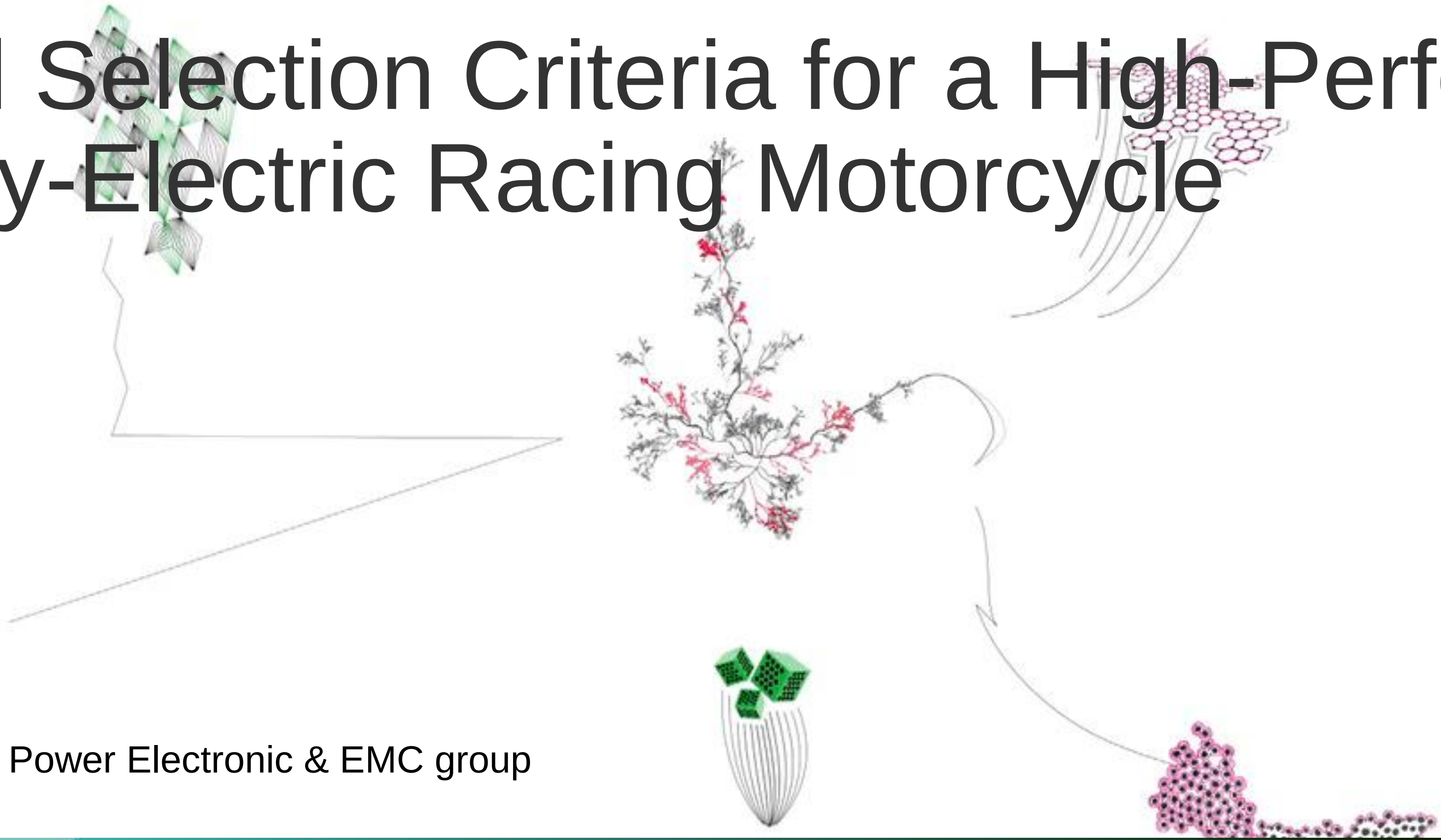
Power Electronic & EMC (PE) group



Cell Selection Criteria for a High-Performance Fully-Electric Racing Motorcycle

Reza Azizighalehsari
University of Twente, Power Electronic & EMC group

Power Electronics & Energy Storage event
14 juni 2022 | 1931 Congrescentrum 's-Hertogenbosch

Cell Selection Criteria for a High-Performance Fully-Electric Racing Motorcycle

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01

Introduction

A brief introduction about the battery technology, Li-Po battery and the reason for selecting this type of battery for the racing motorcycle, and Twente Superbike team.

02

Electrochemical Impedance Spectroscopy (EIS)

EIS as a technique in battery impedance measurement, Find and remove the outlier cells and then categorize them based on their EIS measurement results.

03

Verify the classification method and find the optimal configuration based on cell sequence

Capacity test performed by subjecting the cells in different discharge rate conditions. All possible configurations have been considered and evaluated.

04

CONCLUSION and Future work

Some important information related to battery cell selection criteria, the main challenges and expected future work.

