EMR'23, Lille (France)

http://emrwebsite.org

"Multi-mode EV simulation using EMR"

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- Outline -

1. Context and objective
2. EMR of a battery electro-thermal model
3. EMR of an EV traction system
4. EMR of a charging system
5. Organizing different EV modes with EMR

“Context and objective”

- Important definitions-

- Cell : Battery elementary component

- State of charge SoC (%)

  SoC = 0% ➡ Battery totally discharged

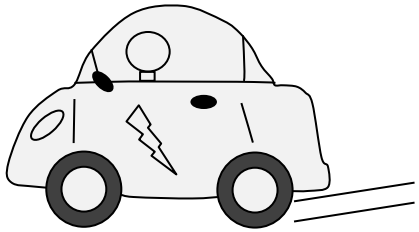
  SoC = 100% ➡ Battery fully charged

- Battery energy (kW.h) ➡ 1 kW.h =3.6 MJ

	Plug in Hybrid electric vehicle (PHEV)	Electric vehicles (EVs)	
			
	Golf GTE : 8 kW.h	Tazzari Zero: 14.5 kW.h	Renault Zoe: 41 kW.h
e-autonomy	50 km	120 km	400 km

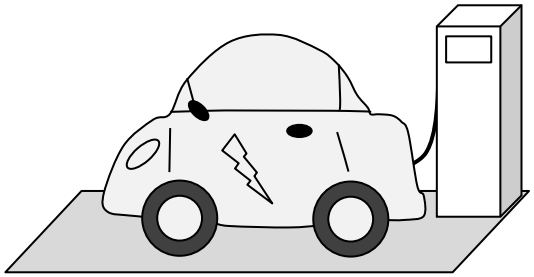
➡ 1 kWh<10 km

Any EV is used in different modes



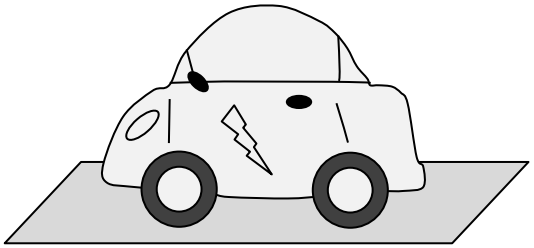
Driving

SoC variation + Self Heating
+ Mechanical power



Charging

SoC variation + Self Heating
+ Charger power



Parking

SoC Constant + influence of T_{Amb}

Objective: put all the domains and modes within a unique representation

EMR is used as a tool :

- to couple different domains
- to switch between modes

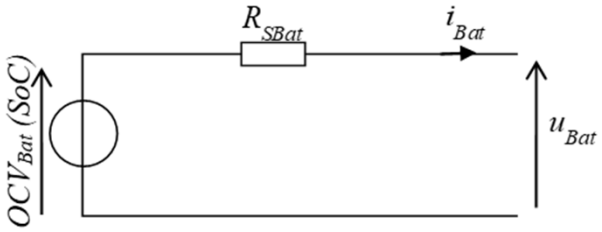
“EMR of a battery electro-thermal model”

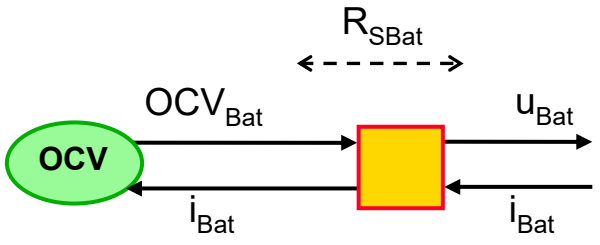
Battery model is composed by electrical and thermal parts

