Film Capacitors

EMI Suppression Capacitors (MKP)

Series/Type: **B32921C/D ... B32928C/D**

Date: December 2012

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Typical applications

- X2 class for interference suppression
- "Across the line" applications

Climatic

- Max. operating temperature: 110 °C
- Climatic category (IEC 60068-1): 40/105/56

Construction

- Dielectric: polypropylene (MKP)
- Plastic case (UL 94 V-0)
- Epoxy resin sealing (UL 94 V-0)

Features

- Very small dimensions
- Self-healing properties
- RoHS-compatible
- Halogen-free capacitors available on request

Terminals

- Parallel wire leads, lead-free tinned
- Special lead lengths available on request

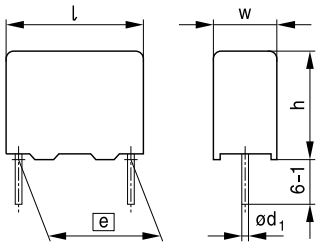
Marking

Manufacturer's logo, lot number,
date code, rated capacitance (coded),
cap. tolerance (code letter),
rated AC voltage,
series number, sub-class (X2),
dielectric code (MKP), climatic category,
passive flammability category, approvals.

Delivery mode

Bulk (untaped)
Taped (Ammo pack or reel)
For taping details, refer to chapter
"Taping and packing"

Dimensional drawing



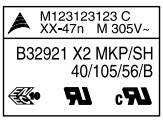
KMK0826-Q-E

Dimensions in mm

Lead spacing e ±0.4	Lead diameter d_1	Type
10	0.6	B32921
15	0.8	B32922
22.5	0.8	B32923
27.5	0.8	B32924
37.5	1.0	B32926
52.5	1.2	B32928

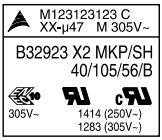
Marking Examples

e = 10 mm



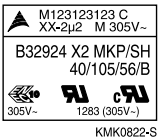
KMK0820-B

e ≥ 15 mm/C_R≤1 µF



KMK0821-J

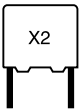
e = 22.5, 27.5,
37 mm/C_R>1 µF



KMK0822-S

Approvals

Approval marks	Standards	Certificate
	EN 60384-14, IEC 60384-14	40010694
	UL 1414 / UL 1283	E97863 / E157153
	CSA C22.2 No.1 / No. 8	E97863 / E157153 (approved by UL)
	CQC (GB/T 14472-1998)	CQC06001015331 / CQC06001016454



Overview of available types

Lead spacing	10 mm	15 mm	22.5 mm	27.5 mm	37.5 mm	52.5 mm
Type	B32921	B32922	B32923	B32924	B32926	B32928
C_R (µF)						
0.010						
0.022						
0.033						
0.047						
0.068						
0.10						
0.15						
0.22						
0.33						
0.47						
0.68						
1.0						
1.5						
2.2						
3.3						
3.9						
4.7						
5.6						
6.8						
8.2						
10						
15						
20						
25						
30						

