1 Definitions of electrical parameters

1.1 Voltages

1.1.1 Rated voltage

The rated voltage is the direct voltage value for which the capacitor has been designed and which is indicated upon it. For Aluminum electrolytic capacitors, rated voltages of 100 V are usually designated as "low voltage" and rated voltages >100 V as "high voltage"

1.1.2 Operating voltage

The capacitors can be operated continuously at full rated voltage (including superimposed AC voltage) within the entire operating temperature range.

1.1.3 Surge voltage

The surge voltage is the maximum voltage which may be applied to the capacitor for short periods of time, i.e. up to 5 times for 1 minute per hour. IEC 60384-4 specifies the surge voltage as follows:

for UR ≤ 315 V Surge voltage = 1.15 UR

for 500V > ≤ UR > 315 V Surge voltage = 1.10 UR

1.1.4 Superimposed AC, ripple voltage

A superimposed alternating (AC) voltage, or ripple voltage, may be applied to Aluminum electrolytic capacitors provided that the sum of the DC voltage and superimposed alternating (AC) voltage does not exceed the rated voltage, and the rated ripple current is not exceeded

1.1.5 Reverse voltage

Aluminum electrolytic capacitors are polar capacitors. Where necessary voltages of opposite polarity should be prevented by connecting a diode. The diode's conducting state voltage of approximately 0.8 V is permissible. Reverse voltages 1.5 V are tolerable for a duration of less than 1 second, but not in continuous or repetitive operation.

2.2 Capacitance

2.2.1 AC and DC capacitance

The capacitance of a capacitor can be determined by measuring its AC impedance (taking into account amplitude and phase) or by measuring the charge it will hold when a DC voltage is applied. The two methods produce slightly different results. As a general rule, it can be said that DC voltage based measurements (DC capacitance) yield higher values (DC capacitance) than the alternating current method (AC capacitance). The factors are approximately 1.0 to 1.5 and maximum deviations occur with capacitors of low voltage ratings. Corresponding to the most common applications (e.g. smoothing and coupling), it is most usual to Determine the AC capacitance of Aluminum electrolytic capacitors. Corresponding to the most common applications (e.g. smoothing and coupling), it is most usual to

Determine the AC capacitance of Aluminum electrolytic capacitors.

Figure 1

Simplified equivalent circuit diagram of an electrolytic capacitor

For this purpose, the capacitive component of the equivalent series circuit (the series capacitance CS) is determined by applying an alternating voltage of ≤ 0.5 V. As the AC capacitance depends on frequency and temperature, IEC 60384-1 and IEC 60384-4 prescribe a measuring frequency of 100 Hz or 120 Hz and a temperature of 20 ºC (other reference values by special request). There are also applications (e.g. discharge circuits and timing elements) in which the DC capacity Trance is decisive. In spite of this fact, capacitors for which the capacitance has been determined by the AC method are also used in such applications, whereby allowances are made to compensate for the difference between the two measuring methods.

However, in exceptional cases it may be necessary to determine the DC capacitance. The IEC Publications do not provide any corresponding specifications. Because of this, a separate DIN standard has been defined. This standard, DIN 41328-4, describes a measuring method involving one-time, non-recurrent charging and discharging of the capacitor.

2.2.2 Rated capacitance CR

The rated capacitance is the AC capacitance value for which the capacitor has been designed and which is indicated upon it. C_R is determined by specific measurement methods described in the relevant standards (IEC 60384-1 and IEC 60384-4).

2.2.3 Capacitance tolerance

The capacitance tolerance is the range within which the actual capacitance may deviate from the specific rated capacitance. Where the capacitance tolerances are to be indicated on the compo nets themselves, CapXon uses code letters to IEC 60062; this code letter is also part of the ordering code.

2.2.4 Temperature dependence of the capacitance

The capacitance of an electrolytic capacitor is not a constant quantity that retains its value under all operating conditions. The temperature has a considerable effect on the capacitance. With decreasing temperature, the viscosity of the electrolyte increases, thus reducing its conductivity. The resulting typical behavior is shown in figure 2.

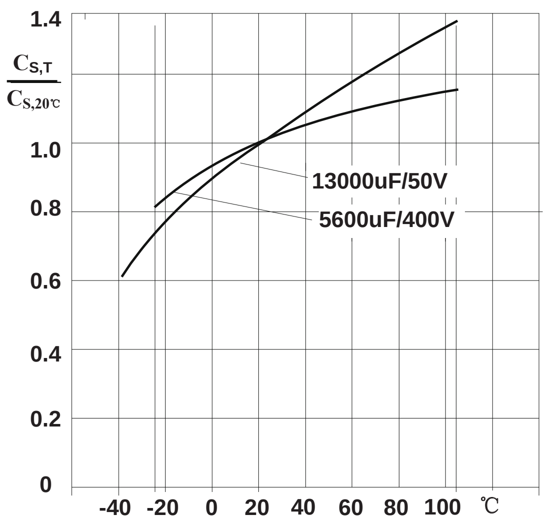


Figure 2

Temperature dependence of series capacitance CS (typical behavior) Reference value: AC capacitance at 20ºC and 120 Hz .As a general rule, the characteristic curves are steeper for lower rated voltages and increasing Anode surface roughness (deeper etching).

