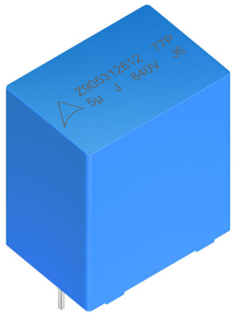
Film Capacitors

Capacitors for DC Link

Series/Type: **B3277*P**

Date: April 2025



Typical applications

- Frequency Converters
- Industrial and high-end power supplies
- Automotive DC-DC and Compressor

Climatic

- Max. operating temperature 125 °C (case)
- 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 50 µF
- Good self-healing properties
- Over-voltage capability
- Low losses with high current capability
- High reliability
- RoHS-compatible
- AEC-Q200 compliant

Terminals

- Parallel wire leads, lead-free tinned
- 2-pin, 4-pin
- Standard lead lengths: 6–1 mm

Marking

- Manufacturer's logo and lot number
- Date code, rated capacitance (coded)
- Capacitance tolerance (code letter)
- Rated DC voltage

Delivery mode

- Bulk (untaped, lead length 6–1)

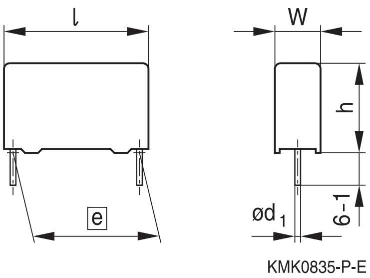
Dimensional drawings

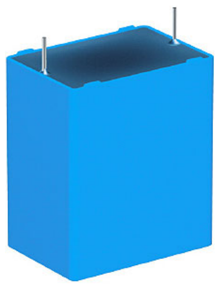
Number of wires	Lead spacing e ±0.4	Lead diameter d_1 ±0.05	Type
2-pin	27.5	1.0[1)]	B32774P
2-pin	37.5	1.0	B32776P
2-pin	37.5	1.0[1)]	B32776P
4-pin	37.5	1.2[1)]	B32776P
4-pin	52.5	1.2[1)]	B32778P

Dimensions in mm

Dimensional drawings 2-pin versions

B32774P, B32776P

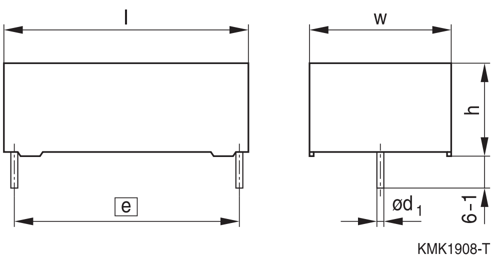


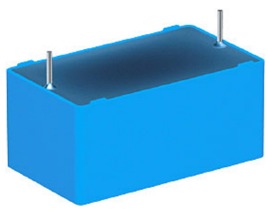


	B32774P	B32776P
Lead spacing e ± 0.4	27.5	37.5
Lead diameter d_1	1.0[1)]	1.0

Dimensions in mm

B32776P





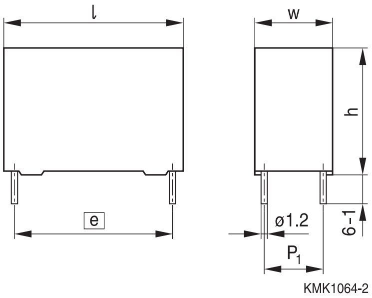
	B32776P
Lead spacing e ± 0.4	37.5
Lead diameter d_1	1.0[1)]

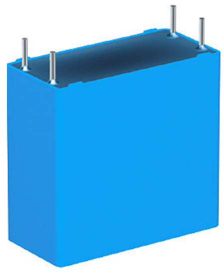
Dimensions in mm

1) Reinforced for vibration

Dimensional drawings 4-pin versions

B32776P, B32778P





	B32776P	B32778P
Lead spacing e ± 0.4	37.5	52.5
Lead diameter d_1	1.2[1)]	1.2[1)]

Dimensions in mm

1) Reinforced for vibration

Overview of available types

Lead spacing	27.5 mm			37.5 mm			52.5 mm		
Type	B32774P			B32776P			B32778P		
V_R (V DC)	630	700	840	630	700	840	630	700	840
C_R (µF)									
1.0									
1.5									
2.0									
2.2									
2.7									
3.0									
3.3									
3.5									
3.9									
4.7									
5.0									
6.8									
7.0									
7.5									
8.0									
10.0									
12.0									
14.0									
15.0									
16.0									
20.0									
22.0									
25.0									
27.0									
30.0									
35.0									
40.0									
50.0									

Ordering codes and packing units (Lead spacing 27.5 mm)

C_R 1) µF	Max. dimensions w x h x l mm	Ordering code (Composition see below)	$I_{RMS,max}$ 2) 85 °C 10 kHz A	ESR_{typ} 10 kHz mΩ	ESL_{typ} 3) 10 kHz nH	tan δ max. 1 kHz 10^{-3}	tan δ max. 10 kHz 10^{-3}	Un-taped pcs./ MOQ
$V_{R,85\,°C}$ = 630 V DC								
1.5	11.0 x 19.0 x 31.5	B32774P6155+000	3.5	22.3	13.2	0.5	3.5	1280
2.2	12.5 x 21.5 x 31.5	B32774P6225+000	4.7	15.5	14.5	0.5	3.5	1120
3.0	14.0 x 24.5 x 31.5	B32774P6305+000	6.0	11.5	16.1	0.5	3.5	1040
4.7	18.0 x 27.5 x 31.5	B32774P6475+000	8.2	7.6	18.7	0.5	3.7	800
6.8	21.0 x 31.0 x 31.5	B32774P6685+000	10.4	5.4	21.3	0.6	3.9	720
8.0	22.0 x 36.5 x 31.5	B32774P6805+000	12.0	4.5	24.0	0.6	4.0	640
$V_{R,85\,°C}$ = 700 V DC								
1.5	11.0 x 19.0 x 31.5	B32774P7155+000	3.6	20.3	18.4	0.5	3.2	1280
2.0	12.5 x 21.5 x 31.5	B32774P7205+000	4.7	15.3	19.8	0.5	3.2	1120
3.3	18.0 x 27.5 x 31.5	B32774P7335+000	7.3	9.6	22.9	0.5	3.3	800
4.7	19.0 x 30.0 x 31.5	B32774P7475+000	9.0	6.9	25.8	0.5	3.4	720
7.0	22.0 x 36.5 x 31.5	B32774P7705+000	11.8	5.0	31.2	0.5	3.7	640
$V_{R,85\,°C}$ = 840 V DC								
1.0	11.0 x 19.0 x 31.5	B32774P8105+000	3.3	25.2	18.3	0.5	2.7	1280
1.5	12.5 x 21.5 x 31.5	B32774P8155+000	4.4	17.2	20.2	0.5	2.7	1120
3.0	18.0 x 27.5 x 31.5	B32774P8305+000	7.5	9.1	25.6	0.5	2.8	800
5.0	22.0 x 36.5 x 31.5	B32774P8505+000	12.5	5.8	31.6	0.5	3.0	640

MOQ = Minimum order quantity, consisting of 4 packing units
Intermediate capacitance values are available on request.

Composition of ordering code

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

Packaging code
000 = Untaped (lead length 6–1 mm)
Other lead lengths available upon request

1) Capacitance value measured at 1 kHz

2) Max. ripple current I_{RMS} at 85 °C at 10 kHz for a ΔT ≤15 °C when $\Delta ESR_{typ} \leq \pm5\%$

3) ESL value measured at resonance frequency (see specific graphs of Z versus frequency)

Ordering codes and packing units (Lead spacing 37.5 mm)

C_R 1) µF	Max. dimensions w x h x l mm	P_1 mm	Ordering code (Composition see below)	$I_{RMS,max}$ 2) 85 °C 10 kHz A	ESR_{typ} 10 kHz mΩ	ESL_{typ} 3) 10 kHz nH	tan δ max. 1 kHz 10^{-3}	tan δ max. 10 kHz 10^{-3}	Un-taped pcs./ MOQ
$V_{R,85\ °C}$ = 630 V DC									
5.0	24.0 x 15.0 x 42.0	-	B32776P6505+000	6.0	13.4	19.4	0.9	6.9	1040
7.5	24.0 x 19.0 x 42.0	-	B32776P6755K000	7.6	9.5	19.6	0.9	6.9	780
10.0	18.0 x 32.5 x 42.0	-	B32776P6106K000	9.6	7.0	23.4	0.9	7.2	720
15.0	20.0 x 39.5 x 42.0	10.2	B32776P6156K000	13.0	4.8	12.4	0.9	7.1	640
20.0	28.0 x 37.0 x 42.0	10.2	B32776P6206K000	16.0	3.6	11.5	0.9	7.1	440
22.0	28.0 x 42.5 x 42.0	10.2	B32776P6226K000	17.5	3.2	13.2	0.9	7.3	440
25.0	30.0 x 45.0 x 42.0	20.3	B32776P6256+000	19.5	2.9	13.9	0.9	7.4	400
30.0	33.0 x 48.0 x 42.0	20.3	B32776P6306+000	22.5	2.4	15.1	0.9	7.6	180
$V_{R,85\ °C}$ = 700 V DC									
3.9	24.0 x 15.0 x 42.0	-	B32776P7395+000	5.6	15.3	19.2	0.8	6.2	1040
5.0	24.0 x 19.0 x 42.0	-	B32776P7505+000	6.8	12.1	19.1	0.8	6.3	780
12.0	20.0 x 39.5 x 42.0	10.2	B32776P7126K000	12.5	5.3	12.4	0.8	6.4	640
14.0	28.0 x 37.0 x 42.0	10.2	B32776P7146+000	14.5	4.4	11.3	0.8	6.4	440
16.0	28.0 x 42.5 x 42.0	10.2	B32776P7166+000	16.0	3.9	12.5	0.8	6.5	440
20.0	30.0 x 45.0 x 42.0	20.3	B32776P7206+000	19.0	3.2	13.5	0.8	6.6	400
22.0	33.0 x 48.0 x 42.0	20.3	B32776P7226+000	20.5	2.9	14.2	0.8	6.7	180
$V_{R,85\ °C}$ = 840 V DC									
2.7	24.0 x 15.0 x 42.0	-	B32776P8275+000	5.2	18.6	19.2	0.7	5.2	1040
3.5	24.0 x 19.0 x 42.0	-	B32776P8355+000	6.2	14.3	19.2	0.7	5.2	780
8.0	20.0 x 39.5 x 42.0	10.2	B32776P8805+000	11.0	6.3	12.4	0.7	5.3	640
10.0	28.0 x 37.0 x 42.0	10.2	B32776P8106+000	13.5	5.1	11.5	0.7	5.3	440
12.0	28.0 x 42.5 x 42.0	10.2	B32776P8126+000	15.0	4.4	12.8	0.7	5.4	440
14.0	30.0 x 45.0 x 42.0	20.3	B32776P8146+000	17.0	3.8	13.7	0.7	5.5	400
16.0	33.0 x 48.0 x 42.0	20.3	B32776P8166+000	19.0	3.3	14.5	0.7	5.5	180

MOQ = Minimum order quantity, consisting of 4 packing units
Intermediate capacitance values are available on request.

