Film Capacitors – Power Electronic Capacitors

General purpose applications

Series/Type: **FilterCap MKD AC – Single phase**
Ordering code: **B3237*F***

Date: 2023-08-21
Version: 1

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Rated capacitance: 10 … 350 µF
Rated Voltage: 750 … 1415 V AC
RMS Voltage: 530 … 1000 V

Construction

- Metallized polypropylene film
- Aluminum can and top
- Filling material: Soft polyurethane resin (Non PCB)
- Diameter: 50/63.5/75/85/96/116/136 mm

B32370F

B32371F

B32373F

B32374F

Features

- Self-healing properties
- Low dissipation factor
- Overpressure disconnector
- Naturally air cooled (or forced air cooling)
- Protection Degree (indoor mounting)
  - IP00: B32370, B32371 and B32373 series
  - IP20: B32374 series
- RoHS compatible
- UL Certified

Application

- Input and output filters in inverter systems
- Filtering of harmonic distortion in power inverters

Terminals

- B32370 series: Fast-on terminals
- B32371 series: (M6) screw terminals type A and B
- B32373 series: (M10) screw terminals type A and B
- B32374 series: (M5) clamp terminals

Mounting

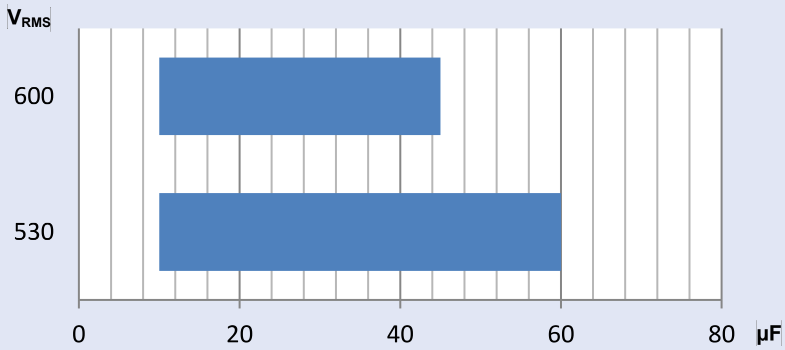
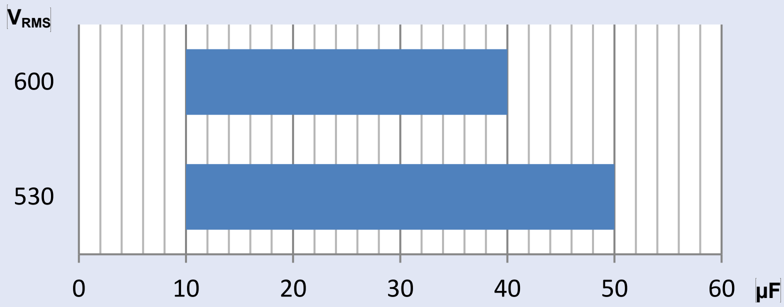
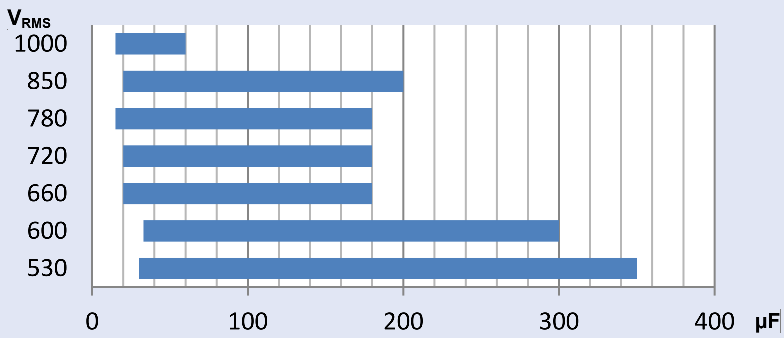
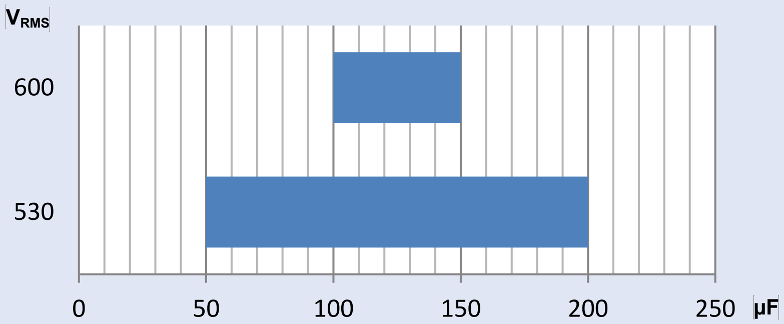
- Threaded stud on the bottom (M12)

Packing

- 50 mm diameter: 50 capacitors per box
- 63.5 mm diameter: 12 capacitors per box
- 75 mm diameter: 6 or 9 capacitors per box
- 85 mm diameter: 4 or 9 capacitors per box
- 96/116/136 mm diameter: 4 capacitors per box

Specifications and characteristics

Rated capacitance C_R: 10 … 350 µF Tolerance: ±5%

Technical data	
Type/series	**Voltage vs Capacitance**
B32370F* Fast-on terminal **Coming soon** 	
B32371F* Screw terminal M6 **Coming soon** 	
B32373F* Screw terminal M10 	
B32374F* Clamp terminal M5 **Coming soon** 	

Technical data and specifications

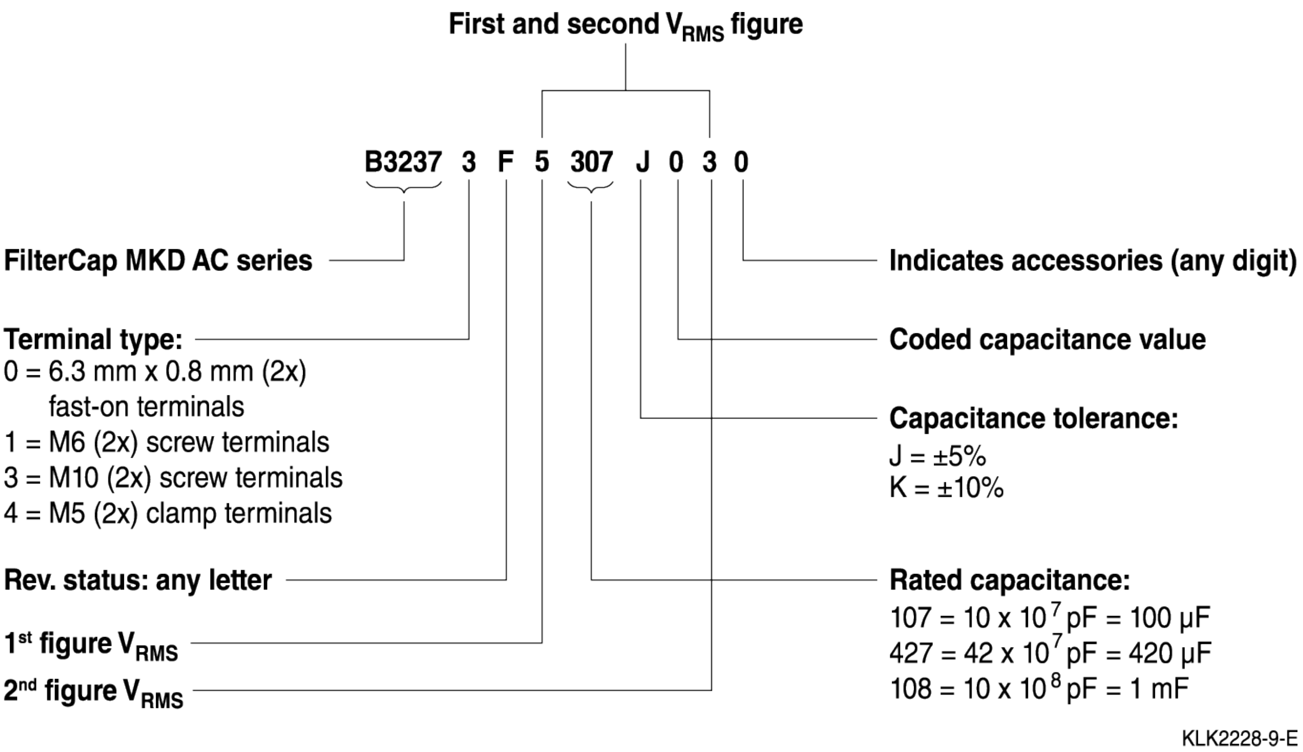
Reference standards	IEC 61071-2017, UL 810 5th, GB/T 17702-2021, RoHS compliance
Rated frequency f_R	50/60 Hz
Voltage V_{RMS}	**Rated AC voltage V_N**
530	750
600	850
660	935
720	1020
780	1100
850	1200
1000	1415
Test data	
Voltage between terminals V_{TT}	2.15 • V_{RMS}, 2 s
Voltage between terminals and Case V_{TC}	4000 V AC, 10 s
Reliability data	
Lifetime expectancy (reference value)[1]	100,000 hours at 70 °C hotspot, rated voltage
Failure in time	100 FIT at 85 °C hotspot, rated voltage
Climatic category 40/70/21 IEC60068-1	
Storage temperature T_{stg}	−40 ...+70 °C
Minimum operation ambient temperature T_{min}	−40 °C
Maximum operation ambient temperature T_{max}	+70 °C
Damp Heat Test T_{test}	21 days @ 40 °C, 93% RH
Maximum hot spot temperature in capacitor T_{HS}	+85 °C
Max. permissible altitude	2000 m above sea level
Mechanical characteristics	
Max. torque (for bottom stud)	M12: 12 Nm
Max. torque (for terminals)	B32371 (M6): 4 Nm B32373 (M10): 10 Nm B32374 Clamp terminal (M5): 2 Nm
Max insertion and withdraw force (for fast-on terminal)	50 N
Installation position[2]	Vertical with terminals upright

