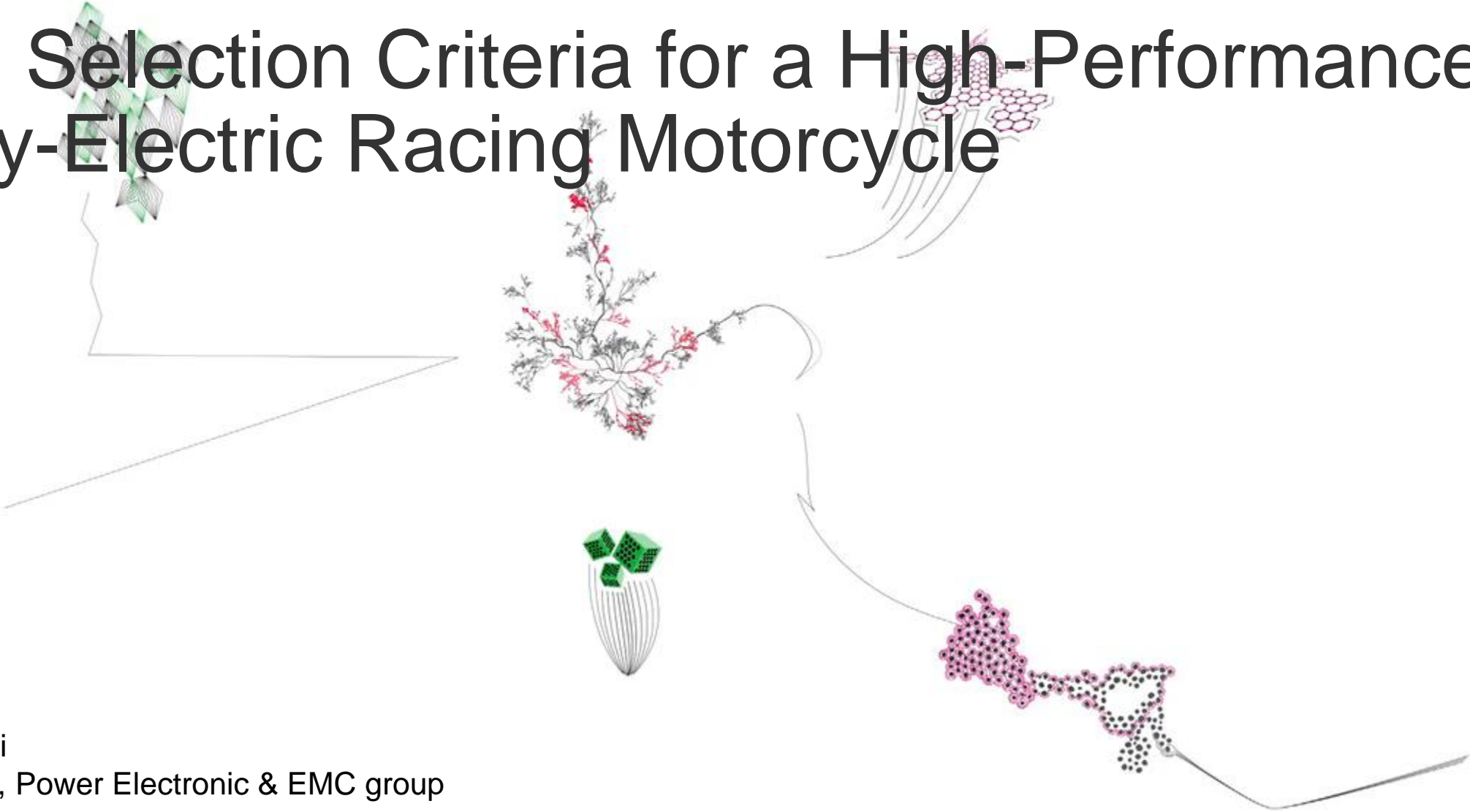# Cell Selection Criteria for a High-Performance Fully-Electric Racing Motorcycle

Reza Azizighalehsari
University of Twente, Power Electronic & EMC group

UNIVERSITY
OF TWENTE.

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

UNIVERSITY
OF TWENTE.