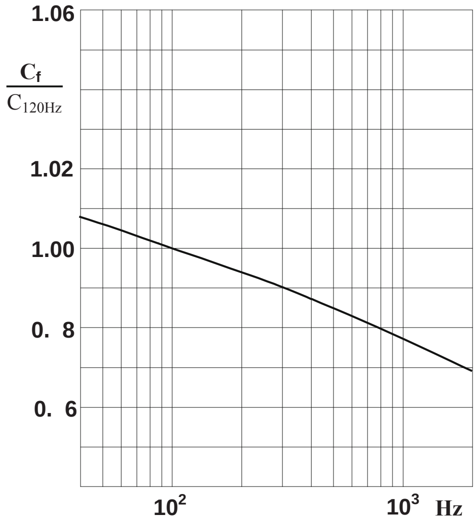
The most favorable flat shape of the curves shown in figure 2 is obtained by using special electrolytes which ensure that the capacitors can be operated at temperatures far below zero.

Radial

The shape of the curves varies widely, depending on whether the temperature relationship of the AC or of the DC capacitance is determined. The DC capacitance has a flatter temperature characteristic.

2.2.5 Frequency dependence of the capacitance

The AC capacitance depends not only on the temperature but also on the measuring frequency. Figure 3 shows the typical behavior. Typical values of the effective capacitance can be derived from the impedance curve, as long as the impedance is still in the range where the capacitive component is dominant.



$$C = \frac{1}{2 * \pi * f * Z}$$

C Capacitance F
f Frequency Hz
Impedance Ω

Figure 3

Capacitance C versus frequency f Typical behavior

2.2.6 Charge-discharge proof

Frequent charging/discharging cycles may lead to a decrease in capacitance. (Charge-discharge test to IEC 60384-4).

3.3 Dissipation factor δtan δ

The dissipation factor tan δ is the ratio of the equivalent series resistance to the capacitive reactance component in the equivalent series circuit, or the ratio of effective power (dissipated power) to reactive power for sinusoidal voltages.

It is measured using the same setup as for the series capacitance C_s (see figure 1).

3.4 Self-inductance ESL

The self-inductance or equivalent series inductance results from the terminal configuration and the internal design of the capacitor. It is defined by the equivalent series circuit shown in figure1

3.5 Equivalent series resistance ESR

The equivalent Series Resistance is the resistive component of the equivalent series circuit.

The ESR value depends on frequency and temperature and is related to the dissipation factor by the following equation:

$$ESR = \frac{\tan \delta}{\omega * C_s}$$

S Equivalent series resistance
tanδ Dissipation factor
s Series capacitance

The tolerance limits of the rated capacitance must be taken into account when calculating this value.

Radial

3.6 Impedance Z

The impedance of an electrolytic capacitor results primarily from the series circuit formed by the following individual equivalent series components (figure 4):

Figure 4
Simplified equivalent circuit diagram of an electrolytic capacitor

1) Capacitive reactance 1/ωCS of the capacitance CS
2) Dielectric losses and ohmic resistance of the electrolyte and the terminals (ESR)
3) Inductive reactance ωESL of the capacitor winding and the terminals.

The inductive reactance ωESL only depends on the frequency, where as $1/\omega C_S$ and ESR depend on frequency and on temperature. The characteristics of the individual resistive and reactive components determine the total impedance of the capacitor.

Capacitive reactance predominates at low frequencies. With increasing frequency, the capacitive reactance ($X_C = 1/\omega C_S$) decreases until it reaches the order of magnitude of the electrolyte resistance.

At even higher frequencies and unchanged temperatures (see 20 ºC curve), the resistance of the electrolyte predominates.

When the capacitor's resonance frequency is reached, capacitive and inductive reactance mutually cancels each other.

Above this frequency, the inductive resistance of the winding and its terminals ($X_L = \omega L$) becomes effective and leads to an increase in impedance.

The resistance of the electrolyte increases strongly with decreasing temperature.

3.7 Leakage current I_{Leak}

Due to the special properties of the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for longer periods. This current is called the leakage current. A low leakage current is an indication that the dielectric is well designed.

3.7.1 Time and temperature dependence of the leakage current

As figure 5 shows, a high leakage current flow (inrush current) in the first minutes after applying a voltage to the capacitor, in particular after prolonged storage without any applied voltage. In the course of continuous operation, the leakage current will decrease and reach an almost constant "steady-state" value. The temperature dependence of the leakage current is shown in figure 6, taking a capacitor of the 85 ºC temperature category as an example.

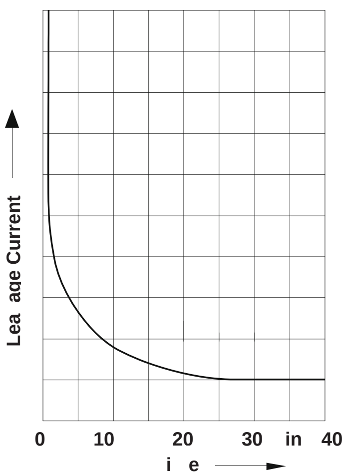


Figure 5
Leakage current versus time for which a voltage is applied

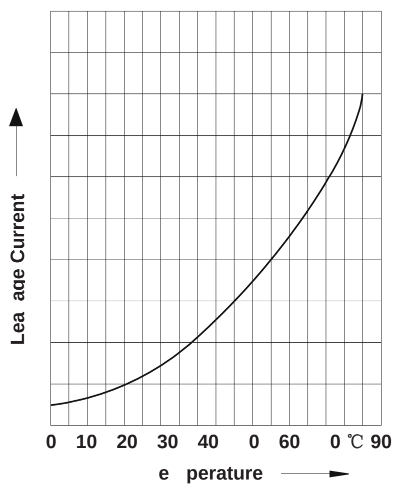


Figure 6
Leakage current versus temperature

3.7.2 Voltage dependence of the leakage current

The relationship between the leakage current and the voltage applied under constant temperature conditions is shown schematically in figure 7.

