EMR'22
HES-SO Sion
June 2022

EMR'22 Summer School
"Energetic Macroscopic Representation"

« EMR-based control HIL testing for a BEV»

Adrien Genic, Milos Miletic
Typhoon HIL, Serbia

Typhoon HIL

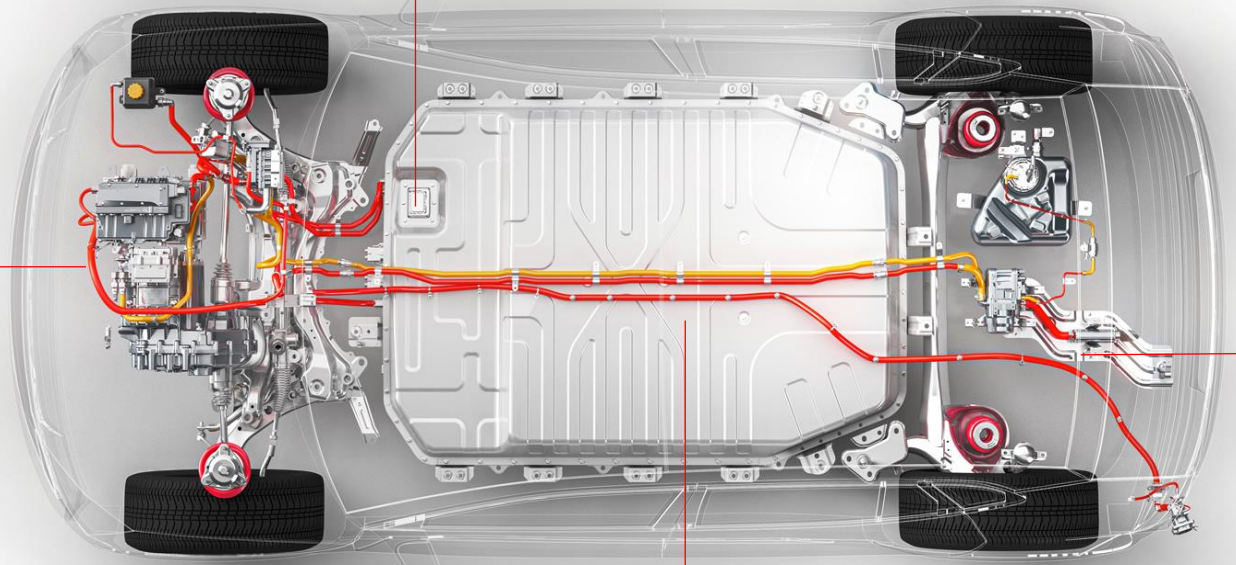
- Outline -

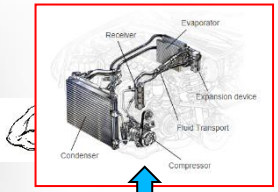
1. Introduction of the Device under Test
2. EMR combined with Structural model for C-HIL testing

«Introduction of the Device under Test»