[1] Lifetime expectancy detail refer to Figure 15

[2] *Capacitors are designed to be mounted with terminals upright. All tests during the approval of the series have been performed in vertical position. Capacitors can be also installed in horizontal position, however, since it might have an impact in performance it is highly recommended by us and it is customer duty to do the assessment on the electrical and mechanical performance with the customer mechanical design, under specific customer working condition.*

Approvals	
B32370, B32371 type A, B32373 type A and B32374: File no.: E487229, CCN:CYWT2/8	UL 810, CSA C22.2, No 190, Max. 600 V_{RMS}, 50/60Hz, “Protected”, 10K AFC, max. +70 °C
B32371 type B and B32373 type B:.File no.: E487229, CCN:CYWT2/8	UL 810, CSA C22.2, No 190, Max.1000 V_{RMS} 50/60Hz, “Protected”, 10K AFC, max. +70 °C

Structure of ordering code



Electrical characteristics

B32373 series - M10 screw terminals (Type A)

V_N/V_{RMS} [3]	C_R	Ordering code	$I_{RMS,max}$ [4] at 70 °C	Î	R_{th} [5]	Rs [6]	tan δ [7]	ESL [8]	D	H	Weight	Packing
V	µF		A	A	K/W	mΩ	$\times 10^{-3}$	nH	mm	mm	kg	unit
750/530	300	B32373F5307J030	67 [9]	5130	2.1	1.2	6.0	100	116	245	2.85	4

B32373 series - M10 screw terminals (Type B)

V_N/V_{RMS} [3]	C_R	Ordering code	$I_{RMS,max}$ [4] at 70 °C	Î	R_{th} [5]	Rs [6]	tan δ [7]	ESL [8]	D	H	Weight	Packing
V	µF		A	A	K/W	mΩ	$\times 10^{-3}$	nH	mm	mm	kg	unit
1020/720	150	B32373F7157J020	42	4100	2.1	1.0	4.5	100	116	215	2.45	4
1100/780	68	B32373F7686J080	37	2320	2.8	1.6	2.5	100	96	195	1.60	4
1200/850	40	B32373F8406J050	27	1870	3.7	2.4	2.0	100	85	165	1.15	4
	68	B32373F8686J050	27	1810	2.9	2.2	2.5	130	85	245	1.55	4
	100	B32373F8107J050	35	3680	2.2	1.5	3.0	100	116	195	2.15	4
1415/1000	20	B32373F1206J000	27	660	3.8	3.0	1.5	130	85	142	1.00	4
	45	B32373F1456J000	29	1480	2.9	2.2	2.0	130	85	245	1.55	4

Display of ordering codes for TDK Electronics products

The ordering code for one and the same product can be represented differently in data sheets, data books, other publications, on the company website, or in order-related documents such as shipping notes, order confirmations and product labels. **The varying representations of the ordering codes are due to different processes employed and do not affect the specifications of the respective products**. Detailed information can be found on the Internet under www.tdk-electronics.tdk.com/orderingcodes

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[3] V_N Rated AC Voltage / V_{RMS}, complete explanation in the section Terms.

[4] Max permissible $I_{RMS,max}$ current for T_{HS} ≤85 ºC, ΔT_{max}≤15K, considering a harmonic spectrum up to 10 kHz. $I_{RMS,max}$ derating vs temperature refer to the *Permissible current versus ambient temperature curve*

[5] Thermal resistance ambient to HS, considering natural convection (10W/(m².K)), terminals without temperature fixation and bottom screw connected to a piece with big thermal inertia

[6] Rs at 1 kHz is typical value

[7] Max tan δ at 1 kHz

[8] ESL at 1 MHz (typical value)

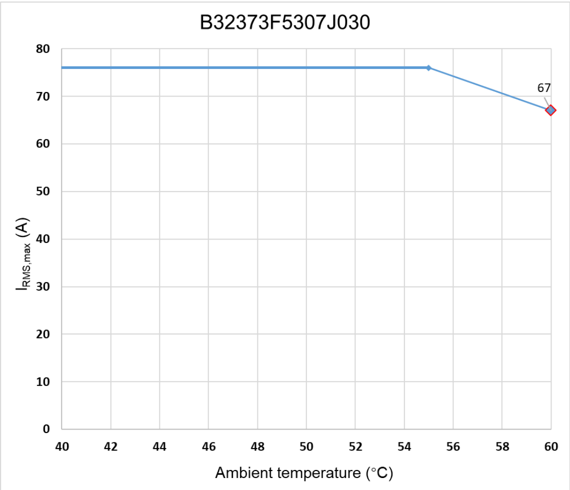
[9] Climatic category 40/60/21. Max. current given at 60°C ambient.

Electrical characteristics: Clearance and creepage distances

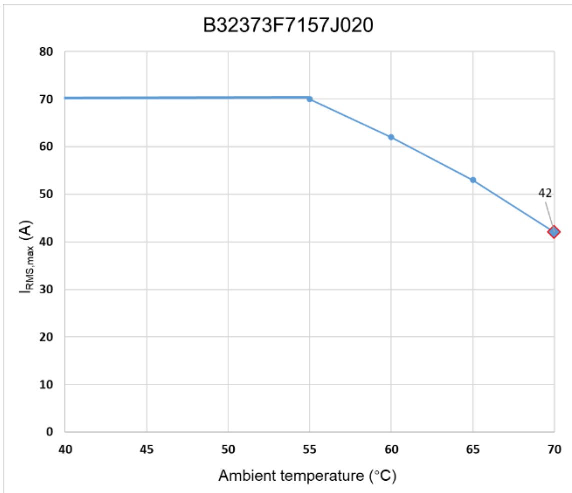
Series	Diameter D	Max. height H_{max}	Terminal to terminal		Terminal to case	
			Min. clearance	Min. creepage	Min. clearance	Min. creepage
	mm	mm	mm	mm	mm	mm
B32370	50/63.5	137	10	36	16	17
B32371 Type A	63.5	142	23	34	13	14
B32371 Type B	75/85/96/116/136	265	20	28	19	20
B32373 Type A	75/85/96/116/136	265	15	26	15	18
B32373 Type B	75/85/96/116/136	265	15	37	20.5	25.6
B32374	75/85/96/116/136	265	35	32	17	18