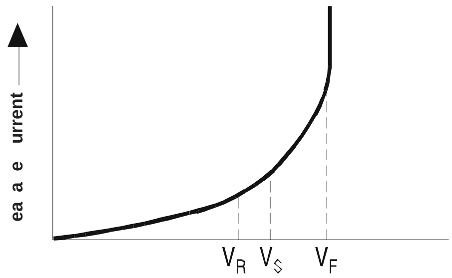


Figure 7→V

3.7.3 Leakage current for acceptance test Ileak

As the leakage current varies with time and temperature, it is necessary to define reference values for measuring time and temperature. To JIS-C-5101 the leakage current is to be measured at
20ºC, after the rated voltage has been applied for 5 minutes. The following equations apply:

$$\mathbf{I_{leak} \leq 0.3\mu A * (C * V)^{0.7} + 4\mu A}$$

Acceptance testing for leakage current can be carried out at any temperature between 15ºC and 35ºC, Referee tests are to be carried out at 20ºC.

3.7.4 Reforming

To IEC 60384-4, Aluminum electrolytic capacitors are to be subjected to a reforming process before acceptance testing. The purpose of this preconditioning is to ensure that the same initial conditions are maintained when comparing and assessing different products.

For this purpose, the rated voltage is applied to the capacitors via a series resistance of approximately 100 Ω for VR ≤ 100 V DC, or 1000 Ω for VR >100 V DC, for a period of one hour.Subsequently, the capacitors are stored under no-voltage conditions for 12 to 48 hours at a temperature between 15 and 35 ºC. The leakage current must then be measured, at the latest after 48 hours.

If the capacitors meet the leakage current requirements without preconditioning, this procedure can be omitted.

3.7.5 Leakage current behavior with no voltage applied (voltage-free storage)

The oxide layer may deteriorate when Aluminum electrolytic capacitors are stored without an externally applied voltage, especially at higher temperatures. Since there is no leakage current to transport oxygen ions to the anode in this case, the oxide layer is not regenerated. The result is that a higher than normal leakage current will flow when a voltage is applied after prolonged storage. As the oxide layer is regenerated in use, however, the leakage current will gradually decrease to its normal level.

If aluminum electrolytic capacitors can be stored voltage-free for more than six months, Provided that these storage periods have not been exceeded, the capacitors can be operated at rated voltage directly after being taken out of storage. When designing application circuits, attention must be paid to the fact that the leakage current may be up to 100 times higher than normal during the first minutes following the application of power. When the capacitors have been stored for more than six months, it is decisive whether the circuit. will tolerate high initial leakage currents. A circuit that has been stored for more than six months with the capacitors incorporated , should be operated trouble-free for one hour. This will usually regenerate the capacitors so far that storage can be continued.

Screw

3.8 Breakdown strength and insulation resistance of insulating sleeves

Most Aluminum electrolytic capacitors made by CapXon are enveloped by an insulating sleeve. The minimum breakdown strength of the sleeve is 2500 V AC or 3500 V DC. A test method for verifying the breakdown strength of the sleeves is described in IEC 60384-4.

In order to ensure full breakdown strength, care must be taken not to damage the insulating sleeve, especially when ring clips are used for mounting.

The insulation resistance of the sleeve is at least 100 MΩ. IEC 60384-4 specifies corresponding test methods.

As a standard feature, capacitors with an upper category temperature of +85 ºC and +105 ºC are fitted with external PET insulation.

4 Ripple current considerations

4.1 General

The term ripple current is used for the RMS value of the alternating current that flows through the device as a result of any pulsating or ripple voltage. The maximum permissible ripple current value depends on the ambient temperature, the surface area of the capacitor (i.e. heat dissipation area), the dissipation factor tan δ (or ESR) and on the AC frequency.

As thermal stress has a decisive effect on the capacitor's life expectancy, the dissipation heat generated by the ripple current is an important factor affecting the useful life. Diagrams showing the useful life as a function of the ambient temperature T_A are given in the individual data sheets

These thermal considerations imply that, under certain circumstances, it may be necessary to select a capacitor with a higher voltage or capacitance rating than would normally be required by the respective application.

4.2 Frequency dependence of the ripple current

The dissipation factor (which is related to the equivalent series resistance)of aluminum electrolytic capacitors varies with the frequency of the applied voltage. As a result, the ripple current is also a function of the frequency. In the individual data sheets, the ripple current capability of the capacitors is generally referred to a frequency of 120 Hz, or in some cases to 10 or 20 kHz. Conversion factors for other operating frequencies are given for each type in the form of a graph.

4.3 Temperature dependence of the ripple current

The data sheets specify the maximum permissible ripple current for the upper category temperature for each capacitor type. For most of the types with category temperature above 85ºC or 105ºC, the ripple current ratings for 85ºC or 105ºC have also been included for the purpose of comparison. The data sheets for each capacitor type also include a diagram showing the limit values for continuous operation at other ambient temperatures and ripple currents. This diagram also permits the expected useful life to be estimated for given operating conditions.

5 Useful life

Useful life (also termed service life or operational life) is defined as the life achieved by the capacitor without exceeding a specified failure rate. Total failure or failure due parametric variation is considered to constitute the end of the useful life

Depending on the circuit design, device failure due to parametric variation does not necessarily Imply equipment failure. This means that the actual life of a capacitor may be longer than the specified useful life. Data on useful life have been obtained from experience gained in the field and from accelerated tests.

The useful life can be prolonged by operating the capacitor at loads below the rating values (e.g. lower operating voltage, current or ambient temperature). In addition to the standard type series, CapXon is able to offer types with useful life ratings specially matched to customer specifications.