Ordering codes and packing units

Lead spacing mm	C_R µF	Max. dimensions w × h × l mm	Ordering code (composition see below)	Ammo pack pcs./MOQ	Reel pcs./ MOQ	Untaped pcs./ MOQ
10	0.010	4.0 × 9.0 × 13.0	B32921C3103+*** ◆	4000	6800	4000
	0.022	4.0 × 9.0 × 13.0	B32921C3223+*** ◆	4000	6800	4000
	0.033	4.0 × 9.0 × 13.0	B32921C3333+*** ◆	4000	6800	4000
	0.047	5.0 × 11.0 × 13.0	B32921C3473+*** ◆	3320	5200	4000
	0.068	6.0 × 12.0 × 13.0	B32921C3683+***	2720	4400	4000
	0.10	6.0 × 12.0 × 13.0	B32921C3104M***	2720	4400	4000
15	0.033	5.0 × 10.5 × 18.0	B32922C3333K***	4680	5200	4000
	0.047	5.0 × 10.5 × 18.0	B32922C3473K***	4680	5200	4000
	0.068	5.0 × 10.5 × 18.0	B32922C3683K*** ◆	4680	5200	4000
	0.10	5.0 × 10.5 × 18.0	B32922C3104+*** ◆	4680	5200	4000
	0.15	6.0 × 12.0 × 18.0	B32922C3154+*** ◆	3840	4400	4000
	0.22	7.0 × 12.5 × 18.0	B32922C3224+*** ◆	3320	3600	4000
	0.33	8.0 × 14.0 × 18.0	B32922C3334M*** ◆	2920	3000	2000
	0.33	8.5 × 14.5 × 18.0	B32922D3334K***	2720	2800	2000
	0.47	9.0 × 17.5 × 18.0	B32922C3474+*** ◆	2560	2800	2000
	0.68	11.0 × 18.5 × 18.0	B32922C3684+*** ◆	–	2200	1000
22.5	0.22	6.0 × 15.0 × 26.5	B32923C3224+***	2720	2800	2880
	0.33	6.0 × 15.0 × 26.5	B32923C3334M***	2720	2800	2880
	0.33	7.0 × 16.0 × 26.5	B32923D3334K***	2320	2400	2520
	0.47	8.5 × 16.5 × 26.5	B32923C3474+***	1920	2000	2040
	0.68	10.5 × 16.5 × 26.5	B32923C3684+***	1560	1600	2160
	1.0	11.0 × 20.5 × 26.5	B32923C3105+*** ◆	1480	1400	2040
	1.5	12.0 × 22.0 × 26.5	B32923C3155M***	–	–	1800
	2.2	14.5 × 29.5 × 26.5	B32923C3225+***	–	–	1040

◆ Preferred type

MOQ = Minimum Order Quantity, consisting of 4 packing units.
For new design, please refer to the B3292xE/F data sheet.
Further intermediate capacitance values on request.

Composition of ordering code

+ = Capacitance tolerance code:
M = ±20%
K = ±10%

*** = Packaging code:
289 = Ammo pack
189 = Reel
000 = Untaped (lead length 6 −1 mm)

(Closer tolerances on request)

Ordering codes and packing units

Lead spacing mm	C_R µF	Max. dimensions w × h × l mm	Ordering code (composition see below)	Ammo pack pcs./MOQ	Reel pcs./ MOQ	Untaped pcs./ MOQ
27.5	0.68	11.0 × 19.0 × 31.5	B32924C3684+***	–	1400	1280
	1.0	11.0 × 19.0 × 31.5	B32924C3105+***	–	1400	1280
	1.5	12.5 × 21.5 × 31.5	B32924C3155+*** ◆	–	1200	1120
	2.2	14.0 × 24.5 × 31.5	B32924C3225+***	–	–	1040
	3.3	16.0 × 32.0 × 31.5	B32924D3335K***	–	–	880
	3.3	18.0 × 27.5 × 31.5	B32924C3335M***	–	–	800
	4.7	18.0 × 33.0 × 31.5	B32924C3475M***	–	–	800
	4.7	21.0 × 31.0 × 31.5	B32924D3475K***	–	–	720
	5.6	22.0 × 36.5 × 31.5	B32924C3565+***	–	–	784
37.5	2.2	14.0 × 25.0 × 41.5	B32926C3225+***	–	–	1380
	3.3	16.0 × 28.5 × 41.5	B32926C3335+***	–	–	800
	3.9	16.0 × 28.5 × 41.5	B32926C3395+***	–	–	800
	4.7	18.0 × 32.5 × 41.5	B32926C3475+***	–	–	720
	5.6	18.0 × 32.5 × 41.5	B32926C3565+***	–	–	720
	6.8	20.0 × 39.5 × 41.5	B32926C3685+***	–	–	640
	8.2	20.0 × 39.5 × 41.5	B32926C3825+***	–	–	640
	10	28.0 × 42.5 × 41.5	B32926C3106+***	–	–	440
	15	30.0 × 45.0 × 42.0	B32926C3156M***	–	–	200
	15	33.0 × 48.0 × 42.0	B32926D3156+***	–	–	180
52.5	20	30.0 × 45.0 × 57.5	B32928C3206+***	–	–	280
	25	35.0 × 50.0 × 57.5	B32928C3256+***	–	–	108
	30	35.0 × 50.0 × 57.5	B32928C3306M***	–	–	108

◆ Preferred type

MOQ = Minimum Order Quantity, consisting of 4 packing units.
For new design, please refer to the B3292xE/F data sheet.
Further intermediate capacitance values on request.

