

Sizing calculations for Substrate-Integrated Lead-Carbon Hybrid Ultracapacitors and their experimental validation

Anjan Banerjee and Ashok K. Shukla

Solid State and Structural Chemistry Unit, Indian Institute of Science, Bangalore-560012, India

Ultracapacitors or supercapacitors typically have low energy storage capacity, but high power yield. These devices are able to rapidly absorb, store and release energy, and assist in delivering the peak power loads. Accordingly, ultracapacitors complement well the steady-state power supplied by the battery modules, and are used primarily for load balancing and power management in order to protect advanced batteries degrade and overheat during rapid charge/discharge cycling. Capacitor-bank sizing is critical for aforesaid applications. At lower voltages, a constant power requires higher current as the voltage decreases. This is often overlooked during the initial analysis, and can result in under sizing a solution. During the sizing calculations if the total voltage drop happens to be greater than the specification limit for the application then one will either need to move to the next size-up cell or to place two series stacks in parallel. In the light of the foregoing, a 24V/150F and a 24V/250F substrate-integrated lead-carbon hybrid ultracapacitor banks are developed from four 12V/150F and four 12V/250F substrate-integrated lead-carbon hybrid ultracapacitor, respectively, following the capacitor-sizing concept (see the schematic circuit diagram shown in Fig. 1). The calculated values of resistance and capacitance from sizing calculations are validated by experiments. The experimental data are depicted in Figs. 2 and 3(a/b).

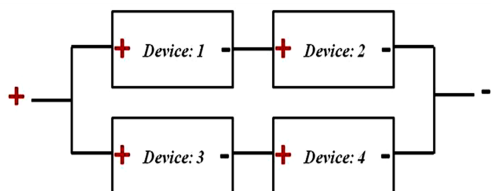


Fig. 1: Schematic diagram for 24V substrate-integrated lead-carbon hybrid ultracapacitor bank.

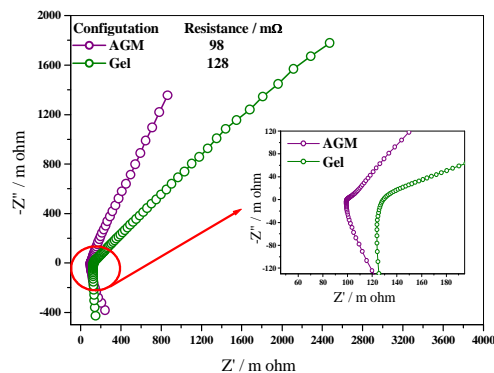


Fig. 2: Nyquist plots for 24 V ultracapacitor bank with absorbent glass mat (AGM) and silica gel electrolyte.

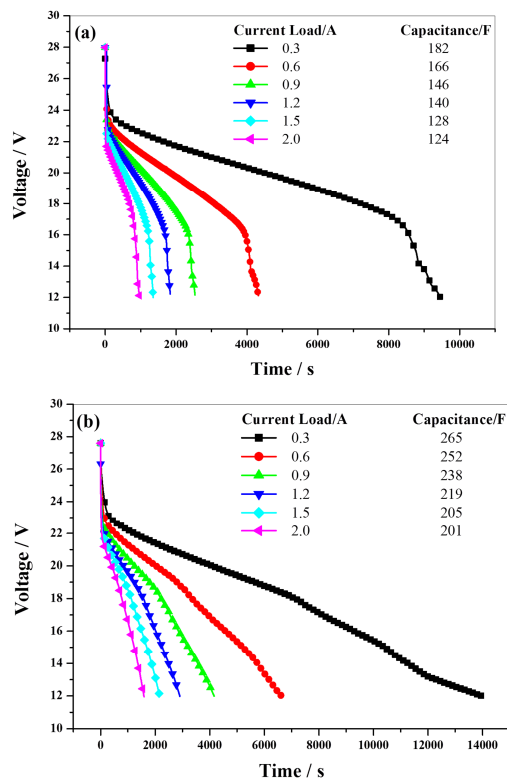


Fig. 3: Discharge profiles at varying current loads (a) AGM-24V/150F and (b) gelled -24V/250F ultracapacitor bank.

References

1. Lead-Carbon Hybrid Ultracapacitors and their Applications, A. K. Shukla, A. Banerjee and M. K. Ravikumar in *Electrochemical Energy Conversion and Storage: Materials, Devices and Mechanisms* (Print ISBN: 9781466575431), Kwong-Yu Chan, Chi-Ying Vanessa Li, Editor(s), CRC Press, Taylor & Francis Group (2013).
2. A. K. Shukla, A. Banerjee, M. K. Ravikumar and S. A. Gaffoor, WO 2013/ 011464 A1 and US 2012/0327560 A1.