Permissible current versus ambient temperature curve

B32373F5307J030
Current derating @ T_{HS} = 85 °C

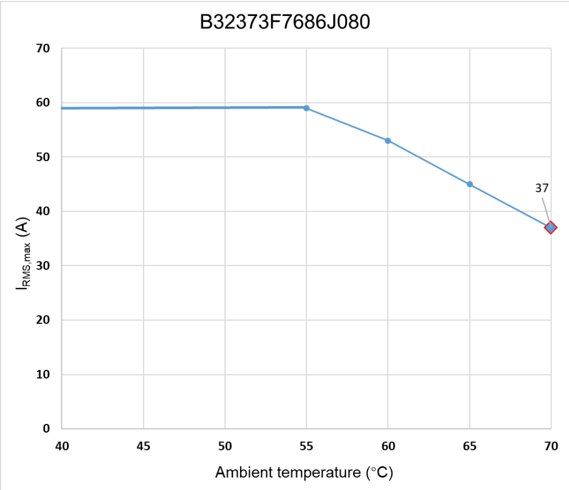


B32373F7157J020
Current derating @ T_{HS} = 85 °C



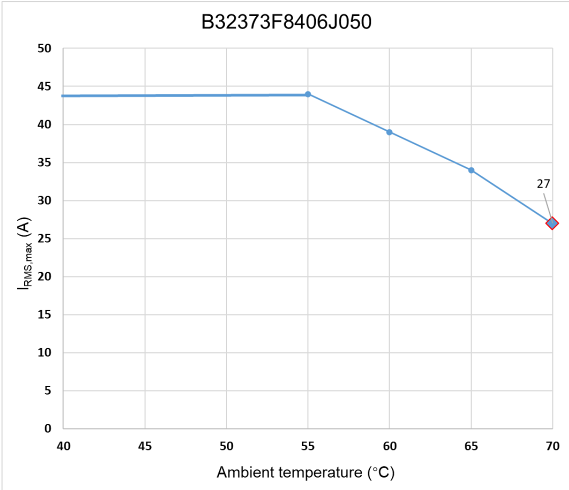
B32373F7686J080

Current derating @ T_{HS} = 85 °C



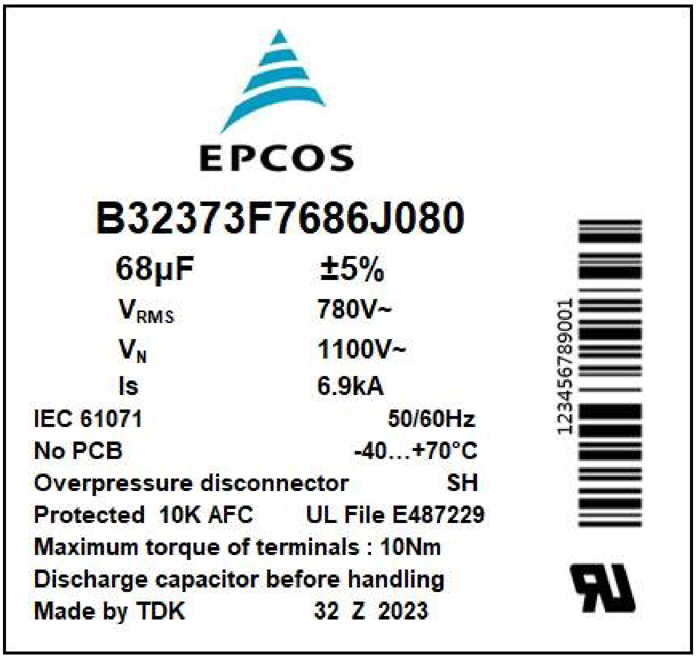
B32373F8406J050

Current derating @ T_{HS} = 85 °C



Permissible current versus ambient temperature curve for other types upon request.

Label Information



Date code explanation

WW Z YYYY: production week (e.g.: CW 32)
WW **Z** YYYY: produced in Zhuhai (China)
WW Z **YYYY**: production year (e.g.: 2023)

Bar code explanation

Bar code consists of batch number and serial number.
Batch number: 9 digits (e.g.: 123456789)
Serial number: 3 digits (e.g.: 001)

