SUPPORT NOTE

SN012 | How does a Supercapacitor age? Lifetime Model of Electric Double Layer Capacitors

Dr. 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.

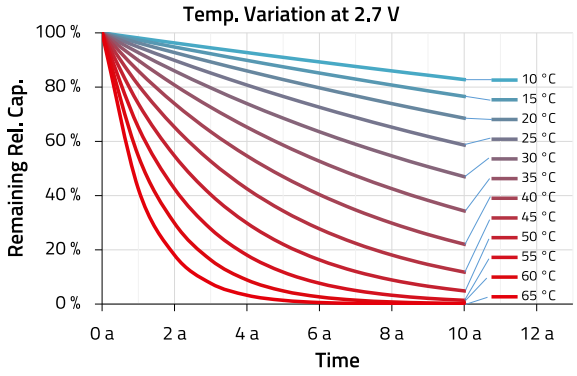

Figure 1: Family of curves calculated for a temperature range from 10 °C to 65 °C at a constant voltage of 2.7 V.

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

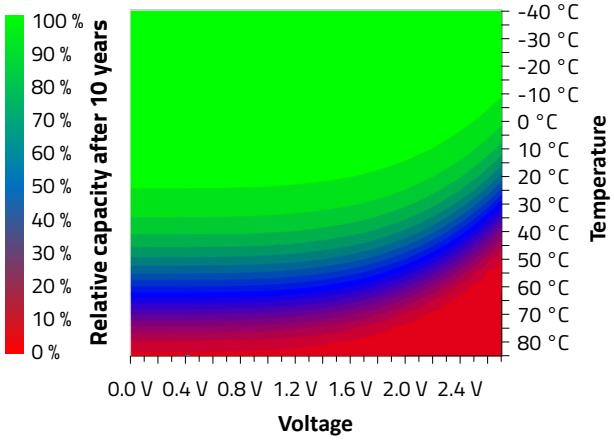

Figure 2: Contour plot shows the relative capacitance after 10 years for parameter sets of voltage (x-axes) and temperature (y-axes). The values of relative capacitance are encoded in the colour.

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 ½ V_r. This current of 0.1 A/F is less than the ½ of the rated current of the EDLCs. The strain due to current load and Joules heating may be therefore considered as relatively small.

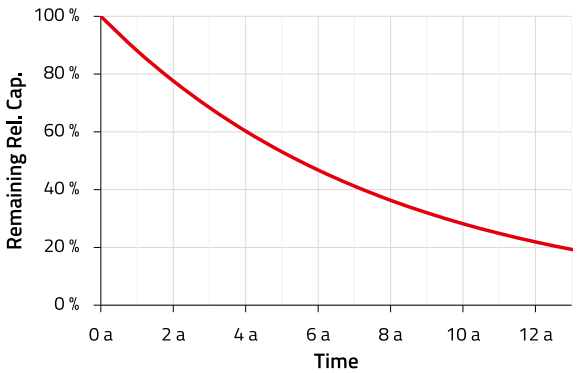

Figure 3: Relative capacitance vs. time for operational profile, given in Table 1.

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

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 support capacitors
- 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 www.we-online.com/SN009

IMPORTANT NOTICE

The Application Note is based on our knowledge and experience of typical requirements concerning these areas. It serves as general guidance and should not be construed as a commitment for the suitability for customer applications by Würth Elektronik eiSos GmbH & Co. KG. The information in the Application Note is subject to change without notice. This document and parts thereof must not be reproduced or copied without written permission, and contents thereof must not be imparted to a third party nor be used for any unauthorized purpose.

Würth Elektronik eiSos GmbH & Co. KG and its subsidiaries and affiliates (WE) are not liable for application assistance of any kind. Customers may use WE's assistance and product recommendations for their applications and design. The responsibility for the applicability and use of WE Products in a particular customer design is always solely within the authority of the customer. Due to this fact it is up to the customer to evaluate and investigate, where appropriate, and decide whether the device with the specific product characteristics described in the product specification is valid and suitable for the respective customer application or not.

The technical specifications are stated in the current data sheet of the products. Therefore the customers shall use the data sheets and are cautioned to verify that data sheets are current. The current data sheets can be downloaded at www.we-online.com. Customers shall strictly observe any product-specific notes, cautions and warnings. WE reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services.

WE DOES NOT WARRANT OR REPRESENT THAT ANY LICENSE, EITHER EXPRESS OR IMPLIED, IS GRANTED UNDER ANY PATENT RIGHT, COPYRIGHT, MASK WORK RIGHT, OR OTHER INTELLECTUAL PROPERTY RIGHT RELATING TO ANY COMBINATION, MACHINE, OR PROCESS IN WHICH WE PRODUCTS OR SERVICES ARE USED. INFORMATION PUBLISHED BY WE REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE A LICENSE FROM WE TO USE SUCH PRODUCTS OR SERVICES OR A WARRANTY OR ENDORSEMENT THEREOF.

WE products are not authorized for use in safety-critical applications, or where a failure of the product is reasonably expected to cause severe personal injury or death. Moreover, WE products are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. Customers shall inform WE about the intent of such usage before design-in stage. In certain customer applications requiring a very high level of safety and in which the malfunction or failure of an electronic component could endanger human life or health, customers must ensure that they have all necessary expertise in the safety and regulatory ramifications of their applications. Customers acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of WE products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by WE.

CUSTOMERS SHALL INDEMNIFY WE AGAINST ANY DAMAGES ARISING OUT OF THE USE OF WE PRODUCTS IN SUCH SAFETY-CRITICAL APPLICATIONS.

USEFUL LINKS

Application Notes
www.we-online.com/appnotes

REDEXPERT Design Plattform
www.we-online.com/redexpert

Toolbox
www.we-online.com/toolbox

Product Catalog
www.we-online.com/products

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