



*EMR'22*  
*HES-SO Sion*  
*June 2022*



**EMR'22 Summer School**  
**“Energetic Macroscopic Representation”**

# «EMR for battery power testing in BEV»

**Dr. Ronan GERMAN, Florian Tournez , Prof. Alain BOUSCAYROL**  
University of Lille, France



- 1** Context and objective
- 2** EMR for vehicle simulation
- 3** EMR for power test organization
- 4** Conclusion

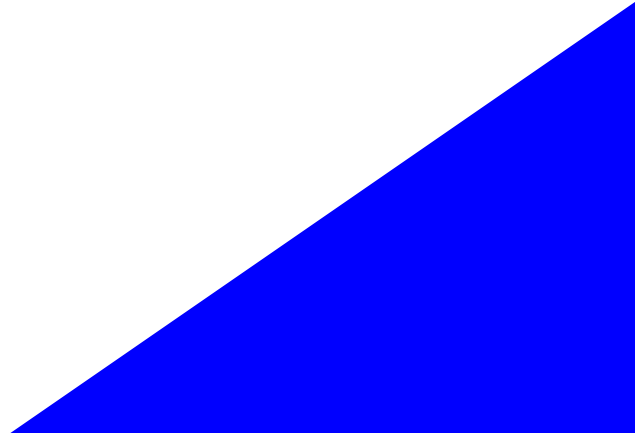


*EMR'22*  
*HES-SO Sion*  
*June 2022*



**EMR'22 Summer School**  
**“Energetic Macroscopic Representation”**

# « Context and objective »



# EMR for battery power testing in BEV

## Why testing the battery compatibility with a vehicle ?

EMR'22, Sion, June 2022

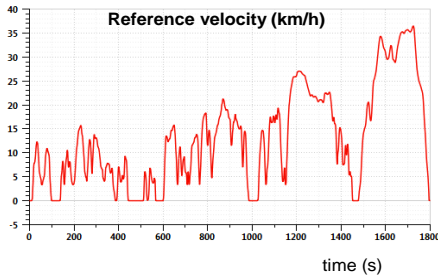
4



Operation limits have to be respected for batteries



For a driving cycle



For a studied vehicle

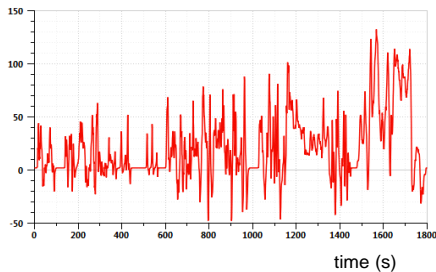


For a battery

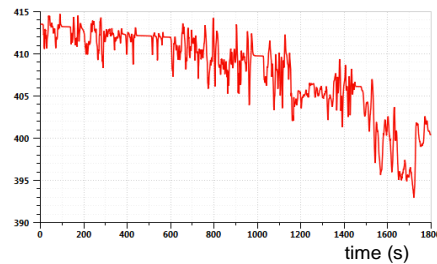


Follow the battery:

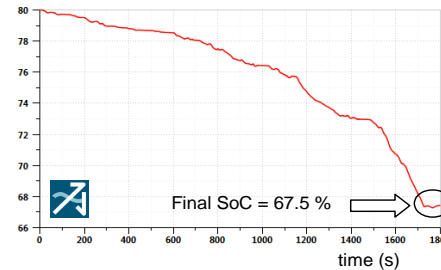
Current



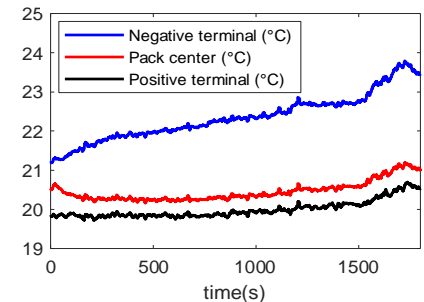
Voltage



SoC



Temperature



The battery HiL testing aims to validate this compatibility without building an EV prototype.

# EMR for battery power testing in BEV

## Example : testing a new battery for a BEV

EMR'22, Sion, June 2022

5

Original BEV (Renault Zoe)

Electrical traction  
power : 65 kW



Weight :  
1480 kg

Original battery : 41 kWh, 120 kW

Low power battery

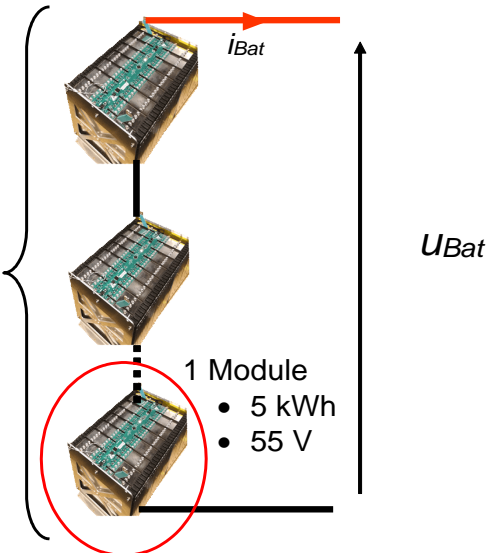
Losses  
(driving range)

