.e., discharging) while at the same time also increasing the resistivity in conductors. Above 60°C , The band gap, on the other hand, declines with increasing thermal energy and thus results in a lower circuit voltage. Generally, the acceptable temperature region for LIBs is -20°C ~ 60°C after which the thermal runaway takes place. Therefore, below or equal to 60°C , voltage keeps decreasing after which it increases but in real life catches fire.

IV. CONCLUSIONS

Modelling and simulation process in OpenModelica tool need a lot of practice and knowledge. The tool allows easier creation of models in small time and also cost efficient. There are several other commercial software's like COMSOL, MapleSim, etc with additional libraries and extra features. However, with OpenModelica tool one can design the required components and make use of it. The Lithium ion battery model is created by making use of the available components and is simulated. The simulation results shows that the proposed project work aims to create the virtual design of battery considering the parameters of OCV, SOC, capacity, temperature dependence of battery using the electrochemical model of the battery.

V. ACKNOWLEDGMENT

The authors would like to sincerely thank and acknowledge the staff of Department of Electronics and Communication, JSS Science and Technology University, Mysuru and all the fellow students for their timely assistance, guidance and valuable suggestion provided throughout the project.

REFERENCES

- [1] Hafsaoui, Julien, and Franck Sellier. "Electrochemical model and its parameters identification tool for the follow up of batteries ageing." *World Electric Vehicle Journal* 4.2 (2010): 386-395.
- [2] Uddin, Kotub, et al. "Characterising Li-ion battery degradation through the identification of perturbations in electrochemical battery models." *World Electric Vehicle Journal* 7.1 (2015): 76-84.
- [3] Ogumi, Zempachi. "Interfacial reactions of lithium-ion batteries." *Electrochemistry* 78.5 (2010): 319-324.
- [4] Anwar, Sohail, Changfu Zou, and Chris Manzie. "Distributed thermal-electrochemical modeling of a lithium-ion battery to study the effect of high charging rates." *IFAC Proceedings Volumes* 47.3 (2014): 6258-6263.
- [5] He, Wei, et al. "A physics-based electrochemical model for lithium-ion battery state-of-charge estimation solved by an optimised projection-based method and moving-window filtering." *Energies* 11.8 (2018): 2120.
- [6] M. Einhorn, F. V. Conte, C. Kral, C. Niklas, H. Popp, J. Fleig "A modelica library for simulation of electric energy storages." *Proceedings of the 8th International Modelica Conference*; March 20th-22nd; Technical University; Dresden; Germany. No. 63. Linköping University Electronic Press, 2011.
- [7] Matejak, Marek, et al. "Free Modelica Library for Chemical and Electrochemical Processes." *Proceedings of the 11th International Modelica Conference*, Versailles, France, September 21-23, 2015. No. 118. Linköping University Electronic Press, 2015.
- [8] Dao, Thanh-Son, and Chad Schmitke. "Developing mathematical models of batteries in modelica for energy storage applications." *Proceedings of the 11th International Modelica Conference*, Versailles, France, September 21-23, 2015. No. 118. Linköping University Electronic Press, 2015.
- [9] DeCaluwe, Steven C. "Open Software for Chemical and Electrochemical Modeling: Opportunities and Challenges." *Electrochemical Society Interface* 28.1 (2019): 47.
- [10] Xing, Yinjiao, et al. "State of charge estimation of lithium-ion batteries using the open-circuit voltage at various ambient temperatures." *Applied Energy* 113 (2014): 106-115.



10.22214/IJRASET



45.98



IMPACT FACTOR:
7.129



IMPACT FACTOR:
7.429



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089  (24*7 Support on Whatsapp)