# Film Capacitors

## Metallized Polypropylene Film Capacitors (MKP)

**Series/Type:** **B32613, B32614**

Date: September 2018

### Typical applications
- Electronic ballasts
- Switch-mode power supplies

### Climatic
- Max. operating temperature: 110 °C
- Climatic category (IEC 60068-1:2013): 55/100/56

### Construction
- Dielectric: polypropylene (PP)
- Wound capacitor technology
- Epoxy resin coating (UL 94 V-0)

### Features
- Very high pulse strength
- RoHS-compatible

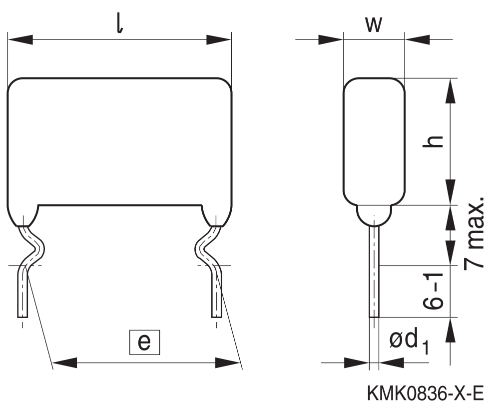
### Terminals
- Crimped wire leads, lead-free tinned, lead length (6 −1) mm
- Double crimped wire leads, lead-free tinned
- Straight wire leads, lead-free tinned, lead length (17 ±3) mm
- Different lead spacings (reduced and enlarged) available, lead length (6 −1) mm

### Marking
Manufacturer's logo, style and type (P61x),
rated capacitance (coded),
capacitance tolerance (code letter),
rated DC voltage, date of manufacture (code)

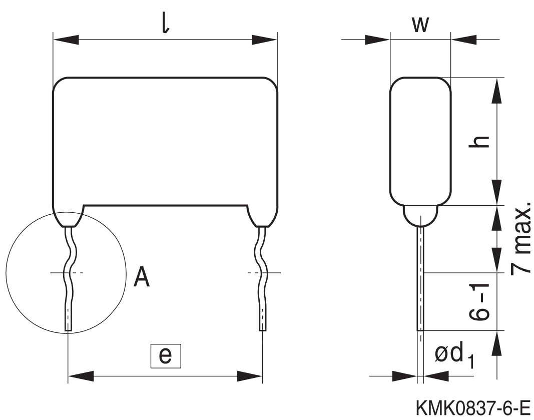
### Delivery mode
Bulk (untaped)
Taped (Ammo pack or reel)
For notes on taping, refer to chapter "Taping and packing“.

## Dimensional drawings

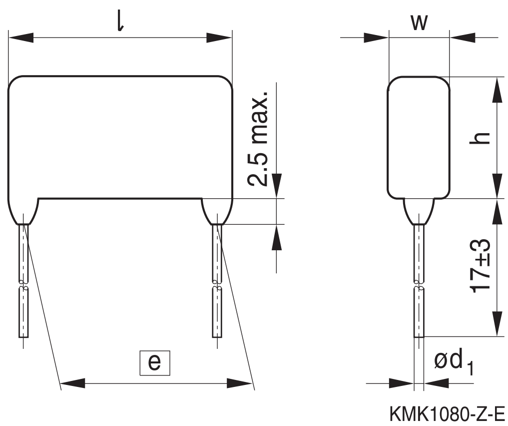
Crimped leads



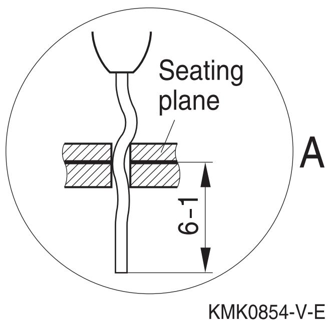

Double crimped leads




Straight leads

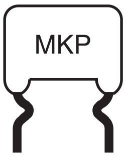



Detail of double crimped version




## Dimensions in mm

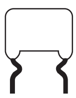
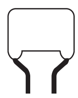
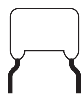
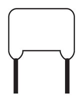
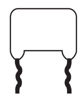
| Lead spacing<br>e ±0.8 | Lead diameter<br>$d_1$ ±0.05 | Type |
|---|---|---|
| 22.5 | 0.8 | B32613 |
| 27.5 | 0.8 | B32614 |

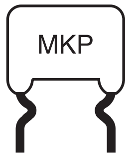



## Overview of available types

| Lead spacing | 22.5 mm | | | | | | |
|---|---|---|---|---|---|---|---|
| Type | B32613 | | | | | | |
| Page | 6 | | | | | | |
| $V_R$ (V DC) | 250 | 400 | 630 | 1000 | 1600 | 2000 | 2000 |
| $V_{RMS}$ (V AC) | 160 | 200 | 250 | 250 | 500 | 700 | 1000 |
| $C_R$ (nF) | | | | | | | |
| 3.3 | | | | | | | |
| 4.7 | | | | | | | |
| 6.8 | | | | | | | |
| 10 | | | | | | | |
| 15 | | | | | | | |
| 22 | | | | | | | |
| 33 | | | | | | | |
| 47 | | | | | | | |
| 68 | | | | | | | |
| 100 | | | | | | | |
| 150 | | | | | | | |
| 220 | | | | | | | |
| 330 | | | | | | | |
| 470 | | | | | | | |
| 680 | | | | | | | |
| 1000 | | | | | | | |

## Lead configurations

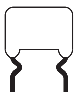
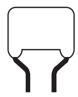
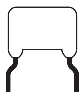
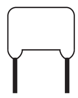
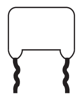
| Serie | Standard | Reduced | Enlarged | Straight | Double crimped |
|---|---|---|---|---|---|
| |  |  |  |  |  |
| B32613 | 22.5 mm | 15 / 17.5 / 20 mm | 25 mm | 22.5 mm | 22.5 mm |
| B32614 | 27.5 mm | 25 mm | – | 27.5 mm | 27.5 mm |

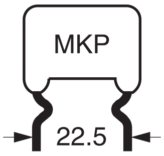



## Overview of available types

| Lead spacing | 27.5 mm | | | | | |
|---|---|---|---|---|---|---|
| Type | B32614 | | | | | |
| Page | 8 | | | | | |
| $V_R$ (V DC) | 250 | 400 | 630 | 1000 | 1600 | 2000 |
| $V_{RMS}$ (V AC) | 160 | 200 | 250 | 250 | 500 | 700 |
| $C_R$ (nF) | | | | | | |
| 10 | | | | | | |
| 15 | | | | | | |
| 22 | | | | | | |
| 33 | | | | | | |
| 47 | | | | | | |
| 68 | | | | | | |
| 100 | | | | | | |
| 150 | | | | | | |
| 220 | | | | | | |
| 470 | | | | | | |
| 680 | | | | | | |
| 1000 | | | | | | |
| 1500 | | | | | | |
| 2200 | | | | | | |

## Lead configurations

| Serie | Standard | Reduced | Enlarged | Straight | Double crimped |
|---|---|---|---|---|---|
| |  |  |  |  |  |
| B32613 | 22.5 mm | 15 / 17.5 / 20 mm | 25 mm | 22.5 mm | 22.5 mm |
| B32614 | 27.5 mm | 25 mm | – | 27.5 mm | 27.5 mm |