Self heating (thermal  
management)

Higher power battery to be tested  
(35 kWh/ 525 kW)

7 modules

BLUWAYS



Battery operation limits

$$-480 < i_{Bat} < 2400 \text{ A}$$

$$300 < u_{Bat} < 440 \text{ V}$$

$$5 < T_{Bat} < 60 \text{ }^\circ\text{C}$$



We want to validate the compatibility of the new battery without thermal management system

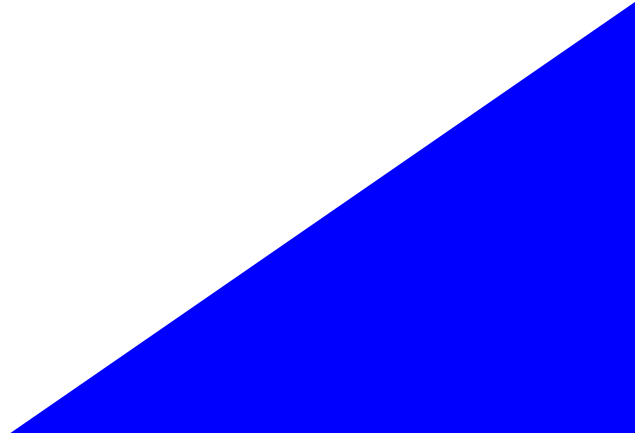


*EMR'22*  
*HES-SO Sion*  
*June 2022*



**EMR'22 Summer School**  
**“Energetic Macroscopic Representation”**

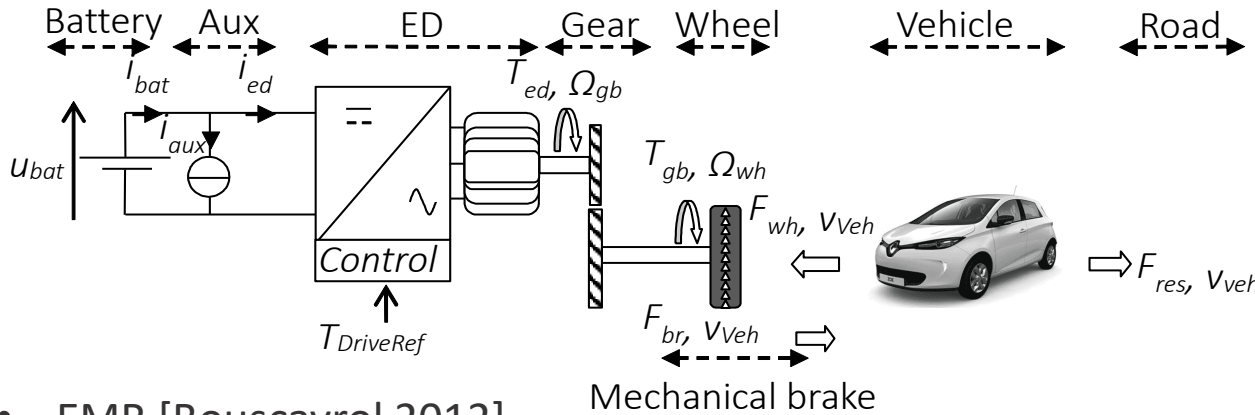
# « EMR for vehicle simulation »



