SIEMENS

Capacitor RFI PTC NTC

Data Book 1984/85
U.S. Edition

SIEMENS
Capacitor RFI PTC NTC 1984/85

Table of Contents

Page

Table of Contents

MK Capacitors

General Technical Information

1. General

Metallized plastic capacitors – briefly MK capacitors – are outstanding for their self-healing property. The dielectric of these capacitors consists of plastic films onto which metal layers of approximately 0.02 to 0.05 µm are vacuum-deposited. The metallized films are either of wound construction in tubular or flattened form or arranged in the more recent stacked construction.

A hot metal spray technique is used for making electrical contact to the edges of the metallized winding. This ensures low loss and low inductance characteristics of the finished capacitor.

MK capacitors comply with VDE specification 0560, part 1, and DIN standard 44 110 as well as with the standard sheets for the individual capacitor types.

2. Self-healing

The electric arc, which occurs with voltage breakdown of the dielectric, evaporates the metallization in the area of the breakdown without impairing the dielectric. This results in effectively isolating the region of the failure. The time necessary for the self-healing process is less than 10 µsec. Since only fractions of the energy stored in the capacitor are dissipated in the self-healing process, the potential drop remains accordingly low. The capacitor design ensures that self-healing processes occur only occasionally, even when the parameters of continuous maximum voltage and maximum limit temperature apply; statistical measurements with MKL capacitors reveal that approx. 0.18 self-healing processes are to be expected per year and per µF. The capacitance variation would therefore be less than 1 % after 10^3 breakdowns. The self-healing characteristic is independent of maintaining the specified limit conditions, and can even be effective at low voltage ratings where electrochemical action takes presidence.

3. Types

Metallized plastic – MK – capacitors are distinguished by their dielectric materials:

MKL capacitors	comprising lacquer films (cellulose acetate) as dielectric and vacuum deposited metal layers. In accordance with DIN 41 379 these are designated MKU[1]) capacitors.
MKT[1]) capacitors	comprising polyethyleneterephthalate (trade name e.g. Hostaphan®, Mylar®, etc.) as dielectric and vacuum-deposited metal layers.
MKC[1]) capacitors	comprising polycarbonate (trade name Makrofol®) as dielectric and vacuum-deposited metal layers.
MKP[1]) capacitors	comprising polypropylene as dielectric and vacuum-deposited metal layers.
MKY capacitors	self-healing capacitors with highly insulating, low loss dielectric and metallized films as electrodes.

[1]) Designation in accordance with the German DIN standard 41 379.

Figure 1 shows characteristic curves of the main metallized film capacitors.

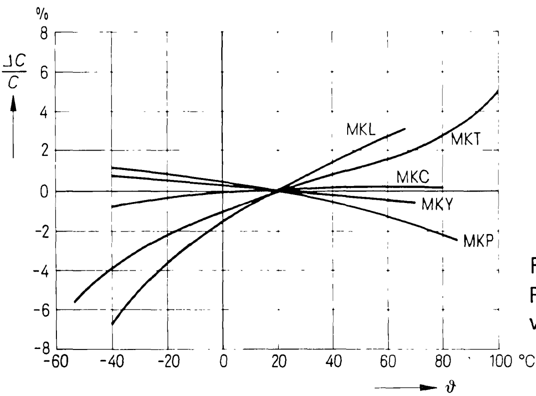


Fig. 1
Relative capacitance variation $\frac{\Delta C}{C}$ versus temperature ϑ

5.1.4. Moisture dependence

The capacitance of sealed capacitors is not subject to moisture under environmental climatic conditions.

With non-hermetically sealed capacitors, the operation at high relative humidity causes an increase in capacitance and a decrease in insulation resistance since the capacitor or the layer package has absorbed moisture, particularly when the relative humidity of the permitted climatic category is prolonged. These variations due to moisture are reversible.

5.1.5. Frequency dependence

Since the dielectric constant of the plastic films is frequency dependent, the capacitance decreases with increasing frequency. An example of this interdependence is shown for MKT capacitors in Fig. 2.

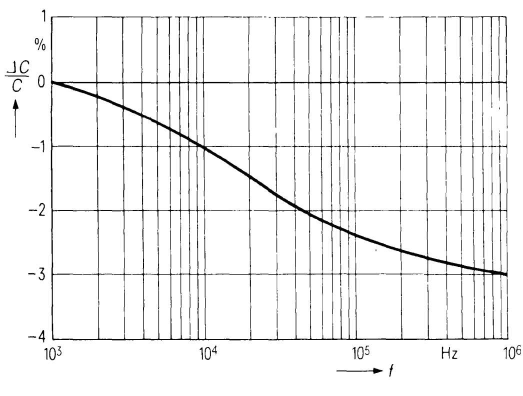


Fig. 2
Relative capacitance variation $\frac{\Delta C}{C}$ versus frequency f, at 20 °C/68 °F

5.2.5. Inherent temperature rise, permissible efficiency

When capacitors are operated at non-sinusoidal ac voltage or at sine voltage load of higher frequency, the inherent temperature rise and the pulse handling capability (see para 5.2.6.) must be taken into account.

The inherent temperature rise ($\Delta\vartheta$) of a capacitor can be calculated from the power dissipation (N_v) occurring during operation and the capacitor surface (F) according to the following formula:

$$\Delta\vartheta\,(\mathrm{K}) = \frac{N_v\,(\mathrm{mW})}{F\,(\mathrm{cm}^2) \times ß}$$

whereby $ß = 1 \dfrac{\mathrm{mW}}{\mathrm{K} \times \mathrm{cm}^2}$ for a plastic case.

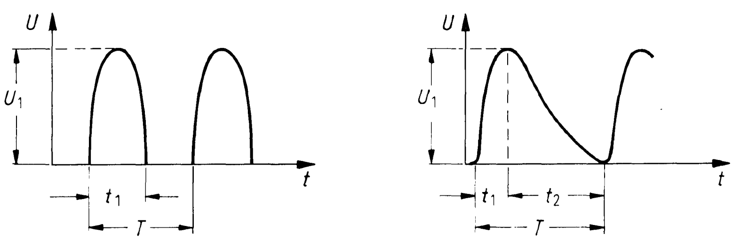
The capacitor's power dissipation (N_V) at a sine voltage load of higher frequency is calculated according to:

$$N_v = U^2_{rms} \times 2\pi f \times C \times \tan\delta_{(f)}$$

whereby C = capacitance in F
U_{rms} = rms voltage in V
f = frequency in Hz
$\tan\delta_{(f)}$ = dissipation factor at frequency f
N_v = power dissipation in W.

A non-sinusoidal ac voltage is to be disintegrated into its sine portions by a Fourier's analysis and the power dissipation is calculated as the sum of the individual power dissipation of each sine portion.

Executing the Fourier's analysis requires a dimensioned voltage/time diagram.



Examples for dividing a non-sinusoidal voltage into approximately sinusoidal parts to calculate the power dissipation for a capacitor.

For some types, the limiting loads are specified by a nomogram for the permissible peak voltage $\hat{U}$. Taken into account are:

- Repetition frequency
- Pulse shape
- Rise and/or fall time of the voltage edges
- Inherent temperature rise by about 10 K

5.3. Dissipation factor

The dissipation factor tan δ is temperature and frequency dependent and rises with increasing frequency and increasing capacitance. It mainly depends on the dielectric losses and the contact resistance of the leads.

The ohmic resistance of the leads is kept especially low and constant due to the contacting method used. For detailed data refer to the individual data sheets.

5.4. Insulation

The insulation of a capacitor is indicated either as a resistance value R_{is} in MΩ or as a time constant τ in seconds = MΩ × µF.

It consists of the insulation resistance of the dielectric (layer to layer) and the insulation resistance between layer and case, which is determined by the quality of the insulating material (plastic case, moulding material, lead-throughs etc.) and by the length of the surface leakage paths.

Because of the high quality of the insulating materials used for metallized film capacitors, the insulation resistance of the dielectric materials is unaffected.

The insulation resistance is the ratio of dc voltage applied to the current, flowing after a defined period. The current flowing after a constant dc voltage has been applied, is dependent on temperature, voltage, and time. It is made up from the charging, recharging and leakage currents (definition in accordance with VDE 0560, part 1, § 11).

In order to determine the limit values the following conditions are specified: The current shall be measured after the voltage has been applied for 1 minute at 23 °C/73.4 °F and a relative humidity ≦ 65%.

Measuring voltage for:

Capacitors with U_R	< 100 V	≧ 100 V
Measuring voltage	10 V	100 V

The insulation resistance for more than 95% of all capacitors lies far above the stated minimum value at delivery. The average value is, therefore, also indicated in the data sheets.

During the service life the insulation resistance can temporarily decrease to about 10% of the values at delivery, especially when the maximum permissible humidity (according to the climatic category) is applied over a longer period or when the capacitor is used continuously in the range of the maximum operating temperature.

5.5. Self inductance and impedance

The self inductance of metallized film capacitors depends on the inductance of their leads and the winding. Because of the large contacting area by which all turns of the winding are connected, the self inductance is especially low. The resonant frequency of a capacitor results from its self-inductance and its capacitance.

6.2. Soldering conditions

As regards **soldering heat resistance tests,** the DIN and IEC standards specified on the data sheets for the individual types apply. MK capacitors meet the **solderability tests** in accordance with DIN IEC 68, part 2–20.

When soldering the capacitors, the maximum temperature specified in section 6.1 may be exceeded for a short time. The following precautions are recommended to keep the maximum capacitor temperature low during soldering and thus to assure a reliable long-term behavior:

Maximum heating on the preheating path (flux dry path) up to 80 °C/176 °F
Soldering temperature $\leqq$ 245 °C/473 °F
Soldering time $\leqq$ 4 sec

Quick cooling, e.g. by a fan, after the actual soldering, to minimize the post-heating effect of the still liquid solder.

6.2.1. Resistance to cleansing solvents

Organic solvents consisting of alcohols or certain fluorocarbons or a mixture of both groups are suitable to clean soldered-in capacitors from flux residues and similar residues.

Suitable solvents are, e.g.:
- Ethyl alcohol
- Isopropyl alcohol
- Trifluor trichloroethane
- Mixtures of the above-mentioned components

By no means should solvents or solvent mixtures be used which contain chlorinated carbons or ketones. This type of solvents may attack or corrode the capacitor or its sleeve.

6.3. Mechanical robustness of terminations

The connecting leads are permitted to be bent at a distance not less than 1 mm from face ends of the capacitor, unless restrictions for particular capacitor types are indicated on the appropriate data sheets.

The terminals meet the requirements of DIN IEC 68-2-21.

Test Ua – Tensile	Cross-sectional area of the wire mm^2	Load N[1]
up to and including	0.8	10
exceeding	0.8	20
Test Ub – Bending	Two bendings through 90° in the opposite direction. The loading weight shall be 5 N at ≦ 0.8 mm^2; 10 N at > 0.8 mm^2	
Test Uc – Torsion of axial wires	Condition 2	
Test Ud – Torque of threaded bolts	Condition 1 M 3 ≙ 0.5 Nm M 4 ≙ 1.2 Nm M 5 ≙ 2 Nm	

For cube-shaped types with parallel leads, the termination tests Ub and Uc are not applicable.

[1]) 10 N = 1 kp

7.2. Load duration

The load duration is the sum of:

- Working time
- Intermittent time
- Storage, testing and checking time at the user
- Transport time

and is identified by the 5th code letter (see table).

4th code letter				5th code letter			
Failure quota given in failures per 10^9 components hours				Load duration in hours			
K	100	L	300	R	100000	S	30000
M	1000	N	3000	T	10000	U	3000

7.3. Relative failure rate

The relative failure rate is the ratio of the number of failed to the total number of components and applies to the load duration indicated. It is the product of failure quota and load duration.

The value quoted in the data sheets is an average value from investigations of a sufficiently large number of components.

7.4. Failure quota

The failure quota is the ratio of failure rate and associated load duration and is indicated in failures per 10^9 component hours. It is identified by the 4th code letter (see table in section 7.2).

7.4.1. Failure criteria

For MK capacitors the following failure criteria are decisive.

Total failure: Short or open circuit

Failure due to variations: exceeding or falling below the limit values given in the data sheets for:

- capacitance change $\frac{\Delta C}{C}$
- dissipation factor change $\Delta \tan \delta$
- insulation resistance

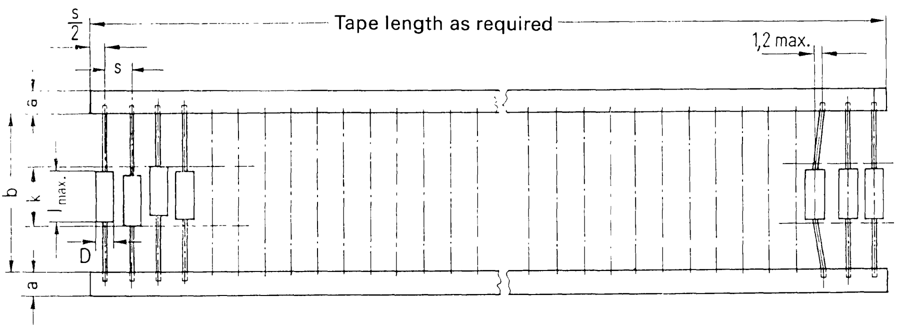
General information

We provide taped versions with axial and radial leads tailored to automatic assembly of equipment. Taping of MK capacitors with axial leads is based on IEC Publication 286-1; taping of types with radial leads is done in accordance with the latest and probably final state of the IEC Standard.

Taped MK capacitors with axial leads

MKL capacitors of types **B 32110** and **B 32112** up to a maximum diameter of 18.7 mm are preferably taped for automatic assembly.

Dimensions and tolerances



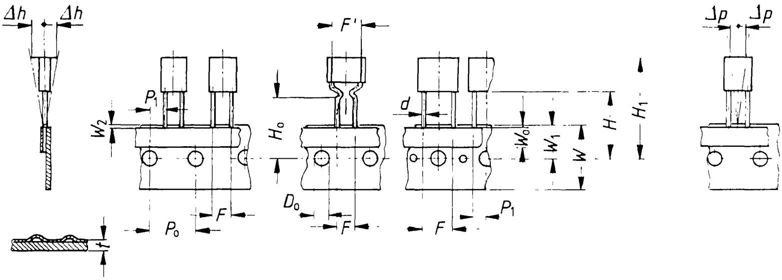
Dimensions in mm

Rated diameter D	Standard spacing between capacitors		Tape spacing b at tape width		Window width of body location k	Kind of packing
	Spacing s	Tolerance over 10 spacings Δs	a = 6±1	a = 9±1		
mm	mm	mm	mm			
5,4... 9,4	10±0,5	±2				
10,7...13,7	15±0,75	±3	96±2	93±2	l_{max}+1,4 mm	AMMO pack
15,7...18,7	20±1	±4				

Tapes MK capacitors with radial leads

Stacked-film capacitors with lead spacings of LS 5, LS 7.5/5 (leads crimped to LS 5), as well as LS 7.5 are particularly suitable for radial taping.

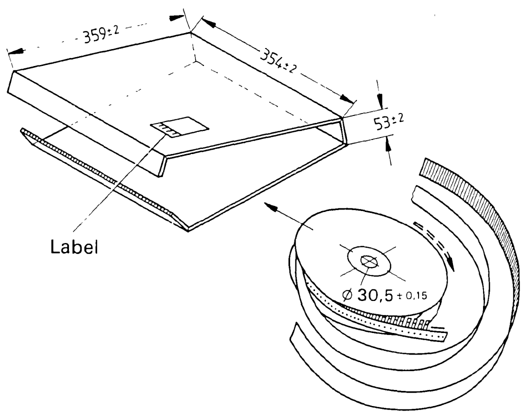
Dimensions and tolerances



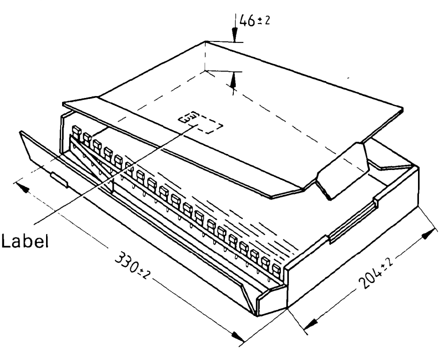
Dimensions in mm

Designation	Symbol	Dimensions at:			Tolerance	Notes
		LS 5	LS 7.5/5	LS 7.5		
Lead diameter	d	0,5	0,6	0,6	± 0,05	
Spacing hole center/ lead center	P_1	3,80	3,80	3,80	± 0,65	
Lead spacing (LS)	F	5	5	7,5	+ 0,6 / − 0,1	measured at tape edge
Lead spacing (LS)'	F'		7,5			
Feed hole spacing	P_0	12,7			± 0,2	± 1 mm/20 × P_0
Slope of capacitors	Δh	0			± 2	
Slope of capacitors	Δp	0			± 1,3	
Base width	W	18			± 0,5	
Adhesive width	W_0	6			± 0,5	
Spacing hole center/ upper tape edge	W_1	9			± 0,5	
Position of adhesive tape	W_2	0,5 – 3,0				
Spacing hole center/ lower component edge	H	18			+ 2	depending on assembly system
		16,5			± 0,3	
Spacing hole center/ start of crimping or bending	H_0	16,0			± 0,5	
Spacing hole center/ upper component edge	H_1	32,20 max.				
Hole diameter	D_0	4,0			± 0,2	
Tape thickness	t	0,7			± 0,2	

Reel packing



AMMO pack



Dimensions in mm

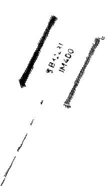
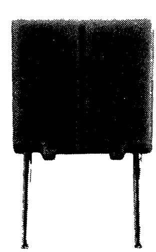
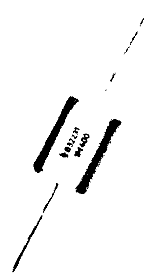
B 32510, lead spacing 7.5/5 or 7.5 mm

Capacitor[1]) C_R/U_R	Minimum order quantity = packaging unit (item) Reel packing	AMMO pack
1 nF/400 V	2000	1900
1,5 nF/400 V	2000	1900
2,2 nF/400 V	2000	1700
3,3 nF/400 V	2000	1800
4,7 nF/400 V	2000	1900
6,8 nF/400 V	2000	1700
10 nF/400 V	2000	1800
15 nF/400 V	1800	1500
10 nF/250 V	2000	1800
15 nF/250 V	2000	1900
22 nF/250 V	2000	1900
33 nF/250 V	1900	1600
47 nF/250 V	1600	1300
68 nF/250 V	1400	1100
0,1 µF/250 V	1200	1000
68 nF/100 V	2000	1800
0,1 µF/100 V	2000	1600
0,15 µF/100 V	1600	1300
0,22 µF/100 V	1200	1000
0,33 µF/100 V	1000	800
0,33 µF/ 63 V	1600	1300
0,47 µF/ 63 V	1400	1100
0,68 µF/ 63 V	1100	900

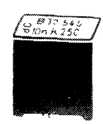
[1]) For dimensions refer to appropriate data sheet.

Summary of Types

MKT Capacitors

Type	B 32 231	B 32 520 . . . 529	I 5200
Rated capacitance (μF)	0.01 to 10	0.01 to 10	0.01 to 3.3.
Rated voltage (V dc)	100 to 630	100 to 630	250 to 630
DIN climatic category (DIN 40 040)	GMG	GME	GMC
IEC climatic category (IEC 68)	40/100/21	40/100/56	40/100/21
Dimensions *d* × *l* or *b* × *h* × *l* in mm (inches)	4.5 × 7.5 × 14 (0.18 × 0.30 × 0.55) to 17.5 × 32.5 × 44 (0.69 × 1.28 × 1.73)	4 × 9.5 × 13 (0.16 × 0.37 × 0.51) to 15 × 24.5 × 31.5 (0.59 × 0.96 × 1.24	(.177 × .315 × .591) to (.472 × .954 × 1.24)
Lead spacing in mm	20 to 50	10 to 27.5	—
Design	Flat winding with insulating sleeve, epoxy resin sealed face ends, central axial leads	Flat winding in rectangular plastic case, epoxy resin sealed to ensure resistance to humidity; leads plug-in in the lead spacing.	Flat winding with insulating sleeve, epoxy resin sealed face ends, central axial leads
Particular features	Standard version	Standard version.	Standard version
Figure			

Summary of Types

MKC Capacitors	MKC Capacitors	
Type	B 32 540 B 32 541	B 32 545
Rated capacitance (μF)	0.001 to 0.47	0.001 to 0.1
Rated voltage (V dc) (V ac)	250	100 to 400
DIN climatic category (DIN 40 040)	FME	FME/LR
IEC climatic category (IEC 68)	55/100/21	55/100/21
Dimensions *b* × *h* × *l* in mm (inches)	2.6 × 7.3 × 9 (0.10 × 0.29 × 0.35) to 9.1 × 11.5 × 11.5 (0.36 × 0.45 × 0.45)	4 × 10 × 10.5 (0.16 × 0.39 × 0.41)
Lead spacing in mm	7.5; 10	7.5
Design	Stacked-film construction; tinned leads, plug-in in the lead spacing	Built into epoxy resin sealed plastic case, leads plug-in the lead spacing
Particular features	Standard version	High reliability
Figure		

MKT Capacitors

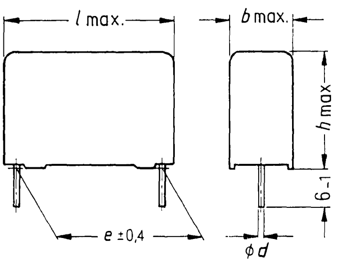
MKT capacitors, standard version, in accordance with DIN 44112

U_R = 63 to 630 V dc

Self-healing capacitor with polyethyleneterephthalate dielectric. Encapsulated in a flame-retardant rectangular plastic case (in accordance with UL 94 V-O). Epoxy resin sealed for humidity resistance. For improved solderability, the package is provided with spacers. Connections: parallel leads, tinned, plug-in in the lead spacing. Particularly suited for space-saving assembly at high packing density on any pc board.

Quality assessment according to CECC 30 400 for these capacitors will be applied for.

Capacitors with 5 mm and 7.5 mm lead spacing[1], as well as capacitors with a lead spacing of 7.5/5 mm[1] (leads crimped to a lead spacing of 5 mm) are also available on continuous tape. For taping specifications and ordering code information refer to data sheet B 32 071.



l	Lead spacing "*e*"	ϕ *d*
7.5	5	0.5
10	7.5	0.6
13	10	0.6
18	15	0.8
27	22.5	0.8
31.5	27.5	0.8

Dimensions in mm

DIN climatic category (DIN 40040)	**F M E / L R**
Lower category temperature	**F** – 55°C/–67°F
Upper category temperature	**M** + 100°C/+212°F[2]
Humidity category	**E** average relative humidity ≦ 75%; 95% on 30 days per year continuously; 85% on the remaining days occasionally; rare, brief dew precipitation permitted
Failure quota	**L** 300 failures per 10^9 component hours
Load duration	**R** 10^5h
Relative failure rate	$300 \cdot 10^{-9} \cdot 10^5 = 3\%$ At normal operational load, a failure quota of $2 \cdot 10^{-9}$/h can be assumed.
Failure criteria	
Total failure	Short or open circuit
Failure due to variation	Capacitance change $\frac{\Delta C}{C}$ >±10%
	Dissipation factor tan δ >2× upper category values
	Insulation resistance <150 MΩ (≦0.33 µF) < 50 sec (>0.33 µF)

[1]) Available from 1984
[2]) Shelf and service life at temperatures > 100 ... 125°C/212 ... 257°F, 1000 h max., , $U_C = 0.5\ U_R$.

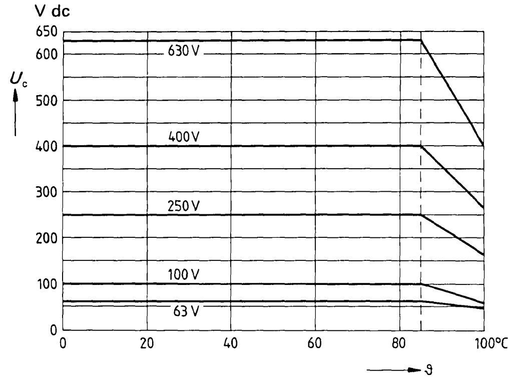
Rated voltage U_R		250 V dc				
Lead spacing		**LS 7.5 mm**	**LS 10 mm**	**LS 15 mm**	**LS 22.5 mm**	**LS 27.5 mm**
Rated capacitance	Tolerance	K; J			M; K; J	
		Dimensions $b \times h \times l$ and ordering code				
C_R		B32520–	B32521–	B32522–	B32523–	B32524–
0.015 µF		4x8.5x10 ◥ –A3153–*				
0.022 µF		4x8.5x10 ◥ –A3223–*				
0.033 µF		4x8.5x10 ◥ –A3333–*	4x9x13 –A3333–*			
0.047 µF			4x9x13 -3473–*			
0.068 µF			4x9x13 –A3683–*			
0.1 µF				5.5x11x18 –A3104–*		
0.15 µF	± 20% ≙ M ± 10% ≙ K ± 5% ≙ J			5.5x11x18 –A3154–*		
0.22 µF				7x13x18 –A3224–*		
0.33 µF				7x13x18 –A3334–*		
0.47 µF					7.3x16.5x27 –M3474–*	
0.68 µF					7.3x16.5x27 –M3684–*	
1 µF					8.5x18.5x27 –M3105–*	
1.5 µF						11.5x21x31.5 –M3155–*
2.2 µF						11.5x21x31.5 –M3225–*
3.3 µF						13.5x23x31.5 –M3335–*
4.7 µF						15x24.5x31.5 –M3475–*

* The code letter for the desired tolerance (refer to table) must be inserted in this position.
◥ Shipment for 1983 still in the dimensions: 4x10x10 (B 32535).
▭ Preferred values

Rated voltage U_R		**630 V dc**		
Lead spacing		**LS 15 mm**	**LS 22.5 mm**	**LS 27.5 mm**
Rated capacitance C_R	Tolerance	M; K; J[1]) Dimensions *b*x*h*x*l* and ordering code B32522–	B32523–	B32524–
0.033 µF	± 20% ≙ M ± 10% ≙ K ± 5% ≙ J	**5.5x11x18 –M8333–***		
0.047 µF		7x13x18 –M8473–*		
0.068 µF		9x14.5x18 –M8683–*		
0.1 µF			**7.3x16.5x27 –M8104–***	
0.15 µF			8.5x18.5x27 –M8154–*	
0.22 µF			10.5x19x27 –M8224–*	
0.33 µF				11.5x21x31.5 –M8334–*
0.47 µF				**13.5x23x31.5 –M8474–***
0.68 µF				15x24.5x31.5 –M8648–*

* The code letter for the desired tolerance (refer to table) must be inserted in this position.
[1]) Upon request
▭ Preferred values

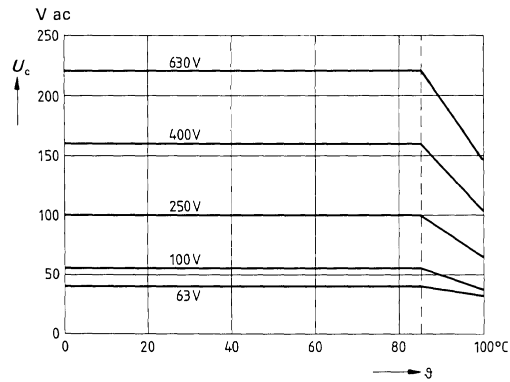
Category voltage U_C
at dc operation
versus temperature ϑ



2000 h max. $1.25 \cdot U_C$

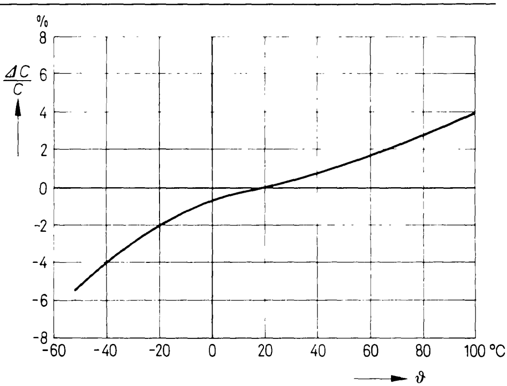
for milliseconds (e.g. switchings) $1.50 \cdot U_C$

Category voltage U_C[1] [2]
ac operation at 50 Hz
versus temperature ϑ



2000 h max. $1.25 \cdot U_c$

Reversible capacitance change $\frac{\Delta C}{C}$
versus temperature ϑ
(typical values, measured at 1 kHz)



[1]) The sum of the dc voltage and the peak value of an ac voltage superimposed on the dc voltage may not exceed the rated voltage.
[2]) Capacitors of the 630 V dc series can be used as 250 V ac line power parallel capacitors if it is ensured that voltage peaks occurring occasionally during operation do not exceed 1000 V.

Pulse handling capability (voltage rate of rise U_{pp}/τ and pulse characteristic k_O).

Maximum permissible voltage change per time unit for non-sinusoidal voltages (pulse, sawtooth).

Rated voltage U_R		LS 5	LS 7.5	LS 10	LS 15	LS 22.5	LS 27.5
63 V dc	U_{pp}/τ in V/µs k_O in V²/µs	80 10000					
100 V dc	U_{pp}/τ in V/µs k_O in V²/µs		50 10000	35 7500	25 5000	2 400	1.5 300
250 V dc	U_{pp}/τ in V/µs k_O in V²/µs		100 50000	75 35000	50 25000	3 1500	2.5 1250
400 V dc	U_{pp}/τ in V/µs k_O in V²/µs		125 100000	90 75000	60 50000	4 3200	3 2400
630 V dc	U_{pp}/τ in V/µs k_O in V²/µs				10 12600	7 8800	5 6300

For a voltage deviation of $U_{pp} < U_R$ the value of the permissible voltage rate of rise U_{pp}/τ can be multiplied by the factor U_R/U_{pp}. The data of the nomogram must be considered in the case of periodic pulses. See also the calculation example in the Chapter "General Technical Information", para 5.2.6, Data Book "Metalized Plastic Capacitors", 1982/83.

AC power handling capability at higher frequencies

The maximum permissible peak voltage $\hat{U}$ for sinusoidal and non-sinusoidal voltages (pulse, sawtooth, trapezoidal voltages) can be determined from the nomogram.
The nomogram is based on 10°C inherent temperature rise of the capacitor; this must be considered during operation with regard to the permissible upper category temperature.

The following limits may not be exceeded:

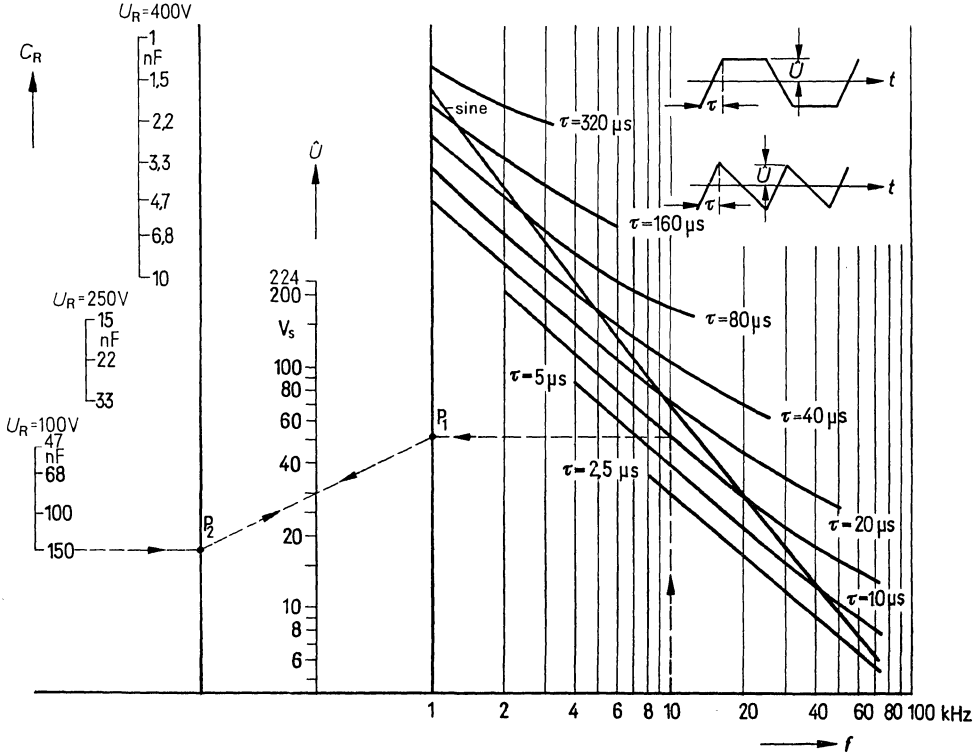
Rated voltage U_R	63 V dc	100 V dc	250 V dc	400 V dc	630 V dc
Limit voltage $\hat{U}_l$	55 V	85 V	140 V	224 V	280 V

B 32520, LS 7.5 mm

Nomogram to determine the permissible peak voltage $\hat{U}$

Determine the intersections P_1 and P_2 according to the plotted example. The intersection of the line connecting P_1 with P_2 and the $\hat{U}$ scale gives the maximum permissible peak voltage.

In case of a trapezoidal voltage load, the second harmonic frequency must be considered. For a sinusoidal voltage load, the "sine" characteristic applies.



Example:

f	= 10 kHz	(repetition frequency)	}	intersection P_1
τ	= 10 μs	(rise time)		
C_R	= 150 nF	(capacitance)	}	intersection P_2
U_R	= 100 V	(rated voltage)		

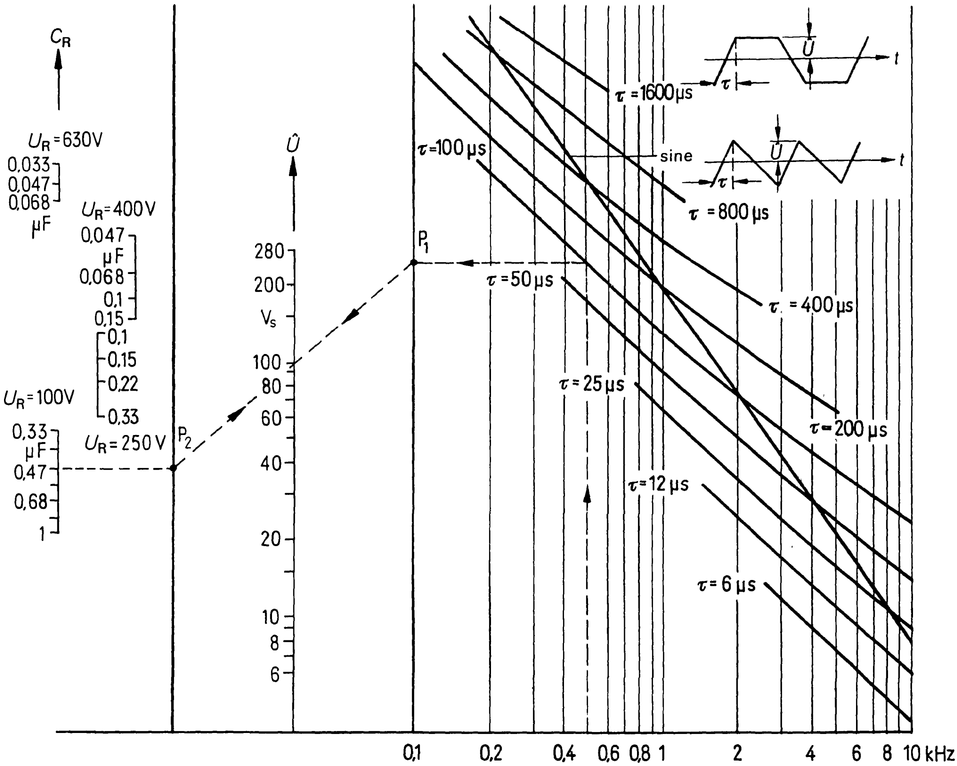
According to the dashed line in the above graph, this results in a max. peak voltage $\hat{U}$ of approx. 30 V.