Composition of ordering code

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

Packaging code
000 = Untaped (lead length 6–1 mm)
Other lead lengths available upon request

1) Capacitance value measured at 1 kHz
2) Max. ripple current I_{RMS} at 85 °C at 10 kHz for a ΔT ≤15 °C when ΔESR_{typ} ≤ ±5%
3) ESL value measured at resonance frequency (see specific graphs of Z versus frequency)

Ordering codes and packing units (Lead spacing 52.5 mm, P_1 = 20.3 mm)

C_R 1) µF	Max. dimensions w x h x l mm	Ordering code (Composition see below)	$I_{RMS,max}$ 2) 85 °C 10 kHz A	ESR_{typ} 10 kHz mΩ	ESL_{typ} 3) 10 kHz nH	tan δ max. 1 kHz 10^{-3}	tan δ max. 10 kHz 10^{-3}	Un-taped pcs./ MOQ
$V_{R,85\,°C}$ = 630 V DC								
35.0	30.0 x 45.0 x 57.5	B32778P6356+000	18.5	4.0	13.9	1.6	14.3	280
50.0	35.0 x 50.0 x 57.5	B32778P6506K000	23.5	2.9	16.0	1.6	14.8	108
$V_{R,85\,°C}$ = 700 V DC								
30.0	30.0 x 45.0 x 57.5	B32778P7306+000	18.5	4.2	14.2	1.5	12.9	280
40.0	35.0 x 50.0 x 57.5	B32778P7406+000	22.5	3.2	15.9	1.5	13.2	108
$V_{R,85\,°C}$ = 840 V DC								
20.0	30.0 x 45.0 x 57.5	B32778P8206+000	16.5	5.1	14.0	1.2	10.6	280
27.0	35.0 x 50.0 x 57.5	B32778P8276+000	20.5	3.9	15.7	1.3	10.8	108

MOQ = Minimum order quantity, consisting of 4 packing units
Intermediate capacitance values are available on request.

Composition of ordering code

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

Packaging code
000 = Untaped (lead length 6–1 mm)
Other lead lengths available upon request

1) Capacitance value measured at 1 kHz

2) Max. ripple current I_{RMS} at 85 °C at 10 kHz for a ΔT ≤15 °C when ΔESR_{typ} ≤ ±5%

3) ESL value measured at resonance frequency (see specific graphs of Z versus frequency)

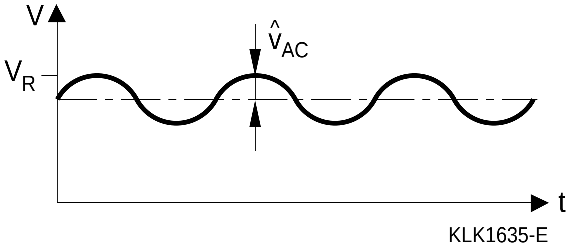
Technical data

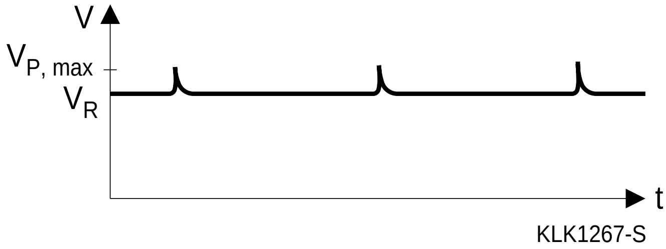
Reference standard: IEC 60384-16 and AEC-Q200. All data given at T = 20 °C, unless otherwise is specified.

Rated temperature T_R	85 °C		
Operating temperature range (case)	Max. Operating temperature, $T_{op,max}$ Upper category temperature, T_{max} Lower category temperature, T_{min}		+125 °C[1)] +110 °C –40 °C
Insulation Resistance R_{ins}, given as time constant $\tau = C_R \cdot R_{ins}$, rel. humidity ≤ 65% (minimum as-delivered values)	τ > 10 000 s (after 1 min) at 500 V		
DC voltage test between terminals (10 s)	$1.5 \cdot V_R$		
Voltage test terminal to case (10 s)	2110 V AC, 50 Hz		
Peak current I_P (A)	C(µF) · dV/dt		
V_R (V DC) at 85 °C[1)]	630 V	700 V	840 V
Continuous operation voltage V_{op} at 105 °C[1)]	540 V	600 V	720 V
Continuous operation voltage V_{op} at 125 °C[1)]	450 V	500 V	600 V
For temperatures between 85 °C and 125 °C[1)]	0.7%/°C of V_{op} de-rating compared to V_{op}@85°C		
Reliability: Failure rate λ Service life tSL	 5 fit ($\leq 5 \cdot 10^{-9}$) at 0.5 • V_R (V_R = 630 V and 700 V), 40 °C 6 fit ($\leq 6 \cdot 10^{-9}$) at 0.5 • V_R (V_R = 840 V), 40 °C 40 000 h at V_R (V_R = 630 V and 700 V), 85 °C 30 000 h at V_R (V_R = 840 V), 85 °C For conversion to other operating conditions and temperatures, refer to chapter “Quality, 2 Reliability”.		

1) Temperatures given as operating temperature Top (ambient temperature + self-heating), for example when ambient temperature is 125 °C, self-heating is 0 °C, or ripple current cannot be permitted.

Typical waveforms





Restrictions:
V_R: Maximum operating peak voltage of either polarity but of a non-reversing waveform, for which the capacitor has been designed for continuous operation.
ûAC ≤ 0.2 • V_R
Vp,max:

Overvoltage	Maximum duration within one day
1.1 • V_R	30% of on-load duration
1.15 • V_R	30 min
1.2 • V_R	5 min
1.3 • V_R	1 min

Pulse handling capability

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

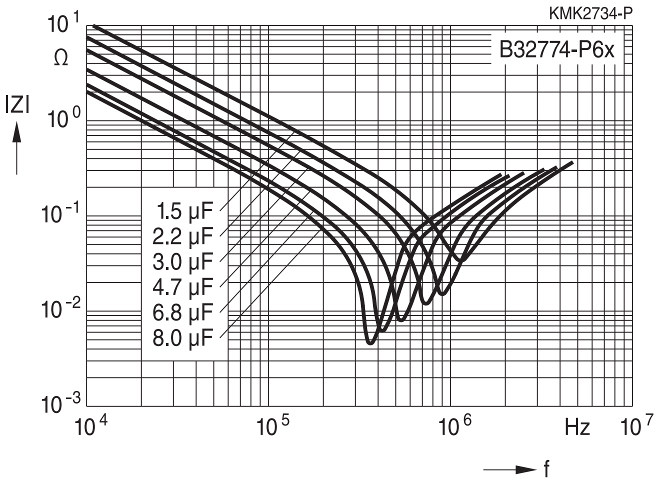
dV/dt values

Lead spacing	27.5 mm			37.5 mm			52.5 mm		
Type	B32774P			B32776P			B32778P		
V_R (V DC)	630 V	700 V	840 V	630 V	700 V	840 V	630 V	700 V	840 V
dv/dt in V/µs	50	75	100	35	54	73	25	35	50

Characteristics curves

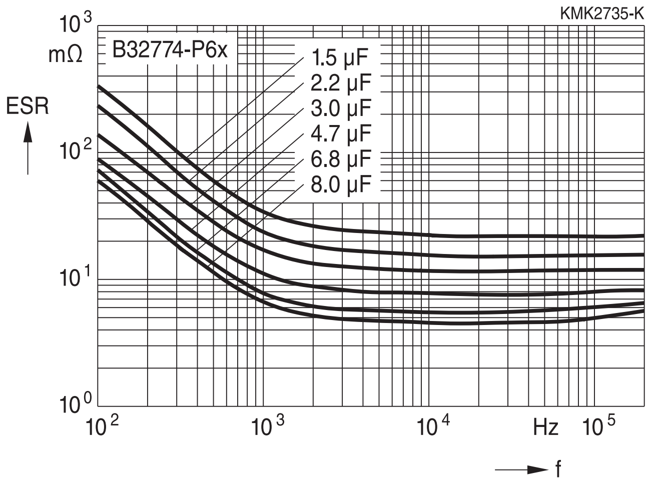
Impedance Z versus frequency f
(Typical values)