Electrical systems on a BEV

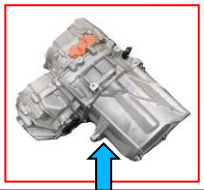
Onboard charger



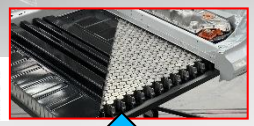


AC Compressor Drives

Propulsion inverter and PMS Motor



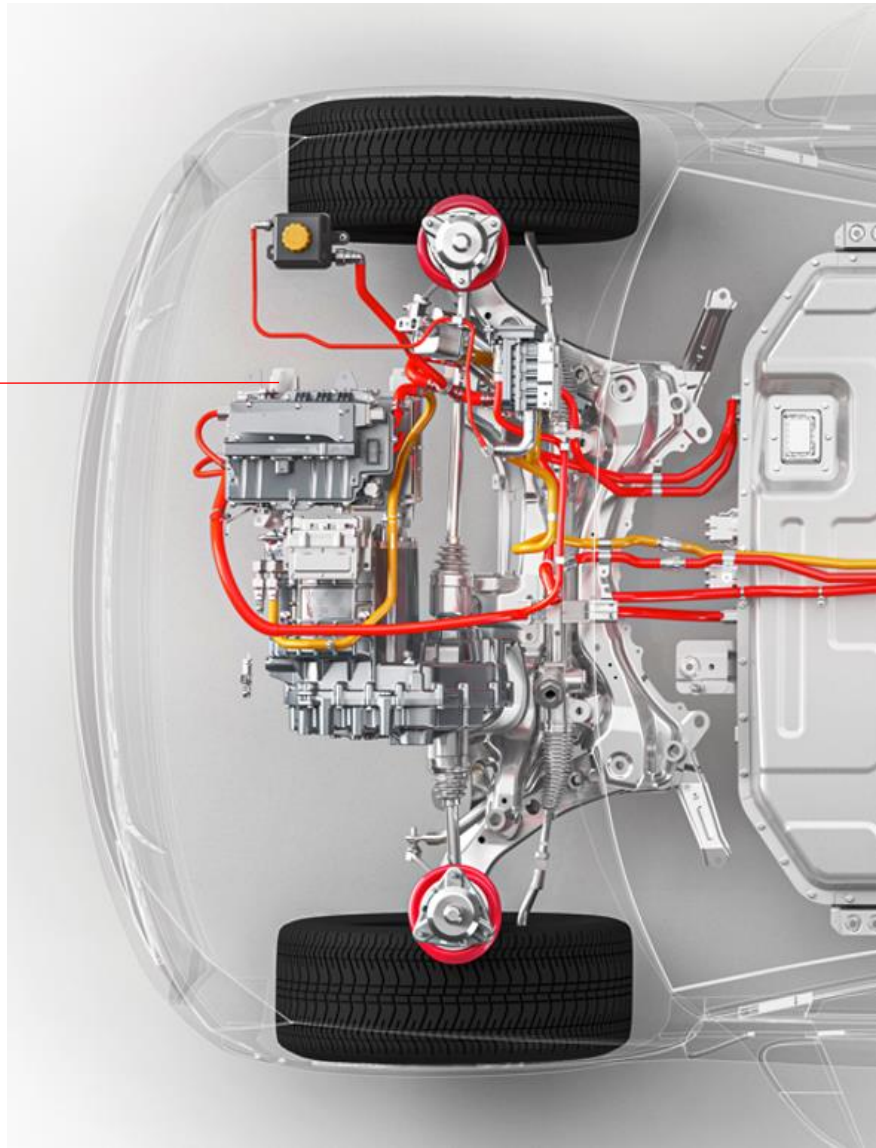
DUT



Battery and BMS

Stationary charging station

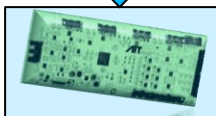
Electrical systems on a BEV



Propulsion inverter and
PMS Motor Controller-HIL

Real-Time
Simulation

Real
Controller



DUT
(Device Under Test)