# EMR for battery power testing in BEV

## - EMR for the simulation of the vehicle -

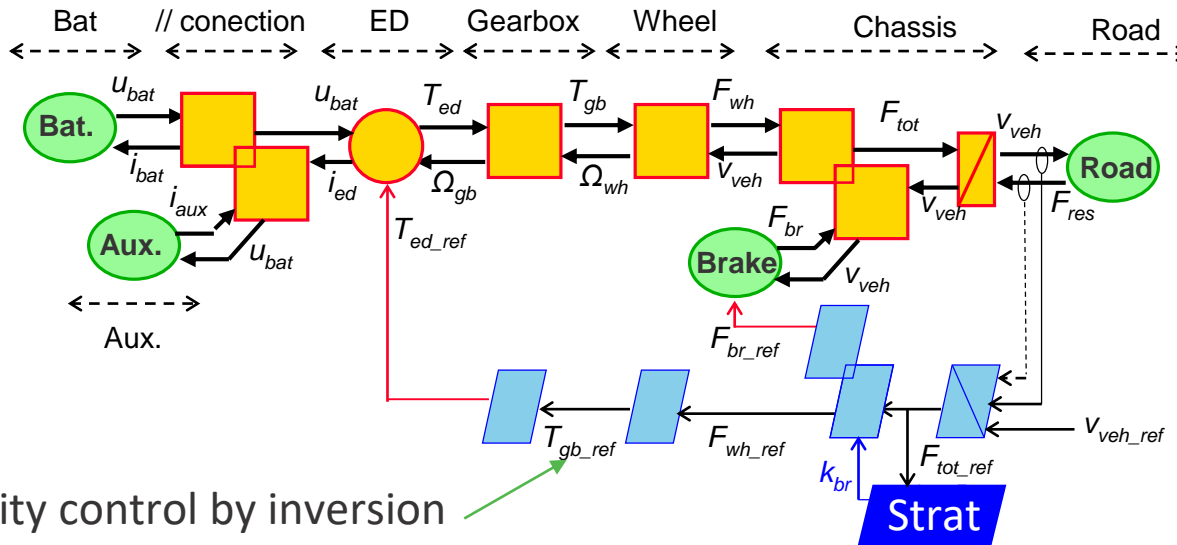
- Structural scheme



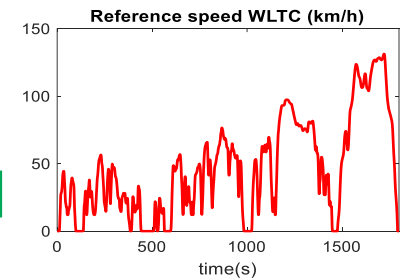
- Electric Drive (ED)

Electric machine + PE  
+ Torque Control

- EMR [Bouscayrol 2012]



Velocity cycle is the simulation input

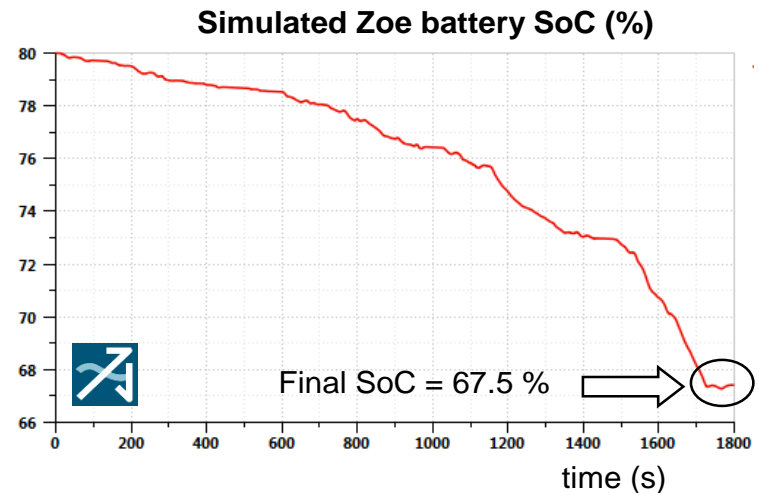
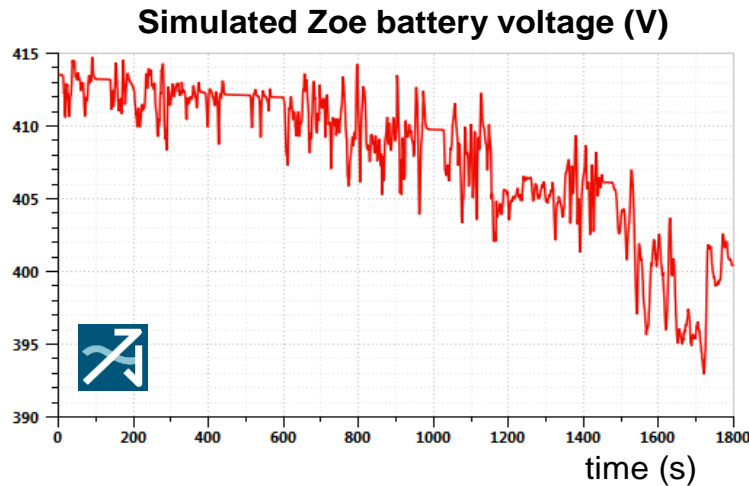
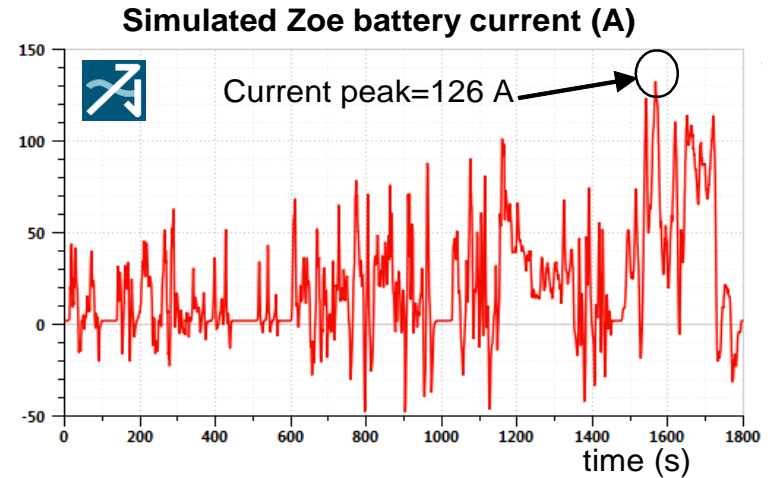
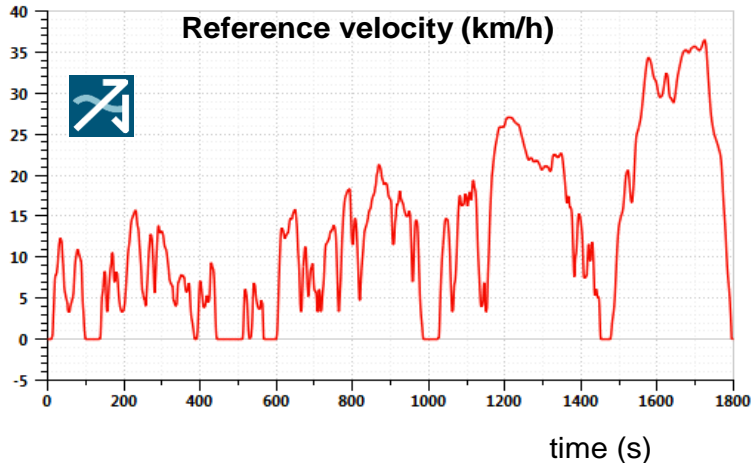