Lead spacing 27.5 mm / B32774P6 (2 pins)
630 V DC



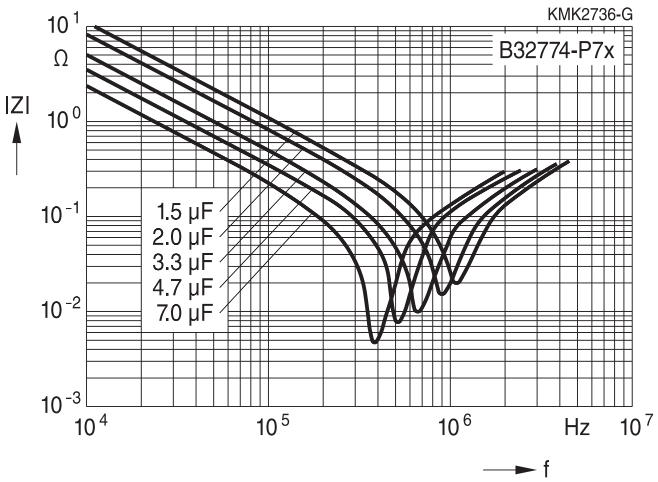
ESR versus frequency f
(Typical values)

Lead spacing 27.5 mm / B32774P6 (2 pins)
630 V DC



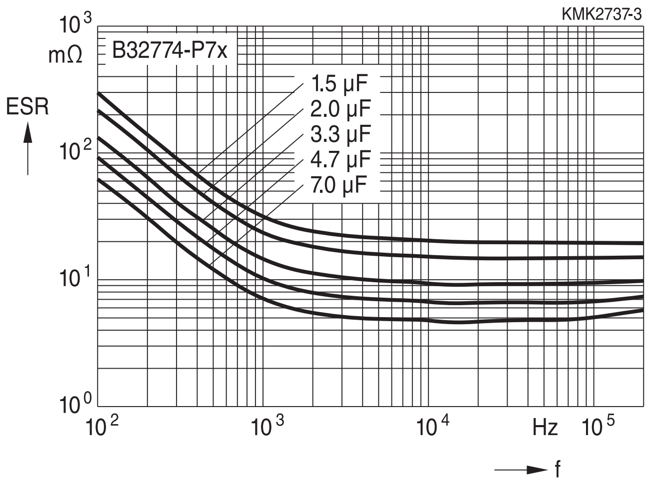
Impedance Z versus frequency f
(Typical values)

Lead spacing 27.5 mm / B32774P7 (2 pins)
700 V DC



ESR versus frequency f
(Typical values)

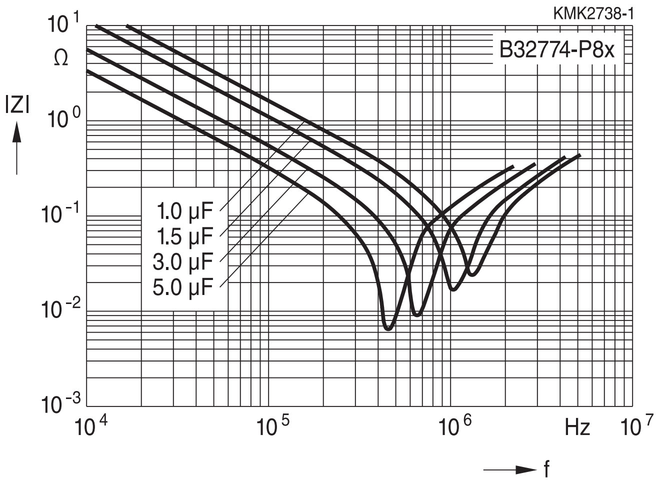
Lead spacing 27.5 mm / B32774P7 (2 pins)
700 V DC



Characteristics curves

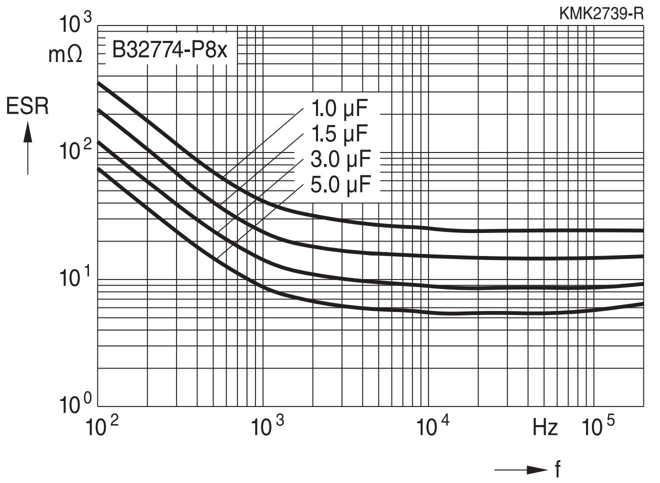
Impedance Z versus frequency f
(Typical values)

Lead spacing 27.5 mm / B32774P8 (2 pins)
840 V DC



ESR versus frequency f
(Typical values)

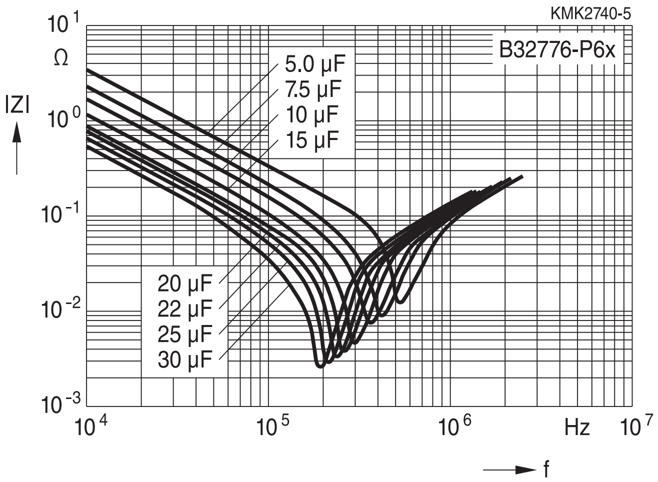
Lead spacing 27.5 mm / B32774P8 (2 pins)
840 V DC



Characteristics curves

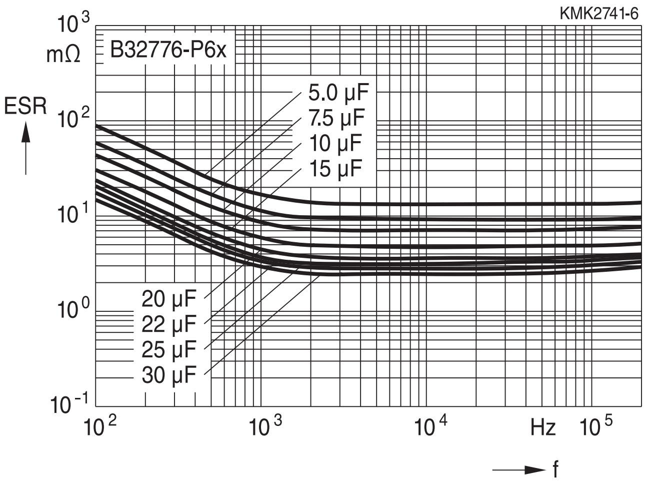
Impedance Z versus frequency f
(Typical values)

Lead spacing 37.5 mm / B32776P6x (2/4 pins)
630 V DC



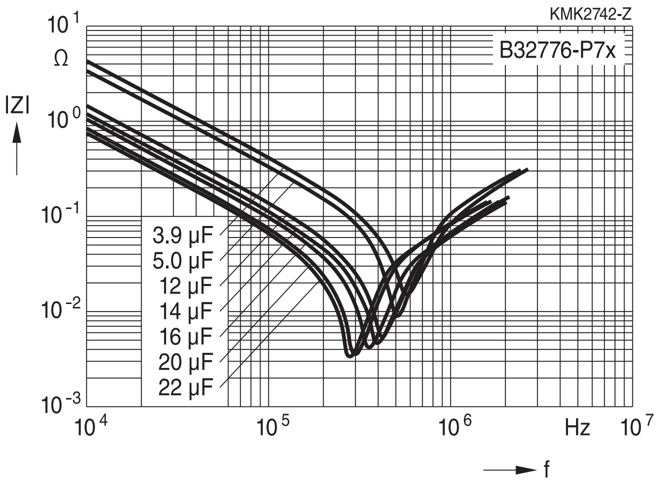
ESR versus frequency f
(Typical values)

Lead spacing 37.5 mm / B32776P6 (2/4 pins)
630 V DC



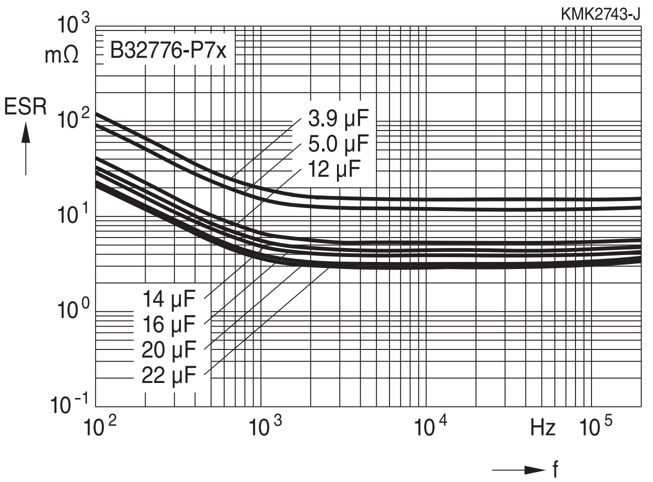
Impedance Z versus frequency f
(Typical values)

Lead spacing 37.5 mm / B32776P7x (2/4 pins)
700 V DC



ESR versus frequency f
(Typical values)

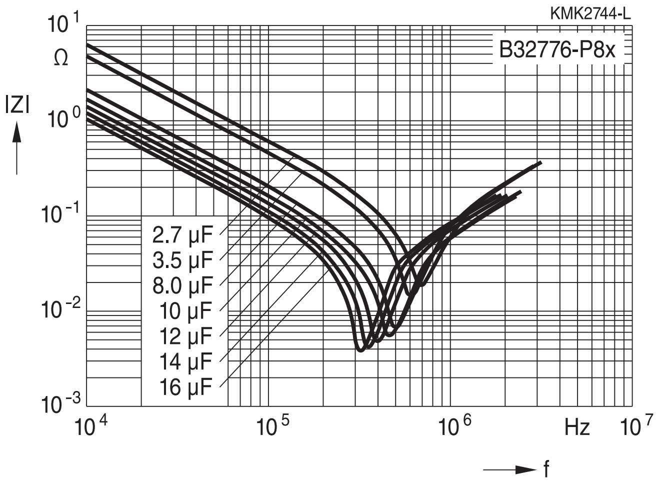
Lead spacing 37.5 mm / B32776P7 (2/4 pins)
700 V DC