Dimensional drawings

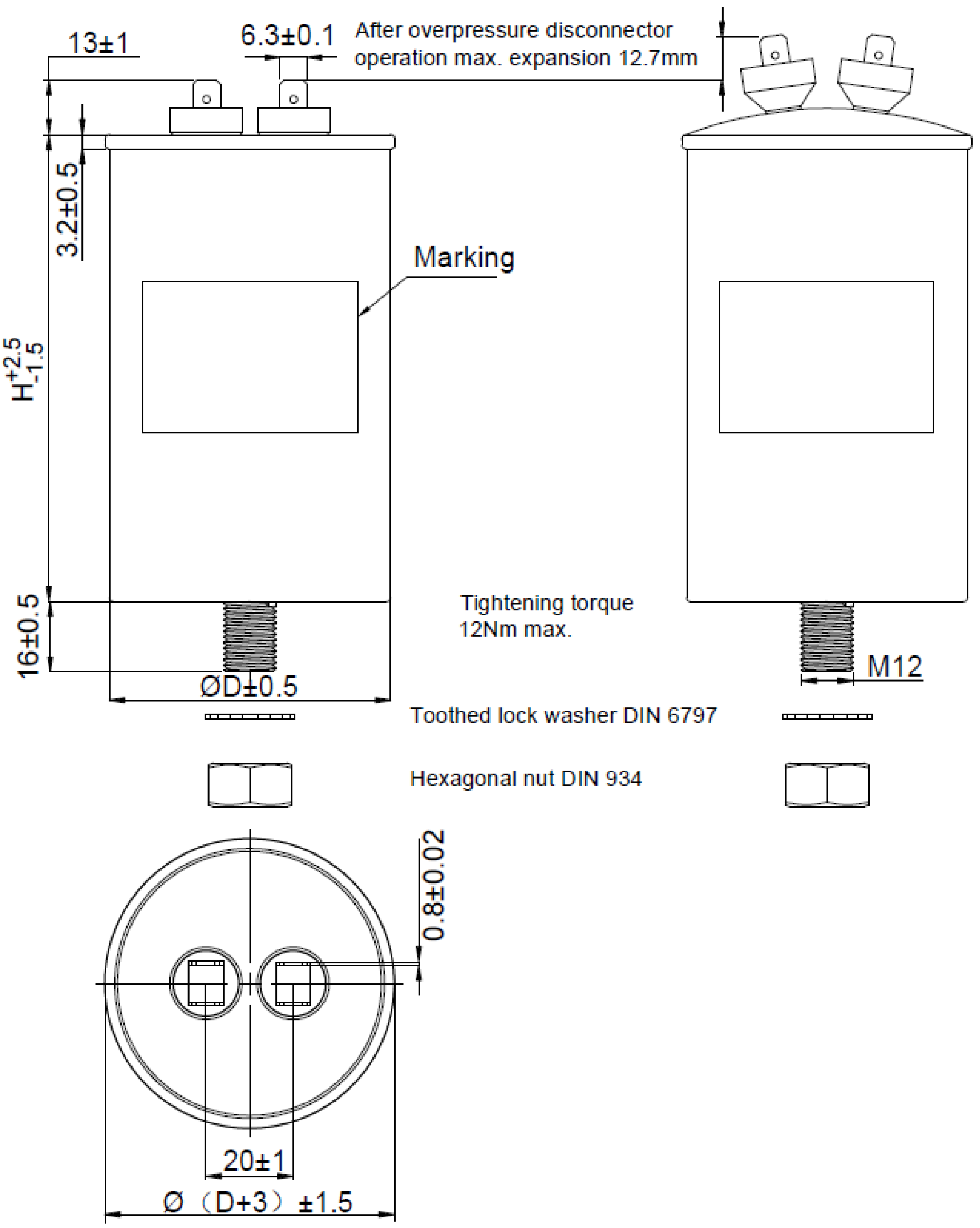


Figure 1: Series B32370 – fast on terminal

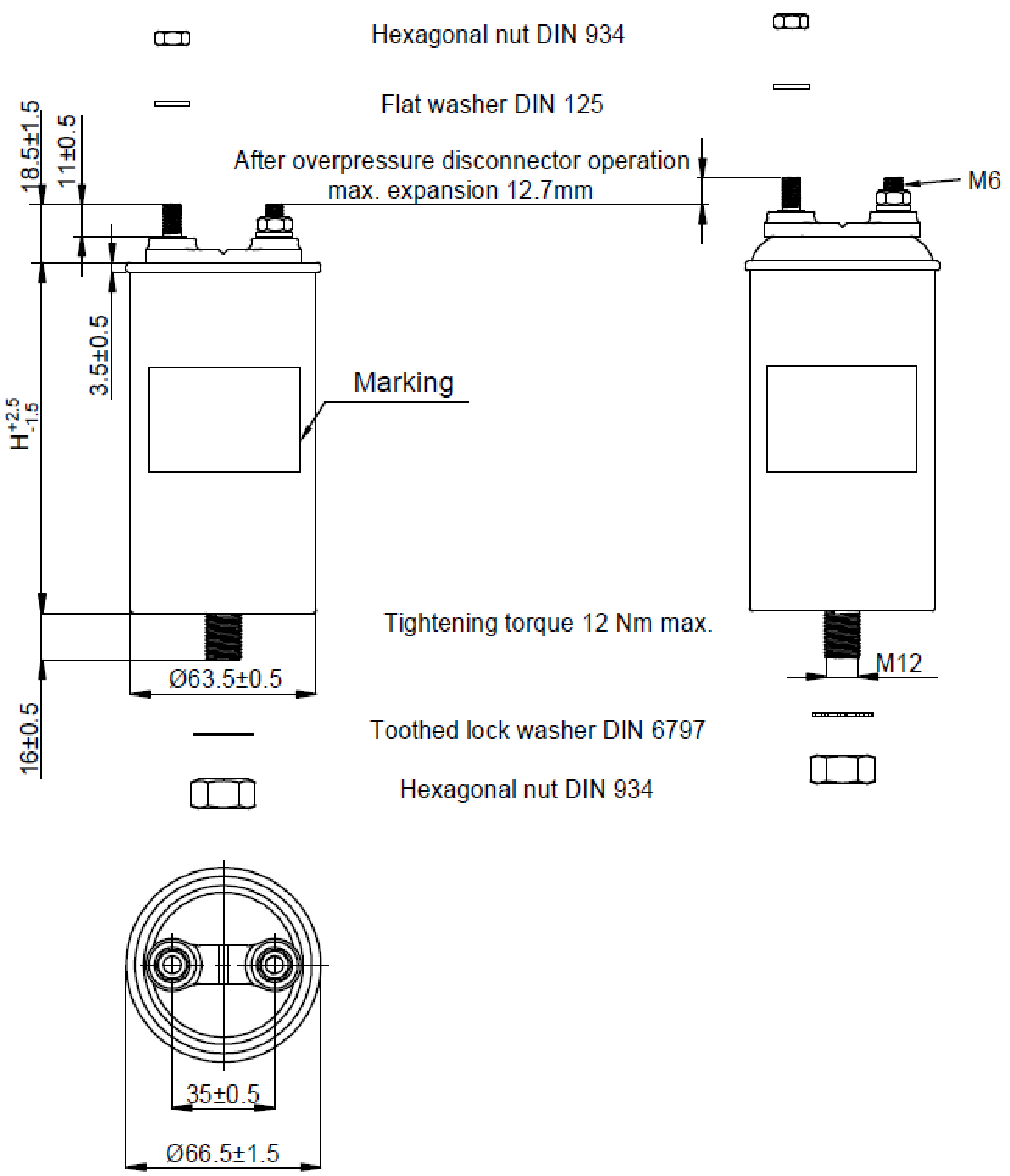


Figure 2: Series B32371 – M6 screw terminal type A

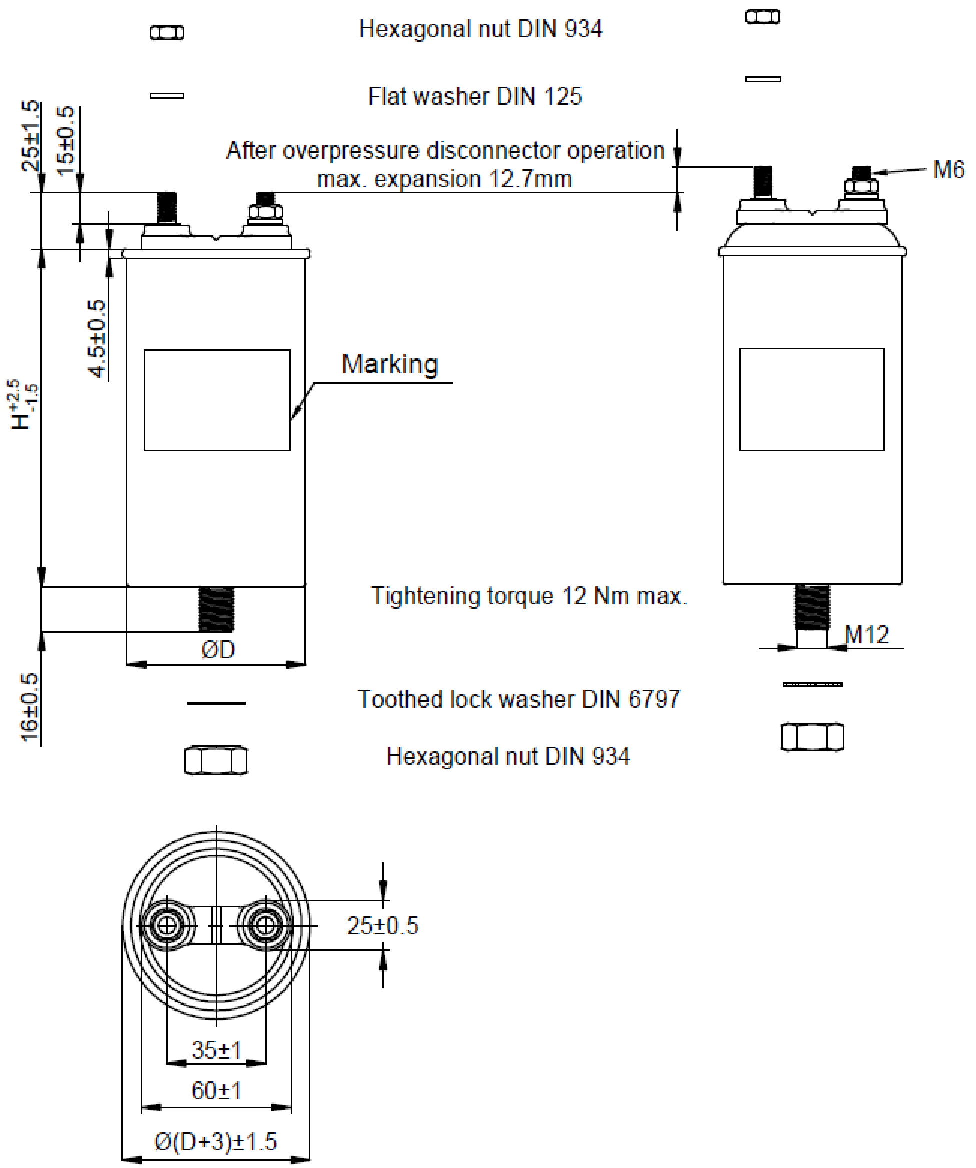


Figure 3: Series B32371– M6 screw terminal type B

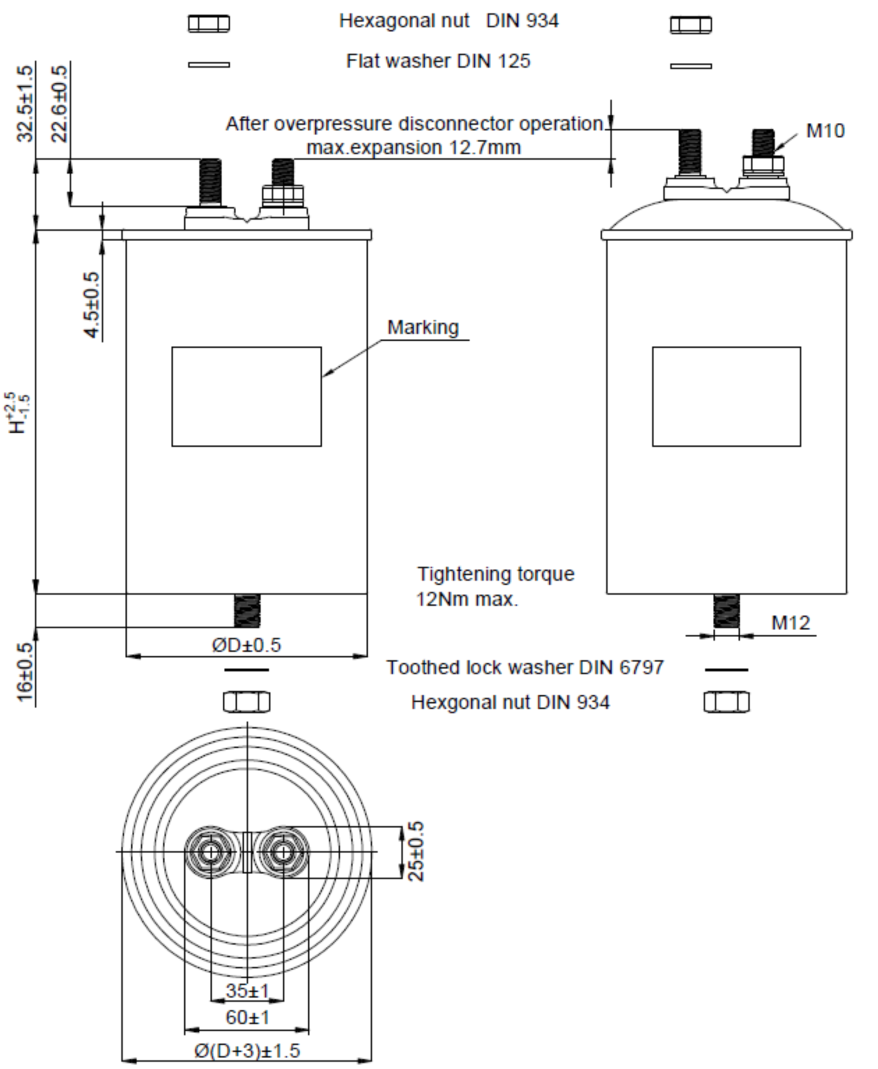


Figure 4: Series B32373* – M10 screw terminal type A

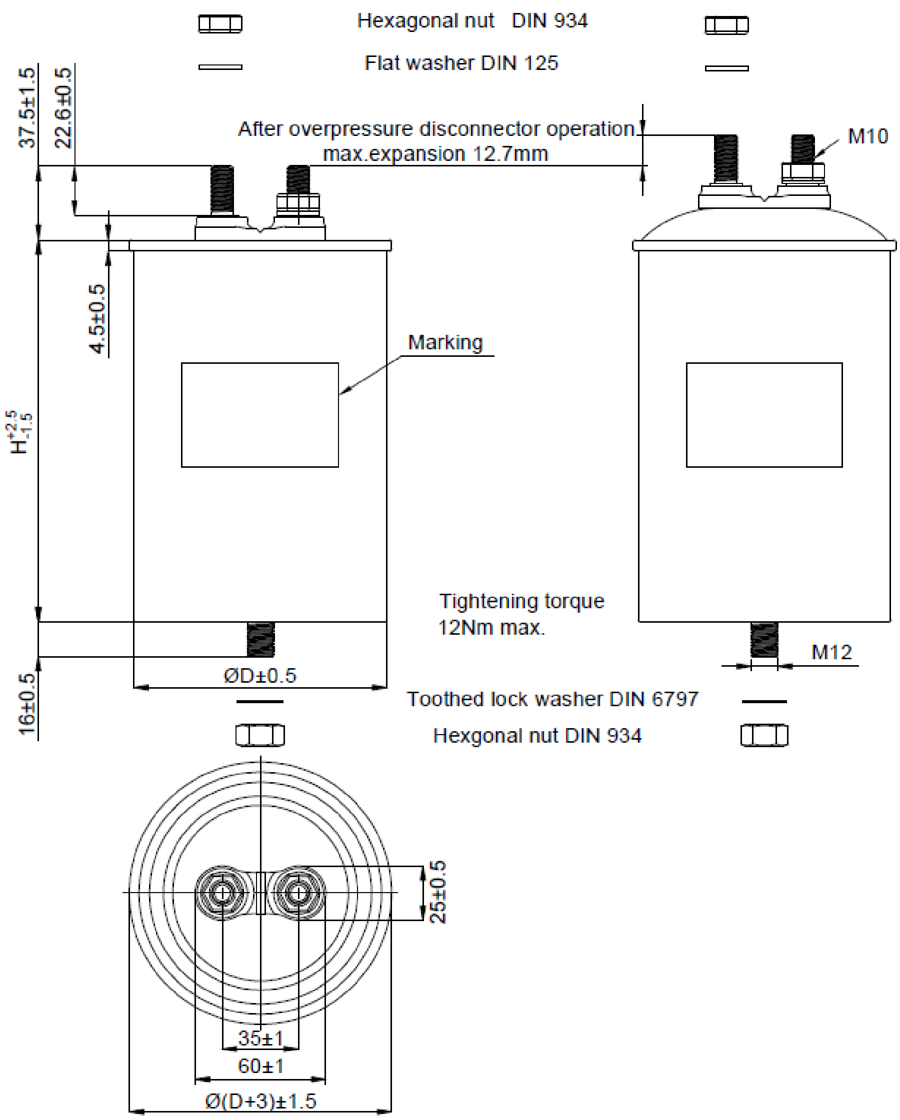


Figure 5: Series B32373* – M10 screw terminal type B

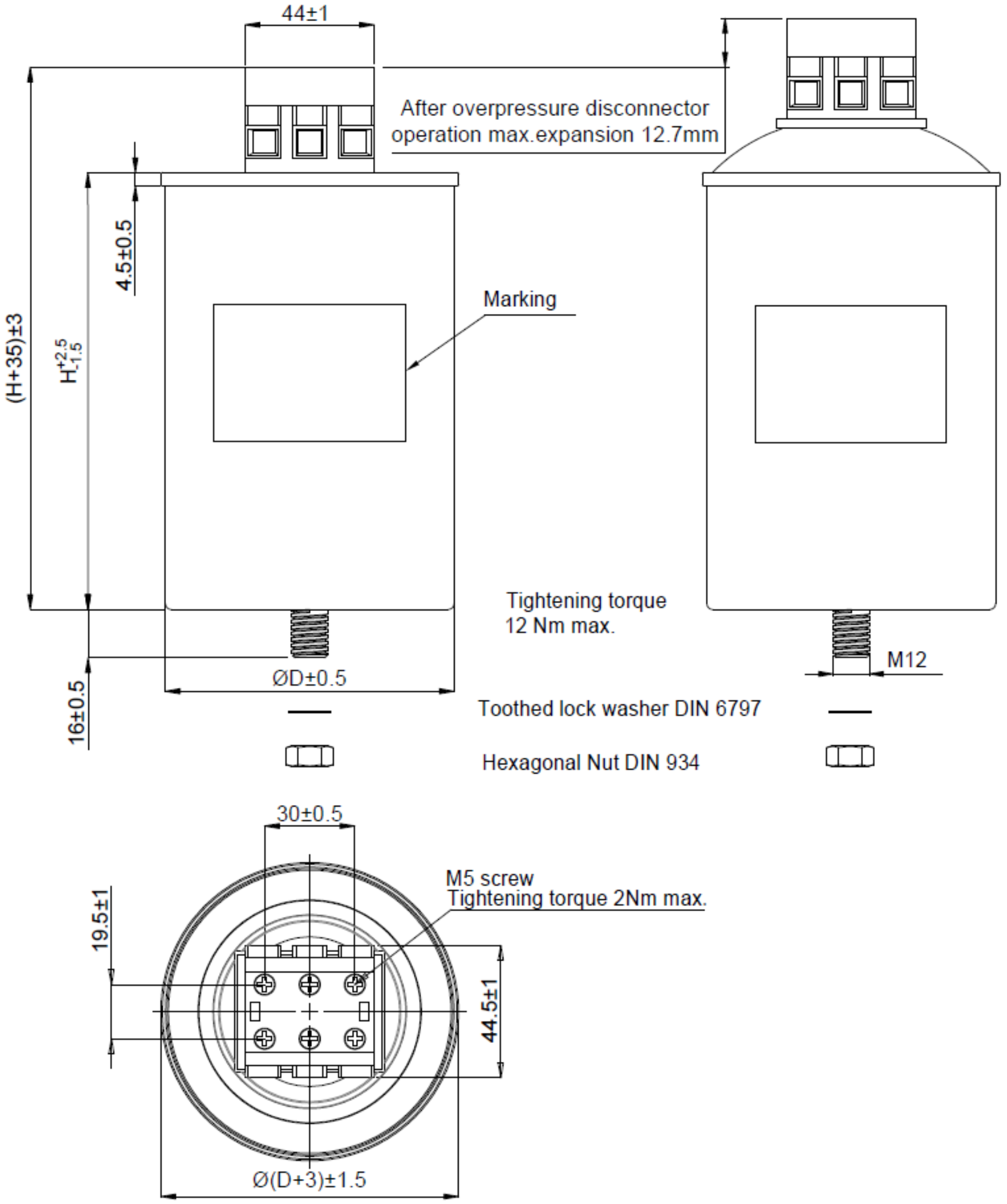


Figure 6: Series B32374 – M5 Clamp terminal

Terms

Design

The winding element of the MKD capacitor consists of metallized polypropylene film. This winding construction achieves low losses and a high pulse-current withstand capability. Soft PU resin is used for impregnation of the capacitor.

Contacting

The end faces of the windings are contacted by metal spraying to ensure a reliable and low-inductance connection between the leads and layers. The leads are welded or soldered to these end faces, brought out through insulating elements (plastic) and soldered to the terminals.

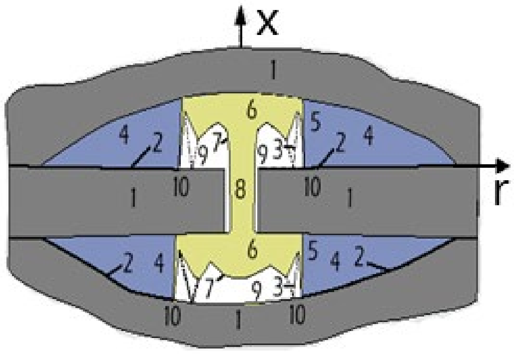
Filler material

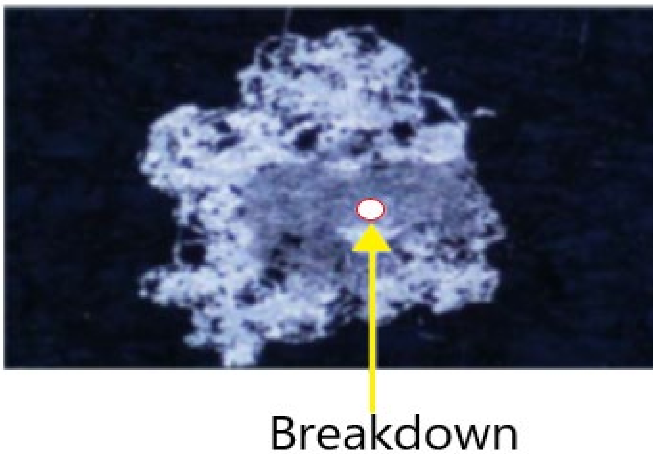
All hollows between the windings and between the windings and the case are filled with a fluid.
Besides increasing dielectric strength, this improves heat dissipation from inside a capacitor. The filler material that we use is free of PCB and halogens.

Self-healing

All MKD capacitors are self-healing, i.e. voltage breakdowns heal in a matter of microseconds and hence do not produce a short circuit.

Breakdowns can occur under heavy electrical load as a result of weaknesses or pores in the dielectric. The integrity of self-healing capacitors is not affected by such breakdowns.





1. Dielectric (Polypropylene)
2. Metallization
3. Material-displacing shock wave
4. Air gap with metal vapor

5,6. Plasma zone

7. Boundary layer between gas-phase dielectric and plasma zones
8. Puncture channel
9. Gas-phase dielectric
10. Zone of displaced metallization and dielectric

Figure 7: Description of self-healing technology

When a breakdown occurs, the dielectric in a breakdown channel is broken down into its atomic components by the electric arc that forms between the electrodes. At the high temperatures of as much as 6000 K, a plasma is created that explodes out of the channel region and pushes the dielectric layers apart. The actual self-healing process starts with the continuation of the electric arc in the propagating plasma. Here the metal layers are removed from the metal edges by evaporation. Insulation areas are formed. The rapid expansion of the plasma beyond the areas of insulation and its cooling in the areas of less field strength allow the discharge to extinguish after a few microseconds.