Velocity control by inversion

# EMR for battery power testing in BEV

## - Simulation results [German 2021]-

EMR'22, Sion, June 2022



- Electrical limits are not crossed

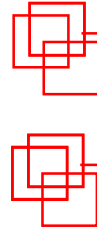
- Estimated autonomy is 184 km

➡ The real battery testing has to be achieved to record self-heating





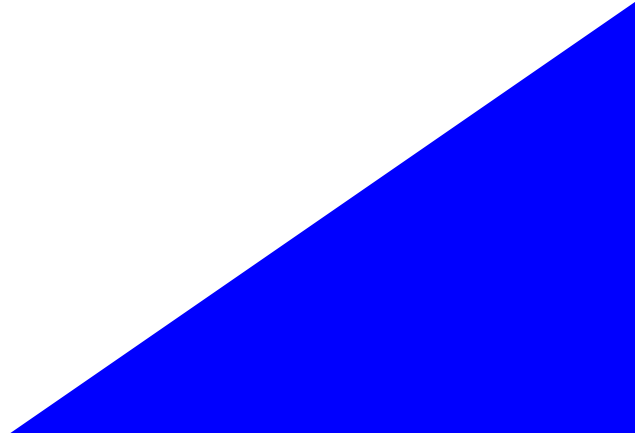
*EMR'22*  
*HES-SO Sion*  
*June 2022*



EMR'22 Summer School  
"Energetic Macroscopic Representation"