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.
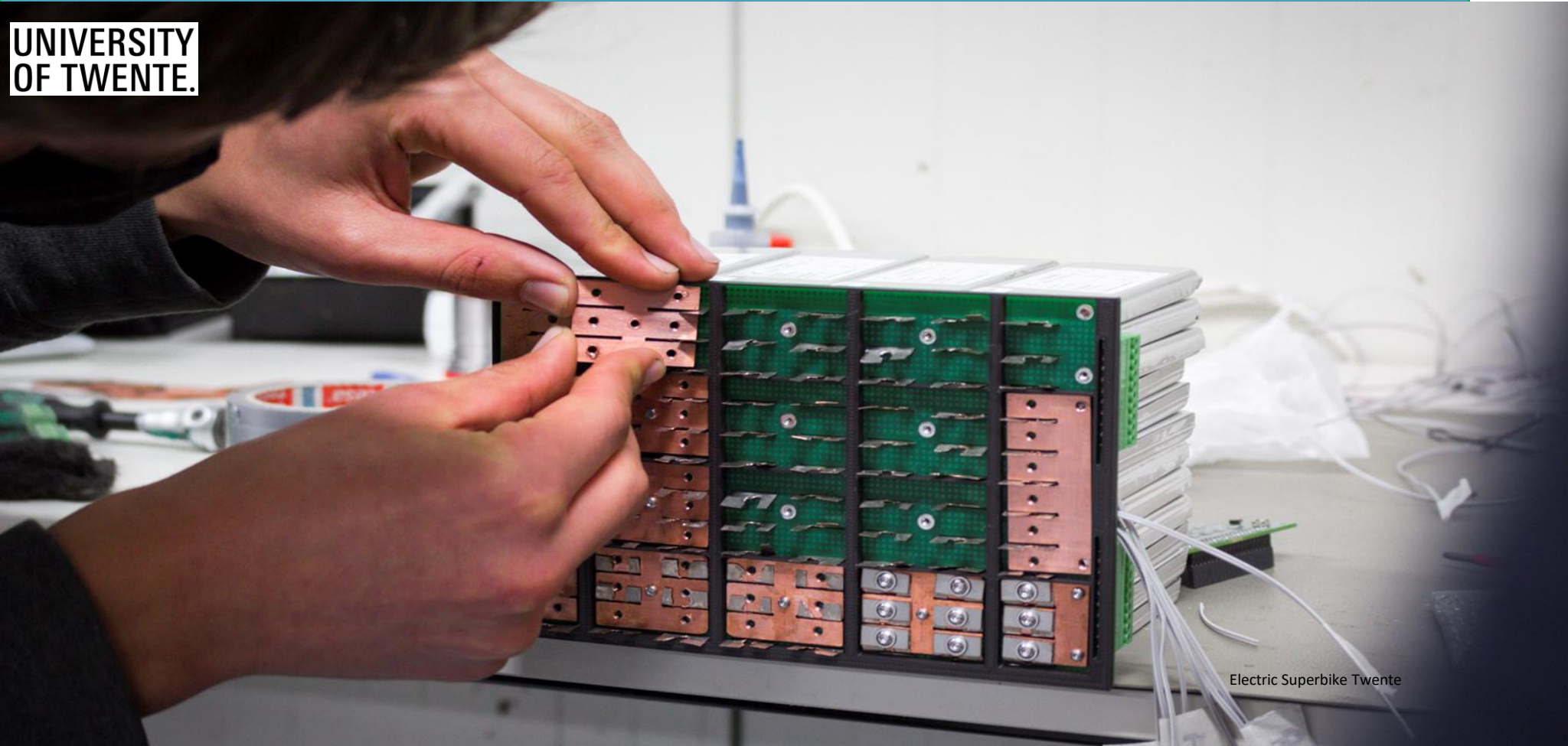
04

CONCLUSION and Future work

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

Electric Superbike Twente

Battery Technology : Important Part of the Puzzle of the Energy Transition

UNIVERSITY
OF TWENTE.

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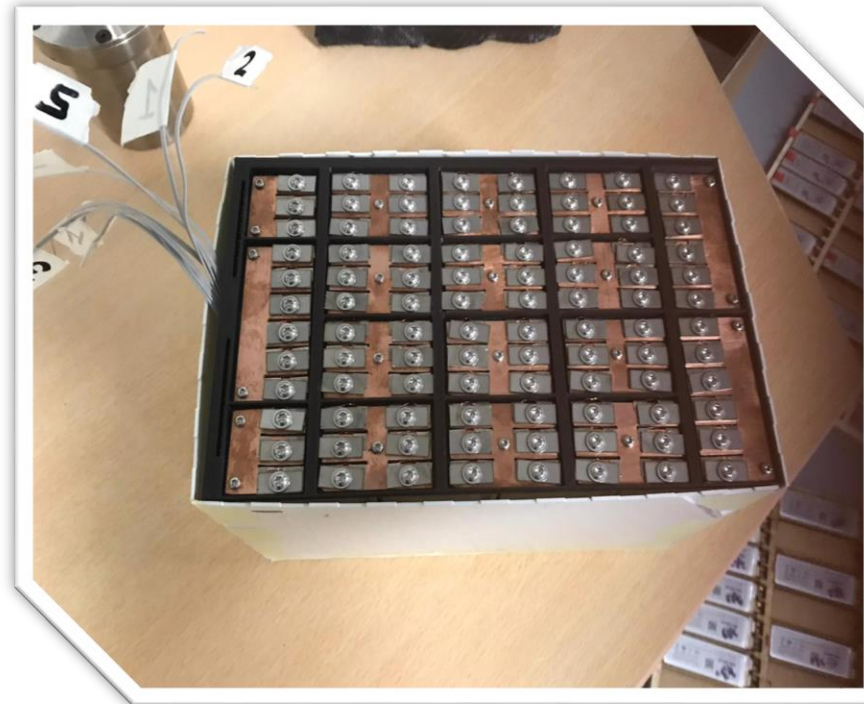
Cell Selection Criteria for a High-Performance Fully-Electric Racing Motorcycle

UNIVERSITY
OF TWENTE.

