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Guide for the application of aluminium electrolytic capacitors

Leitfaden für die Anwendung von Aluminium-Elektrolyt-Kondensatoren

Guide pour l'utilisation de condensateurs électrolytiques a l'aluminium

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Guide for the application of aluminium electrolytic capacitors

Guide pour l'utilisation de condensateurs électrolytiques à l'aluminium

Leitfaden für die Anwendung von Aluminium-Elektrolyt-Kondensatoren

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CENELEC

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Foreword

This Technical Report was prepared by the Technical Committee CENELEC TC 40XA, Capacitors.

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1 Scope and object

1.1 Scope

This Technical Report applies to components as described in the scope of the following standards:

EN 60384-4 Fixed capacitors for use in electronic equipment - Part 4: Sectional specification - Aluminium electrolytic capacitors with solid (MnO_2) and non-solid electrolyte

EN 137100 Sectional Specification: Fixed aluminium electrolytic a.c. capacitors with non-solid electrolyte for motor starter applications - Qualification approval

The information given in these documents apply to capacitors with non-solid electrolyte but may, in its appropriate clauses, apply to capacitors with solid electrolyte as well.

In cases of doubt, the application of this document shall be discussed between the user and the manufacturer of the components.

1.2 Object

Electrolytic capacitors in general – and aluminium electrolytic capacitors in particular – are an exception in the capacitor field because of the components close interaction of physics and chemistry. Therefore, aluminium electrolytic capacitors show, in various aspects, a technical behaviour unaccustomed to the user. That could easily lead to misapplications and even to endangering of persons and goods. The aim of this application guide is to minimize these risks by providing detailed information on the specific peculiarities of the component.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 60384-1:2001 Fixed capacitors for use in electronic equipment - Part 1: Generic specification (IEC 60384-1:1999, mod.)

EN 60384-4:2007 Fixed capacitors for use in electronic equipment - Part 4: Sectional specification - Aluminium electrolytic capacitors with solid (MnO2) and non-solid electrolyte (IEC 60384-4:2007)

EN 137000:1995 Generic Specification: Fixed aluminium electrolytic a.c. capacitors with non-solid electrolyte for use with motors

EN 137100:1995 Sectional Specification: Fixed aluminium electrolytic a.c. capacitors with non-solid electrolyte for motor starter applications - Qualification approval

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
positive electrode (anode)
aluminium (preferably aluminium foil) of extreme purity which is etched in most cases in order to increase the electrodes surface and, consequently, the capacitors capacitance yield

3.2
negative electrode (cathode)
working electrolyte which is a conductive liquid in the case of capacitors with non-solid electrolyte or a layer of manganese dioxide MnO_2, conductive organic salt (e.g. TCNQ) or conductive polymer (e.g. polypyrrole) in the case of capacitors with solid electrolyte

3.3
dielectric
aluminium oxide Al_2O_3 which is formed on the anode's surface by an anodizing process

3.4
contact element for the negative electrode
a high-purity aluminium foil ("cathode foil") in the case of capacitors with non-solid electrolyte or silver epoxy on graphite or other conductive connections in the case of capacitors with solid electrolyte

3.5
separator

layers (preferably of special paper) which separate the anode foil from the "cathode foil" in the case of capacitors with non-solid electrolyte. The other purpose of these layers is to retain the working electrolyte

3.6
external insulation
the metallic case of capacitors with non-solid electrolyte is not insulated against internal capacitor elements as the case may be connected e.g. through the conductive working electrolyte. Therefore, the capacitors need an external insulation sleeve if electrical insulation is required

3.7
polarity
electrolytic capacitors are, on principle, polarized components. For special purposes, so-called non-polar (bipolar) capacitors may be provided. Such special types consist in principle of an internal back-to-back connection of two basically polarized elements

NOTE Motorstart capacitors are bipolar (see 12.4 and Clause 17).

3.8
sealing
the internal element of a non-solid electrolytic capacitor is normally encapsulated in an aluminium case closed with a sealing material which is never perfectly gas-tight. Because of using a non-solid electrolyte, of which, some constituents are slowly diffusing through the sealing, the electrical characteristics of the capacitor are changing gradually over its entire life

4 Protection measures

4.1 Handling and transport

Capacitors are generally housed in a 99,5 % aluminium case giving rise to low mechanical strength. Shocks must be avoided and manufacturer's packaging must always be used to transport capacitors.

4.2 Insulation

Capacitors may be either completely or partially insulated with sleeving. It should be noted that the capacitor case is not insulated from the cathode terminal.

Axial leaded capacitors have a direct contact between case and cathode terminal. Radial leaded capacitors have an undefined contact through electrolyte or other parts inside the case. Dummy pins shall be left potential-free or may be connected to the potential of the negative terminal. Metal parts other than terminals should never make contact to conducting tracks or metal parts of other components.

5 General application limits

5.1 Polarity - Reverse voltage

Electrolytic capacitors for d.c. applications require polarization.

The polarity of each capacitor is to be checked both in circuit design and in mounting. Polarity is clearly indicated on the capacitor. For short periods a limited reverse voltage is allowed as specified in the relevant specification or by the manufacturer (e.g. 1 V for capacitors with non-solid electrolyte). Exceeding the specified reverse voltage can induce damage by causing overheating, over-pressure and dielectric breakdown and may be associated with open circuit or short circuit conditions – it is the most severe failure mechanism with aluminium electrolytic capacitors. There could even be a destruction of the capacitor. Protections are to be used if there are reverse voltage risks (see Clause 10).

