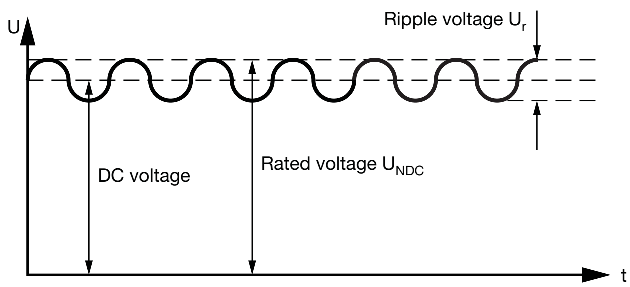
Power Electronic Capacitors

BASIC INFORMATION

Power electronic capacitors (PEC) are specially designed for DC voltage and for non-sinusoidal AC waveforms of voltages and currents.

DC APPLICATION

DC capacitors are periodically charged and discharged. This capacitor type is used to reduce the AC component of a DC voltage. Supporting or DC filter capacitors are used for energy storage.



Definitions:

- **Rated DC Voltage U_{NDC}**
  Maximum operating peak voltage of either polarity but of a non-reversing type waveform for which the capacitor has been designed, for continuous operation.
- **Ripple Voltage U_r**
  Peak to peak alternating component of the unidirectional voltage.

STANDARDS

The capacitors listed in this catalog are subject to the international standards for "capacitors for power electronics:"

- IEC 61071
- IEC 61881-1
- IEC 60068 basic environmental testing procedures
- EN 45545 railway applications
  Fire protection on railway vehicles
- IEC 61373 railway applications
  Rolling stock equipment - shock and vibration tests

TECHNICAL DATA

Operating Mode

- Continuous operation

Filling Material

- Resin [(1)]

Operating Temperature

- Min. / max. operating temperature: -40 °C / +70 °C
- Min. / max. storage temperature: -50 °C / +85 °C
- Max. hot spot temperature: +85 °C

Self-Discharge Time Constant

- > 10 000 s

Life Expectancy With 3 % (ΔC/C) (whereas C describes the initial value measured during routine test)

- Up to 250 000 h depending on hotspot temperature

Mounting Position

- Vertical / horizontal
- Upside down

Protection

- Overpressure valve [(1)] for rectangular caps (overpressure switch on request for rectangular capacitors)

Dielectric Loss Factor

- tan d = 2 x 10^{-4}

Capacitance Tolerance

- ± 10 % or ± 5 % [(1)]

Test Voltages

- Terminal/terminal
  DC test voltage 1.5 U_{NDC}/10 s
- Terminal/casing
  2 x U_l + 1000 V or 2000 V, whichever is the highest value

Notes

- $U_l = U_{NDC}$

(1) If values differ from this data this is mentioned separately

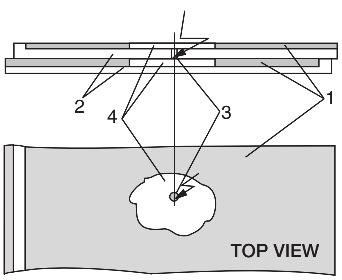
TECHNOLOGY AND DESIGN

MKP-Dielectric

The most common dielectric material for PEC is polypropylene. It is a special high temperature polypropylene film with a thin metallization on one side of the film. The metallization has an optimized structure in a mixture of aluminum / zinc and in the ohmic profile, which depends on the application and capacitor demands. Vishay developed special profiles for the different applications.

Self-Healing Effect

As a result of the self-healing effect, the capacitor is fully operational after an electrical breakdown. A breakdown generates a small electric arc, which evaporates the metallization around the area of breakdown in only a few microseconds and at very low energy. The localized increase in gas pressure caused by the high temperature of the arc blows the gaseous metallization away from the breakdown point. By means of this process, a metal-free, non-conductive isolation crescent is formed, which enables continuous full operation of the capacitor.



Self-healing breakdown

1 Electrodes (metallized)

2 Polypropylene film

3 Point of breakdown

4 Non-conductive insulating area

Winding Element

All self-healing capacitors are comprised of one or more individual cylindric winding elements. For contacting the elements in parallel or in series, a solderable lead (Pb)-free metal base layer is sprayed onto the front sides of the winding elements. The process of metal spraying is called “schooping.” The connection of the windings in parallel or in series is accomplished by means of a highly flexible copper material. In this way the capacitors are able to fulfill the highest demands of current load, low inductive characteristics, low ohmic drop and shock, and vibration-proof performance.