5.1 Load conditions

CECC defines the useful life of capacitors with liquid electrolytes on the basis of the following load conditions:

rated voltage

rated ripple current (the peak value of the AC voltage superimposed on the DC voltage must not exceed the rated voltage)

rated temperature

5.3 Calculation of useful life

The tables in the individual data sheets list the rated ripple current $I_{AC,R}$ for the upper category temperature(+85ºC,+105ºC) and for a frequency of 120Hz. The useful life for known ripple current loads and ambient temperatures is determined on the basis of the useful life graphs as follows:

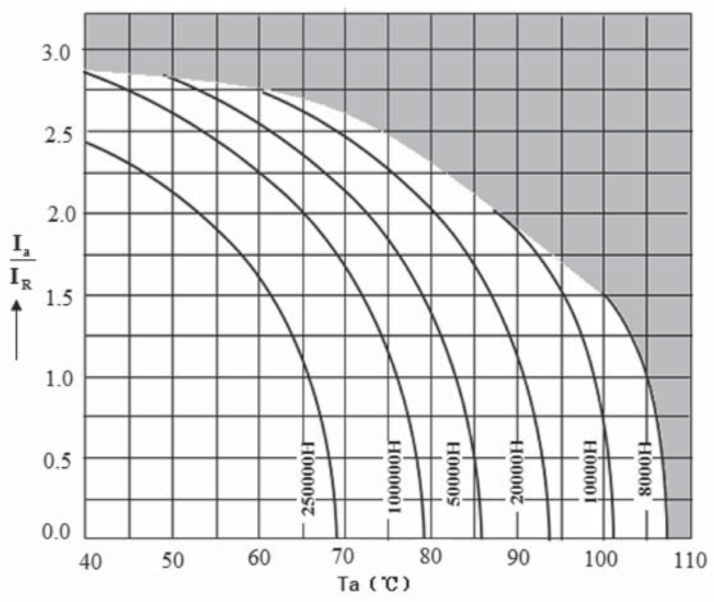
Determine the quotient I_{AC} /$I_{AC,R}$ of the required ripple current at the given ambient temperature

and the rated ripple current at the upper category temperature. The corresponding useful life value is given by the curve passing through the respective ambient temperature and the current quotient coordinates, or it can be interpolated if none of the useful life curves passes directly through these coordinates.

The frequency dependence of the ripple current has not been taken into account in the procedure described above. This must be introduced into the calculation in the form of an additional factor.

For each series precise curves for conversion factor $I_{RC,f}$ /I_{RC},120Hz versus frequency f are given in the individual data sheets.

The following examples illustrate the calculation procedure, using the data of a capacitor of the RH series. For this type series, the upper category temperature is +105 ºC. As an example, a capacitor with the following ratings has been selected from the data sheets:



VR	CR	Case	IRC,max 120Hz 105ºC A
450	6800	89*160	9.5

Example 1 – Calculating the useful life

The following values have been determined for capacitors to be used in a frequency converter. The corresponding useful life is to be calculated.

Ripple current 25 A

Frequency 400 Hz

Ambient temperature 50 ºC

The equivalent ripple current for 120 Hz is calculated using the frequency-dependence conversion factor (see series RH "Frequency factor of permissible ripple current I_{RC}"):

$$\frac{25\ \text{A}}{1.25} = 20\ \text{A}$$

The ripple current factor is then calculated using the resulting equivalent 120 Hz ripple current.

$$\frac{I_{RC}}{I_{RC.R}} = \frac{20\ \text{A}}{9.5\ \text{A}} \approx 2.1$$

The useful life curve passing through the coordinates for the ripple current factor and the ambient temperature (50 ºC) indicates the useful life that can be expected:100 000 h (see figure 8).

Example 2 – Checking the ripple current load on an Aluminum electrolytic capacitor

In many applications, Aluminum electrolytic capacitors are subjected to ripple currents of varying frequencies.

The equivalent total ripple current load shall be calculated for the following given RMS values:

Current 1: $I_{RC, RMS}$ at 400 Hz 20 A

Current 2: $I_{AC, RMS}$ at 4 kHz 16 A

Ambient temperature 50ºC

Required useful life 100000 h

The first step is to calculate the equivalent 120Hz values for the two current values (frequency factors given on series RH "Frequency factor of permissible ripple current I_{RC}") and the root-mean-square value of the two equivalent values:

Current I_1: $\frac{20\text{A}}{1.25} = 16\text{A}$

Current I_2: $\frac{16\ \text{A}}{1.32} \approx 12.12\ \text{A}$

$$I_{total.RMS} = \sqrt{I_1^{\ 2} + I_2^{\ 2}} = \sqrt{(16)^2 + (12.12)^2} \approx 20.07\text{A}$$

The ripple current factor can then be calculated

$$\frac{I_{total.RMS}}{I_{RC.R}} = \frac{23.38\text{A}}{9.5\text{A}} \approx 2.11\text{A}$$

The useful life curve passing through the coordinates for the ripple current factor and the ambient temperature (50 ºC) indicates the useful life that can be expected:100 000 h (see figure 8)

6 Capacitor bank design

In some applications the required capacitance may not be achieved by using a single aluminum electrolytic capacitor. This may be the case if

→ the required electrical charge is too high to be stored in a single capacitor,
→ the voltages that are to be applied are higher than can be attained by the permissible operating voltage ratings,
→ charge-discharge and ripple current loads would generate more heat than could be safely dissipated by a single capacitor, and
→ the requirements on the electrical characteristics (e.g. series resistance, dissipation factor or inductance) are so high that it would be too difficult or even impossible to implement them in a single capacitor.
In these cases, banks of capacitors connected in parallel or in series or in combined parallel and series circuits will be used. To prevent overloading of individual capacitors, the capacitance toler-ance must be taken into account when determining the maximum ripple current. Furthermore, the individual capacitors must not be subjected to negative voltages when the bank is discharged.

