MEASUREMENT AND ESTIMATION OF SUPERCAPACITOR LIFE TIME

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The lifetime of a 350 F electrochemical double layer capacitor (EDLC) was estimated on the basis of leakage current measurements at various temperatures and voltages. Acceleration factors for the degradation processes at increased temperature and voltage were determined from Arrhenius type plots of the measured leakage currents. For standard conditions, a lifetime of more than 100 years was estimated.

1 INTRODUCTION

Electrochemical double layer capacitors (EDLC) are known as high power storage devices, which exhibit very good cycle life performance [1]. Today's capacitor manufacturers guarantee 500'000 full charge / discharge cycles. Life tests are very time consuming and it is therefore important to develop accelerated life tests which allow lifetime estimations under varying conditions. Therefore, life tests are performed at elevated temperatures and at voltages exceeding the nominal voltage, in order to accelerate the degradation processes.

2 EXPERIMENTAL

The leakage current of a commercially available EDLC (BCAP0350, Maxwell SA) with a nominal capacitance of 350 F was measured at various potentials between 2.5 V and 3.0 V and temperatures between -40 °C and +60 °C. In regular time intervals the capacitance and the equivalent series resistance (ESR) of the capacitor was measured by electrochemical impedance spectrometry (EIS).

3 RESULTS

We assume that the leakage current measured during the constant voltage test can be correlated to degradation processes [2]. For an ideal capacitor the leakage current should be zero. Plotting the leakage current as a function of temperature in an Arrhenius plot should allow estimating the respective activation energy.

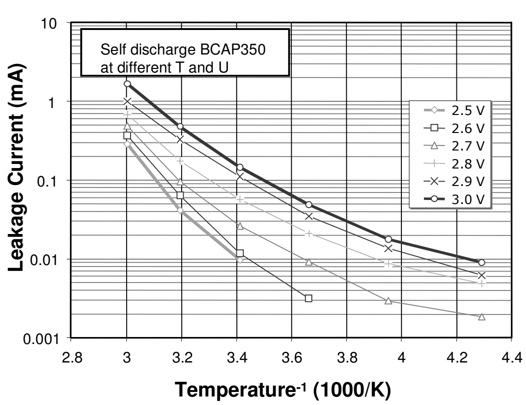

Fig. 1: Arrhenius plot for the leakage current of a 350 F EDLC at temperatures between -40 °C and +60 °C at various voltages.

Figure 1 shows the Arrhenius plot of the leakage current at various capacitor voltages. Unfortunately the data do not result in straight lines. Nevertheless, it is possible to estimate acceleration factors from fig. 1. An increase of 10 °C in temperature will accelerate degradation by a factor of 1.7 … 2.4, and an increase of the voltage by 0.1 V will result in an increase of the degradation processes by a factor of 1.5 … 2.

Figure 2 shows a log/log plot of capacitance and ESR during the constant load test of a BCAP0350 at 25 °C and 2.5 V. The end of life criteria for the capacitor is defined as a 20% capacitance loss and/or a 100 % ESR increase.

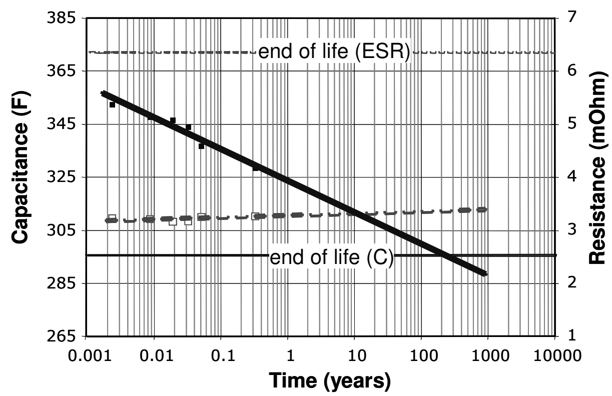

Fig. 2: Capacitance fading (full line) and ESR increase (dashed line) of an EDLC at 25 °C and 2.5 V.

Clearly, by this definition, the end of life is given by the observed capacitance fading. At 25 °C and 2.5 V the lifetime of the capacitor is estimated to more than 100 years. Using the above determined acceleration factors the lifetime of the capacitor at 25 °C and 3.0 V would reduce to ~10 years. A capacitor at 65 °C and 2.5 V would perform well for ~10 years. This is still acceptable for many applications.

4 ACKNOWLEDGEMENTS

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5 REFERENCES

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