Passion for Challenges

SAMWHA Energy Saving Products Guide

ELDIS

ELDIS Ehmki & Schmid OHG

Straßfeld 1
D-85777 Fahrenzhausen

Fon +49 8133 - 444 22 • 0
Fax +49 8133 - 444 22 • 11

info@eldis.de
www.eldis.de

INDEX

1 High Voltage MLCC

2 PEA (Power Electronic Applications)

3 HEV DC link Capacitor

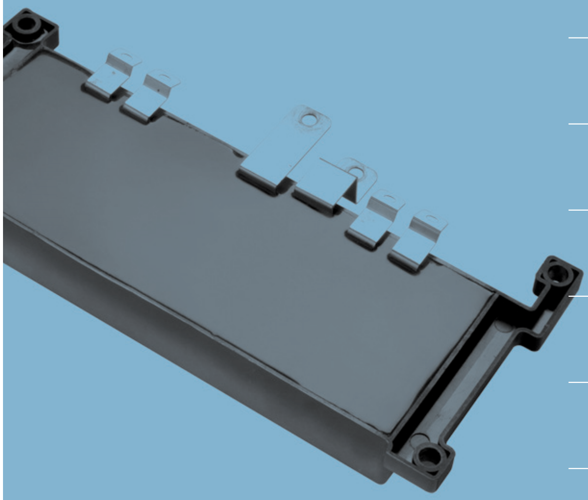
4 RNE (Renwable Energy Capacitor)

5 Green-Cap (EDLC)

6 Ferrite Cores

7 MPC (Magnetic Powder Cores)

8 High Current SMD Power Inductor (MPC Inductor)



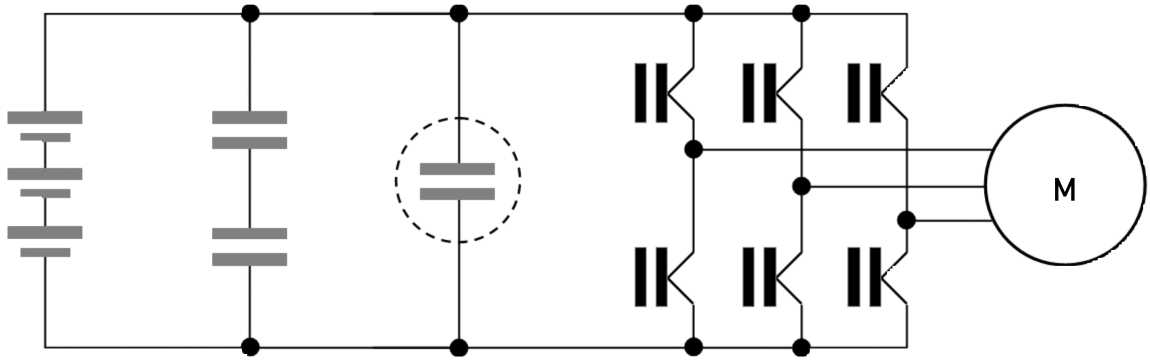
HEV DC link Capacitor

Features

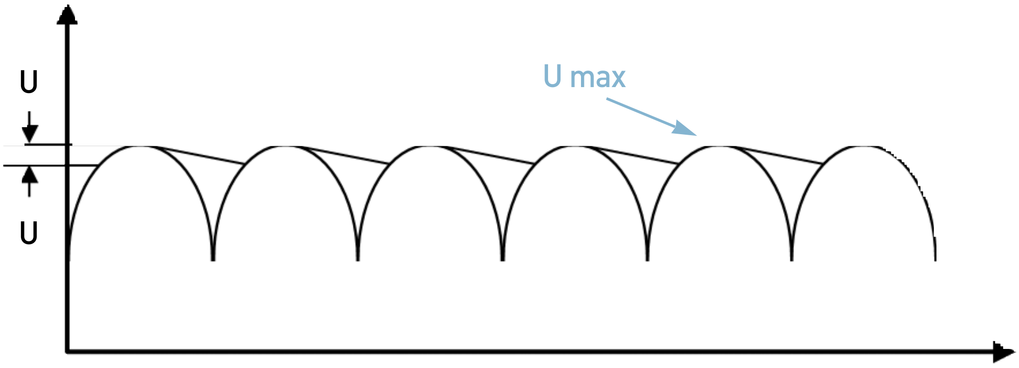
The HEV series uses a metalized poly-propylene dielectric, which features a controlled self-healing process, and treated to have a very dielectric strength in operating conditions up to 105℃.
The HEV designed to withstand high ripple current, there is low-level series inductance (Ls).