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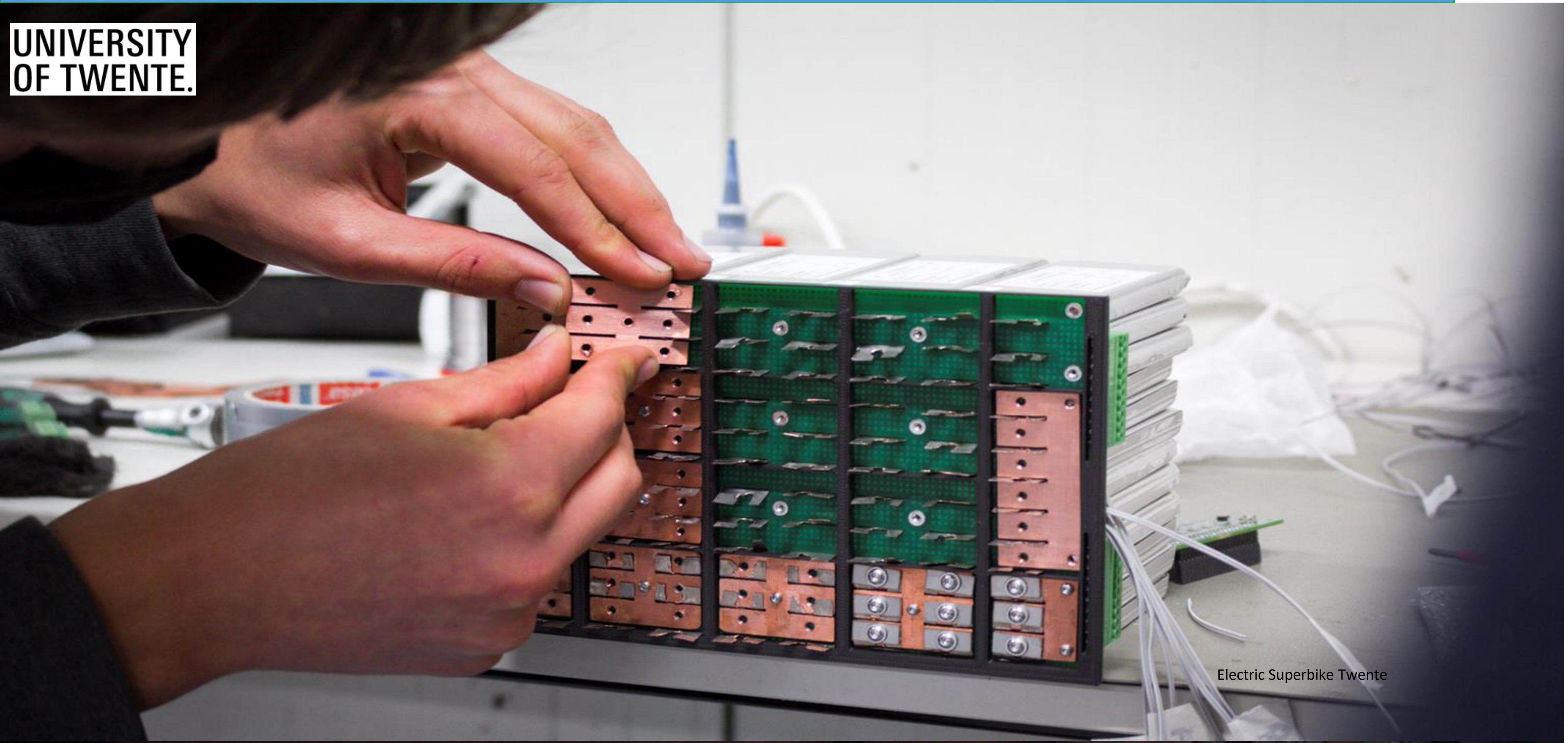

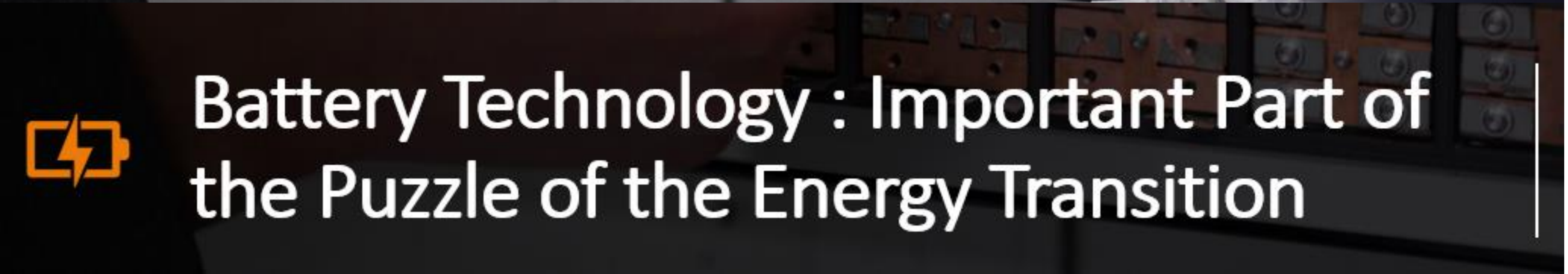

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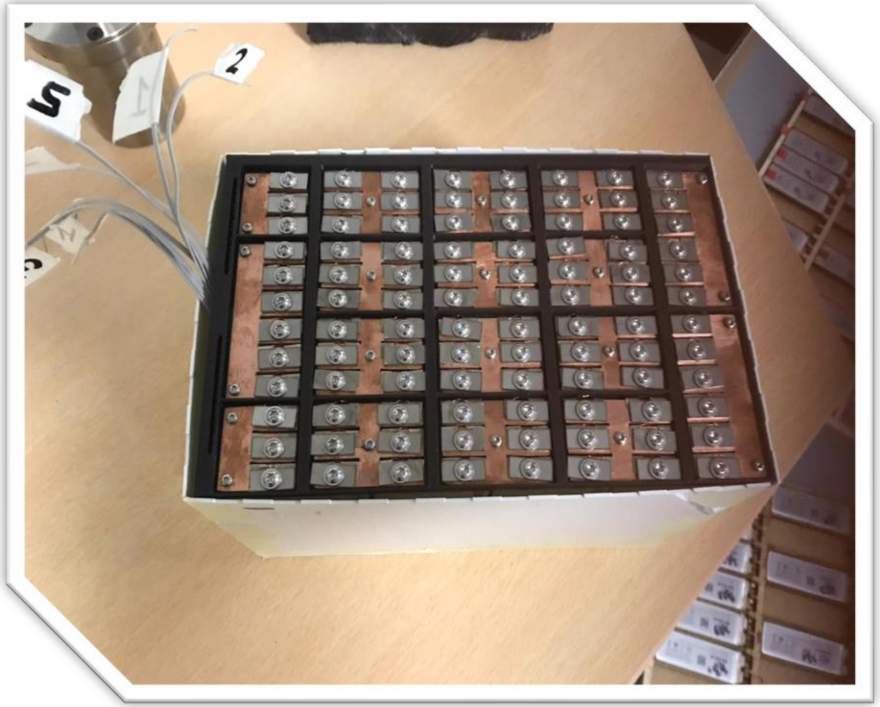
Lithium-Polymer Batteries



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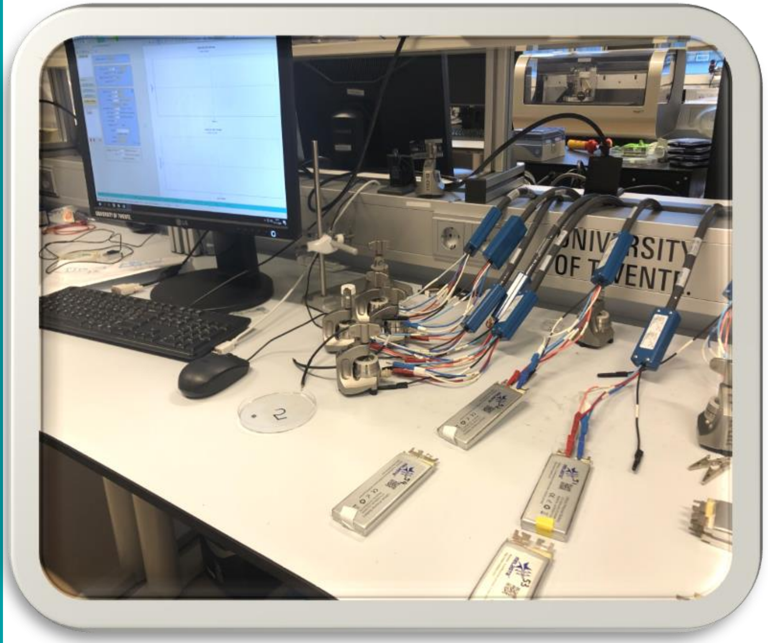