# «EMR for power test organization»



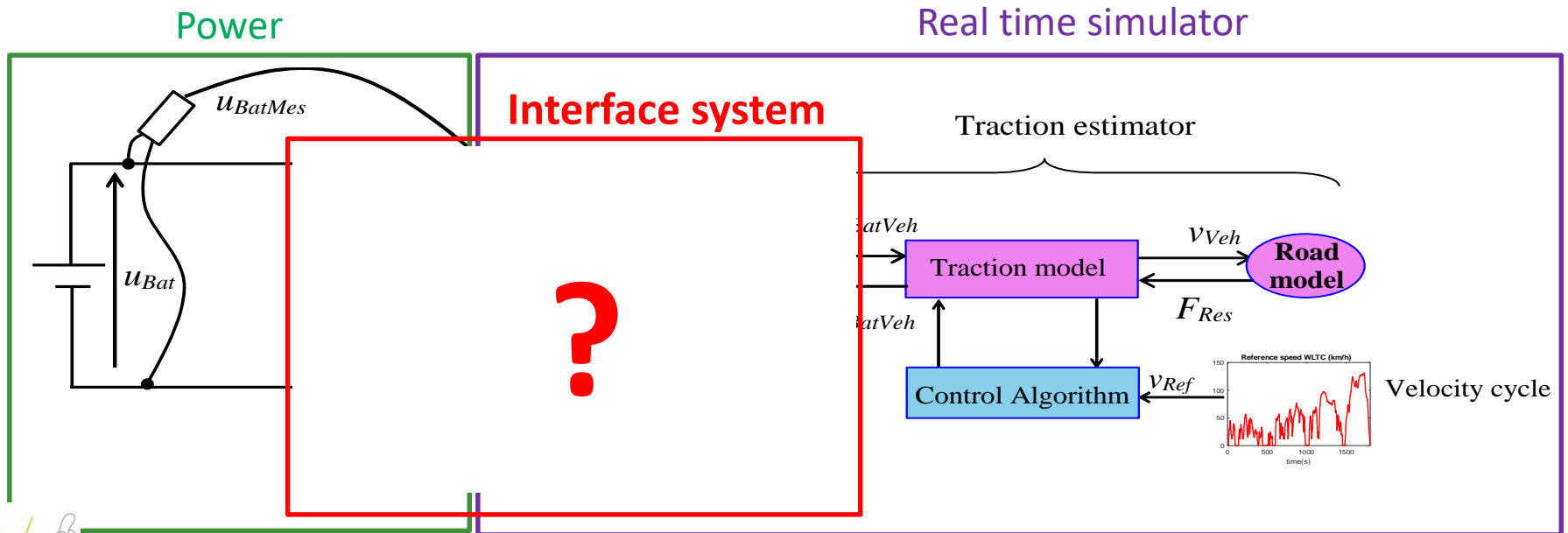
# EMR for battery power testing in BEV

## - Using EMR for power interface choosing-

EMR'22, Sion, June 2022

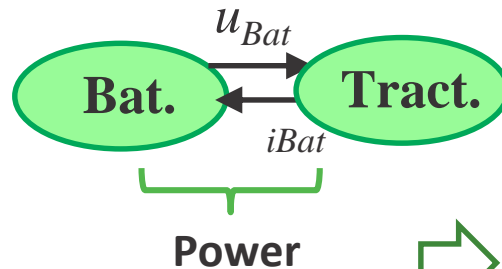
10

- Battery is the real subsystem to test



EMR answers the question with equivalent sources :

Battery is a voltage source



Traction is an equivalent current source

Power interface is a current source

# EMR for battery power testing in BEV

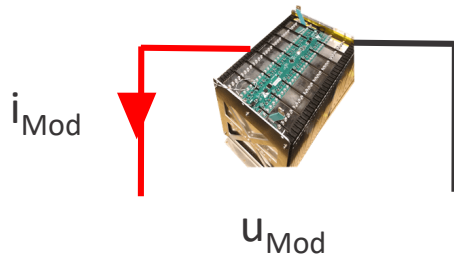
- Using EMR for power adaptation -

EMR'22, Sion, June 2022

11

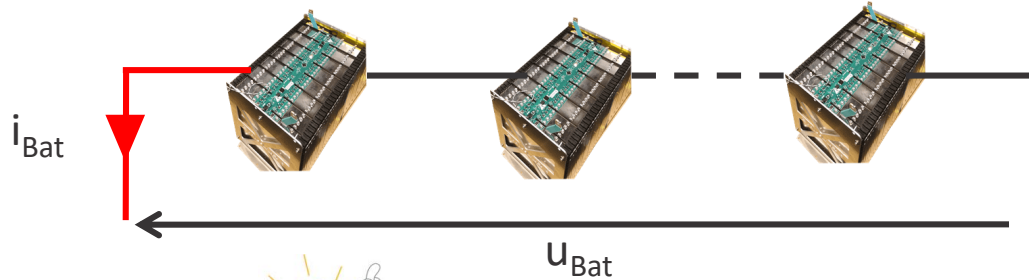
Tested part

1 module 



Studied new Zoe battery

7 modules in series



Link test results with simulation?



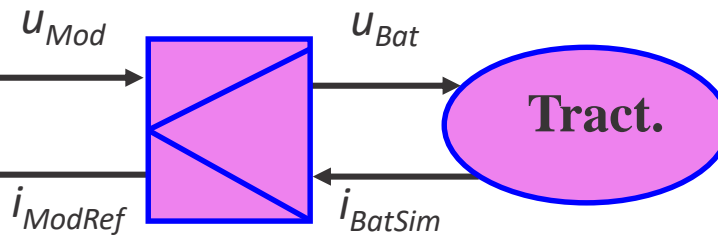
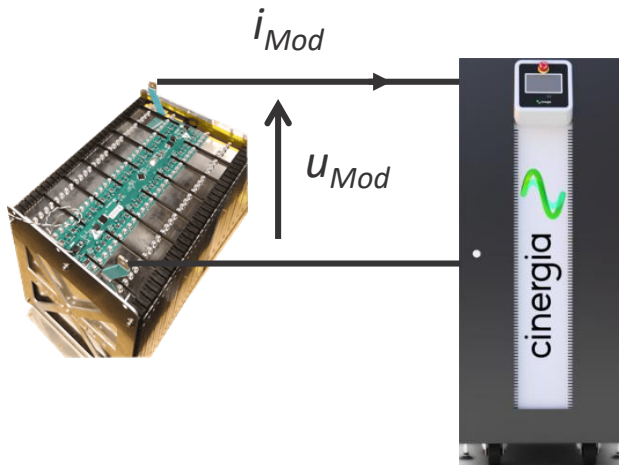
EMR uses power adaptation pictograms