Characteristics curves

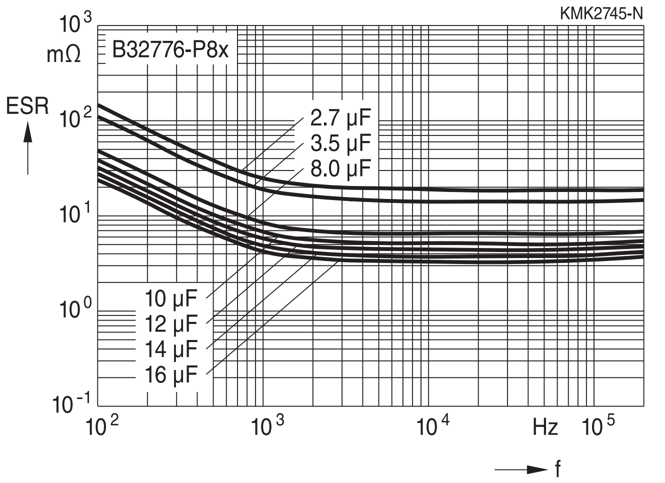
Impedance Z versus frequency f
(Typical values)

Lead spacing 37.5 mm / B32776P8x (2/4 pins)
840 V DC



ESR versus frequency f
(Typical values)

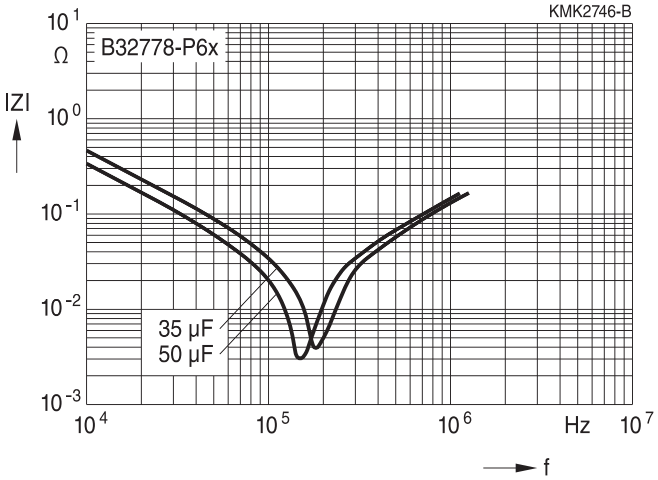
Lead spacing 37.5 mm / B32776P8 (2/4 pins)
840 V DC



Characteristics curves

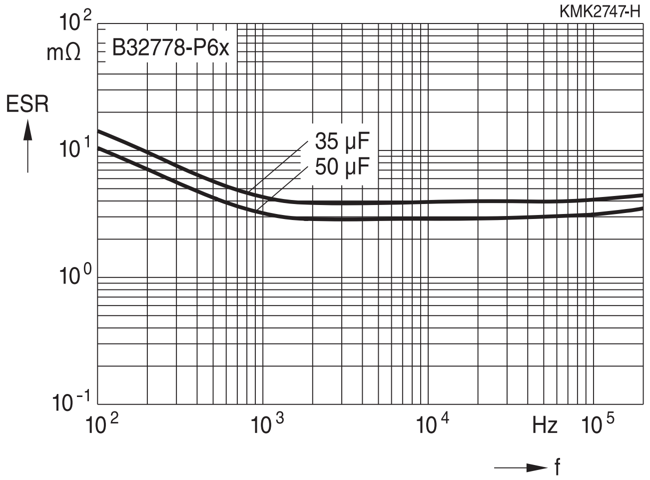
Impedance Z versus frequency f
(Typical values)

Lead spacing 52.5 mm / B32778P6 (4 pins)
630 V DC



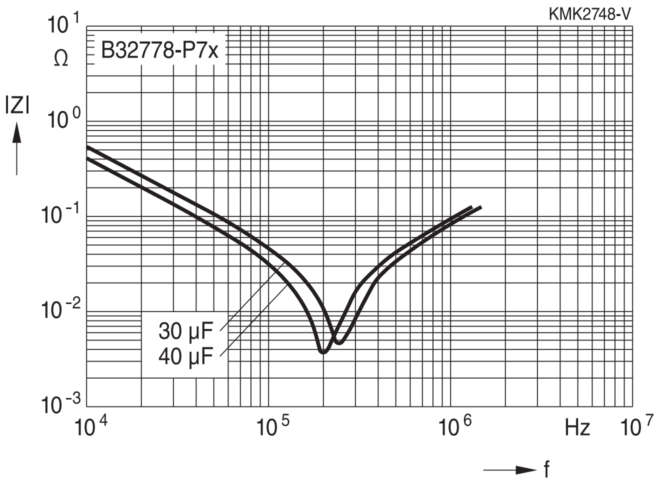
ESR versus frequency f
(Typical values)

Lead spacing 52.5 mm / B32778P6 (4 pins)
630 V DC



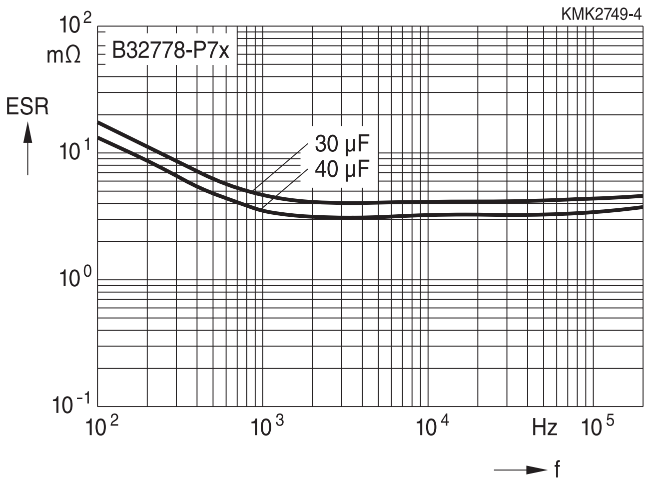
Impedance Z versus frequency f
(Typical values)

Lead spacing 52.5 mm / B32778P7 (4 pins)
700 V DC



ESR versus frequency f
(Typical values)

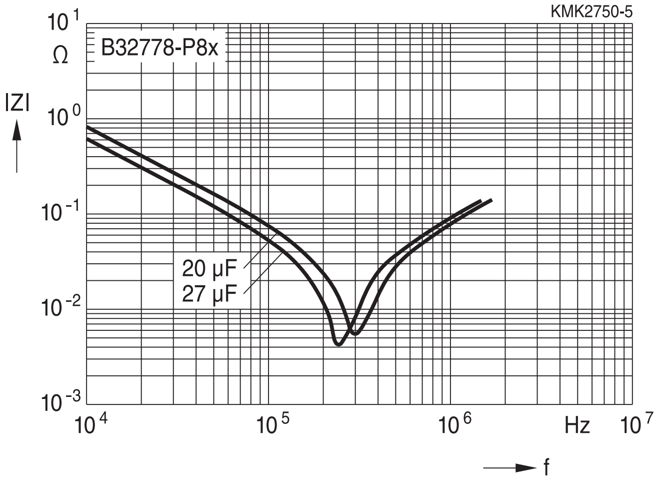
Lead spacing 52.5 mm / B32778P7 (4 pins)
700 V DC



Characteristics curves

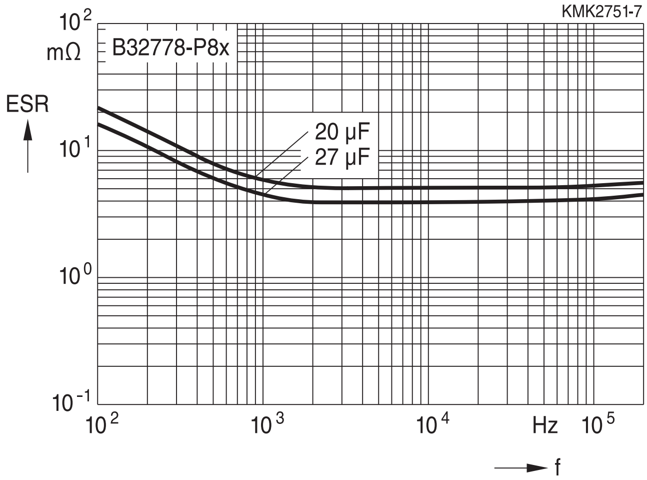
Impedance Z versus frequency f
(Typical values)

Lead spacing 52.5 mm / B32778P8 (4 pins)
840 V DC



ESR versus frequency f
(Typical values)

