**Powerful Advanced N-level Digital Architecture for electrified vehicles and components**

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**www.project-panda.eu**
W-model & digitalization

- Virtual subsystem
- Virtual prototype
- Prototype testing
- Real testing

Level of details

- System requirements
- Subsystem requirements
- Component requirements
- Component testing
- Component realization
- Design

Time

Risk of mistake / long development time

Many simulation tools
Different models for 1 component
Low flexibility / interoperability
Disruptive and open access model organization in the development process for fast and efficient development of innovative EVs.

PANDA concept

-20% for the time-to-market
PANDA disruptive simulation method

**Functional simulation:**
Most of the simulation tools are based on a structural description for an easy interconnection of different components/subsystems but conflicts of association to be solved by the solver.

PANDA use a functional & causal description (fixed I/Os) for a faster simulation and more flexibility.

**Cloud of model:**
Most of virtual/system simulations are developed on co-simulation to interconnect the software of each team but co-simulation increase the computation time.

PANDA use cloud of models with a common software for seamless interoperability and real-time simulation.

Energetic Macroscopic Representation
(graphical formalism for model & control organization)
PANDA supports

Electrical Vehicle
Renault ZOE

Fuel Cell Vehicle
MobyPost

Hybrid Vehicle
48V-based P-HEV

EMR formalism

Application to an industrial software

Simcenter Amesim

study cases
Simcenter Amesim

Model-based system testing
Pre-design
Systems sizing & integration
Performance balancing
Controls validation

Advanced industrial Multiphysics simulation package
based on structural libraries for models and a functional library for control

48 libraries (6500 models)
- Hydraulics
- Pneumatics
- Thermal
- Electrical
- Mechanical
- Signals, etc.

new EMR-based functional library for models & control
Example of simulation of a BEV

1. Tazzari Zero of

2. modelling equations

3. New EMR library In Simcenter Amesim

Simecenter Amesim

model & control organization using EMR

<table>
<thead>
<tr>
<th>Bat.</th>
<th>inverter</th>
<th>AC machine</th>
<th>wheel</th>
<th>chassis</th>
</tr>
</thead>
</table>

\[ J \frac{d}{dt} \Omega_{\text{gear}} = T_{\text{dom}} - T_{\text{gear}} - f\Omega_{\text{gear}} \]
\[ L_{\text{arm}} \frac{d}{dt} \iota_{\text{dcem}} = u_{\text{chop}} - i_{\text{dcm}} - R_{\text{arm}} i_{\text{dcm}} \]
\[ u_{\text{chop}} = m_{\text{chop}} V_{\text{bat}} \]
\[ \iota_{\text{chop}} = m_{\text{chop}} \iota_{\text{dcm}} \]
\[ T_{\text{dom}} = k_{\text{dom}} \iota_{\text{dcm}} \]
\[ T_{\text{gear}} = k_{\text{gear}} \Omega_{\text{gear}} \]
\[ e_{\text{dom}} = k_{\text{dom}} \Omega_{\text{gear}} \]
\[ e_{\text{gear}} = k_{\text{gear}} \Omega_{\text{diff}} \]
Multi-level modelling simulation

Different models can be interchanged by “plug & play”
Cloud simulation platform

- with cloud EMR library and computing facility
- fast sharing models and knowledge between partners, for seamless integration of a complete vehicle model

- Development of models
- EMR organisation of models

Simulation of BEV
Simulation of FCV
Simulation of P-HEV
Stand alone or cloud simulation

- stand-alone simulation on local computer
- Cloud-computing simulation in the cloud
- possibility of black-box models for IP
- upload simulation files
- download component model
- Upload Simulation results
The EMR of the studied BEV

Renault ZOE

Li-Ion
41 kWh / 400 V
290 kg

Synchronous Machine
65 kW

PANDA - GA 824256

30/11/2020
The simulation model

From the EMR library

Example of a simulation model in Simecenter Amesim
Different level of battery models

Model identifications

- Pure electric model
- OCV vs. SoC
- ESR vs. SoC
- OCV vs. SoC
- OCV vs. SoC

Diagram showing the relationship between battery, e-drive, chassis, and road, with variables $U_{bat}$, $i_{bat}$, $T_{Amb}$, $q_{S4}$.
Different level of e-drive models

Parameter identifications

battery e-drive chassis road

$u_{bat}$ $i_{bat}$ $T_{ed}$ $\Omega_{wl}$ $T_{ed-ref}$

static model

dynamic model with saturation

Flux linkage

efficiency map

Groupe Renault

Parameter identifications

$u_{bat}$ $i_{bat}$ $T_{ed}$ $\Omega_{wl}$ $T_{ed-ref}$

inverter

synchronous machine

PWM

Field oriented control

$u_{vsi}$ $u_{sdq}$ $e_{sdq}$ $i_{sdq}$ $i_{sdq-ref}$ $i_{sdq-est}$ $\theta_{d/s-est}$ $m_{vsi}$

$T_{ed-ref}$
Model validation

Different real driving cycles from RTR track

Measurements

Velocity (km/h)

Time (s)

Extra-urban real driving cycle

Input

Results

Energy (kWh)

SoC (%)

Error on energy < 2% for different driving cycle

Measure

Simulation

Time (s)
Comparison structural vs. functional

Classical structural library (Simcenter Amesim)

New EMR-based (functional) library in Simecenter Amesim

First Results

• same model / control
• same accuracy
• -15% of computation time with the functional library

Simulation of Renault ZOE

[Husar VPPC'19]
Next step: P-HEV virtual & real testing

hybridized Peugeot 308 with a 48 V battery and 2 electrical drives for P-HEV

Real-time simulation
Next step: HIL testing of battery

Real battery under test

Power interface & real-time simulator

stand-alone HIL
(upload files)

cloud-based HIL
(real-time exchange)
PANDA perspectives

- PANDA concept
- Cloud of models
- estimation of the reduction time-to-market
- - 20%

- system specifications
- subsystem specifications
- components design
- component realization
- virtual subsystem
- virtual prototype
- subsystem testing
- prototype testing
- usage of the cloud for HIL testing

- estimation of CO2equ of PANDA and mitigation

Level of details

time
Our PANDA
Thanks you for your attention!

H2020 PANDA project
https://project-panda.eu/
References