Filling Material

After mounting the stack of winding elements into the cases, the capacitors are dried under a vacuum, and gas-impregnated with N2 (nitrogen) before filling.

- **Resin Filling / ESTAdry**
  Most of self-healing capacitors in rectangular cases, and a number of capacitors in cylindrical cans, are filled with a soft resin mainly based on vegetable castor oil. The casting compound R25 developed by Vishay remains elastic throughout the entire life of the capacitor.
  This elastic casting compound offers outstanding shock and vibration protection for the internal structure and long lasting protection against the penetration of moisture into the electrical components of the capacitor.
  A very good thermal conductivity of the casting compound enables maximum capacitor loads under high temperature stress conditions.
  The casting compound can be treated as ordinary waste.

DEFINITIONS

Rated Capacitance (C_N)

Capacitance value rated at 20 °C / 53 Hz.

Tolerance on Capacitance (± .. %)

Capacitance range within which the actual capacitance may differ from rated capacitance C_N.

Rated DC Voltage (U_{NDC})

Maximum operating peak voltage of either polarity but of a non-reversing type waveform, for which the capacitors have been designed, for continuous operation.

Ripple Voltage (U_r)

Peak to peak alternating component of the undirectional voltage.

Series Resistance (R_S)

Effective ohmic resistance of the conductors of a capacitor under specified operating conditions.

Thermal Resistance (R_{th})

Thermal resistance indicates by how many degrees the capacitor temperature at the hotspot rises in relation to the power losses.

Maximum Current ($I_{max.}$)

Maximum root mean square current for continuous operation.

Maximum Peak Current ($\hat{I}$)

Maximum peak current that can occur during continuous operation.

Maximum Surge Current ($\hat{I}_S$)

Peak non-repetitive current induced by switching or any other disturbance of the system which is allowed for a limited number of times, for a duration shorter than the basic period.

Dielectric Loss Factor (tan d)

Constant dissipation factor of the dielectric material for all capacitors in their rated frequency.

Inductance (L_S)

Represents the sum of all inductive elements which are for mechanical construction reasons contained in any capacitor.

Lowest operating temperature ($\theta_{min.}$)

Lowest temperature at which the capacitor may be energized.

Maximum operating temperature ($\theta_{max.}$)

Highest temperature of the case at which the capacitor may be operated.

Reliability

The operating reliability of the capacitor is determined by the number of failures, within an adequately large batch, expected to occur after a specified time (life expectancy).
DIN 40040 has replaced the previous term “operating reliability” by the new term “reference reliability.”

Reference Reliability

Reference reliability is expressed in terms of failure quota and respective load duration (not including storage times). Reference reliability is the reliability for defined load (reference load). The reference exposure figure quoted relates to operation under nominal conditions and the application class given in the data lists.

Buzzing Noise

An audible buzzing noise generated by the capacitor during AC voltage application is caused by the vibration of the film due to coulomb forces between the capacitor plates.

Conditions which may lead to and / or amplify the buzzing noise are:

- a wave form with high distortion
- a wave form with high frequency harmonics

The buzzing noise is not indicative of a quality problem and does not affect the performance of the capacitor.

Failure Ratio

The failure ratio is the relationship between the number of failed capacitors and the total number of capacitors used. It applies to a particular capacitor only and the load duration cited (life expectancy). The figure quoted in the data lists is an average, which is generally not exceeded if examining an adequately large number of capacitors.

FIT

FIT = failures in time

The failure rate in FIT indicates the maximum failed components within 1 x 10^9 component operation hours.

Calculation of Hotspot Temperature

$$P = U_{r,\,rms}^2 \times 2\pi f_{ripple} \times C_N \times \tan d + I^2 \times R_S$$

$$\theta_{hotspot} = T_{amb} + R_{th} \times P$$

Tangent of the Loss Angle

$\tan \delta = R_{ESR}\, \omega C = \tan d + R_S\, \omega C$

$\tan d$ = dielectric loss factor