The area of insulation that is created is highly resistive and voltage-proof for all operating requirements of the capacitor. The self-healing breakdown is limited in current and so it does not represent a short circuit. The self-healing process is so brief and low in energy that the capacitor also remains fully functional during the breakdown.

Characteristics

Equivalent circuit diagram

Any real capacitor can be modelled by the following schematic:

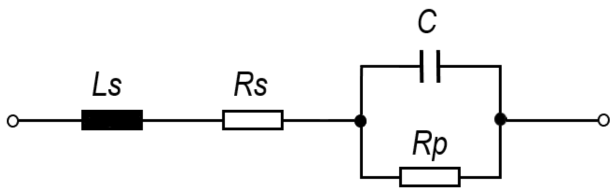


Figure 8: Equivalent circuit diagram

Symbol	Description	Unit
Ls	series inductance	H
Rs	series resistance, due to contacts(leads, sprayed metal and film metallization)	Ω
Rp	parallel resistance, due to insulation resistance	Ω
C	capacitance	F

C and L_S are magnitudes that vary in the frequency domain (AC).
R_P is a magnitude defined in DC (insulation resistance).

Rated capacitance C_R

It is referred to a test temperature of +20 ℃ and a measuring frequency range of 50 Hz to 1 kHz.

Capacitance tolerance range

It is the range within which the actual capacitance may differ from rated capacitance. The actual capacitance is to be measured at a temperature of +20 ℃. This range results from variances in materials and manufacturing processes. The standard manufacturing tolerance for PP film capacitors is ±10% or ‘K’ tolerance or ±5%, ‘J’ tolerance.

Temperature dependence of capacitance

The capacitance variation in the permissible temperature range is not linear, but it is reversible, the characteristic change in capacitance ΔC/C as a function of test temperature is shown as follows:

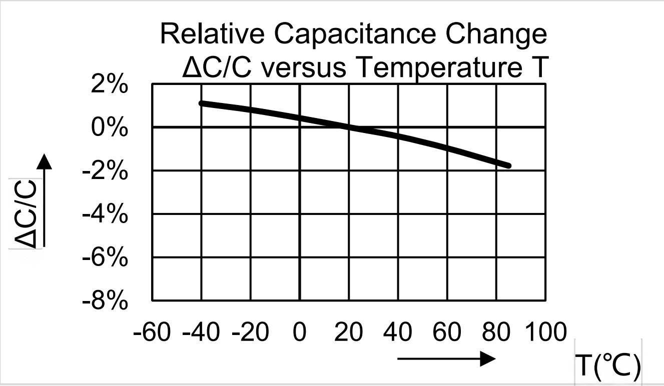


Figure 9: Temperature dependence of capacitance

Capacitance drift

Capacitance is subject to irreversible in addition to reversible changes, i.e. capacitance drift, the sum of all time-dependent, irreversible changes of capacitance during operating life. This variation is stated in percent of the value at delivery. The typical figure is +1/−3%.

Rated AC voltage V_N

The maximum operating peak recurrent voltage of either polarity of a reversing type waveform for which the capacitor has been designed.
Unlike what is common in other standard (e.g. B32304* 3–phase capacitor series for PFC application) the rated voltage **V_N is not the RMS** value, but the maximum or peak value of the capacitor voltage. The voltage at which the capacitor may be operated is dependent on other factors (especially current and frequency) besides rated voltage.

Voltage V_{RMS}

It is the Root Mean Square (RMS) voltage of maximum permissible value of sinusoidal AC voltage in continuous operation.

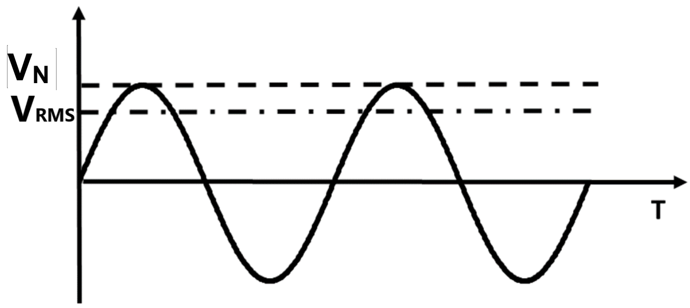


Figure 10: Voltage V_{RMS}

Non-recurrent surge voltage V_S

A peak voltage induced by a switching or any other disturbance of the system which is allowed for a limited number of times and for durations shorter than the basic period.

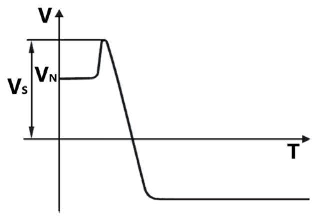


Figure 11: Non-recurrent surge voltage V_S

Maximum duration: 50 ms/pulse
Maximum number of occurrences: 1000 (during load)

Max. Recurrent peak voltage $\hat{u}$

This is the permissible, max. recurrent peak voltage that may appear for max.1% of the period.

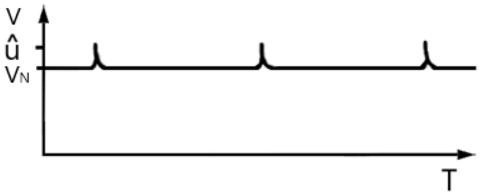


Figure 12: Max. Recurrent peak voltage $\hat{u}$

Symmetric alternating voltage $\hat{u}_{ac}$

The peak values of a symmetrical alternating voltage applied to the capacitor is a decisive factor for the dielectric losses.

For AC capacitors: $\hat{u}_{ac} = V_N$

Insulation voltage V_i

It is the RMS rated value of the insulation voltage of capacitive elements and terminals to case or earth. If not specified, the RMS value of the insulating voltage is equivalent to the rated voltage divided by $\sqrt{2}$.

Maximum current $I_{RMS,max}$

It is the maximum RMS current for continuous operation which, at rated temperature and for given harmonic distortion, will lead to a maximum hot-spot temperature (T_{HS}) of 85 °C.
Note that RMS current with different harmonic distortions could generate different self-heating temperatures. A higher current than $I_{RMS,max}$ value could be possible if the hot-spot temperature (T_{HS}) is lower than 85 °C. On the contrary, same RMS current with more harmonic distortions at higher frequency could have higher self-heating temperature that makes T_{HS} higher than 85 °C (dangerous for capacitor). For that reason, **we strongly suggest end customers to qualify capacitor using samples with thermocouples (upon request) in order to verify the real operating temperature inside of capacitor under real application or to check with TDK company for detail discussions.**

Maximum peak current $\hat{I}$

It is the maximum current amplitude which occurs instantaneously during continuous operation. The maximum peak current and the maximum rate of voltage rise $(dV/dt)_{max}$ on a capacitor are related as follows:

$$\hat{I} = C_R \cdot \left(\frac{dV}{dt}\right)_{max}$$

Maximum surge current I_s

It is the peak non-repetitive current induced by switching or any other disturbance of the system permitted for a limited number of times, at durations shorter than the basic period.

$$I_s = C_R \cdot \left(\frac{dV}{dt}\right)_s$$

Maximum duration: 50 ms/pulse
Maximum number of occurrences: 1000 (during load)

Fault current (AFC)

It is a failure mode in which capacitor is intentionally internally faulted to represent dielectric breakdown that would occur within the capacitor over time.

The fault current test is intended to address protection of the capacitor from available fault currents over the life of the capacitor. The maximum fault current test levels represent a complete internal dielectric breakdown in the capacitor with the maximum fault current available. The lower fault current test levels represent the various stages of internal dielectric breakdown during the life of the capacitor where the available fault current will be less.

Self-inductance L_{self}

The self-inductance is produced by the inductance of the terminals and the windings. Because of the special kind of contacting in self-healing capacitors (large area metal spraying covering all windings), the self-inductance is particularly low. It allows the resonance frequency to be determined:

$$f = \frac{1}{2\pi\sqrt{L_{self} \cdot C_R}}$$

The resonance frequency is high for all capacitors accordingly.

Insulation Resistance (R_{ins})

The dielectric of a capacitor has a large area and a short length. Even if the material is a good isolator there always flows a certain current between the charged electrodes (the current increases exponentially with the temperature). This leakage can be described as a parallel resistance with a high value, an Insulation Resistance.

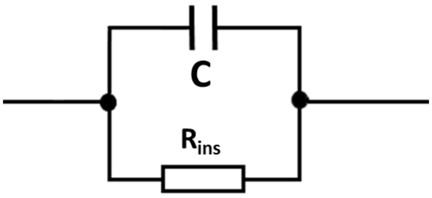


Figure 13: Insulation Resistance (R_{ins})

Insulation resistance and self-discharge time constant

The insulation values for the individual components according to the capacitance are stated as an insulation resistance R_{ins} in MΩ or a self-discharge time constant τ in seconds.

$$\tau = R_{ins} \cdot C_R$$

Series resistance R_S

Resistive losses occur in the electrodes in the contacting and in the inner wiring. These are comprised in the series resistance R_S of a capacitor.
The series resistance R_S generates the ohmic losses ($I^2 \times R_S$) in a capacitor. It is largely independent of frequency.