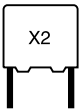
Composition of ordering code

+ = Capacitance tolerance code:
M = ±20%
K = ±10%

*** = Packaging code:
289 = Ammo pack
189 = Reel
000 = Untaped (lead length 6 −1 mm)

(Closer tolerances on request)

For the following types the safety approvals are pending:
B32926C3156M000, B32926D3156K000, B32926D3156M000
B32928C3206K000, B32928C3206M000, B32928C3256K000, B32928C3256M000, B32928C3306M000

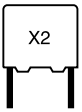


B32921C/D ... B32928C/D

X2 / 305 V AC

Technical data

Max. operating temperature $T_{op,max}$	+110 °C			
Dissipation factor tan δ (in 10^{-3}) at 20 °C (upper limit values)		$C_R \leq 0.1$ µF	0.1µF$< C_R \leq$2.2 µF	$C_R >$2.2 µF
	at 1 kHz	1.0	1.0	2.0
	100 kHz	5.0	–	–
Insulation resistance R_{ins} or time constant $\tau = C_R \cdot R_{ins}$ at 20 °C, rel. humidity ≤ 65% (minimum as-delivered values)	$C_R \leq 0.33$ µF	$C_R > 0.33$ µF		
	100 000 MΩ	30 000 s		
DC test voltage	2121 V, 2 s			
Passive flammability category to IEC 40 (CO) 752	B			
Maximum continuous DC voltage V_{DC}	630 V			
Maximum continuous AC voltage V_{AC}	310 V (50/60 Hz)			
Rated AC voltage (IEC 60384-14)	305 V (50/60 Hz)			
Operating AC voltage V_{op} at high temperature	$T_A \leq 110$ °C	$V_{op} = V_{AC}$ (continuously)		
	$T_A \leq 110$ °C	$V_{op} = 1.25 \cdot V_{AC}$ (1000 h)		
Damp heat test Limit values after damp heat test	56 days / 40 °C / 93% relative humidity Capacitance change $\lvert\Delta C/C\rvert$ ≤ 5% Dissipation factor change Δ tan δ ≤ $0.5 \cdot 10^{-3}$ (at 1 kHz) Insulation resistance R_{ins} ≤ $1.0 \cdot 10^{-3}$ (at 10 kHz) or time constant $\tau = C_R \cdot R_{ins}$ ≥ 50% of minimum as-delivered values			



Pulse handling capability

"dV/dt" represents the maximum permissible voltage change per unit of time for non-sinusoidal voltages, expressed in V/µs.

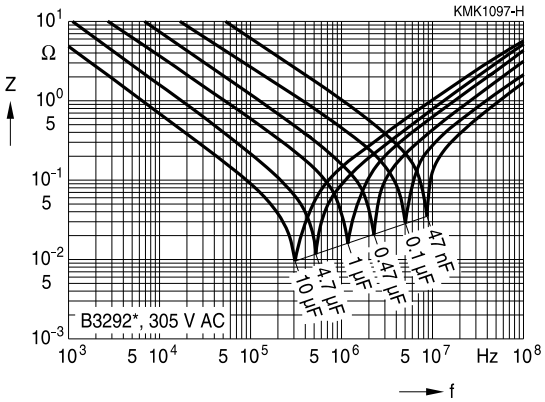
"k_0" represents the maximum permissible pulse characteristic of the waveform applied to the capacitor, expressed in $V^2/\mu s$.