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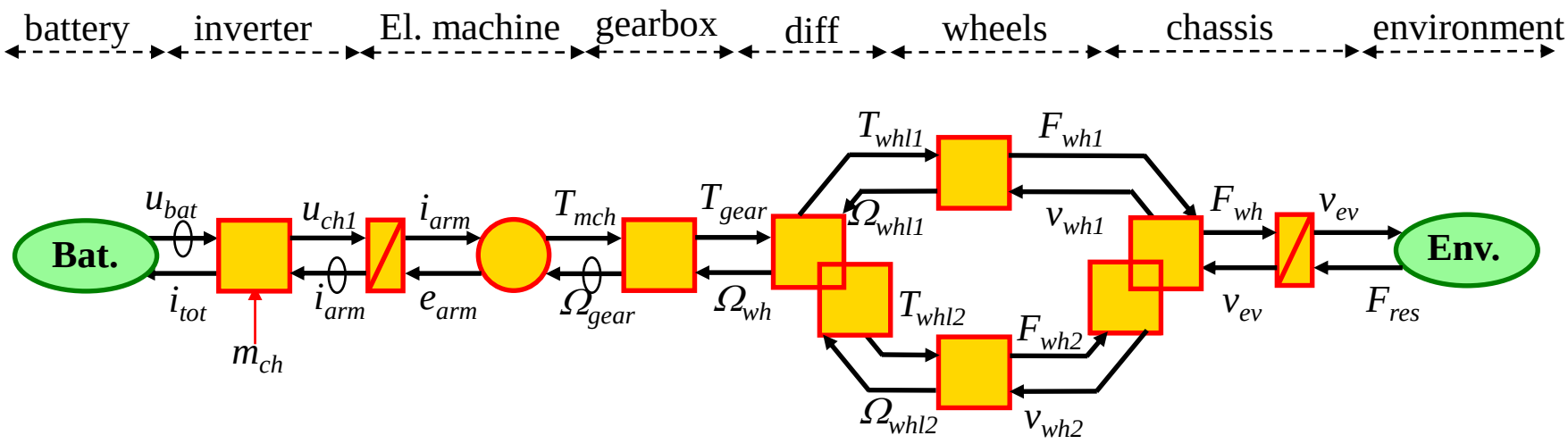
«EMR combined with Structural model for C-HIL testing»