Application

- battery powered car, hybrid electric vehicle, Etc.
- electric folk-lift truck,



DC link Capacitor



Type Designation

HEV	601V	105	K
(1)	(2)	(3)	(4)

1) Series Name

2) Rated Voltage:

The first two digits represents significant figures and the last digit denotes the number of zero.

ex) 601V : 60 X 10^1 = 600V

3) Capacitance Code (pF @1kHz, 1volt):

The first two digits represents significant figures and the last digit denotes the number of zero.

ex) 105 = 10 X 10^5 [pF] = 1[μF]

4) Capacitance Tolerance Code

Code	Tolerance
B	± 0.1pF
C	± 0.25pF
D	± 0.5pF
F	± 1.0%
G	± 2.0%
J	± 5%
K	± 10%
M	± 20%

Specifications

Operation Temperature	-40℃ ~ +105℃
Capacitance Range	200μF ~ 2000μF
Capacitance Tolerance	±10%
Rated DC Voltage	300V ~ 2000V
ESR	Below 10mΩ
Test voltage between terminal @25℃	1.5 x Vn DC x 10s
Test voltage case - terminal @25℃	7kV rms x 60s

Appearance

The case appearance is variable. Classifies with two kind of the case appearance that is a cylinder- type and a box-type.
The shape and count of electrode is various, that is determined by customer.
Figure 1. is an representative exterior of HEV series.
Before ordering consult with head-office certainly about exterior.
Case material is two kinds. One is plastics, and other is metal.

- Plastics case : Self-extinguishing plastic case (V0 = in accordance with UL 94) filled thermosetting resin.
- Metal case : Metal case filled thermosetting resin.