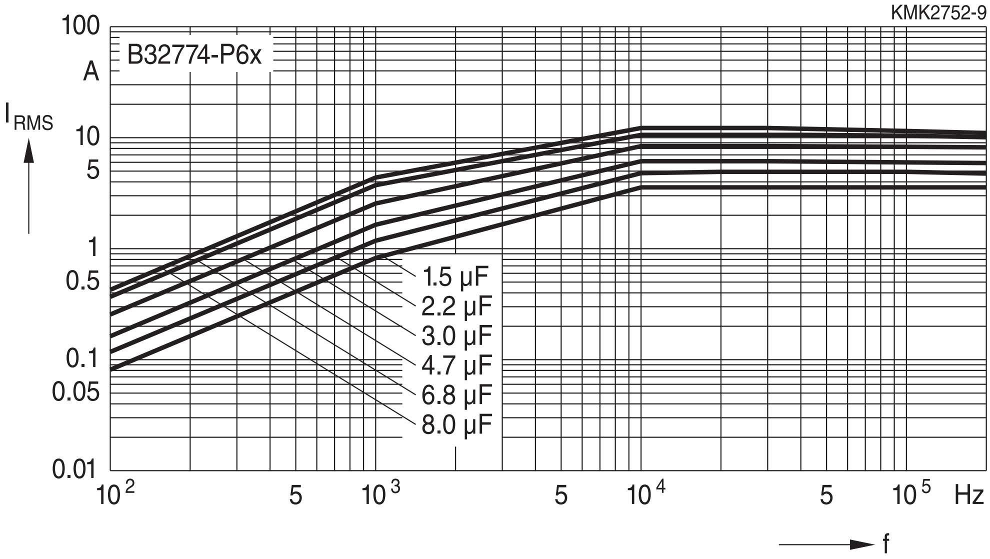
Lead spacing 52.5 mm / B32778P8 (4 pins)
840 V DC



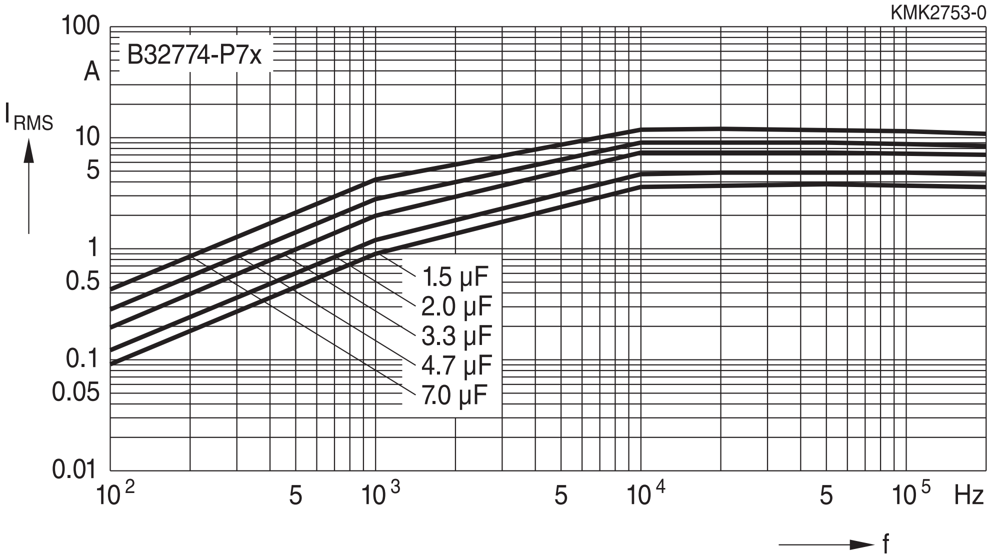
Characteristics curves

Permissible current I_{RMS} versus frequency f (for sinusoidal waveforms, T_a ≤85 °C)
For T_a >85 °C, please refer to I_{RMS} derating versus temperature curve in Page 18.

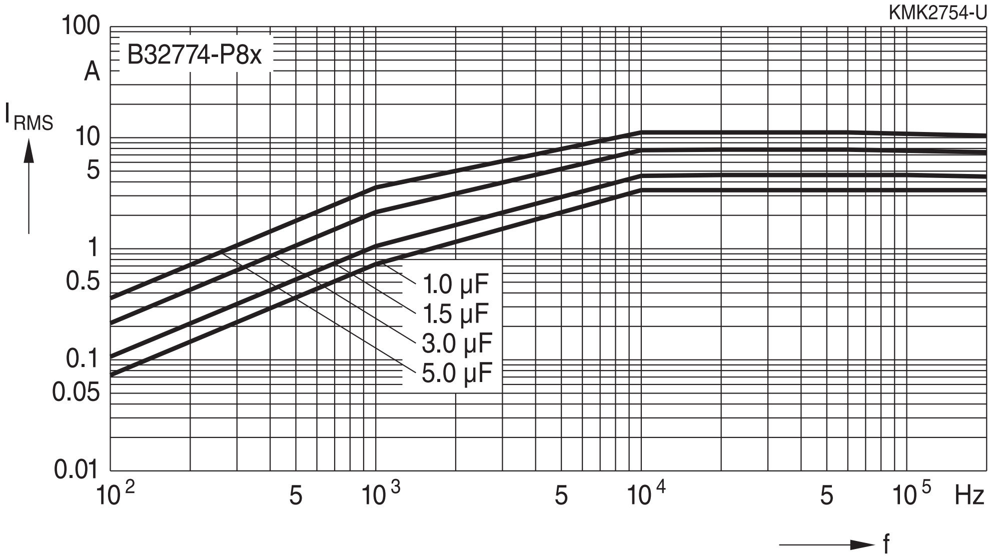
Lead spacing 27.5 mm
B32774P6 (2 pins)



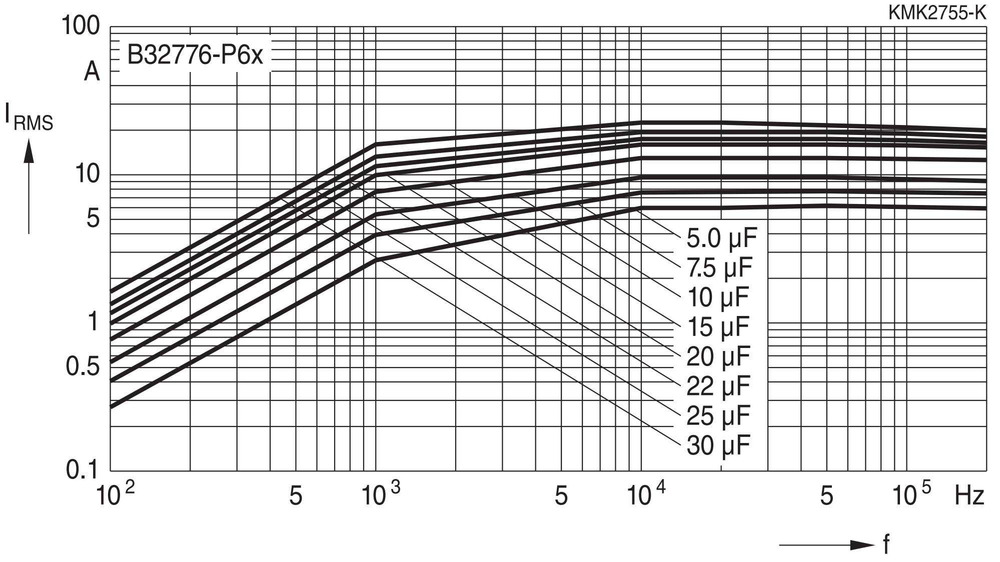
Lead spacing 27.5 mm
B32774P7 (2 pins)



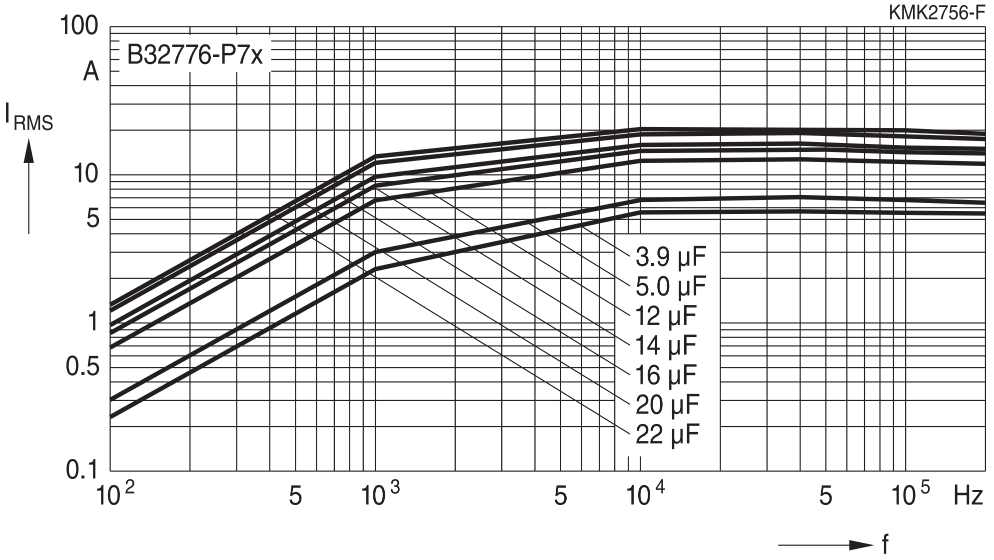
Lead spacing 27.5 mm
B32774P8 (2 pins)



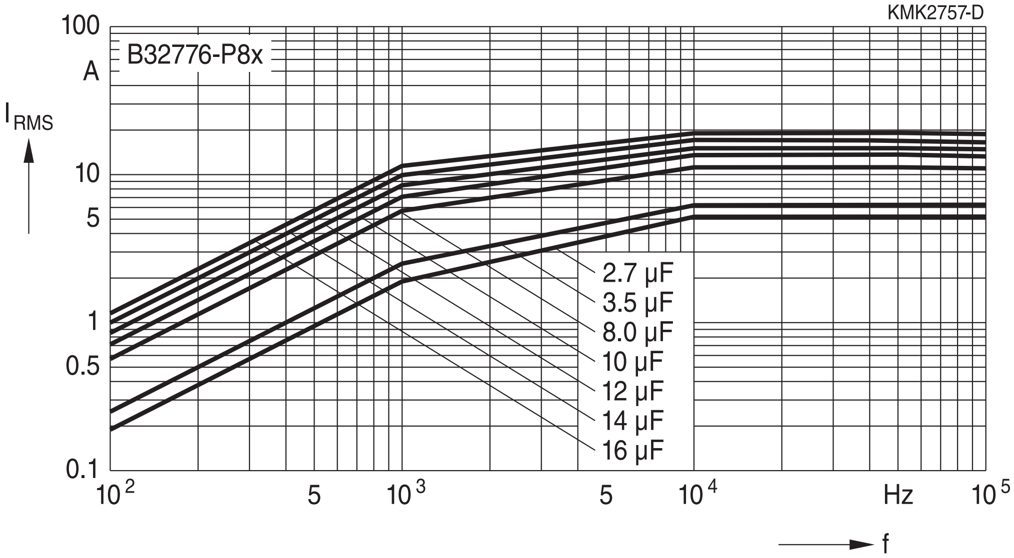
Lead spacing 37.5 mm
B32776P6 (2/4 pins)