B 32522, LS 15 mm

Nomogram to determine the permissible peak voltage $\hat{U}$

Determine the intersections P_1 and P_2 according to the plotted example. The intersection of the line connecting P_1 with P_2 and the $\hat{U}$ scale gives the maximum permissible peak voltage.

In case of a trapezoidal voltage load with two steep edges, the second harmonic frequency must be considered. For a sinusoidal voltage load, the "sine" characteristic applies.



Example:

f = 0.5 kHz (repetition frequency)
τ = 100 µs (rise time)
} intersection P_1

C_R = 0.47 µF (capacitance)
U_R = 100 V (rated voltage)
} intersection P_2

According to the dashed line in the above graph, this results in a max. peak voltage $\hat{U}$ of approx. 100 V.

For loads at frequencies > 10 kHz, please contact us.

MKT Stacked-Film Capacitors

B 32 560 ... B 32 563

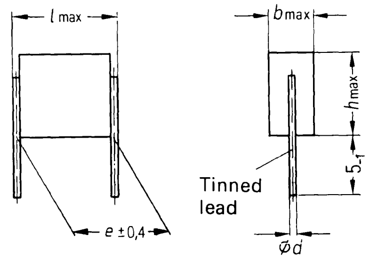
Metallized polyester stacked-film capacitors are delivered as quality assessed version in accordance with CECC 30 401-007, form A (Number of approval: 404.8/10/74).

For use in consumer and entertainment electronics, in semiprofessional and professional systems.

Self-healing capacitor, comprising polyethyleneterephthalate dielectric. When mounting, attention must be given to the surface leakage paths and air paths to adjacent live parts. The insulating strength of the sectional areas to live parts corresponds to 1.5 times the rated dc voltage of a capacitor; it amounts, however, to at least 300 Vdc.
Connections: Parallel leads, tinned, plug-in, lead spacing 7.5 to 22.5 mm.

Type	Lead spacing "e"	dia. *d*
B32 560	7.5 mm	0.6
B32 561	10. mm	0.6
B32 562-D	15 mm	0.6
B32 562-E	15 mm	0.8
B32 563	22.5 mm	0.8

Dimensions in mm

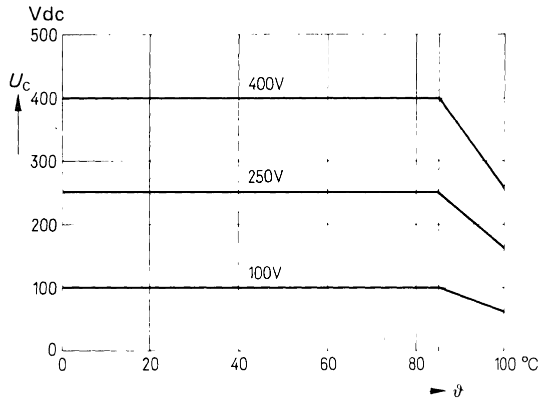


DIN climatic category (DIN 40 040)	**F M E / L R**
Lower category temperature	**F** – 55 °C/–67 °F
Upper category temperature	**M** +100 °C/212 °F
Humidity category	**E** average relative humidity ≦ 75%; 95% for 30 days continuously; 85% for the remaining days, occasionally rare, short dew precipitation permitted
Failure quota	**L** 300 failures per 10^9 component hours
Load duration	**R** 10^5 hours
Relative failure rate	$300 \times 10^{-9} \times 10^5 = 3\%$ At a load, usually occurring in practice, a failure quota of 2×10^{-9}/hour can be assumed.

Failure criteria	
Total failure	Short or open circuit
Failure due to variation	Capacitance change $\frac{\Delta C}{C} > \pm 10\%$
	Dissipation factor tan δ > 2 × max. limit value
	Insulation resistance < 150 MΩ (≦ 0.33 µF)
	< 50 s (> 0.33 µF)

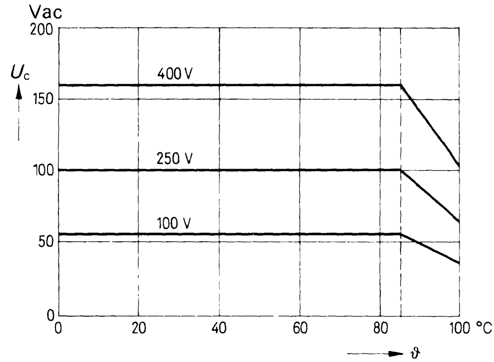
250 Vdc		400 Vdc				U_R
LS 15 mm	**LS 22.5 mm**	**LS 7.5 mm**	**LS 10 mm**	**LS 15 mm**	**LS 22.5 mm**	
Dimensions *b x h x l* Ordering code						
B32562–	B32563–	B32560–	B32561–	B32562–	B32563–	C_R
		2,4x8,2x9 –D6102–*				1000 pF
		2,3x8,2x9 –D6152–*				1500 pF
		2,3x8,2x9 –D6222–*				2200 pF
		2,3x8,2x9 –D6332–*				3300 pF
		2,3x8,2x9 –D6472–*				4700 pF
		2,4x7,3x9 –D6682–*				6800 pF
		2,4x7,3x9 –D6103–*	3,2x6,6x11,5 –D6103–*			0,01 µF
		2,7x7,3x9 –D6153–*	3,2x6,6x11,5 –D6153–*			0,015 µF
			3,2x6,6x11,5 –D6223–*			0,022 µF
			3,3x6,6x11,5 –D6333–*			0,033 µF
			3,9x7,2x11,5 –D6473–*			0,047 µF
				3,8x6,2x16,5 –D6683–*		0,068 µF
				4,5x7,1x16,5 –D6104–*		0,1 µF
				5,5x8,2x16,5 –E6154–*		0,15 µF
				7,2x8,6x16,5 –E6224–*		0,22 µF
5,4x7,7x16,5 –D3334–*				8,3x10,9x16,5 –E6334–*		0,33 µF
6,1x9,4x16,5 –E3474–*					7,3x12,4x24 –D6474–*	0,47 µF
7x11,4x16,5 –E3684–*					8,3x15,4x24 –D6684–*	0,68 µF
9,6x11,5x16,5 –E3105–*	6,5x11,8x24 –D3105–*				10,4x17,5x24 –D6105–*	1 µF
	7,8x14,4x24 –D3155–*					1,5 µF
	9,1x17,5x24 –D3225–*					2,2 µF
						3,3 µF

Category voltage U_C
at dc operation
versus temperature ϑ



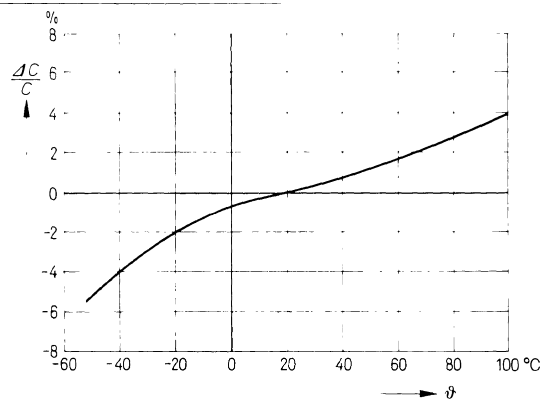
max. 2000 hours 1.25 × U_C
for milliseconds 1.50 × U_C
(e. g. switchings)

Category voltage U_C[1)]
at ac operation
at 50 Hz
versus temperature ϑ



max. 2000 h 1.25 × U_C

Reversible capacitance change $\frac{\Delta C}{C}$
versus
temperature ϑ
at 1 kHz (typical values)



1) When an ac voltage is superimposed on a dc voltage, the sum of the dc voltage and the amplitude of the ac voltage shall not exceed the rated voltage.

Pulse handling capability (voltage rate of rise U_{pp}/τ and pulse characteristic k_O).
Maximum permissible voltage change per time unit with non-sinusoidal voltage load (pulse, sawtooth).

Rated voltage U_R		LS 7.5	LS 10	LS 15	LS 22.5
100 Vdc	U_{pp}/τ in V/µs k_O in V²/µs	100 20000	75 15000	50 10000	50 10 000
250 Vdc	U_{pp}/τ in V/µs k_O in V²/µs	200 100000	150 75000	100 50000	100 50 000
400 Vdc	U_{pp}/τ in V/µs k_O in V²/µs	250 200000	175 150000	125 100000	125 100 000

For a voltage swing $U_{pp} < U_R$ the value of the permissible voltage rate of rise U_{pp}/τ can be multiplied by the factor U_R/U_{pp}. The data of the nomogram must be accounted for periodic pulses. See also calculation example in section "General Technical Information", para 5.2.6, page 24.

AC power handling capability at higher frequencies

The maximum permissible peak voltage $\hat{U}$ for sinusoidal and non-sinusoidal voltage load (pulse, sawtooth, trapezoidal voltages) can be obtained from the nomogram.

The nomogram is based on 10 °C (18 °F) inherent temperature rise of the capacitor; this must be taken into account when considering the permissible max. temperature.

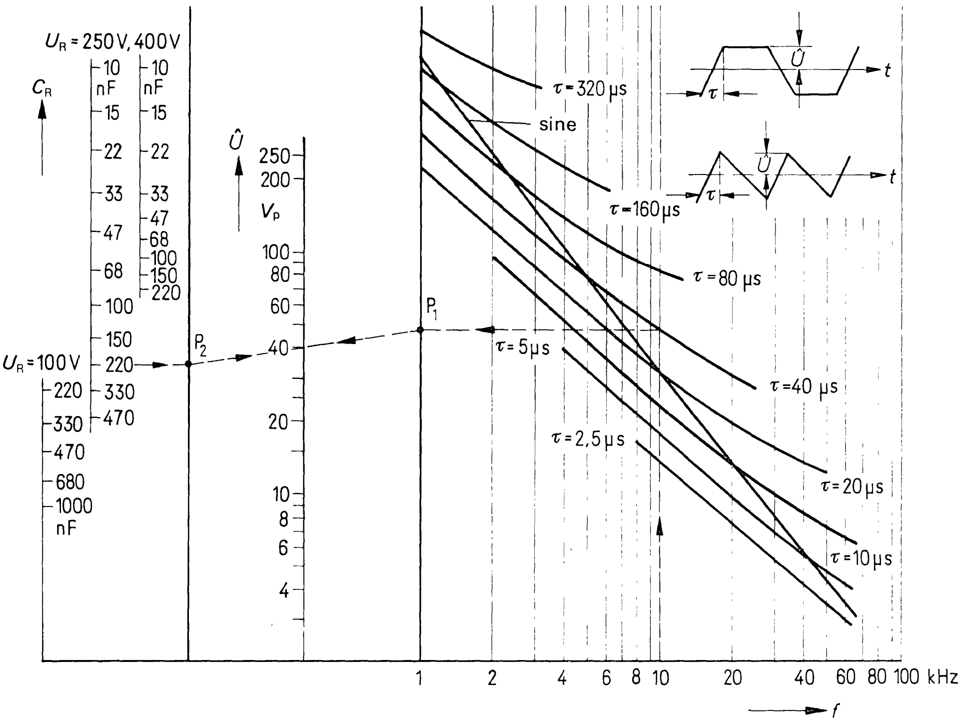
The following limit values $\hat{U}_l$ are not allowed to be exceeded.

Rated voltage U_R	100 V	250 V	400 V
Limit voltage $\hat{U}_l$	85 V	140 V	224 V

B 32 561, lead spacing = 10 mm

Nomogram for determining the permissible peak voltage $\hat{U}$

Determine points of intersection P_1 and P_2 in accordance with the example plotted. The line of communication P_1, P_2 yields the maximum possible peak voltage.
In case of trapezoidal voltage load with two steep edges, the second harmonic frequency has to be taken into account. With sinusoidal voltage load the "sine" characteristic applies.



Example given:

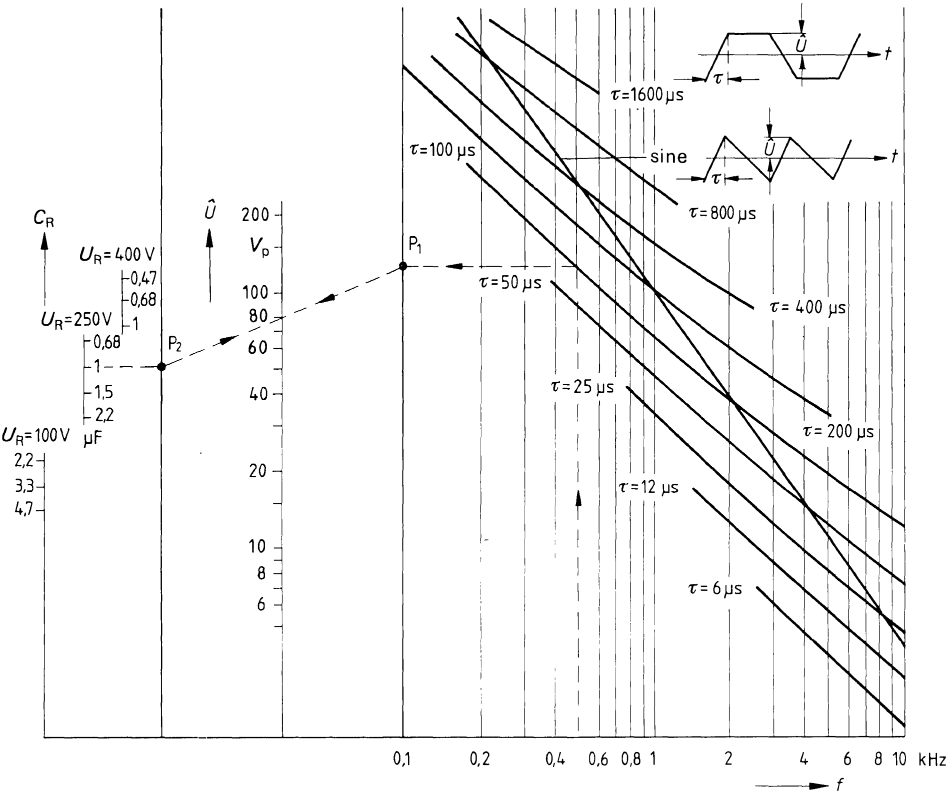
f = 10 kHz	(repetition frequency)	}	Point of intersection P_1
τ = 40 µs	(rise time)		
C_R = 220 nF	(capacitance)	}	Point of intersection P_2
U_R = 250 V	(rated voltage)		

According to the dashed line on the graph above this gives a max. peak voltage $\hat{U}$ of about 40 V.

B 32 563, lead spacing = 22.5 mm

Nomogram for determining the permissible peak voltage $\hat{U}$

Determine points of intersection P_1 and P_2 in accordance with the example plotted. The line of communication P_1, P_2 yields the maximum possible peak voltage.
In case of trapezoidal voltage load with two steep edges, the second harmonic frequency has to be taken into account. With sinusoidal voltage load the "sine" characteristic applies.



Example given:

f	= 0.5 kHz	(repetition frequency)	} Point of intersection P_1
τ	= 100 µs	(rise time)	
C_R	= 1 µF	(capacitance)	} Point of intersection P_2
U_R	= 250 V	(rated voltage)	

According to the dashed line on the graph above this gives a max. peak voltage $\hat{U}$ of about 80 V.

DIN climatic category (DIN 40 040)	**F M E / L R**
Lower category temperature	**F** – 55°C/ – 67°F
Upper category temperature	**M** + 100°C/ + 212°F[2])
Humidity category	**E** average relative humidity ≦ 75%; 95% on 30 days per year continuously; 85% on the remaining days occasionally; rare, brief dew precipitation permitted
Failure quota	**L** 300 failures per 10^9 component hours
Load duration	**R** 10^5h
Relative failure rate	$300 \cdot 10^{-9} \cdot 10^5 = 3\%$ At normal operational load, a failure quota of $2 \cdot 10^{-9}$/h can be assumed.
Failure criteria	
Total failure	Short or open circuit
Failure due to variation	Capacitance change $\frac{\Delta C}{C} > \pm 10\%$
	Dissipation factor tan δ > 2 × upper category values
	Insulation resistance < 150 MΩ
IEC climatic category (DIN 40 045 or IEC publication 68-1)	**55/100/56**
Damp heat test (DIN IEC 68-2-3)	**Conditions**
	Test temperature: + 40°C
	Relative humidity $(93 {}^{+2}_{-3})\%$
	Test duration: 56 days
	Test criteria
	Capacitance change $\frac{\Delta C}{C} \leqq \pm 5\%$
	Dissipation factor change Δ tan δ at 1 kHz: $\leqq 5 \cdot 10^{-3}$
	Insulation resistance: ≧ 50% of the minimum value at delivery
Insulation resistance R_{is}	
Minimum delivery value	3750 MΩ
Average delivery value	> 30 000 MΩ
Resistance to soldering heat[1]) Test Tb (DIN IEC 68-2-20)	Solder bath temperature: max. 260°C (500°F)
	Soldering duration: max. 5 sec.
	Capacitance change $\frac{\Delta C}{C} \leqq \pm 2\%$
Resistance to cleansing agents	Refer to Data Book "Metalized Plastic Capacitors" 1982/83, chapter "General Technical Information", page 27.
Maximum capacitance drift i_z	± 3%

Dissipation factor tan δ measured at 20°C — Upper limits/average production values

	$C_R < 0.1$ µF	$C_R \geqq 0.1 ... < 1$ µF
at 1 kHz	$8/\ 5 \cdot 10^{-3}$	$10/\ 6 \cdot 10^{-3}$
10 kHz	$15/12 \cdot 10^{-3}$	$20/15 \cdot 10^{-3}$
100 kHz	$30/18 \cdot 10^{-3}$	–

The information describes the type of component and shall not be considered as assured characteristics.

Technical Data:

<table>
<tr><td>Climatic category
in accordance with DIN 40040</td><td>G – minimum category temperature .... –40C
M – maximum category temperature .... +100C
F – average relative humidity (RH) .... ≤65%
60 days per year 75%
30 days per year .... 85%</td></tr>
<tr><td>Damp heat test
in accordance with DIN 40046

and IEC 384-2</td><td>Conditions:
Test temperature .... (40±2)C
Relative humidity .... (92±3)%
Test duration .... 21 days

After test:
R_{ins} ≤ 50% of the minimum value at delivery
$\frac{\Delta C}{C} \leq 5\%$
$\Delta tg\delta$ at 1 kHz $\leq 5 \times 10^{-3}$
40/100/21</td></tr>
<tr><td>Solder conditions</td><td>Temperature solder bath: max. 260°C
Solder duration: 5 s
Distance to the soldering joint: min. 6 mm.</td></tr>
<tr><td>Self inductance</td><td><table><tr><td>lead space (mm)</td><td>7.5</td><td>10</td><td>15</td></tr><tr><td>Self
indutance (nH)</td><td>5</td><td>6</td><td>7</td></tr></table></td></tr>
<tr><td>Dissipation factor tg δ
(measured at 20°C) 1 kHz
10 kHz</td><td><table><tr><td>Maximum limit value</td><td>Average value</td></tr><tr><td>10.10^{-3}</td><td>5.10^{-3}</td></tr><tr><td>20.10^{-3}</td><td>15.10^{-3}</td></tr></table></td></tr>
<tr><td>Capacitance drift i_z</td><td>± 3%</td></tr>
</table>

Dimension Table

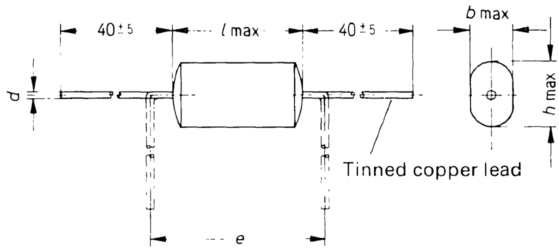
Rated Voltage		**250 V**				
L.S.		7.5mm	10mm	15mm	22.5mm	27.5mm
Rated Capacitance uF	Tol. (%)	MAXIMUM DIMENSION b x h x l (mm)				
		5150	5151	5152	5153	5154
0.01		4 x 9 x11	5 x 8 x13			
0.012		4 x 9 x11	5 x 8 x13			
0.015		4 x 9 x11	5 x 8 x13			
0.018		4 x 9 x11	5 x 8 x13			
0.022		4 x 9.5x11	5 x 8 x13			
0.027		4.5x 9.5x11	5 x 8.5x13			
0.033		4.5x 9.5x11	5 x 9.5x13			
0.039	± 5	4.5x 9.5x11	5 x 8.5x13			
0.047	(J)	4.5x 9.5x11	5 x 8.5x13			
0.056		4.5x 9.5x11	5 x 8.5x13			
0.068		5 x10 x11	5 x 8.5x13			
0.082		5 x11.5x11	5.5x 8.5x13			
0.1		5.5x12 x11	5.5x 9.5x13			
0.12		6.5x12 x11	5.5x 9.5x13			
0.15	± 10	8 x12 x11	5.5x10.5x13			
0.18	(K)		6 x12 x13			
0.22			6.5x12 x13	6 x10x18		
0.27			7 x12 x13	6.5x10x18		
0.33			8.5x12 x13	7 x10x18		
0.39			10 x12 x13	7.5x10x18		
0.47			10 x14 x13	7.5x12x18		
0.56					8.5x16.5x26	
0.68					8.5x18 x26	
0.82					8.5x20 x26	
1.0				10.5x14x18	9 x20 x26	
1.2						9 x20x31
1.5						9 x20x31
1.8						9.5x21x31
2.0						10 x21x31
2.2						10.5x22x31
2.7						12 x23x31
3.3						14 x24x31
4.7						13 x21x31

Dimension Table

Rated Voltage		**630 V**				
L.S.		7.5mm	10mm	15mm	22.5mm	27.5mm
Rated Capacitance uF	Tol. (%)	MAXIMUM DIMENSION b x h x l (mm)				
		5150	5151	5152	5153	5154
0.01			8 x11.5x13			
0.012			8 x11.5x13			
0.015			8 x11.5x13			
0.018			8 x11.5x13			
0.022			8.5x13 x13			
0.027				7 x12x18		
0.033				7 x13x18		
0.039	± 5			7.5x13x18		
0.047	(J)			7.5x13x18		
0.056				8 x14x18		
0.068				8 x15x18		
0.082					8 x15x26	
0.1					8.5x15x26	
0.12					8.5x15x26	
0.15	± 10				9.5x16x26	
0.18	(K)				10 x17x26	
0.22					10 x21x26	
0.27						10x21x31
0.33						10x21x31
0.39						11x22x31
0.47						12x23x31

Metallized polyester capacitors – standard version

Self-healing flat capacitor winding with polyethyleneterephthalate dielectric. Capacitor winding, coated with insulating sleeve, epoxy resin sealed face ends.
Central axial leads.



l	e
14	20
19	25
26.5	32.5
32	37.5
44	50

b	l	dia. d
≦6	–	0.6
>6	–	0.8
–	44	1.0

Dimensions in mm

Minimum lead bend: 1 mm from face ends.

DIN climatic category (DIN 40 040)	**G M G**
Lower category temperature	**G** – 40 °C/– 40 °F
Upper category temperature	**M** +100 °C/+212 °F
Humidity category	**G** average relative humidity ≦ 65%; 85% for 60 days per year; continuously 75% for the remaining days, occasionally
IEC climatic category (DIN 40 045, or IEC publication 68-1)	**40/100/04 or 40/100/21**[1)]
Damp heat test in accordance with DIN IEC 68-2-3	**Conditions**
	Test temperature: +40 °C/104 °F
	Relative humidity: $(93 {}^{+2}_{-3})$ %
	Test duration: 4 days (21 days)
	Capacitance change $\frac{\Delta C}{C}$: ≦ ± 5%
	Dissipation factor change Δ tan δ: ≦ 5×10^{-3} (at 1 kHz); ≦ 7×10^{-3} (at 10 kHz)
	Insulation resistance: ≧ 50% (20%) of the minimum value at delivery

1) The values in parentheses apply to these increased requirements.

Resistance to vibration Test F_C: Vibration partial test B 1 in accordance with DIN 40 046, sheet 8, and IEC publication 68-2-6	Duration of endurance conditioning 6 hours Frequency range 10 to 55 Hz Displacement amplitude 0.75 mm (conforming to max. 10 *g*)
Resistance to soldering heat[1)] Test Tb in acc. with DIN IEC 68-2-20	Temperature of the solder bath max. 260 °C (500 °F) Soldering duration max. 10 s Distance to the soldering joint min. 6 mm Capacitance change $\frac{\Delta C}{C} \leqq \pm 2\%$
Capacitance drift i_Z	±3%

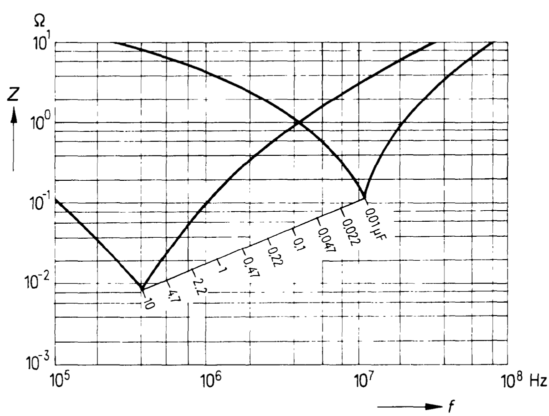
Dissipation factor tan δ in 10^{-3} measured at 20 °C (68 °F) (typical values)

Maximum value / Average value

	for $C \leqq 0.047$ µF	$C > 0.047$ to 1 µF	$C > 1$ µF
at 1 kHz	10/5	10/6	10/7
at 10 kHz	20/15	25/17	–

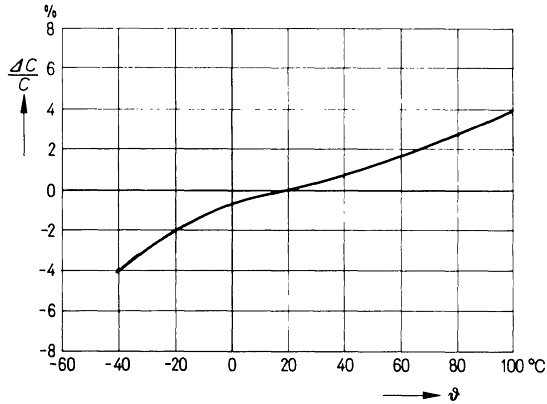
Self inductance	approx. 10 nH (per cm lead and capacitor length)

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

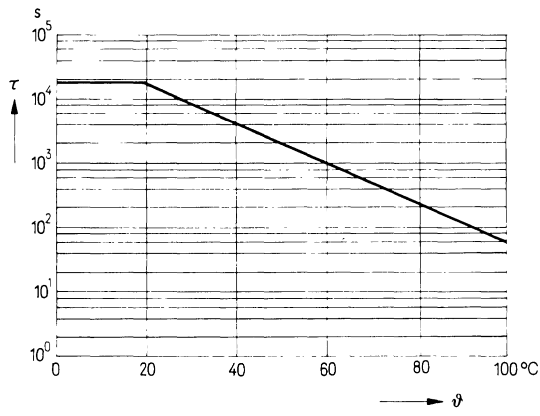


1) For solder recommendations also refer to "General Technical Information", para 6.2., page 27.

Reversible capacitance change $\frac{\Delta C}{C}$
versus temperature ϑ
at 1 kHz (typical values)



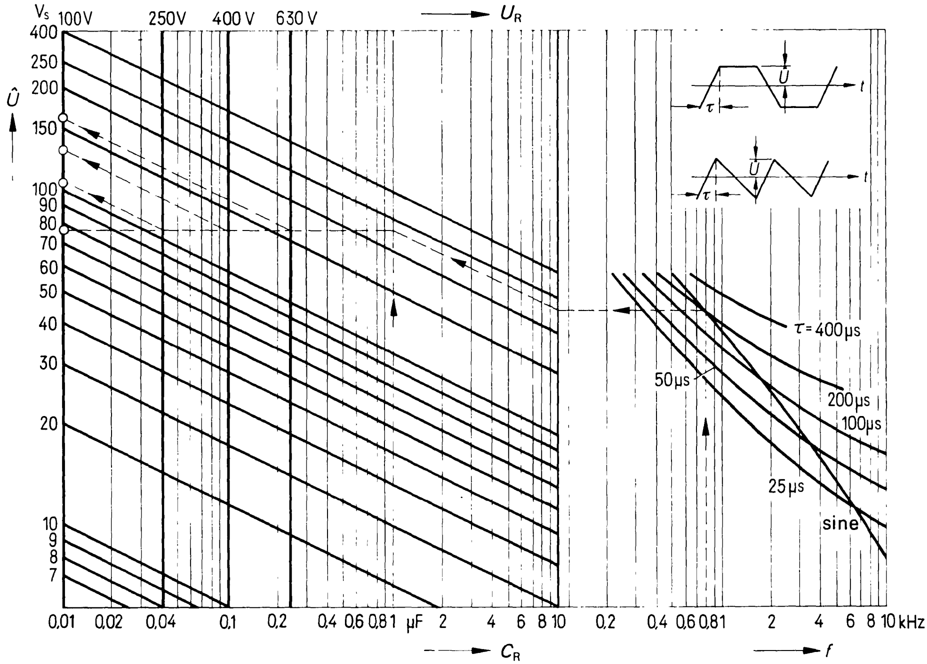
Insulation
(time constant τ)
versus temperature ϑ



Minimum value[1]	for U_R = 100 Vdc	for U_R > 100 Vdc
$C \leqq 0.33$ µF	3 000 MΩ	7 500 MΩ
$C > 0.33$ µF	1 000 s	2 500 s
Average value		
$C \leqq 0.33$ µF	>30 000 MΩ	>75 000 MΩ
$C > 0.33$ µF	>10 000 s	>25 000 s

[1] The indicated values are applicable at the time of delivery. During operational life the insulation may decrease for a short period to about 10% of the values at the time of delivery, especially when the maximum permissible humidity of 85% is applied for a long period, or when the capacitor is operated close to the upper category temperature.

The nomogram is based on 10 °C (50 °F) inherent temperature rise of the capacitor; this must be taken into account when considering the permissible max. temperature.
With trapezoidal voltage load, the second harmonic frequency must be assumed.



Example given:

f = 800 Hz (repetition frequency)
τ = 200 µs (rise time)
C = 1 µF (capacitance)

According to the dashed line on the graph above this gives:

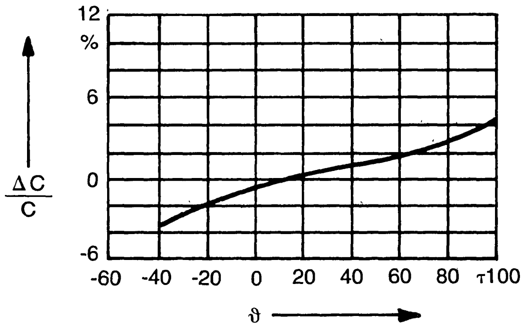
for the 100 Vdc type a max. peak voltage $\hat{U}$ of about 75 V
for the 250 Vdc type a max. peak voltage $\hat{U}$ of about 105 V
for the 400 Vdc type a max. peak voltage $\hat{U}$ of about 135 V
for the 630 Vdc type a max. peak voltage $\hat{U}$ of about 160 V

Technical Data

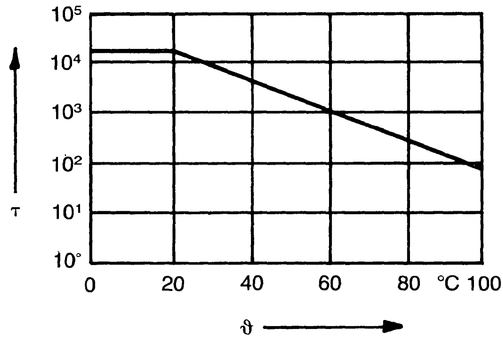
Climatic Category In accordance with DIN	G M C G −40°C/−40°F M +100°C/+212°F G the relative humidity should be ≤ 65%, but it can rise to the following values: 75%, 60 days per year 85%, 30 days per year	
Condensation	No	
Test Category in accordance with DIN 40 046 and IEC 68-2-3	40/100/21	
Damp Heat Test: in accordance with DIN	Conditions: Severity grade 7	
	Test Temperature:	(40 ± 2°C)
	Relative Humidity:	(92 ± 3%)
	Test Duration:	4 days
	After this test the insulation resistance can't be lower than 0.2 of the minimal delivery value.	
Resistance to Vibration: Test F_c: Vibration	Test duration:	6 hours
	Frequency Range:	10 to 55 Hz
	Vibration amplitude:	0.75mm
	(corresponding to a maximum acceleration of 10g = 98m/s^2)	
Solder Conditions:	Temperature of Solder bath:	max. 260°C
	Soldering Duration:	5s
	Distance to the soldering joint:	6mm
Capacitance Drift i_z:	± 3% to 85°C ± 3% to 100°C 6	
Dissipation Factor: t δ d (measured at 20°C) at 1 kHz at 10 kHz	max. value	Average value

Reversible Capacitance:
Change $\frac{\Delta C}{C}$

at 1KHZ (typical values)



Insulation Resintence:
versus temperature
(time constant τ)



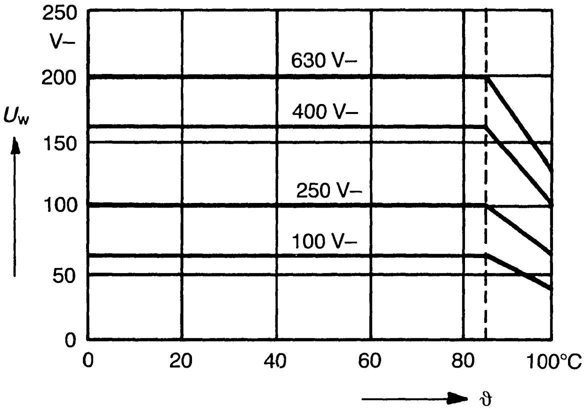
Delivery value at 23°C	
Minimal Value*	
for C≤ 0.33 μF	7.500 MΩ
for C > 0.33 μF	2.500s
Average Value	
for C≤ 0.33 μF	75.000 MΩ
for C > 0.33 μF	25.000 MΩ

*The values above indicated are valid until the delivery date. During the usage of the components, as the time goes by, the insulation can grow less to 10% of the rated value, especially when it is submitted to a maximum permissible humidity of 85% for a long time.

Technical Data

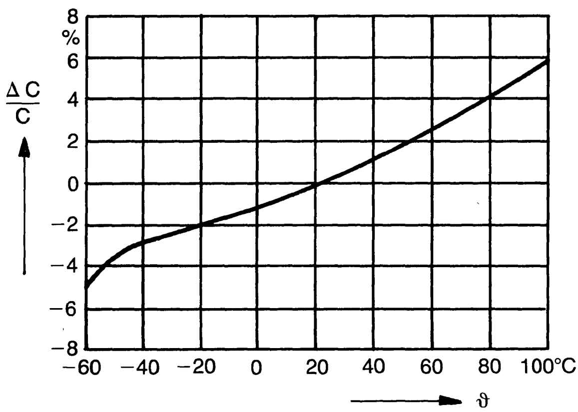
Climatic Category In accordance with DIN	F M F F −55°C/−55°F M +100°C/+212°F F the average relative humidity should be ⩽ 75%, but it can rise to the following values: 85%, 60 days per year 95%, 30 days per year
Condensation	No
Test Category in accordance with DIN 40046 and IEC 68-2-3	40/100/21
Damp Heat Test:	Conditions: Severity grade 4 Test Temperature: (40 ± 2°C) Relative Humidity: (93 ± 2%) Test Duration: 56 days After this test the insulation resistance can't be lower than 0.2 of the minimal delivery value. Capacitance Change $\frac{\Delta C}{C} \leqslant 5\%$ Dissipation Factor change Δ tan δ $< 3 \times 10^{-3}$
Resistance to Vibration: Test F_c: Vibration Procedure B, according to DIN 40046 Page 8 and IEC 68-2-6	Test duration: 6 hours Frequency Range: 10 to 55 Hz Vibration amplitude: 0.75mm (corresponding to a maximum acceleration of 10g = 98m/s²)
Solder Conditions:	Temperature of Solder bath: max. 260°C Soldering Duration: 10s Distance to the soldering joint: 6mm
Capacitance Drift i_z:	± 3%

Category Voltage U_w:*
(at ac operation) versus ambient temperature. Peaks of 1.5 U_w for miliseconds are permissible.