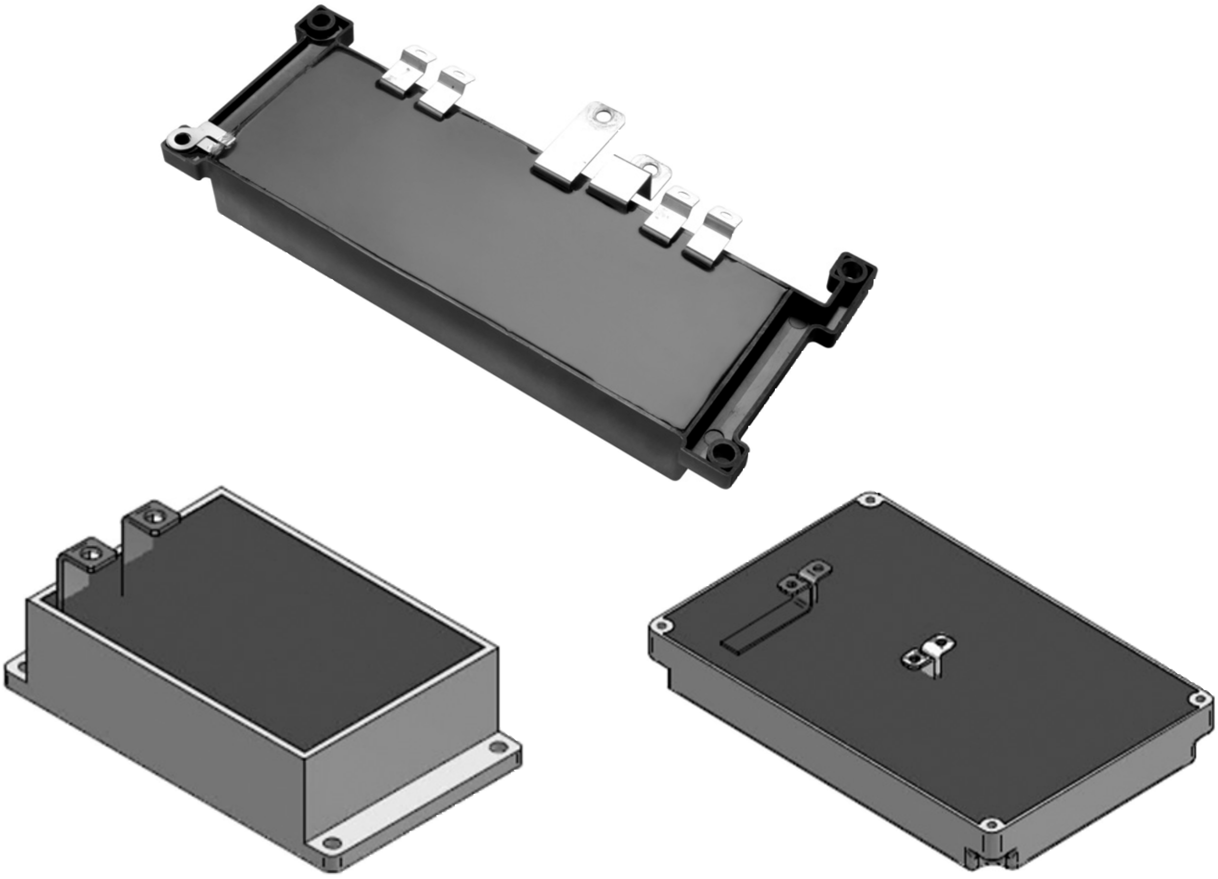


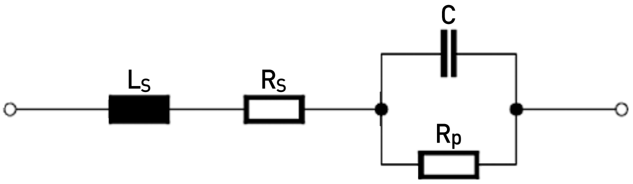
Figure 1. an representative exterior of HEV series.

General technical report

Electrical characteristics

1) Equivalent circuit diagram

Real capacitor can be modeled.



L_S	Series inductance
R_S	Series resistance, due to contacts (leads, sprayed metal and film metallization)
R_P	Parallel resistance, due to insulation resistance
C	Capacitance

In DC, RP is a magnitude defined (Insualtion Resistance)
In AC, C, RS and LS are magnitudes that vary in the frequency domain

Equivalent circuit diagram

2) Capacitance

A. Rated Capacitance

Rated capacitance is measured under standard conditions to IEC 60068-1.

Measuring conditions	Standard conditions	Referee conditions
Temperature	15 ~ 35℃	(23 ± 5) ℃
Relative humidity	45 ~ 75 %	(50 ± 2) %
Ambient atmospheric. pressure	86 ~ 106 kPa	86 ~ 106 kPa
Frequency	1 kHz	1 kHz
Voltage	0.03 x VR (max. 5V)	0.03 x VR (max. 5V)

B. Variation of capacitance with temperature.

Within a range of temperatures between the upper and lower category temperatures, capacitance changes. The gradient of the capacitance/ temperature curve is given by the temperature coefficient of the capacitance. This is defined as next equations.
The temperature coefficient of the capacitance is almost -250 [10^-6/K]

$$\text{Temperature\_cofficient} = \frac{C_2 \quad C_1}{C_3 \times (T_2 \quad T_1)}$$