## B32613

### High pulse (wound)

### Ordering codes and packing units (lead spacing 22.5 mm)

| $V_R$<br><br>V DC | $V_{RMS}$<br>f ≤1 kHz<br>V AC | $C_R$<br><br>nF | Max. dimensions<br>w × h × l<br>mm | Ordering code<br>(composition see<br>below) | Ammo<br>pack<br>pcs./MOQ | Reel<br><br>pcs./MOQ | Untaped<br><br>pcs./MOQ |
|---|---|---|---|---|---|---|---|
| 250 | 160 | 220 | 7.0 × 14.5 × 26.5 | B32613A3224+*** | 2000 | 2800 | 2000 |
| | | 330 | 7.0 × 14.5 × 26.5 | B32613A3334+*** | 2000 | 2800 | 2000 |
| | | 470 | 8.0 × 15.5 × 26.5 | B32613A3474+*** | 1800 | 2400 | 2000 |
| | | 680 | 9.5 × 16.0 × 26.5 | B32613A3684+*** | 1400 | 2000 | 2000 |
| | | 1000 | 11.0 × 19.0 × 26.5 | B32613A3105+*** | 1200 | 1800 | 1000 |
| 400 | 200 | 150 | 7.0 × 13.5 × 26.5 | B32613A4154+*** | 2000 | 2800 | 2000 |
| | | 220 | 7.0 × 14.0 × 26.5 | B32613A4224+*** | 2000 | 2800 | 2000 |
| | | 330 | 8.0 × 16.0 × 26.5 | B32613A4334+*** | 1800 | 2400 | 2000 |
| | | 470 | 9.5 × 16.0 × 26.5 | B32613A4474+*** | 1400 | 2000 | 1000 |
| | | 680 | 11.5 × 17.5 × 26.5 | B32613A4684+*** | 1200 | 1600 | 1000 |
| 630 | 250 | 100 | 7.0 × 12.5 × 26.5 | B32613A6104+*** | 2000 | 2800 | 1000 |
| | | 150 | 7.5 × 14.0 × 26.5 | B32613A6154+*** | 1800 | 2600 | 1000 |
| | | 220 | 9.0 × 15.5 × 26.5 | B32613A6224+*** | 1600 | 2200 | 1000 |
| | | 330 | 10.0 × 18.0 × 26.5 | B32613A6334+*** | 1400 | 2000 | 1000 |
| | | 470 | 11.0 × 20.0 × 26.5 | B32613A6474+*** | 1200 | 1800 | 1000 |
| 1000 | 250 | 33 | 8.5 × 14.5 × 26.5 | B32613A0333+*** | 1600 | 2200 | 2000 |
| | | 47 | 10.0 × 15.5 × 26.5 | B32613A0473+*** | 1400 | 2000 | 1000 |
| | | 68 | 11.0 × 17.5 × 26.5 | B32613A0683+*** | 1200 | 1800 | 1000 |
| | | 100 | 10.0 × 16.5 × 26.5 | B32613A0104+*** | 1400 | 2000 | 1000 |
| | | 150 | 12.0 × 18.0 × 26.5 | B32613A0154+*** | 1200 | 1600 | 1000 |
| 1600 | 500 | 10 | 7.0 × 13.5 × 26.5 | B32613A1103+*** | 2000 | 2800 | 2000 |
| | | 15 | 8.0 × 14.5 × 26.5 | B32613A1153+*** | 1800 | 2400 | 2000 |
| | | 22 | 9.0 × 17.0 × 26.5 | B32613A1223+*** | 1600 | 2200 | 1000 |
| | | 33 | 10.5 × 18.5 × 26.5 | B32613A1333+*** | 1400 | 1800 | 1000 |

MOQ = Minimum Order Quantity, consisting of 4 packing units.
Further E series and intermediate capacitance values on request.

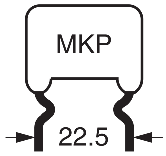
**Composition of ordering code**

+ = Capacitance tolerance code:
K = ±10%
J = ±5%

*** = Packaging code:
289 = Ammo pack
189 = Reel
010 = Untaped crimped (lead length 6 −1 mm)
008 = Untaped straight (lead length 17±3 mm)
020 = Double crimped (lead length 6 −1 mm)

Packaging codes for further lead configurations (untaped):

| Lead configuration (lead length 6 −1 mm) | Reduced | Reduced | Reduced | Enlarged |
|---|---|---|---|---|
| Lead spacing (mm) | 15 mm | 17.5 mm | 20 mm | 25 mm |
| Packaging code | 055 | 060 | 070 | 080 |




## Ordering codes and packing units (lead spacing 22.5 mm)

| $V_R$<br><br>V DC | $V_{RMS}$<br>f ≤1 kHz<br>V AC | $C_R$<br><br>nF | Max. dimensions<br>w × h × l<br>mm | Ordering code<br>(composition see below) | Ammo pack<br>pcs./MOQ | Reel<br><br>pcs./MOQ | Untaped<br><br>pcs./MOQ |
|---|---|---|---|---|---|---|---|
| 2000 | 700 | 3.3 | 7.0 × 13.0 × 26.5 | B32613A2332+*** | 2000 | 2800 | 2000 |
| | | 4.7 | 7.5 × 14.0 × 26.5 | B32613A2472+*** | 1800 | 2600 | 2000 |
| | | 6.8 | 8.5 × 16.0 × 26.5 | B32613A2682+*** | 1600 | 2200 | 2000 |
| | | 10 | 10.5 × 17.0 × 26.5 | B32613A2103+*** | 1400 | 1800 | 1000 |
| | | 15 | 12.0 × 20.5 × 26.5 | B32613A2153+*** | 1200 | 1600 | 1000 |
| 2000 | 1000 | 3.3 | 8.0 × 14.5 × 26.5 | B32613A8332+*** | 1800 | 2400 | 2000 |
| | | 4.7 | 8.5 × 16.5 × 26.5 | B32613A8472+*** | 1600 | 2200 | 1000 |
| | | 6.8 | 10.0 × 18.5 × 26.5 | B32613A8682+*** | 1400 | 2000 | 1000 |
| | | 10 | 11.5 × 21.5 × 26.5 | B32613A8103+*** | 1200 | 1600 | 1000 |

MOQ = Minimum Order Quantity, consisting of 4 packing units.
Further E series and intermediate capacitance values on request.

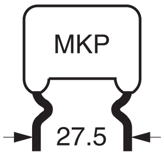
**Composition of ordering code**

+ = Capacitance tolerance code:
K = ±10%
J = ±5%

*** = Packaging code:
289 = Ammo pack
189 = Reel
010 = Untaped crimped (lead length 6 −1 mm)
008 = Untaped straight (lead length 17±3 mm)
020 = Double crimped (lead length 6 −1 mm)

Packaging codes for further lead configurations (untaped):

| Lead configuration (lead length 6 −1 mm) | Reduced | Reduced | Reduced | Enlarged |
|---|---|---|---|---|
| Lead spacing (mm) | 15 mm | 17.5 mm | 20 mm | 25 mm |
| Packaging code | 055 | 060 | 070 | 080 |






