



## Film Capacitors

### EMI Suppression Capacitors (MKP)

**Series/Type:** B32923E/F ... B32928E/F

**Date:** May 2009

### Typical applications

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

### Climatic

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

### Construction

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

### Features

- Capacitance value up to 45 µF
- Very small dimensions
- Good self-healing properties
- High voltage capability

### Terminals

- Parallel wire leads, lead-free tinned
- Standard lead lengths: 6 – 1 mm
- Special lead lengths available on request

### Marking

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

### Delivery mode

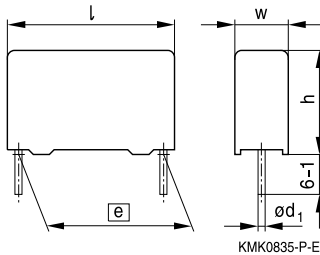
Bulk (untaped)

Reel

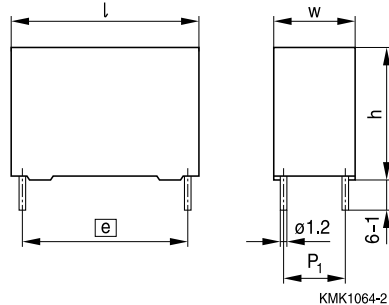
For taping details, refer to chapter "Taping and packing"

### Dimensional drawings

Drawing 1



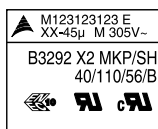
Drawing 2



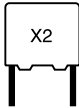
Dimensions in mm

Lead spacing $e \pm 0.4$	Lead diameter $d_1$	Type	Drawing
22.5	0.8	B32923E	1
27.5	0.8	B32924E/F	1
37.5	1.0	B32926E/F	1
52.5	1.2	B32928E	2




### Marking example



KMK1258-5



### Approvals

Approval marks	Standards	Certificate
	IEC 60384-14	40021331
	UL 1283	E301966
 <sup>1)</sup>	CSA C22.2 No.8	E301966

1) approved by UL

### Overview of available types

Lead spacing	22.5 mm	27.5 mm	37.5 mm	52.5 mm
Type	B32923E	B32924E/F	B32926E/F	B32928E
$C_R$ (μF)				
2.2				
3.3				
4.7				
5.6				
6.8				
8.2				
10				
15				
20				
25				
30				
40				
45				


**B32923E/F ... B32928E/F**
**Efficient filtering – X2 / 305 V AC**
**Ordering codes and packing units**

Lead spacing	C <sub>R</sub>	Max. dimensions w × h × l	Ordering code (composition see below)	Reel	Untaped
mm	μF	mm		pcs./MOQ	pcs./MOQ
22.5	2.2	12.0 × 22.0 × 26.5	B32923E3225M*** ◆	–	1800
	3.3	14.5 × 29.5 × 26.5	B32923E3335+***	–	1040
27.5	2.2	11.0 × 21.0 × 31.5	B32924E3225M***	1400	2352
	2.2	12.5 × 21.5 × 31.5	B32924F3225K***	1200	2100
	3.3	14.0 × 24.5 × 31.5	B32924E3335M*** ◆	1000	1848
	3.3	15.0 × 24.0 × 31.5	B32924F3335K***	–	1680
	4.7	16.0 × 32.0 × 31.5	B32924F3475K***	–	1064
	4.7	18.0 × 27.5 × 31.5	B32924E3475M*** ◆	–	1428
	5.6	18.0 × 33.0 × 31.5	B32924F3565K***	–	952
	5.6	19.0 × 30.0 × 31.5	B32924E3565M***	–	896
	6.8	21.0 × 31.0 × 31.5	B32924E3685M*** ◆	–	784
	6.8	22.0 × 36.5 × 31.5	B32924F3685K***	–	784
37.5	8.2	22.0 × 36.5 × 31.5	B32924E3825M*** ◆	–	784
	2.2	12.0 × 22.0 × 42.0	B32926E3225+***	–	1620
	3.3	12.0 × 22.0 × 42.0	B32926E3335M***	–	1620
	4.7	14.0 × 25.0 × 42.0	B32926E3475M***	–	1380
	6.8	18.0 × 32.5 × 42.0	B32926E3685+***	–	720
	10	20.0 × 39.5 × 42.0	B32926E3106+*** ◆	–	640
	15	28.0 × 37.0 × 42.0	B32926E3156+*** ◆	–	440
	20	28.0 × 42.5 × 42.0	B32926E3206M*** ◆	–	440
52.5	20	30.0 × 45.0 × 42.0	B32926F3206K***	–	200
	25	30.0 × 45.0 × 57.5	B32928E3256+*** ◆	–	280
	30	30.0 × 45.0 × 57.5	B32928E3306+*** ◆	–	280
	40	35.0 × 50.0 × 57.5	B32928E3406+*** ◆	–	108
	45	35.0 × 50.0 × 57.5	B32928E3456M*** ◆	–	108

**◆ Preferred type**

MOQ = Minimum Order Quantity, consisting of 4 packing units.