Structural representation

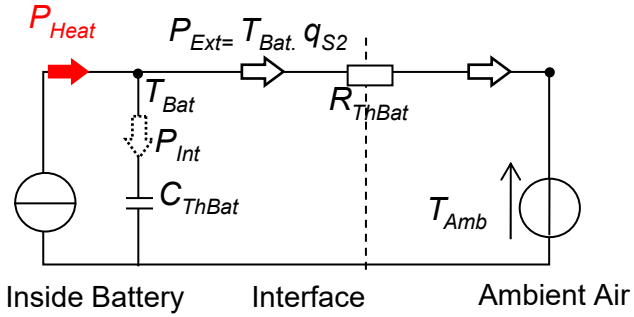
EMR

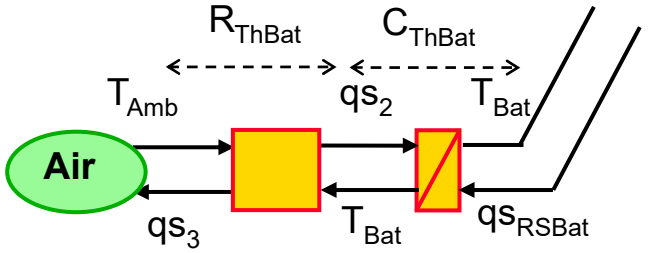
Electrical part of the battery





Thermal part of the battery



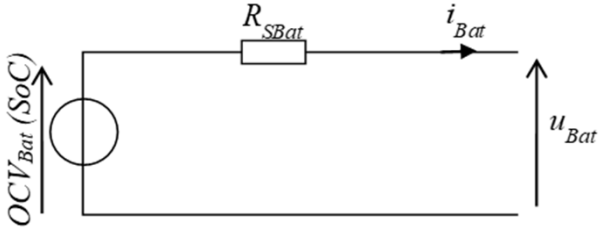


?