## Ordering codes and packing units (lead spacing 27.5 mm)

| $V_R$<br>V DC | $V_{RMS}$<br>f ≤1 kHz<br>V AC | $C_R$<br>nF | Max. dimensions<br>w × h × l<br>mm | Ordering code<br>(composition see below) | Untaped<br>pcs./MOQ |
|---|---|---|---|---|---|
| 250 | 160 | 470 | 7.0 × 15.0 × 31.5 | B32614A3474+*** | 2000 |
| | | 680 | 8.0 × 16.5 × 31.5 | B32614A3684+*** | 2000 |
| | | 1000 | 9.5 × 17.5 × 31.5 | B32614A3105+*** | 800 |
| | | 1500 | 11.5 × 19.5 × 31.5 | B32614A3155+*** | 800 |
| | | 2200 | 14.0 × 22.0 × 31.5 | B32614A3225+*** | 800 |
| 400 | 200 | 470 | 9.5 × 15.0 × 31.5 | B32614A4474+*** | 800 |
| | | 680 | 10.0 × 17.5 × 31.5 | B32614A4684+*** | 800 |
| | | 1000 | 11.5 × 19.5 × 31.5 | B32614A4105+*** | 800 |
| | | 1500 | 14.0 × 22.0 × 31.5 | B32614A4155+*** | 800 |
| | | 2200 | 16.5 × 24.5 × 31.5 | B32614A4225+*** | 600 |
| 630 | 250 | 470 | 10.5 × 18.5 × 31.5 | B32614A6474+*** | 800 |
| | | 680 | 12.0 × 21.5 × 31.5 | B32614A6684+*** | 800 |
| | | 1000 | 14.0 × 24.0 × 31.5 | B32614A6105+*** | 800 |
| 1000 | 250 | 100 | 11.5 × 17.5 × 31.5 | B32614A0104+*** | 2000 |
| | | 150 | 13.0 × 21.0 × 31.5 | B32614A0154+*** | 800 |
| | | 220 | 14.5 × 24.5 × 31.5 | B32614A0224+*** | 800 |
| 1600 | 500 | 22 | 9.0 × 14.5 × 31.5 | B32614A1223+*** | 2000 |
| | | 33 | 10.5 × 16.0 × 31.5 | B32614A1333+*** | 2000 |
| | | 47 | 11.0 × 19.5 × 31.5 | B32614A1473+*** | 800 |
| | | 68 | 13.0 × 21.5 × 31.5 | B32614A1683+*** | 800 |
| 2000 | 700 | 10 | 9.0 × 15.5 × 31.5 | B32614A2103+*** | 2000 |
| | | 15 | 11.0 × 17.5 × 31.5 | B32614A2153+*** | 800 |
| | | 22 | 13.0 × 19.5 × 31.5 | B32614A2223+*** | 800 |
| | | 33 | 14.5 × 23.0 × 31.5 | B32614A2333+*** | 800 |
| | | 47 | 16.5 × 25.5 × 31.5 | B32614A2473+*** | 600 |

MOQ = Minimum Order Quantity, consisting of 4 packing units.
Further E series and intermediate capacitance values on request.

### Composition of ordering code

+ = Capacitance tolerance code:
K = ±10%
J = ±5%

*** = Packaging code:
010 = Untaped crimped (lead length 6 −1 mm)
008 = Untaped straight (lead length 17±3 mm)
020 = Double crimped (lead length 6 −1 mm)

Packaging codes for further lead configurations (untaped):

| | |
|---|---|
| Lead configuration (lead length 6 −1 mm) | Reduced |
| Lead spacing (mm) | 25 mm |
| Packaging code | 090 |

## Technical data

Reference standard: IEC 60384-16:2005. All data given at T = 20 °C, unless otherwise specified.

| | | | | |
|---|---|---|---|---|
| Operating temperature range | Max. operating temperature $T_{op,max}$ | +110 °C | | |
| | Upper category temperature $T_{max}$ | +100 °C | | |
| | Lower category temperature $T_{min}$ | −55 °C | | |
| | Rated temperature $T_R$ | +85 °C | | |
| Dissipation factor tan δ (in $10^{-3}$) at 20 °C (upper limit values) | at | $C_R \leq 0.1\ \mu F$ | $0.1\ \mu F < C_R \leq 1\ \mu F$ | $C_R > 1\ \mu F$ |
| | 1 kHz | – | 0.5 | 0.5 |
| | 10 kHz | – | 0.8 | 1.5 |
| | 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) | $C_R \leq 0.33\ \mu F$ | $C_R > 0.33\ \mu F$ | | |
| | 100 GΩ | 30000 s | | |
| DC test voltage | $1.6 \cdot V_R$, 2 s | | | |
| Category voltage $V_C$ (continuous operation with $V_{DC}$ or $V_{AC}$ at f ≤ 1 kHz) | $T_{op}$ (°C) | DC voltage derating | AC voltage derating | |
| | $T_{op} \leq 85$ | $V_C = V_R$ | $V_{C,RMS} = V_{RMS}$ | |
| | $85 < T_{op} \leq 100$ | $V_C = V_R \cdot (165 - T_{op})/80$ | $V_{C,RMS} = V_{RMS} \cdot (165 - T_{op})/80$ | |
| Operating voltage $V_{op}$ for short operating periods ($V_{DC}$ or $V_{AC}$ at f ≤ 1 kHz) | $T_{op}$ (°C) | DC voltage (max. hours) | AC voltage (max. hours) | |
| | $T_{op} \leq 100$ | $V_{op} = 1.25 \cdot V_C$ (2000 h) | $V_{op} = 1.0 \cdot V_{C,RMS}$ (2000 h) | |
| | $100 < T_{op} \leq 110$ | $V_{op} = 1.25 \cdot V_C$ (1000 h) | $V_{op} = 1.0 \cdot V_{C,RMS}$ (1000 h) | |
| Reliability: | | | | |
| Failure rate λ | 1 fit (≤ $1 \cdot 10^{-9}$ /h) at $0.5 \cdot V_R$, 40 °C | | | |
| Service life $t_{SL}$ | 200 000 h at $1.0 \cdot V_R$, 85 °C<br>For conversion to other operating conditions and temperatures, refer to chapter "Quality, 2 Reliability". | | | |
| Failure criteria: | | | | |
| Total failure | Short circuit or open circuit | | | |
| Failure due to variation of parameters | Capacitance change \|ΔC/C\| | > 10% | | |
| | Dissipation factor tan δ | > 4 · upper limit value | | |
| | Insulation resistance $R_{ins}$ | < 1500 MΩ ($C_R \leq 0.33\ \mu F$) | | |
| | or time constant $\tau = C_R \cdot R_{ins}$ | < 500 s ($C_R > 0.33\ \mu F$) | | |

### Characteristic voltages $V_{DC}$, $V_{AC}$, $V_{pp}$

| $V_{DC}$<br>V | $V_{AC}$<br>V | $V_{pp}$<br>V |
|---|---|---|
| 1000 | 250 | 700 |
| 1250 | 500 | 1250 |
| 1600 | 500 | 1400 |
| 1600 | 700 | 1600 |
| 2000 | 700 | 1600 |
| 2000 | 1000 | 2000 |

**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 $V^2$/µs.

*Note:*
*The values of dV/dt and $k_0$ provided below must not be exceeded in order to avoid damaging the capacitor. These parameters are given for isolated pulses in such a way that the heat generated by one pulse will be completely dissipated before applying the next pulse. For a train of pulses, please refer to the curves of permissible AC voltage-current versus frequency.*