Further intermediate capacitance values on request.

**Composition of ordering code**

+ = Capacitance tolerance code:

M = ±20%

K = ±10%

\*\*\* = Packaging code:

189 = Reel

000 = Untaped (lead length 6 – 1 mm)

**Technical data**

Maximum continuous DC voltage $V_{DC}$	500 V
Maximum continuous AC voltage $V_{AC}$	310 V (50/60 Hz)
Rated AC voltage ( IEC 60384-14 )	305 V (50/60 Hz)
Max. operating temperature $T_{op,max}$	+110 °C
DC test voltage	2121 V, 2 s
Dissipation factor $\tan \delta$ (in $10^{-3}$ ) at 20 °C (upper limit values)	at 1 kHz: 2
Insulation resistance $R_{ins}$ or time constant $\tau = C_R \cdot R_{ins}$ at 100 V DC, 20 °C, rel. humidity $\leq 65\%$ and for 60 s (minimum as-delivered values)	30 000 s
Passive flammability category to IEC 40 (CO) 752	B
Capacitance tolerances (measured at 1 kHz)	$\pm 10\%$ (K), $\pm 20\%$ (M)

**Pulse handling capability**

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

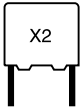
" $k_0$ " represents the maximum permissible pulse characteristic of the waveform applied to the capacitor, expressed in  $V^2/\mu$ s.

**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	22.5 mm	27.5 mm	37.5 mm	52.5 mm
dV/dt in V/ $\mu$ s	140	100	70	40
$k_0$ in $V^2/\mu$ s	120 400	86 000	60 200	34 400

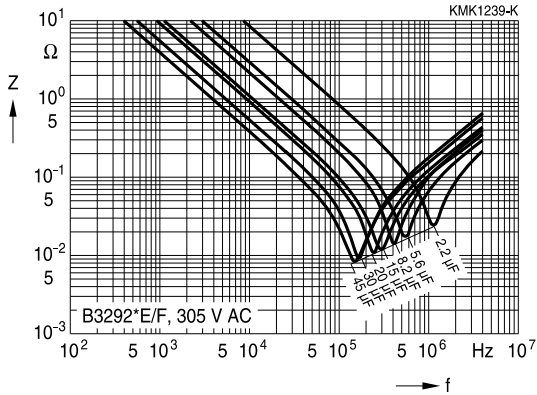


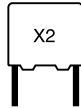
B32923E/F ... B32928E/F

Efficient filtering – X2 / 305 V AC

### 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 (lead spacing ≤ 7.5 mm)		< 4 s
MKT uncoated (lead spacing ≤ 10 mm) insulated (B32559)		recommended soldering profile for MKT uncoated (lead spacing ≤ 10 mm) and insulated (B32559)



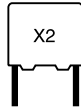
**B32923E/F ... B32928E/F**

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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
$\tan \delta$	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.

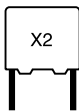
EPCOS recommends the following conditions:

- 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  $\leq 10$  mm (B32560/B32561) the following measures are recommended:

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


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**Efficient filtering – X2 / 305 V AC**

## 2 Cleaning

To determine whether the following solvents, often used to remove flux residues and other substances, are suitable for the capacitors described, refer to the table below:

Type	Ethanol, isopropanol, n-propanol	n-propanol-water mixtures, water with surface tension-reducing tensides (neutral)	Solvent from table A (see next page)	Solvent from table B (see next page)
MKT (uncoated)	Suitable	Unsuitable	In part suitable	Unsuitable
MKT, MKP, MFP (coated/boxed)		Suitable	Suitable	

Even when suitable solvents are used, a reversible change of the electrical characteristics may occur in uncoated capacitors immediately after they are washed. Thus it is always recommended to dry the components (e.g. 4 h at 70 °C) before they are subjected to subsequent electrical testing.

