Optimization of scalaBle rEaltime modeLs and functIonal testing for e-drive ConceptS

EUROPEAN COMMISSION
Horizon 2020
GV-07-2017
GA # 769506

Deliverable No.	OBELICS D4.3	
Deliverable Title	Methodology and scalable test description for HF-inverters with e-motors and batteries	
Deliverable Date	2019-09-30	
Deliverable Type	REPORT	
Dissemination level	Confidential	
Written By	**UCC 1&2 Complete System (incl. E-Motor):** Mathieu Ponchant (SIE-SAS) - Bart Forrier (SIE NV) - David Delichristov (ViF) - Gerhard Benedikt Weiss (ViF) **UCC 3 Battery:** Vincent Heiries (CEA) - Marco Ranieri (CEA) - Oliver König (AVL) - Martin Zaversky - Ramaka Vishwasri - Ngoc Nguyen Raul Estrada Vazquez (FHJ) - Benjamin Zillmann (Bosch) - Jürgen (FhG LBF) - Ashwin Karthikeyan **UCC 4 HF-Inverter:** El Hassan Ourami (Valeo) - Oliver König (AVL) - Thorsten Fischer (AVL SFR) - Ouael Manaa (AVL SFR) - Raul Estrada Vazquez (FHJ) - Damian Miljavec (UL) - Tomaz Katrasnik (UL) **All/Undefined:** Andreas Stadler (AVL SFR) Mohamed El Baghdadi (VUB) - Yousef Firouz (VUB) - Luca Pugi (UNIFI) - Edoardo Lorenzo	2019-09-15
Reviewed by	Alfredo Primon (CRF) Luca Pugi (UNIFI)	2019-09-15 2019-09-15
Approved by	Horst Pfluegl (AVL) – Project Coordinator	2019-09-27
Status	Final	2019-09-30

Public/Publishable Summary

Alternative energy in combination with E-mobility will replace combustion drive-chains step by step in the next years and decades – due to technical and environmental advantages. Highly efficient E-cars and a narrow mesh of service stations is needed, therefore. Pioneers in industrial E-car manufacturing, as Tesla Motors, which was founded in 2003 by Martin Eberhard and Marc Tarpenning, started their production in 2012, when the company began to produce and deliver the Tesla Model S after receiving nearly 7000 preorders. Today, Tesla produces 100% electric vehicles. At present, every well-known car-manufacturer – even Ferrari – provides at least one model with electrical power-train.

Within the Horizon 2020 program of the European Union, the OBELICS (Optimization of scalaBle rEaltime modeLs and functIonal testing for e-drive ConceptS) project refers to functional testing and test/system integration of battery, E-motor and inverter.

The present report, deliverable 4.3 (D4.3), in combination with the past D4.2 (which was due in end of June) are the 2nd yearly deliverable within workpackage 4 of the Horizon 2020 OBELICS-project. It focusses on methodology and scalable test description for HF-inverters with e-motors and batteries – i.e. report over methodologies and test integration activities in different testing environments (Sil, HiL, PowerHiL). This, in order to shorten the time between design and test, simplify the handling of scalable real-time models for the purpose of testing and reduce the effort for transformation of testing methodologies in different stages of the development process.

The objective regarding to requirements is the efficiency increase of system engineering testing to increased improvement of test case generation and its management. These requirements are defined implicitly within the models (V-model) or are only loosely coupled. Aimed are: An improved degree of automation, a reduced set of test overhead, Project collaboration within Europe becomes more straightforward.

With view to a high quality of the undertaken R&D activities, several use-cases (UCs) were implemented, where similar ones were bound together to use-case clusters (UCCs). The whole project is developed along these UCs.

Moreover, a unique OBELICS-use-case contribution matrix was installed, which allows in steps of work-packages an interacting comparison of methods and results of all parallel developed UCs, resulting in discussions and conclusions. The implemented UCCs are here:

- UCCs 1 & 2 Complete Systems (incl. E-Motors): New e-drive concept & component sizing in earlier design phase (scalable models); E-vehicle system integration, optimization with real world verification (model-based testing)
- UCC 3 Batteries: Battery design and testing for improved safety & reliability
- UCC 4 HF-Inverters: E-motor, control and inverter design & testing

Work-package 4 (WP4), which is regarded here contains requirements, designs, test methodologies, and executes first well-defined tests. The test environment covers all tests, starting from MiL to SiL and furthermore the HiL, ViL, PiL via XiL test cases for HF-inverters in combination with e-motors and batteries and its Infrastructure.

The investigated methods and results are manifold, several high-sophisticated project partners are delivering contributions to this report. Representatively, the following three examples may illustrate the contributions of the tree named UCCs to the WP4-activities:

Replacing physical systems with virtual devices can drastically reduce the costs of testing control systems, software, and hardware. So, inputs and outputs into and out of the virtual world of simulation must be read or updated synchronously with the real world. Realizations within the project are: Real-Time simulations with variable-step solvers. Identification of the simulation step size, for real-time simulations. Therefore, different solvers are distinguished: Fix-step solver (FSS), Variable step solver (VSS), Nature type of solver (Numerical method of computation). Their selection depends on the following criteria: The dynamics of the system, The stability of the solution, The speed of computation, The robustness of the solver.

A (Power) Hardware-in-the-Loop ((P)HiL) E-Motor Emulator (EME) represents the electrical schematic of a three-phase E-Motor. Software models are available that correspond to various motor types that can be emulated. These motor models can be quickly changed by software, so that one single emulator can be used to represent different

motor types very efficiently within test-sequences. The methodology and scalable test description for HF inverters describes how to realize a high-quality level of test execution on a test bench at AVL SFR, under realistic load condition, as it is in the field. The device under test (DUT) is the inverter. The steps are: Step 1 – Commissioning and configuration. Step 2 – Calibration. Step 3 – Test activation. Step 4 – HF inverter start-up tests. Step 5 – HF inverter component calibration. Step 6 – HF inverter behavior and key parameter. Step 7 – Thermal and stress tests. Step 8 – Inverter performance tests.

8. Acknowledgement

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

Project partners:

Partner no.	Partner organisation name	Short Name
1	AVL List GmbH	AVL
2	Centro Richerche Fiat SCpA	CRF
3	FORD Otomotiv Sanayi Anonim sirketi	FO
4	Renault Trucks SAS	RT-SAS
5	AVL Software and Functions GmbH	AVL-SFR
6	Robert Bosch GmbH	Bosch
7	SIEMENS INDUSTRY SOFTWARE NV	SIE-NV
8	SIEMENS Industry Software SAS	SIE-SAS
9	Uniresearch BV	UNR
10	Valeo Equipements Electroniques Moteurs	Valeo
11	Commissariat à l’Energie Atomique et aux Energies Alternatives	CEA
12	LBF Fraunhofer	FhG-LBF
13	FH Joanneum Gesellschaft M.B.H.	FHJ
14	National Institute of Chemistry	NIC
15	University Ljubljana	UL
16	University Florence	UNIFI
17	University of Surrey	US
18	Das Virtuelle Fahrzeug Forschungsgesellschaft mbH	VIF
19	Vrije Universiteit Brussel	VUB

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 769506.