EMR of a BEV


battery
inverter
El. machine
gearbox
diff
wheels
chassis
environment
Bat.
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e_{arm}
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Ω_{gear}
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Ω_{whl1}
F_{wh1}
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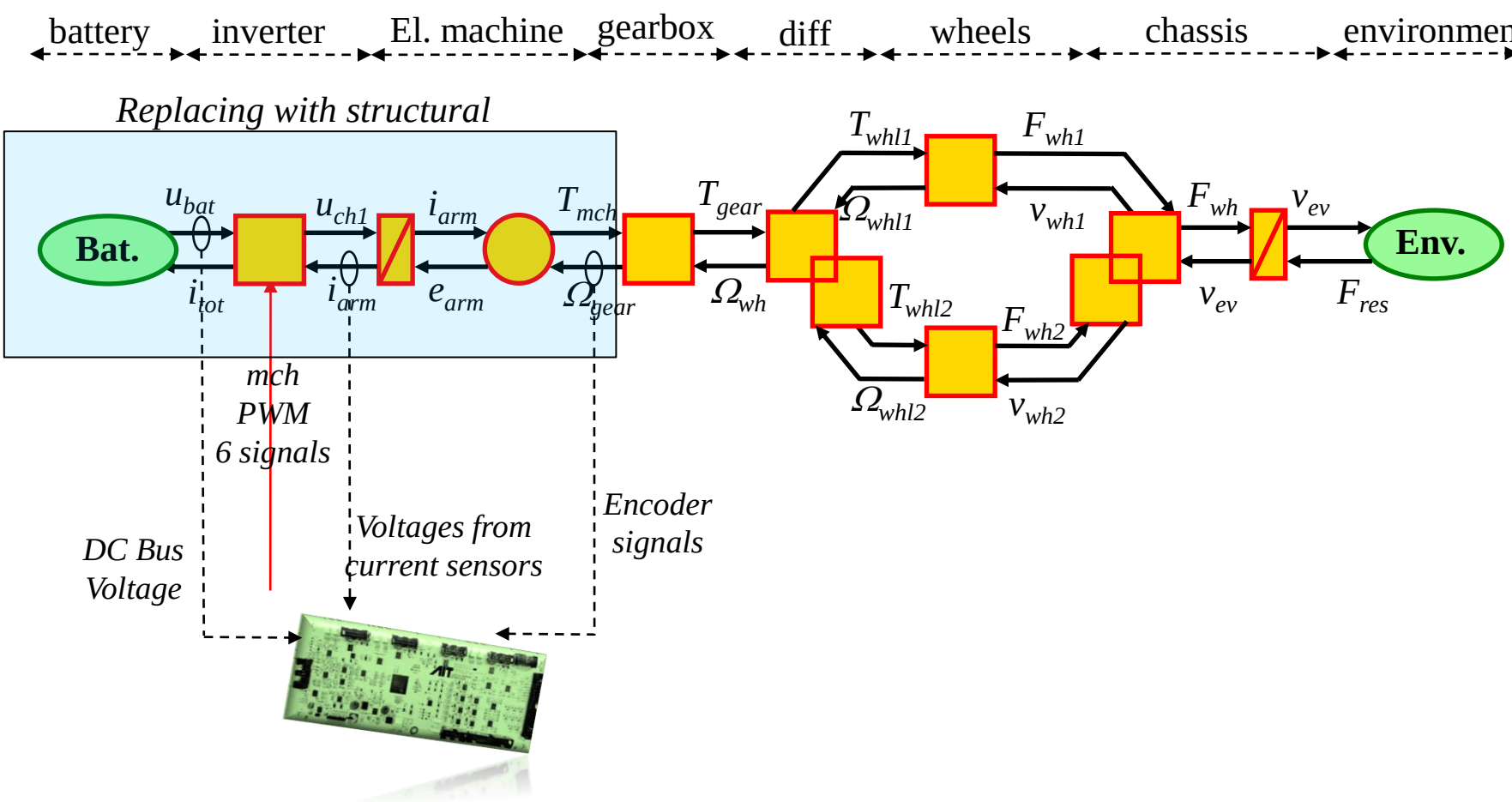
battery
inverter
El. machine
gearbox
diff
wheels
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Replacing with structural
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v_{wh1}
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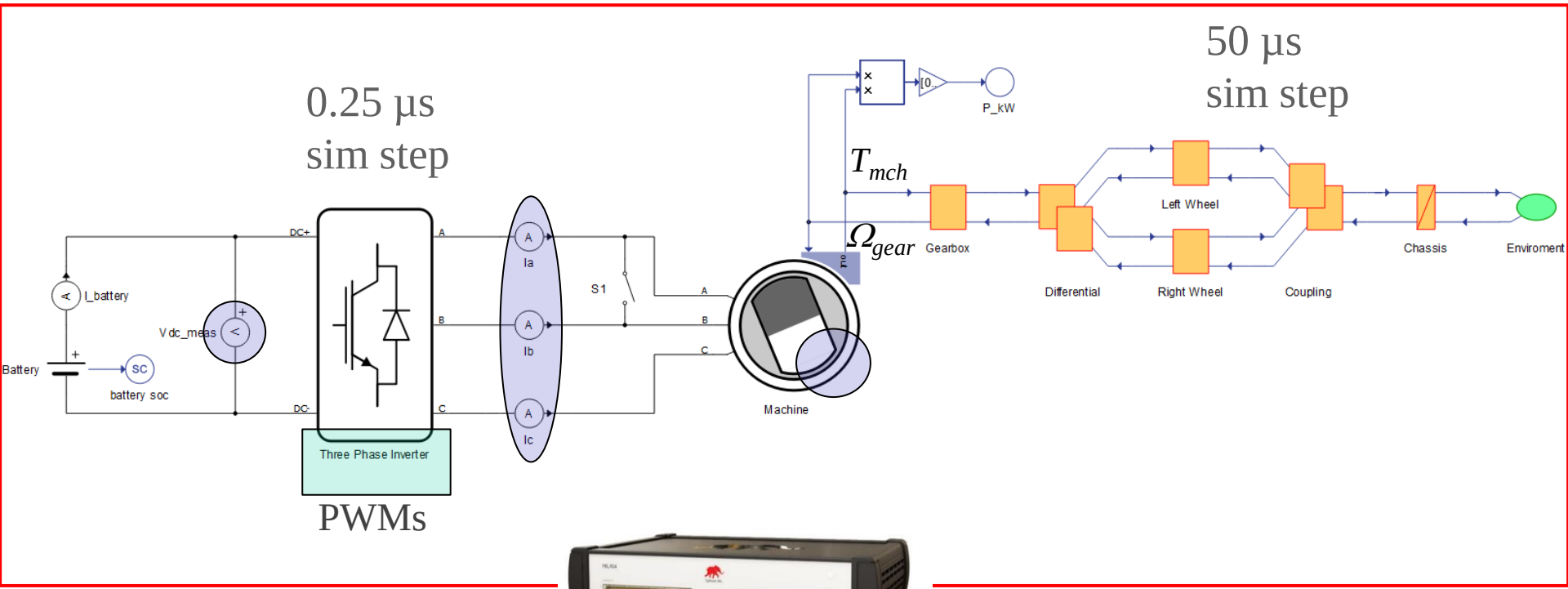
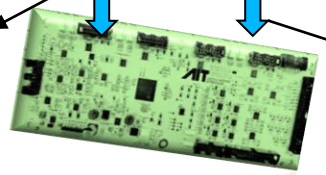
Ω_{whl2}
F_{wh2}
v_{wh2}
F_{wh}
v_{ev}
v_{ev}
F_{res}
Env.
mch
PWM
6 signals
DC Bus
Voltage
Voltages from
current sensors
Encoder
signals