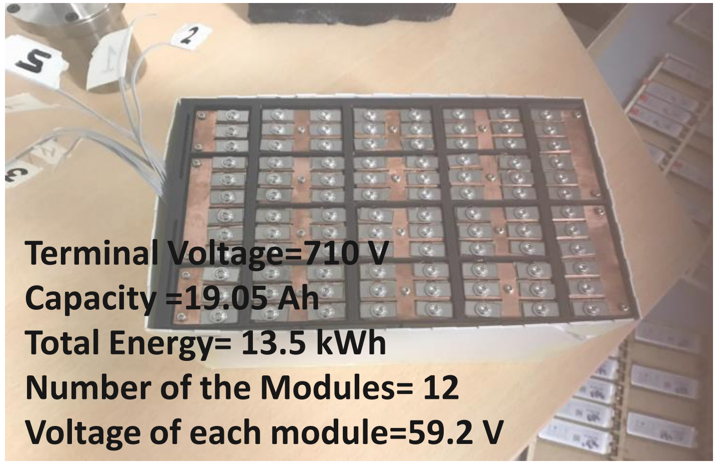

- Qualification Testing.
- Avoid Impedance Mismatching.
- Performance Optimization.
- Configuration Optimization and Cell Sequence.

https://electricsuperbiketwente.nl/

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ELECTRIC
SUPERBIKE
TWENTE

- Student Team
- Fully Electric Superbike
- Future Proof

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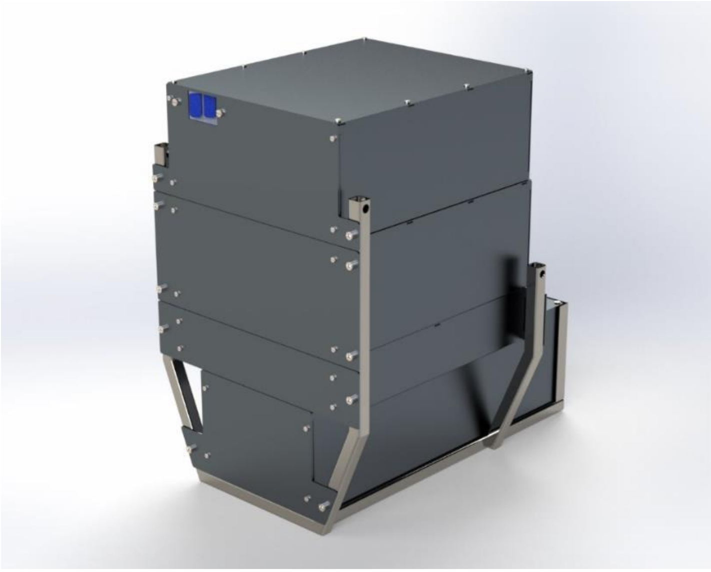
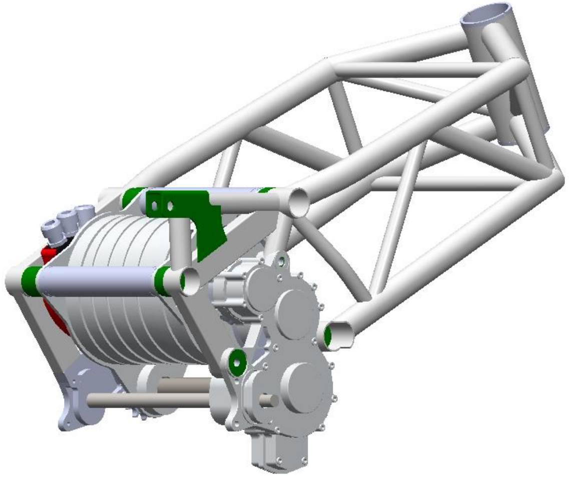
Power Electronics of the Superbike

Battery Pack → Motor Controller → Motor





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Performance of the Superbike

