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State of Health Estimation of LMO/NMC-based Electric Vehicle Lithium-Ion Batteries Using the Incremental Capacity Analysis Technique

Accurate & **low computational demanding state-of-health (SOH) estimation algorithm battery management systems in electric vehicle (EV) incremental capacity analysis (ICA) technique** *for estimating* - the capacity fade - the SOH of **LMO/NMC-based EV** *Lithium-ion batteries*. Based on **ageing results** collected during **eleven months of testing**, we were able to **accurately relate** the **capacity fade** of the studied batteries to the evolution of the voltage value, which corresponds to one of the incremental capacity (IC) valleys, obtained using the ICA technique.

State of Health Estimation EV batteries Li-Ion (LMO, NMC) Incrementl capacity analysis

Incremental Capacity Analysis as a State of Health Estimation Method for Lithium-Ion Battery Modules with Series-Connected Cells

TODO, TBH, nothing new seems to emerge out of this article, so, move on

Computer modelling of electricl power systems

Electrical power systems

What the hell is a **steady and dynamic** state of electrical power systems?

Prereqs

- power system theory
- matrix analysis
- neumerical techniques

computational and transmission system developments **FACTS** & **HVDC** links General purpose single phase load flow program

Neuton fast decoupled algorithm power system in dynamic states electronagmetic transients with reference to the EMPT method power electronic components electromechanical models

Chapter-1(Introduction)

FORTRAN based power system computer progarams implemented to run on mainframes

HVDC && FACTS technologies *modern power transmission and distribution systems are A.C. right?*

EMTP -> Electro Magnetic Transient Programs RTDS -> Real Time Digital Simulation

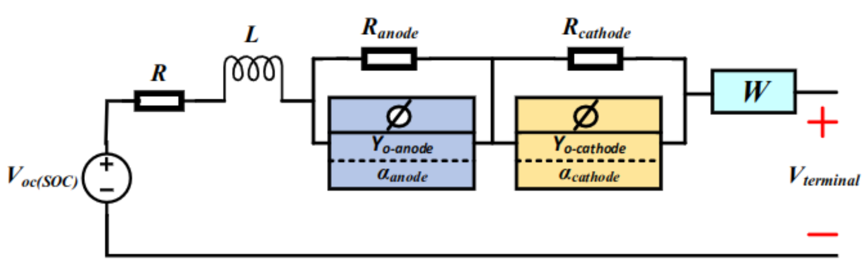
- **HIGH VOLTAGE DIRECT CURRENT** => HVDC
- **FLEXIBLE ALTERNATING CURRENT TRANSMISSION SYSTEMS** => FACTS

Okay, I'm looking to gain understanding on Battery Management Systems Current book that I'm reading is **Computer Modelling of Electrical Power Systems** You have to stop reading this book because

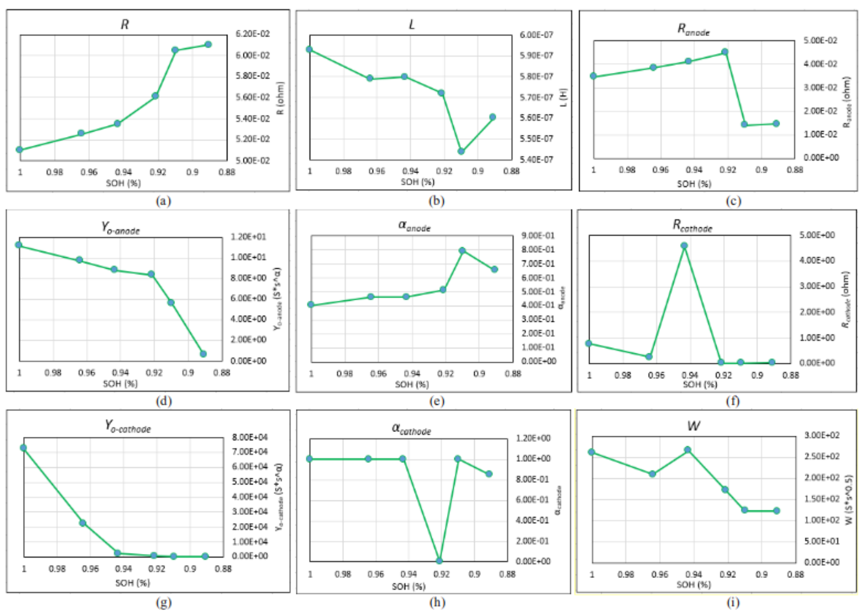
1. It doesn't have any thing on BMS
2. It contains topics on **Load Flow** and **Transmission Systems Modelling**
3. It contains topics like **FACTS** & **HVDC** transmission, which, Right now, I don't give a flying fuck.

