Battery test results

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1 Publishable Executive Summary

New and ageing battery cell parameters play the key role in the determination of the BMS algorithms (SoH, SoC, and SoF). Battery testing will be conducted in order to fill the gap between the data provided by the cell supplier and the data requested for the BMS algorithms.

The INCOBAT WP4 is dedicated to perform tests on different battery cell chemistries, in order to:

- determine proper parameters for the characterization of the battery cell model used in the simulation framework in the WP2
- get data for the mission profile definition
- ageing testing of the battery cells (with accelerated ageing approach)

As a part of this task, a number of tests will be conducted in the laboratory environment using innovative equipment. These tests will allow us to collect information about battery behavior in different environmental conditions with the focus on the battery charge and discharge characteristics in various temperatures. Ageing data will be collected from normal ageing process of battery or, in case of a large number of tests to be run, from accelerating process of ageing described in results of Liberal project. Collected data will operate as input parameters to optimize and set SoH, SoC and SoF algorithms.

During the course of INCOBAT, the performance of two different strategies / algorithms will be investigated and compared to each other to find the best performance to cost ratio:

- An industrial approach, based on a model-based estimation method for the SOC, SOF and SOH calculation. This algorithm will be enhanced, thanks to the upgraded computational power, to run on each single cell, instead of currently state-of-the-art, that can perform only lumped parameter estimation (i.e. the SOC is estimated for the average of 12 or more cells)
- A more innovative approach, based on the Electro-chemical Impedance Spectroscopy (EIS) will be considered for evaluation purposes as well. This approach is more oriented to the R&D phase of the project, and will lead to an estimation of the impedance of the cell, from which to derive an estimation of the State of Health of the cells.

Therefore, two different sets of tests shall be performed:

1. Model based approach: to determine the parameters of the battery model used by model-based approach
2. Battery tests for Electrochemical Impedance Spectroscopy (EIS): to set-up, fine tune and validate the EIS algorithm. In a second step, the impedance curves resulting from the battery tests shall be possibly used to find a relationship for SOC and SOH determination.

In both cases, tests will be performed on a test bench, with a laboratory instruments and / or custom hardware devices, needed to generate the stimulus signal for the cells under test. Charge and discharge

cycles will be applied, to measure the parameters of the cells, and to bring the cells to the desired SOC needed for the measure.

The test bench for EIS measurements is based on a trans conductance amplifier, which is forcing an AC current waveform in the battery cell under test. The resulting AC voltage is measured on the battery cell by means of a National Instruments Multi DAQ card. The same card is used to generate a voltage command signal for the trans conductance amplifier.

The first tests will be aimed at the validation of the EIS measurement system: at first, the battery cell will be replaced by a power resistor, to check both the test bench setup and the capability of the algorithm to produce correct results. Furthermore, before applying the real EIS current stimulus, the system will be tested with a series of sine wave current waveform at different frequencies to check the frequency response of the test bench. The same tests will be performed replacing the power resistor with a real battery cell.

For each manufacturer and each type of cell, different tests will be performed to determine the impedance curve of the battery cells (EIS) as a function of the State of Charge, temperature, and ageing. This can help in understanding how the impedance curve changes in different operating conditions and during the battery lifetime. Furthermore, some damaged battery cells will be characterized to reveal how the impedance curve is modified when a failure occurs.