High power double-layer capacitor developments and applications

V. Hermann, A. Schneuwly and R. Gallay, montena components, Switzerland

Tel : ++41 26 411 22 22 ; Fax : ++41 26 411 25 25 ; E-mail : roland.gallay@montena.com

Montena components has started recently the production of very high capacitance double-layer capacitors under the trade name of Boostcap. The development of these high power capacitors open the door to a great number of applications in the power electronic domain. These components are able to supply very high current during several seconds. They are mainly used as power booster in applications where loads are changing very fast. In the automotive domain, the typical examples are the vehicle kinetic energy management during the accelerations and deceleration phases or the power leveling in hybrid vehicles. In the industrial domain, the main applications are the electrical network interruption suppression and the network power leveling. Some particular application which have been done with double-layer capacitors will be presented.

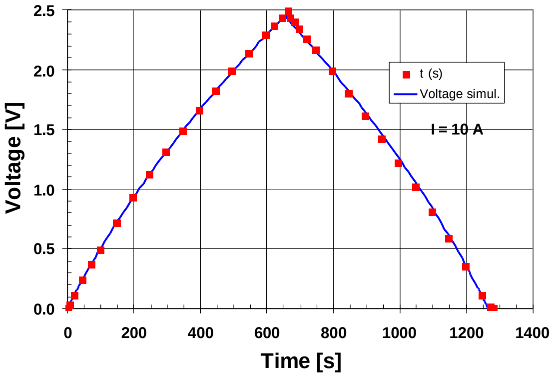

Figure 1: BCAP0010 Ultracapacitor 10 A charging curve

The double-layer capacitor development goals are a low component price, a long lifetime, an increase of the rated voltage and an increase of the energy and power densities. What is expected from the research and development are the increase of the electrolyte decomposition voltage and ionic conductance, the increase of the carbon powder accessible surface and electronic conductance and the separator electronic insulation level and ionic conductance. The components available on the market reach now an energy density of 4.9 Wh/kg and a power density of 4.5 kW/kg, both rated at 2.5 Vdc.

The characterization of these new double-layer capacitors requires some new definitions and standardization. The simple concept of capacitance of a linear capacitor must be changed for a more complex one, consisting of two parameters: C_o and K. C_o is a basic capacitance which is independent of the voltage while K is linearly dependent

$$C_u = C_o + K*U_c$$

The charging current, as shown on figure 1 for a Boostcap double-layer capacitor BCAP0010, is proportional to

$$i(t) = (C_o + 2*K*|U_c|)\frac{dU_c}{dt}$$

The points corresponds to measures; the curve to theoretical simulation with the model. The energy content is given by

$$E(U) = (C_o + \frac{4}{3}K|U_c|)*\frac{U_c^2}{2}$$

The capacitor performances at “high” voltage are much better than expected from the nominal value. Figure 2 shows the behavior of the different parameters as the capacitance, the “current” equivalent capacitance and the “energetic” equivalent capacitance. In most of the applications the capacitors operate between 50% and 100% of the nominal voltage. In the case of a BCAP0010 which has a nominal capacitance of 2600 F, the actual “energetic” equivalent capacitance is equal to 2800 F at 2.5 V. The available current at this voltage corresponds to a “current” equivalent capacitance of 3500 F.

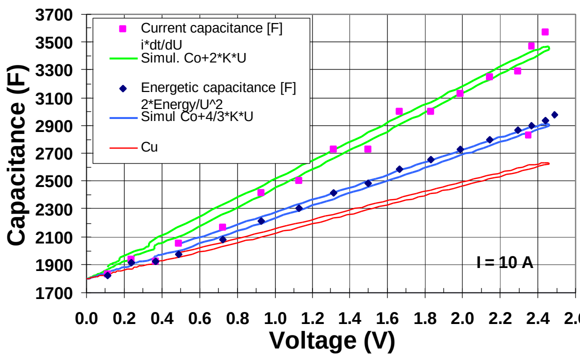

Figure 2: BCAP0010 Ultracapacitor equivalent capacitances

In most of the power electronic applications the operating voltage is higher than the cell voltage and a series connection has to be done. The voltage repartition on the cells depends on the capacitance for the transients operations and on the parallel resistance for the continuous operations. For safety reasons and for an energetic content optimization, different methods of voltage equalizing have been developed. These systems may be either active or passive. The different solutions will be discussed.