Combined structural and EMR based functional model for C-HIL





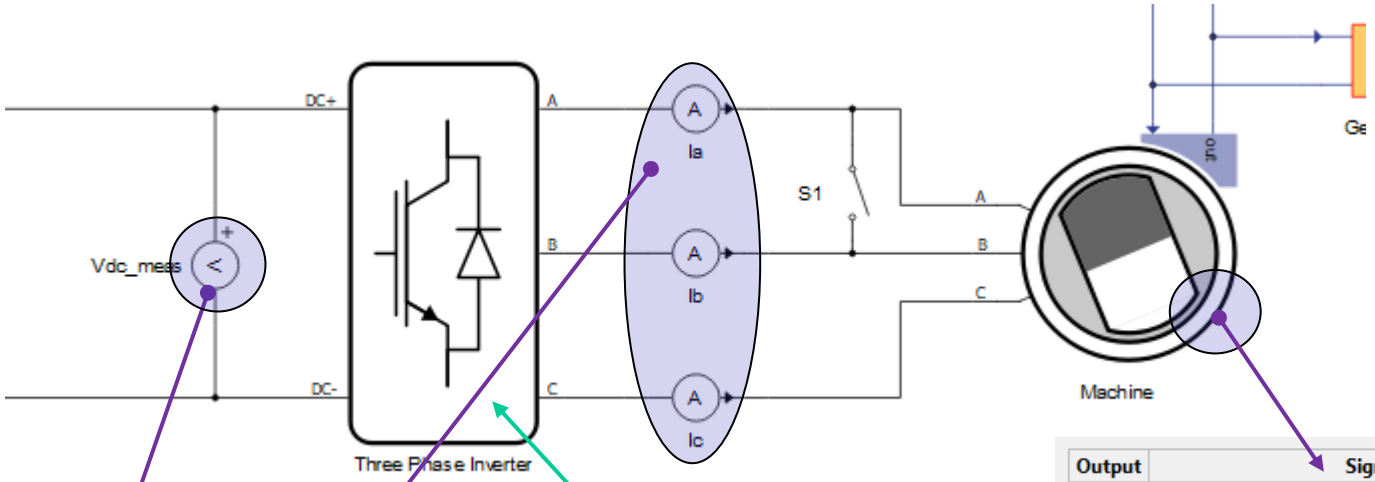
Analog Feedbacks:
-DC Bus voltage,
-Motor Currents