*When an oc voltage is superimposed on a dc voltage, the sum of the dc voltage and the amplitude of the oc voltage shall not exceed the rated voltage.

Reversible Capacitance:
Change $\frac{\Delta C}{C}$ versus temperature at 1KHZ (typical values)

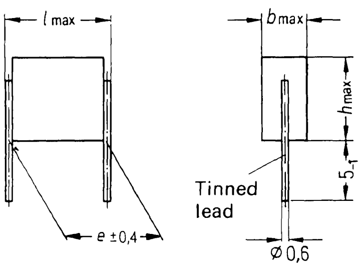


MKC Stacked-Film Capacitors

Metallized polycarbonate stacked-film capacitors – standard version

Self-healing stacked-film capacitor with polycarbonate dielectric.
When mounting, attention must be given to the surface leakage paths and air paths to adjacent live parts.

Connections: Parallel leads, tinned, plug-in, lead spacing 7.5 mm and 10 mm.
Suitable for use in single-clad printed circuit boards. Molded types on request.



Dimensions in mm

Type	e
B 32 540	7.5 mm
B 32 541	10 mm

DIN climatic category (DIN 40 040)	**F M E**
Lower category temperature	**F** – 55°C/– 67°F
Upper category temperature	**M** +100°C/+212°F
Humidity category	**E** average relative humidity ≦ 75%; 95% for 30 days per year, continuously; 85% for the remaining days, occasionally rare, short dew precipitation permitted

IEC climatic category
(DIN 40 045,
or IEC publication 68-1)

Damp heat test
in accordance with
DIN IEC 68-2-3

55/100/21

Conditions

Test temperature	+40 °C/+104 °F
Relative humidity	$(93 {}^{+2}_{-3})$ %
Test duration	21 days

Test criteria

Capacitance change $\frac{\Delta C}{C}$	$\leqq \pm 5\%$ ($\leqq 0.1$ µF) $\leqq \pm 3\%$ (> 0.1 µF)
Dissipation factor change $\Delta \tan \delta$	$\leqq 5 \times 10^{-3}$ at 1 kHz $\leqq 7 \times 10^{-3}$ at 10 kHz
Insulation resistance	$\geqq 10\%$ of the minimum value at delivery

---

Resistance to vibration
Test F_C: Vibration
partial test B 1 in accordance
with DIN 40 046, sheet 8
and IEC publication 68-2-6

Duration of endurance conditioning	6 hours
Frequency range	10 to 55 Hz
Displacement amplitude	0.75 mm (conforming to max. 98.1 m/s² or 10 *g*)

Resistance to soldering heat[1)]
Test Tb in acc.
with DIN IEC 68-2-20

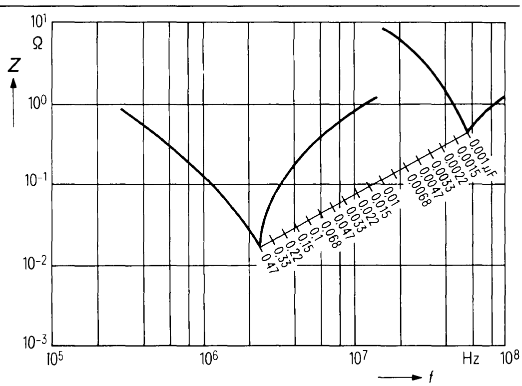
Temperature of the solder bath	max. 255 °C/491 °F
Soldering duration	max. 5 sec

Test criterion:
capacitance change $\frac{\Delta C}{C} \leqq \pm 2\%$

Capacitance drift i_z — $\pm 3\%$

Self inductance — approx. 6 nH

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



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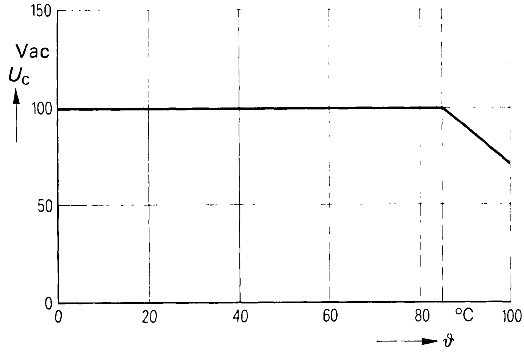
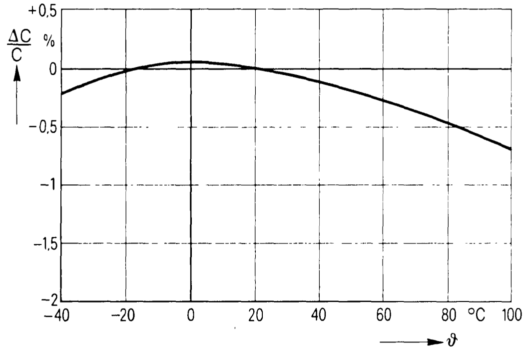
1) For solder recommendations also refer to "General Technical Information", para. 6.2, page 27.

Category voltage U_C[1)]
at ac operation, 50 Hz
versus ambient
temperature ϑ

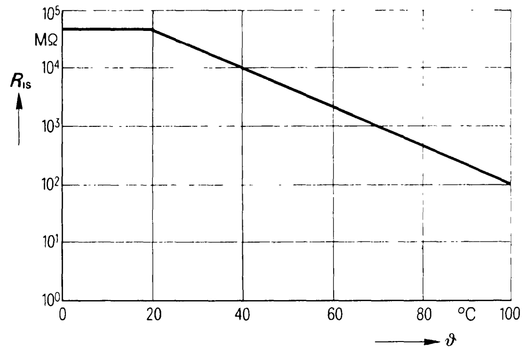


max. 2000 hours 1.25 × U_C

Reversible capacitance change $\frac{\Delta C}{C}$
versus temperature ϑ
at 1 kHz (typical values)



Insulation resistance R_{is}
versus temperature ϑ

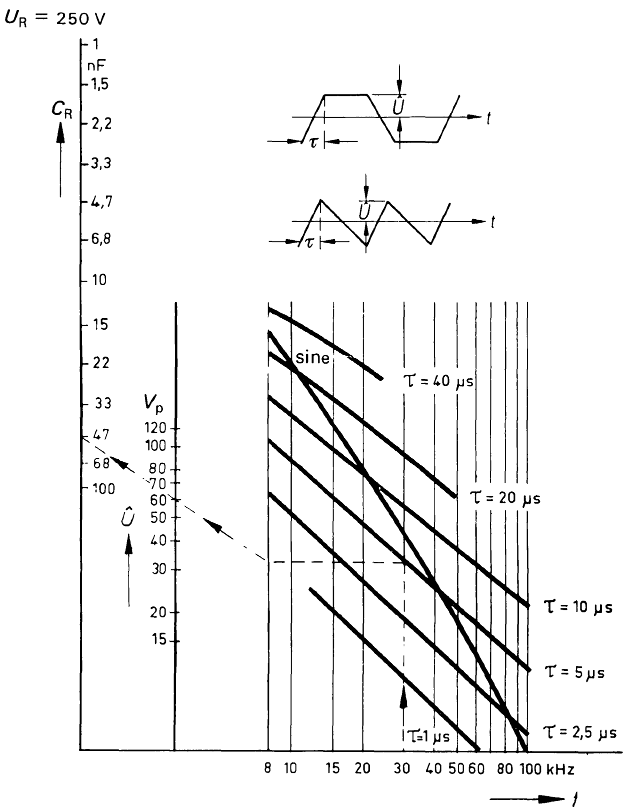


1) When an ac voltage is superimposed on a dc voltage, the sum of the dc voltage and the amplitude of the ac voltage may not exceed the rated voltage.

B 32 540, lead spacing = 7.5 mm

Nomogram for determining the permissible peak voltage $\hat{U}$

The nomogram is based on 10 °C (18 °F) inherent temperature rise of the capacitor; this must be taken into account when considering the permissible max. temperature.
With trapezoidal voltage load the second harmonic frequency must be assumed.



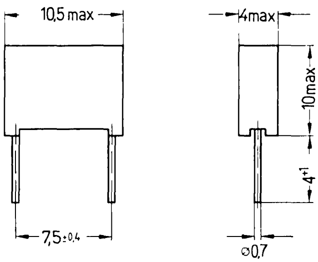
Example given:

f = 30 kHz (repetition frequency)
τ = 5 µs (rise time)
C_R = 47 nF (capacitance)

According to the dashed line on the graph above this gives a peak voltage $\hat{U}$ of about 60 V.

Metallized polycarbonate capacitors – high rel version

Self-healing capacitor with polycarbonate dielectric. Encapsulated in rectangular plastic case, epoxy resin sealed. Parallel leads, plug-in, lead spacing 7.5 mm. The case is provided with spacers to improve solderability in the solder bath.



Dimensions in mm

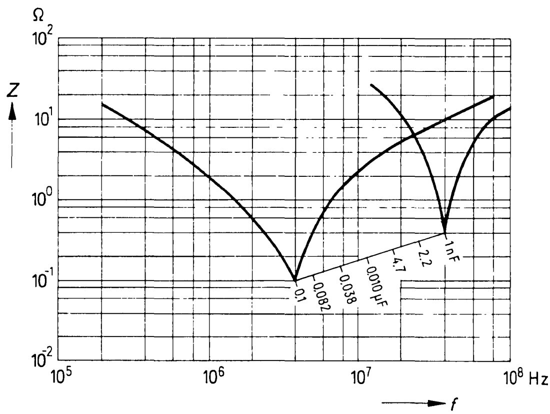
Capacitance µF	Rated voltage	Capacitance tolerance	Ordering code
1.0	400 Vdc	±10% ≙ K ±20% ≙ M	B32545-C6102-*
1.2			B32545-C6122-*
1.5			B32545-C6152-*
1.8			B32545-C6182-*
2.2			B32545-C6222-*
2.7			B32545-C6272-*
3.3			B32545-C6332-*
3.9			B32545-C6392-*
4.7			B32545-C6472-*
5.6			B32545-C6562-*
6.8		(± 5% ≙ J)[1] ±10% ≙ K ±20% ≙ M	B32545-C6682-*
8.2			B32545-C6822-*
10			B32545-C6103-*
12			B32545-C6123-*
15			B32545-C6153-*
18	250 Vdc		B32545-C3183-*
22			B32545-C3223-*
27			B32545-C3273-*
33			B32545-C3333-*
39			B32545-C3393-*
47	100 Vdc		B32545-C1473-*
56			B32545-C1563-*
68			B32545-C1683-*
82			B32545-C1823-*
100			B32545-C1104-*

* When ordering, the code letter for the requested tolerance must be substituted for *

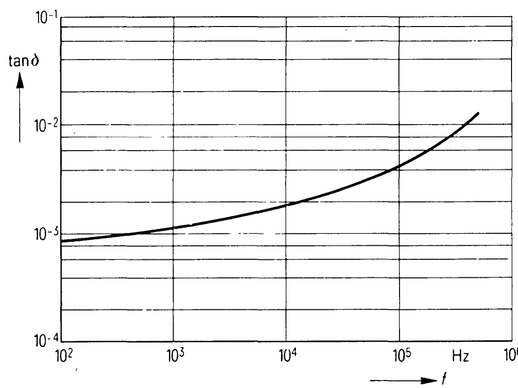
[1] Closer capacitance tolerance upon request.

Self inductance — approx. 8 nH

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

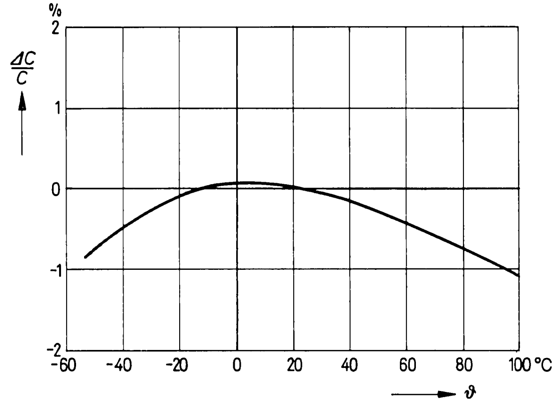


Dissipation factor tan δ
versus frequency *f*

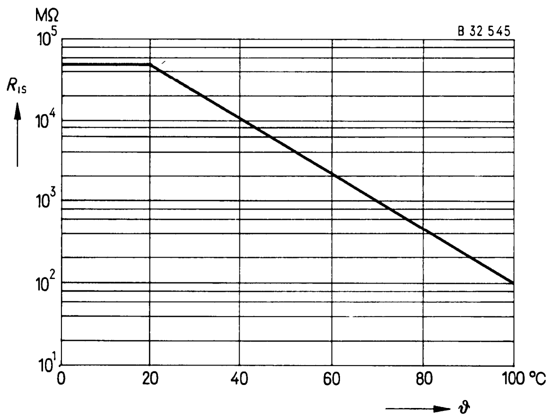


Typical values measured at 20 °C/68 °F	Maximum value	Average value
at 1 kHz	3×10^{-3}	1×10^{-3}
at 10 kHz	5×10^{-3}	2×10^{-3}
at 100 kHz	10×10^{-3}	5×10^{-3}

Reversible capacitance change $\frac{\Delta C}{C}$
versus temperature ϑ
at 1 kHz (typical values)



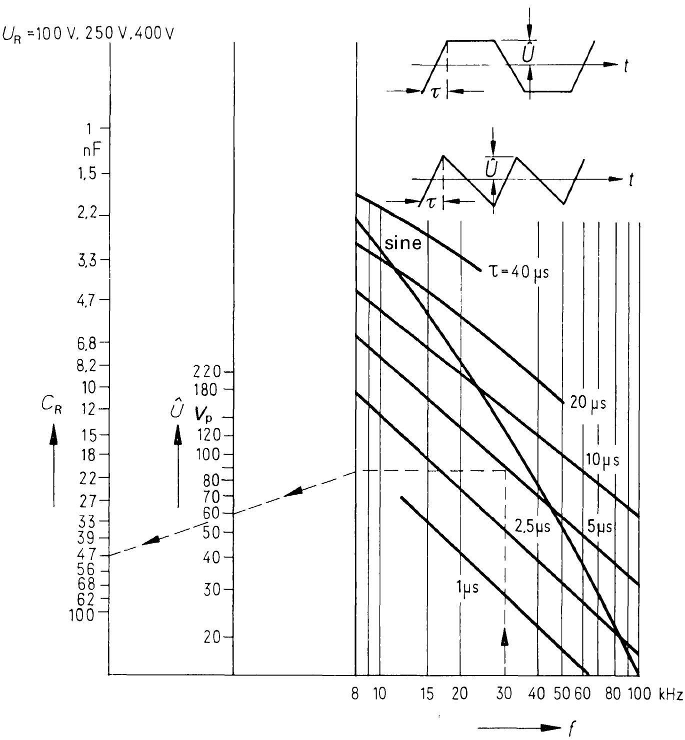
Insulation resistance R_{is}
versus temperature ϑ



Minimum value[1)]	
for U_R = 100 V	15 000 MΩ
for U_R > 100 V	30 000 MΩ
Average value	
for U_R = 100 V	>75 000 MΩ
for U_R > 100 V	

[1)] The indicated values are applicable at the time of delivery. During operational life the insulation may decrease for a short period to about 10% of the values at the time of delivery especially when the max. permissible humidity of 95% is applied for a long period, or when the capacitor is operated close to the upper category temperature.

The nomogram is based on 10 °C (18 °F) inherent temperature rise of the capacitor; this must be taken into account when considering the permissible max. temperature.
With trapezoidal voltage load the second harmonic frequency must be assumed. At sinusoidal voltage load, the "sine" characteristic applies.



Example given:

f = 30 kHz (repetition frequency)
τ = 5 µs (rise time)
C = 47 nF (capacitance)

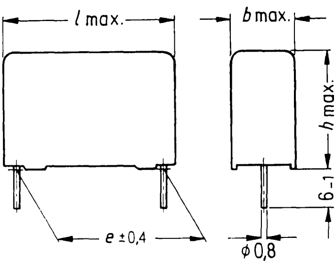
According to the dashed line on the graph above this gives a peak voltage $\hat{U}$ of about 60 V.

MKP Capacitors

Metallized polypropylene capacitors – standard version

Self-healing wound capacitor with face-end contacts, comprising a polypropylene dielectric. Built into flame-retardant, rectangular plastic case; epoxy resin sealed to ensure resistance to humidity. The capacitor is provied with spacers to improve solderability in the solder bath. Parallel leads, plug-in.

These pulse-proof capacitors are particularly suited for use in deflection and high voltage stages of TV sets; e.g. as reservoir and S-correction capacitor (400 V series), as commutation capacitor in thyristor deflection circuits (1000 V series) and as line flyback capacitor (1500 V series).



l	e
18	15
27	22,5
31,5	27,5

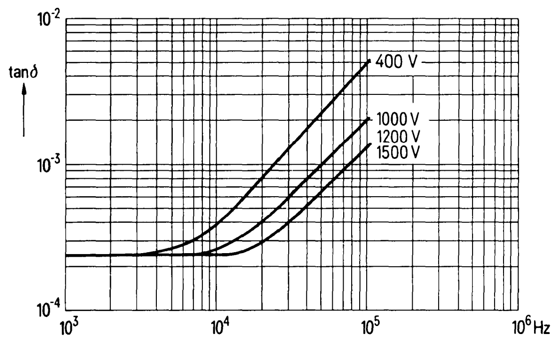
Dimensions in mm

DIN climatic category (DIN 40 040) Lower category temperature Upper category temperature Humidity category	**G P E** **G** −40°C/−40°F **P** + 85°C/+185°F **E** average relative humidity ≦ 75% 95% for 30 days per year; continuously 85% for the remaining days; occasionally rare, short dew precipitation permitted
IEC climatic category (DIN 40 045, or IEC publication 68-1) Damp heat test in accordance with DIN IEC 68-2-3	**40/085/56** **Conditions** Test temperature: +40°C/+104°F Relative humidity: (93^{+2}_{-3}) % Test duration: 56 days **Test criteria** Capacitance change $\frac{\Delta C}{C}$: ≦±3% Dissipation factor change $\Delta \tan \delta$: ≦ 0.5 x 10^{-3} (at 1 kHz); ≦ 1 x 10^{-3} (at 10 kHz) Insulation resistance: ≧ 50% of the minimum value at delivery

Resistance to vibration Test F_c: Vibration partial test B1 in accordance with DIN 40046, sheet 8 and IEC publ. 68-2-6	Duration of endurance conditioning: 6 hours Frequency range: 10 to 55 Hz Displacement amplitude: 0.75 mm (conforming to max. 98.1 m/s^2 or 10 g)
Resistance to soldering heat[1)] Test Tb in acc. with DIN IEC 68-2-20	Temperature of the solder bath max. 260 °C/500 °F Soldering duration max. 10 sec. Capacitance change $\frac{\Delta C}{C} \leqq \pm 2\%$
Capacitance drift i_z	± 2%

Dissipation factor tan δ versus frequency f (average values)

Parameter: Voltage series
Max. lead spacing

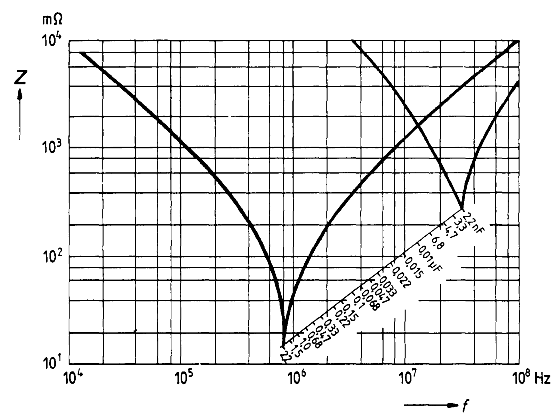


Dissipation factor tan δ measured at 20 °C/68 °F

	Minimum value		Average value	
	$C \leqq 1\ \mu F$	$C > 1\ \mu F$	$C \leqq 1\ \mu F$	$C > 1\ \mu F$
for 1 kHz	$0.5 \cdot 10^{-3}$	$0.5 \cdot 10^{-3}$	$0.25 \cdot 10^{-3}$	$0.25 \cdot 10^{-3}$
for 10 kHz	$0.8 \cdot 10^{-3}$	$1.2 \cdot 10^{-3}$	$0.4 \cdot 10^{-3}$	$0.6 \cdot 10^{-3}$

Self inductance	approx. 20 nH

Impedance Z versus frequency f (typical values)



1) For solder recommendations also refer to "General Technical Information", para. 6.2, page 27.

Inherent heating	
Power loss at 10 °C/18 °F excess temperature of the case (typical values)	90 mW (capacitor length 18 mm) 160 mW (capacitor length 27 mm) 260 mW (capacitor length 31.5 mm)

Pulse handling capability (voltage rate of rise U_{pp}/τ and pulse characteristic k_o)
Maximum permissible voltage change per time unit with non-sinusoidal voltage load (pulse, sawtooth).

Rated voltage U_R	$U_{pp\ perm.}$		Pulse handling capability		
			Capacitor length 18 mm	27 mm	31.5 mm
400 Vdc	500 V_{pp}	U_{pp}/τ k_O	50 V/µs 0.5 × 10^5 V^2/µs	30 V/µs 0.3 × 10^5 V^2/µs	20 V/µs 0.2 × 10^5 V^2/µs
1000 Vdc	700 V_{pp}	U_{pp}/τ k_O	215 V/µs 3 × 10^5 V^2/µs	115 V/µs 1.6 × 10^5 V^2/µs	90 V/µs 1.25 × 10^5 V^2/µs
1200 Vdc	1200 V_{pp}	U_{pp}/τ k_O	– –	250 V/µs 6 × 10^5 V^2/µs	165 V/µs 4 × 10^5 V^2/µs
1500 Vdc	1500 V_{pp}	U_{pp}/τ k_O	– –	430 V/µs 13 × 10^5 V^2/µs	330 V/µs 10 × 10^5 V^2/µs

For a voltage swing $U_{pp} < U_{pp\ perm.}$ the value of the permissible voltage rate of rise U_{pp}/τ can be multiplied by the factor $U_{pp\ perm.}/U_{pp}$. See also calculation example in section "General Technical Information", para 5.2.6, page 24.

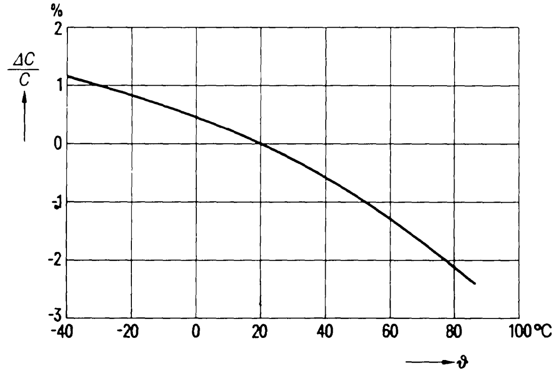
AC power handling capability at higher frequencies

Values upon request; a voltage/time diagram as well as indication of ambient temperature and other operational conditions are requested. Refer also to para. 5.2.5 "Inherent temperature rise, permissible efficiency", page 23.

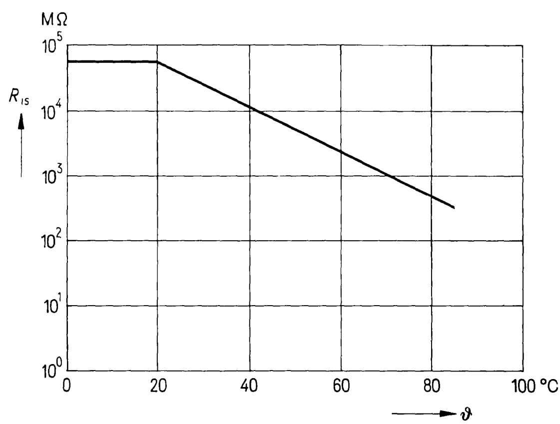
DIN climatic category (DIN 40 040)	**G P E**
Lower category temperature Upper category temperature Humidity category	**G** −40 °C/− 40 °F **P** +85 °C/+185 °F **E** average relative humidity ≦ 75%; 95% for 30 days per year, continuously 85% for the remaining days, occasionally rare, short dew precipitation permitted
IEC climatic category (DIN 40 045, or IEC publication 68-1)	**40/085/56**
Damp heat test in accordance with DIN IEC 68-2-3	**Conditions** Test temperature + 40 °C/104 °F Relative humidity $(93 {}^{+2}_{-3})\%$ Test duration 56 days **Test criteria** Capacitance change $\frac{\Delta C}{C} \leqq \pm 3\%$ Dissipation factor change $\Delta \tan \delta$ $\leqq 0.5 \times 10^{-3}$ (at 1 kHz) $\leqq 1 \times 10^{-3}$ (at 10 kHz) Insulation resistance ≧ 50% of the minimum value at delivery
Resistance to vibration Test F_c: Vibration partial test B 1 in accordance with DIN 40 046, sheet 8 and IEC publication 68-2-6	Duration of endurance conditioning 6 hours Frequency range 10 to 55 Hz Displacement amplitude 0.75 mm (conforming to max. 98.1 m/s² or 10 *g*)
Resistance to soldering heat[1] Test Tb in accordance with DIN IEC 68-2-20	Temperature of the solder bath max. 260 °C/500 °F Soldering duration max. 10 sec Capacitance change $\frac{\Delta C}{C} \leqq \pm 2\%$
Capacitance drift i_z	± 2%

[1] For solder recommendations also refer to "General Technical Information", para. 6.2., page 27.

Reversible capacitance change $\frac{\Delta C}{C}$
versus temperature ϑ
at 1 kHz (typical values)



Insulation resistance R_{is}
versus temperature ϑ



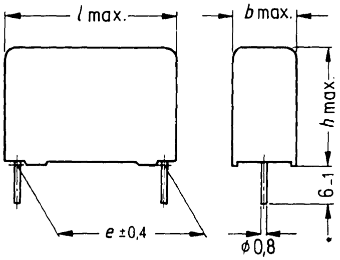
Minimum value[1]	
for $C \leqq 0.33\ \mu F$	30 000 MΩ
for $C > 0.33\ \mu F$	10 000 s
Average value	
for $C \leqq 0.33\ \mu F$	$>$ 75 000 MΩ
for $C > 0.33\ \mu F$	$>$ 25 000 s
Inherent heating	
Power dissipation at 10 °C/18 °F excess temperature of the case (typical values)	90 mW (capacitor length 18 mm) 160 mW (capacitor length 27 mm) 260 mW (capacitor length 31.5 mm)

[1] The indicated values are applicable at the time of delivery. During operational life the insulation may decrease for a short period to about 10% of the values at the time of delivery, especially when the max. permissible humidity of 95% is applied for a long period, or when the capacitor is operated close to the upper category temperature.

Metallized polypropylene capacitors – high rel version

Self-healing wound capacitor with face-end contacts, comprising a polypropylene dielectric. Built into flame-retardant, rectangular plastic case, epoxy resin sealed to ensure resistance to humidity. The capacitor is provided with spacers to improve solderability in the solder bath. Parallel leads; plug-in.

The capacitors are particularly suited for use at mains ac voltage load and in pulse circuits.



l	e
27	22.5
31.5	27.5

Dimensions in mm

Rated ac voltage U_R up to 2 kHz Perm. dc voltage U		400 V ac 1000 V dc	
Rated capacitance C_R	Tolerance	Dimensions $b \times h \times l$	Ordering code
0.0022 µF		7.3 × 16.5 × 27	B32656-K8222-*
0.0033 µF		7.3 × 16.5 × 27	B32656-K8332-*
0.0047 µF		7.3 × 16.5 × 27	B32656-K8472-*
0.0068 µF		7.3 × 16.5 × 27	B32656-K8682-*
0.01 µF	± 5% ≙ J ± 10% ≙ K	7.3 × 16.5 × 27	B32656-K8103-*
0.015 µF		8.5 × 18.5 × 27	B32656-K8153-*
0.022 µF		10.5 × 19 × 27	B32656-K8223-*
0.033 µF		11 × 20.5 × 27	B32656-K8333-*
0.047 µF		11.5 × 21 × 31.5	B32656-K8473-*
0.068 µF		13.5 × 23 × 31.5	B32656-K8683-*
0.1 µF		15 × 24.5 × 31.5	B32656-K8104-*

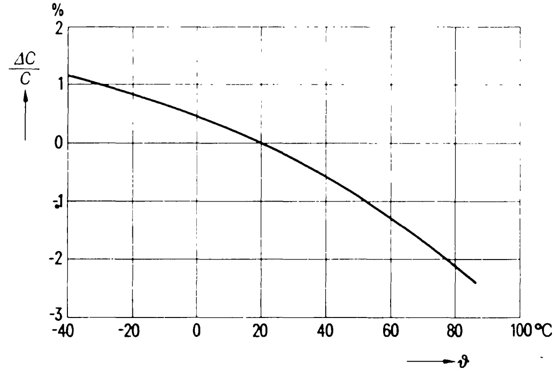
* When ordering, the code letter for the requested tolerance must be substituted for *

Capacitance drift i_Z

± 2%

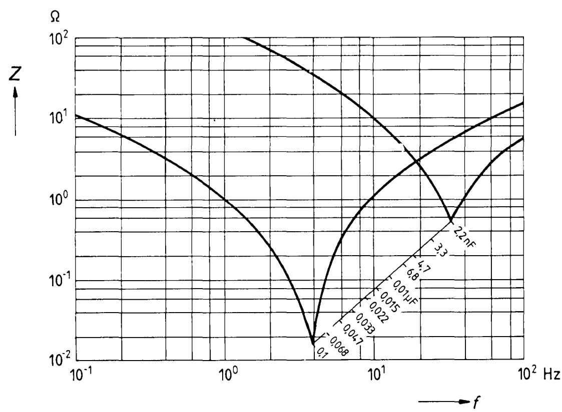
Reversible capacitance change $\frac{\Delta C}{C}$

versus temperature ϑ
at 1 kHz (typical values)



Impedance Z

versus frequency f
(typical values)



Inherent heating Power loss at 10 °C/18 °F excess temperature of the case (typical values)	Lead spacing 22.5: 0.16 W Lead spacing 27.5: 0.26 W
Voltage load Test voltage U_t Category voltage U_c	2500 Vdc 400 Vac 1000 V dc

Pulse handling capability (voltage rate of rise U_{pp}/τ and pulse characteristic k_o)
Maximum permissible voltage change per time unit at non-sinusoidal voltages (pulse, sawtooth).

Rated voltage U_R	$U_{pp\ perm.}$		Pulse handling capability	
			Capacitor length 27 mm	
400 Vac	1130 V_{pp}	U_{pp}/τ k_o	350 V/µs 8×10^5 $V^2/\mu s$	175 V/µs 4×10^5 $V^2/\mu s$

For a voltage swing $U_{pp} < U_{pp\ perm}$ the value of the permissible voltage rate of rise U_{pp}/τ can be multiplied by the factor $U_{pp\ perm}/U_{pp}$. See also calculation example in section "General Technical Information", para 5.2.6, page 24.

AC power handling capability at higher frequencies

Values upon request; a voltage/time diagram as well as indication of ambient temperature and other operational conditions are requested. Refer also to para. 5.2.5 "Inherent temperature rise, permissible efficiency", page 23.

Aluminum Electrolytic Capacitors

I. Basic construction

Metals the oxides of which are capable of blocking the current flow in one direction and of passing it in the other are called valve metals. This blocking effect can be utilized for the construction of electrolytic capacitors. Metals such as aluminum and tantalum have obtained practical importance. The following details only deal with aluminum (Al) electrolytic capacitors, whereas tantalum electrolytic capacitors are to be found in Data Book (B 45 010).

The electrolytic capacitor has gained an exceptional position among the numerous kinds of capacitors since its operating characteristic is partly based on electrochemical processes. In order to understand its properties, a closer consideration of its design seems advisable.
Generally, each capacitor consists of two electrically conducting layers. A dielectric may be put in between. The aluminum electrolytic capacitor as well is always based on these 3 components. However, the difference to all other capacitor types consists in their conductive liquid, the operating electrolyte, forming one electrode (the cathode) instead of the otherwise used metal layer. As counter electrode (anode) serves an aluminum body (in most cases an aluminum foil resulting from the winding method which is commonly used today). By means of electrolytic processes an aluminum oxide film (the dielectric) is generated on the surface of the aluminum body. The aluminum that has not been exploited for oxidation (starting metal) results in forming the necessary positive layer.

The advantages of electrolytic capacitors that have caused their widespread application are their high capacitance per unit volume (high capacitance values at low space requirements), which permits the production of capacitors up to 1 Farad, and on the other hand the reasonable price in proportion to its capacitance value.

Like other capacitors, the capacitance is directly proportional to the effective surface and inversely proportional to the distance of both layers, given for electrolytic capacitors by the thickness of the oxide film. The aluminum oxide has the particular advantage over other dielectrics that it is not only remarkably thinner but also features high dielectric strength. Its thickness can be fitted exactly to the operating conditions of the capacitor.

The aluminum oxide film is generated by anodic oxidation (anodization). The thickness of the film grows practically proportionally to the applied forming voltage. For safety reasons, the final forming voltage is chosen higher than the rated or peak voltage values.

The film thickness ist approx. 0.0012 µm per Volt, i.e. even with high voltage capacitors, a distance of both layers of only approx. 0.7 µm can be expected; thus, the high capacitance per unit volume is partly explained. (The minimum thickness of a paper dielectric for example is 6 to 8 µm). A further factor is given by the electrode surface being many times enlarged because of an electrochemical etching process (see fig. 1). Since one of the layers of electrolytic capacitors is liquid (operation electrolyte), its surface ideally fits to the anode.

During the anodization of the etched foil, the fine etching pits partially incrust and that the more the higher the forming voltage and thus the film thickness is. With different etching processes the magnitude of the pores can be matched to the required voltage. The relative dielectric constant of the aluminum oxide of about 10 is comparatively high. The permissible operating field strength is approx. 800 MV/m thus being extremely high.

II. Terms, technical data, explanations

All data given in the following including numerical values, is of general importance. To certain types often better values apply which are given on the data sheet for the appropriate type.

1. Plain and etched

Because of their small dimensions, aluminum electrolytic capacitors with etched, and surface enlarged foils are today nearly exclusively required. Electrolytic capacitors with non-etched foils (plain) partly feature better electrical ratings but are on the other hand considerably larger. They are only used for particular applications; their percentage share permanently decreases, so that the complete suspension of this production line will be only a question of time. The specifications existing as yet contain a reference saying that these capacitors are not to be used for new equipment.