C1	Capacitance measured at temperature T1
C2	Capacitance measured at temperature T2
C3	Reference capacitance measured at (25±5)℃

C. Variation of capacitance with humidity.

The PP-film capacitor will undergo a reversible change of value in relation to any change in the ambient humidity. Depending on the type of capacitor design, both the dielectric and the effective air gap between the films will react to changes in the ambient humidity, which will thus affect the measured capacitance.
The humidity coefficient is defined as the relative capacitance change determined for a 1% change in humidity (at constant temperature). The humidity coefficient of PP-film is from 40 to 100 [10^-6 /%R.H]

$$\text{Humidity\_cofficient} = \frac{2 \times (C_2 \quad C_1)}{(C_2 + C_1)(F_2 \quad F_1)}$$

C1	Capacitance at relative humidity F1
C2	Capacitance at relative humidity F2

D. Variation of capacitance with frequency

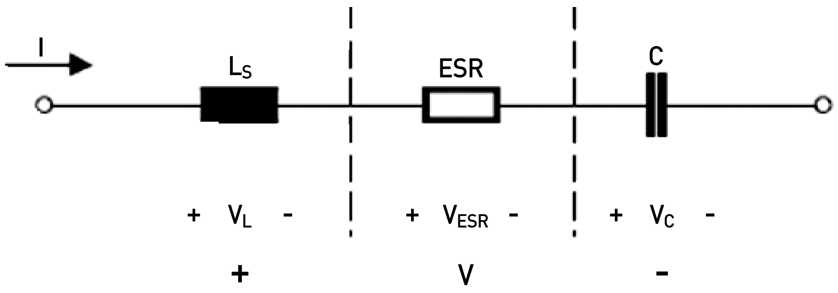
In the vicinity of the natural resonant frequency of the capacitors, self-inductance leads to an additional decrease of impedance. This has the same effect as an increase in capacitance.

E. Variation of capacitance with time

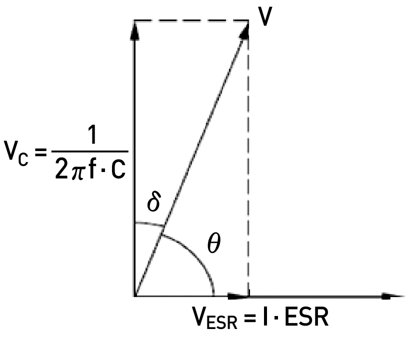
In addition to the changes described, the capacitance of a capacitor is also subjected to irreversible changes known as change rate = △C/C□. The values stated for capacitance drift (see table below) are maximum values and refer to a two-year period and a temperature up to 40℃. Here the reversible effects of temperature changes (bc) and changes in relative humidity (ac) are not taken into consideration. Approximately variational rate of capacitance with time is 3%.

3) ESR and dissipation factor

Under an AC voltage signal of specified frequency, the equivalent circuit diagram can be simplified to a series connection of the capacitance C, an equivalent series resistance (ESR) and the series inductance Ls.



Equivalent series circuit diagram



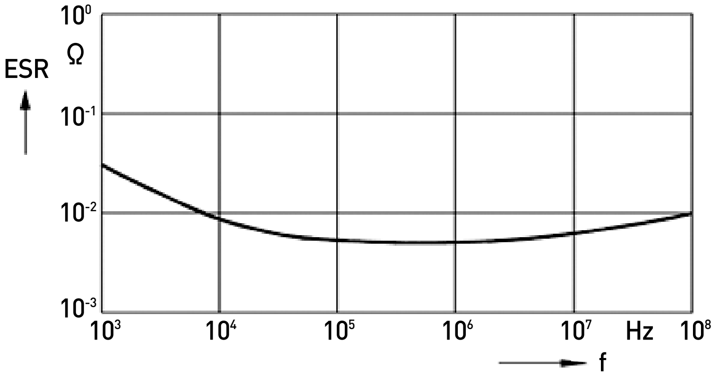
Impedance diagram

In AC source, capacitor generated loss. This is called to dissipation Factor ratio, expressed with 'tan δ'.
The followed equation calculated with capacitor ESR loss.