Note:
The values of dV/dt and k_0 provided below must not be exceeded in order to avoid damaging the capacitor.

dV/dt and k_0 values

Lead spacing	10 mm	15 mm	22.5 mm	27.5 mm	37.5 mm	52.5 mm
dV/dt in V/µs	475	340	170	120	80	50
k_0 in $V^2/\mu s$	408500	292400	146200	103200	68800	43200

Impedance Z versus frequency f
(typical values)



Mounting guidelines

1 Soldering

1.1 Solderability of leads

The solderability of terminal leads is tested to IEC 60068-2-20, test Ta, method 1.

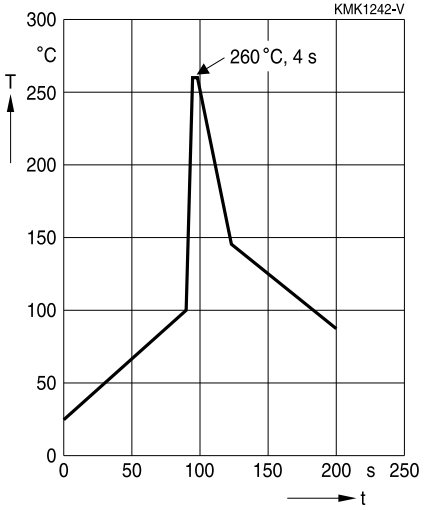
Before a solderability test is carried out, terminals are subjected to accelerated ageing (to IEC 60068-2-2, test Ba: 4 h exposure to dry heat at 155 °C). Since the ageing temperature is far higher than the upper category temperature of the capacitors, the terminal wires should be cut off from the capacitor before the ageing procedure to prevent the solderability being impaired by the products of any capacitor decomposition that might occur.

Solder bath temperature	235 ±5 °C
Soldering time	2.0 ±0.5 s
Immersion depth	2.0 +0/−0.5 mm from capacitor body or seating plane
Evaluation criteria: Visual inspection	 Wetting of wire surface by new solder ≥90%, free-flowing solder

1.2 Resistance to soldering heat

Resistance to soldering heat is tested to IEC 60068-2-20, test Tb, method 1A.
Conditions:

Series		Solder bath temperature	Soldering time
MKT	boxed (except 2.5 × 6.5 × 7.2 mm) coated uncoated (lead spacing > 10 mm)	260 ±5 °C	10 ±1 s
MFP MKP	 (lead spacing > 7.5 mm)		
MKT	boxed (case 2.5 × 6.5 × 7.2 mm)		5 ±1 s
MKP MKT	(lead spacing ≤ 7.5 mm) uncoated (lead spacing ≤ 10 mm) insulated (B32559)		< 4 s recommended soldering profile for MKT uncoated (lead spacing ≤ 10 mm) and insulated (B32559)



Immersion depth	2.0 +0/−0.5 mm from capacitor body or seating plane
Shield	Heat-absorbing board, (1.5 ±0.5) mm thick, between capacitor body and liquid solder
Evaluation criteria:	
Visual inspection	No visible damage
$\Delta C/C_0$	2% for MKT/MKP/MFP 5% for EMI suppression capacitors
tan δ	As specified in sectional specification

1.3 General notes on soldering

Permissible heat exposure loads on film capacitors are primarily characterized by the upper category temperature T_{max}. Long exposure to temperatures above this type-related temperature limit can lead to changes in the plastic dielectric and thus change irreversibly a capacitor's electrical characteristics. For short exposures (as in practical soldering processes) the heat load (and thus the possible effects on a capacitor) will also depend on other factors like:

- Pre-heating temperature and time
- Forced cooling immediately after soldering
- Terminal characteristics:
  diameter, length, thermal resistance, special configurations (e.g. crimping)
- Height of capacitor above solder bath
- Shadowing by neighboring components
- Additional heating due to heat dissipation by neighboring components
- Use of solder-resist coatings

The overheating associated with some of these factors can usually be reduced by suitable countermeasures. For example, if a pre-heating step cannot be avoided, an additional or reinforced cooling process may possibly have to be included.