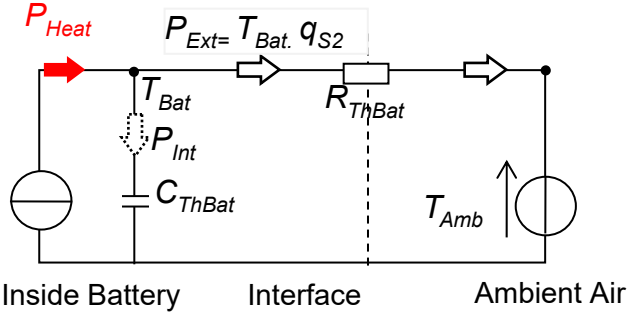
$$P_{Heat} = R_{sBat} i_{Bat}^{2}$$

EMR solution to couple electrical and thermal parts

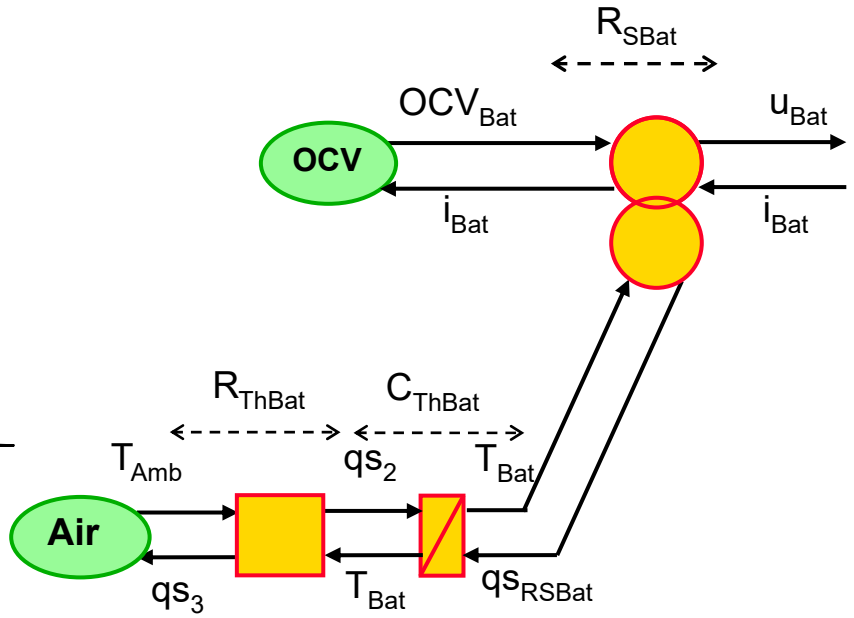
Electrical part of the battery



Thermal part of the battery



$$P_{Heat} = R_{sBat} i_{Bat}^2$$



R_{SBat} is in the thermal part and the electrical part

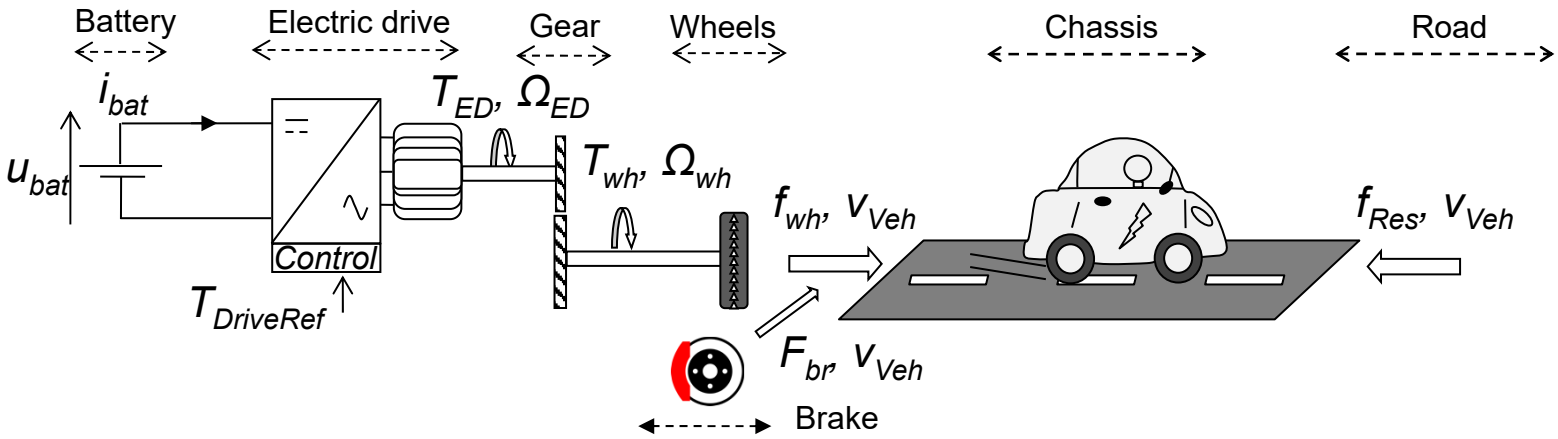
➡ Solution in EMR : Multi-physical coupling element

“EMR of an EV traction system”