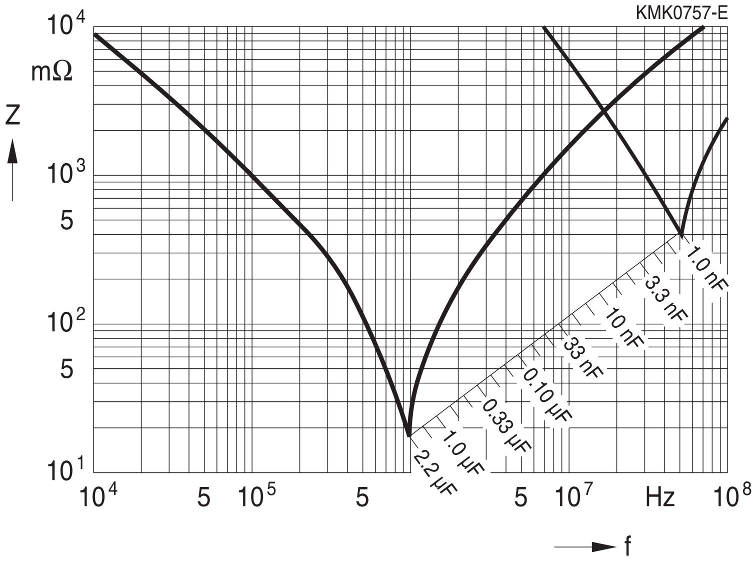
**dV/dt values**

| Lead spacing | | 22.5 mm | 27.5 mm |
|---|---|---|---|
| $V_R$ V DC | $V_{RMS}$ V AC | dV/dt in V/µs | |
| 250 | 160 | 120 | 50 |
| 400 | 200 | 180 | 100 |
| 630 | 250 | 300 | 150 |
| 1000 | 250 | 600 | 300 |
| 1250 | 500 | 1150 | 600 |
| 1600 | 500 | 2400 | 1000 |
| 1600 | 700 | – | – |
| 2000 | 700 | 7000 | 2300 |
| 2000 | 1000 | 7500 | – |

**$k_0$ values**

| Lead spacing | | 22.5 mm | 27.5 mm |
|---|---|---|---|
| $V_R$ V DC | $V_{RMS}$ V AC | $k_0$ in $V^2$/µs | |
| 250 | 160 | 60 000 | 25 000 |
| 400 | 200 | 200 000 | 110 000 |
| 630 | 250 | 350 000 | 250 000 |
| 1000 | 250 | 1 500 000 | 1 000 000 |
| 1250 | 500 | 3 750 000 | 2 000 000 |
| 1600 | 500 | 10 000 000 | 4 000 000 |
| 1600 | 700 | – | – |
| 2000 | 700 | 40 000 000 | 15 000 000 |
| 2000 | 1000 | 50 000 000 | – |

**Impedance Z versus frequency f**
(typical values)

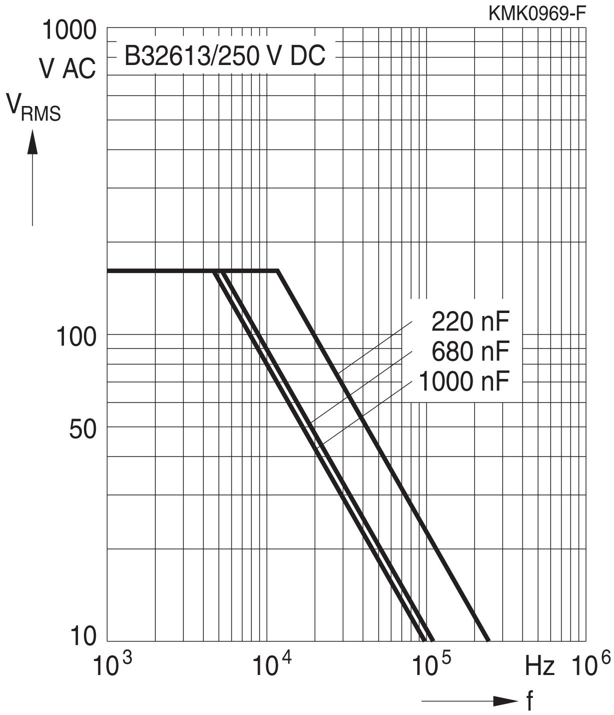


**Permissible AC voltage $V_{RMS}$ versus frequency f (for sinusoidal waveforms, $T_A \leq 90$ °C)**

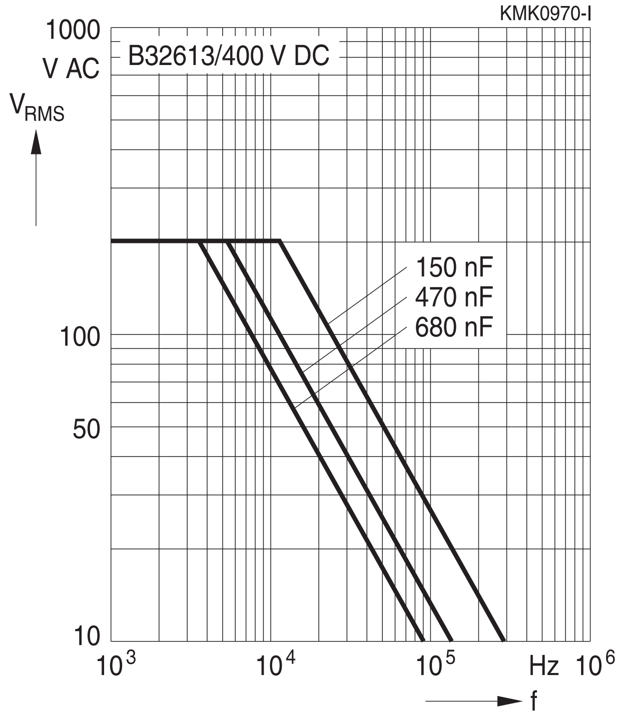
For $T_A > 90$ °C, please use derating factor $F_T$.