Terminal Voltage=710 V
Capacity =19.05 Ah
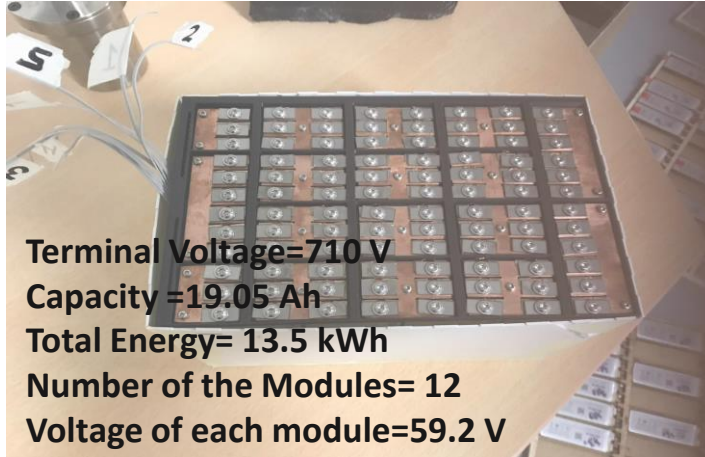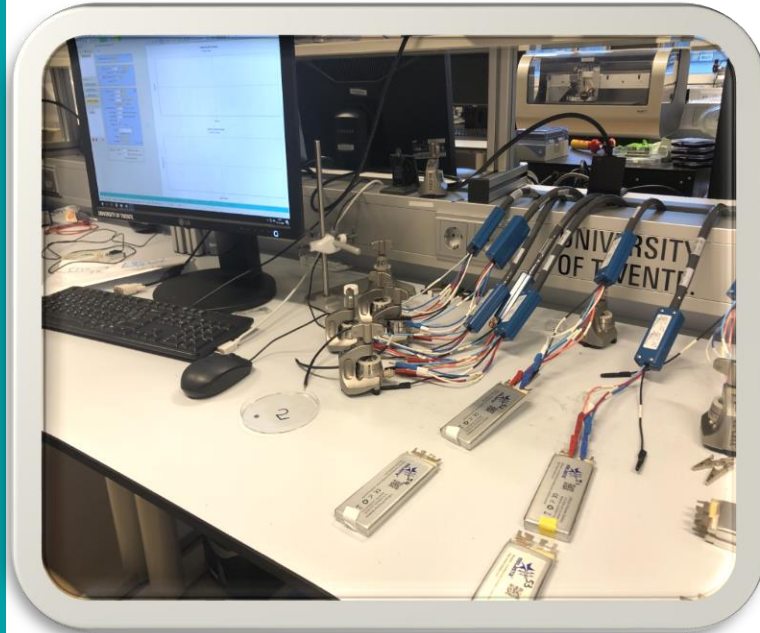Total Energy= 13.5 kWh
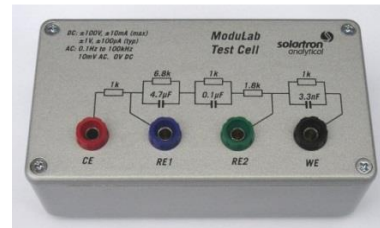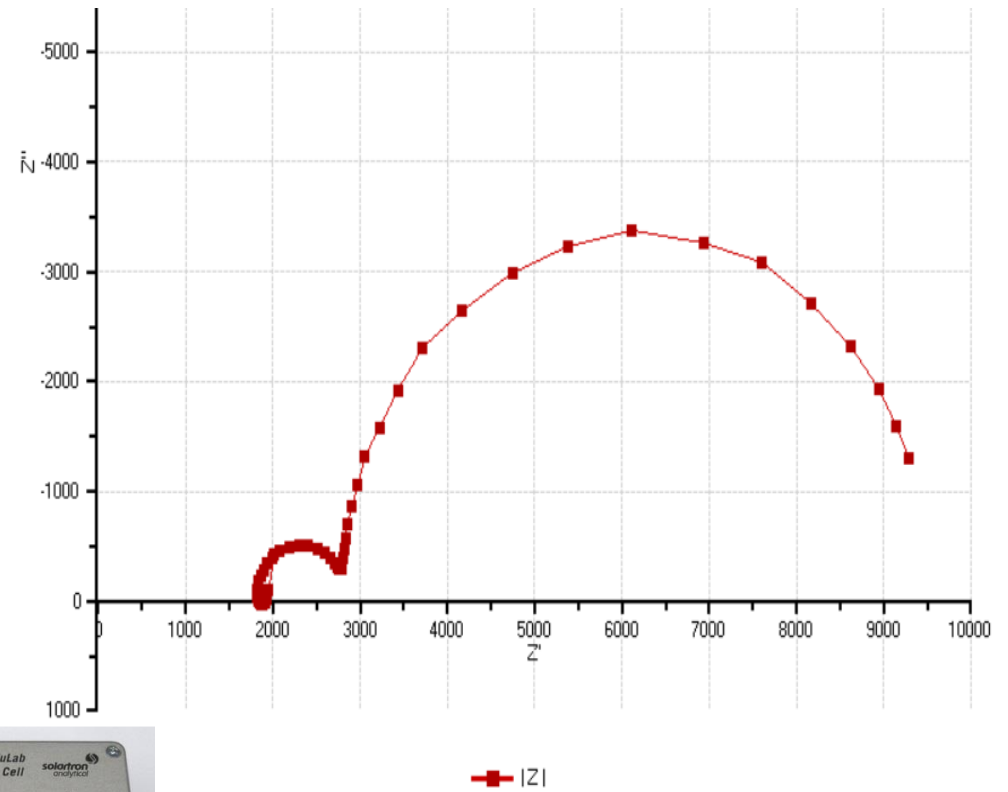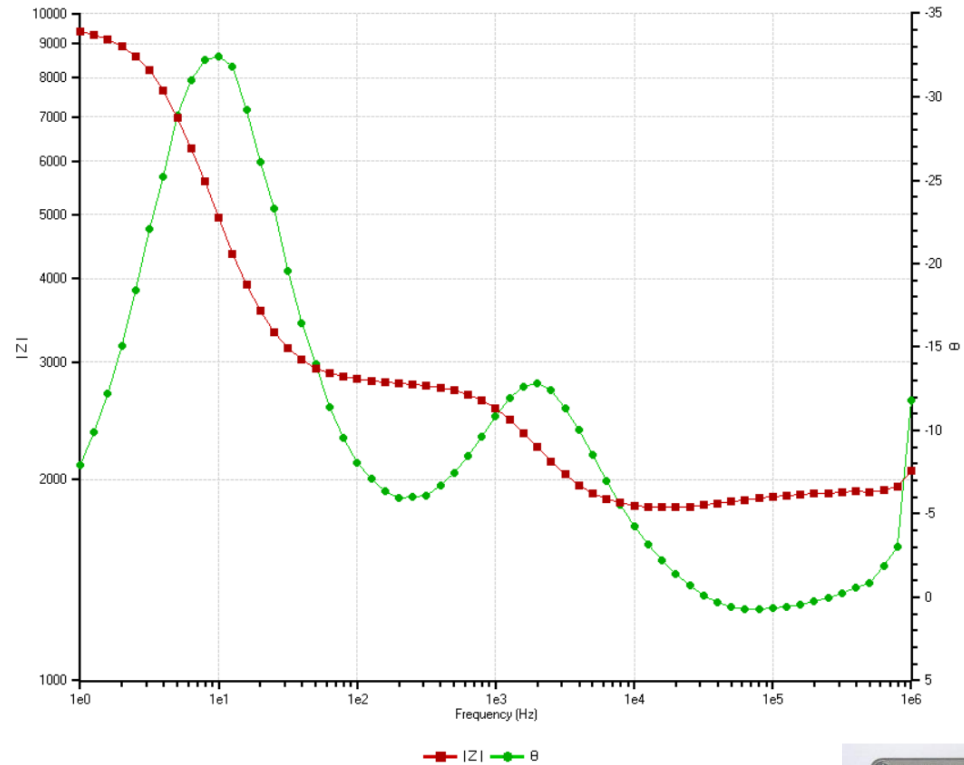Number of the Modules= 12
Voltage of each module=59.2 V

- **Qualification Testing.**

- **Avoid Impedance Mismatching.**

- **Performance Optimization.**

- **Configuration Optimization and Cell Sequence.**

https://electricsuperbiketwente.nl/

UNIVERSITY
OF TWENTE.