Dissipation factor tan δ

The equivalent circuit diagram used for the losses in a capacitor can be shown as follows:

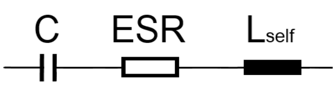


Figure 14: Simplified equivalent circuit diagram of a capacitor

Symbol	Description	Unit
C	Capacitor	F
L_{self}	Self-inductance	H
ESR	Equivalent series resistance, representing the entire active power in capacitor	Ω

The self-inductance and capacitance of a capacitor produce its resonance frequency (natural frequency).

$$\tan \delta(f) = \tan \delta_0 + Rs \cdot \omega \cdot C$$

From the frequency dependence of the equivalent series resistance can be derived:

$$\mathrm{ESR} = \frac{\tan\delta}{\omega \cdot C} = \mathrm{Rs} + \frac{\tan\delta_0}{\omega \cdot C}$$

Symbol	Description	Unit
$\tan\delta$	Dissipation factor of capacitor	-
$\tan\delta_0$	Dissipation factor of dielectric	-
R_S	Series resistance	Ω

Dielectric dissipation factor tan δ_0

The dissipation factor tan δ_0 of the dielectric is assumed to be constant for all capacitors in their frequency range of use. The figures stated in data sheets apply to rated operation.

Expected FIT rate λ

The FIT (Failure In Time) of a component is defined as the number of expected failures in 10^9 hours of operation.

The FIT rate is calculated based on the number of components operating in the field and the estimated hours of operation. Field failure information is taken into consideration for this calculation which is updated every year.

Thermal design

In order to scale a capacitor correctly for a particular application, the permissible ambient temperature versus maximum current must be determined as explained along this chapter.

Introducing power dissipation (P) and thermal resistance (R_{th}) concepts are required for this estimation.

Calculation of power dissipation P

At each frequency the power dissipation P is composed of the dielectric losses (P_D) and the resistive losses (P_R).
Generally, a secondary sinusoidal AC voltage can be used for calculating with sufficient accuracy, besides fundamental frequency.

$$P\,(f_i) = P_D\,(f_i) + P_R(f_i)$$

Which can be also calculated as:

$$P\,(f_i) = I\,(f_i)^2 \cdot ESR(f_i)$$

Dielectric losses (P_D) at each frequency f_i can be calculated as follows:

$$P_D(f_i) = V(f_i)^2 \cdot 2\pi \cdot f_i \cdot C \cdot tan\,\delta_0 = \frac{I\,(f_i)^2}{2 \cdot \pi \cdot f_i \cdot C} \cdot tan\,\delta_0$$

Symbol	Description	Unit
$V(f_i)$	RMS voltage at frequency f_i applied to capacitor	V
$I(f_i)$	RMS current at frequency f_i applied to capacitor	A
f_i	Frequency	Hz
C	Capacitance	F
$\tan \delta_0$	Dissipation factor of dielectric	-

Note: value of dielectric losses (P_D) at frequencies much higher than fundamental frequency are negligible.

Resistive losses (P_R) at each frequency f_i can be calculated as follows:

$$P_R(f_i) = I\,(f_i)^2 \cdot R_s$$

Symbol	Description	Unit
$I(f_i)$	RMS current at frequency f_i applied to capacitor	A
R_S	Series resistance	Ω

The total power dissipation P will be:

$$P = \sum_i [P_D(f_i) + P_R(f_i)]$$

Which can be also simplified as follows:

$$P = P_D(f_0) + \sum_i P_R(f_i) = (V_{RMS}^2 \cdot 2\pi \cdot f_0 \cdot C \cdot tan\,\delta_0) + (I^2 \cdot R_s)$$

Or alternatively:

$$P = \sum_i [I(f_i)^2 \cdot ESR(f_i)]$$

Symbol	Description	Unit
V_{RMS}	RMS voltage at fundamental frequency f_0 applied to capacitor	V
I	Total RMS current applied to capacitor	A
f_0	Fundamental frequency	Hz

C	Capacitance	F
ESR(f_i)	Equivalent Series Resistance at frequency f_i	Ω
tan δ_0	Dissipation factor of dielectric	-

Thermal resistance R_{th}

The thermal resistance is defined as the ratio of a temperature difference and the power dissipation produced in a capacitor. The decisive factor here is ΔT where the temperature difference between an external reference point of the coolant (e.g. air) surrounding the capacitor and the hot spot (zone with highest temperature occurring in the component). In a steady state:

$$\mathrm{R_{th}} = \frac{\Delta T}{\mathrm{P}}$$

Symbol	Description	Unit
R_{th}	Thermal resistance (ambient to hot-spot)	K/W
ΔT	Temperature difference between hot-spot and ambient	K
P	Power dissipation	W

Thermal design: Estimation of hot-spot temperature in capacitor (T_{HS})

As a basic rule of thermal design, hot-spot can never exceed a maximum temperature of 85 ºC, what means:

$$T_{HS} = T_{amb} + \Delta \mathrm{T} = T_{amb} + (\mathrm{P} \cdot R_{th}) \leq 85\ ^\circ\mathrm{C}$$

Symbol	Description	Unit
T_{amb}	Ambient temperature around capacitor	ºC
ΔT	Temperature difference between hot-spot temp. and ambient	K
P	Power dissipation	W
R_{th}	Thermal resistance (ambient to hot-spot)	K/W

Else, maximum currents can be taken from the diagram of *Permissible current versus ambient temperature.*

Thermal design example

Capacitor electrical parameters		
Reference	B32373F7686J080	
V_{RMS}	780	V (50Hz)
$I_{RMS,max}$	37	A (70ºC)
Capacitance	68	µF
R_s	1.6	mΩ
R_{th}	2.8	K/W
tan δ_0	0.0002	-

Operating conditions		
V_{RMS}	780	V (50Hz)
Fundamental frequency (f_0)	50	Hz
Ripple frequency (f_1)	8,000	Hz
I_{RMS} total	21	A
T_{amb}	40	ºC

1) Verification of initial requirements

   a. I_{RMS} total = 21 A ≤ 37 A
   b. V_{RMS} = 780 V ≤ 780 V

2) Estimation of T_{HS}

$$I_0(50\ Hz) = 780 \cdot 2\pi \cdot 50 \cdot 68 \cdot 10^{-6} = 16.7A$$
$$I_1(8\ kHz) = \sqrt{21^2 - 16.7^2} = 12.7A$$

$$P_D(50\ Hz) = 780^2 \cdot 2\pi \cdot 50 \cdot 68 \cdot 10^{-6} \cdot 0.0002 = 2.598\ W$$

$$P_D(8k\ Hz) = \frac{12.7^2}{2 \cdot \pi \cdot 8{,}000 \cdot 68 \cdot 10^{-6}} \cdot 0.0002 = 0.009W$$