6.1 Parallel connection of Aluminum electrolytic capacitors

If one of the capacitors in a parallel circuit fails as a result of an internal short circuit, the entire bank is discharged through the defective capacitor. In the case of large banks with high energy content this may lead to extremely abrupt and severe discharge phenomena. It is therefore advisable to take measures to prevent or limit the short-circuit discharge current. In smoothing capacitor banks, e.g., this is achieved by installing individual fuses; the principle is shown in figure 9.

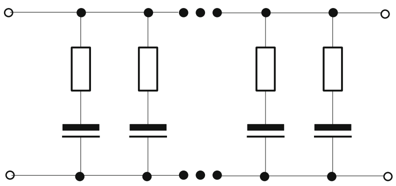


Figure 9
Individual fuses in smoothing capacitor banks

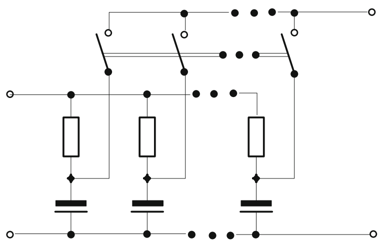


Figure 10
Protection by charging resistors

This principle is not suitable for capacitor banks designed for impulse discharges. Here, the capacitors should be protected during the charging process by means of appropriate resistors. The capacitors are then connected in parallel immediately before they are to be discharged. The principle is shown in figure 10.

6.2 Series connection of Aluminum electrolytic capacitors

When designing series circuits with Aluminum electrolytic capacitors, care must be taken to ensure that the load on each individual capacitor does not exceed its maximum permissible voltage. Here, the fact that the total DC voltage applied is divided up among the individual capacitors in proportion to their individual dielectric insulation resistances (figure 11) must be taken into consideration.

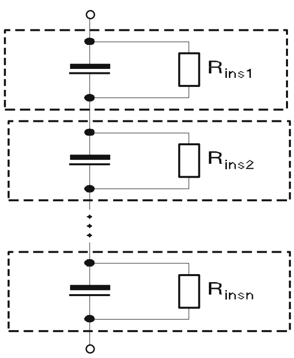


Figure 11
Series connection (with dielectric resistances)

If this is not possible, external balancing resistors R $_{\text{balance resistor}}$ (see figure 12) can be connected to the individual capacitors. The balancing resistances must be equal to one another, and must be substantially lower than the dielectric insulation resistance of the capacitor

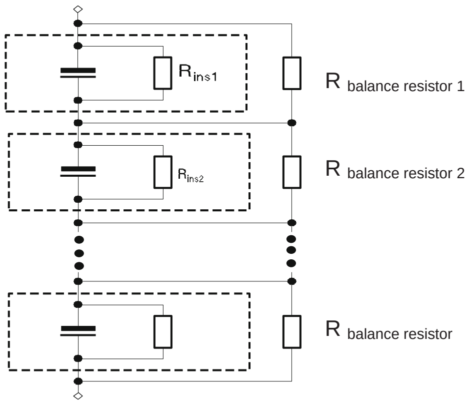


Figure 12
Series connection (external balancing resistors R connected to the individual capacitors)

Experience has shown that it is preferable to choose balancing resistance values that will cause a current of approximately 20 times the leakage current of the capacitor to flow through the resistors. The equation for calculating the resistance value is:

$$R_{\text{balance resistance}} = 50\text{M}\Omega * \mu\text{F} * \frac{1}{C_R}$$

The balancing measures described above may be omitted in cases where the total DC voltage to be applied is substantially lower than the sum of the rated voltages of the capacitors to be used.
Experience has shown that this is possible for n = 2 to 3 single capacitors in series without any considerable risk if the total voltage does not exceed 0.8 n V_R. However, this solution can only be implemented if the series circuit consists of matching capacitors (same type, same capacitance), so that the dielectric insulation resistance of the capacitors, which is the only factor determining the voltage distribution in this case, will not vary too greatly from one capacitor to the next.

6.3 Combined parallel and series connection

The recommendations given above apply similarly to combinations of parallel and series circuits. If balancing resistors are to be used, it is advisable to allocate a separate resistor to each capacitor (figure 13).

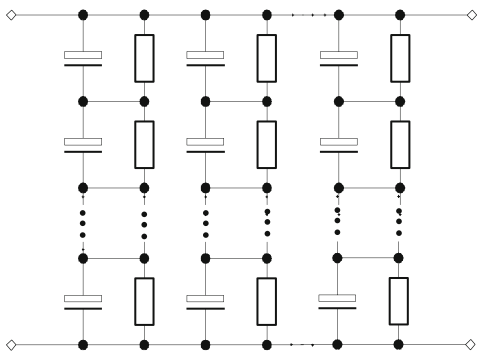


Figure 13
Combined parallel / series connection
(voltage balancing by shunt resistors)

The alternative solution, parallel connection of the series capacitors in the individual branch and the use of one balancing resistor for each capacitor group, is shown in figure 14

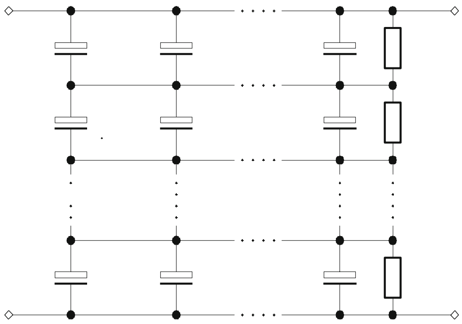


Figure 14

Combined parallel / series connection (group voltage balancing)

7 Climatic conditions

Limits must be set for the climatic conditions to which electrolytic capacitors are subjected (in part for reasons of reliability and in part due to the variation of the electrical parameters with tempera-ture). It is therefore important to observe the permissible minimum and maximum temperatures and the humidity conditions stated in coded form as IEC climatic category (refer to chapter "Gen-eral technical information, 7.4 IEC climatic category"). The IEC categories are given for each type in the corresponding data sheet.