5.2 Voltage

Exceeding the capacitors specified voltage limits may cause premature damage (e.g. by breakdown with open or short circuit) affecting the useful life. Even destruction of the capacitor may be the consequence.

5.2.1 Rated voltage

The rated voltage U_R given in the relevant specification or by the manufacturer is the value permitted for continuous operation in the rated temperature range.

5.2.2 Surge voltage

For short periods the voltage may be increased up to the surge voltage value according to EN 60384-4, 4.14, and to manufacturer specification.

5.2.3 Transient voltages

The surge voltage value may be exceeded for very short periods or short pulses when in accordance with the relevant specification or as specified by the manufacturer. A test method is given in an amendment to EN 60384-4, 4.22.

5.3 Temperature range

The capacitors are to be used within specified temperature range.

Applicable temperature ranges are given in the relevant specifications and/or in manufacturer's data. A general principle is: lower ambient temperature means longer life. Therefore, electrolytic capacitors should be placed at the coolest positions wherever possible.

Exceeding the permitted temperature causes overheating and over-pressure which can affect the useful life.

5.4 Ripple current

The sum of d.c. voltage and maximum amplitude of ripple voltage shall remain within rated voltage and 0 V.

Electrolytic capacitors are not normally designed for a.c. application (see Clauses 1 and 17).

No excessive ripple current must be allowed to pass. Exceeding the ripple current specification reduces life and can induce overheating and over-pressure. Even destruction of the capacitor may be the consequence.

The useful life of the capacitor is a function of the r.m.s. ripple current. Temperature, frequency and cooling conditions are other influences on the useful life.

5.5 Charge - Discharge

Under the conditions defined in EN 60384-4, 4.20, or in manufacturers specifications, frequent charge/discharge operation is allowed.

Exceeding charge/discharge frequency leads to a high ripple current and induces damage by overheating and overpressure or breakdown with open circuit or short circuit, leading to a reverse voltage risk (see 5.1). Even destruction of the capacitor may be the consequence.

6 Storage

Capacitors should be stored at room temperature, normal atmospheric pressure, low humidity, and in manufacturers packaging (for more details see EN 60384-1, 4.25).

Storage at elevated temperature (higher than 40 °C to 50 °C) has a negative influence to leakage current inducing increases up to 10 times the maximum limit where the capacitors are off duty (see EN 60384-1, 4.25, and EN 60384-4, 4.17).

High humidity and/or high temperature may impair solderability and taping accuracy as well as the leakage current of the capacitors.

Storage at conditions defined above has a negligible effect on capacitance, tangent of loss angle or equivalent series resistance, and impedance.

Manufacturers recommendations (reforming procedures, etc.) shall be considered because long storage may influence the leakage current to increase beyond a reasonable level.

7 External pressure

(Not relevant for capacitors with solid electrolyte)

7.1 Low air pressure

Minimum air pressure is 8 kPa for short periods in accordance with EN 60384-4, 4.11.4.

7.2 High air pressure

The maximum operating pressure is dependant upon size and style of the capacitor. It should be specified by the manufacturer on request. Exceeding the specified value may damage the capacitor (e.g. destroyed cases, open pressure relief device, short circuit, etc.).

8 Self-recharge phenomenon (dielectric absorption)

Even if aluminium electrolytic capacitors are totally discharged, these components may afterwards develop some voltage without external influence. This self-recharge phenomenon is known as dielectric absorption or as dielectric relaxation.

The capacitor is a non-ohmic conductor and has, therefore, a non-uniform distribution of the electric field. This is correlated with electric space charges within the dielectric layer. In the case of open terminals, an increasing voltage is built up in the course of the electric charges relaxation.

Depending on the capacitor type and its designed voltage, such self-recharge may result in values (even several tens of volts) which could represent some risk: damage of semiconductor devices, sparking when by-passing the terminals, and so on.

Therefore, appropriate measures are advisable if such risks are to be avoided. In particular for capacitors of high capacitance and high electric charge, it is recommended, for instance, to keep the terminals shorted or to repeat the discharge before mounting them.

9 Flammability (passive and active)

Aluminium electrolytic capacitors contain materials which may inflame under the influence of external fire (passive flammability) or in case of a defect of the component (active flammability). Such flammable parts of the capacitor are for instance: plastic parts, insulation sleeve, moulding compounds, paper of the capacitors winding element, in some cases working electrolytes.

9.1 Passive flammability

Under the influence of high external energy, such as fire or electricity, the flammable parts may ignite. Subclause 4.38 of EN 60384-1 refers to the needle flame test (EN 60695-2-2 has been replaced by EN 60695-11-5) for testing the passive flammability of capacitors. The severities and requirements for different categories of flammability are listed in Table 7 of EN 60384-1. Most aluminium electrolytic capacitors meet the requirements of category B or C as given in the relevant specifications or by the manufacturer.

9.2 Active flammability

In rare cases the component may ignite caused by heavy overload or some capacitor defect. One reason could be that during the operation of an aluminium electrolytic capacitor with non-solid electrolyte, there is a small quantity of hydrogen developed in the component. Under normal conditions, this gas permeates easily out of the capacitor.