$$\tan\delta = ESR \times 2\pi f \times C$$

Power loss calculated

$$P = \frac{V^2_{ESR}}{ESR} = ESR \times I^2$$



ESR vs Frequency

Both ESR and tan d are important because they dictate the power dissipation of a capacitor and thus its self-heating.
ESR depends in frequency.

4) Self - Inductance

The self-inductance or series inductance Ls of a film capacitor is due to the magnetic field created by the current in the film metallization and the connections. It is thus determined by the winding structure, the geometric design and the length and thickness of the contact paths. As far as possible, all capacitors described in this data book are constructed with low-inductance bifilar electrode current paths or extended-foil contacts, and thus feature very low inductance. A general rule for deducing Ls states that the maximum value is 1nH per mm of lead length and capacitor length. Ls can also be calculated from the resonant frequency.

5) Impedance, resonant frequency

The impedance Z represent the component's opposition to current flow and is both resistive and reactive in nature. It is thus of particular importance in AC and ripple current filtering.

From the capacitor model in figure 5, Z is defined as the magnitude of the vector's sum of ESR and the total reactance (inductive reactance minus capacitive reactance) :

$$Z=\sqrt{ESR^2+(2\pi fL_S-\frac{1}{2\pi fC})^2}$$

At low frequencies, the capacitive reactance $Xc = 1/(2\pi f\cdot C)$ prevails, whereas at very high frequencies the inductive reactance $XL=(2\pi f\cdot Ls)$ is dominant. When capacitive reactance equals inductive reactance, natural resonance occurs. At this point the reactance cancel each other out and impedance equals ESR. The natural resonant frequency is therefore given by :

$$f_{resonant}=\frac{1}{2\pi\sqrt{C\cdot L_S}}$$

Definitions

C	Rated Capacitance
Ur	Rated (repetitive peak) voltage
Urms	Rated rms ripple voltage = 0.1 x UN max (max 150 Vrms)
Us	Surge (not repetitive) peak voltage
Ui	rms value of the AC voltage for which the terminal to case insulation has been designed and tested
Imax	Maximum rms current value for continuous operation
Clearance	shortest distance in air between terminals conducting parts or between terminal and case
Creepage	shortest distance along an insulated surface between terminals conducting parts or between terminal and case
Q	Reactive power = 2 x π x f x C x Urms^2
F	Fundamental frequency
Rs	Series resistance representing the sum of all ohmic resistancesin the capacitor
ESR	Equivalent Series Resistance defined asESR = RS+ tan δ0 / (2 x π x f x C)
tan δ0	Dielectric dissipation factor. It can be considered constant in the normal working frequency range. Typical value for polypropylene is 2 x 10-4
tan δ	Dissipation factor calculated as follows tan δ0 + 2 x π x f x C x RS.
dv/dt	Maximum slope of the voltage waveform
IPK	Peak current IPK = C dV/dt.
P	Active power (losses) = Q x δ0 + RS x Irms^2
Rth	Thermal resistance between the hot-spot in the winding and the environment(natural cooling), so that: P = (θh - θ0) / Rth In case of forced air cooling the thermal resistance will be reduced of 20%.
θhot	Hottest point in the capacitor winding = Rth x P + θ0
θoper	Operating ambient temperature. It is the air temperature measured under steady conditions at 0,1m from the capacitor case.
Ln	Expected life at rated voltage UN and hot-spot temperature
L	Expected life at the actual working conditions
LS	Self inductance of the capacitor. It is due to the internal connections, terminals, winding characteristics and physical dimensions.
λ	Failure rate (FIT) = 109 x failures/component x hour

※ According to IEC 61071