**Lead spacing 22.5 mm**

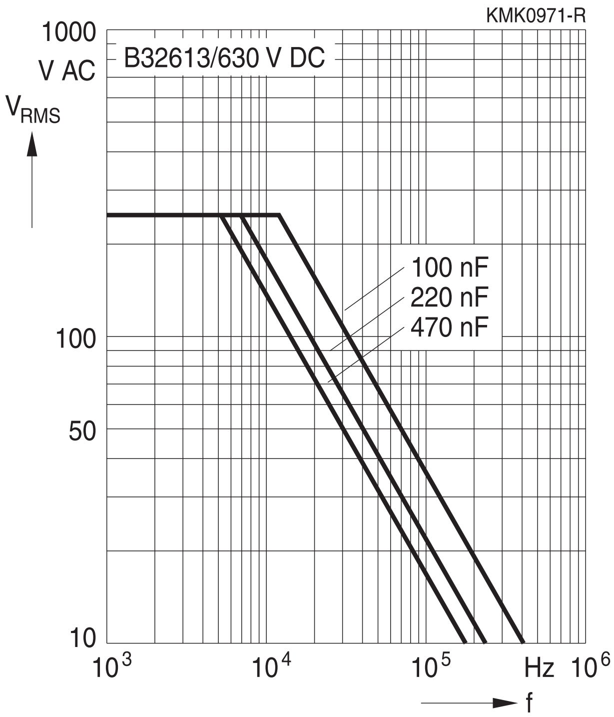
250 V DC/160 V AC



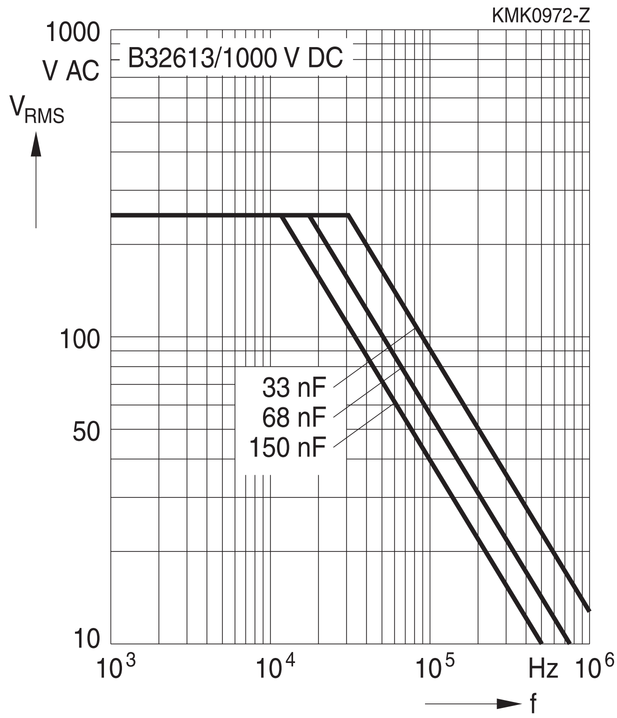

400 V DC/200 V AC




630 V DC/250 V AC




1000 V DC/250 V AC

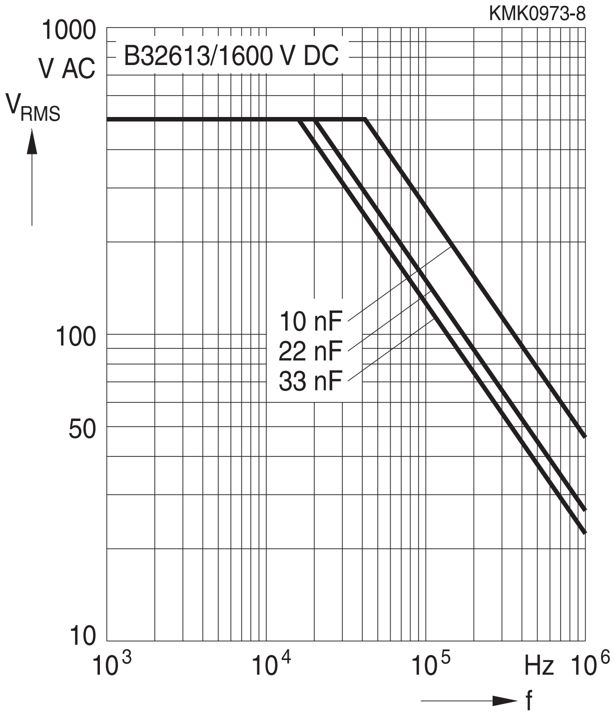


**Permissible AC voltage $V_{RMS}$ versus frequency f (for sinusoidal waveforms, $T_A \leq 90$ °C)**

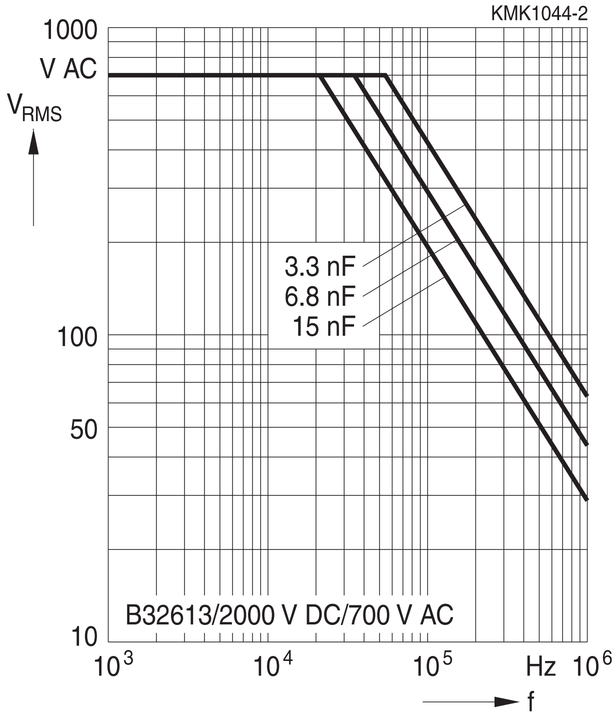
For $T_A > 90$ °C, please use derating factor $F_T$.