Tested module

Current source

Power

Real-time simulation



Simulation is used as an estimator (purple)

$$\begin{cases} u_{Mod} \cdot 7 = u_{Bat} \\ i_{ModRef} = i_{BatSim} \end{cases}$$

Inputs / outputs are fixed by EMR

# EMR for battery power testing in BEV

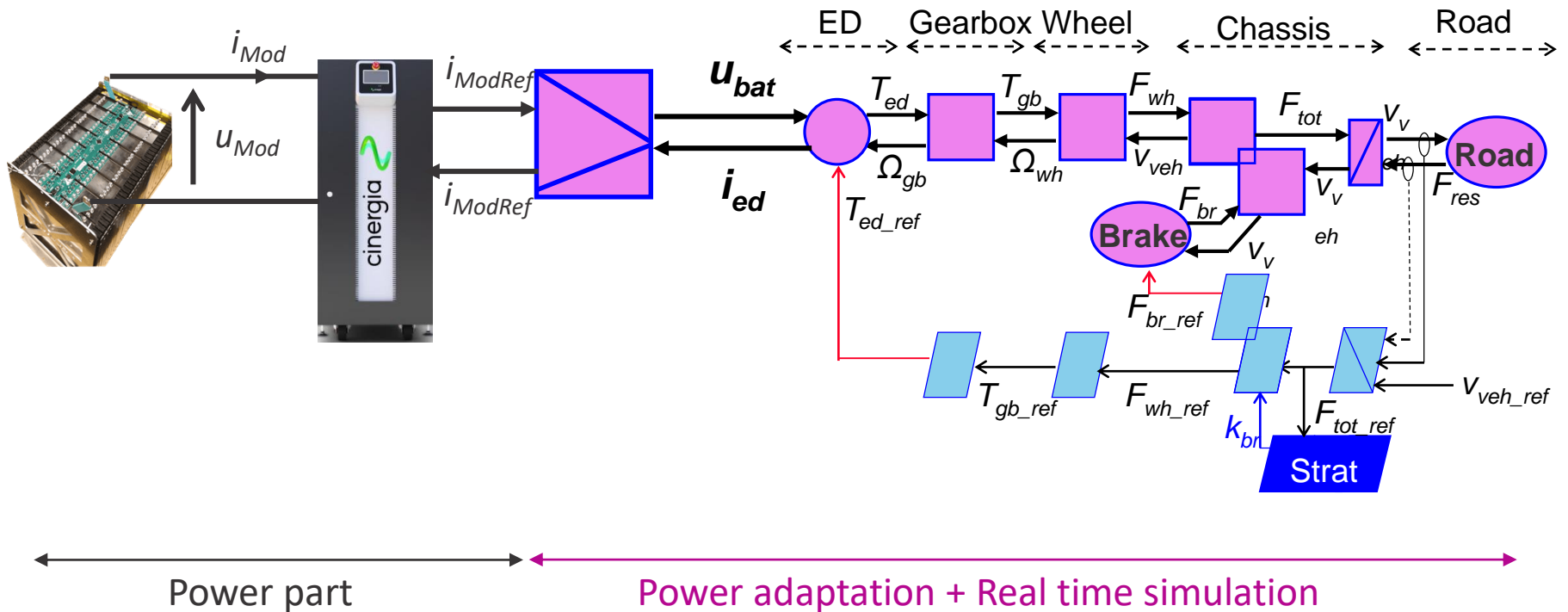
## - Power test configuration using EMR-