2. Polarized and non-polarized

The electrolytic capacitor designed as described above, consisting of an anodized aluminum foil on which the dielectric film is applied, a second aluminum foil and the electrolyte being between both foils, can only function correctly when the positive pole is connected to the anodized aluminum foil (anode) and the negative pole to the other (cathode). A reversed polarization would cause an electrolytic process and a dielectric film would be generated on the cathode foil as well as on the anode. Thus, high internal heating and gas formation would arise which could possibly destroy the capacitor. The total capacitance would also be reduced by the increasing thickness of the oxide film which reduces the capacitance of the cathode in series with the capacitance of the anode.
Due to its basic design the electrolytic capacitor is only suitable for dc voltage applications, since this direct voltage is a waveform voltage, i.e. a direct voltage with a superimposed alternating voltage and the positive pole connected to the anode. This is understood as the polarized version, which is suitable for most applications. The requirement of correct polarizing of the polarized capacitor types is valid with the only exception that incorrect polarization is permitted up to 2 V, since the damaging anodization of the cathode as described above only begins to rise at this range. (The cathode foil is covered by an air-oxide layer which corresponds to an anodically generated layer with a blocking voltage of about 2 V.)
Non-polarized (bipolar) electrolytic capacitors are also available. In addition to the anode foil they also have a second foil which is anodized during the production process and its capacitance value is of the same range as that of the anode. This construction allows for operation at direct voltage ratings and either polarization, as well as at pure alternating voltage ratings. Since the latter causes inherent heating, the alternating voltage must be kept considerably below the direct voltage rating. Due to series-connection of both equal capacitance parts the total capacitance amounts only to half the individual capacitance values. A non-polarized electrolytic capacitor compared with a polarized one, needs therefore up to twice the volume for the same total capacitance at the same construction.

ifications also include the maximum permissible dimensions in correlation with capacitance and rated voltage. In recent specifications capacitance ratings in accordance with the E3 or E6 series are given. The rated voltage values are standardized according to the R5 series, some exceptions according to requirements.
The number of the type specification, if there is any, is given on the individual data sheets. The capacitors are marked with this number as well, if allowed for by the case size. If there is no type specification available (as yet), the capacitors are marked with the number of the fundamental specification. The capacitance/voltage range given on the data sheets is not always equal to that of the type specifications. It is more or less comprehensive, as required.
If necessary, the specifications given by DIN sheets will be transferred to the Siemens data sheets for completion.
A DIN specification for non-polarized electrolytic capacitors is not available, since there is only little demand for these types. Photoflash electrolytic capacitors are produced in large quantities, however, they are at present not subject to standardization due to plurality of types requested.

5. Electrical characteristics

5.1 Rated voltage U_R

The rated voltage is the operating voltage which is indicated upon the capacitor. It is a dc voltage. The ratings are based on an R-5 series; in addition voltages of 350 V and 450 V have been included.

	Low voltage (NV) ratings								High voltage (HV) ratings		
U_R in Volts	6.3	10	16	25	40	63	100	160	250	350	450

Not each of the type specifications and not all Siemens data sheets comprise all voltage ratings; the actual demand is covered.

5.2 Category voltage U_C

The category voltage U_C is the voltage which may be applied continuously to a capacitor in use at its upper category temperature. Within a certain limit, the category voltage depends on the ambient temperature.
For aluminum electrolytic capacitors with an upper temperature limit of 85° C (185° F), for several Siemens electrolytic capacitors even up to 105° C (221° F), the category voltage may be equal to the rated voltage. For electrolytic capacitors with a higher maximum temperature a voltage derating is necessary (see individual types).

5.3 Operating voltage U_{op}

All unfavorable operating conditions (e.g. possible overvoltage of mains, unfavorable tolerances of the transformation ratio of mains transformers in the device, repeated overvoltage for 1 minute at switching-on, high ambient temperatures etc.) have to be taken into account in order to determine the voltage intended for continuous i.e. the operating voltage, which is not allowed to exceed the category voltage. Operation below the category voltage is permitted.
By this derating important functions reducing the service life of the electrolytic capacitor will be delayed. However, other factors – in particular at higher temperatures – not depending on the operating voltage U_{op} (for instance diffusion processes or material fatigue) will also take decisive influence. Therefore the advantages to be expected for service life due to derating can only partly be utilized. Data on the increase of service life due to derating is given in para. 7.6.

5.6.1 Permissible superimposed alternating current for high reliability aluminum electrolytic capacitors
(typical values for the rms current in mA at $\vartheta_{amb} \leqq 85°C/185°F$ and $f = 100$ Hz)

Rated capacitance in μF	Rated voltage in Vdc 6.3	10	16	25	40	63	100	160	250	350	450
0.47										9	10
1									13	14	15
2.2							18	20	22	23	24
4.7					25	30	32	34	37	40	43
10				38	42	48	52	56	60	71	75
22				60	68	78	86	97	110	120	130
47		71	92	98	120	130	150	170	190	220	240
100	100	120	130	160	190	220	250	280	320	350	380
220	170	200	240	270	310	360	420	460	600	650	710
470	270	320	370	440	510	600	710	870	980	1100	1200
1 000	400	490	600	710	870	980	1200	1500	1700	2000	2200
1 500	490	610	750	930	1100	1300	1600	1900	2300	2600	2900
2 200	600	760	920	1200	1400	1700	2000	2500	3000	3400	3800
3 300	750	960	1200	1500	1800	2200	2600	3200	3900	4600	5100
4 700	920	1200	1500	1800	2200	2700	3300	4000	5000	5600	
6 800	1200	1500	1800	2300	2800	3300	4100	5100	6300		
10 000	1500	1800	2200	2800	3400	4100	5100	6800			
15 000	1800	2200	2800	3400	4200	5100	6300	7600			
22 000	2200	2800	3400	4200	5200	6000	7000				
33 000	2800	3400	4200	5200	6400	7400	9000				
47 000	3400	4200	5200	6500	7100	8600					
68 000	4200	5200	6500	7400	8800	11000					
100 000	5200	6400	7500	9100	11000						
150 000	6400	8100	9600	12000							
220 000	7800	9500	12000								

5.6.3 Frequency dependence of the permissible superimposed ac current

For frequencies deviating from 100 Hz other ac currents apply. Typical values for the conversion factors are tubulated below. More detailed values are given in the data for individual types.

Frequency in Hz	Conversion factor
50	0.8
100	1.0
400	1.2
800	1.3
1000	1.35
≧ 2000	1.4

5.6.4 Temperature dependence of the permissible superimposed ac current

At temperatures deviating from 85° C/185° F the permissible superimposed ac current changes. Typical values for the conversion factors to be applied are as follows; specific data is also in this case given in the individual data sheets.

	Standard versions		High reliability versions			
Climatic category	GPF and HPF		GPF, HPF and FPD		FKD	
Ambient temperature ϑ_{amb} in ° C/° F	Permissible percentage of the 85° C value	Surface temperature in ° C/° F	Permissible percentage of the 85° C value	Surface temperature in ° C/° F	Permissible percentage of the 85° C-value	Surface temperature in ° C/° F
≦ 40/104	220%	55/131	180%	50/122	145%	50/122
45/113	210%	59/138.2	175%	55/131	140%	55/131
50/122	200%	62/143.6	170%	60/140	135%	60/140
55/131	190%	66/150.8	160%	64/147.2	130%	65/149
60/140	180%	70/158	150%	68/154.4	125%	70/158
65/149	170%	73/163.4	140%	72/161.6	120%	74/165.2
70/158	155%	77/170.6	130%	76/168.8	115%	78/172.4
75/167	140%	81/177.8	120%	80/176.0	110%	82/179.6
80/176	120%	85/185	110%	84/183.2	105%	86/186.8
85/185	100%	88/190.4	100%	88/190.4	100%	90/194
90/194	90%*)	92/197.6*)	90%*)	92/197.6*)	95%	94/201.2
95/203	80%*)	97/206.6*)	80%*)	97/206.6*)	90%	98/208.4
100/212	70%*)	101/213.8*)	70%*)	101/213.8*)	85%	102/215.6
105/221	60%*)	106/222.8*)	60%*)	106/222.8*)	80%	106/222.8
110/230	–	–	–	–	70%	111/231.8
115/239	–	–	–	–	60%	116/240.8
120/248	–	–	–	–	50%	121/249.8
125/257	–	–	–	–	40%	126/258.8

*) Values apply only to types that are permitted for operation at 105° C/221° F.

5.7.3 Capacitance dependence on the temperature

The capacitance of an electrolytic capacitor is not a constant magnitude that remains unchanged under all operating conditions. The temperature is of great influence. The viscosity of the electrolyte increases at decreasing temperatures thus reducing its conductivity. A typical behavior is shown in fig. 3, where the capacitance at 20° C/68° F is equal to 1.

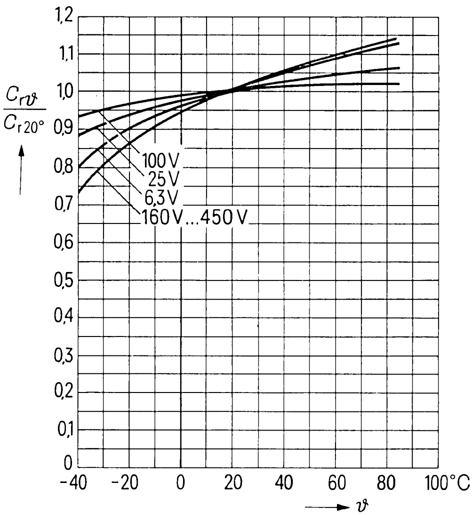


Fig. 3
Series capacitance C_r versus temperature. Typical behavior.

The lower the rated voltage and the more the foils are roughened at otherwise the same conditions the steeper is the run of the characteristic curves. The favorable flat shape of the curve shown in fig. 3 has been obtained by using special electrolytes, and thus the capacitors are capable of operation even at temperatures far below zero. The shape of the curves is subject to strong variations depending on whether the temperature dependence of the ac or dc capacitance is determined. A dc capacitance attains a more favorable and thus a flatter shape of the curve.

5.7.4 Capacitance dependence on frequency

The effective capacitance depends in addition to the temperature also on the measuring frequency. It decreases with increasing frequency. If there is no particular data in the individual data sheets, typical values for the effective capacitance can be obtained from the impedance characteristic:

$$C = \frac{1}{2 \cdot \pi \cdot f \cdot Z}$$

5.8.1 Frequency and temperature dependence of the dissipation factor

Like the capacitance, also the dissipation factor depends on temperature and frequency. The dependence is shown in fig. 4 for a low voltage electrolytic capacitor and in fig. 5 for a high voltage electrolytic capacitor. The special data sheets indicate some more specific values.

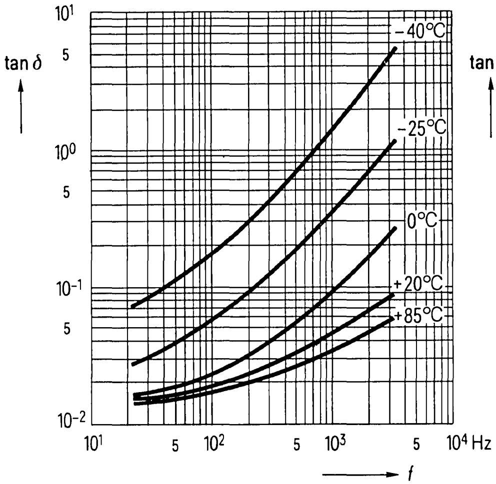


Fig. 4
Low voltage electrolytic capacitor
(example 100 μF/63 V)

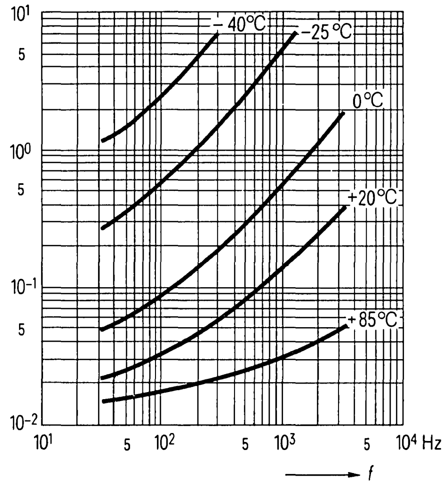


Fig. 5
High voltage electrolytic capacitor
(example 47 μF/350 V)

DIN 41 240 also contains conversion factors as typical values at 50 Hz and 100 Hz for different temperatures:

Temperature	0° C	+20° C	+60° C
Factor	approx. 4	1	< 1

The tan δ values of Siemens electrolytic capacitors are normally better than those given in the DIN specification. The values of the table above only apply unless the specific data sheets contain the better.

Diagrams 6 and 7 show examples of the aluminum electrolytic capacitor's typical frequency and temperature behavior.

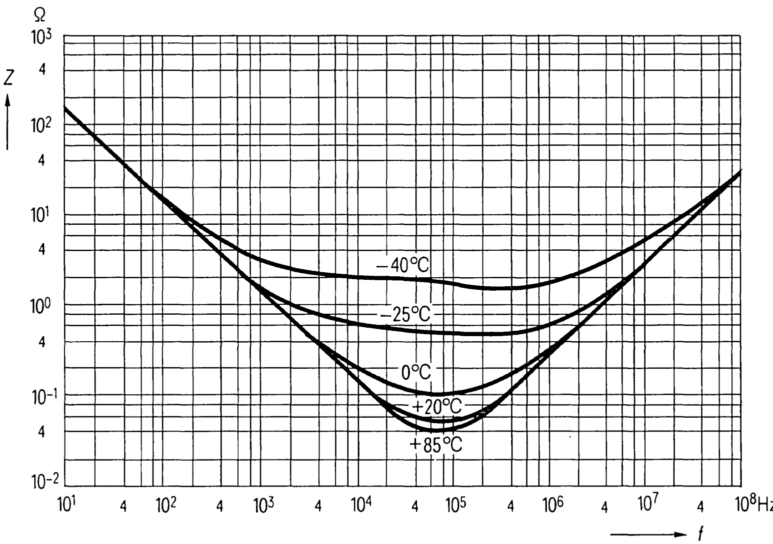


Fig. 6
Impedance of a low voltage electrolytic capacitor versus frequency and temperature (example 100 μF/63 V, simplified diagram)

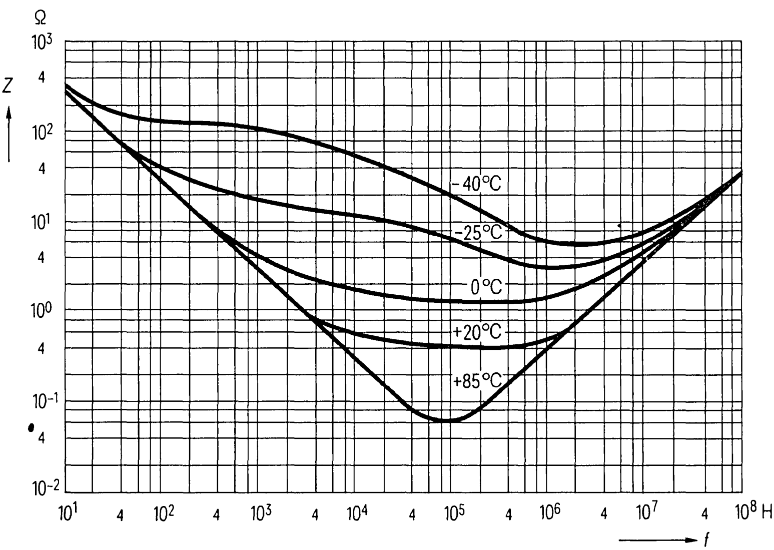


Fig. 7
Impedance of a high voltage capacitor versus frequency and temperature (example 47 μF/350 V, simplified diagram)

5.11.2 Leakage current dependence on temperature

As can be seen in fig. 9 the leakage current strongly depends on temperature.

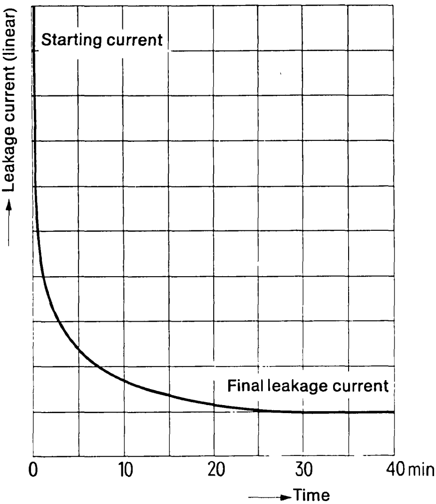


Fig. 8
Leakage current versus starting time

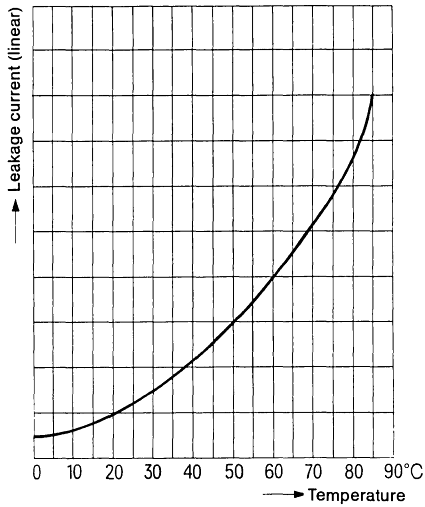


Fig. 9
Leakage current versus temperature

5.11.3 Leakage current dependence on voltage

This is shown in fig. 2, para. 1, where a constant temperature is assumed.

5.11.4 Operational leakage current

This is the final current, appearing after a longer working time (see para. 5.11.1 and diagram 8). Typical values in µA can be obtained according to DIN standards by the following formulae:

In accordance with DIN 41240 (high reliability versions)

$$I_{rb} = \frac{0.005\ \mu A}{\mu F \times V} \times C_R \times U_R \text{ or } 1\ \mu A$$

(whichever is the greater)

In accordance with DIN 41332 (standard versions):

$$I_{rb} = \frac{0.02\ \mu A}{\mu F \times V} \times C_R \times U_R + 3\ \mu A$$

C_R is in µF and U_R in V
(To non-polarized capacitors twice the values apply.)

The test of the output leakage current can be performed at temperatures of 15 to 35° C/59 to 95° F. Compared to the value at 20° C the permissible limit values are to be multiplied by the following factors:

Temperature °C/°F	15/59	20/68	25/77	30/86	35/95
Factor	0.8	1	1.5	2	2.5

Before the output measurement takes place that serves for judging the capacitors or even for comparison of different products, a re-anodization is necessary in order to obtain the same starting conditions. For this aim the capacitors must be applied to the rated voltage via a series resistance of about 100 Ω for $U_R \leqq 100$ V and about 1000 Ω for $U_R > 100$ V and afterwards stored for 12 to 48 hours without voltage at 15 to 35° C (59 to 95° F). The leakage current measuring should take place within this period of storage. As far as the capacitors meet the leakage current requirements without a re-anodization process, it can be omitted.

5.11.6 Leakage current behavior at voltage-free storage

The oxide film can be affected during voltage-free storage (especially at high storage temperatures). Since no leakage current flows, carrying oxygen ions to the anode, a regeneration of the film is impossible. Consequently, on application of voltage after a storage period, the leakage current will at first increase, however, with the increasing oxide film will gradually decrease to a normal amount.
The capacitors can be stored without voltage for at least 1 year without any reduction of their reliability (for storage temperatures see para. 6.3). They can be operated at rated voltage directly afterwards (the re-anodization according to para. 5.11.5 is therefore not a prerequisite for the operation of the capacitors). However, during the first minutes of the switching-on period the current values can be up to 100 times higher. This is to be taken into consideration when designing the circuit.

5.12 Coupling impedance

The coupling impedance Z_K of multiple electrolytic capacitors indicates the coupling of partial capacitances (see DIN 41328, sheet 1).

5.13 Dielectric strength of the insulating sleeve

Certain types of electrolytic capacitors are provided with insulation sleeves. The dielectric strength of these electrolytic capacitors is greater than 500 V dc.

6. Climatic conditions

The climatic stress on the aluminum electrolytic capacitor has to be limited (partly for reliability reasons and partly due to temperature dependence of the electric parameters). Minimum and maximum temperature limits are most important climatic conditions for the aluminum electrolytic capacitor. Furthermore, the arising humidity stress takes influence as well. Relevant data is also coded in the climatic category (IEC), (see para. 6.6).

6.4 Lower storage temperature

The DIN specifications for aluminum electrolytic capacitors coordinate a respective lower storage temperature with the lower temperature limit. Siemens aluminum electrolytic capacitors principally resist to the lowest of these lower storage temperatures, i.e. −65° C/−85° F, without being damaged.

6.5 Humidity stress

It has to be distinguished between aluminum electrolytic capacitors which have been especially protected against infiltrating humidity by special constructive measures (e.g. hermetically sealed case), and such versions with humidity protection sufficient for usual applications. The especially humidity resistant versions allow dew precipitation and are coded "C" and "D", respectively, for the climatic category (IEC). DIN specifications provide the coding "F" for standard versions, according to which no dew precipitation should occur. The respective Siemens aluminum electrolytic capacitors, however, also comply with the test conditions of the humidity category "E", according to which a rare and minor dew precipitation, as often cannot be avoided (e.g. at a short opening of the outdoors installed equipment) is permissible.

6.6 Climatic categories

For the discription of the capacitor, uncoded temperature and humidity indications are too complicated. The IEC publications use the so-called IEC climatic categories. On the individual data sheets both DIN and IEC indications are quoted. The climatic category also appears on the electrolyte capacitor legend, as far as necessary and possible.

6.6.1 DIN climatic categories

According to DIN 40040 for aluminum electrolytic capacitors the climatic categories consist of three code letters. The first indicates the lower temperature limit, the second the upper temperature limit and the third the permitted humidity.

1st letter	F	G	H
lower temperature limit	−55° C/ −67° F	−40° C/ −40° F	−25° C/ −13° F

2nd letter	K	P	S
upper temperature limit	+125° C/ +257° F	+85° C/ +185° F	+70° C/ +158° F

3rd letter	C	D	E	F
rel. humidity per annual average	≦ 95%	≦ 80%	≦ 75%	≦ 75%
up to 30 days per annum	100%	100%	95%	95%
occasionally	100%	90%	85%	85%
dew precipitation permissible	yes	yes	yes[1])	no

[1]) Contrary to humidity category F, a rare and minor dew precipitation is permissible for the humidity category E (e.g. at a short opening of the outdoors installed equipment).

7.3 Failure rate

The failure rate indicates the relation between the number of failed components and their total number, valid only for the appropriate required load duration. It is generally indicated in per cent.

7.4 Relative failure rate

The relative failure rate is the failure rate related to the load duration. It indicates the number of failures per component and time unit (failure per component hour).

7.4.1 Failure quota (f i t)

The failure quota is principally another failure rate. It will, however, be indicated in failures per 10^9 component hours and helps to find the reliability prognosis in the usual failure rate calculation. In Anglo-American areas the failure quota is indicated as f i t (failure in time).
During usual application an aluminum electrolytic capacitor generally will not be operated up to its maximum load limit. Long years of practice have shown that Siemens aluminum electrolytic capacitors have an experience guiding value of 20 f i t at 50% load and less than 40° C (104° F) ambient temperature. For deviating load and temperature conditions see conversion factors as listed below:

Load rate	Conversion factor
100%	2
75%	1.5
50%	1
25%	0.9
10%	0.8

Temperature	Conversion factor
≦40° C (104° F)	1
55° C (131° F)	3
70° C (158° F)	8
ϑ_{max}	25

Concluding these explications it must, however, be mentioned that the term failure quota (f i t = failure in time) does not necessarily presume the long term stability of the failure behavior.

7.6 Operational life

The operational life indicates the period of time until a determined failure rate at defined failure criteria is reached. To forecast the expectable operational life, MIL-STD 690 B regulations with a confidence coefficient of 60 % are used.

At temperatures above 40° C (104° F) up to the upper temperature limit at 10 K temperature increase only one half of the normal operational life can be expected, based on a constant failure rate.

The operational life data indicated on the specific data sheet has been determined for Siemens aluminum electrolytic capacitors under these conditions. This data is based on a load at full category voltage U_c. As explained in para 5.3 the operational life increases at reduced voltage load. Figure 10 shows typical values of the operational life depending on the operating voltage. If specific data applies to special types the appropriate data sheet gives the necessary information.

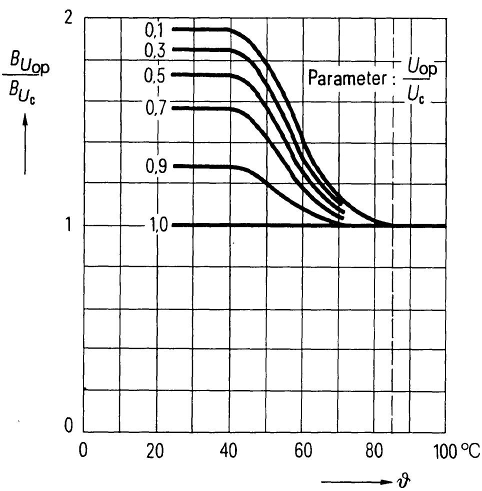
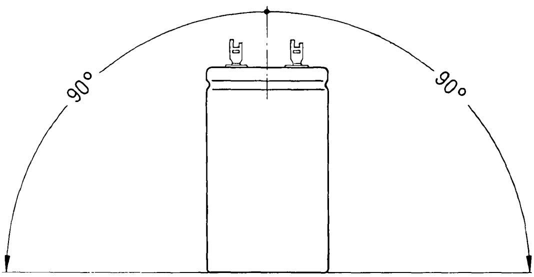


Fig. 10
Increase in operational life *B* by reducing of operating voltage

8.1 Working position of tubular case aluminum electrolytic capacitors

When electrolytic capacitors are operated, a leakage current steadily flows, and the dielectric film regenerates because of the electrolytic refining process, but on the other hand the electrolyte causes the generation of hydrogen. Thus, a slow pressure rise in the capacitor is caused. By means of suitable overpressure protectors it has been achieved that the gas, when attaining a certain pressure, can be removed.
In order to avoid that during the "removing" a disturbing quantity of the electrolyte emerges, the working positions as illustrated in DIN specifications 41248, 41250, 41238 are recommended. They are aimed at not arranging the valves downward.

Example from DIN 41238:



Permissible working position range

When used horizontally the valve shall be in "12 o'clock position".
When the pressure emerges it may happen that little electrolyte traces become visible in the vicinity of the valve. But this doesn't mean any disturbance of the capacitor function.
The optimum working position is the vertical, particularly when the capacitors are to be mounted at their terminals (solder peaks) or on the threaded stud or socket.
It must, however, be emphasized that a deviating working position does not damage the aluminum electrolytic capacitor. In this case a minor contamination of the electrolyte cannot be excluded if the overpressure protector operates.

8.2 Resistance to vibration

Unless otherwise stated on the individual data sheets, the DIN specification 40046, sheet 8, partial test B 1 with 5 *g*, and IEC publication 68-2–6 applies:

Duration of endurance conditioning:	1.5 hours
Frequence range:	10 to 55 Hz
Displacement amplitude:	0.35 mm

8.3 Cleaning agents

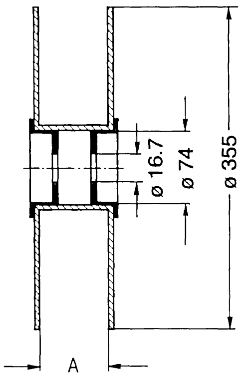
Halogenated hydrocarbons can be of harmful influence when they directly act upon aluminum electrolytic capacitors. When cleaning printed circuit boards, after the soldering of components, or removing the remainders of the fluxing agents by means of such solvents, care should be taken that the electrolytic capacitors don't get in direct touch with the cleaning agent. If wetting of the electrolytic capacitors cannot be avoided, halogen-free solvents (for examples refer to page 43) are to be used in order to exclude any damage of the electrolytic capacitor.

8.5 Weights of electrolytic capacitors
(typical values, deviations up to ±30% possible)

Nominal dimensions (mm)	Weight (g)
3.2 dia × 11	0.36
4.5 dia × 11	0.54
5.8 dia × 11	0.76
6.5 dia × 17.5	1.1
8.5 dia × 17.5	1.8
10 dia × 20	2.6
10 dia × 25	3.2
12 dia × 30	5.4
14 dia × 30	7.5
16 dia × 30	9.3
18 dia × 30	11
18 dia × 40	14
21 dia × 40	18
25 dia × 35	19

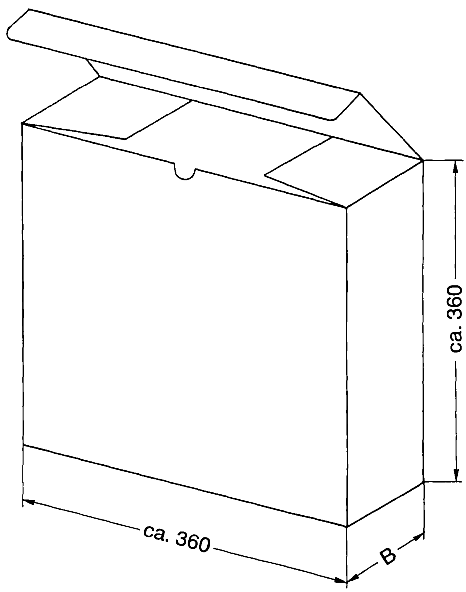
Nominal dimensions (mm)	Weight (g)
25 dia × 40	26
25 dia × 45 (43)	28
30 dia × 45 (43)	34
30 dia × 55 (53)	42
35 dia × 55 (53)	57
35 dia × 75 (73)	78
40 dia × 75 (73)	100
40 dia × 105 (103)	150
50 dia × 80	170
50 dia × 105	210
65 dia × 105	360
75 dia × 105	480
75 dia × 140	640
75 dia × 220	1100

Coil



Packaging parcel

Dimensions in mm



Tape spacing b	Coil width A	Parcel width B
63 ± 2	78	approx. 92
73 ± 2	88	approx. 102

3. Minimum order quantities for ordering taped electrolytic capacitors

The application of taped components in small quantities would not be economical, because the share of the taping and packaging costs would then be too high. Moreover automatic assembly is only profitable in larger quantities. Therefore, minimum quantities for ordering taped electrolytic capacitors have been determined, corresponding to the size of the reel or the parcel, respectively.

Rated diameter of the capacitor (mm)	Minimum order quantity = contents of the package (items)
3.2 . . . 3.4	5000
4.5 . . . 4.7	1800
5.8	1250
6.5 . . . 7.3	1000
8.5 . . . 8.9	800
10	700
12	600
14	500
16	300

Electrolytic Capacitor – Axial

Aluminum electrolytic capacitor with etched electrodes encapsulated in aluminum case with external insulation. Axial leaded with negative pole connected to the case.

Technical Data:

General Specification:
IEC 384-4 Type GP and DIN 41332, Sheet 1

Climatic Category DIN:
GPF [−40 to +85°C/ Humidity Category F]
According to DIN 40040.

Climatic Category IEC:
40/085/56

Life Test: Conditions 1000h/+85°C/V_R

Evaluation:

- $\Delta C/C$: +25% of initially measured value.
- $+g\delta < 200\%$ of initially specified value.
- $I_R <$ than initially specified value.

Storage Test: Conditions 1000h/+85°C/OV

Evaluation:

- $\Delta C/C$: +25% of initially measured value.
- $+g\delta < 200\%$ of initially specified value.
- $I_R <$ than initially specified value.

Ordering Code Example

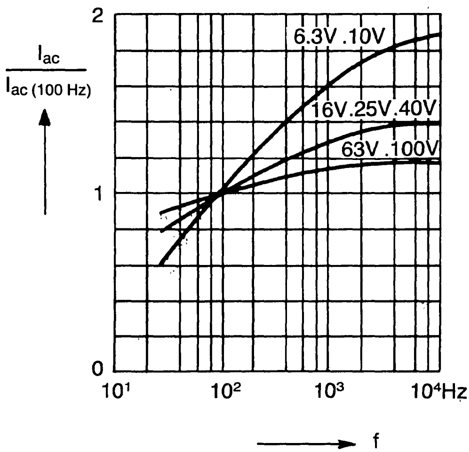
Example: 2200 / 6.3 - 82009

- Capacitance (μF) — 2200
- Rated Voltage (V) — 6.3
- Order Number — 82009

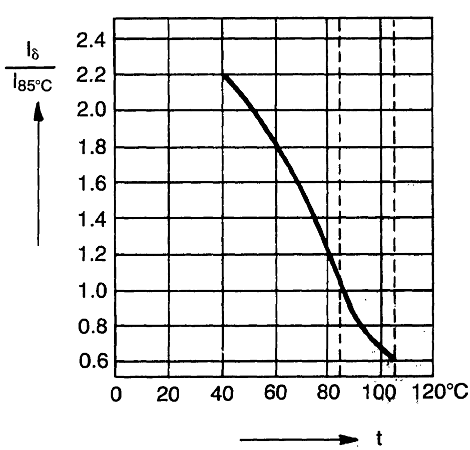
End sealed Order Number — 82006

Rated Voltage		6.3 Vdc	10 Vdc	16 Vdc	25 Vdc	40 Vdc	63 Vdc	100 Vdc	160 Vdc	250 Vdc	350 Vdc
Rated Capacitance		Rated dimensions d x l inches mm									
µF	Tolerance										
10	+50%										.571x1.20 14.5x30.5
22	−10%									.571x1.20 14.5x30.5	.650x1.20 16.5x30.5
33										.571x1.20 14.5x30.5	.650x1.20 16.5x30.5
47									.571x1.20 14.5x30.5		.728x1.40 18.5x35.5
68									.650x1.20 16.5x30.5	.728x1.40 18.5x35.5	.807x1.59 20.5x40.5
100									.728x1.40 18.5x35.5	.807x1.59 20.5x40.5	1.0x1.59 25.5x40.5
220								.650x1.20 16.5x30.5	1.0x1.59 25.5x40.5		
330							.571x1.20 14.5x30.5	.728x1.40 18.5x35.5	1.0x1.59 25.5x40.5		
470							.728x1.40 18.5x35.5	.807x1.59 20.5x40.5			
680						.571x1.20 14.5x30.5	.728x1.40 18.5x35.5	1.0x1.59 25.5x40.5			
1000					.571x1.20 14.5x30.5	.728x1.40 18.5x35.5	.807x1.59 20.5x40.5				
2200			.571x1.20 14.5x31.5	.650x1.20 16.5x30.5	.807x1.59 20.5x40.5	1.0x1.59 25.5x40.5					
3300		.571x1.20 14.5x30.5	.650x1.20 16.5x30.5	.728x1.40 18.5x35.5	.807x1.59 20.5x40.5	1.0x1.59 25.5x40.5					
4700		.728x1.40 18.5x35.5		.807x1.59 20.5x40.5	1.0x1.59 25.5x40.5						
6800		.728x1.40 18.5x35.5		.807x1.59 20.5x40.5	1.0x1.59 25.5x40.5						
10000		.807x1.59 20.5x40.5	1.0x1.59 25.5x40.5								

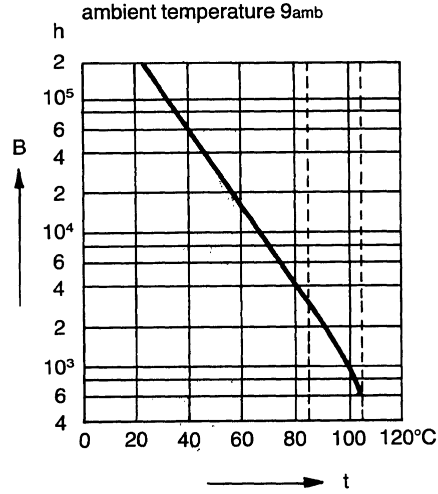
Ac power handling capacity Iac versus frequency f



Permissible superimposed ac current versus ambient temperature ϑamb



Load duration B versus ambient temperature ϑamb



Life expectancy X temperature

Technical Data

General Specifications	IEC 384-4, Type GP & DIN 41332, page 1
Climatic Category (in accordance with DIN 40040)	GPF (−40 at +85°C/humidity category F)
IEC	40/085/56
Life Test 1000 h/+85°C/UN	Criteria: Δ C/C ± 25% of value initially measured Tgd < 200% of value initially specified I_L < than the value initially specified
Storage Test 1000 h/+85°C/OV The measurements shall be performed after application of rated voltage to the capacitor a series limiting resistor (appr. 1000Ω) for 30 minutes. Then the capacitor must be stored for 24 to 48 hours at room temperature.	Criteria: Δ C/C ± 25% of value initially measured Tgd < 200% of value initially specified I_L < than the value initially specified

U_N U_P (V)	C_N (μF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5[1], +20/25°C) (μA)	Dissipation Factor – tgd máx. (120 Hz, +20/+25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions D (ø)	Dimensions L
	33		3,0	0,25	12,6	4.9	12.5
	100		6,3	0,25	4,1	6.2	12.5
6,3	220		13,9	0,25	1,9	7	18
	470		29,6	0,25	0,9	9	18
(7,2)	680		42,8	0,25	0,6	9	18
	2200		138,6	0,27	0,2	12.5	30.5
	4700		296,1	0,31	0,1	16.5	30.5
	6800		428,4	0,35	0,1	18.5	35.5
	10000		630,0	0,41	0,1	18.5	40.5
	47		4,7	0,20	7,1	6.2	12.5
	68		6,8	0,20	4,9	6.2	12.5
10	100		10,0	0,20	3,3	7	18
	330		33,0	0,20	1,0	9	18
(11,5)	1000		100,0	0,20	0,3	10.5	25.5
	1500		150,0	0,20	0,2	12.5	30.5
	2200		220,0	0,22	0,2	14.5	30.5
	3300		330,0	0,24	0,1	16.5	30.5
	4700		470,0	0,26	0,1	18.5	35.5
	6800		680,0	0,30	0,1	18.5	40.5
	10000		1000,0	0,36	0,1	20.5	40.5
		± 20					
	15		3,0	0,17	18,8	4.9	12.5
	22		3,5	0,17	12,8	4.9	12.5
16	33		5,3	0,17	8,5	6.2	12.5
	47		7,5	0,17	6,0	6.2	12.5
(18,4)	100		16,0	0,17	2,8	7	18
	150		24,0	0,17	1,9	7	18
	220		35,2	0,17	1,3	9	18
	470		75,2	0,17	0,6	10.5	25.5
	680		108,8	0,17	0,4	10.5	25.5
	1000		160,0	0,17	0,3	12.5	30.5
	1500		240,0	0,17	0,2	14.5	30.5
	2200		352,0	0,19	0,1	16.5	30.5
	3300		528,0	0,21	0,1	18.5	35.5
	4700		752,0	0,23	0,1	18.5	40.5
	6800		1088,0	0,27	0,1	20.5	40.5

U_N U_P (V)	C_N (μF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5^1, +20/25°C) (μA)	Dissipation Factor – tgd máx. (120 Hz, +20/+25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions	
						D (ø)	L
	1,5		3,0	0,10	110,5	4.9	12.5
	2,2		3,0	0,10	75,4	4.9	12.5
	3,3		3,0	0,10	50,2	6.2	12.5
	4,7		3,0	0,10	35,3	6.2	12.5
63	6,8		4,3	0,10	24,4	7	18
	10		6,3	0,10	16,6	7	18
(72,4)	22		13,9	0,10	7,5	9	18
	33		20,8	0,10	5,0	9	18
	47		29,6	0,10	3,5	9	18
	68		42,8	0,10	2,4	9	18
	100		63,0	0,10	1,7	10.5	25.5
	220		138,6	0,10	0,8	12.5	30.5
	330		207,9	0,10	0,5	14.5	30.5
	470		296,1	0,10	0,4	16.5	30.5
	680		428,4	0,10	0,2	18.5	40.5
	1000		630,0	0,10	0,2	18.5	40.5
	1500		945,0	0,10	0,1	20.5	40.5
	2200		1386,0	0,10	0,1	25.5	40.5
		± 20					
	0,1		3,0	0,08	1326,3	4.9	12.5
	0,15		3,0	0,08	884,2	4.9	12.5
	0,22		3,0	0,08	602,9	4.9	12.5
	0,33		3,0	0,08	401,9	4.9	12.5
	0,47		3,0	0,08	282,2	4.9	12.5
	0,68		3,0	0,08	195,0	4.9	12.5
100	1		3,0	0,08	132,6	4.9	12.5
	1,5		3,0	0,08	88,4	6.2	12.5
(115)	2,2		3,0	0,08	60,3	6.2	12.5
	3,3		3,3	0,08	40,2	7	18
	4,7		4,7	0,08	28,2	7	18
	6,8		6,8	0,08	19,5	7	18
	10		10,0	0,08	13,3	9	18
	22		22,0	0,08	6,0	9	18
	33		33,0	0,08	4,0	10.5	25.5
	47		47,0	0,08	2,8	10.5	25.5
	68		68,0	0,08	2,0	10.5	25.5
	100		100,0	0,08	1,3	12.5	30.5
	150		150,0	0,08	0,9	12.5	30.5
	220		220,0	0,08	0,6	16.5	30.5
	330		330,0	0,08	0,4	18.5	35.5
	470		470,0	0,08	0,3	18.5	40.5
	680		680,0	0,08	0,2	20.5	40.5
	1000		1000,0	0,08	0,1	20.5	40.5

Electrolytic Capacitor with etched aluminum electrodes, encapsulated in aluminum case with external insulation. They are Axial Leaded with negative pole connected to the case.