**Lead spacing 22.5 mm**

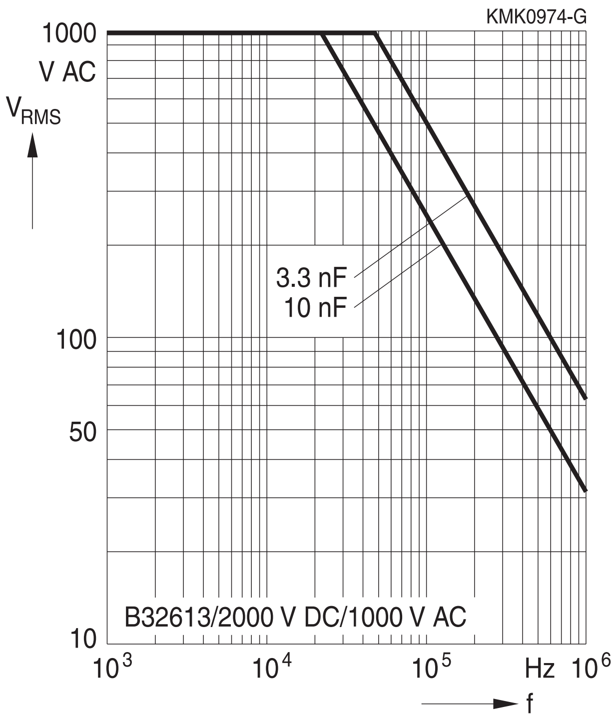
1600 V DC/500 V AC




2000 V DC/700 V AC




2000 V DC/1000 V AC

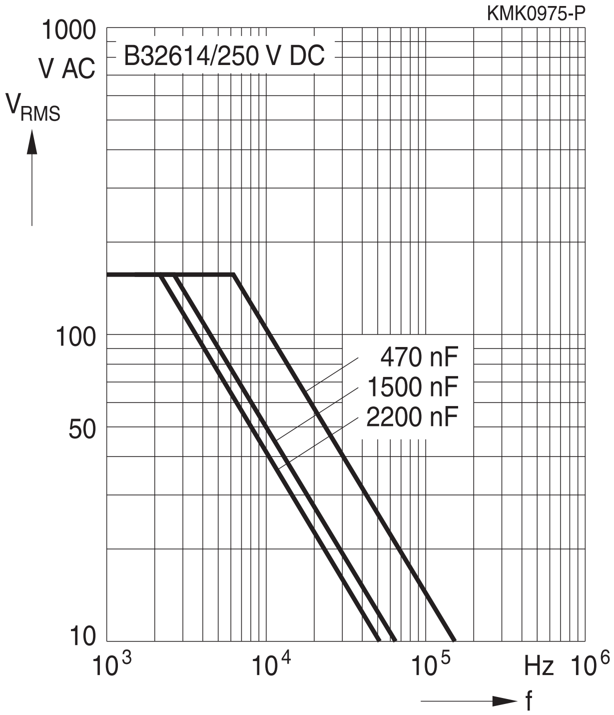


**Permissible AC voltage $V_{RMS}$ versus frequency f (for sinusoidal waveforms, $T_A \leq 90$ °C)**

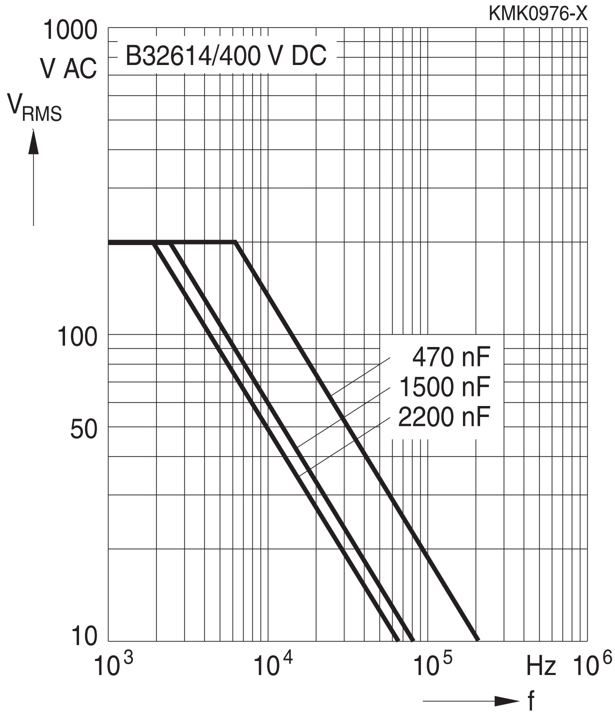
For $T_A > 90$ °C, please use derating factor $F_T$.

**Lead spacing 27.5 mm**

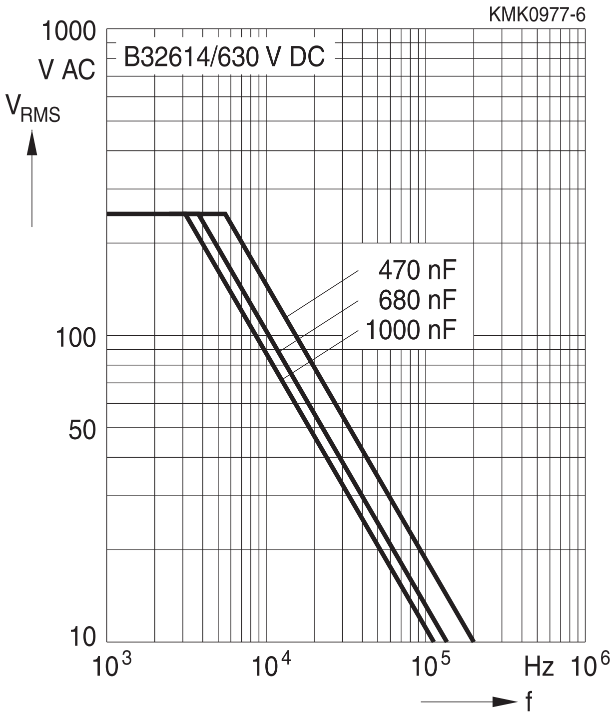
250 V DC/160 V AC



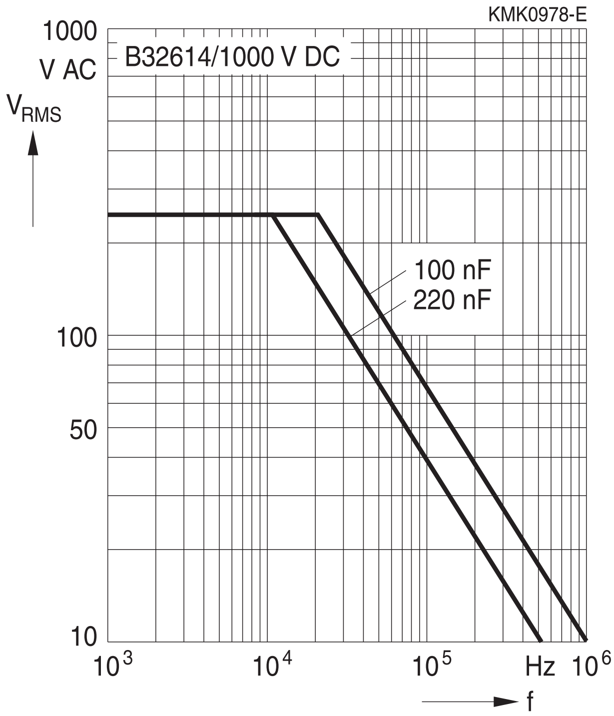

400 V DC/200 V AC




630 V DC/250 V AC




1000 V DC/250 V AC

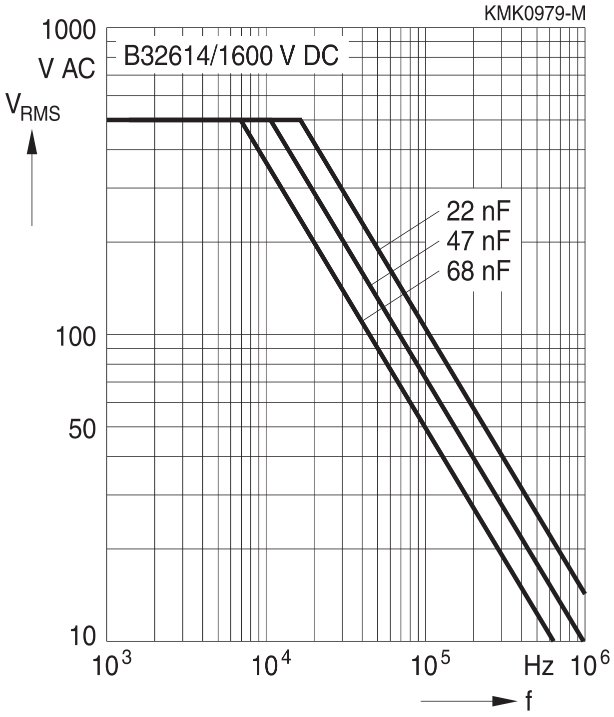


**Permissible AC voltage $V_{RMS}$ versus frequency f (for sinusoidal waveforms, $T_A \leq 90$ °C)**

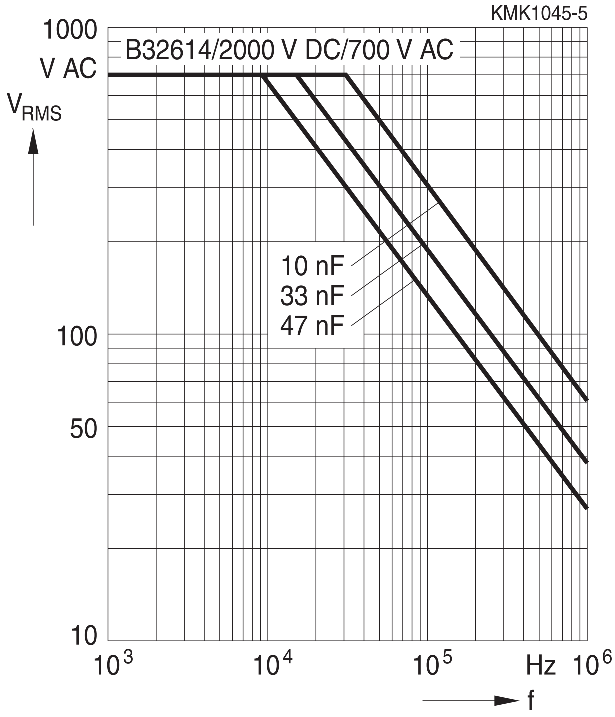
For $T_A > 90$ °C, please use derating factor $F_T$.