EPCOS recommends the following conditions:

- Pre-heating with a maximum temperature of 110 °C
- Temperature inside the capacitor should not exceed the following limits:
  - MKP/MFP 110 °C
  - MKT 160 °C
- When SMD components are used together with leaded ones, the leaded film capacitors should not pass into the SMD adhesive curing oven. The leaded components should be assembled after the SMD curing step.
- Leaded film capacitors are not suitable for reflow soldering.

Uncoated capacitors

For uncoated MKT capacitors with lead spacings ≤10 mm (B32560/B32561) the following measures are recommended:

- pre-heating to not more than 110 °C in the preheater phase
- rapid cooling after soldering

Application note for X1 / X2 EMI capacitors

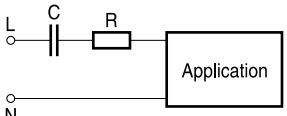
Application note for the different possible X1 / X2 positions

In series with the powerline (i.e. capacitive power supply)

Typical Applications:

- Power meters
- ECUs for white goods and household appliances
- Different sensor applications
- Severe ambient conditions

Basic circuit



KMK1336-2-E

Required features

- High capacitance stability over the lifetime
- Narrow tolerances for a controlled current supply

Recommended EPCOS product series

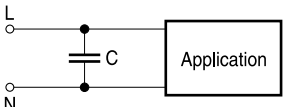
- B3293* (305 V AC) heavy duty with EN approval for X2 (UL Q1/2010)
- B3292*7 (305 V AC) improved standard series, approved as X2
- B3291* (330 V AC), approved as X1
- B3265* MKP series standard MKP capacitor without safety approvals
- B3267*L MKP series standard MKP capacitor without safety approvals

In parallel with the powerline

Typical Applications:

Standard X2 are used parallel over the mains for reducing electromagnetic interferences coming from the grid. For such purposes they must meet the applicable EMC directives and standards.

Basic circuit



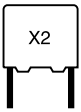
KMK1337-G-E

Required features

- Standard safety approvals (ENEC, UL, CSA, CQC)
- High pulse load capability
- Withstand surge voltages

Recommended EPCOS product series

- B3292*C/D (305 V AC) standard series, approved as X2
- B3292*E/F (305 V AC) miniaturized series (> 2.2 µF), approved as X2
- B3291* (330 V AC), approved as X1

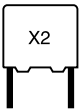


Cautions and warnings

- Do not exceed the upper category temperature (UCT).
- Do not apply any mechanical stress to the capacitor terminals.
- Avoid any compressive, tensile or flexural stress.
- Do not move the capacitor after it has been soldered to the PC board.
- Do not pick up the PC board by the soldered capacitor.
- Do not place the capacitor on a PC board whose PTH hole spacing differs from the specified lead spacing.
- Do not exceed the specified time or temperature limits during soldering.
- Avoid external energy inputs, such as fire or electricity.
- Avoid overload of the capacitors.

The table below summarizes the safety instructions that must always be observed. A detailed description can be found in the relevant sections of the chapters "General technical information" and "Mounting guidelines".

Topic	Safety information	Reference chapter "General technical information"
Storage conditions	Make sure that capacitors are stored within the specified range of time, temperature and humidity conditions.	4.5 "Storage conditions"
Flammability	Avoid external energy, such as fire or electricity (passive flammability), avoid overload of the capacitors (active flammability) and consider the flammability of materials.	5.3 "Flammability"
Resistance to vibration	Do not exceed the tested ability to withstand vibration. The capacitors are tested to IEC 60068-2-6. EPCOS offers film capacitors specially designed for operation under more severe vibration regimes such as those found in automotive applications. Consult our catalog "Film Capacitors for Automotive Electronics".	5.2 "Resistance to vibration"



Topic	Safety information	Reference chapter "Mounting guidelines"
Soldering	Do not exceed the specified time or temperature limits during soldering.	1 "Soldering"
Cleaning	Use only suitable solvents for cleaning capacitors.	2 "Cleaning"
Embedding of capacitors in finished assemblies	When embedding finished circuit assemblies in plastic resins, chemical and thermal influences must be taken into account. Caution: Consult us first, if you also wish to embed other uncoated component types!	3 "Embedding of capacitors in finished assemblies"

Design of EMI Capacitors

EPCOS EMI capacitors use polypropylene (PP) film metalized with a thin layer of Zinc (Zn). The following key points have made this design suitable to IEC/UL testing, holding a minimum size.