Ordering Code Example

Example: 47 / 25 - 81009

Capacitance (μF) — 47

Rated Voltage (V) — 25

Order Number — 81009

End sealed Order Number — 81006

Technical Data:

General Specification:
IEC 384-4 Type GP and DIN 41332, Sheet 1

Climatic Category DIN:
GPF [−40 to +85°C/ Humidity Category F]
According to DIN 40040.

Climatic Category IEC:
40/085/56

Life Test: Conditions 1000h/+85°C/UR

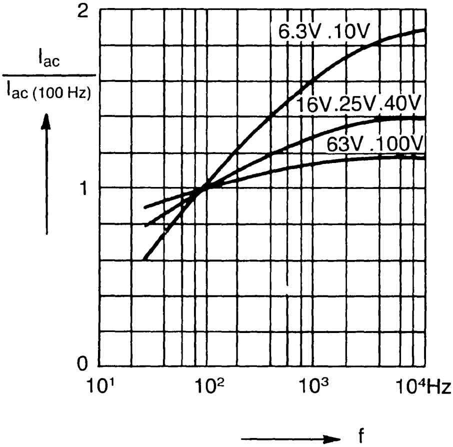
Evaluation:
- $\Delta C/C$: +25% of initially measured value.
- +gδ<200% of initially specified value.
- I_R<than initially specified value.

Storage Test: Conditions 1000h/+85°C/OV

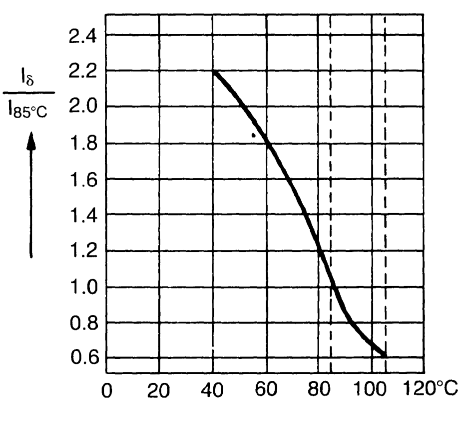
Evaluation:
- $\Delta C/C$: +25% of initially measured value.
- +gδ<200% of initially specified value.
- I_R<than initially specified value.

Rated Voltage		6.3 Vdc	10 Vdc	16 Vdc	25 Vdc	40 Vdc	63 Vdc	100 Vdc	160 Vdc	250 Vdc	350 Vdc
Rated Capacitance		Rated dimensions d x l inches mm									
µF	Tolerance										
1											.354x.709 9.0x18.0
2.2										.354x.709 9.0x18.0	.354x.709 9.0x18.0
3.3										.354x.709 9.0x18.0	.413x1.0 10.5x25.5
4.7	+50%							.276x.709 7.0x18.0		.354x.709 9.0x18.0	.413x1.0 10.5x25.5
6.8	−10%							.276x.709 7.0x18.0	.354x.709 9.0x18.0		.413x1.0 10.5x25.5
10							.276x.709 7.0x18.0	.354x.709 9.0x18.0		.413x1.0 10.5x25.5	
22						.276x.709 7.0x18.0		.354x.709 9.0x18.0	.413x1.0 10.5x25.5		
33						.276x.709 7.0x18.0	.354x.709 9.0x18.0	.413x1.0 10.5x25.5			
47					.276x.709 7.0x18.0		.354x.709 9.0x18.0	.413x1.0 10.5x25.5			
68					.276x.709 7.0x18.0		.413x1.0 10.5x25.5	.492x1.20 12.5x30.5			
100			.276x.709 7.0x18.0		.354x.709 9.0x18.0		.413x1.0 10.5x25.5	.492x1.20 12.5x30.5			
220				.354x.709 9.0x18.0		.413x1.0 10.5x25.5	.492x1.20 12.5x30.5				
330			.354x.709 9.0x18.0		.413x1.0 10.5x25.5						
470		.354x.709 9.0x18.0		.413x1.0 10.5x25.5		.492x1.20 12.5x30.5					
680				.413x1.0 10.5x25.5	.492x1.20 12.5x30.5						
1000		.413x1.0 10.5x25.5		.492x1.20 12.5x30.5							

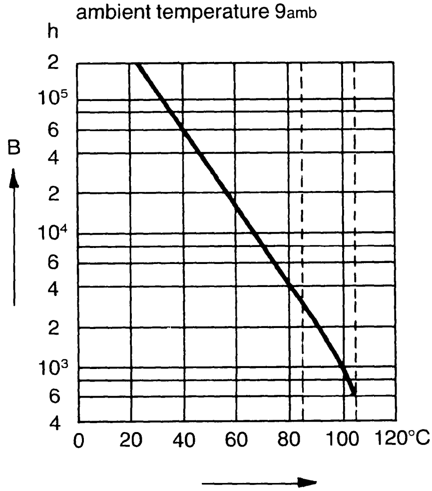
Ac power handling capacity Iac versus frequency f



Permissible superimposed ac current versus ambient temperature ϑamb



Load duration B versus ambient temperature ϑamb



Life expectancy X temperature

Technical Data

General Specifications	IEC 384-4, Type GP & DIN 41332, page 1
Climatic Category (in accordance with DIN 40040)	GPF (−40 at +85°C/humidity category F)
IEC	40/085/56
Life Test 1000 h/+85°C/UN	Criteria: Δ C/C ± 25% of value initially measured Tgd < 200% of value initially specified I_L < than the value initially specified
Storage Test 1000 h/+85°C/OV The measurements shall be performed after application of rated voltage to the capacitor a series limiting resistor (appr. 1000Ω) for 30 minutes. Then the capacitor must be stored for 24 to 48 hours at room temperature.	Criteria: Δ C/C ± 25% of value initially measured Tgd < 200% of value initially specified I_L < than the value initially specified

U_N U_P (V)	C_N (μF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5[1], +20/25°C) (μA)	Dissipation Factor – tgd máx. (120 Hz, +20/ +25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions D (ø)	Dimensions L
	33		3,0	0,25	12,6	4.9	12.5
	100		6,3	0,25	4,1	6.2	12.5
6,3	220		13,9	0,25	1,9	7	18
	470		29,6	0,25	0,9	9	18
(7,2)	680		42,8	0,25	0,6	9	18
	2200		138,6	0,27	0,2	12.5	30.5
	4700		296,1	0,31	0,1	16.5	30.5
	6800		428,4	0,35	0,1	18.5	35.5
	10000		630,0	0,41	0,1	18.5	40.5
	47		4,7	0,20	7,1	6.2	12.5
	68		6,8	0,20	4,9	6.2	12.5
10	100		10,0	0,20	3,3	7	18
	330		33,0	0,20	1,0	9	18
(11,5)	1000		100,0	0,20	0,3	10.5	25.5
	1500		150,0	0,20	0,2	12.5	30.5
	2200		220,0	0,22	0,2	14.5	30.5
	3300		330,0	0,24	0,1	16.5	30.5
	4700		470,0	0,26	0,1	18.5	35.5
	6800		680,0	0,30	0,1	18.5	40.5
	10000		1000,0	0,36	0,1	20.5	40.5
		± 20					
	15		3,0	0,17	18,8	4.9	12.5
	22		3,5	0,17	12,8	4.9	12.5
	33		5,3	0,17	8,5	6.2	12.5
	47		7,5	0,17	6,0	6.2	12.5
	100		16,0	0,17	2,8	7	18
	150		24,0	0,17	1,9	7	18
	220		35,2	0,17	1,3	9	18
	470		75,2	0,17	0,6	10.5	25.5
	680		108,8	0,17	0,4	10.5	25.5
	1000		160,0	0,17	0,3	12.5	30.5
	1500		240,0	0,17	0,2	14.5	30.5
	2200		352,0	0,19	0,1	16.5	30.5
	3300		528,0	0,21	0,1	18.5	35.5
	4700		752,0	0,23	0,1	18.5	40.5
	6800		1088,0	0,27	0,1	20.5	40.5

U_N U_P (V)	C_N (μF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5[1], +20/25°C) (μA)	Dissipation Factor – tgd máx. (120 Hz, +20/ +25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions D (ø)	L
	1,5		3,0	0,10	110,5	4.9	12.5
	2,2		3,0	0,10	75,4	4.9	12.5
	3,3		3,0	0,10	50,2	6.2	12.5
	4,7		3,0	0,10	35,3	6.2	12.5
63	6,8		4,3	0,10	24,4	7	18
	10		6,3	0,10	16,6	7	18
(72,4)	22		13,9	0,10	7,5	9	18
	33		20,8	0,10	5,0	9	18
	47		29,6	0,10	3,5	9	18
	68		42,8	0,10	2,4	9	18
	100		63,0	0,10	1,7	10.5	25.5
	220		138,6	0,10	0,8	12.5	30.5
	330		207,9	0,10	0,5	14.5	30.5
	470		296,1	0,10	0,4	16.5	30.5
	680		428,4	0,10	0,2	18.5	40.5
	1000		630,0	0,10	0,2	18.5	40.5
	1500		945,0	0,10	0,1	20.5	40.5
	2200		1386,0	0,10	0,1	25.5	40.5
		± 20					
	0,1		3,0	0,08	1326,3	4.9	12.5
	0,15		3,0	0,08	884,2	4.9	12.5
	0,22		3,0	0,08	602,9	4.9	12.5
	0,33		3,0	0,08	401,9	4.9	12.5
	0,47		3,0	0,08	282,2	4.9	12.5
	0,68		3,0	0,08	195,0	4.9	12.5
100	1		3,0	0,08	132,6	4.9	12.5
	1,5		3,0	0,08	88,4	6.2	12.5
(115)	2,2		3,0	0,08	60,3	6.2	12.5
	3,3		3,3	0,08	40,2	7	18
	4,7		4,7	0,08	28,2	7	18
	6,8		6,8	0,08	19,5	7	18
	10		10,0	0,08	13,3	9	18
	22		22,0	0,08	6,0	9	18
	33		33,0	0,08	4,0	10.5	25.5
	47		47,0	0,08	2,8	10.5	25.5
	68		68,0	0,08	2,0	10.5	25.5
	100		100,0	0,08	1,3	12.5	30.5
	150		150,0	0,08	0,9	12.5	30.5
	220		220,0	0,08	0,6	16.5	30.5
	330		330,0	0,08	0,4	18.5	35.5
	470		470,0	0,08	0,3	18.5	40.5
	680		680,0	0,08	0,2	20.5	40.5
	1000		1000,0	0,08	0,1	20.5	40.5

Electrolytic Capacitor — I 80009

Electrolytic Capacitor with etched aluminum electrode encapsulated in aluminum case with external insulation. They are Axial Leaded with negative pole connected to the case.

Ordering Code Example

Example: 10 / 25 - 80009 80006

- Capacitance (μF) — 10
- Rated Voltage (V) — 25
- Order Number — 80009
- End Sealed Ordering Code — 80006

Technical Data:

General Specification:

IEC 384-4 Type GP and DIN 41332, Sheet 1

Climatic Category DIN:

GPF [−40 to +85°C/ (Humidity Category F)]
According to DIN 40040.

Climatic Category IEC:

(According to DIN 40040) 40/085/56

Life Test: Conditions 1000h/+85°C/UN

Evaluation:

- $\Delta C/C$: +25% of initially measured value.
- +gδ<200% of initially specified value.
- I_R<than initially specified value.

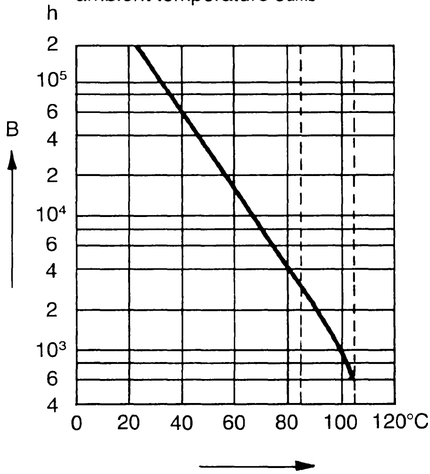
Storage Test: Conditions 1000h/+85°C/OV

Evaluation:

- $\Delta C/C$: +25% of initially measured value.
- +gδ<200% of initially specified value.
- I_R<than initially specified value.

Rated Voltage		6.3 Vdc	10 Vdc	16 Vdc	25 Vdc	40 Vdc	63 Vdc	100 Vdc
Rated Capacitance		Rated dimensions d x l inches mm						
μF	Tolerance							
.33								.193x.492 4.9x12.5
.47								.193x.492 4.9x12.5
.68								.193x.492 4.9x12.5
1	+100%							.193x.492 4.9x12.5
2.2	−10%						.193x.492 4.9x12.5	.244x.492 6.2x12.5
3.3								.244x.492 6.2x12.5
4.7						.193x.492 4.9x12.5	.244x.492 6.2x12.5	
6.8								
10					.193x.492 4.9x12.5	.244x.492 6.2x12.5		
22				.193x.492 4.9x12.5	.244x.492 6.2x12.5			
33				.193x.492 4.9x12.5	.244x.492 6.2x12.5			
47				.244x.492 6.2x12.5				
68			.193x.492 4.9x12.5	.244x.492 6.2x12.5				

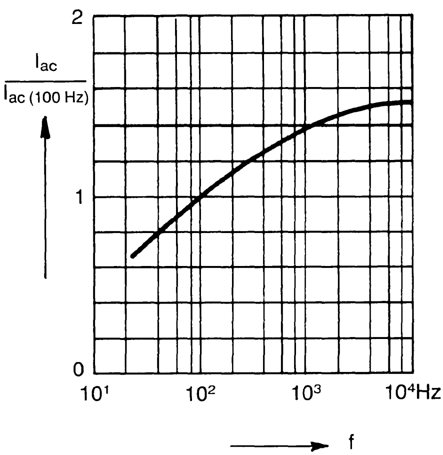
Load duration B versus
ambient temperature ϑ_{amb}



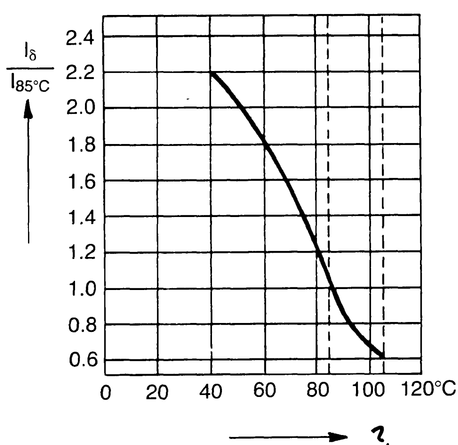
Relative failure rate ≤ 3%
(during load duration)

Typical value for the relation
total failure/failure due to variation 10/90

Ac power handling capacity Iac versus
frequency f



Permissible superimposed ac current
versus ambient temperature ϑ_{amb}



Technical Data

General Specifications	IEC 384-4, Type GP & DIN 41332, page 1
Climatic Category (in accordance with DIN 40040)	GPF (−40 at +85°C/humidity category F)
IEC	40/085/56
Life Test 1000 h/+85°C/UN	Criteria: Δ C/C ± 25% of value initially measured Tgd < 200% of value initially specified I_L < than the value initially specified
Storage Test 1000 h/+85°C/OV The measurements shall be performed after application of rated voltage to the capacitor a series limiting resistor (appr. 1000Ω) for 30 minutes. Then the capacitor must be stored for 24 to 48 hours at room temperature.	Criteria: Δ C/C ± 25% of value initially measured Tgd < 200% of value initially specified I_L < than the value initially specified

U_N U_P (V)	C_N (μF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5[1], +20/25°C) (μA)	Dissipation Factor – tgd máx. (120 Hz, +20/ +25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions	
						D (ø)	L
	33		3,0	0,25	12,6	4.9	12.5
	100		6,3	0,25	4,1	6.2	12.5
6,3	220		13,9	0,25	1,9	7	18
	470		29,6	0,25	0,9	9	18
(7,2)	680		42,8	0,25	0,6	9	18
	2200		138,6	0,27	0,2	12.5	30.5
	4700		296,1	0,31	0,1	16.5	30.5
	6800		428,4	0,35	0,1	18.5	35.5
	10000		630,0	0,41	0,1	18.5	40.5
	47		4,7	0,20	7,1	6.2	12.5
	68		6,8	0,20	4,9	6.2	12.5
10	100		10,0	0,20	3,3	7	18
	330		33,0	0,20	1,0	9	18
(11,5)	1000		100,0	0,20	0,3	10.5	25.5
	1500		150,0	0,20	0,2	12.5	30.5
	2200		220,0	0,22	0,2	14.5	30.5
	3300		330,0	0,24	0,1	16.5	30.5
	4700		470,0	0,26	0,1	18.5	35.5
	6800		680,0	0,30	0,1	18.5	40.5
	10000		1000,0	0,36	0,1	20.5	40.5
		± 20					
	15		3,0	0,17	18,8	4.9	12.5
	22		3,5	0,17	12,8	4.9	12.5
	33		5,3	0,17	8,5	6.2	12.5
	47		7,5	0,17	6,0	6.2	12.5
	100		16,0	0,17	2,8	7	18
16	150		24,0	0,17	1,9	7	18
(18,4)	220		35,2	0,17	1,3	9	18
	470		75,2	0,17	0,6	10.5	25.5
	680		108,8	0,17	0,4	10.5	25.5
	1000		160,0	0,17	0,3	12.5	30.5
	1500		240,0	0,17	0,2	14.5	30.5
	2200		352,0	0,19	0,1	16.5	30.5
	3300		528,0	0,21	0,1	18.5	35.5
	4700		752,0	0,23	0,1	18.5	40.5
	6800		1088,0	0,27	0,1	20.5	40.5

U_N U_P (V)	C_N (μF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5[1], +20/25°C) (μA)	Dissipation Factor – tgd máx. (120 Hz, +20/+25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions D (ø)	Dimensions L
	1,5		3,0	0,10	110,5	4.9	12.5
	2,2		3,0	0,10	75,4	4.9	12.5
	3,3		3,0	0,10	50,2	6.2	12.5
	4,7		3,0	0,10	35,3	6.2	12.5
63	6,8		4,3	0,10	24,4	7	18
	10		6,3	0,10	16,6	7	18
(72,4)	22		13,9	0,10	7,5	9	18
	33		20,8	0,10	5,0	9	18
	47		29,6	0,10	3,5	9	18
	68		42,8	0,10	2,4	9	18
	100		63,0	0,10	1,7	10.5	25.5
	220		138,6	0,10	0,8	12.5	30.5
	330		207,9	0,10	0,5	14.5	30.5
	470		296,1	0,10	0,4	16.5	30.5
	680		428,4	0,10	0,2	18.5	40.5
	1000		630,0	0,10	0,2	18.5	40.5
	1500		945,0	0,10	0,1	20.5	40.5
	2200		1386,0	0,10	0,1	25.5	40.5
		± 20					
	0,1		3,0	0,08	1326,3	4.9	12.5
	0,15		3,0	0,08	884,2	4.9	12.5
	0,22		3,0	0,08	602,9	4.9	12.5
	0,33		3,0	0,08	401,9	4.9	12.5
	0,47		3,0	0,08	282,2	4.9	12.5
	0,68		3,0	0,08	195,0	4.9	12.5
100	1		3,0	0,08	132,6	4.9	12.5
	1,5		3,0	0,08	88,4	6.2	12.5
(115)	2,2		3,0	0,08	60,3	6.2	12.5
	3,3		3,3	0,08	40,2	7	18
	4,7		4,7	0,08	28,2	7	18
	6,8		6,8	0,08	19,5	7	18
	10		10,0	0,08	13,3	9	18
	22		22,0	0,08	6,0	9	18
	33		33,0	0,08	4,0	10.5	25.5
	47		47,0	0,08	2,8	10.5	25.5
	68		68,0	0,08	2,0	10.5	25.5
	100		100,0	0,08	1,3	12.5	30.5
	150		150,0	0,08	0,9	12.5	30.5
	220		220,0	0,08	0,6	16.5	30.5
	330		330,0	0,08	0,4	18.5	35.5
	470		470,0	0,08	0,3	18.5	40.5
	680		680,0	0,08	0,2	20.5	40.5
	1000		1000,0	0,08	0,1	20.5	40.5

Electrolytic Capacitor — I 85209

Aluminium electrolytic Capacitor with etched electrodes, encapsulated in aluminum case with external insulation. They are radial Leaded, special for vertical mounting.

Ordering Code Example

Example: 10 / 25 - 85209

- Capacitance (μF) — 10
- Rated Voltage (V) — 25
- Order Number — 85209
- End Sealed — 85206

Technical Data:

General Specification:
IEC 384-4 Type GP and DIN 41332, Sheet 1

Climatic Category DIN:
GPF [−40 to +85°C/ Humidity Category F]
According to DIN 40040.

Climatic Category IEC:
40/085/56

Life Test: Conditions 2000h/+85°C/UN or 500h/+105°C/UN

Evaluation:

- $\Delta C/C$: ±25% of initially measured value.
- +gδ<200% of initially specified value.
- I_R<than initially specified value.

Storage Test: Conditions 1000h/+85°C/OV

Evaluation:

- $\Delta C/C$: ±25% of initially measured value.
- +gδ<200% of initially specified value.
- I_R<than initially specified value.

Rated Voltage		6.3 Vdc	10 Vdc	16 Vdc	25 Vdc	40 Vdc	63 Vdc	100 Vdc	160 Vdc	250 Vdc
Rated Capacitance μF	Tolerance	Rated dimensions d x l inches mm								
.33								.217x.472 5.5x12	.268x.531 6.8x13.5	.335x.531 8.5x13.5
.47								.217x.472 5.5x12	.268x.531 6.8x13.5	.355x.531 8.5x13.5
.68								.217x.472 5.5x12	.268x.531 6.8x13.5	.355x.531 8.5x13.5
1.0								.217x.472 5.5x12	.268x.531 6.8x13.5	.355x.531 8.5x13.5
2.2							.217x.472 5.5x12	.268x.531 6.8x13.5	.335x.531 8.5x13.5	.413x.531 10.5x13.5
3.3							.217x.472 5.5x12	.268x.531 6.8x13.5	.335x.531 8.5x13.5	.413x.531 10.5x13.5
4.7	+100% −10%					.217x.472 5.5x12	.268x.531 6.8x13.5	.335x.531 8.5x13.5	.413x.531 10.5x13.5	.413x.827 10.5x21
6.8						.217x.472 5.5x12	.268x.531 6.8x13.5	.335x.531 8.5x13.5	.413x.531 10.5x13.5	.413x.827 10.5x21
10					.217x.472 5.5x12	.268x.531 6.8x13.5	.335x.531 8.5x13.5	.413x.531 10.5x13.5	.413x.827 10.5x21	.512x1.02 13.26
22				.217x.472 5.5x12	.268x.531 6.8x13.5	.335x.531 8.5x13.5	.413x.531 10.5x13.5	.413x.827 10.5x21	.512x1.02 13x26	.650x1.02 16.5x26
33				.217x.472 5.5x12	.268x.531 6.8x13.5	.335x.531 8.5x13.5	.413x.531 10.5x13.5	.413x.827 10.5x21	.512x1.20 13x26	.650x1.02 16.5x26
47		.217x.472 5.5x12		.268x.531 6.8x13.5	.335x.531 8.5x13.5	.413x.531 10.5x13.5		.413x.827 10.5x21	.650x1.02 16.5x26	.728x1.28 18.5x32.5
68		.217x.472 5.5x12		.268x.531 6.8x13.5	.335x.531 8.5x13.5	.413x.531 10.5x13.5	.413x.827 10.5x21	.512x1.02 13x26	.650x1.02 16.5x26	.728x1.28 18.5x32.5
100		.268x.531 6.8x13.5		.335x.531 8.5x13.5	.413x.531 10.5x13.5		.413x.827 10.5x21	.512x1.02 13x26		
220		.335x.531 8.5x13.5		.413x.531 10.5x13.5	.413x.827 10.5x21		.512x1.02 13x26	.650x1.28 16.5x32.5		
330			.413x.531 10.5x13.5		.413x.827 10.5x21	.512x1.02 13x26	.650x1.02 16.5x26	.728x1.28 18.5x32.5		
470		.413x.531 10.5x13.5		.413x.827 10.5x21	.512x1.02 13x26	.650x1.02 16.5x26	.650x1.28 16.5x32.5			
680			.413x.827 10.5x21		.512x1.02 13x26	.650x1.02 16.5x26	.728x1.28 18.5x32.5			
1000		.413x.827 10.5x21		.512x1.02 13x26	.650x1.02 16.5x26	.650x1.28 16.5x32.5				
2200	+50% −10%	.512x1.02 13x26	.650x1.02 16.5x26	.650x1.28 16.5x32.5	.728x1.28 18.5x32.5					
3300		.650x1.02 16.5x26	.650x1.28 16.5x32.5	,728x1.28 18.5x32.5						
4700		.650x1.28 16.5x32.5	.728x1.28 18.5x32.5							
6800		.728x1.28 18.5x32.5								

CN (μF)	UN (Up) (V)	Dissapation Factor tg. δ. max. 120 HZ +20/+25°C	Capacitance Tolerance 120 HZ +20/+25°C (%)	ESR 120 HZ +20/ +25°C Ω	Leakage Current IR-max. (5 min. +20/ +25°C (uA)	Ripple Current IN-max. (85°C 120 HZ (mA)	Basic Dimensions (mm) D (ø)	L	Weights
0.47	100	0.10		313.5	4	8	5	11	0.45g
1	(115)	0.10		147.3	5	11	5	11	0.45g
2.2		0.10		66.98	7	20	6.3	11	0.55g
4.7		0.10		31.35	12	34	8	12.5	1.00g
10		0.10		14.74	23	55	10	12.5	1.50g
22		0.10		6.70	47	100	10	20	2.30g
47		0.10		3.14	97	140	10	20	2.30g
100		0.10		1.47	203	250	12.5	25	4.00g
220		0.10		0.67	443	470	16	31.5	8.00g
0.47	160	0.20		627.09	22	7	6.3	11	0.55g
1	(176)	0.20		294.73	25	10	6.3	11	0.55g
2.2		0.20		133.97	31	17	8	12.5	1.00g
4.7		0.20		62.71	43	27	10	12.5	1.50g
10		0.20		29.47	68	46	10	20	2.30g
22		0.20		13.4	126	85	12.5	25	4.00g
47		0.20		6.27	246	140	16	25	7.00g
0.47	250	0.20		627.09	24	8	8	12.5	1.00g
1	(275)	0.20		249.73	28	11	8	12.5	1.00g
2.2		0.20		133.97	37	19	10	12.5	1.50g
4.7		0.20		62.71	55	32	10	20	2.30g
10		0.20		29.47	95	60	12.5	25	4.00g
22		0.20		13.40	185	96	16	25	7.00g
47		0.20		6.27	373	150	18	31.5	8.00g

Aluminium electrolytic Capacitor with etched electrodes, encapsulated in aluminum case with external insulation. They are radial Leaded, special for vertical mounting.
High capacitance, voltage product for volume unit, with capacitance tolerance of ±20%.

Ordering Code Example

Example: 47 / 10 - 85049

Capacitance (μF) — 47

Rated Voltage (V) — 10

Order Number — 85049

End Sealed — 85046

Technical Data:

General Specification:

IEC 384-4 Type GL and DIN 41332, Sheet 1

Climatic Category DIN:

GPF [−40 to +85°C/ Humidity Category F]
According to DIN 40040.

Climatic Category IEC:

40/085/56

Leakage Current (5 minutes) $I_R \leqslant 0.01 - C_R - U_R - + 2$ (μA)

Life Test: Conditions 2000h/+85°C/UN or 500h/+105°C/UN

Evaluation:

- ΔC/C: +25% of initially measured value.
- +gδ<200% of initially specified value.
- I_R<than initially specified value.

Storage Test: Conditions 1000h/+85°C/OV

Evaluation:

- ΔC/C: +25% of initially measured value.
- +gδ<200% of initially specified value.
- I_R<than initially specified value.