- 0-100 km/h ~ 3s
- 300 km/h
- 190 hp / 140 kW

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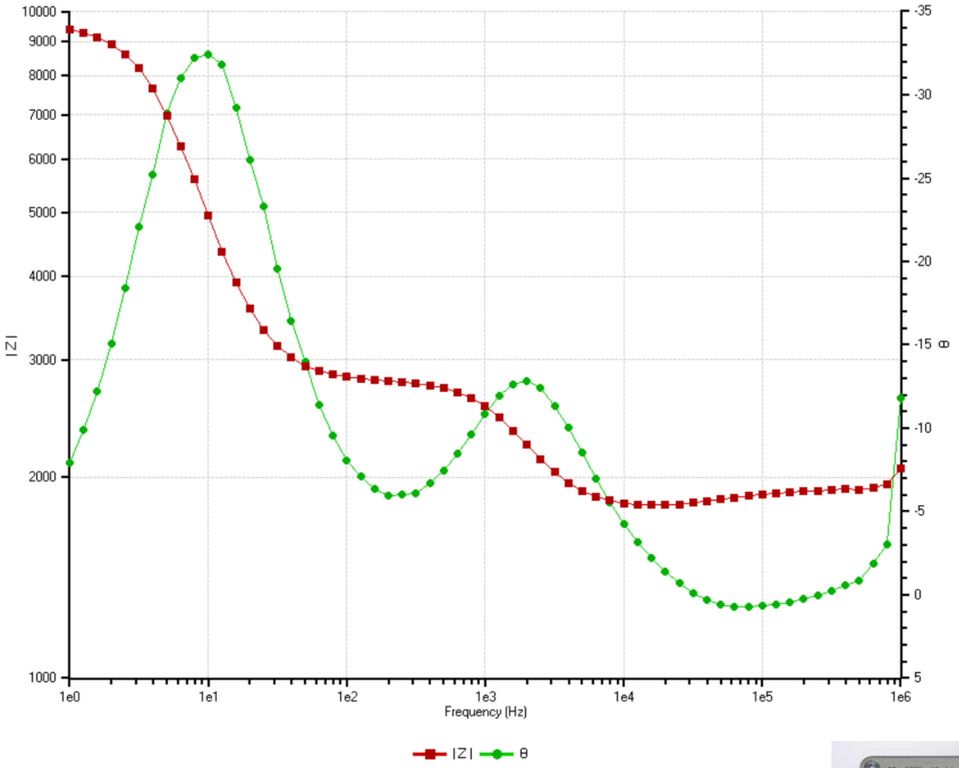
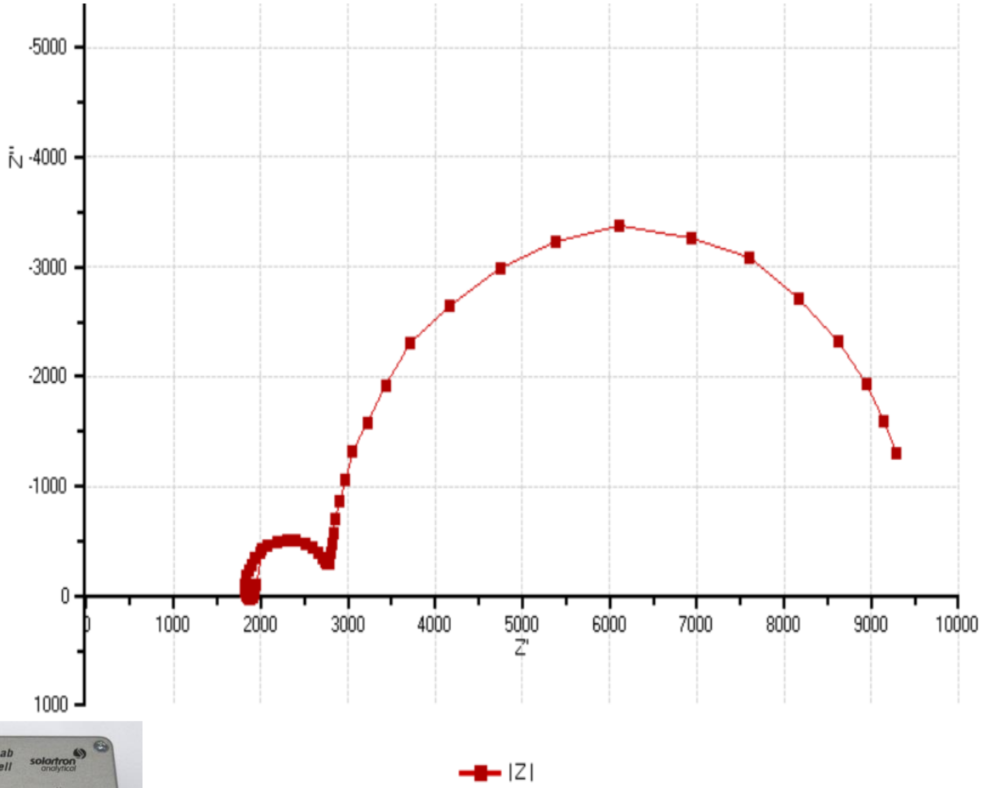
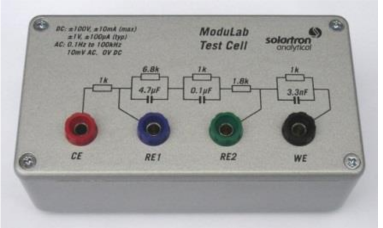
Electrochemical Impedance Spectroscopy (EIS)







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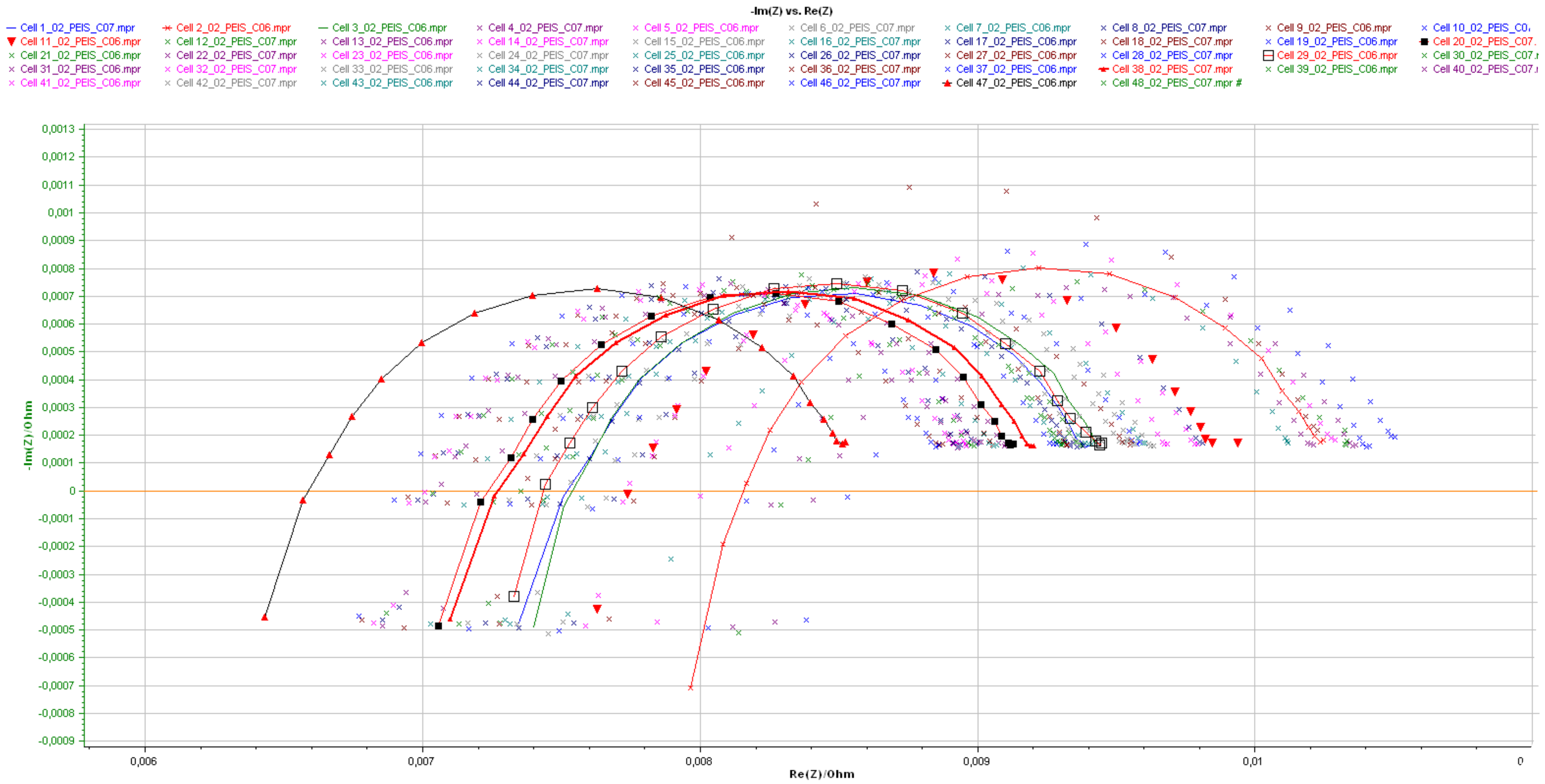
EIS results in Nyquist form for 48 randomly selected cells to show the outlier cells



