

SUPPORT NOTE

ANP012 | How does a Supercapacitor age? Lifetime Model of Electric Double Layer Capacitors



Rene Kalbitz

01. LIFETIME MODEL

Supercapacitors show a gradual deterioration with time. Two possible approaches can be applied to anticipate the gradual loss of performance: firstly, by simply oversizing the capacitance, secondly, by adjusting the choice of specific operational parameters such as voltage and temperature. The graphs in Figure 1 show estimates of the remaining relative capacitance vs. time for different temperatures. With the given remaining capacitance, you may estimate the right oversizing.

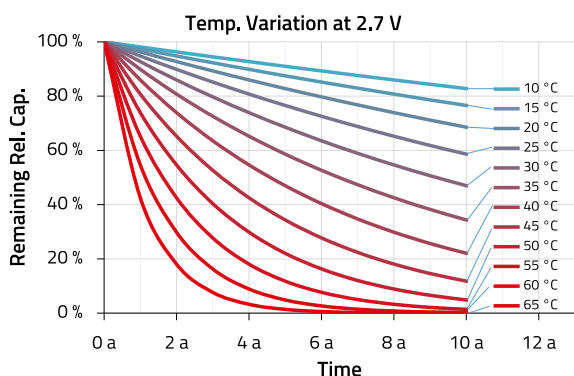


Figure 1: Family of curves calculated for a temperature range from 10°C to 65°C at a constant voltage of 2.7 V.

In Figure 2, the colour indicates the relative capacitance in units of percentage after 10 years for a specific set of temperature and voltage.

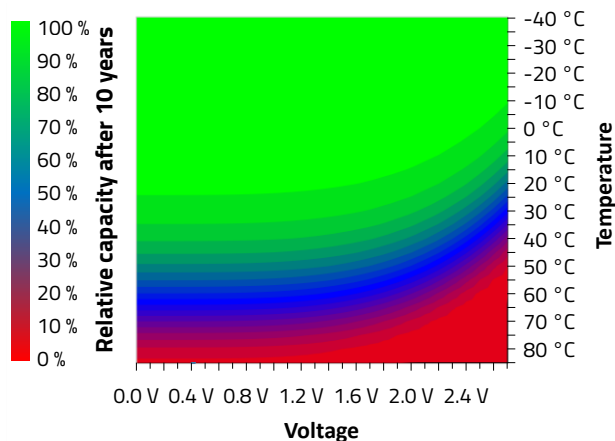


Figure 2: Contour plot shows the relative capacitance after 10 years for parameter sets of voltage (x-axes) and temperature (y-axes). The values of relative capacitance are encoded in the colour.

With this plot it is relatively convenient to determine the parameters, necessary to have a certain relative capacitance after a fixed time (in this case, 10 years). We may also estimate the degradation of capacitance for user defined operational profiles. The user may define a “typical working day” (24 h), such as given in Table 1. Based on this operational profile the remaining relative capacitance vs. time can be calculated, as given in Figure 3. You may choose between two load schemes.

	Periode 1	Periode 2	Periode 3	Periode 4
Load Scheme	Current ^[1]	Voltage	Voltage	Voltage
Op. Time	3 h	4 h	12 h	5 h
Op. Temp.	65 °C	50 °C	40 °C	22 °C
Appl. Voltage	/	2.7 V	2.7 V	0 V

Table 1: Example of high temperature operational profile for 24 h
^[1] Deterioration model is valid for conditions as used for cycle life tests. The capacitor is charged/discharged with a constant current of 0.1 A/F between the rated voltage V_r and $\frac{1}{2} V_r$. This current of 0.1 A/F is less than the $\frac{1}{2}$ of the rated current of the EDLCs. The strain due to current load and Joules heating may be therefore considered as relatively small.

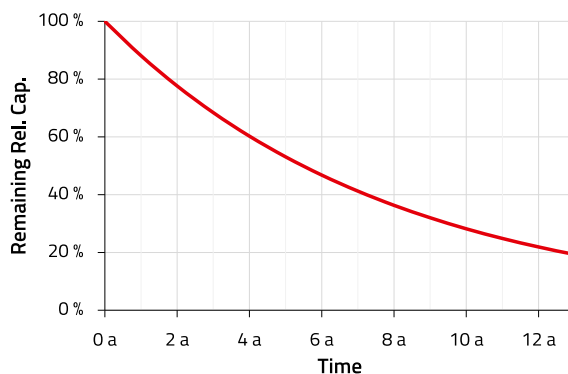


Figure 3: Relative capacitance vs. time for operational profile, given in Table 1.

The mathematical theory behind the diagrams presented above are based on models as well as specific endurance measurements.

Instead of leaving you alone with technicalities of mathematical calculations, we would like to perform the

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above mentioned lifetime calculations for you (see contact address below).

To assist in the service lifetime calculations, information on the load type is required, as shown in Table 1.

For lifetime calculations or further information on supercapacitors, please contact the Würth Elektronik support team via

- [Email-Hotline](#)
- [Contact form Würth Elektronik](#)

For more information on the use of supercapacitors, see:

[1] Supercapacitors - A Guide to the Design-In Process,

www.we-online.com/ANP077

[2] Balancing Supercapacitors,

www.we-online.com/ANP090

[3] How to use supercapacitors,

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CONTACT INFORMATION

appnotes@we-online.de

Tel. +49 7942 945 - 0



Würth Elektronik eiSos GmbH & Co. KG
Max-Eyth-Str. 1 · 74638 Waldenburg Germany
www.we-online.com