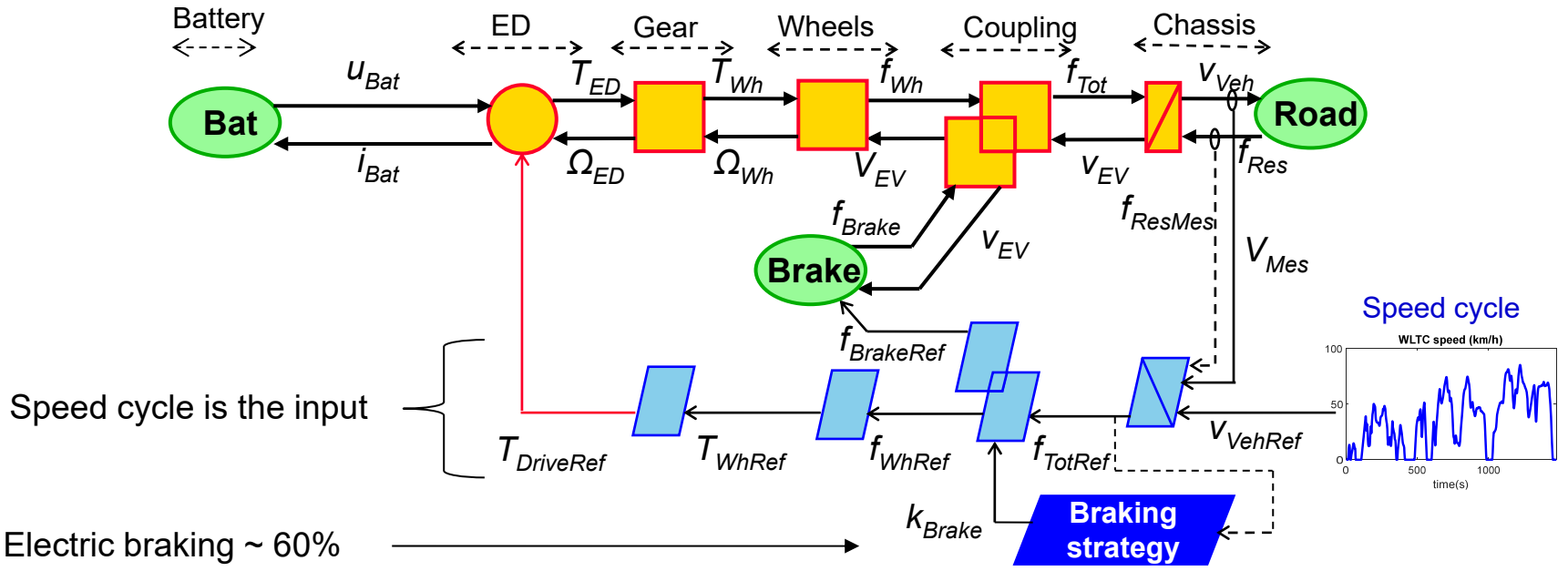
Multi-mode EV simulation using EMR

- EMR and MSC of the traction-

Structural representation



EMR and MSC

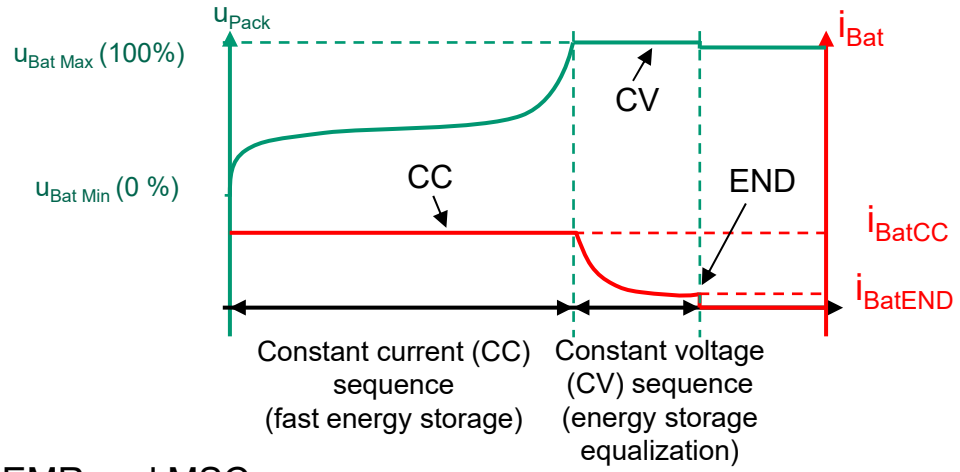


« EMR of a charging system»

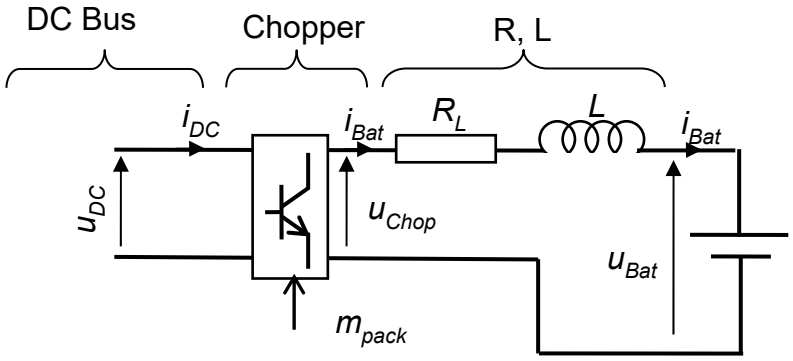
Multi-mode EV simulation using EMR

- EMR of a charging system-

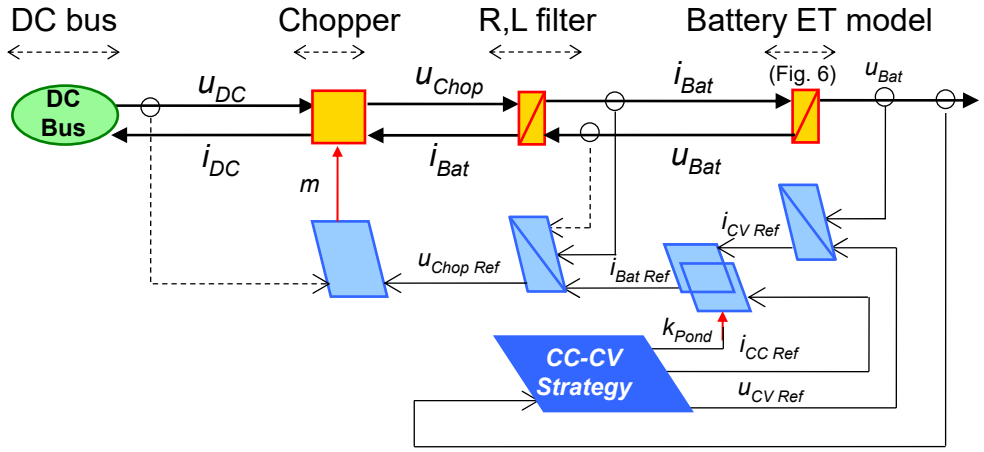
2 Phases for battery pack charge (CC-CV method)