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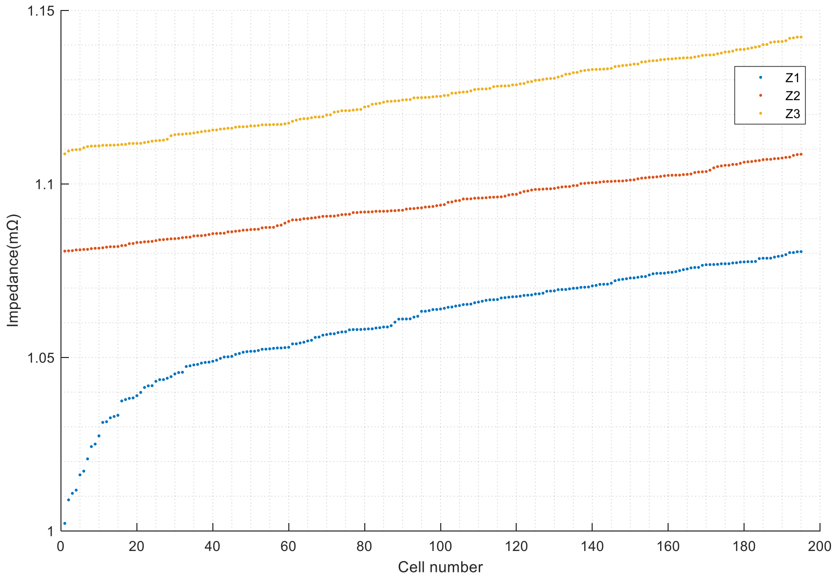
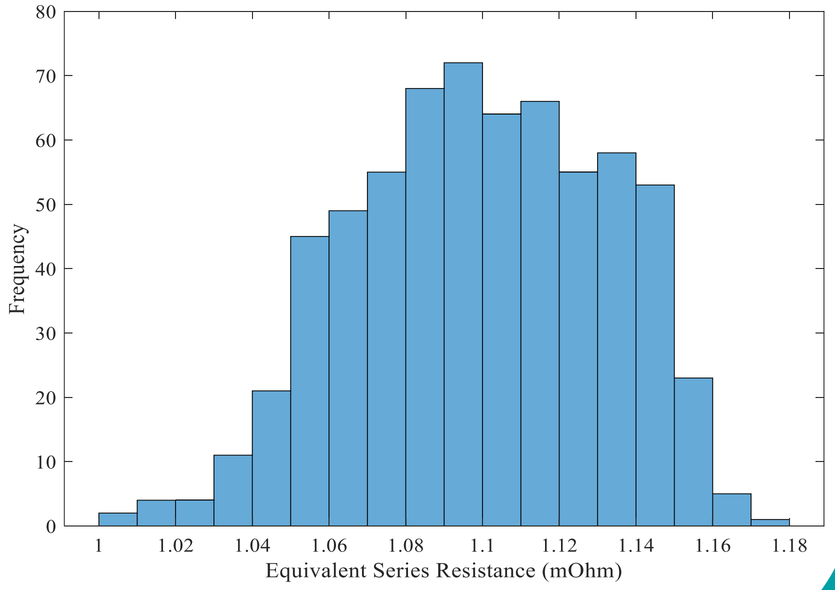
Cell categorization based on DC internal Resistance

- Electrochemical Impedance Spectroscopy (EIS) from low to high frequency
- Remove the outlier cells
- Categorize the cells based on the high frequency response according to their internal resistance





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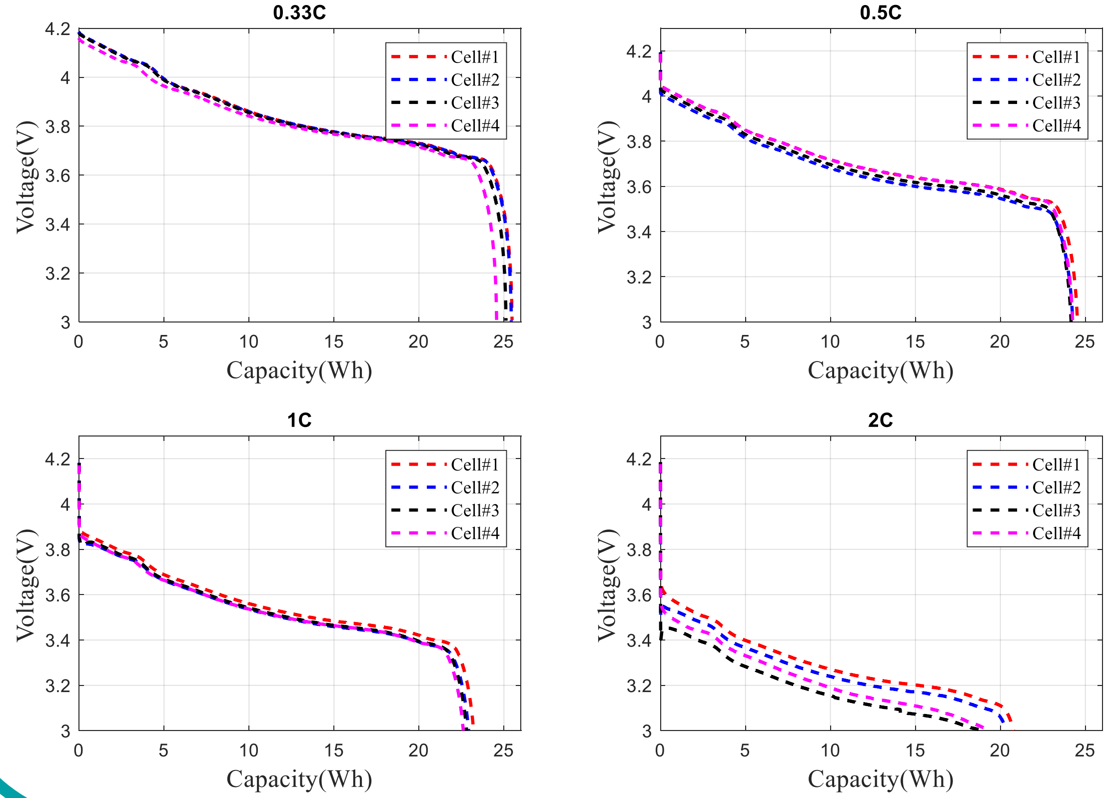
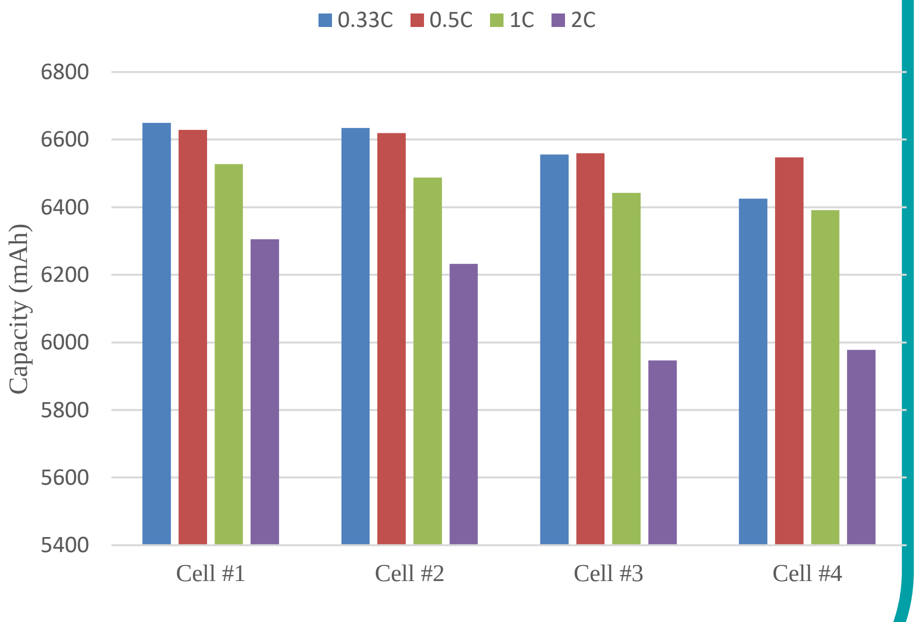
Capacity Test Results For Selected Cells From Each Group