Rated Voltage		6.3 Vdc	10 Vdc	16 Vdc	25 Vdc	40 Vdc	50 Vdc	63 Vdc	100 Vdc	160 Vdc	250 Vdc	350 Vdc
Rated Capacitance		Rated dimensions d x l inches mm										
μF	Tolerance											
0.1									5x11			
0.15									5x11			
0.22									5x11			
0.33									5x11			
.47									5x11		6.3x11	8x12.5
.68	±20%								5x11		6.3x11	8x12.5
1									5x11	6.3x11	8x12.5	10x12.5
1.5									5x11	6.3x11	8x12.5	10x12.5
2.2									5x11	8x12.5	10x12.5	10x12.5
3.3									5x11		10x12.5	10x20
4.7							5x11	5x11	6.3x11	10x12.5	10x12.5	10x20
6.8							5x11	5x11	6.3x11	10x12.5		10x20
10							5x11	6.3x11	8x12.5	10x20	10x20	12.5x25
15						5x11		6.3x11	8x12.5	10x20		12.5x25
22					5x11		6.3x11	8x12.5	10x12.5	12.5x25	12.5x25	16x25
33				5x11		6.3x11		8x12.5	10x12.5		16x25	16x31.5
47			5x11		6.3x11		8x12.5x	10x12.5	10x20	16x25	16x31.5	18x31.5
68			5x11	6.3x11		8x12.5	10x12.5		10x20	16x25	16x31.5	
100		5x11	6.3x11	8x12.5	8x12.5	10x12.5		10x20	12.5x25	16x31.5		
150	±20%	6.3x11		8x12.5	10x12.5		10x20		12.5x25			
220			8x12.5	10x12.5	10x20	10x20	10x20	12.5x25	16x25			
330		8x12.5	10x12.5		10x20			12.5x25	16x31.5			
470			10x12.5	10x20	10x20	12.5x25		16x25	18x31.5			
680				10x20		16x25	16x31.5	18x31.5				
1000			10x20	12.5x25	16x25		16x31.5					
1500			12.5x25	16x25	16x31.5	18x31.5						
2200		12.5x25	16x25	16x25	18x31.5							
3300		16x25	16x31.5	18x31.5								
4700		16x31.5	18x31.5									
6800		18x31.5										

CR (μF)	UR (Up) (V)	Dissapation Factor tg. δ. max. 120 HZ +20/+25°C	Capacitance Tolerance 120 HZ +20/+25°C (%)	ESR 120 HZ +20/ +25°C Ω	Leakage Current IR-max. (5 min. +20/ +25°C (uA)	Ripple Current IN-max. (85°C 120 HZ (mA)	Basic Dimensions (mm) D (ø)	L	Weights
22		0.15		11.3		44	5	11	0.45g
47		0.15		5.29		75	6.3	11	0.55g
100		0.15		2.49		130	8	12.5	1.00g
150		0.15		1.66		180	10	12.5	1.50g
220		0.15		1.13		250	10	20	2.30g
330	25	0.15		0.75		310	10	20	2.30g
470	(28.8)	0.15		0.53		370	10	20	2.30g
1000		0.15		0.25		750	16	25	7.00g
1500		0.15		0.17		1000	16	31.5	8.00g
2200		0.17		0.13		1200	18	31.5	10.0g
15		0.12		13.3		41	5	11	0.45g
33		0.12		6.03		70	6.3	11	0.55g
68		0.12		2.93		120	8	12.5	1.00g
100		0.12		1.99		160	10	12.5	1.50g
220		0.12		0.91		280	10	20	2.30g
470	40	0.12		0.43		510	12.5	25	4.00g
680	(46)	0.12		0.29		690	16	25	7.00g
1500		0.12	±20	0.13		1200	18	31.5	10.0g
4.7		0.10		35.9		20	5	11	0.45g
6.8		0.10		24.5		25	5	11	0.45g
10		0.10		16.6		36	5	11	0.45g
22		0.10		7.53		60	6.3	11	0.55g
47		0.10		3.53		110	8	12.5	1.00g
68		0.10		2.44		145	10	12.5	1.00g
150	50	0.10		1.10		260	10	20	2.30g
220	(57.5)	0.10		0.75		310	10	20	2.30g
680		0.10		0.24		890	16	31.5	8.00g
1000		0.10		0.17		1000	16	31.5	8.00g

CR (μF)	UR (Up) (V)	Dissapation Factor tg. δ. max. 120 HZ +20/+25°C	Capacitance Tolerance 120 HZ +20/+25°C (%)	ESR 120 HZ +20/ +25°C Ω	Leakage Current IR-max. (5 min. +20/ +25°C (uA)	Ripple Current IN-max. (85°C 120 HZ (mA)	Basic Dimensions (mm) D (ø)	L	Weights
1		0.16		265		10	6.3	11	0.55g
1.5		0.16		177		13	6.3	11	0.55g
2.2		0.16		124		18	8	12.5	1.00g
4.7		0.16		55		30	10	12.5	1.50g
6.8		0.16		39		36	10	12.5	1.50g
10		0.16		26		55	10	20	2.30g
15	160	0.16		18		65	10	20	2.30g
22	(176)	0.16		12		95	12.5	25	4.00g
47		0.16		5.65		160	16	25	7.00g
68		0.16		3.90		190	16	25	7.00g
100		0.16		2.65		250	16	31.5	8.00g
0.47		0.18		635		7	6.3	11	0.55g
0.68		0.18		434		8	6.3	11	0.55g
1		0.18		298		12	8	12.5	1.00g
1.5		0.18		199		14	8	12.5	1.00g
2.2		0.18		140		20	10	12.5	1.50g
3.3		0.18		92		24	10	12.5	1.50g
4.7		0.18		64.5		29	10	12.5	1.50g
10	250	0.18		30		50	10	20	2.30g
22	(275)	0.18		13.5		85	12.5	25	4.00g
33		0.18		9.05		125	16	25	7.00g
47		0.18		6.35		160	16	31.5	8.00g
68		0.18		4.39		200	16	31.5	8.00g
0.47		0.20		705		8	8	12.5	1.00g
0.68		0.20		487		9	8	12.5	1.00g
1		0.20		332		12	10	12.5	1.50g
1.5		0.20		221		15	10	12.5	1.50g
2.2		0.20		155		18	10	12.5	1.50g
3.3		0.20		101		27	10	20	2.30g
4.7		0.20		70		32	10	20	2.30g
6.8		0.20		48		38	10	20	2.30g
10	350	0.20		33		60	12.5	25	4.00g
15	(385)	0.20		22		70	12.5	25	4.00g
22		0.20		15		95	16	25	7.00g
33		0.20		10		130	16	31.5	8.00g
47		0.20		7.05		170	18	31.5	10.0g

The Mini-super, radial leaded, Aluminum Electrolytics are available in capacity values from 0.1μF to 100μF and in voltalge ratings from 10V to 63V. Their small size and low leakage currents are comparable to their equivalent tantalum counterparts. Their cost is considerably less.

Ordering Code:

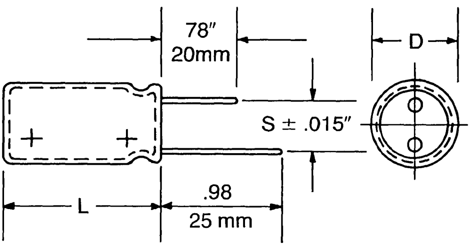
Example: 10 / 25 / 85555

Capacity — 10

Voltage — 25

Part Number — 85555

End Sealed — 85556



Lead Spacing and Diameter (mm)

Case	Spacing (S)	Diameter (d)
5.5x12	2.0	0.5
6.8x12	2.5	0.5
8.5x13.5	3.5	0.5

Technical Data

Operating Temperature Range: −40° to +85°

Leakage Current: (Max) after 2 min. of applied rated voltage at 25°C.
I_R = .002xCxV or .4μA
I_R = Leakage Current in μA
C = Capacity in μF
V = Rated Voltage

Dissipation Factor: Tan δ at 25°C and 120 Hz

V	10	16	25	63
Tan δ	.2	.17	.15	.1

Surage Voltage: 1.25 x Vdc

Life Test: 2,000 hours at 85°C with voltage applied.
or
(1,000 hrs./+ 95°C/U_n or
500 hrs./+105°/U_n)

Failure Criteria:
$\frac{\Delta C}{C}$ ≤ 20% of value initially measured.
Tan ≤ 200% of value initially specified.
I_R < Value initially specified.

Aluminum electrolytic capacitor with etched electrodes, encapsulated in aluminum case with external insulation.

They are radial leaded for vertical mounting usage. Low impedance at high frequency, high ripple current and long life with high stability are the most important features.

Ordering Code:

Example: 2200 / 16 / 85600

Capacitance (μF) — 2200

Rated Voltage — 16

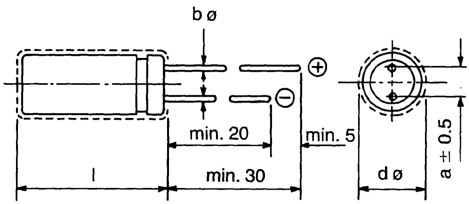
Code — 85600

End Sealed — 85606

Marking:

SIEMENS
HFC
Capacitance/Voltage
85600
Brazilian Industrie
Date

Polarity indicative in black border



Dimension Table

d x l	d_{max} x l_{max} (with insulation)	a	b
10 x 20	10.5 x 21	5	0.6
12.5 x 25	13 x 26		
16 x 25	16.5 x 26	7.5	0.8
16 x 31.5	16.5 x 32.5		
18 x 31.5	18.5 x 32.5		
18 x 35	18.5 x 36		

Dimensions in mm.

Technical Data

General specifications: IEC – 344 – 4 LL type

Climatic category DIN: GPF (−40 to +35°C/humidity category in accordance with DIN 40040)

Climatic category IEC: 40/085/56

Rated voltage range: 10 to 63V DC

Capacitance range: 22 to 2200μF

Capacitance tolerance: ± 20% (∂ 120Hz/20°C)

Max. dissipation factor: (∂ 120Hz/20°) according to the table

Max. impedance (20 – 100kHz/20°C) according to the table

Max. ripple current: (10 – 100kHz/ + 85°C) according to the table
When capacitors are utilized in another frequency and temperature conditions, the conversion factors given in the following tables must be utilized:

Temperature – °C	+40	+85
Conversion factor	2.5	1.0

U_R (V) \ freq. Hz	120	1K	10K	100K
10–16	0,7	0,92	1	1
25–40	0,6	0,9	1	1
63	0,5	0,87	1	1

The DC voltage plus the AC peak voltage value applied to the capacitor, must not exceed its rated voltage.

Peak voltage: 1.20 times the rated voltage (U_R)

Peak voltage test: It must not occur mechanical damage and electrolyte lost, if capacitance and dissipation factor are maintained within the specified limits, after 1000 successive cycles of test (½ minute ON and 5½ min. OFF) with the specified peak voltage applied to the capacitor using a series resistor of 1000Ω, at 25°C, and stabilized for about one hour.

Specified limits:

– $|\Delta C/C| \leq$ 10% of value initially measured.
– tgδ $\leq$ 150% of value initially specified.

Polystyrene/Styroflex® Polypropylene Capacitors

1. General

The film capacitors covered here in detail, are wound capacitors. According to their dielectric they are known as polystyrene (STYROFLEX) or polypropylene capacitors. The films used are flexible, biaxially aligned electro-insulating films. STYROFLEX®[1)] is made from the thermoplastic material polystyrene. Similar to DIN 41379 and VDE 0560-18 the abbreviations used are:

KS capacitors with polystyrene as dielectric
KP capacitors with polypropylene as dielectric

where K is derived from the German word "Kunststoff" (plastic) and S or P from the 5th letter of the dielectric material used. Aluminum foils and for some types also tin foils are used as electrodes.

After the winding process, the capacitors are subjected to a temperature treatment which causes the stretched polystyrene films to shrink. Thus, the capacitors are sealed and sufficient protection from moisture is ensured without being a hermetically sealed construction. Moreover, the wound unit is made mechanically rigid in order to provide stabilization of its main electrical properties.

STYROFLEX and polypropylene capacitors are preferably used in circuits, where particularly low loss capacitors, high capacitance stability and a constant temperature coefficient are required.

Because of the low dielectric losses and the constant negative temperature coefficient, the capacitors are particularly suitable for use as resonant circuit capacitors. The temperature coefficient of STYROFLEX capacitors is approximately -150×10^{-6}/K. Compared to polypropylene capacitors, they have a somewhat lower dissipation factor and better stability. The advantages of polypropylene capacitors with a temperature coefficient of approximately -200×10^{-6}/K are the better temperature behavior in the range of 70 °C/158 °F and 85 °C/185 °F, the only slight sensitivity against soldering, and the better resistance to solvents.

If ferrite coils with a correspondingly positive temperature coefficient are used the resonant frequency of the circuit can be kept largely independent of temperature.

2. Classification of capacitors

The choice of capacitors is determined by the following aspects:

Dielectric (because of the electrical properties)
Construction of the capacitors
Standard or high reliability versions
Humidity category (possibly hermetically sealed)
Minimum category temperature ϑ_{min}
Maximum category temperature ϑ_{max}

[1)] STYROFLEX® is a registered trademark of Norddeutsche Seekabelwerke Aktiengesellschaft, Nordenham.

2.2. Polypropylene capacitors (maximum category temperature 85 °C/185 °F)

2.2.1. Unprotected standard capacitors, meeting medium climatic requirements (humidity category E) page 93

These capacitors comply with the STYROFLEX types according to para. 2.1.1. They meet however humidity category E.

2.2.2. Protected types in plastic case, high reliability capacitors, meeting medium climatic requirements (humidity category E) page 103

These capacitors comply with the STYROFLEX types according to para. 2.1.3., they are, however, temperature stable up to +85 °C/+185 °F.

3. Dimensions

3.1. Unprotected capacitors

The thickness of the films used for the windings of the capacitors varies depending on their manufacturing process, hence resulting in varying diameters of the wound capacitors. The maximum diameters of unprotected capacitors indicated for the individual capacitor types can be understood as the upper limit of deviations, met on the average by 98% of a batch.

The diameter indications refer to the rated capacitance. The tendency of capacitance and diameter tolerance need not necessarily be synonymous.

The twin types B31070 to B31073 consist of two individual windings. The diameter indications refer to one individual winding. The diameter of the individual winding is referred to half the rated capacitance; its capacitance may amount to 45 to 55% of the total capacitance.

3.2. Protected and sealed capacitors

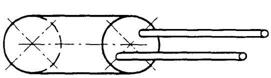
For these types, the capacitor windings are incorporated in cases which are epoxy resin sealed or hermetically sealed.

4. Capacitor terminations

The terminations of the capacitors are either on both sides of the winding or on one end.

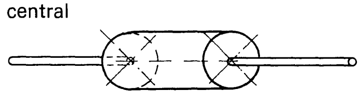
There are the following versions:

single-ended leads

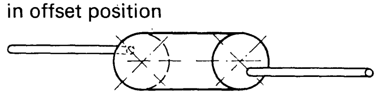


axial leads on both sides

central



in offset position



Preferred values:
E standard in accordance with DIN 41426 and IEC publication 63 (1963)

The following values of the E series have to be multiplied with the necessary integral positive or negative exponents of 10.

In any case the E standard values available have to be quoted from the individual data sheets.

E 6	E 12	E 24	E 48	E 96	E 192
100	100	100	100	100	100
					101
				102	102
					104
			105	105	105
					106
				107	107
					109
		110	110	110	110
					111
				113	113
					114
			115	115	115
					117
				118	118
					120
	120	120			
			121	121	121
					123
				124	124
					126
			127	127	127
					129
		130		130	130
					132
			133	133	133
					135
				137	137
					138
			140	140	140
					142
				143	143
					145
			147	147	147
					149
150	150	150		150	150
					152
			154	154	154
					156
				158	158
					160
		160			
			162	162	162
					164
				165	165
					167
			169	169	169
					172
				174	174
					176

E 6	E 12	E 24	E 48	E 96	E 192
			178	178	178
	180	180			180
				182	182
					184
			187	187	187
					189
				191	191
					193
			196	196	196
					198
		200		200	200
					203
			205	205	205
					208
				210	210
					213
			215	215	215
					218
220	220	220			
				221	221
					223
			226	226	226
					229
				232	232
					234
			237	237	237
					240
		240			
				243	243
					246
			249	249	249
					252
				255	255
					258
			261	261	261
					264
				267	267
	270	270			
					271
			274	274	274
					277
				280	280
					284
			287	287	287
					291
				294	294
					298
		300			
			301	301	301
					305
				309	309
					312

The series E 48 (complying with DIN 41426 and IEC publication 63/1963, refer to table on page 30) is also available as special version for the high reliability capacitors with $C_R \geqq 100$ pF. The standards E 96 and E 192 should be used for exceptions, only.

The available capacitance tolerances are also quoted. The code letters used comply with the IEC publication 62/1968 and are tabulated below.

Every tolerance is indicated in per cent down to a lower limit value of the rated capacitance. If capacitance ratings below these limits are ordered, the tolerance ranges of the individual data sheets apply.

Tolerances and values deviating from the table values will suitably be changed by us. Special versions are available, they need, however, our previous, expressive agreement.

Capacitance ratings of the **E 6 series** are **to be preferred.**

Capacitance tolerance	%	±10	±5	±2,5	±2	±1	±0,5	±0,3	Special value
Code letter in accordance with IEC publ. 62/1968		K	J	H	G	F	D	C	A
Appropriate E series for **standard** and **high reliability** capacitors above 10 pF		E 6 E 12 E 24	E 6 E 12 E 24	E 6 E 12 E 24	E 6 E 12 E 24	E 6 E 12 E 24	E 6 E 12 E 24	E 6 E 12 E 24	
Appropriate E series as special version for **high reliability** capacitors above 100 pF				E 48	E 48	E 48 E 96 E 192	E 48 E 96 E 192	E 48 E 96 E 192	
Limit value. Down to this value the above stated tolerances are valid in per cent	pF	10	20	40	50	100	200	330	
Tolerance below the limit value	see individual data sheets								

For rated capacitance values below 10 pF integral values are available.

5.3. Examples for rated capacitance values available

1st Example:

A capacitance of 651,32 pF has been calculated for a high reliability resonant circuit capacitor. Since the resonant circuit can only be adjusted within the close range of ± 1,3%, the capacitor is required to comply with the calculated value as exactly as possible. In the E 48 series the value 649 pF is tabulated. Some capacitor types are available with the necessary tolerance of ± 1%, thus meeting the requirement of being adjustable within ± 1,3%. They are thus suitable for circuit applications.

When measuring, it must be taken into account that each temperature change also causes a change in humidity, which influences the capacitors appropriate to their type and their time constant value of humidity (refer to para. 5.5.). The deviations of α_c caused by humidity, are at 65% air humidity and after a short-time measurement normally contained in the stated *TC* deviation limits. For sealed capacitors, the value α_c is independent of humidity and lower deviations are caused. For capacitances below 100 pF the α_c deviation limits are nonuniform, whereas the medium α_c values of the same type and the same aluminum foils used are decreasing with increasing capacitance.

The α_c values of types with tin foils, however, tend to increase with increasing capacitances. Some high-reliability types with aluminum foils have achieved a particularly low deviation of the α_c value because of a suitable construction.

In order to obtain a specified temperature coefficient deviating from that of polystyrene or polypropylene materials, for special applications (e.g. temperature compensated resonant circuits with a positive temperature coefficient α_1 of the inductance, which is different from the capacitor material) ceramic capacitors type 1 can be connected in parallel. As far as the capacitance of capacitors connected in parallel is mainly determined by STYROFLEX or polypropylene capacitors, a substantial improvement of the dissipation factor tan δ, as compared to ceramic capacitors, can be achieved. The parallel connection is of particular advantage for high capacitance values.

5.5. Moisture dependence of capacitance, humidity coefficient β_c

The capacitance value of unprotected and protected (sealed) capacitors is subject to humidity. Water vapor is absorbed by the dielectric as well as by the pockets and capillary tubes in the winding.

Low capacitance values up to approx. 100 pF (dependent on the capacitor type also up to 250 pF) reveal relatively high capacitance changes. At a relative humidity below 30%, the capacitance change is equal or lower than 0,1%, whereas at humidities above approx. 80% relatively high variations can be expected.

The humidity coefficient β_c of capacitance is in accordance with DIN 41380, part 3 and 4, para. 2.7.5., defined as follows:

$$\beta_c = \frac{2\,(C_2 - C_1)}{(C_2 + C_1)\cdot(F_2 - F_1)}$$

C_2 = Capacitance after humidity effect (relative humidity F_2)
C_1 = Capacitance before humidity effect (relative humidity F_1)

The value β_c is indicated in 10^{-6}/% relative humidity. Measurement takes place in accordance with DIN 41380, part 3, para. 5.4.3.2. and part 4, para. 5.3.3.2.

The following values apply:

	Range of relative humidity	Humidity coefficient β_c
STYROFLEX	50 to 85%	$+(60 \text{ to } 200)\cdot 10^{-6}$ per % rel. humidity
Polypropylene	50 to 95%	$+(40 \text{ to } 100)\cdot 10^{-6}$ per % rel. humidity

5.8. Temporary instability of capacitance

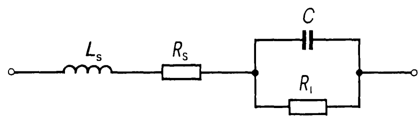
A temporary instability of capacitance, a sudden irregularity, as occurring with mica and ceramic capacitors does not appear with STYROFLEX capacitors and polypropylene capacitors because of their different construction.

6. Dissipation factor tan δ

Apart from the desired capacitance, each capacitor has further electrical characteristics, which can be shown as additional components in an equivalent circuit diagram as follows:

Equivalent circuit diagram:

L_s Series inductance
R_s Series resistance
R_i Insulation resistance (parallel resistance)
C Capacitance



Neglecting the inductance L_s, the following formula applies to the dissipation factor tan δ at the frequency f

$$\tan\delta = \frac{1}{2\pi \cdot f \cdot C \cdot R_i} + 2\pi \cdot f \cdot C \cdot R_s$$

taking $R_i \gg R_s$ and $f \ll f_r$ into consideration,

where $f_r = \frac{1}{2\pi\sqrt{L_s C}}$ is the self resonant frequency of L_s and C.

In the **lower** frequency range ($f < 1$ kHz) applies:

$$\tan\delta_l = \frac{1}{2\pi \cdot f \cdot C \cdot R_i}$$

In the **upper** frequency range ($f \gg 1$ kHz) applies:

$$\tan\delta_u = 2\pi \cdot f \cdot C \cdot R_s$$

The value R_s is determined by the lead and junction resistances and largely corresponds to the equivalent series resistance *ESR* (compare to DIN 41380, part 3 and 4, para. 4.4.).

6.1. Measurement

The dissipation factor values indicated for the individual types are measured at temperatures between 15 and 35 °C/59 and 95 °F and a relative humidity of max. 50%, thus largely meeting DIN 41380, part 3 and 4, para. 3.3.6. (edition Feb. 1978). When measuring, the ac voltage applied may not be higher than the permitted rms ac voltage and in no event higher than 20 V. The dissipation factor values indicated with the measuring frequencies for the individual capacitor types may be exceeded by 10% of the capacitors up to a factor of 1.5.

7.2. Minimum and maximum category temperature ϑ_{min} and ϑ_{max}[1)]

The temperature range[2)] at which the capacitor may be operated continuously according to its climatic category, lies between the minimum and maximum category temperature ϑ_{min} and ϑ_{max}.

7.3. Category voltage U_c

The category voltage is the maximum voltage, at which the capacitor, may be operated continuously.

The sum of several partial voltages should not exceed the category voltage U_c. U_c depends on the capacitor surface temperature. At 40 °C/104 °F, U_c of STYROFLEX capacitors always complies with the rated voltage U_R. The category voltage U_c can be determined with the aid of the factors lying between the rated temperature ϑ_R and the max. category temperature ϑ_{max} as tabulated below:

Temperature		Derating factor for the rated voltage U_R and the permissible rms ac voltage Uac, respectively	
		STYROFLEX	Polypropylene
40 °C/104 °F	Rated temperature ϑ_R	1,0	1,0
50 °C/122 °F 60 °C/140 °F 70 °C/158 °F		0,95 0,9 –	1,0 1,0 1,0
70 °C/158 °F 85 °C/185 °F	Maximum category temperature ϑ_{max}	0,8 –	– 1,0

7.4. Alternating voltage loading capability Uac

The superimposed alternating voltage Uac is the rms alternating voltage that may be applied to a capacitor in addition to a direct voltage. The sum of the direct voltage and the peak value of the superimposed alternating voltage shall not exceed the category voltage U_c (see para. 7.3.). The maximum alternating voltage Uac at rated temperature ϑ_R is indicated for the individual types. At temperatures between ϑ_R and ϑ_{max}, the same derating applies to the alternating voltage as to the category voltage U_c (see table, para. 7.3.).

7.5. Category current I_c

The category current I_c is the current, at which the capacitor may be operated continuously.

[1)] In accordance with IEC publication 384-1 "Lower category temperature ϑ_{LC}" and "Upper category temperature ϑ_{UC}."
[2)] In accordance with IEC publication 384-1, "Limit temperature range" or "Climatic category".

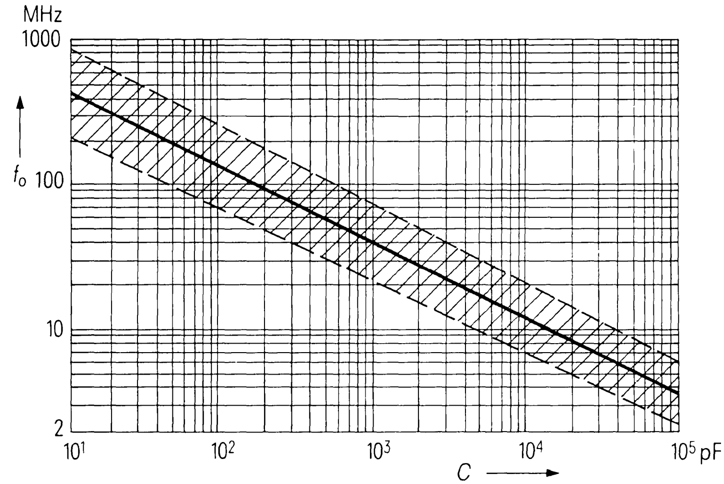
9. Self inductance L_s Self resonance f_r

At high frequencies, STYROFLEX and polypropylene capacitors are subject to self resonances caused by the self inductance. The self resonance may disturb the design of circuits. The self inductance is influenced by the number of supply lines to the electrodes and by the winding construction. All capacitors described here, are of low inductance due to bifilar layer currents in accordance with DIN 41380, part 3 and part 4 (Febr. 1978), para. 2.3.2.4. or because of face-contacting. If not otherwise stated,

max. 1 nH per 1 mm lead or capacitor length

is the typical value of the self inductance.

The self inductance for the capacitors can be reduced by special measures. Particularly low values are characteristic for capacitors with face contacts. The frequency range of the self resonance versus capacitance is illustrated in the following diagram:



10. Screening

As far as the outer layer of the capacitor is grounded, it also performs screening effects.

This applies to unprotected capacitors as well as to those in metal cases where the outer layer is connected to the metal case. The outer layer connection (and possibly the metal case) is marked by a colored ring or a symbol.

Capacitors enclosed in a metal case, that is physically not connected to the layer, have a screening capacitance between the cases grounded in most cases and the identified layer. This must be accounted for in the design of circuits.

15. Removal of soldering agents

The films of unprotected STYROFLEX capacitors can be attacked by some cleaning agents used to remove the soldering agent. It is, therefore, recommended to use protected or sealed STYROFLEX capacitors, when a special cleaning is necessary.

Polypropylene capacitors are resistant to those cleaning agents which are based on hydrocarbon halides. Such agents are trichloroethylene, perchloroethylene, and 1,1,1 trichlorothene (trade name Chlorothene, Mecloran etc.); furthermore, trifluorine-trichlorothene (trade name Freon, Frigen, Kaltron, Arklone, Flugene, etc.) purely, or mixed with alcohol or other solvents.

The reference reliability is the reliability for a particularly defined load (reference load). In para. 3.4. of the DIN specification mentioned, the following parameters are quoted for the reference load: e.g.

ambient temperature: 40 °C/104 °F
relative humidity: 65%

where appendix 2 of the DIN specification 40040, page 7, should be taken into consideration. This specification includes graphs for a reduced relative humidity versus temperatures above room temperature.

The failure quota (para. 16.3.) and the load duration (para. 16.4.) are quoted as value for the reference reliability.

Our data sheets, generally, contain data on the reference reliability at rated voltage U_R and at the low voltage of 12 V.

16.3. Failure quota

The failure quota means:

Failures in 10^9 component hours for an adequately large batch at rated load and a defined load duration (see para. 16.4.). The unit applied is "fit" (failure in time 10^{-9}/h).

The failure quota is coded in the first code letter after the climatic category, i.e. in the 4th code letter.

4th code letter	Failure quota (failures per 10^9 component hours)
H	10 fit
J	30 fit
K	100 fit
L	300 fit
M	1000 fit
N	3000 fit
Z	see data sheet

16.3.1. Failure criteria

The following failure criteria are taken as a basis for STYROFLEX and polypropylene capacitors:

Total failure: short or open circuit

Failure due to variation:
- capacitance: change $> 3 \cdot i_z$
- dissipation factor: $> 2 \tan \delta$ (tabulated value)
- insulation resistance: less than half the values permitted in accordance with DIN 41380, part 3 and 4, para. 3.7., after storage of 2 years.

17. Additional sealed assembly of unprotected capacitors

Even traces of humidity can affect the capacitance of STYROFLEX capacitors. Polypropylene capacitors are insensitive in this respect. In this context capacitors are only understood as sealed, when they are soldered or welded in metal, glass, or ceramic cases.

Organic materials as sealing agents or the use of stuffing bushes for rotatable axes only provide insufficient sealing. Despite the sealed assembly, often traces of water vapor existing in the capacitor and in the case are sufficient to condense after cooling below the dew point. Therefore, the variations of capacitance or insulation resistance could possibly be higher than those of unprotected capacitors.

For a common assembly of capacitors and other components in one case, the mutual influences should be taken into account. Chemical separations can affect or impair the delicate dielectric. Assemblies should therefore be made only in special cases after their compatibility has carefully been tested. Filters and circuits should be adjusted after having been assembled.

18. Tests

18.1. Material test

All materials necessary for the production of capacitors are subject to cycle-checking with regard to their electrical and mechanical characteristics. The yielded test values include, as a released value, a certain safety range compared to the guaranteed values.

18.2. Final test

Detailed inspection

Capacitance tolerance and voltage resistance of the capacitors are checked. To capacitors of medium climatic requirements a leakage test is performed, meeting the DIN 40046, sheet 15, test Q, requirements. Further tests are provided for capacitors with particular applications.

Random test

Dissipation factor, insulation resistance and mechanical performance are tested by method of random sampling.

18.3. Quality inspection

A quality test field being independent of the manufacturing department continually tests selected production samples. The measurements of the detailed inspection and random sampling are checked; the following properties are additionally tested:

Resistance to climatic conditions
Operational reliability in endurance tests
Solderability

18.4. Acceptance test

For an acceptance test and the measurement of the capacitance refer to para 5.1. A capacitor test at test voltage in accordance with DIN 41380, part 3, para. 5.4.2. and part 4, para. 5.3.2. may be performed by the customer only once.

DIN 41 313	Marking of terminals of capacitors for rated dc voltages up to 1000 V.
DIN 41 314	Coded marking of the data on components for telecommunications equipment.
DIN 42 007, Part 1 and 2 (draft)	Terms and additional data for capacitors (edition November 1974).

20. Characterization and marking

The following data is stamped on:

Rated capacitance
Tolerance code letter

Depending on the size of the capacitor, the following additional data is printed on:

Climatic category } (only for high reliability types)
Date of manufacture }
Rated voltage (for assembled types)
Type number
Ordering code

The outer layer of unprotected capacitors is designed with a color ring or a line. The rated voltage can be marked by the color of the ring or in an uncoded imprint. Each rated voltage is assigned to definite colors (see para. 7.1.). The outer layer and possibly also the ground connection of a metal case of sealed capacitors is symbolized in accordance with DIN 41313.

The following colors are used:

		STYROFLEX	Polypropylene
Standard versions	unprotected types	black	red
High reliability versions	unprotected types	blue	–
	types in plastic case	black	black
	sealed types in metal case	blue	–

The rated capacitance for the flat-winding types B 31112 and B 31113 is only indicated on the package.

21. Designation of capacitors

In accordance with DIN 41379 8/68, plastic capacitors are designated according to the 5th letter of the dielectric material. As already mentioned in para. 1, STYROFLEX capacitors with a polystyrene dielectric are designated as KS capacitors, film capacitors comprising a polypropylene dielectric as KP capacitors.

The ordering code examples on page 54 and on the individual data sheets are similar to those of DIN 41380, part 3 and 4, para. 9.

Since the 15 digits available are insufficient for differing all the capacitor characteristics the letters intended for the revision status designation are divided into 3 groups:

A to H; J to R and S to Z

Components with the same B-number and a revision status between A and H are related to components of the revision status J to R, but they are generally not interchangeable. The group S to Z is intended to mark special versions. Detailed data is given for the individual types.

Example: The height of a capacitor has been shortened from 40 to 30 mm at unchanged shape and electrical data. The capacitor with the larger dimensions was marked with the revision status code letter A, whereas the smaller size is designated with B. A can be replaced by B, but usually not vice versa.

Despite their unimportance for most users, these designations should be given, since a certain percentage of uncommon application excludes the above mentioned interchange. In these cases the changed code letter causes the person who attends the collecting card or the reviser of the production planning, to check whether the change is acceptable or not.

Important component variations regarding construction or electrical properties which exclude the exchange of former types by new ones, are principally performed by a completely changed designation and not only by a changed revision status code letter.

A certain period of time is necessary to perform the change of the revision status. After this period of time which is often indicated on the data sheets, the change has been completed, so that components in accordance with the former revision status are no longer available. If components of the former revision status are ordered, automatically those of the new one will be delivered.

22.4. Digit 8 (rated voltage)

The code figures for capacitor voltage ratings are not systematized. The meaning of the rated voltage code figures is indicated on the individual data sheets.

22.5. Digits 9 to 14 (rated capacitance and tolerance)

When ordering capacitors it is necessary to code the desired rated capacitance as well as the appropriate tolerance values.

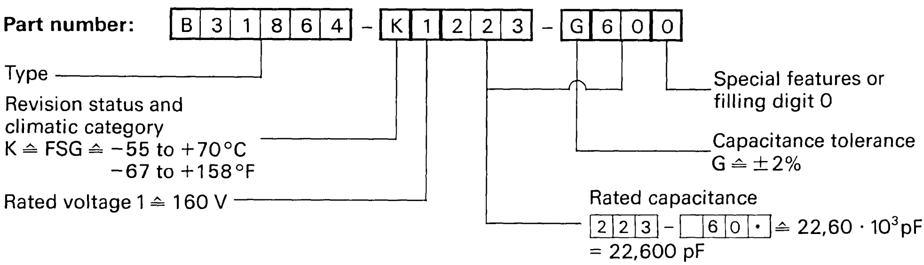
a) The value will be converted into the form $a \times 10^b$ pF; the μF values must be converted into the basic unit "pF". The factor a is the unchanged figure sequence of the value, with the decimal comma (decimal point) behind the second figure. The exponent *b* of the multiplier 10^b is clearly specified by the position of the decimal comma (decimal point) and the basic unit "pF", and can admit values from 0 to 9. The lowest value to be represented is therefore 0,01 pF, the highest 99,990 μF.

b) The 2 figures before the comma (point) are contained in the 9th and 10th digit; thus the decimal comma (decimal point) must always be imagined as being behind digit 10.

c) The exponent *b* which designates the number of naughts of the multiplier (see the following code table for capacitance values) is the code number in digit position 11.

d) 2 figures max. behind the decimal comma (decimal point) are contained in digit position 13 and 14.

The Siemens ordering codes (part numbers) are to be found on the data sheets. The capacitor quoted in the above mentioned ordering code example has the following Siemens ordering code:



Zeroes immediately after the tolerance code letters may be omitted (abbreviated writing, see next paragraph).

23.1. Writing of part numbers

The SN standard 01001, November 1977, allows abbreviated writing of Siemens part numbers (ordering codes). Many types, however, are also known under their unabbreviated part number.

The following examples will explain both identical writing methods which can occur for one component.

We don't want to bother our clients with the writing rules for our part numbers. When ordering, please write the part numbers in the same way as listed in our data books, data sheets, or SCS List.

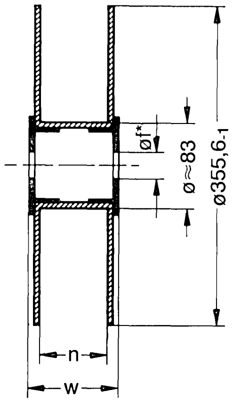
It is understood that both writing methods are accepted. Please be understanding when you have ordered "unabbreviated" and receive "abbreviated".