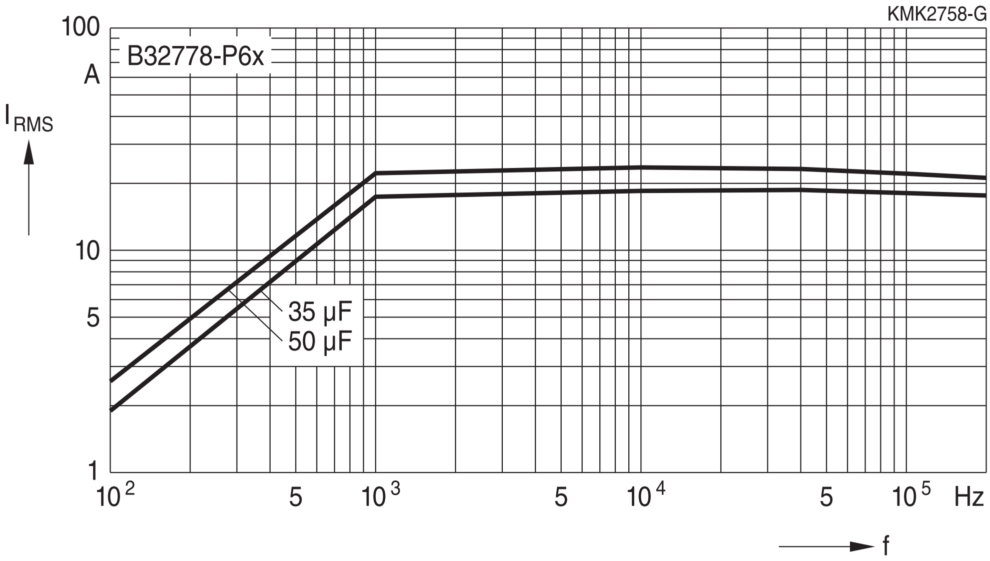
Lead spacing 37.5 mm
B32776P7 (2/4 pins)



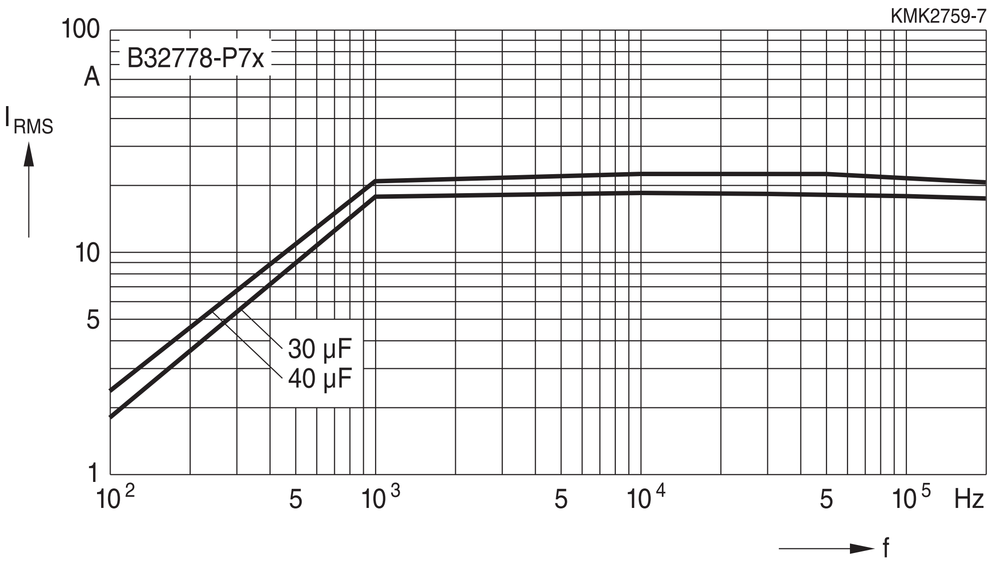
Lead spacing 37.5 mm
B32776P8 (2/4 pins)



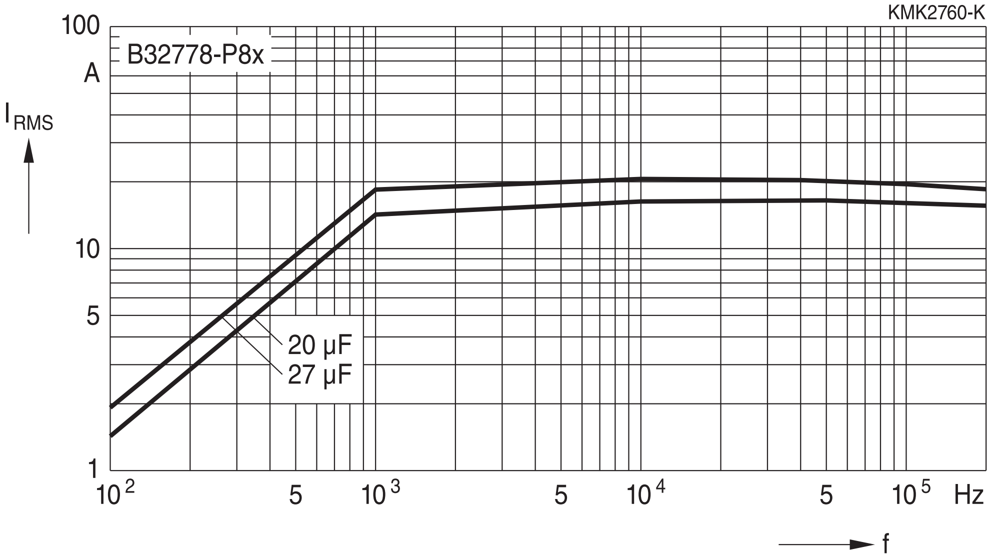
Lead spacing 52.5 mm
B32778P6 (4 pins)



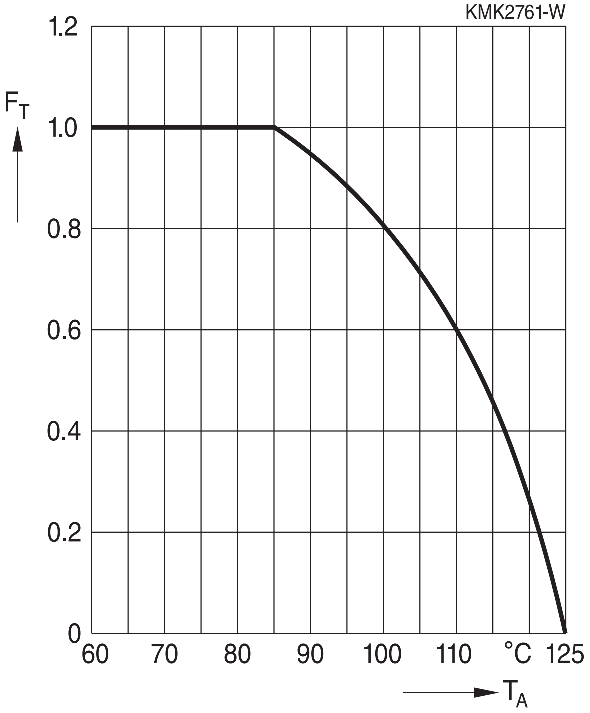
Lead spacing 52.5 mm
B32778P7 (4 pins)



Lead spacing 52.5 mm
B32778P8 (4 pins)



Curves characteristics (I_{RMS} derating versus temperature)



Maximum I_{RMS} current as function of the ambient temperature: I_{RMS} (T_{amb}) = Factor x I_{RMS} (85 °C)

Heat transference for self heating calculation

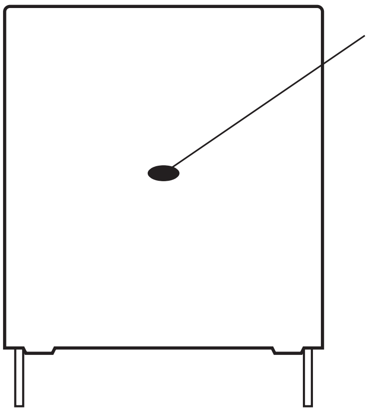


Figure 1

BOX DIMENSIONS			EQUIVALENT HEAT COEFFICIENT
w (mm)	h (mm)	l (mm)	G (mW/°C)
11.0	19.0	31.5	25
11.0	21.0	31.5	28
12.5	21.5	31.5	30
13.5	23.0	31.5	32
14.0	24.5	31.5	35
15.0	24.5	31.5	36
16.0	32.0	31.5	45
18.0	27.5	31.5	44
18.0	33.0	31.5	48
19.0	30.0	31.5	48
21.0	31.0	31.5	51
22.0	36.5	31.5	58
12.0	22.0	42.0	40
14.0	25.0	42.0	43
16.0	28.5	42.0	50
18.0	32.5	42.0	59
20.0	39.5	42.0	72
24.0	19.0	42.0	50
24.0	15.0	42.0	44
28.0	37.0	42.0	83
28.0	42.5	41.5	90
30.0	45.0	42.0	100
33.0	48.0	42.0	110
30.0	45.0	57.5	125
35.0	50.0	57.5	145

The equivalent heat coefficient “G(mW/°C)” is given for measuring the temperature on the lateral surface of the plastic box as figure 1 shows. By using a thermocouple and avoiding effect of radiation and convection the temperature measured during operation conditions should be a result of the dissipated power divided by the equivalent heat coefficient.