- **One cell from each group and one cell from outlier cells have been selected**
- **Capacity test at different Crate to verify the classification method**





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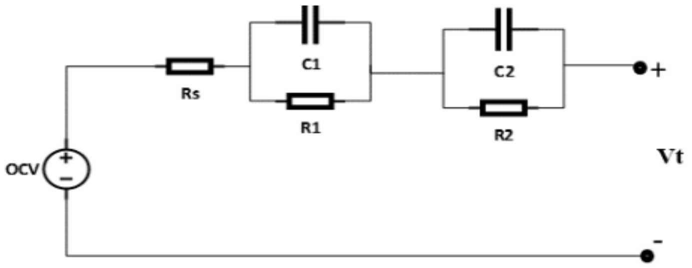
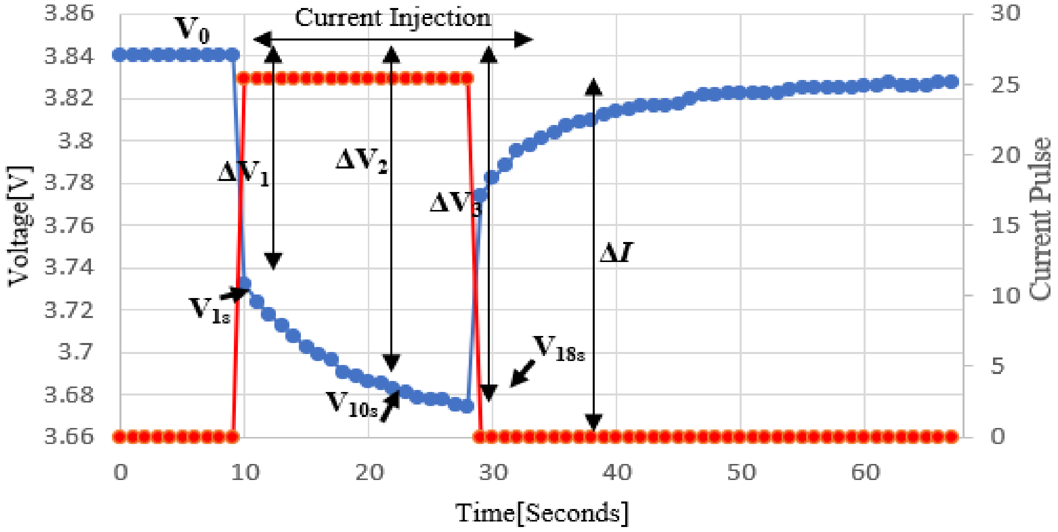
Electrical Modelling of Cells





Current pulse approach method to model Li-Po cell

$$R_S = \frac{V_{1s} - V_0}{\Delta I}$$

$$R_1 = \frac{V_{10s} - V_{1s}}{\Delta I}$$

$$R_2 = \frac{V_{18s} - V_{10s}}{\Delta I}$$

$$C_1 = \frac{(t_2 - t_1)}{R_1 * Ln\left(\frac{V_{10s}}{V_{1s}}\right)} \qquad C_2 = \frac{(t_3 - t_2)}{R_2 * Ln\left(\frac{V_{18s}}{V_{10s}}\right)}$$