- Overvoltage AC capability with very high temperature Endurance test of IEC60384-14 (3rd edition, 2005-07) / UL60384-14 (1st edition, 2009-04) must be performed at $1.25 \times V_R$ at maximum temperature, during 1000 hours, with a capacitance drift less than 10%.
- Higher breakdown voltage withstanding if compared to other film metallizations, like Aluminum. IEC60384-14 (3rd edition, 2005-07) / UL60384-14 (1st edition, 2009-04) establishes high voltage tests performed at $4.3 \times V_R$ −1 minute, impulse testing at 2500 V for C= 1 µF and active flammability tests.
- Damp heat steady state: 40 °C/ 93% RH / 56 days. (without voltage or current load)

Effect of humidity on capacitance stability

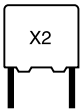
Long contact of a film capacitor with humidity can produce irreversible effects. Direct contact with liquid water or excess exposure to high ambient humidity or dew will eventually remove the film metallization and thus destroy the capacitor. Plastic boxed capacitors must be properly tested in the final application at the worst expected conditions of temperature and humidity in order to check if any parameter drift may provoke a circuit malfunction.

In case of penetration of humidity through the film, the layer of Zinc can be degraded, specially under AC operation (change of polarity), accelerated by the temperature, provoking an increment of the serial resistance of the electrode and eventually a reduction of the capacitance value. For DC operation, the parameter drift is much less.

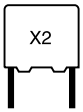
Plastic boxes and resins can not protect 100% against humidity. Metal enclosures, resin potting or coatings or similar measures by customers in their applications will offer additional protection against humidity penetration.

Symbols and terms

Symbol	English	German
α	Heat transfer coefficient	Wärmeübergangszahl
α_C	Temperature coefficient of capacitance	Temperaturkoeffizient der Kapazität
A	Capacitor surface area	Kondensatoroberfläche
β_C	Humidity coefficient of capacitance	Feuchtekoeffizient der Kapazität
C	Capacitance	Kapazität
C_R	Rated capacitance	Nennkapazität
ΔC	Absolute capacitance change	Absolute Kapazitätsänderung
$\Delta C/C$	Relative capacitance change (relative deviation of actual value)	Relative Kapazitätsänderung (relative Abweichung vom Ist-Wert)
$\Delta C/C_R$	Capacitance tolerance (relative deviation from rated capacitance)	Kapazitätstoleranz (relative Abweichung vom Nennwert)
dt	Time differential	Differentielle Zeit
Δt	Time interval	Zeitintervall
ΔT	Absolute temperature change (self-heating)	Absolute Temperaturänderung (Selbsterwärmung)
$\Delta \tan \delta$	Absolute change of dissipation factor	Absolute Änderung des Verlustfaktors
ΔV	Absolute voltage change	Absolute Spannungsänderung
dV/dt	Time differential of voltage function (rate of voltage rise)	Differentielle Spannungsänderung (Spannungsflankensteilheit)
$\Delta V/\Delta t$	Voltage change per time interval	Spannungsänderung pro Zeitintervall
E	Activation energy for diffusion	Aktivierungsenergie zur Diffusion
ESL	Self-inductance	Eigeninduktivität
ESR	Equivalent series resistance	Ersatz-Serienwiderstand
f	Frequency	Frequenz
f_1	Frequency limit for reducing permissible AC voltage due to thermal limits	Grenzfrequenz für thermisch bedingte Reduzierung der zulässigen Wechselspannung
f_2	Frequency limit for reducing permissible AC voltage due to current limit	Grenzfrequenz für strombedingte Reduzierung der zulässigen Wechselspannung
f_r	Resonant frequency	Resonanzfrequenz
F_D	Thermal acceleration factor for diffusion	Therm. Beschleunigungsfaktor zur Diffusion
F_T	Derating factor	Deratingfaktor
i	Current (peak)	Stromspitze
I_C	Category current (max. continuous current)	Kategoriestrom (max. Dauerstrom)