Examples:

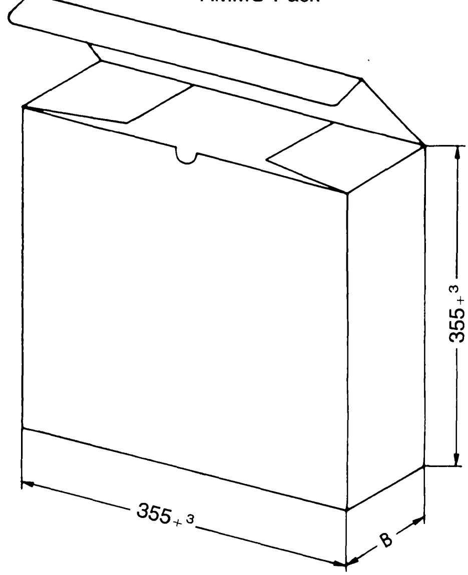
Unabbreviated writing	Abbreviated writing	Remarks
STYROFLEX capacitors		
B 31 063-B1222-H000	B 31 063-B1222-H	i.e. 2200 pF untaped
B 31 063-B1222-H006	B 31 063-B1222-H6	i.e. 2200 pF taped
B 31 861-A1222-F090	B 31 861-A1222-F90	i.e. 2209 pF untaped
B 31 861-A1222-F900	B 31 861-A1222-F900	i.e. 2290 pF untaped

Types of packaging

Reel packing



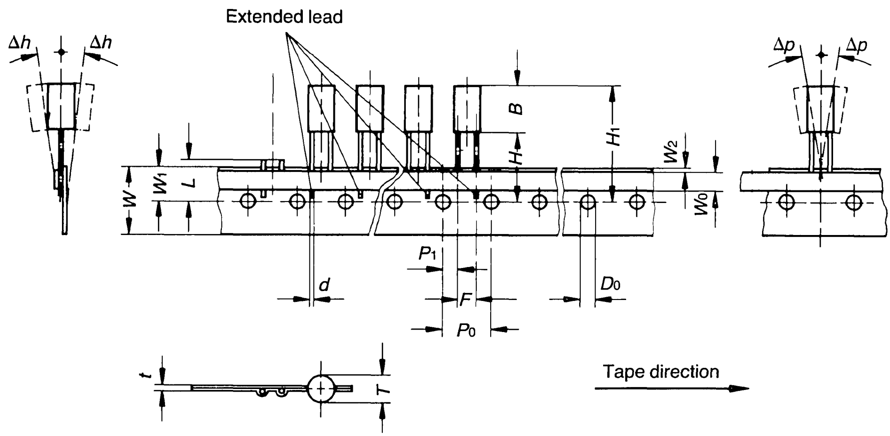
AMMO-Pack



Tape spacing b	Reel width w	Reel distance n	Carbon width B
63±2	87^{+1}	78^{+1}	ca. 87^{+2}
68±2	92^{+1}	83^{+1}	ca. 92^{+2}
73±2	98^{+1}	89^{+1}	ca. 98^{+2}
83±2	$111^{+1,5}$	$102^{+1,5}$	ca. 111^{+2}

*) old: ø f = 16.5 ± 1 mm
new: ø f = 30 ±1 mm

Taping of radial polypropylene capacitors type B 33061



Designation	Symbol	Dimension	Tolerance	Notes
Lead diameter	d	0,5	±0,05	
Spacing hole center/ lead center	P_1	3,85	±0,7	
Lead spacing (LS)	F	5	+0,6 −0,1	measured at tape edge
Feed hole spacing	P_0	12,7	±0,2	± 1 mm/72 x P_0
Slope of capacitors	Δh	0	±2	measured at upper head edge
Slope of capacitors	Δp	0	±1,3	measured at upper head edge
Base width	W	18	±0,5	
Adhesive width	W_0	6	±0,5	
Spacing hole center/ upper tape edge	W_1	9	±0,5	
Position of adhesive tape	W_2	0,5	+0,5	
Spacing hole center/ lower component edge	H	18 16,5	+2 ±0,3	B33061-E... } depending on B33061-Z... } assembly system
Spacing hole center/ upper component edge	H_1	32,2 max.		
Hole diameter	D_0	4,0	±0,2	
Tape thickness	t	0,7	±0,2	
Spacing hole center/ lead cutting position	L	11,0 max.		
Capacitor diameter	T	6,7 max.		
Capacitor height	B	12,5 max.		

Polystyrene/Styroflex® Capacitors (KS)

STYROFLEX Capacitors (KS), unprotected, axial

in accordance with DIN 44126, part 1 (Dec. 1974); standard versions

Axial-leaded standard capacitors intended for use at 160 V and 630 V. Suitable for RF and IF filters.

U_R	**160 V**	**630 V**			
ϑ_R	40°C/104°F	40°C/104°F			
U_c at ϑ_{max}	130 V	500 V			
Uac	65 V	125 V			
l =	**11,5 mm**	**16,5 mm**	**21,5 mm**	**31,5 mm**	
I_c	1,0 A	1,2 A	1,5 A	2,0 A	
DIN climatic category	HSG				
ϑ_{min}	−25°C/−13°F				
ϑ_{max}	+70°C/+158°F				
IEC climatic category	25/070/04				
$\|\Delta C/C\|$	≦(1% + 1 pF)				
tan δ_F	1,4 times the tabulated value				
	160 V	**630 V**			
R_{iF} 98%	≧ 10^4 MΩ	≧ 10^4 MΩ			
2%	≧ 10^3 MΩ	≧ 10^3 MΩ			
i_Z for C_R > 100 pF	≦(0,2% + 0,4 pF)	≦(0,2% + 0,4 pF)			
α_C for C_R > 100 pF	−(100 to 250) · 10^{-6}/K	−(100 to 200) · 10^{-6}/K			
tan δ (in 10^{-3})	**≦100 pF**	**... 1000 pF**	**... 4700 pF**	**... 22000 pF**	**... 27000 pF**
≦1 kHz	0,1	0,1	0,1	0,2	0,4
10 kHz	0,2	0,2	0,2	0,3	0,5
100 kHz	0,3	0,3	0,4	–	–
1000 kHz	0,4	0,5	–	–	–
R_i 98%	10^5 MΩ				
2%	10^4 MΩ				

STYROFLEX Capacitors (KS), protected

in square plastic case; high reliability versions

DIN draft 44127 in preparation

Epoxy resin sealed plastic case (flame retardant in accordance with VL 94 V-0). Particularly suitable for use in RF, IF, and carrier frequency filters owing to low self inductance (≧ 180 pF due to face contacting) and low relative failure rate during a load duration of 10^5 hours. Their square shape provides particular suitability for use in combination with RM SIFERRIT cores.

U_R ϑ_R U_c at ϑ_{max} Uac	**63 V** 70°C/158°F[1] 63 V 25 V		**Resistance to vibration** Test F_c: Vibration partial test B 1 in accordance with DIN 40046, sheet 8, 7.70 and IEC publication 68-2-6 "Vibration", edition 1970
I_c	1,0 A		
at U_c at 12 V	GSE/ZR 200 fit GSE/KR 100 fit	Rare and slight dew precipitation permitted	Duration of endurance conditioning: 3 x 120 min. Frequency range: 10 to 55 Hz Displacement amplitude: 0.75 mm (max. 10g)
ϑ_{min} ϑ_{max} **IEC climatic category** $\mid \Delta C/C \mid$ tan δ_F R_{IF} 98%	−40°C/−40°F +70°C/+158°F[1] 40/070/56 ≦(1%+1 pF) 1,4 times the tabulated value ≧5 · 10^4 MΩ		**after damp heat test of 21 days** ≦|0,75%+0,75 pF| 1,4 times the tabulated value ≧5 · 10^4 MΩ
i_Z[2]	≦ (0,25%+0,4 pF)		
α_C[2]	−(60 to 180) · 10^{-6}/K		

tan δ (in 10^{-3})	≦ 1000 pF	... 4700 pF	... 22000 pF	... 56000 pF
≦ 1 kHz	0,2	0,2	0,2	0,3
10 kHz	0,2	0,3	0,3	0,4
100 kHz	0,3	0,4	0,5	0,6
1000 kHz	0,5	–	–	–

R_i	
98%	10^5 MΩ
2%	5 · 10^4 MΩ

[1]) Operation at 85 °C/185 °F possible for max. 1000 hours, typical value for capacitance changes at 0,8 U_c = ± 0,5%.
[2]) For C_R ≧ 180 pF.

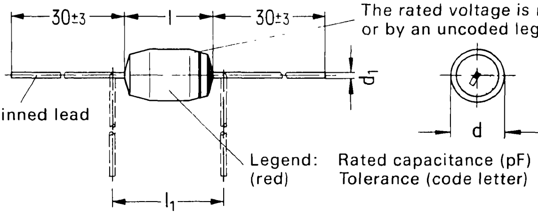
Polypropylene Capacitors (KP)

Polypropylene Capacitors

B 33062

Tubular, axial-leaded capacitor with plastic-sealed face ends; standard version.

Apart from general applications the capacitor can be used at temperatures between −25 and +85°C (−13 and 185°F) as resonant circuit capacitor in RF and IF filters because of its low dissipation factor and a sufficiently high stability. Negative temperature coefficient. Increased protection against humidity or chemical effects is obtained by the plastic-sealed face ends. Due to an upper category temperature of 85°C (185°F), the capacitor is particularly suitable for use in printed circuits.



Dimensions in mm

$l_{1.5}$	l_1	d_1
13.5	15	0.6
18.5	20	0.8
23.5	25	

Rated voltage U_R Color ring					**160 V dc** red-violet	**630 V dc** black
Type with code for revision status and rated voltage					**B 33062–B1**	**B 33062–B6**
Rated capacitance C_R in pF	Tolerance B 33062–B1	Tolerance B 33062–B6			**Dimensions** Diameter d_{max} × length l	
2... 10		± 1 pF ≙ F				4.0 x 13.5
> 10... 20						
> 20... 40				±5% ≙ J		
> 40... 47			±2.5% ≙ H			
> 47... 100						4.5 x 13.5
> 100... 330		±1% ≙ F				
> 330... 1000	± 1% ≙ F ± 2.5% ≙ H ± 5% ≙ J				4.5 x 13.5	6.0 x 13.5
> 1000... 1500						6.9 x 13.5
> 1500... 2200					5.0 x 13.5	7.9 x 13.5
> 2200... 3300					5.7 x 13.5	
> 3300... 7500					7.8 x 13.5	
> 7500... 8200					8.1 x 13.5	
> 8200...10000					8.7 x 13.5	
> 10000...22000					9.4 x 18.5	
> 22000...27000					10.2 x 18.5	
> 27000...33000					10.0 x 23.5	

E series available:
E 24 series

E 24:	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91

The dimensions apply to the greatest capacitance value.
Diameters for lower capacitance values can be interpolated.

(cont'd)

Permissible tensile strength of the leads in accordance with DIN 40046, sheet 19	10 N in the lead direction (for 10 sec)
Solder conditions Max. soldering duration Max. solder bath temperature	6 sec 265°C/509°F The capacitors are resistant to cleaning agents based on halogen hydrocarbons, such as Freon and Chlorothene

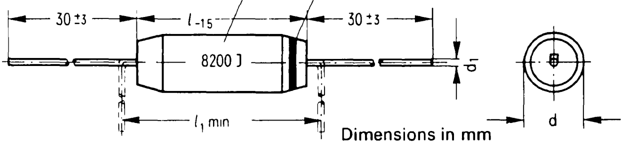
Rated voltage U_R Rated temperature ϑ_R Category voltage U_c (at ϑ_{max}) Perm. sinusoidal rms ac voltage U_{AC} (at ϑ_R)	100 V dc 85°C 100 V dc 40 V
Category current I_c	1.0 A
DIN climatic category	G PE Rare and slight dew precipitation permitted
Lower category temperature Upper category temperature IEC climatic category Capacitance change $\Delta C/C$ Dissipation factor tan δ_F Insulation resistance R_{IF} 98% 2%	− 40°C/ + 85°C/ 40/085/56 $<$ + [0.75% + 0.5 pF] 1.4 times the tabulated value $\geqslant 5 \times 10^4$ MΩ $\geqslant 10^4$ MΩ
Capacitance drift i_z	$\leqslant$ [0.3% + 0.4 pF]
Temperature coefficient α_C of capacitance	− (150 to 300) x 10^{-6},K

Dissipation factor tan δ

(in 10^{-3})	..1000pF	..1500pF	..10000pF	..33000pF	..100000pF
$\leqslant$ 1 kHz	0.3	0.3	0.2	0.2	0.3
10 kHz	0.3	0.4	0.3	0.3	0.4
100 kHz	0.4	0.5	0.4	0.5	0.8
1000 kHz	0.6	–	–	–	–

Insulation resistance R 98% 2%	10^5 MΩ 5×10^4 MΩ
Self-inductance Ls per cm lead and capacitor length	approx. 10 nH
Solder conditions Max. soldering duration Max. solder bath temperature (see also data book "Low Loss Capacitors" page 32)	 6 sec. 265°C The capacitors are resistant to cleaning agents based on halogen hydrocarbons, such as Freon and Chlorothene
Vibration resistance Test F_c: vibration partial test B 1 in accordance with DIN 40046 and IEC publication 68-2-6	Endurance conditioning: 3 x 120 minutes Frequency range: 10 to 55 Hz Displacement amplitude: 0.75 mm (conforming to max 10 g or 89m/sec^2)
Permissible tensile strength of the leads in accordance with DIN 40046, sheet 19	25 N in the lead direction (for 10 sec)
The information describes the type of component shall not be considered as assured characteristics.	Terms of delivery and rights to change design are reserved.

Legend: (red)
Rated capacitance (pF)
Tolerance (code letter)
Rated voltage (uncoded or color ring)
Outer layer (line or color ring)



$l_{-1,5}$	$l_{1\,min}$	d_1
11,5	15	0,6
16,5	20	0,8
21,5	25	

Rated voltage U_R Color ring				**160 V** red-violet	**630 V** black
Type with code for revision status and rated voltage				**B 33063-B1**	**B 33063-B6**
Rated capacitance C_R pF	Tolerance			**Dimensions** Diameter d_{max} × length l	
2 to 10	± 1 pF ≙ F				4,0 × 11,5
> 10 to 20					
> 20 to 40			± 5% ≙ J		
> 40 to 47		± 2,5% ≙ H			
> 47 to 100					4,5 × 11,5
> 100 to 330	± 1% ≙ F				
> 330 to 1000				4,5 × 11,5	6,0 × 11,5
> 1000 to 1500					6,9 × 11,5
> 1500 to 2200				5,0 × 11,5	7,9 × 11,5
> 2200 to 3300				5,7 × 11,5	7,6 × 16,5
> 3300 to 7500				7,8 × 11,5	10,4 × 16,5
> 7500 to 8200				8,1 × 11,5	9,6 × 21,5
> 8200 to 10000				8,7 × 11,5	10,4 × 21,5
> 10000 to 15000				8,0 × 16,5	12,3 × 21,5
> 15000 to 22000				9,5 × 16,5	14,5 × 21,5
> 22000 to 27000				10,2 × 16,5	
> 27000 to 33000				10,2 × 21,5	
> 33000 to 47000				11,7 × 21,5	
> 47000 to 82000				15,0 × 21,5	
> 82000 to 100000				16,5 × 21,5	

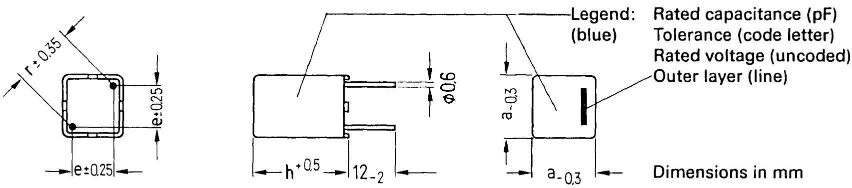
Ordering example B 33063-B 1 823-H

Type — B 33063-B
Revisions status, Rated voltage 1 = 160 Vdc, 6 = 630 Vdc — 1
Rated capacitance 823 ≙ 82 · 10^3 pF = 82000 pF — 823
Capacitance tolerance, e.g. H ≙ ± 2,5% — H

For ordering information refer to page 51 to 54.

E-series available: E 6, E 12, and E 24 (see page 30). The E 6 values are preferred values.

The dimensions apply to the greatest capacitance value.
Diameters for lower capacitance values can be interpolated.



Dimensions in mm

Rated voltage U_R	**63 V**					
Type with code for revision status and rated voltage	**Rated capacitance** C_R		**Dimensions**			
	pF	Tolerance	*a*	*h*	*e*	*r*
B33531-A5	100 to 9200	± 2,5% ≙ H ± 1% ≙ **F**	6,3	10,5	5,08	7,2
	> 9200 to 21 000		7,5	12,5		
	> 21 000 to 43 000		10,0		7,62	10,75
	> 43 000 to **68 000**		12,5		10,16	14,35

Ordering code example:

B 3 3 5 3 1 - A 5 6 8 3 - F

Polypropylene capacitor B33531 68000 pF ± 1% 63 V FPE

For ordering information refer to page 51 to 54.

E-series available: E 24, E 48, and E 96 (see page 30).
The E 24 values are preferred values.

Multilayer Capacitors

Multilayer Capacitors

1. Introduction

Owing to special production methods thin layers can be manufactured from the ceramic materials. These layers are used to design capacitors of highly reliable mechanical and electrical properties. The ceramic multilayer capacitors consist of a monolithic ceramic block into which the capacitor electrodes are sintered comblike. At the front ends of the ceramic block the individual metal layers appear at the surface where they are joined by sintered metal layers. Oxide and titanate ceramic are used as dielectric materials. Depending on requirements the four materials COG (NPO), BX, X7R, and Z5U are available.

2. Capacitor construction

The capacitance depends on the following parameters:

- dielectric material
- dielectric thickness
- effective area

To increase the volume capacitance you can

- raise the dielectric constants
- increase the effective area
- reduce the dielectric thickness

With multilayer ceramic capacitors two of these possibilities have been taken into account:

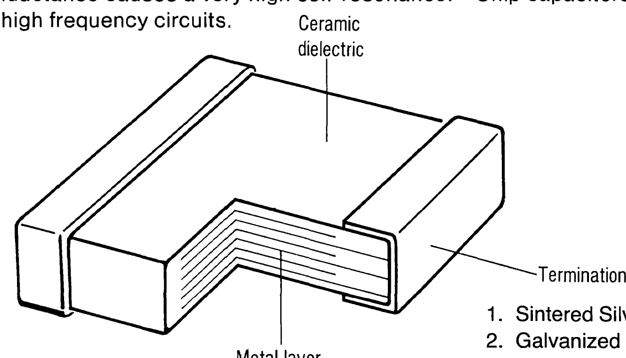
- increase the active areas by connecting individual layers in parallel
- reduce the dielectric thickness by appropriate production methods

Multilayer capacitors are available as:

- chips
- caps

2.1 Chips

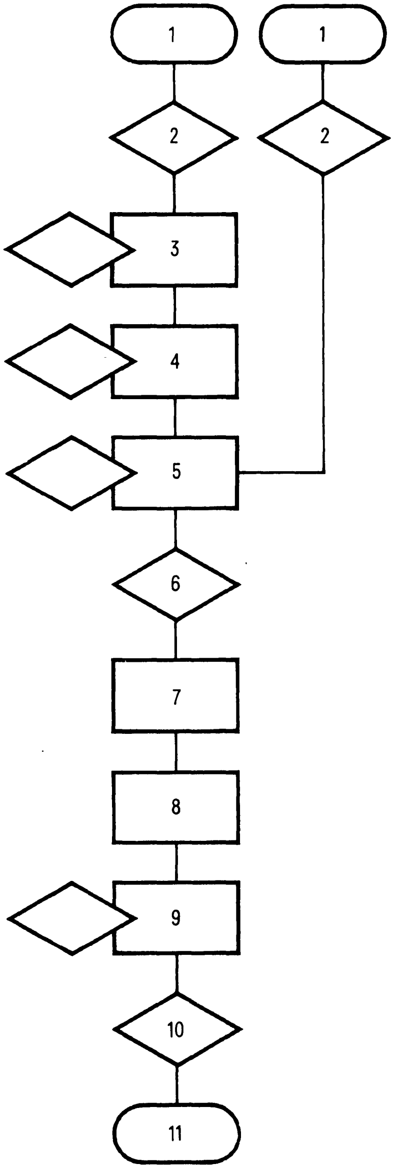
Chips are available without leads for direct soldering or cementing into film circuits. Their insignificant self-inductance causes a very high self-resonance. – Chip capacitors are particularly suitable for high frequency circuits.



1. Sintered Silver
2. Galvanized Nickel
3. Galvanized Tin

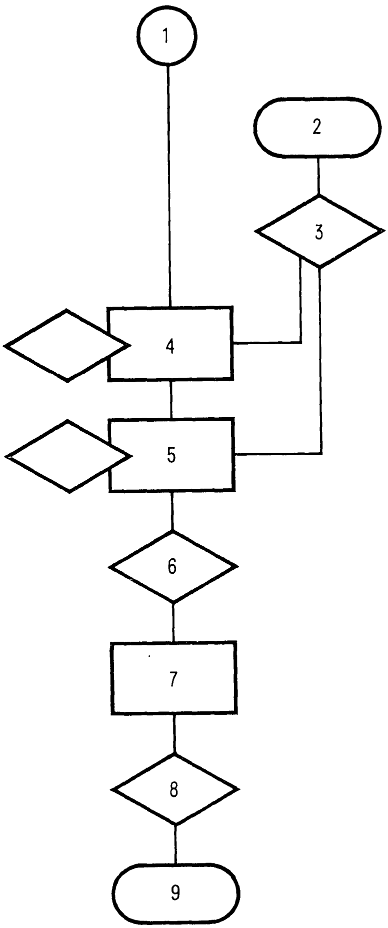
3. Production and examination plan

3.1 Dielectric



1 Incoming ceramic raw materials
2 Incoming examination
3 Preliminary grinding
4 Transformation (solid state reaction)
5 Subsequent grinding
6 Release examination
7 Production of binding agent
8 Production of ceramic slip
9 Production of ceramic film
10 Optical and mechanical examination
11 Storage

3.3 Cap production



1 Supplied chips
2 Incoming material
3 Incoming examination of the raw material
4 Connecting the leads
5 Encapsulating the wired chips
6 Thermal and chemical examination
7 Marking
8 Quality and reliability examination
9 Delivery to shipping warehouse

4. Types available (survey)

4.1. COG chips

Rated capacitance C_R	Rated voltage V_R	EIA standard	Page
1.0 pF – 680 pF 10 pF – 820 pF 100 pF – 1 200 pF 150 pF – 1 500 pF 47 pF – 1 500 pF 330 pF – 3 900 pF 330 pF – 4 700 pF 1 000 pF – 6 800 pF 1 500 pF – 15 000 pF	50 V dc; 100 V dc	0805 1005 1505 1805 1206 1808 1210 1812 2220	

4.5. COG caps

Rated capacitance C_R	Rated voltage V_R	Dimensions in mm (w x l x t)	Lead spacing	Page
4.7 pF – 560 pF 4.7 pF – 82 pF	50 V dc, 100 V dc 200 V dc	5.5 x 5.0 x 2.5	2.5 mm	
330 pF – 6800 pF 100 pF – 680 pF	50 V dc, 100 V dc 200 V dc	6.5 x 5.0 x 3.2		
4.7 pF – 560 pF 4.7 pF – 82 pF	50 V dc, 100 V dc 200 V dc	5.5 x 5.0 x 2.5	5.0 mm	
330 pF – 6800 pF 100 pF – 680 pF	50 V dc, 100 V dc 200 V dc	6.5 x 5.0 x 3.2		
3300 pF – 27000 pF 820 pF – 4700 pF	50 V dc, 100 V dc 200 V dc	9.0 x 7.5 x 3.8		
12000 pF – 68000 pF 5600 pF – 8200 pF	50 V dc, 100 V dc 200 V dc	11.5 x 10.0 x 5.0		
4700 pF – 68000 pF 4700 pF – 8200 pF	50 V dc, 100 V dc 200 V dc	11.5 x 10.0 x 5.0	10 mm	
27000 pF – 100000 pF 10000 pF – 18000 pF	50 V dc, 100 V dc 200 V dc	14.0 x 12.5 x 5.0		

5. Brief data

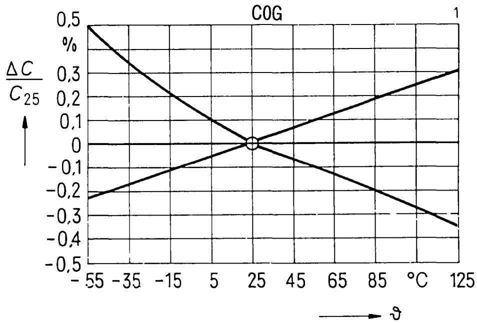
Designation in acc. with EIA standard RS-198-B	C0G	X7R	Z5U
Dielectric	class 1	class 2	class 2
Temperature range	–55 to +125°C	–55 to +125°C	+10°C to +85°C
DIN climatic category (DIN 40040)	FKF	FKF	LPF
IEC climatic category (IEC 68, part 1; DIN 40045)	55/125/56	55/125/56	05/85/56
Capacitance change within temperature range	$\pm 30 \times 10^{-6}$/K	±15%	+22% –56%
at rated voltage V_R	$\pm 30 \times 10^{-6}$/K	–	–
Voltage test	$2.5 \times V_R$		
Dissipation factor tan δ > 50 pF	$< 1.5 \times 10^{-3}$		
(limit value) ≦ 50 pF	$< \left(\frac{15}{C} + 0.7\right) \times 10^{-3}$	$< 25 \times 10^{-3}$	$< 30 \times 10^{-3}$
Insulation resistance[1] R_{is} at 25°C	$> 10^5$ MΩ	$> 10^5$ MΩ	$> 10^4$ MΩ
at 125°C	$> 10^4$ MΩ	$> 10^4$ MΩ	–
Time constant τ at 25°C	> 1000 sec	> 1000 sec	> 500 sec
at 125°C	> 100 sec	> 100 sec	–
Capacitance drift $\|i_z\|$	≦ (0.2% + 0.4 pF)	–	–
Aging (typical value) Capacitance change for each logarithmic time decade	–	–2%	–5%
Capacitance values available E series	E12	E12	E6

[1]) the smaller value has to be applied

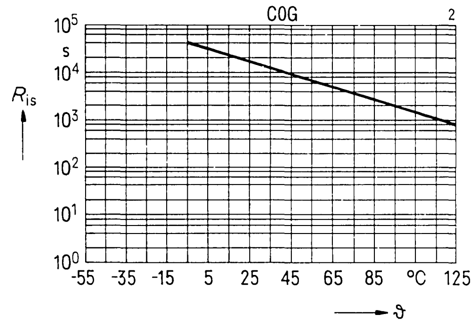
7. Characteristic curves

7.1. Characteristic curves for C0G capacitors

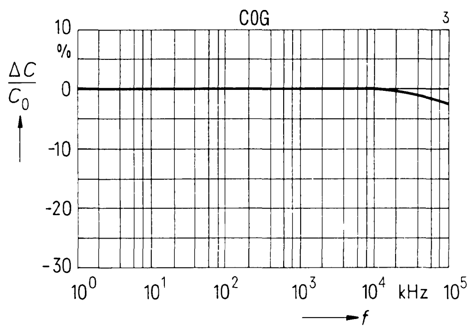
Capacitance change versus temperature
(typical values)



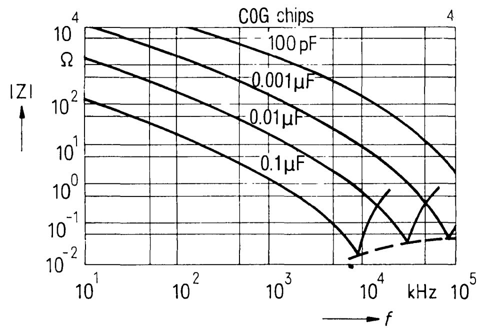
Insulation resistance versus temperature
(typical values)



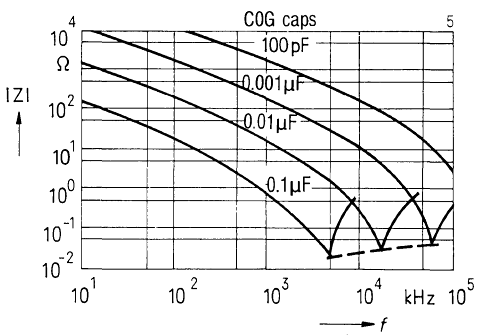
Capacitance change versus frequency
(typical values)



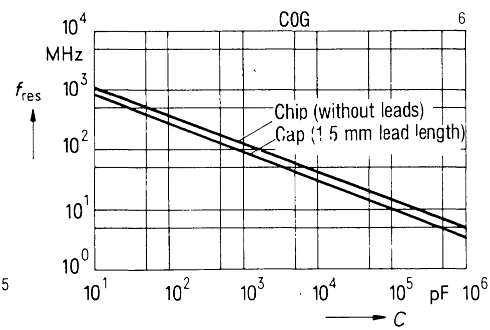
Impedance versus frequency
for chips (typical values)



Impedance versus frequency
for caps (typical values)

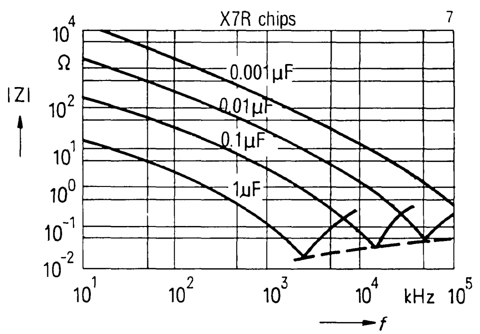


Resonant frequency versus capacitance
for chips and caps (typical values)

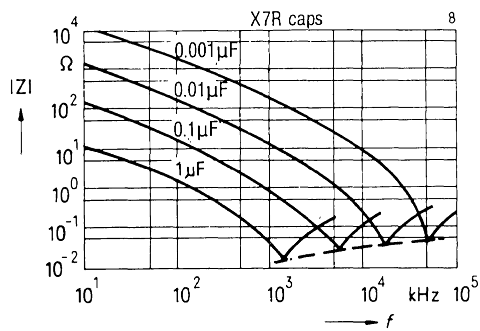


Characteristic curves for X7R capacitors (cont'd)

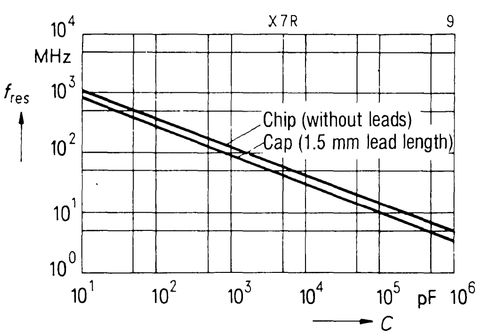
Impedance versus frequency
for chips (typical values)



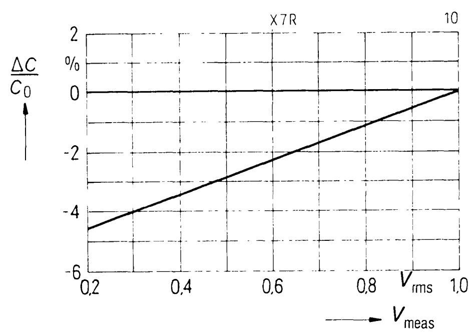
Impedance versus frequency
for caps (typical values)



Resonant frequency versus capacitance
for chips and caps (typical values)

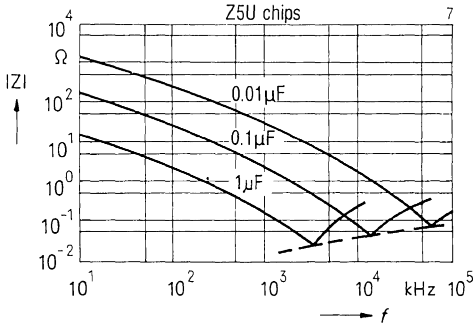


Capacitance change versus measuring voltage
(typical values)

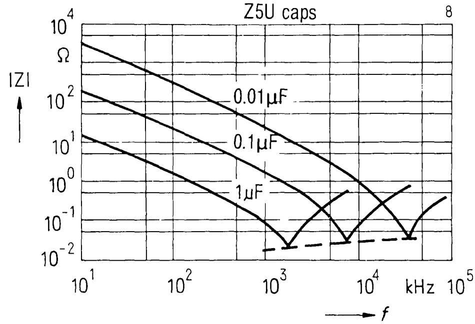


Characteristic curves for Z5U capacitors (cont'd)

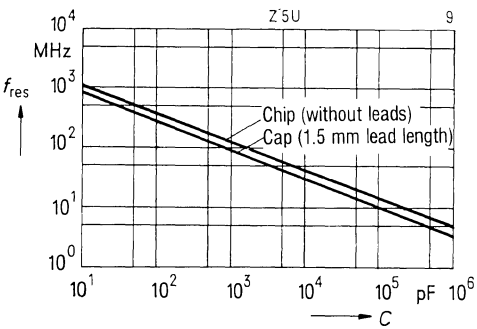
Impedance versus frequency
for chips (typical values)



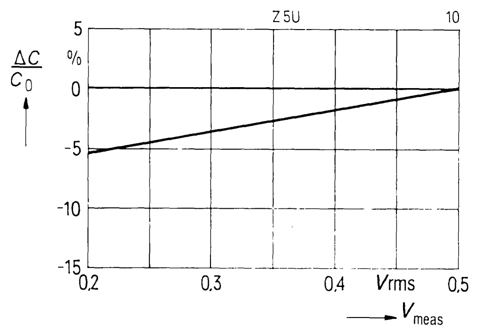
Impedance versus frequency
for caps (typical values)



Resonant frequency versus capacitance
for chips and caps (typical values)



Capacitance change versus measuring voltage
(typical values)



8.8. Solderability

Test conditions comply with MIL-STD-202 E, method 208 C

8.9. Moisture resistance

Test conditions comply with MIL-STD-202 F, method 106 E

Test voltage: rated voltage or 100 V dc

The lower voltage has to be applied.

8.10. Resistance to soldering heat (chips)

Test conditions comply with MIL-STD-202 E, method 210 A, test condition B

Soldering bath temperature:	(260 ± 5) °C
Immersion duration:	max. 15 sec
Soldering bath:	Sn 62 Pb 36 Ag 2

Permissible variation

COG ≦ 1% or 1 pF (the larger value has to be applied)
X7R ≦ ± 10%
Z5U ≦ ± 20%

8.11. Resistance to soldering heat (caps)

Test conditions comply with MIL-STD-202 E method 210 A, test condition D

Soldering bath temperature:	(260 ± 5) °C
Immersion duration:	(20 ± 2) sec

Permissible variation

COG ≦ 0.5% or 0,5 pF (the larger value has to be applied)
X7R ≦ ± 10%
Z5U ≦ ± 20%

8.12. Thermal shock test

Test conditions comply with MIL-STD-202 E, method 107 D, test condition A

8.13. Life test

Test conditions comply with MIL-STD-202 E, method 108 A

Test temperature:	max. categoy temperature	With X7R, BX, and Z5U pretreatment and aftertreatment like in moisture test
Test voltage:	1.5 x V_R	
Test duration:	1000 hrs	

Permissible variation

COG: ≦ 3% or 1 pF (the larger value has to be applied)
tan δ ≦ 1.5 x tan δ limit value
R_{is} ≧ 4000 MΩ or 40 sec

9. Mounting instructions for chips and caps

Common mounting methods are:

- flow soldering
- reflow soldering
- cementing

9.1. Flow soldering

The components are sticked onto the thick film substrate (glass, ceramic) or onto the etched PCB (glass fiber) by a silicone adhesive. The adhesive may be applied by means of silk screening. With this process, care must be taken of the contacting areas not to be covered by the adhesive.

The components are pressed onto the substrate. An excellent adherence is ensured by a glue depth of 60 to 80 μm. This amount will also not contaminate the contacting areas while the contacting pressure is applied. Soldering can be effected by flow or dip soldering. An Sn-Po alloy next to the eutecticum with an Ag additive of 3.5 to 4% has proved successful as a solder (e.g. Solldamoll 170 Sn/PB/Ag: 60/35/4). The solder bath temperature should amount to (225 ± 10) °C; a maximum soldering time of 5 seconds is permitted. A nonactivated 45% resin dissolved in a 55% ethyl alcohol with glycerin additive serves as an appropriate flux. The flux remainders should be removed after the components have been soldered. Cleaning baths containing isopropyl alcohol are suitable for this process.

9.2. Reflow soldering

The solder powder together with a flux is applied as paste onto the PCB. This process ist appropriately carried out with silk screening. The coating thickness should thereby amount to approximately 80 μm.

The equipped substrates are best heated in a continuous-heating or reflow furnace. In such furnaces, the objects are gradually heated to 200 °C. A minimum soldering time has to be kept in order to avoid dry joints. The maximum soldering time ist 5 seconds. This period diminishes a possible unalloying which is due to the tin's high absorptive power on silver. Using silver-palladium contacts also contributes to prevent unalloying of the contacts, and it additionally prolongs the shelf live. However, a sulfurous atmosphere is to be avoided since it would generate silver sulfide impairing the solderability of the chips. An appropriate solder would be Sn/Pb/Ag (60%/36%/4% or 60%/38%/2%). The melting points of the solders lie at 183 °C or 189 °C. The flux should be organic and of medium activity.

