PhD activity proposal

Analysis, modelling and characterization of supercapacitors

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The overall objective of the PhD activity is to establish a **traceable**, **consistent and** sound measurement and characterisation framework for both SCs and SCs modules. This includes the development of rapid techniques for the determination of SoC/SoH of SCs, for the determination and assessment of ECMs parameters, the verification of the proposed techniques in real conditions.

The activity will be carried out in the framework of the European project 23IND04 MetSuperCap.

Supercapacitors (SCs), an environmentally friendly technology, are being used across an increasing number of fields, including as a replacement for batteries in higher-power density applications. This electrochemical energy storage device has an operating principle and charge storage mechanism which is more closely associated with those of rechargeable batteries than electrostatic capacitors. However, the behaviour of SCs differs from both and in order to support the growing use of SCs, accurate characterisation is required for SCs and SCs banks, both in the laboratory and under operating conditions. In addition to this, validated software is needed to identify the equivalent electrical model of SCs for dynamic applications. Quick, traceable and effective measurement techniques are also required to evaluate the State of Charge (SoC) and State of Health (SoH) of SCs and to promote the uptake of SCs in industrial and energy applications. In this context the PhD student is called to develop original measurement and modelling techniques, including identification procedures from laboratory measurements, to be applied to SoC, SoH and aging analyses.

The PhD activity can focus on one or more of the following objectives.

- 1. To develop **methods**, including the assessment of uncertainty, **for characterising** the capacitance, resistance, specific power and energy for **SCs of different sizes** (from 1 farad to 3000 farads, for discharge currents up to 500 A and voltages up to 60 V). The developed methods should be suitable for the characterisation of **SCs modules** with maximum instantaneous **discharge power up to 25 kW** (e.g., 420 A at 60 V).
- 2. To develop **software/models for identifying relevant parameters** for the static and dynamic characterisation **of SC and SC bank models**. The **target error** of the developed software/models will be **lower than 5 %**. In addition, to define **optimised voltage/current waveforms**, based on representative **SC charging and discharging cycles**, for characterising SCs and for validating models by measurement.
- 3. To develop **rapid techniques**, including the assessment of uncertainty, for accurately **measuring the SoC and SoH of SCs**.
- 4. To evaluate the actual behaviour of SCs under operating conditions, including battery/emulator-SCs hybrid systems.