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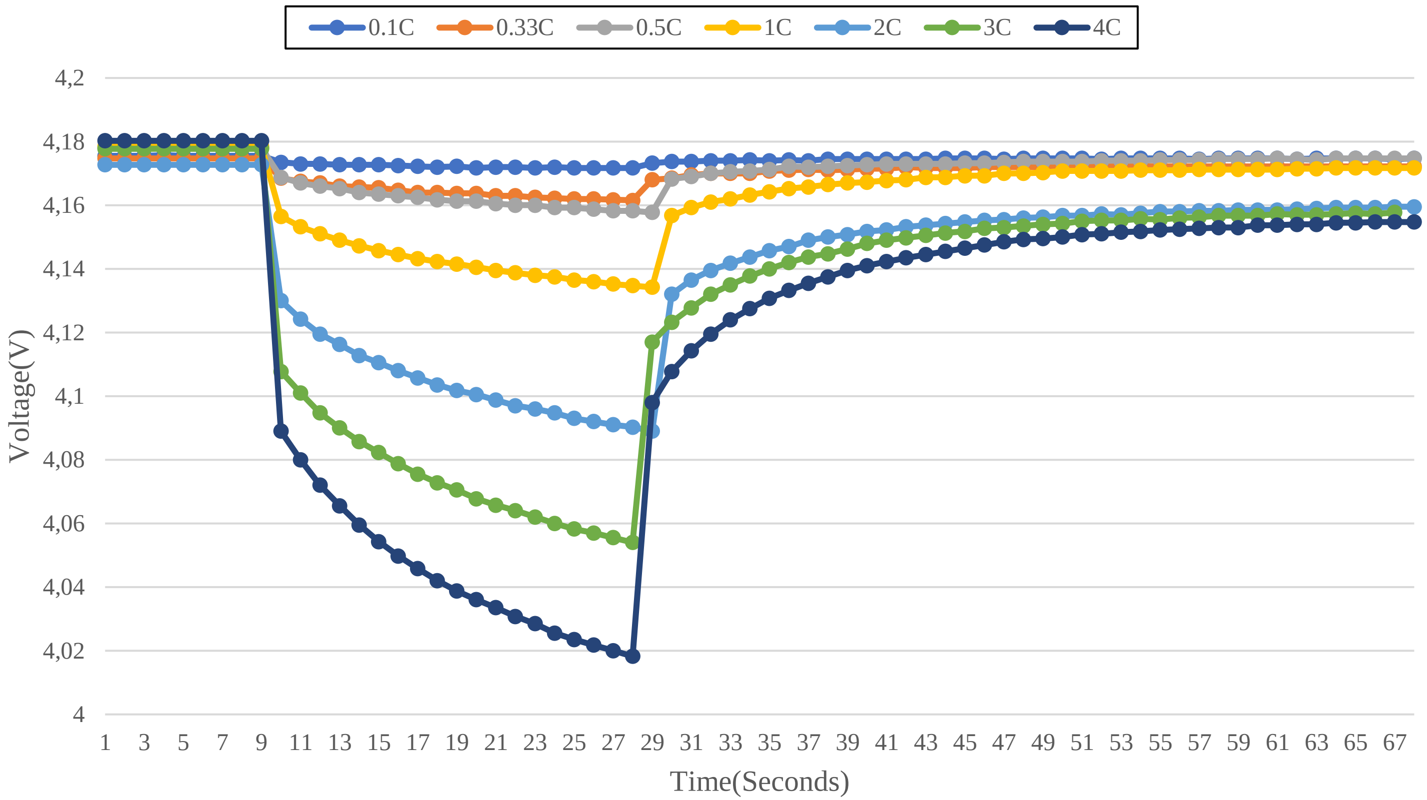
Voltage variation in current pulse approach method to model Li-Po cell in different C rate



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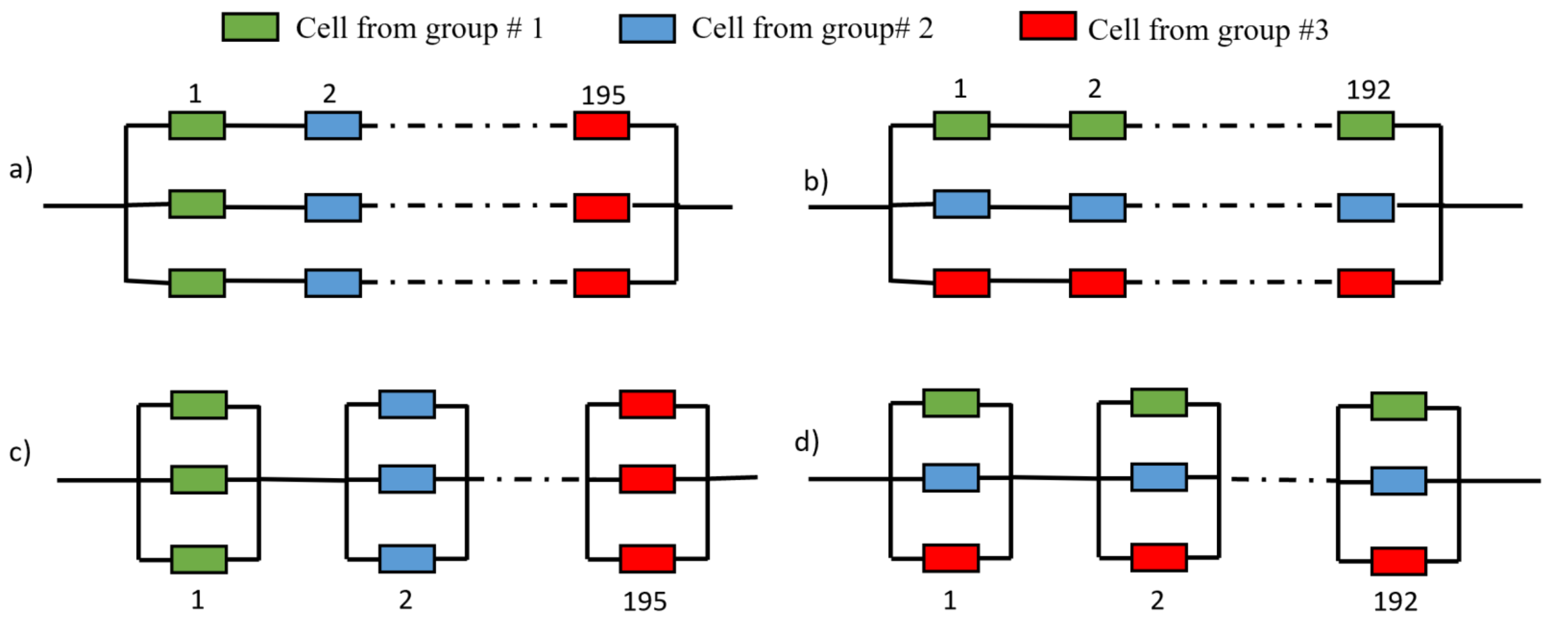
Battery Pack Design