Structural representation



EMR and MSC



EMR ad control of the charger

CC : Control of the current

$i_{Bat\ Ref} = I_{CC}$

CV : Control of the voltage

$u_{Bat\ CV\ Ref} = u_{CV}$

Coupling of the two controls

$$i_{Bat\ Ref} = k_{Pond}.\ i_{Bat\ CC\ Ref} + (1-k_{Pond}).\ I_{Bat\ CV\ Ref}$$

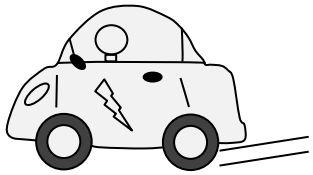
CC : $k_{Pond} = 1$ CV : $k_{Pond} = 0$

“Organizing different EV modes with EMR”

Multi-mode EV simulation using EMR

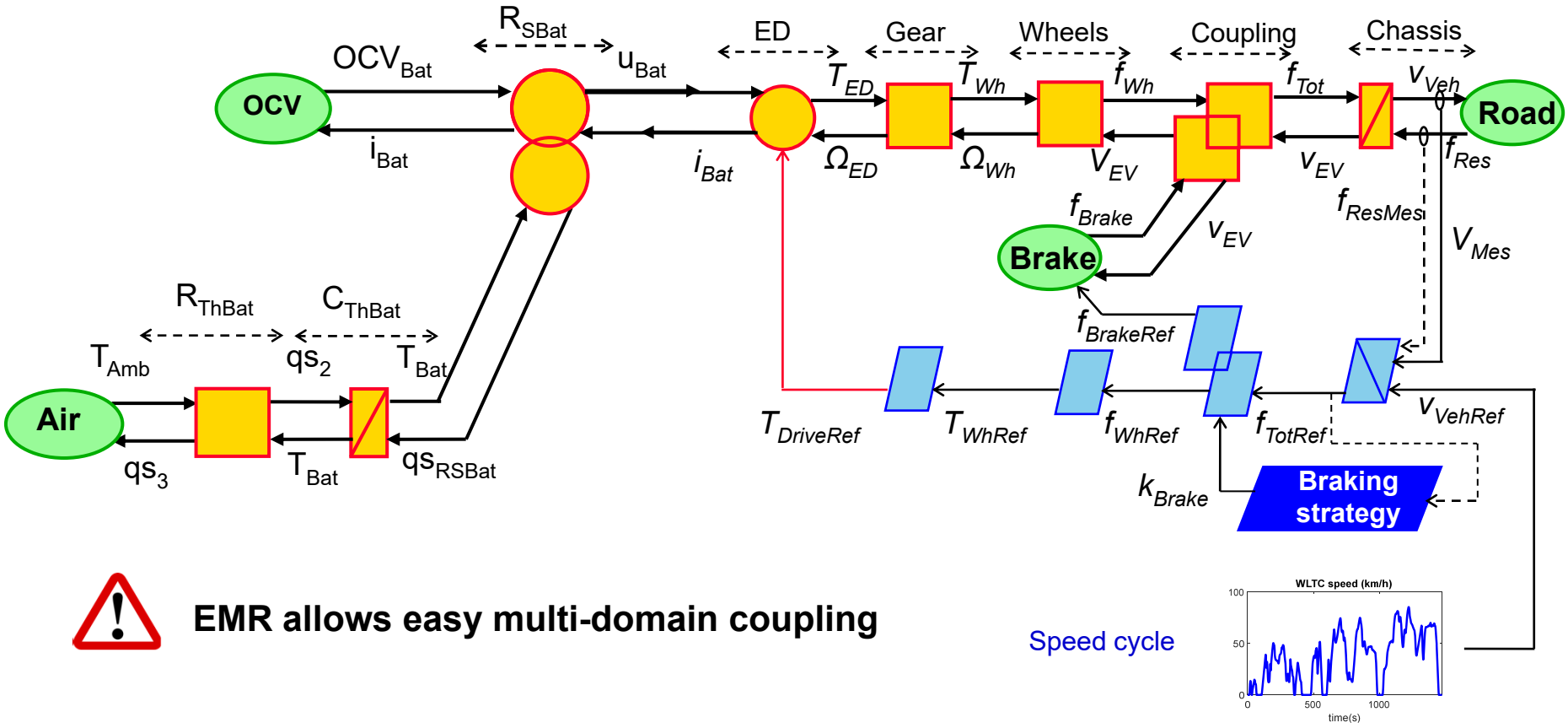
- EMR when driving-

Battery ET model