Symbol	English	German
I_{RMS}	(Sinusoidal) alternating current, root-mean-square value	(Sinusförmiger) Wechselstrom
i_z	Capacitance drift	Inkonstanz der Kapazität
k_0	Pulse characteristic	Impulskennwert
L_S	Series inductance	Serieninduktivität
λ	Failure rate	Ausfallrate
λ_0	Constant failure rate during useful service life	Konstante Ausfallrate in der Nutzungsphase
λ_{test}	Failure rate, determined by tests	Experimentell ermittelte Ausfallrate
P_{diss}	Dissipated power	Abgegebene Verlustleistung
P_{gen}	Generated power	Erzeugte Verlustleistung
Q	Heat energy	Wärmeenergie
ρ	Density of water vapor in air	Dichte von Wasserdampf in Luft
R	Universal molar constant for gases	Allg. Molarkonstante für Gas
R	Ohmic resistance of discharge circuit	Ohmscher Widerstand des Entladekreises
R_i	Internal resistance	Innenwiderstand
R_{ins}	Insulation resistance	Isolationswiderstand
R_P	Parallel resistance	Parallelwiderstand
R_S	Series resistance	Serienwiderstand
S	severity (humidity test)	Schärfegrad (Feuchtetest)
t	Time	Zeit
T	Temperature	Temperatur
τ	Time constant	Zeitkonstante
tan δ	Dissipation factor	Verlustfaktor
tan δ_D	Dielectric component of dissipation factor	Dielektrischer Anteil des Verlustfaktors
tan δ_P	Parallel component of dissipation factor	Parallelanteil des Verlfustfaktors
tan δ_S	Series component of dissipation factor	Serienanteil des Verlustfaktors
T_A	Ambient temperature	Umgebungstemperatur
T_{max}	Upper category temperature	Obere Kategorietemperatur
T_{min}	Lower category temperature	Untere Kategorietemperatur
t_{OL}	Operating life at operating temperature and voltage	Betriebszeit bei Betriebstemperatur und -spannung
T_{op}	Operating temperature	Beriebstemperatur
T_R	Rated temperature	Nenntemperatur
T_{ref}	Reference temperature	Referenztemperatur
t_{SL}	Reference service life	Referenz-Lebensdauer
V_{AC}	AC voltage	Wechselspannung



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X2 / 305 V AC

Symbol	English	German
V_C	Category voltage	Kategoriespannung
$V_{C,RMS}$	Category AC voltage	(Sinusförmige) Kategorie-Wechselspannung
V_{CD}	Corona-discharge onset voltage	Teilentlade-Einsatzspannung
V_{ch}	Charging voltage	Ladespannung
V_{DC}	DC voltage	Gleichspannung
V_{FB}	Fly-back capacitor voltage	Spannung (Flyback)
V_i	Input voltage	Eingangsspannung
V_o	Output voltage	Ausgangssspannung
V_{op}	Operating voltage	Betriebsspannung
V_p	Peak pulse voltage	Impuls-Spitzenspannung
V_{pp}	Peak-to-peak voltage Impedance	Spannungshub
V_R	Rated voltage	Nennspannung
$\hat{v}_R$	Amplitude of rated AC voltage	Amplitude der Nenn-Wechselspannung
V_{RMS}	(Sinusoidal) alternating voltage, root-mean-square value	(Sinusförmige) Wechselspannung
V_{SC}	S-correction voltage	Spannung bei Anwendung "S-correction"
V_{sn}	Snubber capacitor voltage	Spannung bei Anwendung "Beschaltung"
Z	Impedance	Scheinwiderstand
e	Lead spacing	Rastermaß

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