Digital Control Signals:
-PWM Signals

Digital Feedbacks:
-Motor Speed – Encoder Signals

EMR-based control HIL testing for a BEV

Digital and Analog IO Conection



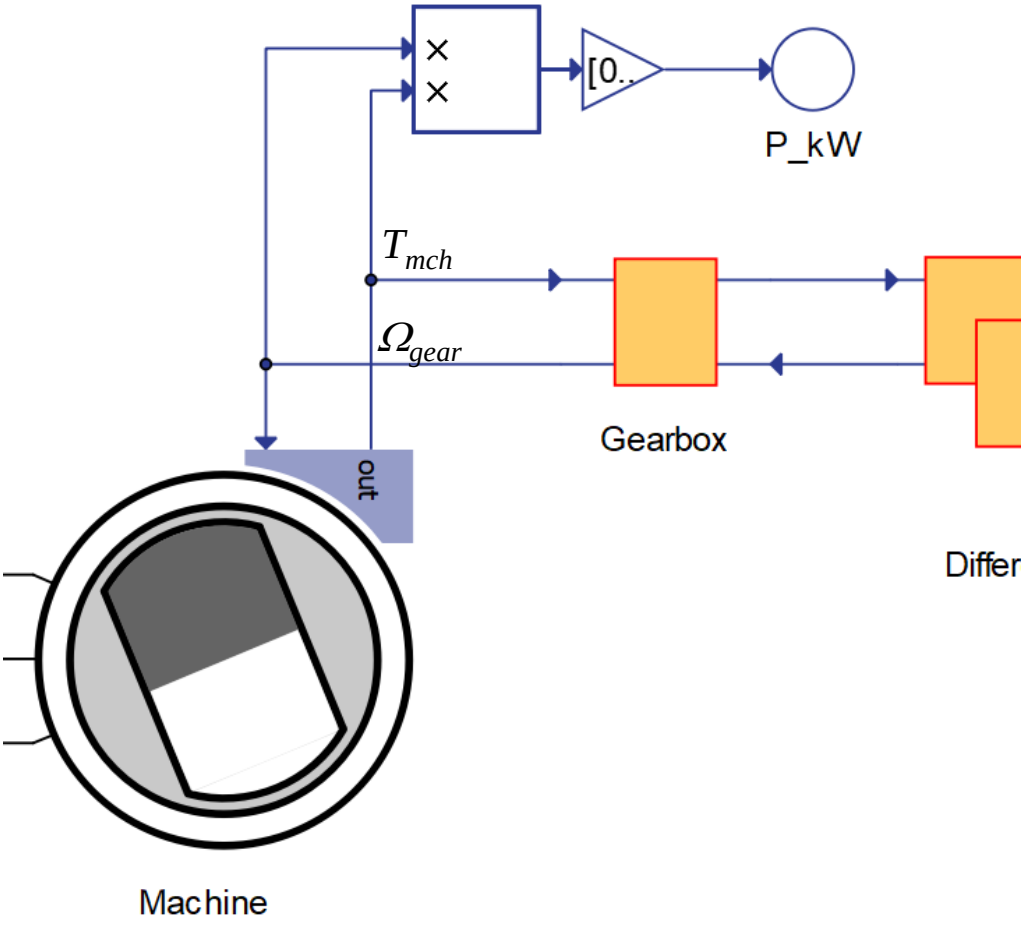
Output	Signal	Invert
DO1	machine encoder A	
DO2	machine encoder B	
DO3	machine encoder Z	