Electrochemical Impedance Spectroscopy (EIS)

UNIVERSITY
OF TWENTE.

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

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

UNIVERSITY
OF TWENTE.
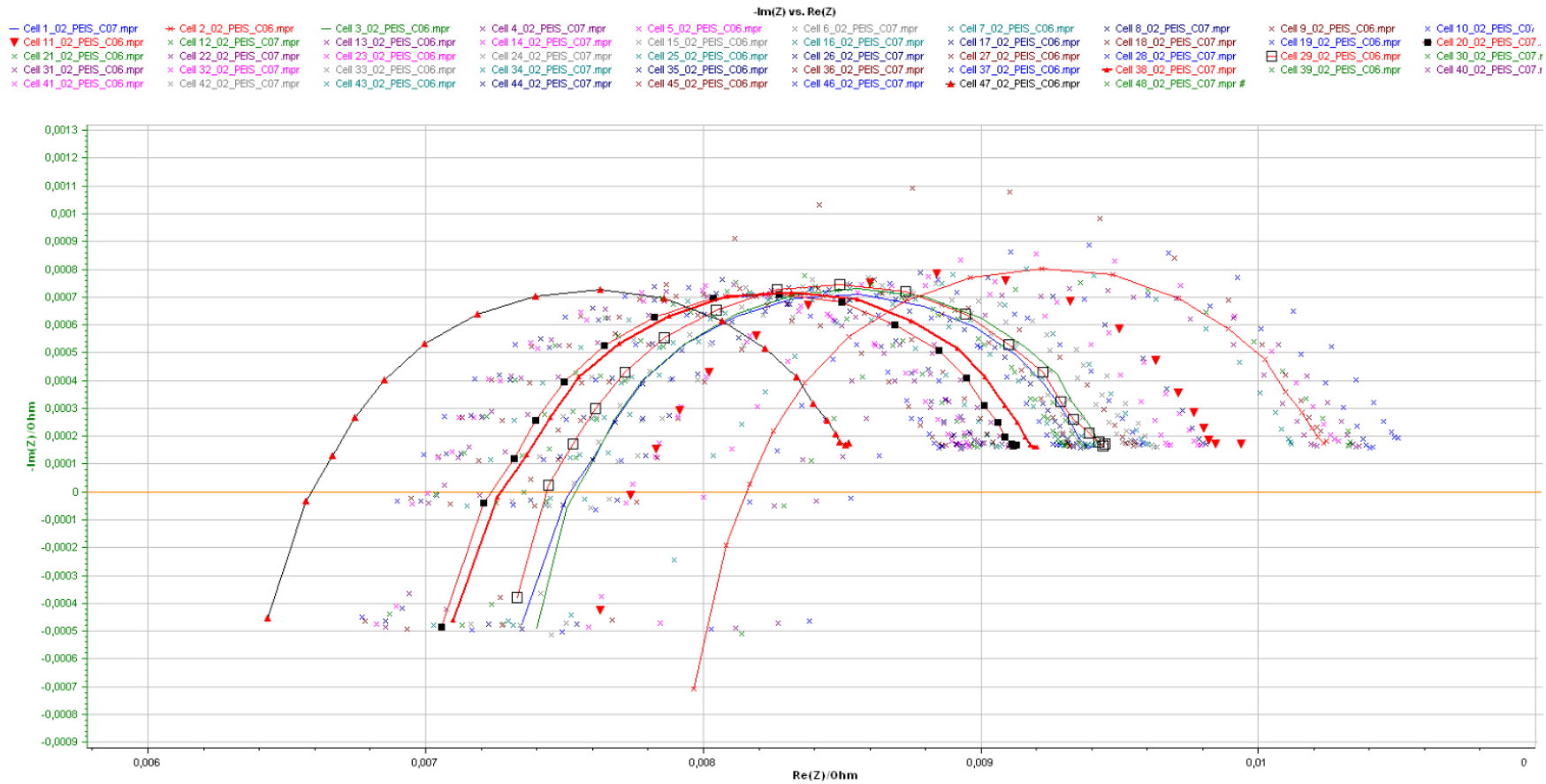
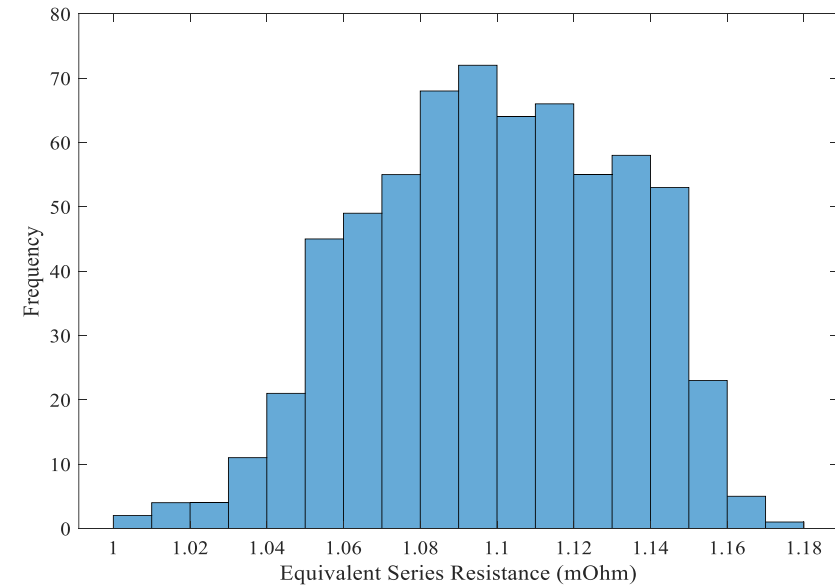## Cell categorization based on DC internal Resistance

