Rare Earth Free e-Drives Featuring Low Cost Manufacturing

ReFreeDrive

Collaborative Project
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Executive Summary

This report D7.2 details the activities carried out in Task 7.2 of ReFreeDrive's Work Package 7 (WP7), contributing to the overall objective of the WP, which is to test and gather experimental evidence of the powertrains performance following an incremental approach, starting from the testing of the motors and Power Electronics (PE) designed in WP3, WP4 and WP5 and manufactured in WP6, up to the full vehicle integration.

According to the ReFreeDrive's Grant Agreement (GA), Task 7.2 is focused on the integration of the powertrain and various vehicle systems in a test bench at CIDAUT, in order to characterize and to validate the vehicle functioning conditions in a controlled and measurable environment. To this end, CIDAUT carried out a series of integration tests on powertrain components, such as accelerator pedal and CAN communication, with the support of IFP Energies Nouvelles (IFPEN), PRIVÉ, University of L'Aquila (UAQ) and R13.

Taking advantage of the capabilities available at CIDAUT and the suggestions of some project partners, additional actions not included in the GA were carried out, namely:

- Functional testing on Medium Power Silicon Carbide (SiC) PE, which supplemented the laboratory characterization activities carried out by R13 within WP5.
- Acoustic characterization.

The experimental facility used for testing the 75kW powertrains was equipped with: High Voltage (HV) power supply, Low Voltage (LV) power supply, test bench (load motor), water cooling circuit, accelerator pedal, Controller Area Network (CAN) bus and motor control software, and data acquisition systems. It is presented in Figure 1.

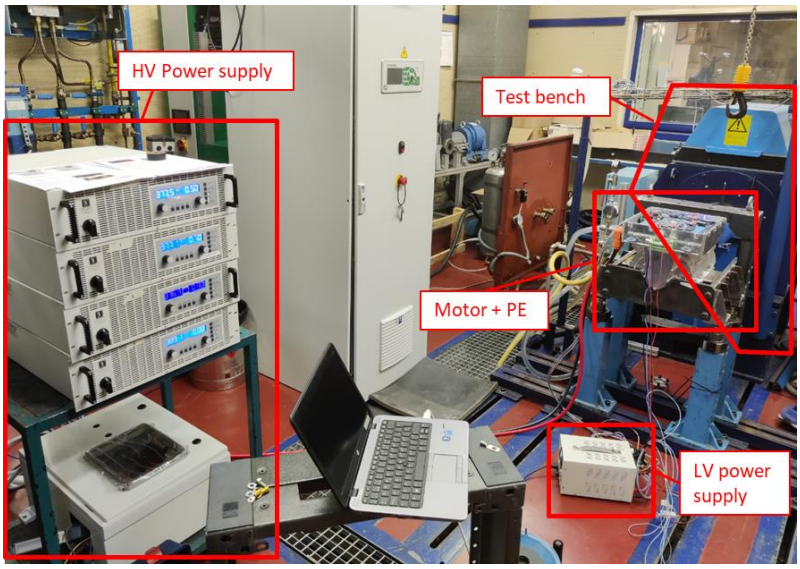

Figure 1. Experimental facility

Prior to evaluating the performances of the powertrain in real-world based scenarios, a tuning stage was carried out with a double objective:

- Optimize the control firmware of the motor and the motor response to the accelerator pedal inputs.
- Check that all systems were operating and communicating properly. Concretely the focus was put on ensuring, through a series of functional tests supervised by UAQ and R13, that the medium power PE behaved as expected. Main efforts were dedicated to enhancing the firmware that controls the motor.

Once the setup was properly adjusted, a series of tests were performed to evaluate the behavior of the powertrains in real-world based driving scenarios, focusing on the low efficiency regions of the system (motor + powertrain) efficiency maps, such as the following ones:

- Constant speed tests. Efficiencies ranged from 57% (at 20 km/h) to 91% (at 60 km/h).
- Acceleration steps on flat terrain (efficiency 84%) and on a 10% slope (efficiency 87%).
- Low speed driving cycle. Efficiency measured: 84%.

All efficiencies measured were in line with the expectations. These tests allowed completing the characterization carried out within Task 7.1 by IFPEN. Finally, noise emitted by the pure Synchronous Reluctance (SynRel) motor was measured, obtaining values of 88 dB and 82 dB(A), what emphasizes the importance of addressing this aspect as part of the in-vehicle integration activities.

The impact of Covid-19 on Task 7.2 and accordingly on D7.2 was severe and caused some deviations both in content and in time. In terms of time, lockdowns, national and international travel restrictions and freight traffic inconveniences that happened throughout 2020 and the beginning of 2021 affected the development of the project and specifically of WP7 tasks. The greatest impact was on WP6 (Prototypes manufacturing) activities. The manufacturing of components and the assembly of the prototypes, including the sub-contracting of some activities underwent significant challenges and delays. Delays in WP6 implied that the beginning of Task 7.2 had to be postponed, therefore coinciding in time with Task 7.3. In terms of content, Task 7.3 was considered of higher priority; hence some powertrain components such as battery pack and gearbox were kept at PRIVÉ and were not included in the tests carried out in Task 7.2.

To mitigate the negative impacts and make possible the completion of both affected Tasks, actions and countermeasures were defined in agreement with the partners involved in WP7, mainly IFPEN, R13, UAQ and PRIVÉ.

Despite the deviations, it is considered that D7.2 fully fulfils its objectives, bridging the gap between the component testing and the full in-vehicle testing.