7.1 Minimum permissible operating temperature (lower category temperature)

The conductivity of the electrolyte diminishes with decreasing temperature, causing an increase
in electrolyte resistance. This, in turn, leads to increasing impedances and dissipation factors (or equivalent series resistances). For most applications, these increases are only permissible up to
a certain maximum value. Therefore, minimum permissible operating temperatures are specified for Aluminum electrolytic capacitors. These temperature limits are designated "lower category temperature" and are also part of the IEC climatic category.
It should be emphasized that operation below this temperature limit will not damage the capacitor.
Especially when a ripple current flows through the device, the heat dissipated by the increased equivalent series resistance will raise the capacitor temperature so far above the ambient temperature that the capacitance will be adequate to maintain equipment operation.
The typical response of impedance and capacitance of a capacitor with a lower category tempera
ture of 25ºC

7.2 Maximum permissible operating temperature (upper category temperature)

The upper category temperature is the maximum permissible ambient temperature at which a
capacitor may be continuously operated. It depends on the capacitor design and is stated in the
respective IEC climatic category. If this limit is exceeded the capacitor may fail prematurely.
For some type series, however, operation at temperatures above the upper category temperature
is permissible for short periods of time. Details are given in the individual data sheets.
Useful life and reliability depend to a large extent on the capacitor's temperature. Operation at the
Lowest possible temperature will increase both useful life and reliability and is therefore recommended. For the same reason, it is advisable to select the coolest possible position within the equipment as a location for Aluminum electrolytic capacitors.

7.3 Storage temperature

Aluminum electrolytic capacitors can be stored voltage-free at temperatures up to the upper category temperature.

However, it must be taken into account that storage at elevated temperatures will reduce leakage
current stability, useful life and reliability. In order not to impair these qualities unnecessarily, the storage temperature should not exceed +40ºC and should preferably be below +25ºC.The standards for Aluminum electrolytic capacitors specify a lower storage temperature that corresponds to the lower category temperature.

8 Mechanical stress resistance

8.1 Vibration resistance

The vibration resistance values are specified in the individual data sheets.

8.2 Operating altitude

Aluminum electrolytic capacitors can be used in high-altitude locations (to EN 130300 subclause 4.11.4).

8.3 Robustness of terminals

The mechanical strength of terminals and leads is defined in the respective detail specifications. Terminals of the capacitors in this book also meet the test conditions specified by IEC 60068-2-21. For tightening torques for screw terminals, refer to chapter "General technical information, 11.3 mounting torques".

9 Maintenance

CENELEC R040-001 (chapter 1 to19) provides general information on applications in which
Aluminum electrolytic capacitors are used. The most important subjects are: safety requirements and measures, installation in equipment with inherent heating, destruction by overpressure, parallel and series capacitor circuits.

Make periodic inspections for the capacitors that have been used in the devices for industrial
applications. Before the inspection, make sure to turn off the power supply and carefully discharge the electricity of the capacitors. To check the capacitors, make sure of the polarity when measuring the capacitors by using a volt-ohm meter, for instance. Also, do not apply any mechanical stress to the capacitor terminals. The following items should be checked by the periodic inspections:

Significant damage to appearances: venting, electrolyte leakage, etc.

Electrical characteristics: leakage current, capacitance, tan and other characteristics prescribed in the catalogs or product specifications.

If any of the above is found, replace it or take any other proper measure.

10 Mounting

10.1 Mounting positions of capacitors with screw terminals

During operation Aluminum electrolytic capacitors will always conduct a leakage current which causes electrolysis. On one hand, the oxygen produced by electrolysis will regenerate the dielectric layer, but, on the other hand, the hydrogen released may cause increased internal pressure of the capacitor.

A safety vent in the can disk allows the gas to escape when the pressure reaches a certain level
and prevents the capacitor from exploding in case of pressure increase due to an overload condition.

To prevent electrolyte from leaking out when the gas has vented, the capacitor should not be mounted with the terminals (safety vent) upside down. The recommended mounting positions to avoid a vent-down installation of the capacitor are shown in figure 15.

Radial

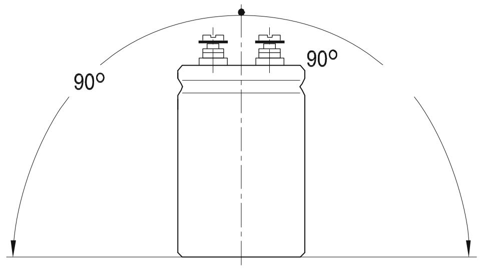


Figure 15
Recommended range of mounting positions

Upright mounting is recommended, particularly when the capacitors are fixed by their terminals, by a threaded stud or near the base.
In case of horizontal mounting, the safety vent should be at the "12 o'clock" position.
Mounting positions other than recommended will not cause any direct damage to the capacitor, but may result in serious consequential damage in the application during operation due to electrolyte leakage in the case of venting.