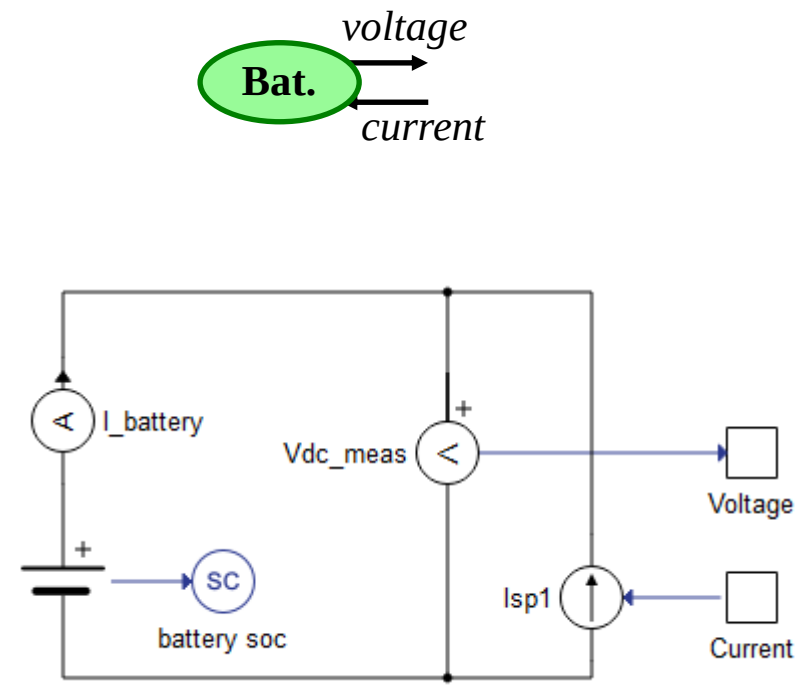
Output	Signal	Scaling
AO1	Ia	169.7 A per 1 Vdac
AO2	Ib	169.7 A per 1 Vdac
AO3	Ic	169.7 A per 1 Vdac
AO4	Vdc_meas	330.5746 V per 1 Vdac

General | Measurements | Timing | Losses

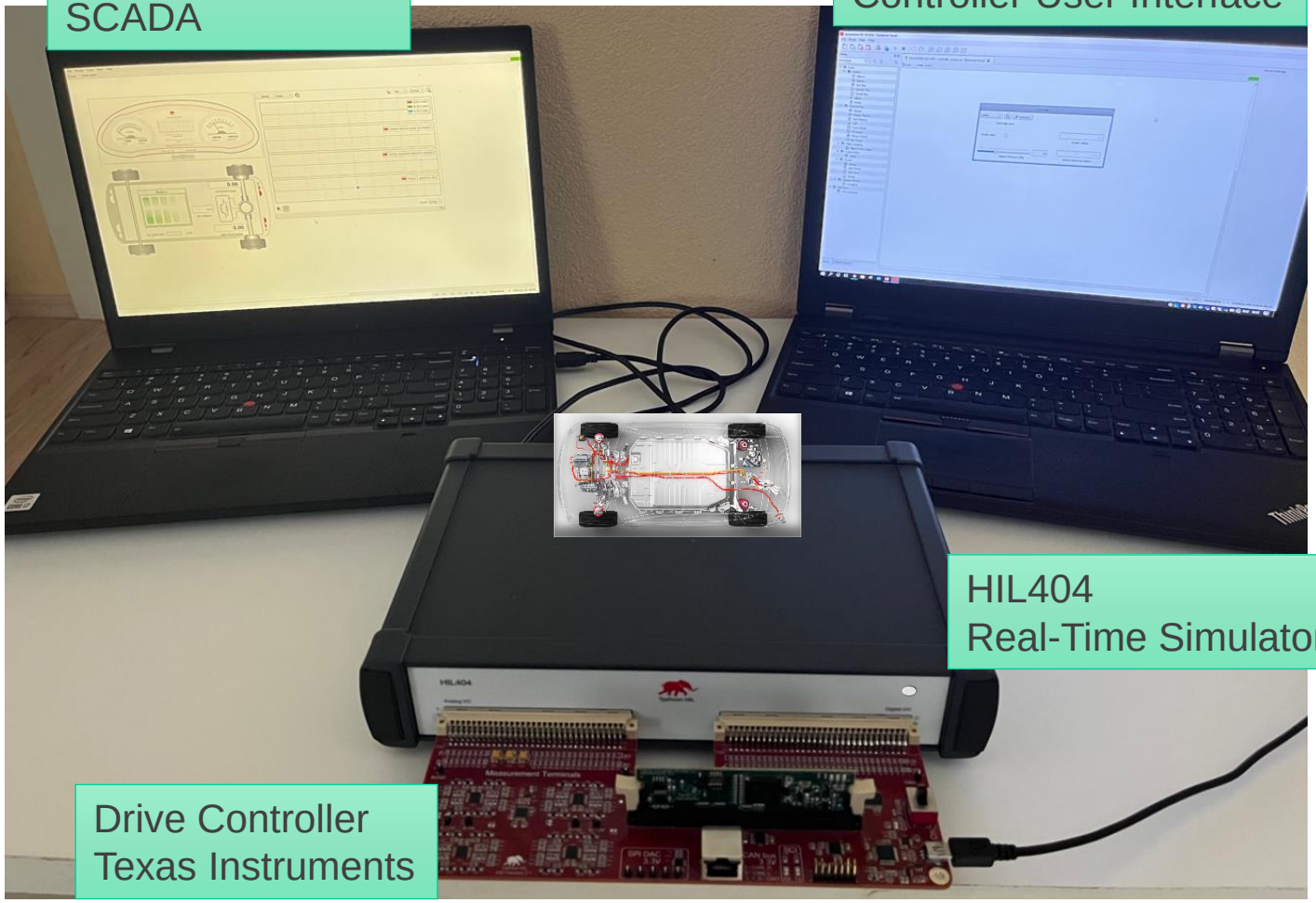
Control:	Digital input per switch
Phase A S1:	1
Phase A S2:	2
Phase B S1:	3
Phase B S2:	4
Phase C S1:	5
Phase C S2:	6