EMR'22, Sion, June 2022

12

Test output is a voltage      Traction simulation output is a current

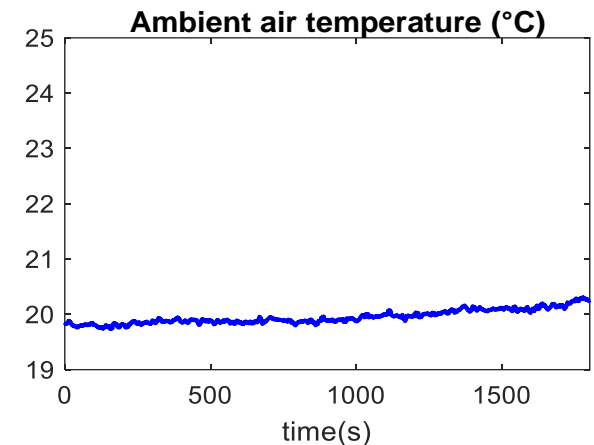
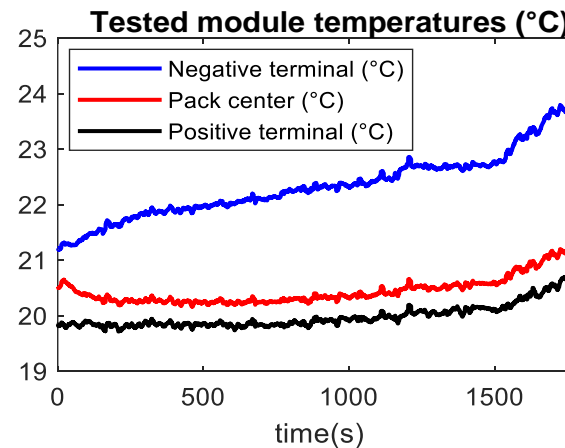
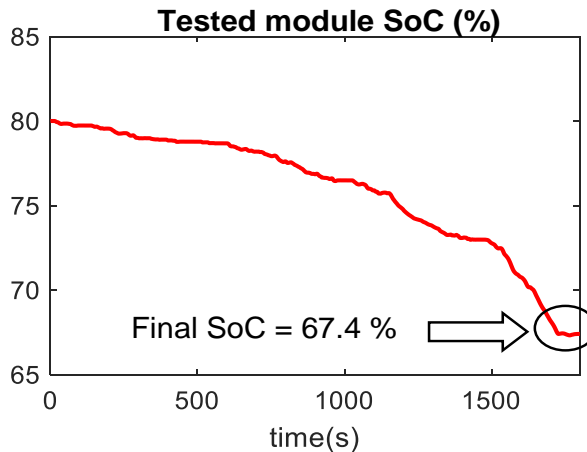
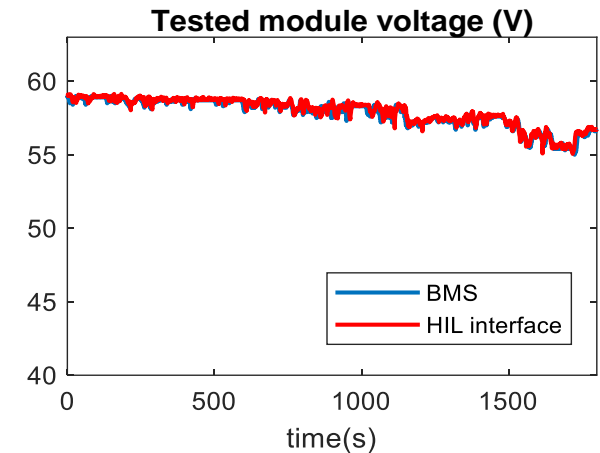
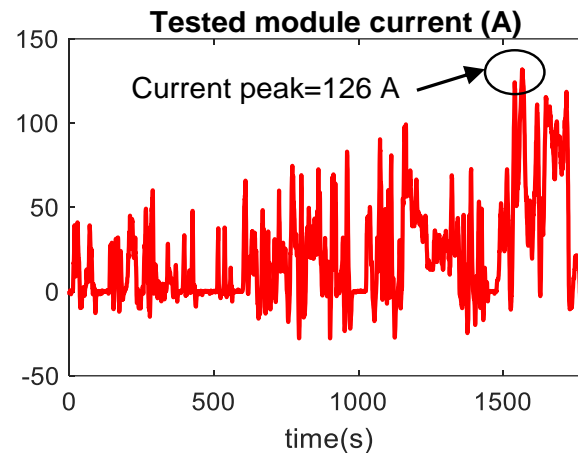
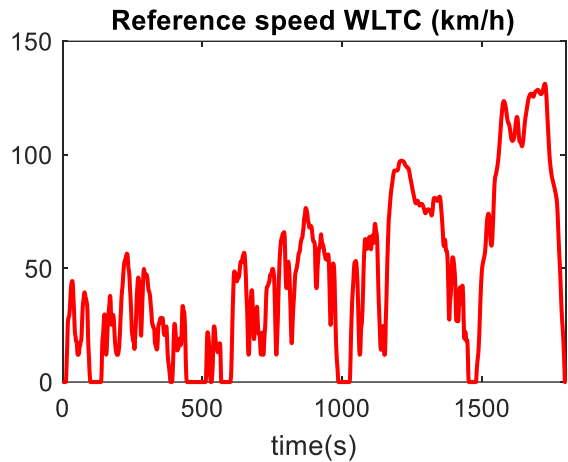
Easy interconnection