- 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

Cell Selection Criteria for a High-Performance Fully-Electric Racing Motorcycle
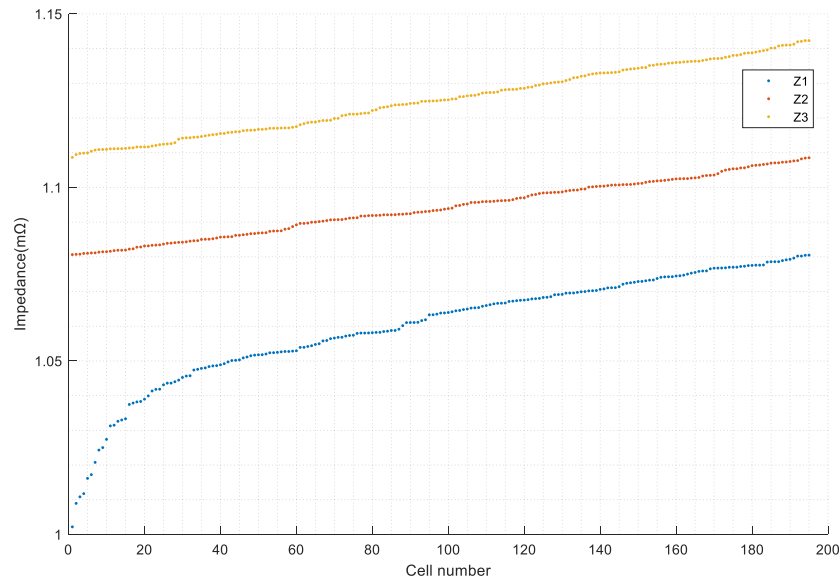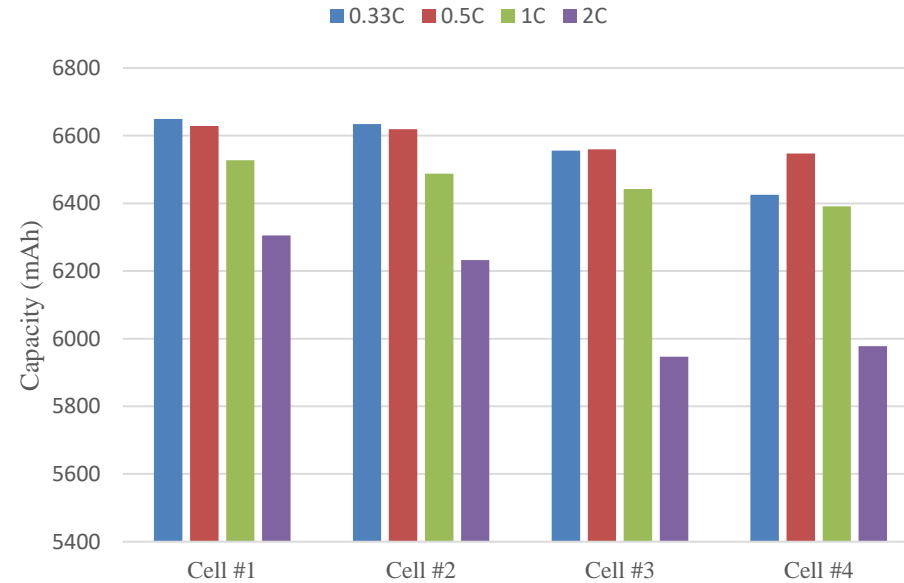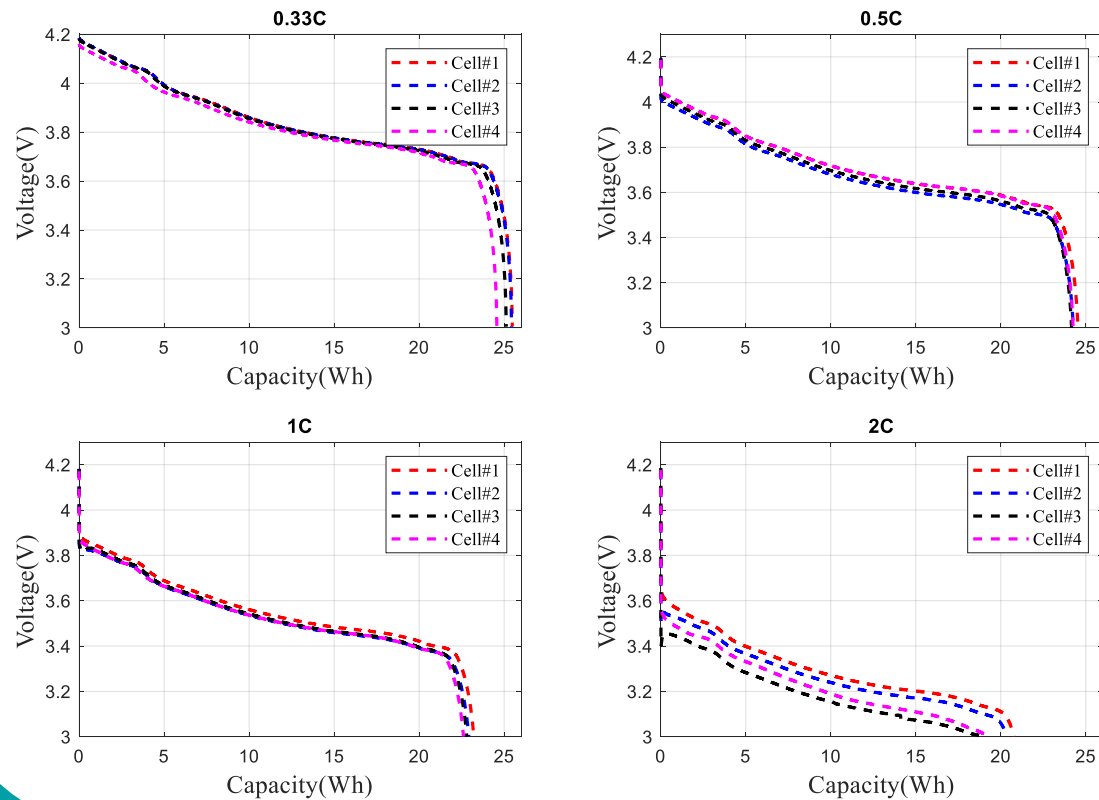
UNIVERSITY
OF TWENTE.