Connection between EMR and Structural Model





C-HIL setup


Simulation Control
SCADA
Controller User Interface
HIL404
Real-Time Simulator
Drive Controller
Texas Instruments

Structural vs Functional Modeling

- Why structural model was used for C-HIL testing of drive controller?
  1. To achieve required performance (real-time simulator specific):
     - 0.25us simulation step
     - Fast PWM sampling (6.66ns)
  2. Ready to use components in the library
     - battery, converter, motor

	EMR based functional models	Structural models
PROS	• Applicable to all domains. • Naturally standardized interface • Engineers have deep understanding of the model • Structured and organized control design process	• In real-time these models are usually solved by fast custom solvers, enabling better performance • Component libraries are available which speeds up the modeling process
CONS	• Usually these models end up as code that needs to be executed sequentially, resulting in performance issues • Lack of pre-built components	• Easily applicable and standardized only in electrical domain • Engineers do not have good insight in the underlying models

« BIOGRAPHIES AND REFERENCES »

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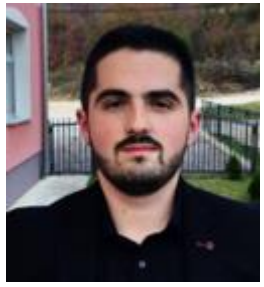

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- References -

[Bouscayrol 2000] A. Bouscayrol, & al. "Multimachine Multiconverter System: application for electromechanical drives", *European Physics Journal - Applied Physics,* vol. 10, no. 2, May 2000, pp. 131-147 (common paper GREEN Nancy, L2EP Lille and LEEI Toulouse, according to the SMM project of the GDR-SDSE).

[A. Genic 2017] A. Genic, C. Mayet, M. Almeida, A. Bouscayrol, N. Stojkov, "EMR-based Signal-HIL Testing of an Electric Vehicle Control", IEEE Vehicle Power and Propulsion Conference (VPPC), Belfort, December 2017, 10.1109/VPPC.2017.8331047

HIL Academy: https://hil.academy/

EMR Library in Typhoon: https://github.com/typhoon-hil/emr-typhoon-hil-library

Typhoon Software Download: https://www.typhoon-hil.com/products/software-download/