3V EDLC products for a longer useful life

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ABSTRACT

Few manufacturers have developed and launched 3.0V EDLC products in addition to 2.7V! In order to achieve a longer useful life in applications, there are innovative products that also meet the tougher and harsher requirements in terms of high humidity and low losses over a wide temperature range.

Electrical Double Layer Capacitors (EDLC) have shown significant growth in last several years.

EDLC products are high capacity rechargeable energy storage devices that can be charged and discharged very quickly. Due to their very low ESR (internal resistance), they deliver and absorb high peak power and are therefore also ideal for booster applications. Their capacity and storage capability is stable over a wide temperature range! Due to the virtually unlimited number of charging and discharging cycles, EDLC products can help to extend the useful life of a battery systems. In addition, EDLC products can downsize or completely replace the battery in a given application. This is useful for backup, energy harvesting and self-powered IoT applications.

The advantage of EDLC over batteries is that they can be charged much faster than batteries. EDLC products with 3V also store 20% more energy than a 2.7V system with the same size. In addition, 3V components helps electronic development engineers to get a longer useful life, as the voltage window is lager and will save space and costs on a PCB.

Today's 3V Vishay products can be exchanged 1:1 with the existing 2.7V types and enable a two to three times longer service life.

GENERAL EDLC TECHNOLOGY OVERVIEW

Vishay's electrical double layer capacitors (EDLC) are classic supercapacitors in radial design. An EDLC is a very high capacitance product that can reach up to 100 Farad values even in radial design. This technology fills the gap between aluminum electrolytic capacitors and rechargeable batteries. Much more energy can be stored in a supercapacitor than in conventional aluminum capacitors. High discharge currents are another advantage over rechargeable batteries, and EDLCs can tolerate many more charge and discharge cycles (> 1 million). Typical applications for EDLCs include backup power supplies, burst power support, energy harvesting storage devices, micro-UPS and energy recovery systems.

SPECIFIC CHARACTERISTICS

The basic structure of an EDLC consists of two activated carbon electrodes separated by a paper and an electrolyte that electrically connects the two electrodes. Fig. 1. EDLC capacitors use the so-called double layer effect to store electrical energy. A double layer capacitor has no solid dielectric separating the different potentials. The electrodes are polarized by an applied voltage. This causes the ions in the electrolyte to form electrical double layers on the two electrode surfaces. This physical effect enables the high energy density of this capacitor technology.

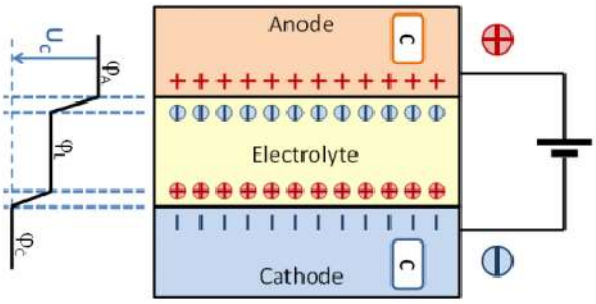

Fig. 1 Electrostatic Helmholtz EDLC I = 0

As a result of self-discharge, the charge retention of EDLC products is limited to a few weeks.

The useful lifetime of an EDLC is temperature- and voltage-dependent. 10 K (Kelvin) lower temperature will double the lifetime, and a 200 mV lower applied voltage will double the lifetime as well. This principle is derived from the well-known Arrhenius law on the acceleration of reaction processes. To ensure full performance even in elevated humidity conditions, Vishay has developed rugged EDLC versions such as the 225 EDLC-R and 235 EDLC-HVR.

If more than two capacitors are in a series connection, don’t forget to balance the products. Otherwise a voltage mismatch may occur.

The advantage of "ruggedized" EDLC variants is that these products can withstand harsher environmental conditions than standard versions.

Tests have shown that these "ruggedized" variants achieve service lives of 1,500 hours and longer even at 85°C/85%RH (source: Vishay, 235 EDLC-HVR). According to the IEC standard, only 1,000 hours are required for these components.

reference [1]

CALCULATION

In general, life time of EDLC’s is limited by degradation of electricl parameters. Usually no sudden failures occur. Life time of EDLC Systems is mainly dependent on application ambient temperature and applied voltage!