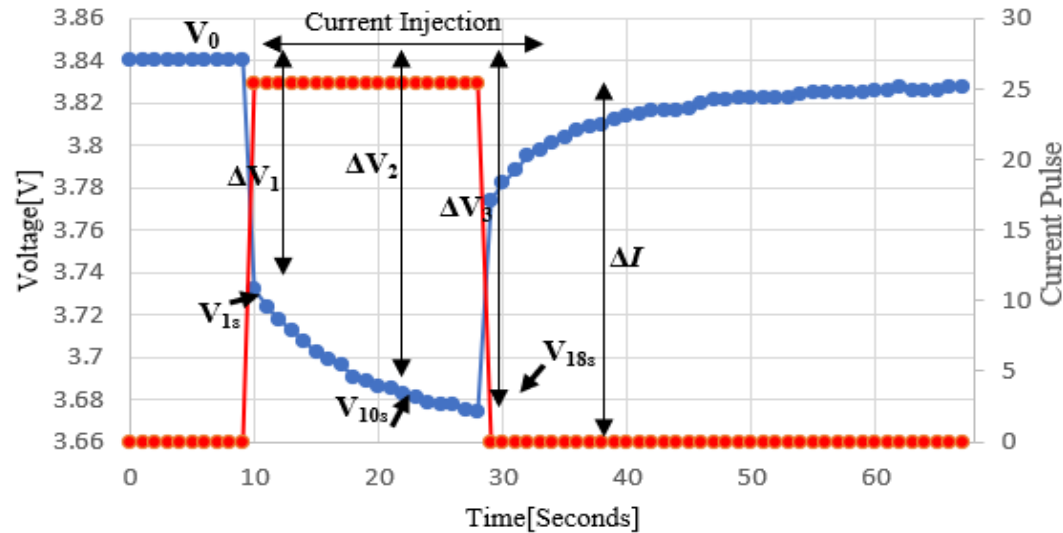## Capacity Test Results For Selected Cells From Each Group

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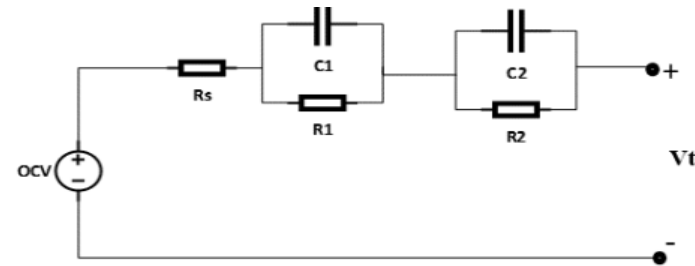- Capacity test at different Crate to verify the classification method

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

UNIVERSITY OF TWENTE.

Electrical Modelling of Cells

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

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

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

Current pulse approach method to model Li-Po cell

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

UNIVERSITY
OF TWENTE.