Evaluation of Electrical Circuit Model Parameter variations under different state-of-health conditions for Litihium-ion battery.

- ECM parameter variation
- different state-of-health conditions



Model component	Description
$V_{oc(SOC)}$	Open circuit voltage of battery. It varies with the SOC value of battery.
R	Series resistor which mainly models the resistance of electrolyte and current collector of battery.
L	Inductive component which models the porous nature of battery electrodes [12].
R_{anode}	Resistance parameter to characterize the behavior of double layer effect occurring close to anode electrode. It is responsible for one of two semi-circles in the EIS [21].
$Y_{o\text{-}anode}$	Capacitance parameter of CPE for anode electrode. It is responsible for one of two semi-circles in the EIS.
α_{anode}	Fractional phase element coefficient of CPE for anode electrode.
$R_{cathode}$	Resistance parameter to characterize the behavior of double layer effect occurring close to cathode electrode. It is responsible for one of two semi-circles in the EIS.
$Y_{o\text{-}cathode}$	Capacitance parameter of CPE for cathode electrode. It is responsible for one of two semi-circles in the EIS.
$\alpha_{cathode}$	Fractional phase element coefficient of CPE for cathode electrode.
W	Warburg impedance which models diffusion process occurring in low frequency region of EIS.



keywords

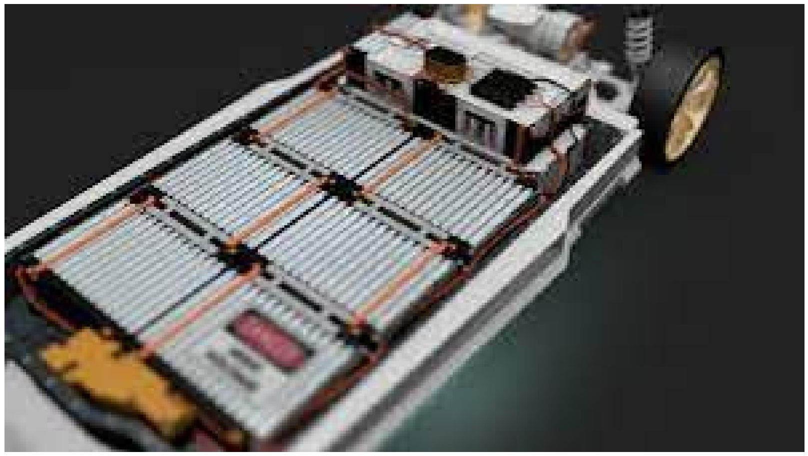
- ageing
- capacity fade
- EIS

Questions

what are computationally economical methods for determining SoH of a BMS which are Accurate as well?

First of all, State of Health is not a term related to BMS. BMS computes the **State of Health** for a **battery pack**. **State of Health is a property of a battery pack** like this one

Figure 1: EV Battery Pack

Or, this one 

What are the most common methods used for determining SoH of a BMS?

How can we use such methods to determing SoH of a BMS for a real world EV?

Okay, ICA(Incremental Capacity Analysis) is a method for determining SoH, which is, both, computationally economical as well as pretty much accurate?

ICA can further be used for Capacity Fade?

What the hell is capacity fade anyway?

What are the most common types of batteries used in Modern EVs? In the paper which I'm reading, they discussed LMO and NMC based batteries

What are ageing results?

What are capacity fade of a battery?