**Lead spacing 27.5 mm**

1600 V DC/500 V AC




2000 V DC/700 V AC



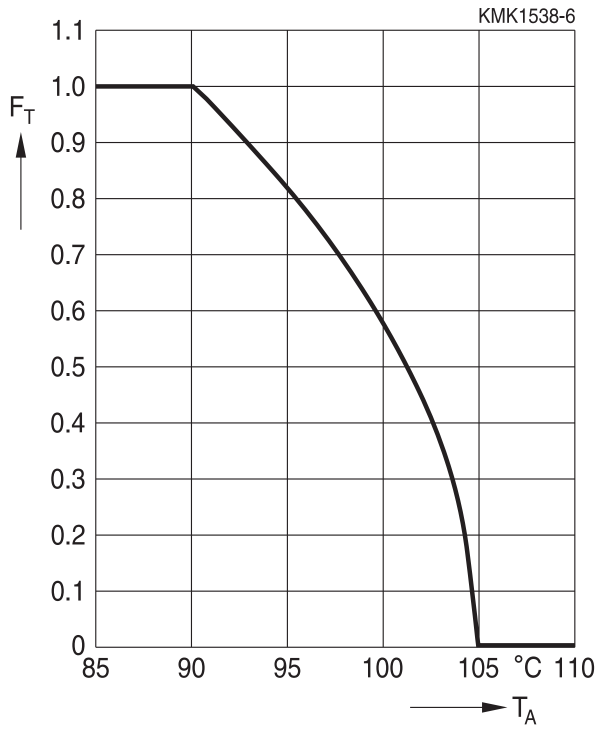
**Maximum AC voltage ($V_{RMS}$), current ($I_{RMS}$) versus frequency and temperature for $T_A$ >90 °C**

The graphs described in the previous section for the permissible AC voltage ($V_{RMS}$) or current ($I_{RMS}$) versus frequency are given for a maximum ambient temperature $T_A \leq 90$ ºC. In case of higher ambient temperatures ($T_A$), the self-heating ($\Delta T$) of the component must be reduced to avoid that temperature of the component ($T_{op} = T_A + \Delta T$) reaches values above maximum operating temperature.The factor $F_T$ shall be applied in the following way:

$$I_{RMS}(T_A) = I_{RMS, T_A \leq 90\,°C} \cdot F_T(T_A)$$

$$V_{RMS}(T_A) = V_{RMS, T_A \leq 90\,°C} \cdot F_T(T_A)$$

And $F_T$ is given by the following curve:



## Testing and Standards

| Test | Reference | Conditions of test | Performance requirements |
|---|---|---|---|
| Electrical parameters | IEC 60384-16:2005 | Voltage proof, 1.6 $V_R$, 1 minute<br>Insulation resistance, $R_{ins}$<br>Capacitance, C<br>Dissipation factor, tan $\delta$ | Within specified limits |
| Robustness of terminations | IEC 60068-2-21:2006 | Tensile strength (test Ua1)<br>Wire diameter: $0.5 < d_1 \leq 0.8$ mm — Tensile force: 10 N | Capacitance and tan $\delta$ within specified limits |
| Resistance to soldering heat | IEC 60068-2-20:2008, test Tb, method 1A | Solder bath temperature at 260 ±5 °C, immersion for 10 seconds | $\Delta C/C_0 \leq 2\%$<br>$\lvert\Delta \tan \delta\rvert \leq 0.002$ |
| Rapid change of temperature | IEC 60384-16:2005 | $T_A$ = lower category temperature<br>$T_B$ = upper category temperature<br>Five cycles, duration t = 30 min. | $\lvert\Delta C/C_0\rvert \leq 2\%$<br>$\lvert\Delta \tan \delta\rvert \leq 0.002$<br>$R_{ins} \geq 50\%$ of initial limit |
| Vibration | IEC 60384-16:2005 | Test $F_C$: vibration sinusoidal<br>Displacement: 0.75 mm<br>Accleration: 98 m/s$^2$<br>Frequency: 10 Hz ... 500 Hz<br>Test duration: 3 orthogonal axes, 2 hours each axe | No visible damage |
| Bump | IEC 60384-16:2005 | Test Eb: Total 4000 bumps with 390 m/s$^2$ mounted on PCB<br>Duration: 6 ms | No visible damage<br>$\lvert\Delta C/C_0\rvert \leq 2\%$<br>$\lvert\Delta \tan \delta\rvert \leq 0.002$<br>$R_{ins} \geq 50\%$ of initial limit |
| Climatic sequence | IEC 60384-16:2005 | Dry heat Tb / 16 h<br>Damp heat cyclic, 1st cycle<br>+55 °C / 24 h / 95% ... 100% RH<br>Cold Ta / 2 h<br>Damp heat cyclic, 5 cycles<br>+55 °C / 24 h / 95% ... 100% RH | No visible damage<br>$\lvert\Delta C/C_0\rvert \leq 3\%$<br>$\lvert\Delta \tan \delta\rvert \leq 0.001$<br>$R_{ins} \geq 50\%$ of initial limit |
| Damp heat, steady state | IEC 60384-16:2005 | Test Ca<br>40 °C / 93% RH / 56 days | No visible damage<br>$\lvert\Delta C/C_0\rvert \leq 3\%$<br>$\lvert\Delta \tan \delta\rvert \leq 0.001$<br>$R_{ins} \geq 50\%$ of initial limit |
| Endurance A | IEC 60384-16:2005 | 85 °C / 1.25 $V_R$ / 2000 hours | No visible damage<br>$\lvert\Delta C/C_0\rvert \leq 5\%$<br>$\lvert\Delta \tan \delta\rvert \leq 0.002$<br>$R_{ins} \geq 50\%$ of initial limit |

| Test | Reference | Conditions of test | Performance requirements |
|---|---|---|---|
| Endurance B | IEC 60384-16:2005 | 100 °C / 1.25 $V_C$ / 2000 hours | No visible damage<br>$\lvert \Delta C/C_0 \rvert \leq 5\%$<br>$\lvert \Delta \tan \delta \rvert \leq 0.002$<br>$R_{ins} \geq 50\%$ of initial limit |

**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.

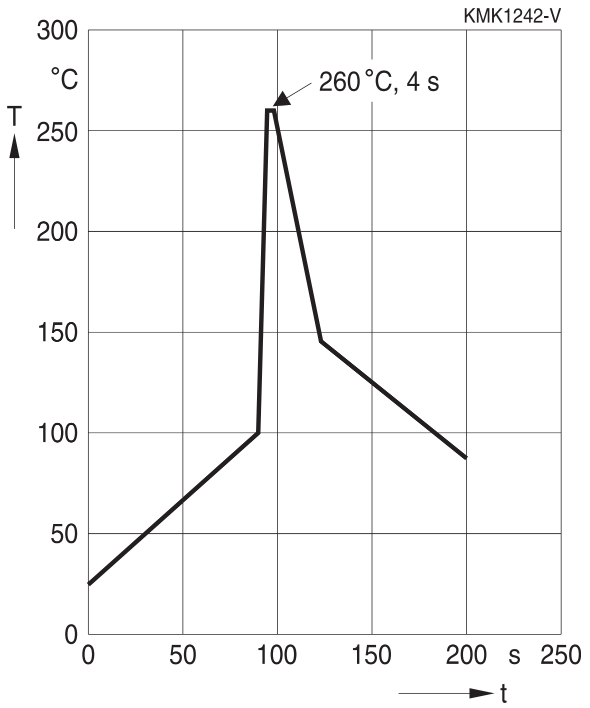
Before a solderability test is carried out, terminals are subjected to accelerated ageing (to IEC 60068-2-2, test Ba: 4 h exposure to dry heat at 155 °C). Since the ageing temperature is far higher than the upper category temperature of the capacitors, the terminal wires should be cut off from the capacitor 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:<br>Visual inspection | Wetting of wire surface by new solder ≥90%,<br>free-flowing solder |