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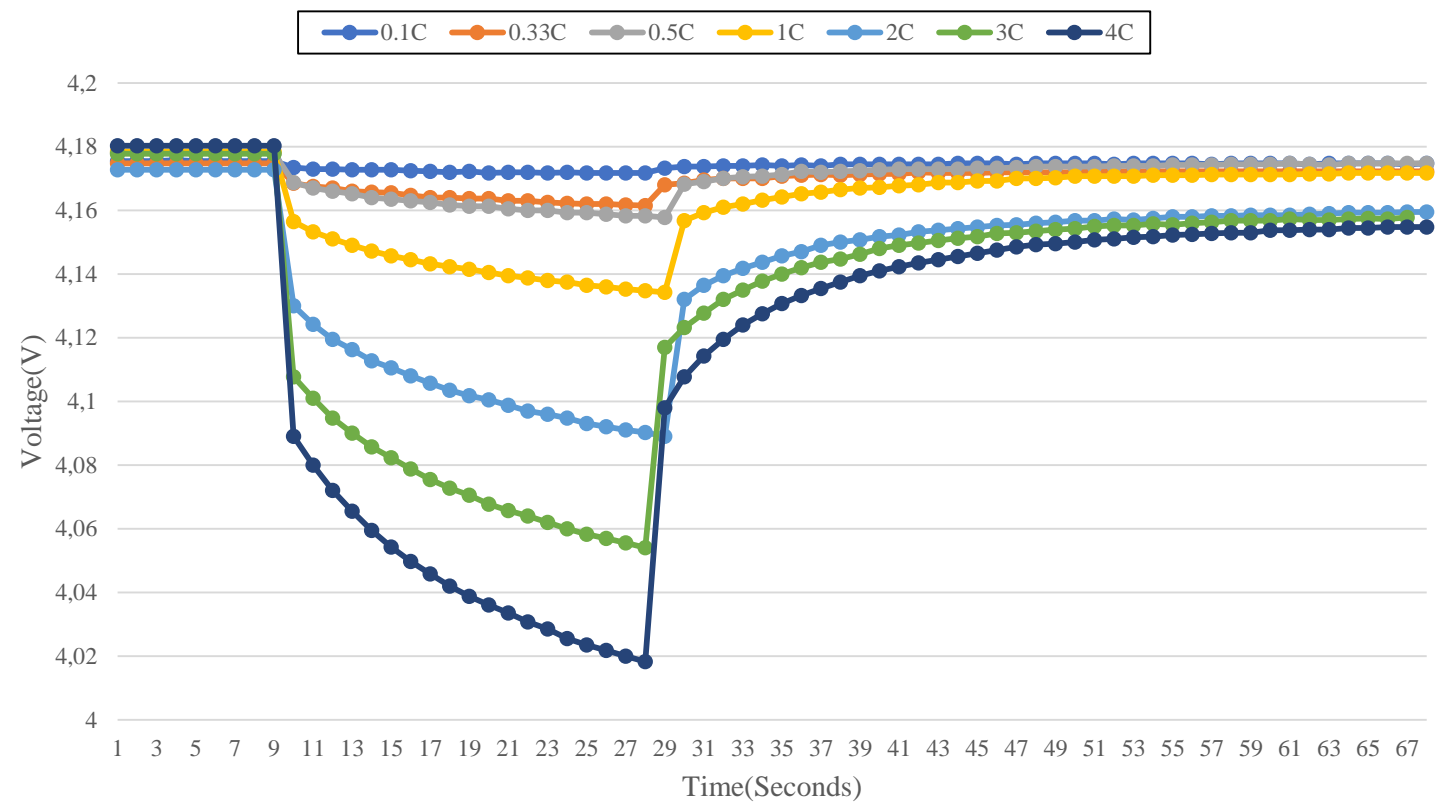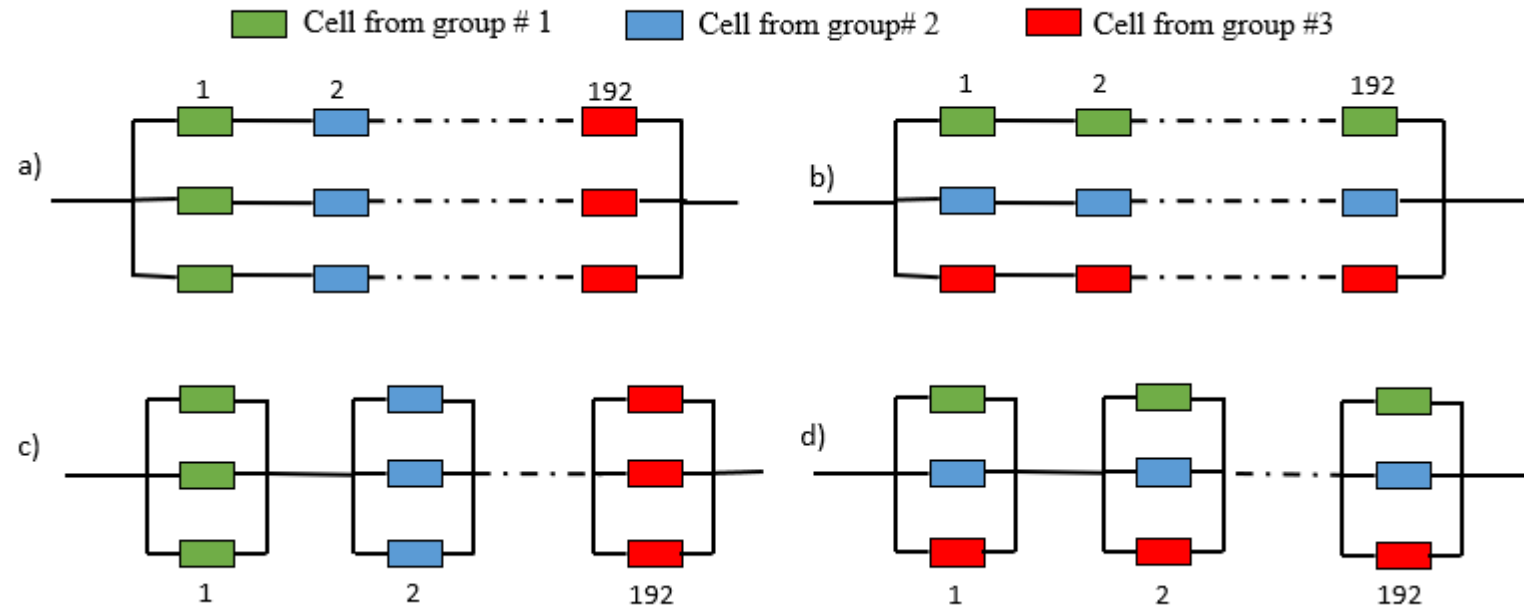
UNIVERSITY
OF TWENTE.

Battery Pack Design

UNIVERSITY
OF TWENTE.