10.2 Soldering

Excessive time or temperature during soldering will affect capacitor's characteristics and cause damage to the insulation sleeve.
Contact of the sleeve with soldering iron must be avoided.
Soldering conditions (preheat, solder temperature and dipping time) should be within the limits prescribed in the product specifications.

10.3 Cleaning agents

Halogenated hydrocarbons may cause serious damage if allowed to come into contact with
aluminum electrolytic capacitors. These solvents may dissolve or decompose the insulating film and reduce the insulating properties to below the permissible level. The capacitor seals may be affected and swell and the solvents may even penetrate them. This will lead to premature component failure.
Because of this, measures must be taken to prevent electrolytic capacitors from coming into con-
Tact with the solvents when using halogenated hydrocarbon solvents to clean printed circuit boards after soldering the components, or to remove flux residues. If it is not possible to prevent the electrolytic capacitors from being wetted by the solvent, halogen-free solvents must be used
in order to eliminate the possibility of damage.

Halogen-free solvents:

Ethanol (methylated spirits) Propanol
Isopropanol Isobutanol Propylenglycolether
Diethyleneglycoldibutylether

Critical solvents:

The following list contains a selection of critical halogenated hydrocarbons and other solvents fre- quently used, partially in pure form, partially in mixtures with other solvents, as cleaning agents in the electrical industry.
Trichlorotrifluoroethane (trade names e.g. Freon, Kaltron, Frigene)
Trichloroethylene
Trichloroethane (trade names e.g. Chlorothene, Wacker 3 1) Tetrachloroethylene (trade name: Per)
Methylenechloride Chloroform Carbontetrachloride Acetone Methylethylketone Ethylacetate Butylacetate

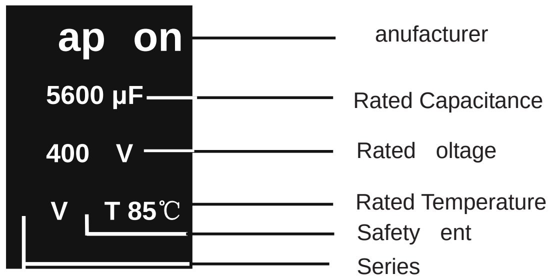
However, printed-circuit board cleaning equipment is available which uses halogenated solvents but is designed to enable thorough cleaning in a very short time (four-chamber ultrasonic cleaning process). Furthermore, the processes used ensure that virtually no solvent remains on the cleaned parts.

This means that the general warning against the use of halogenated cleaning solvents on aluminum electrolytic capacitors can be qualified if the following conditions are met:

1. The cleaning period in each chamber must not exceed 1 minute.
2. The final cleaning stage must use a solvent vapor only. The temperature must be 50ºCor lower.
3. Adequate drying must be ensured immediately after the cleaning process in order to evaporate any condensed residual solvent.
4. Contaminated cleaning agents must be regularly replaced as specified by the manufacturer and by legal regulations.

11 Marking of the capacitors

The example below shows how the screw capacitors are marked:



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Screw

Corporate goals

We adhere to the tenet of "QUALITY FIRST", and offer satisfying products and service to the customer. This aim is shared by the CapXon quality and environment management system:

1 CapXon quality system

1.1 CapXon quality policy and entironment policy

We adhere to the tenet of "QUALITY FIRST", and offer satisfying products and service to the customer.

1.2 Quality management system

The quality management system to ISO/TS 16949:2009 is applied throughout the company and is used to implement the CapXon quality policy.

The implications include:

As a rule, product and process developments follow the rules of APQP),

Quality tools such as FMEA), MSA) and SPC) minimize risks and ensure continuous improvements in conjunction with regular internal audits and QM reviews.

1.3 Certification

The CapXon quality management system forms the basis for the company certification to ISO 9001-2008 and ISO/ TS16949:2009 that comprises the CapXon plants and sales organizations.

1.4 Delivery quality

“Delivery quality” means compliance with the agreed data at the time of delivery.

1.5 Failure criteria

A component is defective if one of its features does not correspond to the specification of the data sheet or an agreed delivery specification. Failure criteria please refer to Defective degree evaluation and handling method of reliability experiment.

1.6 Incoming goods inspection at the customer

We recommend the use of a random sampling plan according to ANSI-ASQC Z 1.4 (contents compliant with MIL STD 105 D and IEC 60410) for incoming goods inspection. The test methods to be used are laid down in the relevant standards. Deviations must be agreed by the customer and the supplier.

1.7 Duration of use

The service life in terms of reliability is the time period during which random failures occur, i.e. the range in the product operating life in which the failure rate remains largely constant (early failures and end of operating life excepted). The value depends strongly on conditions of use.

1.7.1 Failure rate (long-term failure rate)

The failure rate is defined as the failure percentage divided by a specified operating period. The failure rate is expressed in fit (failures in 10^9 component hours) or as percentage of failures in1000 hours.