# EMR for battery power testing in BEV

## - Battery power test results [German 2021]-

All the results presented here are experimental



- Electrical limits are not crossed
- Thermal limits are not crossed

➡ The new battery is compatible with the studied EV under the test conditions

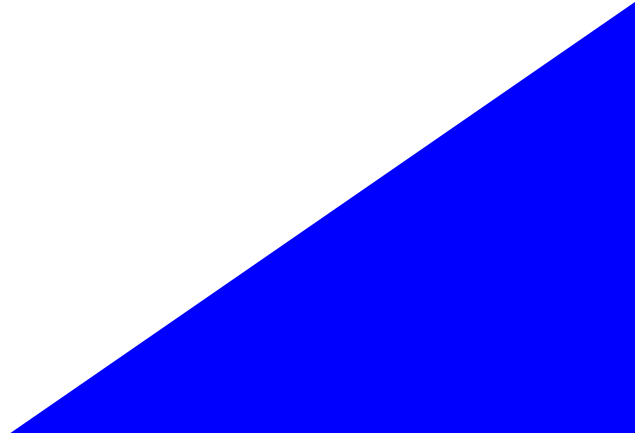


*EMR'22*  
*HES-SO Sion*  
*June 2022*



**EMR'22 Summer School**  
**“Energetic Macroscopic Representation”**

# « Conclusion »

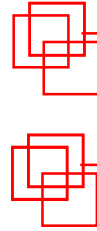


## - Conclusion -

- EMR is used to organize the simulation
- EMR defines clearly the inputs and the outputs of the different sub-systems
- The power interface to be used is defined by the EMR
- Power adaptation issues are taken into account in EMR



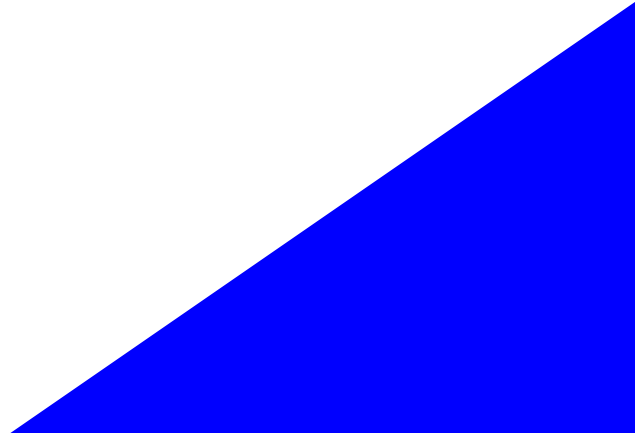
*EMR'22*  
*HES-SO Sion*  
*June 2022*



EMR'22 Summer School  
"Energetic Macroscopic Representation"



# « BIOGRAPHIES AND REFERENCES »





# EMR for battery power testing in BEV

- Authors -

EMR'22, Sion, June 2022

17



[Ronan.german@univ-lille.fr](mailto:Ronan.german@univ-lille.fr)

**Dr. R. GERMAN**

Associate professor, University of Lille, L2EP, France

PhD in Electrical Engineering at University of Lyon (2013)

Research topics: Energy Storage, EMR formalism, HIL battery tests



[Florian.tournez@univ-lille.fr](mailto:Florian.tournez@univ-lille.fr)

**F. Tournez**

PhD student, Research engineer at the L2EP EV platform

University of Lille, L2EP, France

Research topics: Real time control, EMR formalism, HIL tests for BEVs and P-HEVs



[Alain.Bouscayrol@univ-lille.fr](mailto:Alain.Bouscayrol@univ-lille.fr)

**Prof. Alain BOUSCAYROL**, University of Lille, L2EP,  
Head of the Master “Automatic control & Electrical Systems”

Coordinator of the CUMIN interdisciplinary programme

Coordinator of the PANDA European project

Chair of the steering committee of IEEE-VPP Conference of IEEE-VTS

PhD in Electrical Engineering at University of Toulouse (1995)

Research topics: EMR formalism, HIL testing, control & EV-HEVs



- [Bouscayrol 2012] A. Bouscayrol, J. P. Hautier, B. Lemaire-Semail, "Graphic Formalisms for the Control of Multi-Physical Energetic Systems", Systemic Design Methodologies for Electrical Energy, tome 1, Analysis, Synthesis and Management, Chapter 3, ISTE Willey editions, October 2012, ISBN: 9781848213883
- [German 2021] R. German, F. Tournez, A. Desreveaux, A. Bouscayrol, C. Husar, M. Ciocan, A. Genic, D. Zuber, "Full Power Constraints HiL Setup for Battery Module Testing in Electric Vehicles," *2021 IEEE Vehicle Power and Propulsion Conference (VPPC)*, 2021, pp. 1-6, doi: 10.1109/VPPC53923.2021.9699218.