## 1.2 Resistance to soldering heat

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

| Series | Solder bath temperature | Soldering time |
|---|---|---|
| MKT boxed (except 2.5 × 6.5 × 7.2 mm)<br>coated<br>uncoated (lead spacing >10 mm) | 260 ±5 °C | 10 ±1 s |
| MFP<br>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)<br>MKT uncoated (lead spacing ≤10 mm)<br>insulated (B32559) | | <4 s<br>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<br>5% for EMI suppression capacitors |
| tan $\delta$ | As specified in sectional specification |

## 1.3 General notes on soldering

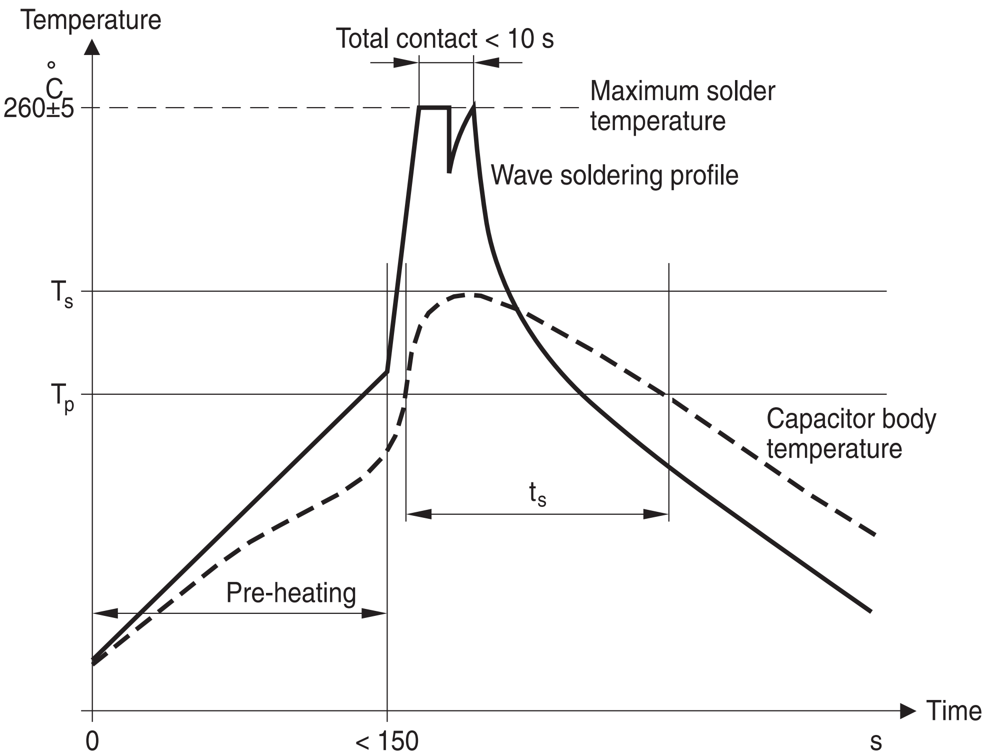
Permissible heat exposure loads on film capacitors are primarily characterized by the upper category temperature $T_{max}$. Long exposure to temperatures above this type-related temperature limit can lead to changes in the plastic dielectric and thus change irreversibly a capacitor's electrical characteristics. 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.

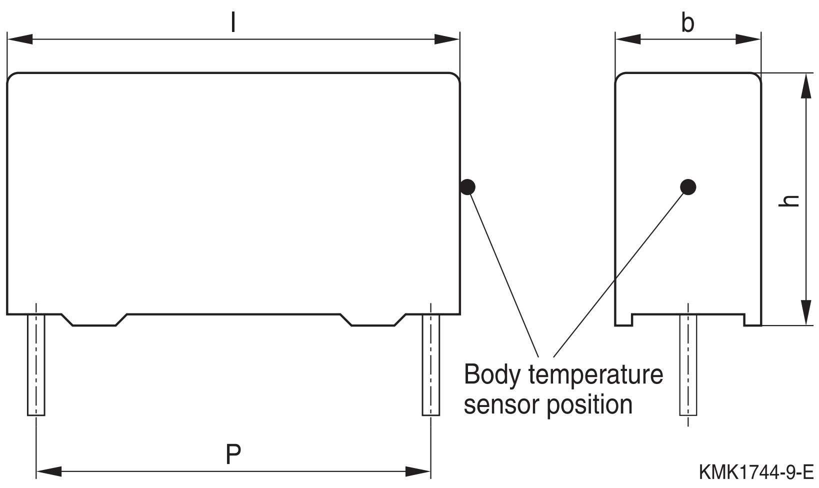
**Recommendations**

As a reference, the recommended wave soldering profile for our film capacitors is as follows:




$T_s$: Capacitor body maximum temperature at wave soldering
$T_p$: Capacitor body maximum temperature at pre-heating

KMK1745-A-E




Body temperature should follow the description below:

- MKP capacitor
  During pre-heating: $T_p$ ≤110 °C
  During soldering: $T_s$ ≤120 °C, $t_s$ ≤45 s
- MKT capacitor
  During pre-heating: $T_p$ ≤125 °C
  During soldering: $T_s$ ≤160 °C, $t_s$ ≤45 s

When SMD components are used together with leaded ones, the 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.

In order to ensure proper conditions for manual or selective soldering, the body temperature of the capacitor ($T_s$) must be ≤120 °C.

One recommended condition for manual soldering is that the tip of the soldering iron should be <360 °C and the soldering contact time should be no longer than 3 seconds.

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

Please refer to our Film Capacitors Data Book in case more details are needed.

## 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.
- Consult us if application is with severe temperature and humidity condition.
- There are no serviceable or repairable parts inside the capacitor. Opening the capacitor or any attempts to open or repair the capacitor will void the warranty and liability of TDK Electronics.
- Please note that the standards referred to in this publication may have been revised in the meantime.

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 60068-2-6:2007. TDK Electronics 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.<br>Caution: Consult us first, if you also wish to embed other uncoated component types! | 3 "Embedding of capacitors in finished assemblies" |

**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.

**Correlation of data sheet values and modelling tool outputs**

Data sheet values and results of design tools may deviate as they have not been derived in the same context.
While data sheets show individual parameter statements without considering a possible dependency to other parameters. Tools model a complete given scenario as input and processed inside the tool.
Furthermore as we constantly strive to improve our models, the results of tools can change over time and be a non-binding indication only.

## 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 | Impulskennwert |
| $L_S$ | 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 (Feuchtetest) |
| 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 Verlfustfaktors |
| tan $\delta_S$ | Series component of dissipation factor | Serienanteil des Verlustfaktors |
| $T_A$ | Temperature of the air surrounding the component | Temperatur der Luft, die das Bauteil umgibt |
| $T_{max}$ | 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, $T_A + \Delta T$ | Beriebstemperatur, $T_A + \Delta T$ |
| $T_R$ | Rated temperature | Nenntemperatur |
| $T_{ref}$ | Reference temperature | Referenztemperatur |
| $t_{SL}$ | Reference service life | Referenz-Lebensdauer |

| Symbol | English | German |
|---|---|---|
| $V_{AC}$ | AC voltage | Wechselspannung |
| $V_C$ | 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 |
| $\boxed{e}$ | 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, 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 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.
3. **The warnings, cautions and product-specific notes must be observed.**
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