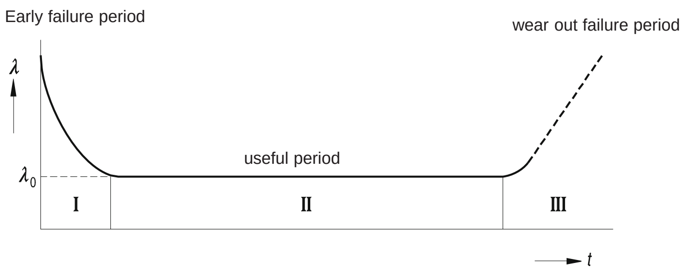
1 fit = 1 $\times 10^{-9}$/h (fit = failure in time)

Example of a failure rate test determined by a useful life test:

1. Number of components tested N = 10000
2. Operating hours tb = 20000 h
3. Number of failures n = 2

$$\lambda_{test} = \frac{n}{N} * \frac{1}{t_b} = \frac{2}{10000} * \frac{1}{20000H} = 10FIT = 0.001\%/1000H$$

Failure rate specifications must include failure criteria, operating conditions and ambient conditions. Usually the failure rate of components, when plotted against time, shows a characteristic curve with the following three periods: I: early failure period, II: useful period, III: wear-out failure period



Unless otherwise specified, the failure rate refers to the useful period (II). During this period, an approximately constant failure rate 0 can be assumed.

1.8 AQL values

The AQL (AQL= acceptable quality level) figures are based on a random sampling plan to ANSI-ASQC Z1.4.

The sampling instructions of this standard are such that a delivered lot will be accepted with a probability of 90% if the percentage of non-conformancies does not exceed the stated AQL figure. As a rule, the percentage of non-conformancies in deliveries from CapXon is significantly below the AQL figure. The acceptance value we apply to inoperatives, i.e. unusable components is c= 0.

2 Environmental management system

2.1 Environmental policy

CapXon defines the following environmental protection principles:

Comply with the law, Govern the pollution, Produce Cleanly, Reduce the consume, Save resource, Cut down the toxic substance, Make Improvement Continuously, Beautify the environment

2.2 Environmental management system

The CapXon ISO 14001 based environmental management system is applied company wide for implementing the CapXon environmental policy. It is posted on the CapXon Intranet and is thus accessible to all employees.

2.3 Environmental Hazardous Substances Free management system

The CapXon QC080000 based HSF management system is applied company wide for implementing the CapXon environmental Hazardous Substances management. that Capxon products effectively in the management of hazardous substances.

2.4 Certification

2.4.1 The CapXon Group operates an environmental management system that conforms to the require- ments of ISO14001 and is mandatory for all plants. The CapXon Group operates an environmental Hazardous Substances Free management system that conforms to the requirements of QC080000 and is mandatory for all plants.The company certificate is posted on the CapXon internet:
(www.capxongroup.com).

2.4.2 SONY GP certification: On Nov 2011, CAPXON have already got the SONY GP certification .GP NO.:FC012746

2.4.3 C-ROHS certification: On Dec 2012, CAPXON have already got the C-ROHS certification. products type: SMD

Screw

type, Snap-in type and Radial type.

2.5 RoHS

The term “RoHS-compatible” shall mean the following:

The components described as“RoHS-compatible” are compatible with the requirements of the regulations listed below(“Regulations”) and with the requirements of the provisions which will result from transformation of the Regulations into national law to the extent such provisions reflect the Regulations:

Directive 2002/95/EC of the European Parliament and of the Council of January 27, 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment

("Directive 2002/95/EC");The directive from July 1, 2006 entered into force.

Commission Decision of 1August 18, 2005 amending Directive 2002/95/EC (2005/618/EC); Commission Decision of October 13, 2005 and of October 21, 2005 amending the Annex to Directive 2002/95/EC (2005/717/EC, 2005/747/EC, 2006/310/EC, 2006/690 .692/EC).

December 3, 2008 The European Commission published its official Web site of the RoHS directive revised draft COM (2008) 809 / 4.

September 3, 2009 RoHS EU issued a revised second draft Directive COM (2008) 809final.

October 22, 2009 EU Environment Public Health and Food Safety Committee (Committee on the environment, public health and food safely) released on COM (2008) 809 of the amendments.

July 1, 2011,the European Parliament and Council issued directive 2011/65/EU(ROHS.2.0) in the official Journal of the European Union to replace the 2002/95/EC. The new directive has been fully implemented on January 1,2013, the old directive 2002/95/EC has been abolished.

RoHS Directive, also known as Amendment RoHS 2.0, the amendment involves a lot of content. But the basic objectives and mechanisms have not been changes, the ultimate goal still is to reduce the electrical and electronic products of certain hazardous substances.

The instruction modified to increase 4 to be "priority review" the use of substances HBCDD, DEHP, DBP and BBP.

2.6 Halogen Free(HF)

Base on customer and environmental regulations on the management and control requirements of halogen , such as the European 2002-95-EC, IEC 61249-2-1, ”Montreal Protocol on Substances that Deplete the Ozone Layer”, “Controls the Stockholm joint pledge about durable organic pollutant”, CapXon has imported halogen-free materials of all electrolytic capacitors completely at the beginning of 1st,June,2009. All products shipped meet the halogen-free requirements on 31th,Oct,2009.

2.7 Banned and Environmental Hazardous Substances in components

As a manufacturer of passive components, we develop our products on the basis of sustainability.

In order to guarantee a standardized procedure for CapXon Group, a mandatory list of Environmental Hazardous Substances of special interest is part of our environmental management system. The planning and development instructions include regulations and guidelines that aim to identify environmental aspects and to optimize products and processes with respect to material use and environmental compliance, to design them with sparing use of resources and to substitute hazardous substances as far as possible.

In consideration of the environmental aspects are checked and recorded in the design reviews: the environmental officer provides support in the assessment of the environmental impacts of a development project.

2.8 Product Series and Specifications for product catalog

CapXon Product Series and Specifications on the Internet (www.capxongroup.com) ,It is available to refer to check for customers.

2.9 Disposal

All aluminum electrolytic capacitors can be disposed off, reused or recycled. However as disposal is regulated by national law, the respective national provisions have to be observed.