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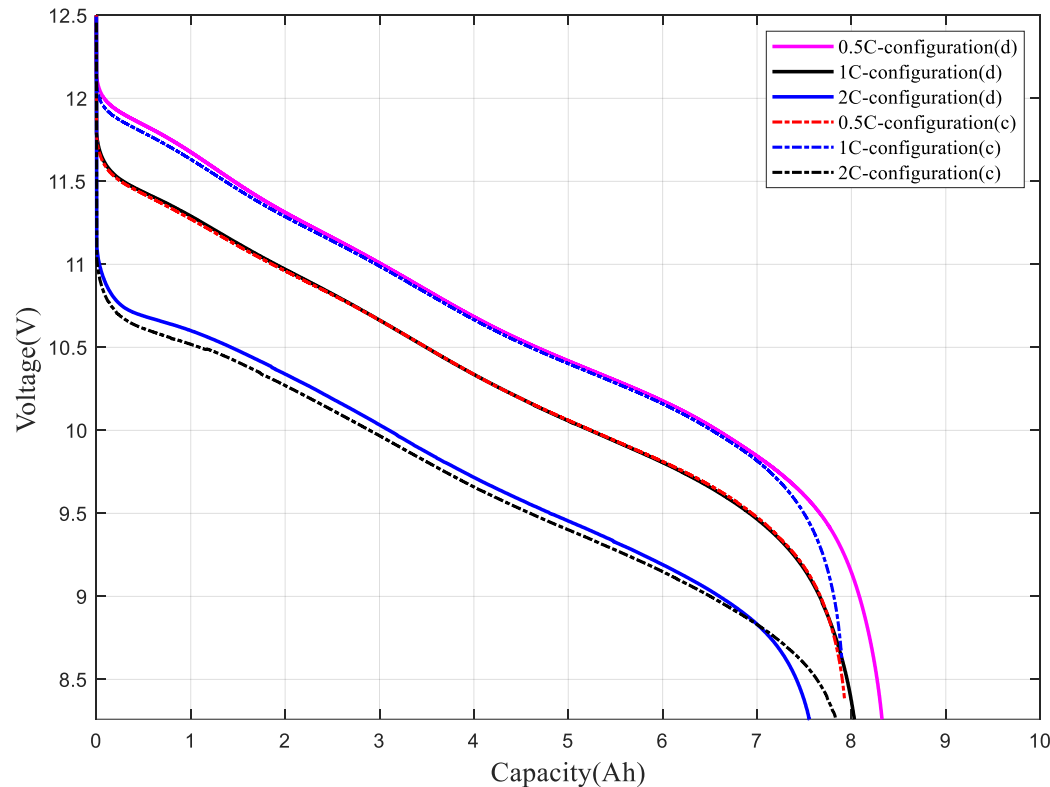
Discharge capacity for two mini battery packs with configuration (c) and (d) with 10% discrepancy between the capacity of the cells

- **Find optimal configuration based on cell sequence**

- **Configuration (d) has been selected to avoid impedance mismatching between the strings**

Cell Selection Criteria for a High-Performance Fully-Electric Racing Motorcycle
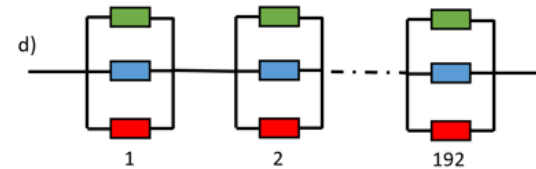
UNIVERSITY OF TWENTE.

Equivalent impedance of each string according to the (d) configuration
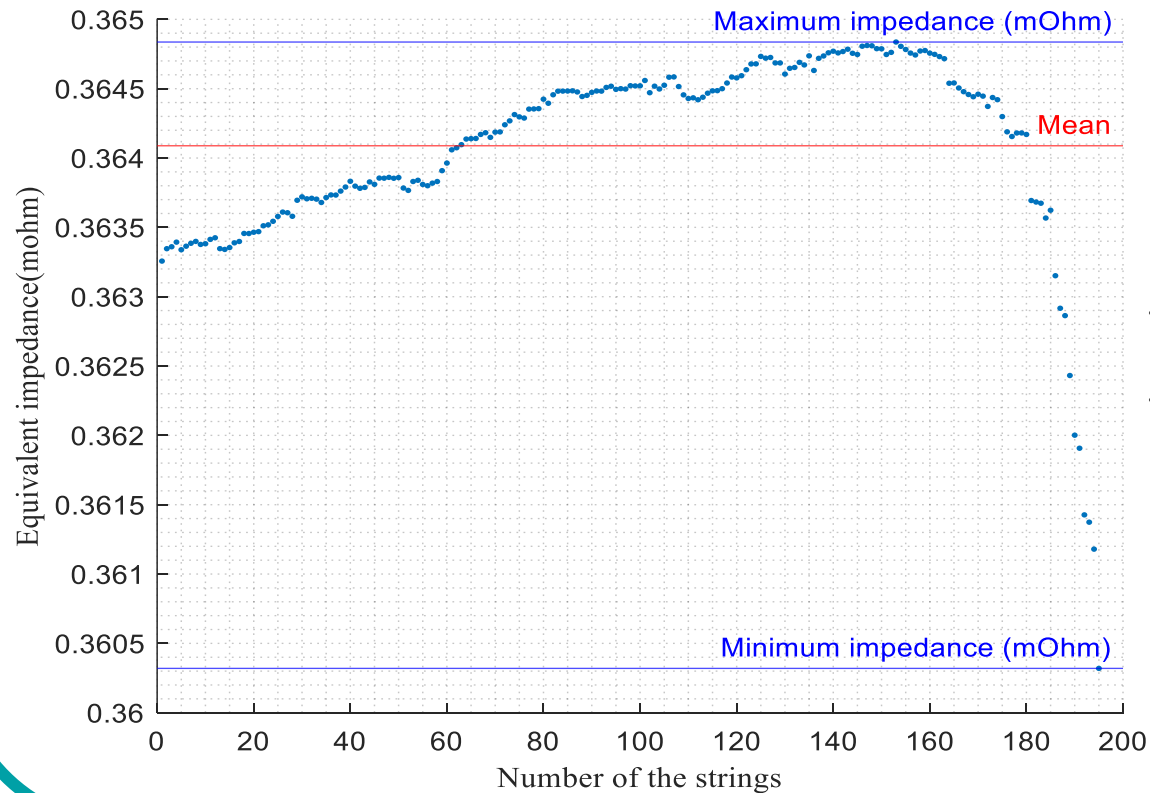
- **Standard deviation really close to zero**

- **best balance between the modules and in terms of impedance uniformity between the strings for the battery pack in configuration (d)**

UNIVERSITY
OF TWENTE.

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.**

UNIVERSITY OF TWENTE.

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

s.azizighalehsari@utwente.nl

Contact information:

✉ s.azizighalehsari@utwente.nl

in linkedin.com/in/reza-azizighalehsari-b0912b90/

🖥 https://www.utwente.nl/en/eemcs/pe/4.people-new/phd/azizighalehsari_s/

GET IN TOUCH!