$$\mathrm{P_R(50\ Hz)} = 16.7^2 \cdot 0.0016 = 0.446\ \mathrm{W}$$

$$\mathrm{P_R(8\ kHz)} = 12.7^2 \cdot 0.0016 = 0.258\ \mathrm{W}$$

$$P = 2.598 + 0.009 + 0.446 + 0.258 = 3.311\ W$$

$$\Delta T = P \cdot \mathrm{R_{th}} = 3.311 \cdot 2.8 = 9.3\ K$$

$$T_{HS} = T_{amb} + \Delta\mathrm{T} = 40 + 9.3 = 49.3\ ℃ \leq 85\ ℃$$

Lifetime Expectancy Graphs

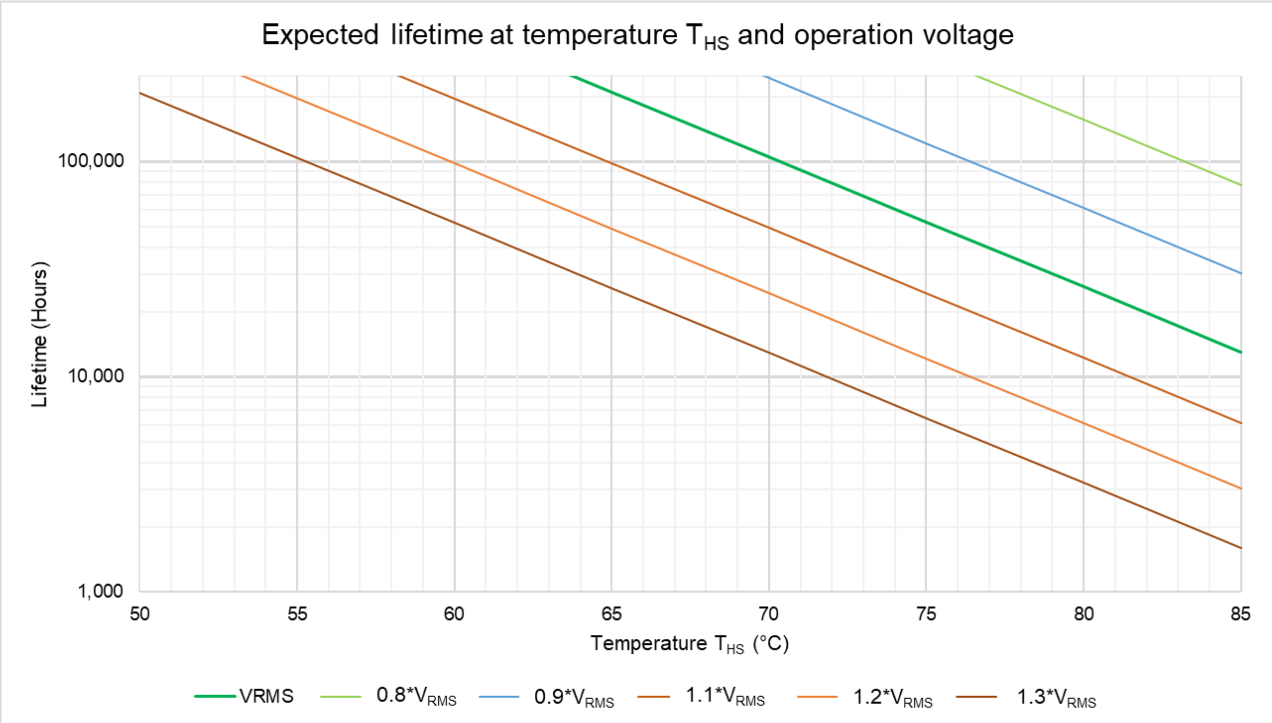


Figure 15: Expected lifetime in hours at different hotspot temperatures (T_{HS}) and voltages V_{RMS}.

Lifetime estimations are typical values derived from lifetime tests based on TDK internal standards or mutually agreed test methods and are intended for guidance purposes only. The useful life does not constitute a warranty of any kind or a prolongation of the agreed warranty period.

General

- In case of dents of more than 1 mm depth or any other mechanical damage, capacitors must not be used at all.
- Check tightness of the connections/terminals periodically.
- The energy stored in capacitors may be lethal. To prevent any chance of shock, discharge and short-circuit the capacitor before handling.
- Failure to follow cautions may result, worst case, in premature failures, bursting and fire.
- Protect the capacitor properly against over current and short circuit.
- TDK Electronics is not responsible for any kind of possible damages to persons or objects due to improper installation and application of capacitors for power electronics.

Safety

- Electrical or mechanical misapplication of capacitors may be hazardous. Personal injury or property damage may result from bursting of the capacitor or from expulsion melted material due to mechanical disruption of the capacitor.
- Ensure good, effective grounding for capacitor enclosures.
- Observe appropriate safety precautions during operation (self-recharging phenomena and the high energy contained in capacitors).
- Handle capacitors carefully, because they may still be charged even after disconnection.
- The terminals of capacitors, connected bus bars and cables, as well as other devices, may also be energized after disconnecting.
- Follow good engineering practices.
- When power capacitors are used, suitable measures must always be taken to eliminate possible danger to humans, animals and property both during operation and when a failure occurs. This applies to capacitors both with and without protective devices. Regular inspection and maintenance by trained personnel is therefore essential.
- The maximum permissible fault current (AFC) of 10 kA in accordance with the UL 810 standard must be assured by the application.

Handling

Do not handle the capacitor before it is discharged! When handling the capacitor, do not take the capacitor from the terminal. This can cause accidents in case the capacitor is charged and additionally the terminal could break.

Thermal load

After installation of the capacitor, it is necessary to verify that the maximum hot-spot temperature is not exceeded at extreme service conditions.

Installation

Capacitors must be installed in a cool and well-ventilated place, away from objects that radiate heat, or from direct sunlight. Within high-power inverter systems the capacitors usually produce the smallest portion of the total losses, and the permissible operating temperatures are low compared to power semiconductors, reactors and resistors. So, the distance between capacitor and heating sources must be far enough to prevent the capacitor from overheating. In case of space constraint to make the best possible use of capacitors, technically and economically, it is advisable to supply forced cooling air.

Mechanical protection

The capacitor has to be installed in a way that mechanical damages and dents in the aluminum can be avoided.

Connecting

Ensure firm fixing of terminals, fixing torque to be applied as per individual specification.

In any case, the maximum specified terminal current may not be exceeded. Please refer to the technical data of the specific series.

Grounding

The threaded bottom stud of the capacitor must be used for grounding. In case grounding is done via metal chassis where the capacitor is mounted on, the layer of varnish beneath the washer and nut should be removed. In case, capacitor with plastic case, this is not applicable. Ensure the tightening torque does not exceed the specified limit.

Maintenance recommendation

Disregarding the following measures may result in severe operation failures, bursting and fire:

- Check tightness of the connections/terminals periodically.
- Clean the terminals/bushings periodically to avoid short circuits due dust or other contamination.
- Ensure the current does not exceed the limit.
- In case of a current above the nominal current check your application for modification.
- Check the temperature of energized capacitors. In case of excessive temperature of individual capacitors, it is recommended to replace this capacitor, as this could be an indication for loss factor increase, which is a sign for reaching end of life.

Storage and operating conditions

Do not use or store capacitors in corrosive atmosphere, especially where chloride gas, sulfide gas, acid, alkali, salt or the like are present. In dusty environments regular maintenance and cleaning especially of the terminals is required to avoid conductive path between phases and/or phases and ground.

- Capacitors must not be stored in high temperatures and/or high humidity, we recommend the following storage conditions
  - Temperature between -40 °C ~ 40 °C
  - Humidity <= 80% RH as average per year
- Storage should not exceed 2 years (from the date code printed on the capacitor). After 1 year of storage time, capacitors must be checked electrically.

Overpressure disconnector

To ensure full functionality of an overpressure disconnector, the following must be observed:

1. The elastic elements must not be hindered, i.e.

- Connecting lines must be flexible leads (cables)
- There must be sufficient space (min.20 mm) for expansion above the connections
- Metal cover must not be retained by rigid parts, like: bus bars.

2. Stress parameters of the capacitor must be within the IEC 61071-2017 specification.

NOTE 1: As the actual conditions can be significantly different in service, the behavior at the end of life may also be different. Stored energy expected short-circuit current, duration of failure current (and so on) has to be considered in the application. Compliance with IEC 61071-5.16 does not guarantee safe end of life of a capacitor.

NOTE 2: Successful completion of the IEC 61071-5.16 test is not sufficient to guarantee the total safe failure of the components in service. For this reason, there is a residual risk of fire and/or explosions that has to be carefully taken in consideration.

Lifetime expectancy

As a rule, TDK Electronics is unfamiliar with individual customer applications or less familiar with them than the customers themselves. The results will not contain the various influences which might occur in respect to TDK products, when TDK products will be incorporated into the customer application. For these reasons, it is ultimately incumbent on the customer to check and decide whether an TDK product with the properties described in the product specification is suitable for use in a particular customer application.

We also point out that in individual cases a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified. In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.

Important notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application.** As a rule we are either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether a product with the properties described in the product specification is suitable for use in a particular customer application.
2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified.** In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
3. **The warnings, cautions and product-specific notes must be observed.**
4. In order to satisfy certain technical requirements, **some of the products described in this publication may contain substances subject to restrictions in certain jurisdictions (e.g. because they are classed as hazardous)**. Useful information on this will be found in our Material Data Sheets on the Internet (www.tdk-electronics.tdk.com/material). Should you have any more detailed questions, please contact our sales offices.
5. We constantly strive to improve our products. Consequently, **the products described in this publication may change from time to time**. The same is true of the corresponding product specifications. Please check therefore to what extent product descriptions and specifications contained in this publication are still applicable before or when you place an order.

   We also **reserve the right to discontinue production and delivery of products**. Consequently, we cannot guarantee that all products named in this publication will always be available. The aforementioned does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.
6. Unless otherwise agreed in individual contracts, **all orders are subject to our General Terms and Conditions of Supply.**
7. **Our manufacturing sites serving the automotive business apply the IATF 16949 standard.** The IATF certifications confirm our compliance with requirements regarding the quality management system in the automotive industry. Referring to customer requirements and customer specific requirements (“CSR”) TDK always has and will continue to have the policy of respecting individual agreements. Even if IATF 16949 may appear to support the acceptance of unilateral requirements, we hereby like to emphasize that **only requirements mutually agreed upon can and will be implemented in our Quality Management System.** For clarification purposes we like to point out that obligations from IATF 16949 shall only become legally binding if individually agreed upon.

Important notes

8. The trade names EPCOS, CarXield, CeraCharge, CeraDiode, CeraLink, CeraPad, CeraPlas, CSMP, CTVS, DeltaCap, DigiSiMic, FilterCap, FormFit, InsuGate, LeaXield, MediPlas, MiniBlue, MiniCell, MKD, MKK, ModCap, MotorCap, PCC, PhaseCap, PhaseCube, PhaseMod, PhiCap, PiezoBrush, PlasmaBrush, PowerHap, PQSine, PQvar, SIFERRIT, SIFI, SIKOREL, SilverCap, SIMDAD, SiMic, SIMID, SineFormer, SIOV, ThermoFuse, WindCap, XieldCap are **trademarks registered or pending** in Europe and in other countries. Further information will be found on the Internet at www.tdk-electronics.tdk.com/trademarks.

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