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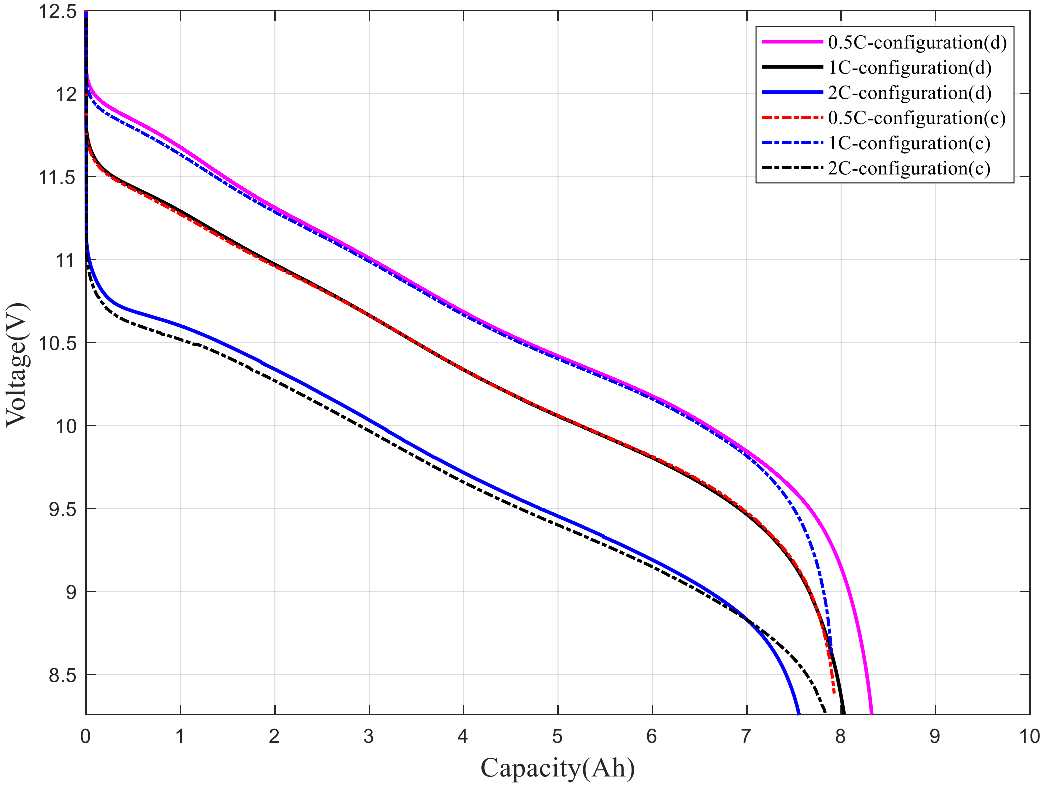
Battery Pack Design



Discharge capacity for two mini battery packs with configuration (c) and (d) with 10% discrepancy between the capacity of the cells

- **Find optimal configuration based on cell sequence**
- **Configuration (d) has been selected to avoid impedance mismatching between the strings**

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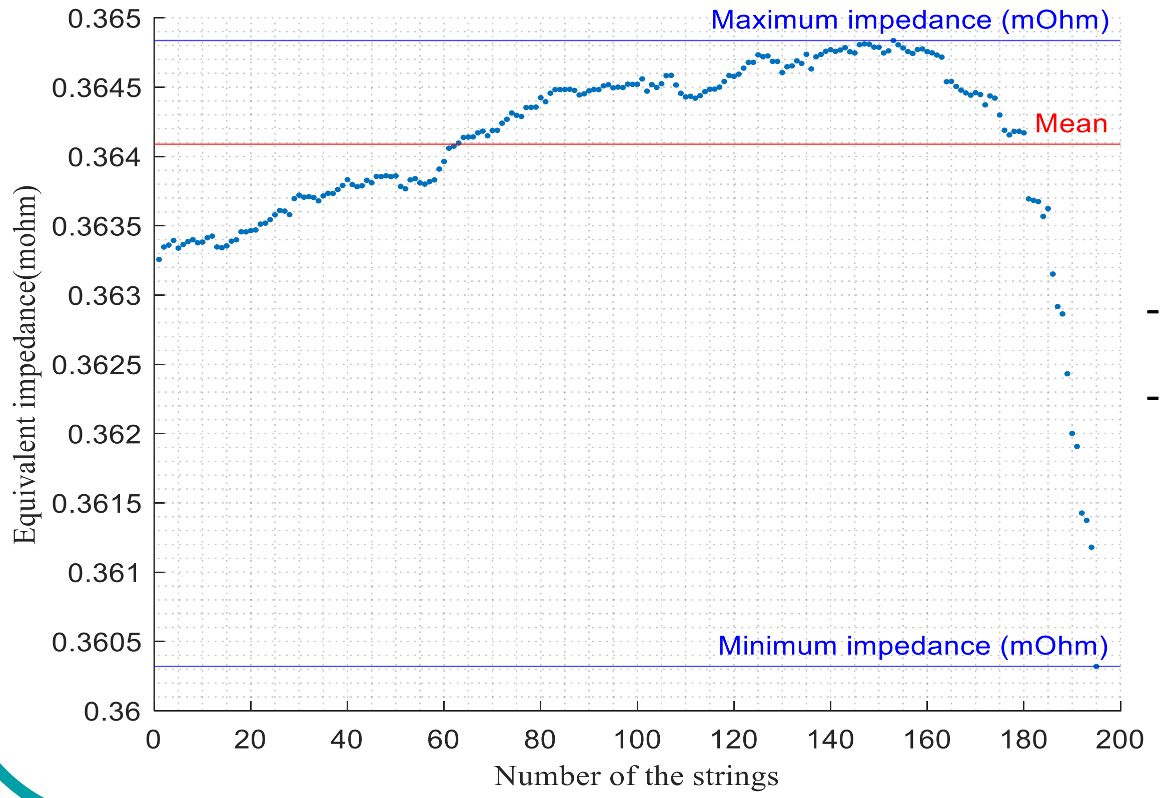
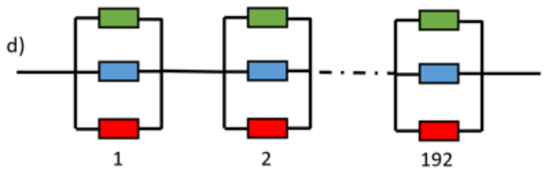
Equivalent impedance of each string according to the (d) configuration





- **Standard deviation really close to zero**
- **best balance between the modules and in terms of impedance uniformity between the strings for the battery pack in configuration (d)**

Conclusions

- Discrepancy exist even for the cells from the same batch from the same manufacturer.
- Measurements of internal resistance by EIS and other approaches is different as a result of the battery's complicated electrochemical dynamics.
- There is a real need for standardization of the tests for repeatability.
- The best impedance uniformity between the strings in proposed configuration.
- As a consequence of impedance uniformity, the voltage disparity between the strings is less in proposed configuration.

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Battery Diagnostics and Prognostics

WORKSHOP

IN-PERSON || ONLINE

University of Twente
Power Electronics and EMC
Drienerlolaan 5, 7522 NB, Enschede

28 October 2022

Motivation:

- Create awareness about R&D within the field of power electronics, measurements, and the battery ecosystem.
- Bridge the gap between knowledge institutions and the battery industry in the Netherlands.
- Train industry partners from the Netherlands and north-west Europe on battery performance and testing within the ambit of the STEPS project.
- Future collaboration between various stakeholders and the University of Twente.

THANKS FOR YOUR ATTENTION

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