Self heating by power dissipation & equivalent heat coefficient

The I_{RMS} and consequently the power dissipation must be limited during operation in order to not exceed the maximum limit of ΔT allowed for this series. ΔT_{max} given for this series is equal or lower than 15 °C at rated temperature (85 °C), for higher ambient temperatures ΔT_{max} (T) will have the same derating factor than I_{RMS} vs temperature and then an equivalent derating as per:

ΔT_{max} (T) = $(\text{Factor})^2$ x ΔT(85 °C)

For any particular I_{RMS} the ΔT may be calculated by: ΔT(°C) = P_{dis}(mW) / G(mW/°C)

Where ΔT(°C) is the difference between the temperature measured on the box (see figure 1) and the ambient temperature when capacitor is working during normal operation; ΔT(°C) = T_{op}(°C) – T_{amb}(°C). It represents the increasing of temperature provoked by the I_{RMS} during operation. G(mW/°C) is the equivalent heat coefficient described above and P_{dis}(mW) is the dissipated power defined by:

P_{dis}(mW) = ESR_{typ}(mΩ) x $I_{RMS}{}^2$(Arms)

Example for thermal calculation:

We will take as reference B32778P6506K (50 µF/630 V) type for thermal calculation. Considering the following load and capacitor characteristics:

I_{RMS}: 10 Arms@20 kHz
T_{amb}: 100 °C
35 x 50 x 57.5 box
G(mW/°C): 145

Then we have to search the ESR_{typ} at 20 kHz what is approx 2.9 mΩ.

So according to:	P_{dis}(mW) = ESR_{typ}(mΩ) x $I_{RMS}{}^2$(Arms)
we have the following:	P_{dis}(mW) = 2.9 mΩ x 10 Arms ^{2} = 290 mW
And as per:	ΔT(°C) = P_{dis}(mW) / G(mW/°C)
we have the following:	ΔT(°C) = 290(mW) / 145(mW/°C) = 2.0 °C

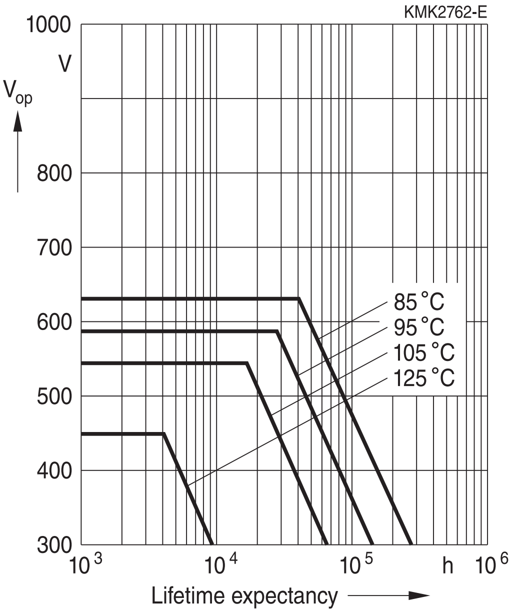
What is below of the ΔT_{max} (100 °C) = $(\text{Factor})^2$ x ΔT(85 °C) = $(0.80)^2$ x 15 °C = 9.6 °C

On the other hand we may confirm that max I_{RMS}@20 kHz@85 °C = 23.5 Arms
And then max I_{RMS} for 100 °C of ambient temperature is defined as follows:
I_{RMS} (100 °C) = Factor x I_{RMS} (85 °C) = 0.80 x 23.5 Arms = 18.8 Arms
What confirms once again that I_{RMS} (10 Arms@20 kHz@100 °C) is below the max specified for such frequency and ambient temperature.

Service life

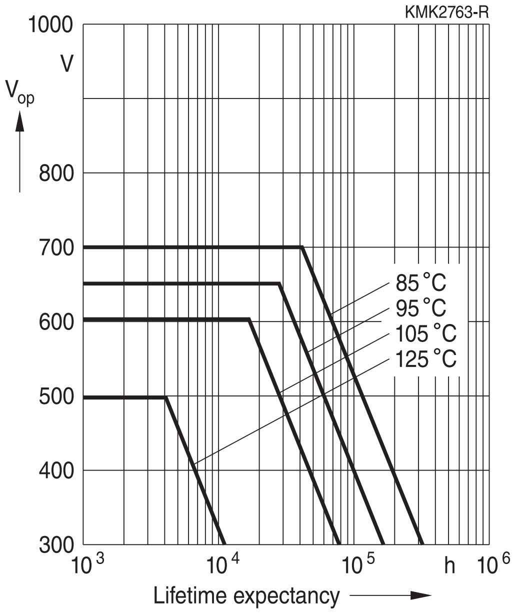
630 V DC

Life time expectancy-typical curve



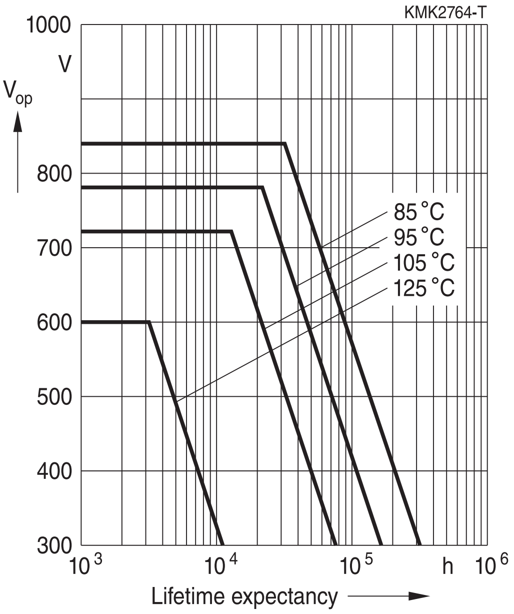
700 V DC

Life time expectancy-typical curve



840 V DC

Life time expectancy-typical curve



Note:
(1) Confidence level of 98%
(2) Life expectancy is given as a function of operating temperature (capacitor body temperature).

Testing and standards (IEC60384-16 and AEC-Q200)

Test	Reference	Conditions of Test	Performance requirements
Electrical parameters (Routine test)	IEC 61071-11	Voltage between terminals, 1.5 V_R, during 10 s Insulation Resistance, R_{ins} at 500 V Capacitance, C at 1 kHz (room temperature) Dissipation factor, tan δ at 1/10 kHz (room temperature)	Within specified limits
Robustness of terminations (Type test)	IEC 60068-2-21	Tensile strength (test Ua1) Wire diameter: Tensile force 0.5 < d1 ≤ 0.8 mm: 10 N 0.8 < d1 ≤ 1.25 mm: 20 N	Capacitance and tan δ within specified limits
Resistance to soldering heat (Type test)	IEC 60068-2-20, test Tb, method 1A	Solder bath temperature at 260 ± 5 °C, immersion for 10 seconds	$\|\Delta C/C_0\| \leq 2\%$ $\|\Delta \tan \delta\| \leq 0.002$ (1 kHz)
Bump (Type test)	IEC 60384-16	Test Eb: Total 4000 bumps with 390 m/s^2 mounted on PCB 6 ms duration	No visible damage $\|\Delta C/C_0\| \leq 2\%$ $\|\Delta \tan \delta\| \leq 0.002$ $R_{ins} \geq 50\%$ of initial limit
Climatic sequence (Type test)	IEC 60384-16	Dry heat -- Tb / 16 h. Damp heat cyclic, 1st cycle -- + 55 °C / 24h / 95%...100% RH Cold -- T_a / 2 h Damp heat cyclic, 5 cycles -- + 55 °C / 24h / 95%...100% RH	No visible damage $\|\Delta C/C_0\| \leq 3\%$ $\|\Delta \tan \delta\| \leq 0.001$ $R_{ins} \geq 50\%$ of initial limit
Thermal shock	AEC-Q200	–55 °C...85 °C, 1000 cycles	No visible damage $\|\Delta C/C_0\| \leq 2\%$ $\|\Delta \tan \delta\| \leq 0.002$ (1 kHz) $R_{ins} \geq 50\%$ of initial limit
Vibration	AEC-Q200	5 g for 20 minutes, 12 cycles each of 3 orientations (X, Y, Z axis), 240 min/axis, total 12 hours Test from10-2000 Hz.	No visible damage
High temperature high humidity with load	AEC-Q200	40 °C / 93% RH / 1000 hours with V_R	No visible damage $\|\Delta C/C_0\| \leq 5\%$ $\|\Delta \tan \delta/\tan \delta\| \leq 400\%$ (1 kHz) $R_{ins} \geq 50\%$ of initial limit

Test	Reference	Conditions of Test	Performance requirements
High temperature high humidity with load		60 °C / 95% RH / 500 hours with V_R	No visible damage $\|\Delta C/C_0\| \leq 5\%$ $\|\Delta \tan\delta/\tan\delta\| \leq 400\%$ (1 kHz) $R_{ins} \geq 50\%$ of initial limit
High temperature high humidity with load		V_R = 630 V DC: 85 °C / 85% RH / 1000 hours with 450 V DC V_R = 700 V DC: 85 °C / 85% RH / 1000 hours with 500 V DC V_R = 840 V DC: 85 °C / 85% RH / 1000 hours with 600 V DC	$\|\Delta C/C_0\| \leq 5\%$ $\|\Delta \tan\delta\| \leq 0.005$ (1 kHz) $R_{ins} \geq 50\%$ of initial limit
Endurance (Type test)	IEC 60384-16	85 °C/ 1.25 V_R / 1000 hours or 105 °C/ 1.25 V_{op} / 1000 hours or 125 °C/ 1.25 V_{op} / 1000 hours	No visible damage $\|\Delta C/C_0\| \leq 5\%$ $\|\Delta \tan\delta\| \leq 0.005$ (1 kHz) $R_{ins} \geq 50\%$ of initial limit