### Table A

Manufacturers' designations for trifluoro-trichloro-ethane-based cleaning solvents (selection)

Trifluoro-trichloro-ethane	Mixtures of trifluoro-trichloro-ethane with ethanol and isopropanol	Manufacturer
Freon TF	Freon TE 35; Freon TP 35; Freon TES	Du Pont
Frigen 113 TR	Frigen 113 TR-E; Frigen 113 TR-P; Frigen TR-E 35	Hoechst
Arklone P	Arklone A; Arklone L; Arklone K	ICI
Kaltron 113 MDR	Kaltron 113 MDA; Kaltron 113 MDI; Kaltron 113 MDI 35	Kali-Chemie
Flugene 113	Flugene 113 E; Flugene 113 IPA	Rhone-Progil

### Table B (worldwide banned substances)

Manufacturers' designations for unsuitable cleaning solvents (selection)

Mixtures of chlorinated hydrocarbons and ketones with fluorated hydrocarbons	Manufacturer
Freon TMC; Freon TA; Freon TC	Du Pont
Arklone E	ICI
Kaltron 113 MDD; Kaltron 113 MDK	Kali-Chemie
Flugene 113 CM	Rhone-Progil



### 3 Embedding of capacitors in finished assemblies

In many applications, finished circuit assemblies are embedded in plastic resins. In this case, both chemical and thermal influences of the embedding ("potting") and curing processes must be taken into account.

Our experience has shown that the following potting materials can be recommended: non-flexible epoxy resins with acid-anhydride hardeners; chemically inert, non-conducting fillers; maximum curing temperature of 100 °C.

**Caution:**

Consult us first if you wish to embed uncoated types!

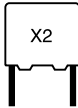

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**Efficient filtering – X2 / 305 V AC**

### 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"


**Symbols and terms**

Symbol	English	German
$\alpha$	Heat transfer coefficient	Wärmeübergangszahl
$\alpha_C$	Temperature coefficient of capacitance	Temperaturkoeffizient der Kapazität
A	Capacitor surface area	Kondensatoroberfläche
$\beta_C$	Humidity coefficient of capacitance	Feuchtekoeffizient der Kapazität
C	Capacitance	Kapazität
$C_R$	Rated capacitance	Nennkapazität
$\Delta C$	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
$\Delta t$	Time interval	Zeitintervall
$\Delta T$	Absolute temperature change (self-heating)	Absolute Temperaturänderung (Selbsterwärmung)
$\Delta \tan \delta$	Absolute change of dissipation factor	Absolute Änderung des Verlustfaktors
$\Delta V$	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	Impuls Kennwert
$L_S$	Series inductance	Serieninduktivität
$\lambda$	Failure rate	Ausfallrate
$\lambda_0$	Constant failure rate during useful service life	Konstante Ausfallrate in der Nutzungsphase
$\lambda_{test}$	Failure rate, determined by tests	Experimentell ermittelte Ausfallrate
$P_{diss}$	Dissipated power	Abgegebene Verlustleistung
$P_{gen}$	Generated power	Erzeugte Verlustleistung
$Q$	Heat energy	Wärmeenergie
$\rho$	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 (Feuchtest)
$t$	Time	Zeit
$T$	Temperature	Temperatur
$\tau$	Time constant	Zeitkonstante
$\tan \delta$	Dissipation factor	Verlustfaktor
$\tan \delta_D$	Dielectric component of dissipation factor	Dielektrischer Anteil des Verlustfaktors
$\tan \delta_P$	Parallel component of dissipation factor	Parallelanteil des Verlustfaktors
$\tan \delta_S$	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	Betriebstemperatur
$T_R$	Rated temperature	Nenntemperatur
$T_{ref}$	Reference temperature	Referenztemperatur
$t_{SL}$	Reference service life	Referenz-Lebensdauer
$V_{AC}$	AC voltage	Wechselspannung


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Symbol	English	German
$V_C$	Category voltage	Kategorie <span>spannung</span>
$V_{C,RMS}$	Category AC voltage	(Sinusförmige) Kategorie-Wechsel <span>spannung</span>
$V_{CD}$	Corona-discharge onset voltage	Teilentlade-Einsatz <span>spannung</span>
$V_{ch}$	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-Spitzen <span>spannung</span>
$V_{pp}$	Peak-to-peak voltage Impedance	Spannungshub
$V_R$	Rated voltage	Nennspannung
$\hat{V}_R$	Amplitude of rated AC voltage	Amplitude der Nenn-Wechsel <span>spannung</span>
$V_{RMS}$	(Sinusoidal) alternating voltage, root-mean-square value	(Sinusförmige) Wechsel <span>spannung</span>
$V_{SC}$	S-correction voltage	Spannung bei Anwendung "S-correction"
$V_{sn}$	Snubber capacitor voltage	Spannung bei Anwendung "Beschaltung"
$Z$	Impedance	Scheinwiderstand
$e$	Lead spacing	Rastermaß



## 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, EPCOS is 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 an EPCOS 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 lifesaving 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.
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