Driving

Traction electro-mechanical model

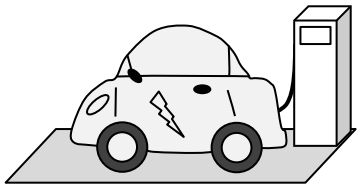


EMR allows easy multi-domain coupling

Speed cycle

Multi-mode EV simulation using EMR

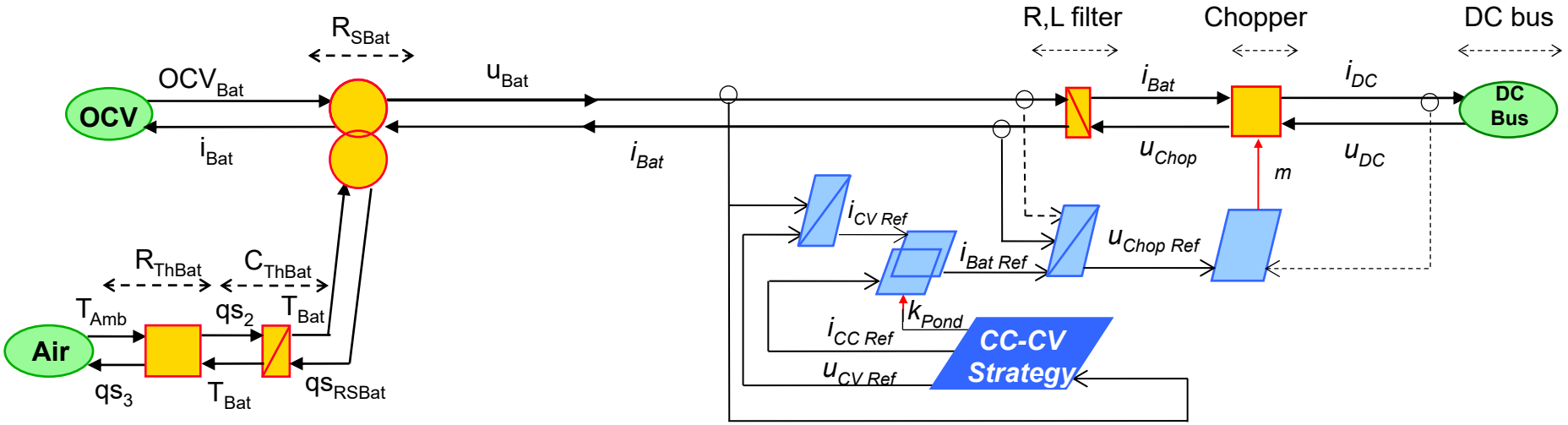
- EMR when charging / parking-

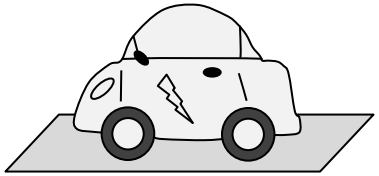


Charging

Battery ET model

Charger model



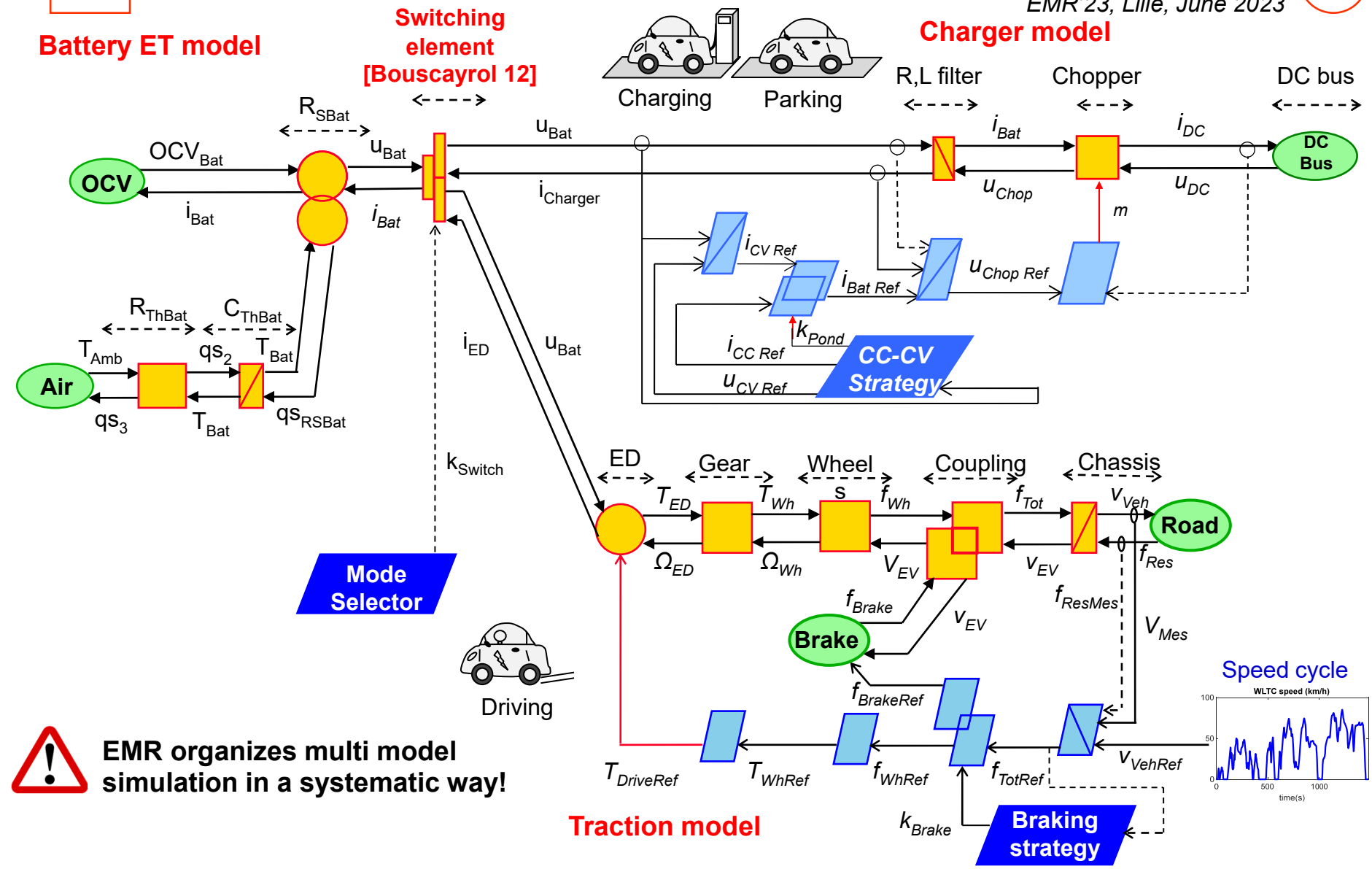


Parking

Parking simulation achieved with input current set to 0 A

Multi-mode EV simulation using EMR

- EMR for all EV modes-



“Conclusion”

-Conclusion-

The EMR formalism is used for multi-physical modelling [German 2020]

The EMR formalism is used for organizing multi-mode EV modelling

Coupling elements are important to couple different domains

Switching elements are important to organize multi-modes simulations

Strategy elements are used to manage the modes and energy flows

Estimator elements can be added to complement the models (example : ageing law [Ndiaye 21])

« BIOGRAPHIES AND REFERENCES »

Multi-mode EV simulation using EMR

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