An Arrhenius approximation is sufficient to describe lifetime „t“ within limits. Commonly used acceleration factors / activation energies for EDLC models are:

Temperature T: activation energy $\Delta T = 10K$
rule: „Temperature reduction of $\Delta T = 10K$ (°C) doubles the lifetime

Voltage U: activation energy $\Delta U = 0.2V$
rule: „Voltage reduction of $\Delta U = 0.2V$ doubles the lifetime“

LIFE TIME t:

$$\mathbf{t} = \mathbf{t_o} * 2^{\frac{T_0 - T}{\Delta T_0}} * 2^{\frac{U_0 - U}{\Delta U_0}}$$

for $T < T_0$ and $2.2V < U < U_o < 3.0V$

T_0 ... rated temperature e.g. 3V @ 65C

U_0 ... rated voltage e.g. 3V @ 65C

LIFE TIME Multiplier m:

$$m1 = 2^{\frac{T_o - T}{\Delta T_0}}$$

$$m2 = 2^{\frac{U_o - U}{\Delta U_0}}$$

m = m1 * m2

$$\mathbf{t} = \mathbf{t_o} * \mathbf{m}$$

Fig. 2 life time calculation reference [2]

The service life can be determined using the multiplier diagram (Fig. 3), which shows the service life expectancy as a function of the ambient temperature and the applied voltage!

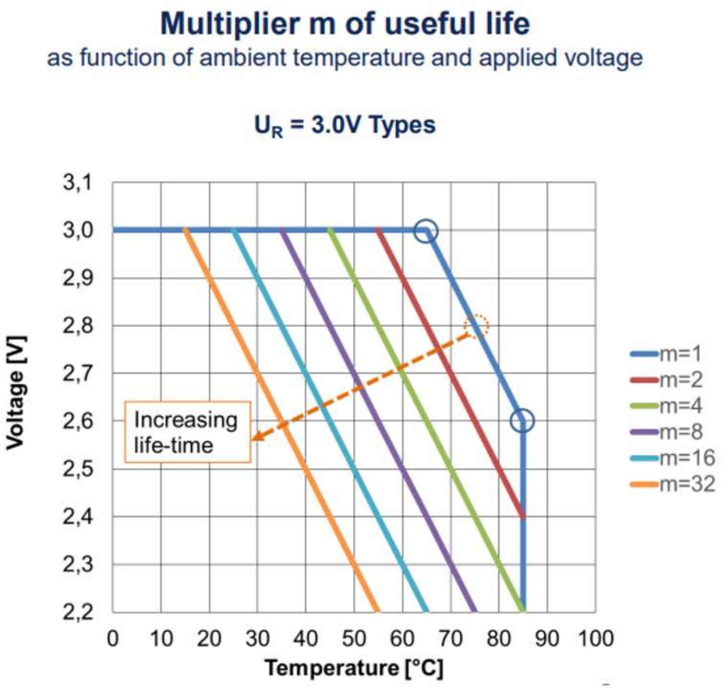

Fig. 3 multiplier graph for 3V EDLC products

Specified rated Voltage UR can be applied in the temperature range -40°C to +65°C. From +65°C to +85°C a linear voltage derating has to be applied.

The following diagram, Fig. 4, shows the safe operating range for the working voltage of 2.7 V and 3.0 V systems.

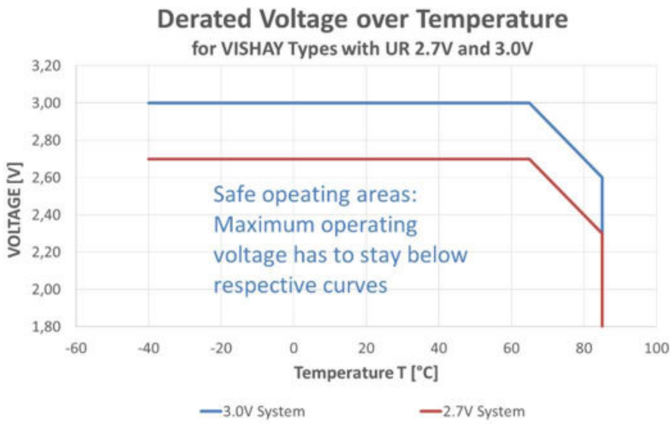

Fig. 4 voltage and temperature derating

Arrhenius modeling is standard for lifetime (t) prediction. Used acceleration factors and the simplified formula for multiplier calculation are commonly used in industry.

The typical degradation behavior of the supercapacitor resembles that of an exponential decay.
The majority of the performance change occurs during the initial use of the capacitor and this performance change then levels off over time. The most dramatic effect of the life degradation is on the internal resistance of the device (compared to initial value). This effect is taken into account in the product specifications, therefor the specified maximum initial ESR is higher than the typical value.

reference [3]

SUMMARY & CONCLUSION

This paper explains for a 3V product the increased lifetime compared to standard 2.7V products. 3V EDLC systems optimize the service life of the application. Lifetimes of supercapacitors >10 years are possible even above room temperature. The trend for the future is the development of products for higher application temperatures and smaller case sizes.

REFERENCES

[1] Vishay BCcomponents Austria, dokuwiki

[2] Supercapacitors, G.Q. Max Lu et. al; Wiley-CHV; ISBN 978-3-527-32883-3; 2013;p483ff

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