Soldering

Solderability of leads

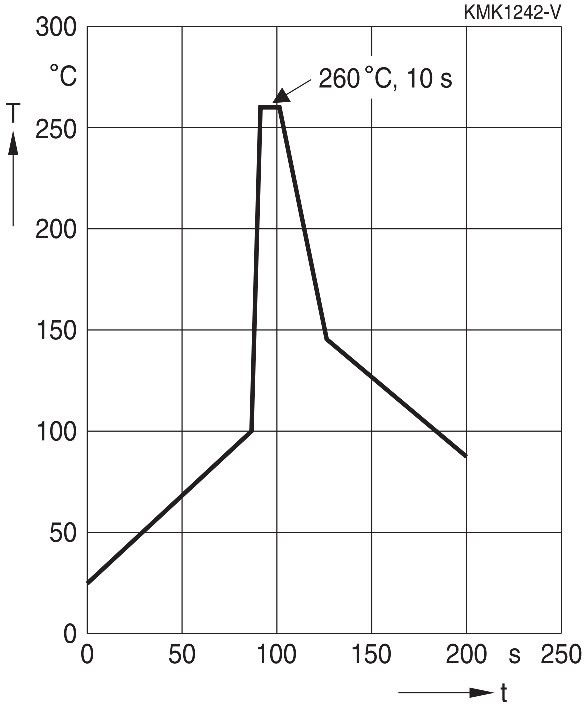
The solderability of terminal leads is tested to IEC 60068-2-20:2008, test Ta, method 1.
Before a solderability test is carried out, terminals are subjected to accelerated ageing (to IEC 60068-2-2:2007, test Ba: 4 h exposure to dry heat at 155 °C). Since the ageing temperature is far higher than the 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 ≥ 95%, free-flowing solder

Resistance to soldering heat

Resistance to soldering heat is tested to IEC 60068-2-20:2008, test Tb, method 1.
Conditions:

Series		Solder bath temperature	Soldering time
MKT	boxed (except 2.5 x 6.5 x 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 x 6.5 x 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

General notes on soldering

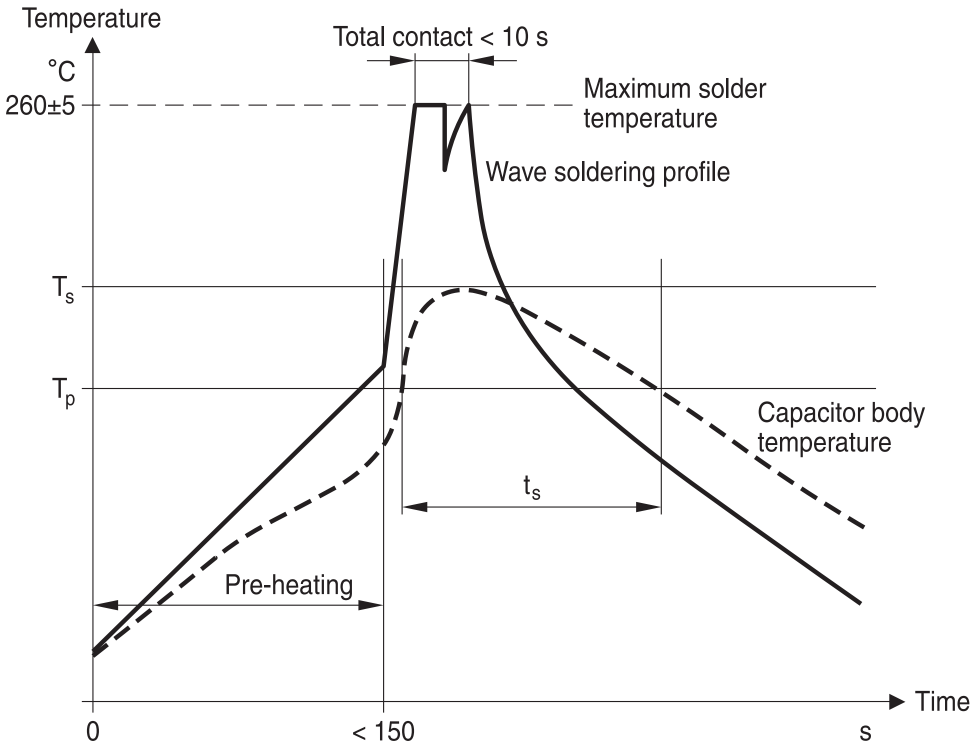
Permissible heat exposure loads on film capacitors are primarily characterized by the upper category temperature T_{max}. Long exposure to temperatures above this type-related temperature limit can lead to changes in the plastic dielectric and thus change irreversibly a capacitor's electrical characteristics.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

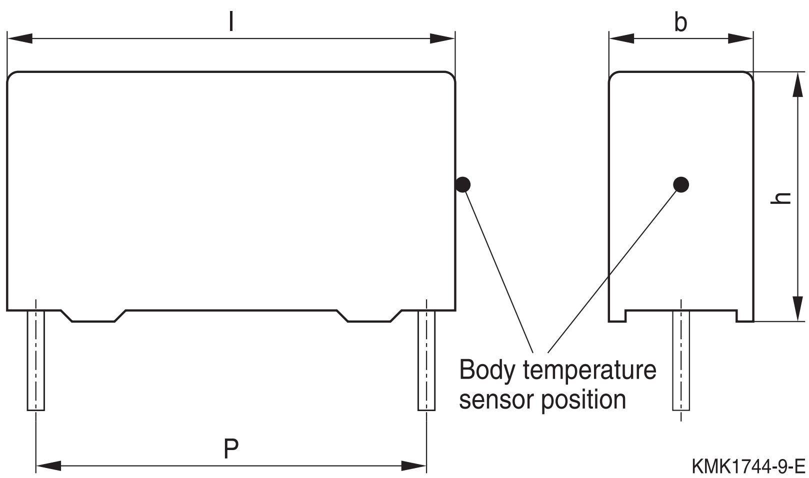
TDK Recommendations

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



KMK1744-9-E

Body temperature should follow the description below:

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

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)
MKT (uncoated)	Suitable	Unsuitable
MKT, MKP, MFP (coated/boxed)		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.

Caution:

Consult us first if you wish to use new solvents!

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.

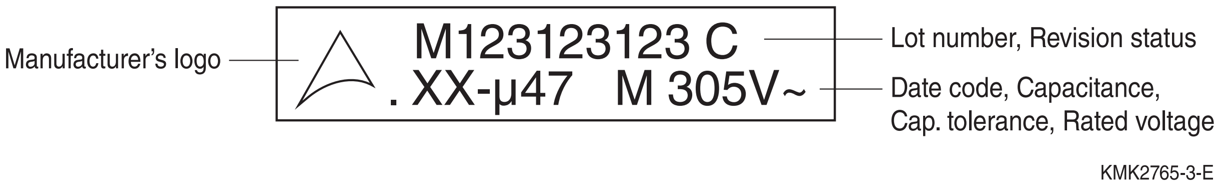
Caution:

Consult us first if you wish to embed uncoated types!

Marking

Capacitor markings

Depending on the capacitor size, the markings are positioned either on the side and/or the top of the component. The coded forms specified in IEC 60062:2004 are used to indicate the rated capacitance, capacitance tolerance and date of manufacture.
The lot number (production batch number) ensures unique identification of a particular capacitor and allows, together with the date of manufacture, exact assignment to the process data of the entire production run (traceability).
If the capacitor is not wide enough for the entire marking, the information in the marking will be split between the top and side. In this case, the following partial information will be found on the top:



Codes for rated capacitance

Rated capacitance	To IEC 60062	Short code
100 pF	100p	n1
150 pF	150p	n15
1.0 nF	1n0	1n
1.5 nF	1n5	
10 nF	10n	
100 nF	100n	µ1
150 nF	150n	µ15
1.0 µF	1µ0	1µ
1.5 µF	1µ5	
10 µF	10µ	
15 µF	15µ	

Codes for capacitance tolerance

Capacitance tolerance	Code letter	Remark
	A	Capacitance tolerances for which no code letter is defined can be indicated by an A. The meaning of code A must then be mutually specified in other documentation.
± 2.5%	H	
± 5%	J	
± 10%	K	
± 20%	M	

Codes for date of manufacture (to IEC 60062:2016)

Code for year					Code for month				
Year	Code letter		Year	Code letter	Month	Code numeral		Month	Code numeral/letter
2018	K		2024	S	January	1		July	7
2019	L		2025	T	February	2		August	8
2020	M		2026	U	March	3		September	9
2021	N		2027	V	April	4		October	O
2022	P		2028	W	May	5		November	N
2023	R		2029	X	June	6		December	D

E.g.: R5 2023 May

Marking types

The capacitors may have either an ink-jet marking or a laser marking. The main advantage of laser marking is that it cannot be removed by solvents, which ensures the reliable identification of the capacitor. Moreover, because the laser marking process reduces the amount of chemicals used, it is an environmentally friendly marking solution.

2 Ordering code system

A component and the packing in which it is to be delivered are defined by the ordering code, which has 15 digits (plus 3 additional digits for internal use). For all capacitors the ordering codes are explicitly stated (together with the corresponding tolerance and/or packing variants) in the data sheets.
Should there be any doubt about the coding system, however, then it is better to order the capacitor using a plain text description (i.e. without a code).

Basic structure of the ordering code:

Digit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	B																	
	Block 1							Block 2					Block 3			Block 4 (for internal use)		

Digit	Meaning
1	B = Passive components
2, 3	32 = Metallized film capacitors, EMI suppression capacitors 81 = EMI suppression capacitors
4 ... 6	Type (block 1 is termed the "type number")
7	Revision status
8	Rated DC voltage, coded (not for EMI suppression capacitors)
9 ... 11	Rated capacitance (coding method for value in pF) Examples: Digit 9 10 11 1 5 4 K = 15 • 10^4 pF = 150 nF B 3 2 6 5 2 A 3
12	Code letter for capacitance tolerance
13 ... 15	Codes for lead and taping parameters (refer to respective data sheet)
16 ... 18	Internal use

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"
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"

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
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)
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

Symbol	English	German
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
$\tan \delta$	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
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)

Symbol	English	German
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

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