The objects are to be cleaned by a mild agent or in an ultrasonic bath.

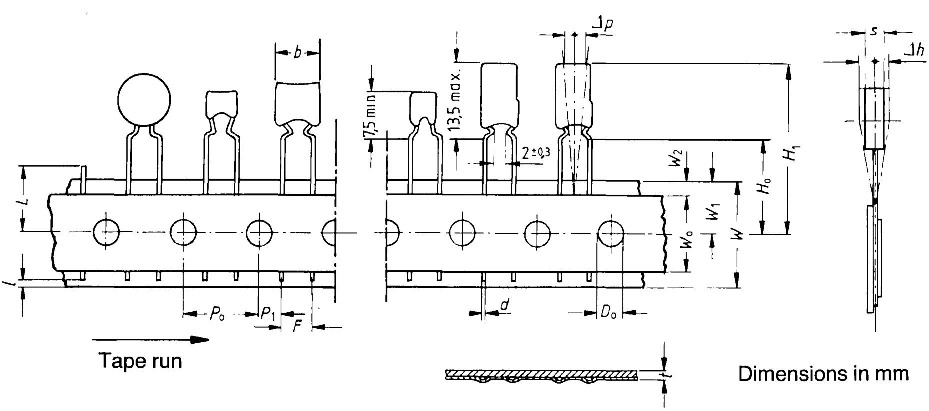
9.3. Cementing

A 'silver-bearing two-component expoxy resin adhesive is suitable for cementing chips.

Such adhesives may be applied by means of dosing silk screen processes or stamping machines. The duration of the curing process depends on the curing temperatures and lasts between 1 minute and 12 hours.

Dimensions and tolerances

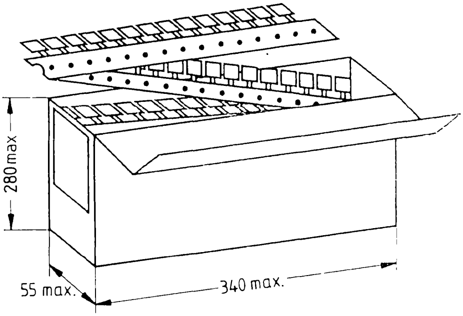
Multilayer capacitors **SIBATIT 50000 capacitors**



Dimensions in mm

Designation	Symbol	Dimensions in mm Value	Tolerance	Notes
Head width	b	11	max.	
Head thickness	s	3.8	max.	
Lead diameter	d	0,6	±0.05	
Hole spacing	P_0	12.7	±0.2	± 1 mm/10 hole spacings[1]
Spacing: hole center to lead center	P_1	3.85	±0.7	
Lead spacing	F	5	+0.6/−0.1	
Slope of capacitor	Δh	0	±2.0	measured of upper head edge
Slope of capacitor	Δp	0	±1.3	
Base width	W	18	±0.5	
Adhesive width	W_0	15	max.	removal force ⩾ 5 N
Spacing: hole to upper tape edge	W_1	9	±0.5	
Position of adhesive tape	W_2	2.5	−2	
Spacing: hole center to kink	H_0	16	±0.5	
Spacing: hole center to upper component edge	H_1	32.2	max.	
Hole diameter	D_0	4	±0.2	
Tape thickness	t	0.7	+0.2	
Projecting length of lead	l	1	max.	
Length of cut lead	L	11	max.	

AMMO-PACK



Ordering code and packaging quantities

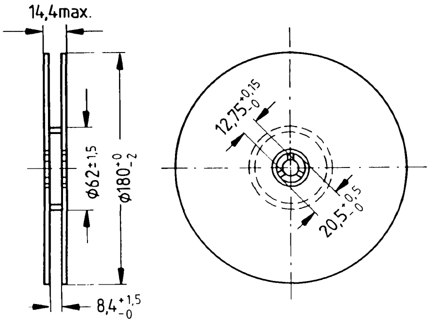
Type of Caps	Lead Spacing	Ordering code for taped parts	Minimum order quantities packaging unit (pieces/carton)
Multilayers Caps	2,5 mm	B37979–N**** – +5*	2500
		B37981–M**** – +5*	2500
		B37982–N**** – +5*	2500
		B37986–N**** – +5*	2500
		B37987–M**** – +5*	2500
		B37988–N**** – +5*	2500
	5 mm	B37979–G**** – +5*	2500
		B37981–F**** – +5*	2500
		B37982–G**** – +5*	2500
		B37983–N**** – +5*	2000
		B37984–M**** – +5*	2000
		B37985–N**** – +5*	2000
		B37986–G**** – +5*	2500
		B37987–F**** – +5*	2500
		B37988–G**** – +5*	2500
SIBATIT® 50000	2,5 mm	B37448–F**** – S5*	2000
		B37448–N**** – S5*	2000
	5 mm	B37449–F**** – S5*	2000
		B37449–N**** – S5*	2000

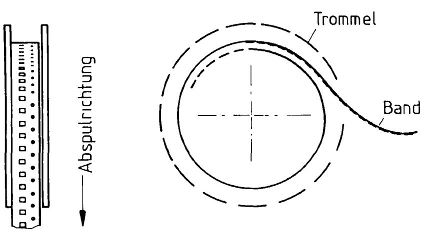
Ordering code for taping

B37979–S1470–+5*

- Type → B37979
- Code (see data sheet) → S1470
- Tolerance → +
- Code → 5*
  - 0 = Cassette pack
  - 1 = Reel pack
  - 4 = AMMO-PACK

Drums for packaging





Packaging units:
5000 pieces for thickness 0.5
3000 pieces for thickness 1.0

Ceramic material: X7R

Rated capacity	EIA standard 0805		EIA standard 1206	
	Chip thickness S±0.1	Ordering code	Chip thickness S±0.1	Ordering code
470 pF		B37941-K5471-*61		
560 pF		B37941-K5561-*61		
680 pF		B37941-K5681-*61		
820 pF		B37941-K5821-*61		
1,0 nF	0,5 mm	B37941-K5102-*61		
1,5 nF		B37941-K5152-*61		B37872-K5152-*61
2,2 nF		B37941-K5222-*61		B37872-K5222-*61
3,3 nF		B37941-K5332-*61	0,5 mm	B37872-K5332-*61
4,7 nF		B37941-K5472-*61		B37872-K5472-*61
6,8 nF	1,0 mm	B37941-K5682-*61		B37872-K5682-*61
10 nF		B37941-K5103-*61		B37872-K5103-*61
15 nF				B37872-K5153-*61
22 nF			1,0 mm	B37872-K5223-*61
33 nF				B37872-K5333-*61

*Insert letter for capacitance tolerance.

Ceramic material: Z5U

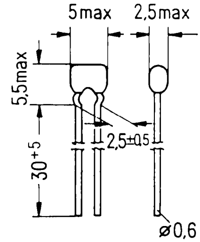
Rated capacity	EIA standard 0805		EIA standard 1206	
	Chip thickness S±0.1	Ordering code	Chip thickness S±0.1	Ordering code
10 nF	0,5 mm	B37942-K5103-*61	0,5 mm	B37873-K5103-*61
22 nF	1,0 mm	B37942-K5223-*61		B37873-K5223-*61
47 nF			1,0 mm	B37873-K5473-*61
100 nF				B37873-K5104-*61

*Insert letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage



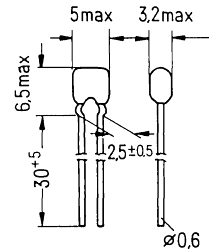
Dimensions in mm

Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage



Dimensions in mm

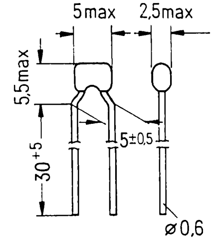
Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage

Taped version
LS 5 mm available



Dimensions in mm

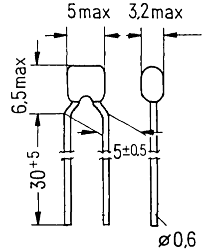
Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage

Taped version
LS 5 mm available



Dimensions in mm

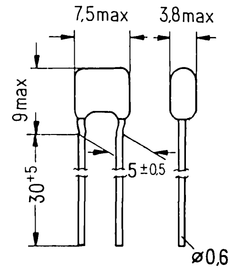
Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage

Taped version
LS 5 mm available



Dimensions in mm

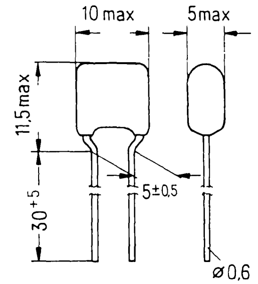
Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage

Taped version
LS 5 mm available



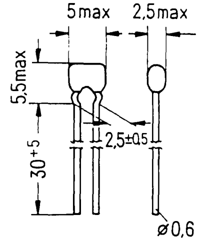
Dimensions in mm

Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage



Dimensions in mm

Rated voltage V_R = 100 V dc

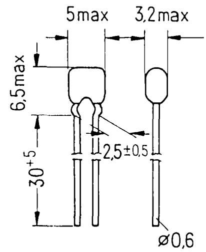
C_R (pF)	Ordering code	C_R (pF)	Ordering code
220	B37981–M1221–x	1000	B37981–M1102–x
270	B37981–M1271–x	1200	B37981–M1122–x
330	B37981–M1331–x	1500	B37981–M1152–x
390	B37981–M1391–x	1800	B37981–M1182–x
470	B37981–M1471–x	2200	B37981–M1222–x
560	B37981–M1561–x	2700	B37981–M1272–x
680	B37981–M1681–x	3300	B37981–M1332–x
820	B37981–M1821–x	3900	B37981–M1392–x
		4700	B37981–M1472–x

Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage



Dimensions in mm

Rated voltage V_R = 100 V dc

C_R (pF)	**Ordering code**	C_R (pF)	**Ordering code**
5600	B37987–M1562–x	10000	B37987–M1103–x
6800	B37987–M1682–x	12000	B37987–M1123–x
8200	B37987–M1822–x	15000	B37987–M1153–x
		18000	B37987–M1183–x
		22000	B37987–M1223–x
		27000	B37987–M1273–x
		33000	B37987–M1333–x
		39000	B37987–M1393–x

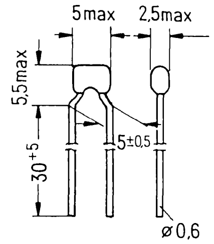
Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage

Taped version
LS 5 mm available



Dimensions in mm

Rated voltage V_R = 100 V dc

C_R (pF)	**Ordering code**	C_R (pF)	**Ordering code**
220	B37981–F1221–x	1 000	B37981–F1102–x
270	B37981–F1271–x	1 200	B37981–F1122–x
330	B37981–F1331–x	1 500	B37981–F1152–x
390	B37981–F1391–x	1 800	B37981–F1182–x
470	B37981–F1471–x	2 200	B37981–F1222–x
560	B37981–F1561–x	2 700	B37981–F1272–x
680	B37981–F1681–x	3 300	B37981–F1332–x
820	B37981–F1821–x	3 900	B37981–F1392–x
		4 700	B37981–F1472–x

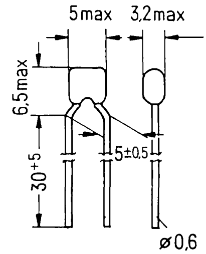
Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance, trademark, ceramic material, rated voltage

Taped version
LS 5 mm available



Dimensions in mm

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
5600	B37987–F1562–x	10000	B37987–F1103–x
6800	B37987–F1682–x	12000	B37987–F1123–x
8200	B37987–F1822–x	15000	B37987–F1153–x
		18000	B37987–F1183–x
		22000	B37987–F1223–x
		27000	B37987–F1273–x
		33000	B37987–F1333–x
		39000	B37987–F1393–x

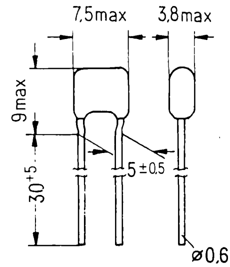
Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage

Taped version
LS 5 mm available



Dimensions in mm

Rated voltage V_R = 100 V dc

C_R (pF)	**Ordering code**	C_R (pF)	**Ordering code**
47000	B37984–M1473–x	100000	B37984–M1104–x
56000	B37984–M1563–x	120000	B37984–M1124–x
68000	B37984–M1683–x	150000	B37984–M1154–x
82000	B37984–M1823–x	180000	B37984–M1184–x

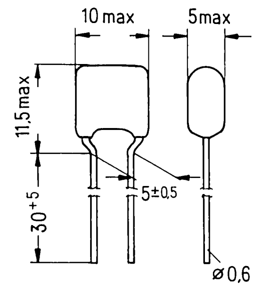
Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage

Taped version
LS 5 mm available



Dimensions in mm

Rated voltage V_R = 100 V dc

C_R (pF)	**Ordering code**
220000	B37901–M1224–x
270000	B37901–M1274–x
330000	B37901–M1334–x

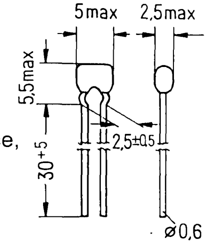
Note: x = Insert appropriate letter for capacitance tolerance.

Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

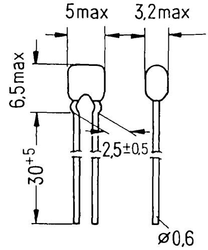
Leads
Shorter leads are available

Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage

B 37982



B 37988



Dimensions in mm

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**	C_R (pF)	**Ordering code**
68000	B37988–N5683–x	100000	B37988–N5104–x
		150000	B37988–N5154–x
		220000	B37988–N5224–x
		330000	B37988–N5334–x

Note: x = Insert appropriate letter for capacitance tolerance.

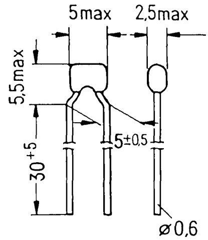
Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

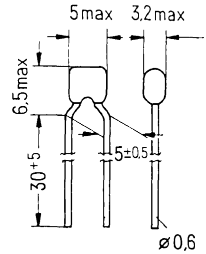
Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage

Taped version
LS 5 mm available

B37982



B37985
B37988



Dimensions in mm

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
68000	B37988–G5683–x	100000	B37988–G5104–x
		150000	B37988–G5154–x
		220000	B37988–G5224–x
		330000	B37988–G5334–x

Note: x = Insert appropriate letter for capacitance tolerance.

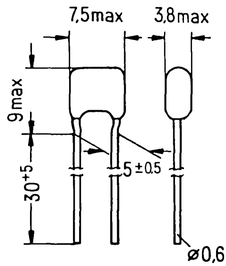
Version
Caps with thickly tinned leads
in acc. with DIN 40500, part 5

Leads
Shorter leads are available

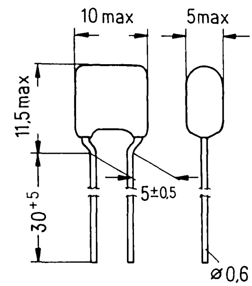
Marking
Rated capacitance, capacitance tolerance,
trademark, ceramic material,
rated voltage

Taped version
LS 5 mm available

B37985
B37902–J5155–*



B37902



Dimensions in mm

Rated voltage V_R = 50 V dc

C_R (µF)	**Ordering code**
2200000	B37902–N5225–x

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	47 pF to 1 000 pF
Rated voltage V_R	50 V dc; 100 V dc
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 1
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 30 x 10^{-6}/K
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 1.5 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K; $\pm$ 5% ≙ J

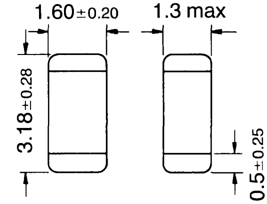
Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code	C_R (pF)	Ordering code
1	B37871–K5010–+1	10	B37871–K5100–+1	100	B37871–K5101–+1
1.2	B37871–K5010–+201	12	B37871–K5120–+1	120	B37871–K5121–+1
1.5	B37871–K5010–+501	15	B37871–K5150–+1	150	B37871–K5151–+1
1.8	B37871–K5010–+801	18	B37871–K5180–+1	180	B37871–K5181–+1
2.2	B37871–K5020–+201	22	B37871–K5220–+1	220	B37871–K5220–+1
2.7	B37871–K5020–+701	27	B37871–K5270–+1	270	B37871–K5271–+1
3.3	B37871–K5030–+301	33	B37871–K5330–+1	330	B37871–K5331–+1
3.9	B37871–K5030–+901	39	B37871–K5390–+1	390	B37871–K5391–+1
4.7	B37871–K5040–+701	47	B37871–K5470–+1	470	B37871–K5471–+1
5.6	B37871–K5050–+601	56	B37871–K5560–+1	560	B37871–K5561–+1
6.8	B37871–K5060–+801	68	B37871–K5680–+1	680	B37871–K5681–+1
8.2	B37871–K5080–+201	82	B37871–K5820–+1	820	B37871–K5821–+1
				1 000	B37871–K5102–+1

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
47	B38871–K1470–+1	100	B38871–K1101–+1
56	B38871–K1560–+1	120	B38871–K1121–+1
68	B38871–K1680–+1	150	B38871–K1151–+1
82	B38871–K1820–+1	180	B38871–K1181–+1
		220	B38871–K1221–+1
		270	B38871–K1271–+1
		330	B38871–K1331–+1
		390	B38871–K1391–+1
		470	B38871–K1471–+1

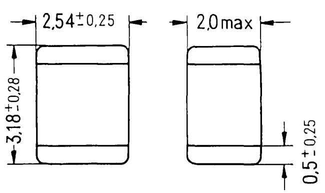
EIA standard 1206
B 37871



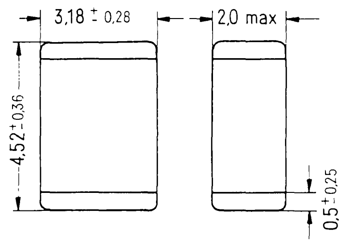
Note: + = Insert appropriate letter for capacitance tolerance.

Version
Chips without leads with silver-palladium terminations

EIA standard 1210
B 37949



EIA standard 1812
B 37952



Dimensions in mm

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code
1200	B37952–K5122–+1
1500	B37952–K5152–+1
1800	B37952–K5182–+1
2200	B37952–K5222–+1
2700	B37952–K5272–+1
3300	B37952–K5332–+1
3900	B37952–K5392–+1
4700	B37952–K5472–+1
5600	B37952–K5562–+1
6800	B37952–K5682–+1

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code
1000	B37952–K1102–+1
1200	B37952–K1122–+1
1500	B37952–K1152–+1
1800	B37952–K1182–+1
2200	B37952–K1222–+1
2700	B37952–K1272–+1
3300	B37952–K1332–+1

Note: + = Insert appropriate letter for capacitance tolerance.

Multilayer Capacitors

X7R Chips

B 37941
EIA Std. 0805

Rated capacitance C_R	470 pF to 15000 pF
Rated voltage V_R	50 V dc; 100 V dc
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 2
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 15%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 25 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^5$ MΩ at 25°C
Time constant τ	> 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K

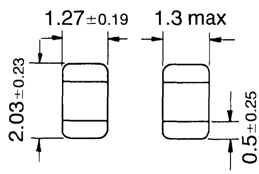
Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code	C_R (pF)	Ordering code
10000	B37941–K5103–+1	1000	B37941–K5102–+1	470	B37941–K5471–+1
12000	B37941–K5123–+1	1200	B37941–K5122–+1	560	B37941–K5561–+1
15000	B37941–K5153–+1	1500	B37941–K5152–+1	680	B37941–K5681–+1
180	B37941–J5181–*9	1800	B37941–K5182–+1	820	B37941–K5821–+1
220	B37941–J5221–*9	2200	B37941–K5222–+1		
270	B37941–J5271–*9	2700	B37941–K5272–+1		
330	B37941–J5331–*9	3300	B37941–K5332–+1		
390	B37941–J5391–*9	3900	B37941–K5392–+1		
470	B37941–J5471–*9	4700	B37941–K5472–+1		
560	B37941–J5561–*9	5600	B37941–K5562–+1		
680	B37941–J5681–*9	6800	B37941–K5682–+1		
820	B37941–J5821–*9	8200	B37941–K5822–+1		

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
470	B37941–K1471–+1	1000	B37941–K1102–+1
560	B37941–K1561–+1	1200	B37941–K1122–+1
680	B37941–K1681–+1	1500	B37941–K1152–+1
820	B37941–K1821–+1	1800	B37941–K1182–+1
		2200	B37941–K1222–+1
		2700	B37941–K1272–+1
		3300	B37941–K1332–+1

EIA standard 0805
B 37941



Note: + = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	8200 pF to 120000 pF
Rated voltage V_R	50 V dc; 100 V dc
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 2
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 15%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 25 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^5$ MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code	C_R (pF)	Ordering code
8200	B37950–K5822–+1	10000	B37950–K5103–+1	0.10 µF	B37950–K5104–+1
		12000	B37950–K5123–+1	0.12 µF	B37950–K5124–+1
		15000	B37950–K5153–+1		
		18000	B37950–K5183–+1		
		22000	B37950–K5223–+1		
		27000	B37950–K5273–+1		
		33000	B37950–K5333–+1		
		39000	B37950–K5393–+1		
		47000	B37950–K5473–+1		
		56000	B37950–K5563–+1		
		68000	B37950–K5683–+1		
		82000	B37950–K5823–+1		

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
8200	B37950–K1822–+1	10000	B37950–K1103–+1
		12000	B37950–K1123–+1
		15000	B37950–K1153–+1
		18000	B37950–K1183–+1
		22000	B37950–K1223–+1
		27000	B37950–K5173–+1
		33000	B37950–K1333–+1

Note: + = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	47000 pF to 680000 pF
Rated voltage V_R	50 V dc; 100 V dc
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 2
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 15%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 25 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% $\triangleq$ M; $\pm$ 10% $\triangleq$ K

Rated voltage V_R = 50 V dc

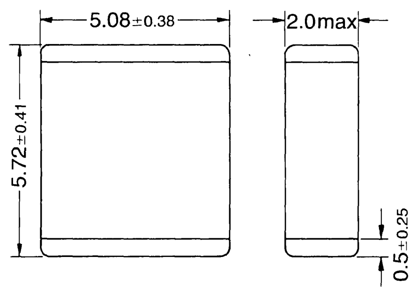
C_R (pF)	Ordering code
0.18 µF	B37956–K5184–+1
0.22 µF	B37956–K5224–+1
0.27 µF	B37956–K5274–+1
0.33 µF	B37956–K5334–+1
0.39 µF	B37956–K5394–+1
0.47 µF	B37956–K5474–+1
0.56 µF	B37956–K5564–+1
0.68 µF	B37956–K5684–+1

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
47000	B37956–K1473–+1	0.10 µF	B37956–K1104–+1
56000	B37956–K1563–+1	0.12 µF	B37956–K1124–+1
68000	B37956–K1683–+1	0.15 µF	B37956–K1154–+1
82000	B37956–K1823–+1		

Note: + = Insert appropriate letter for capacitance tolerance.

EIA standard 2220
B 37956



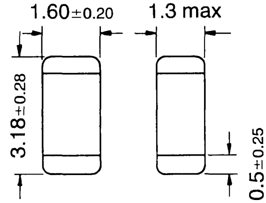
Rated capacitance C_R	10000 pF to 100000 pF
Rated voltage V_R	25 V dc; 50 V dc
DIN climatic category (DIN 40040)	LPF (+10°C to +85°C, humidity category F)
IEC climatic category (IEC 68, part 1)	05/085/56
Dielectric	class 2
Temperature range ϑ	+10°C to +85°C
Capacitance change ΔC	+22/–56%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 30 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^4$ MΩ at 25°C
Time constant τ	> 500 sec at 25°C
Capacitance values available	E 6 series (preferred series)
Capacitance tolerance and code letters	+80% to –20% ≙ Z; ± 20% ≙ M

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
10000	B37873–K6103–+1	0.1 µF	B37873–K6104–+1
15000	B37873–K6153–+1		
22000	B37873–K6223–+1		
33000	B37873–K6333–+1		
47000	B37873–K6473–+1		
68000	B37873–K6683–+1		

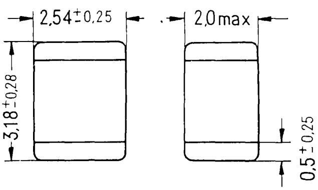
Note: + = Insert appropriate letter for capacitance tolerance.

EIA standard 1206
B 37873

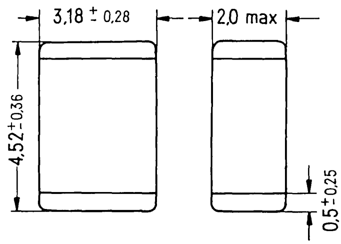


Version
Chips without leads with silver-palladium terminations

EIA standard 1210
B 37951



EIA standard 1812
B 37954



Dimensions in mm

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**
0.22 μF	B37954–K6224–+1
0.33 μF	B37954–K6334–+1
0.47 μF	B37954–K6474–+1

Note: + = Insert appropriate letter for capacitance tolerance.

SIBATIT® 50 000 Capacitors

SIBATIT® 50000 Capacitors

1. Introduction

The development of a special ceramic material – SIBATIT 50000 – also offered the possibility to produce capacitors featuring various improvements, compared to the usual single-layer surface barrier layer ceramic capacitors.

The capacitance is produced by internal dielectric barrier layers on the surface of the semiconducting ceramic material.

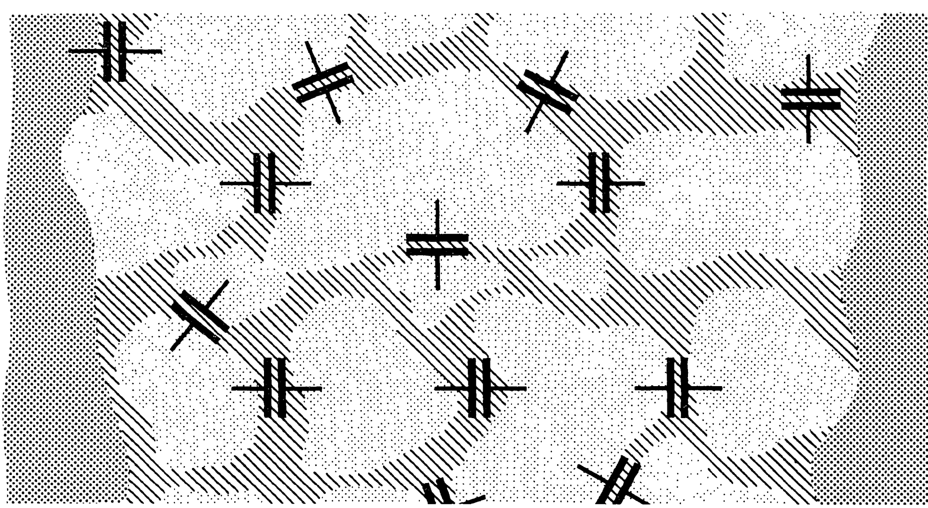
With usual single-layer capacitors, these barrier layers are generated at the outer surfaces of the ceramic body. However, as those areas are highly sensitive they require a rugged protective encapsulation. And moreover, those capacitors can only be produced as disc-types.

2. Capacitor construction

SIBATIT 50000 capacitors are produced from a ceramic tube which has a rectangular cross-section. This design offers particularly favorable space utilization on PCBs or volume efficiency for circuits.

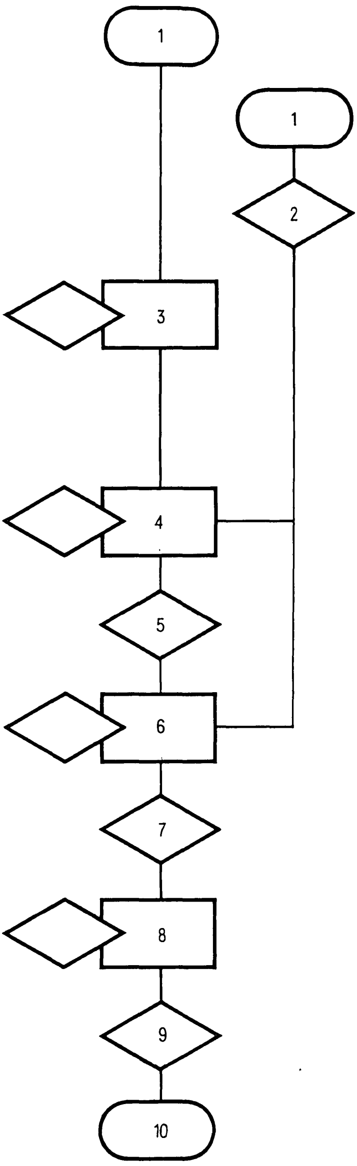
Internal construction

With SIBATIT 50000 capacitors, the barrier layers are built up in the boundaries of the individual barium titanate grains, i. e. within the capacitor body. In this way material with very thin dielectric layers is obtained. Those layers may repeatedly be connected in parallel and in series with the conductive zones of the ceramic grains. Altogether this material features an outstanding permittivity (dielectric constant) ε of approx. 50000.



Contacting — Conducting zones — Barrier layers

3.2. Capacitor production



1. Raw material storage
2. Incoming raw material
3. Incoming examination of the raw material
4. Separating
5. Wiring
6. Checking the wiring
7. Encapsulating
8. Electrical tests
9. Marking, cutting, packing
10. Quality and reliability tests
11. Delivery to shipping warehouse

5. Brief data

Designation	SIBATIT 50000	Low-loss capacitors
Dielectric	class 2	class 2
Temperature range	–40°C to +85°C	–40°C to +85°C
DIN climatic category (DIN 40040)	GPF	GPF
IEC climatic category (IEC 68, part 1; DIN 40045)	40/085/56	40/085/56
Capacitance change ΔC within temperature range	+20 to –55%	+20 to –55%
Voltage test V_{test} at 2 x V_R; 1 sec (max.)	130 V dc (layer/layer)	130 V dc (layer/layer)
Dissipation factor tan δ at f_m = 1 kHz; $V_m \leqq 0.2$ V dc at f_m = 100 kHz; $V_m \leqq 0.2$ V dc	 $\leqq 50 \times 10^{-3}$ –	 – $\leqq 50 \times 10^{-3}$
Insulation resistance R_{is}	–	$\geqq 10$ MΩ
Self-discharge time constant τ at t_m = 1 min; V_m = 10 V dc	$\geqq 50$ sec	–
Impedance |Z| at f_m = 10.7 MHz	– –	$\leqq$ 2 Ω (C_R = 10000 pF) $\leqq$ 0.9 Ω (C_R = 22000 pF)
Aging Capacitance change per time decade	–2% (typ. value)	–2% (typ. value)

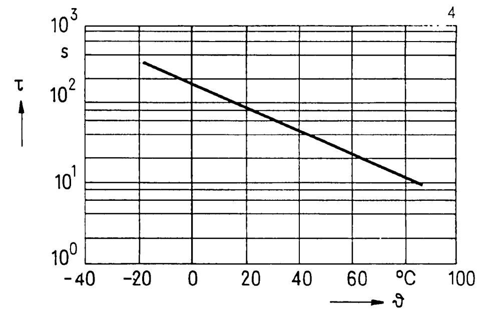
6. Technical explanation

Due to their polarity independence SIBATIT 50000 capacitors are suitable for circuits operating with voltage reversal of RF ac voltages, e. g. coupling, filter, and RFI suppression capacitors.

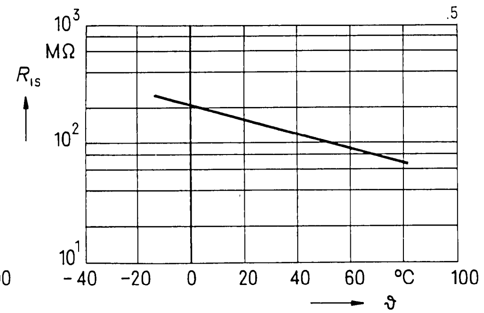
SIBATIT 50000 also has a particularly high long-term capacitance stability. The capacitance decrease amounts to 2% per time decade which is far below the usual values of comparable capacitors.

Characteristic curves (cont'd)

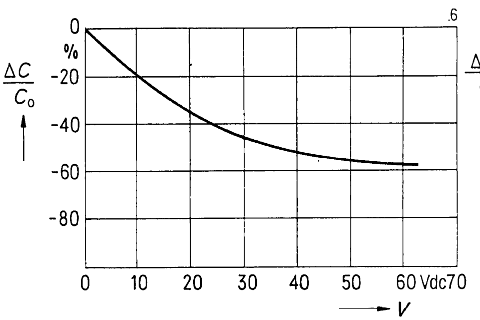
Self-discharge time constant versus temperature
(typical values)



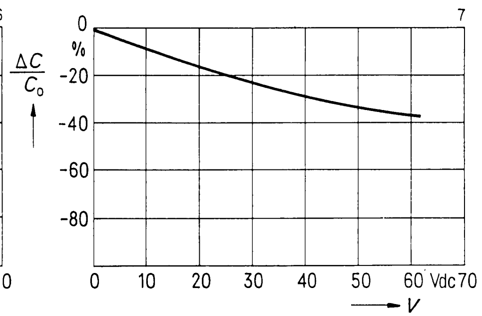
Insulation resistance versus temperature
for low-loss capacitors (typical values)



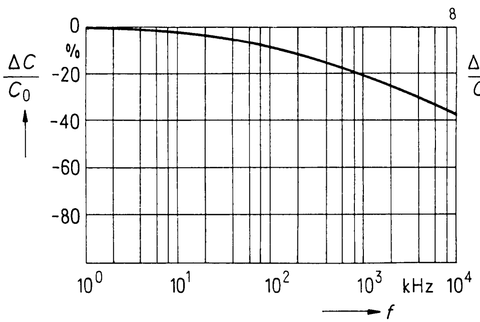
Capacitance change versus dc voltage
(typical values)



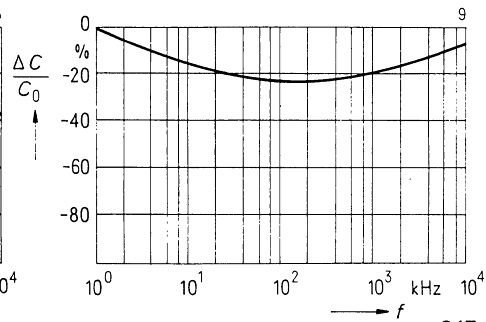
Capacitance change versus dc voltage
for low-loss capacitors (typical values)



Capacitance change versus frequency
(typical values)



Capacitance change versus frequency
for low-loss capacitors (typical values)



8. Test and measuring conditions

8.1. Standards

SIBATIT 50000 capacitors comply which DIN 41920, DIN 40045, DIN 40046, and DIN 40040, as well as IEC Publication 68.

8.2. DIN climatic category — GPF

(DIN 40040)	
Minimum category temperature	**G** – 40 °C
Maximum category temperature	**P** + 85 °C
Humidity category	**F** $\leqq$ 75% average relative humidity 15% continuously on 30 days per year 85% occasionally on the remaining days

8.3. IEC climatic category — 40/085/56

(IEC 68, part 1, or
DIN 40045)

8.4. Dry heat and damp heat tests

Pretreatment:
Stored for 1 hour at maximum category temperature; (24 ± 2) hours recovery; final measurements

Aftertreatment:
like pretreatment

- **Dry heat test**
  in accordance with DIN 40046, part 4, or IEC Publ. 68–2–2

Conditions

Test temperature	(85 ± 2) °C
Test duration	1000 hrs
Test voltage	1.5 x V_R

Failure criteria

Capacitance change	> ± 20% from initial value
Dissipation factor	> 1.5 x tan δ limit value
Time constant	< 1.25 sec (SIBATIT 50000)
Insulation resistance	< 10 MΩ (low loss)

- **Damp heat test**
  in accordance with DIN 40046, part 5, or IEC Publ. 68–2–3

Conditions

Test temperature	(40 ± 2) °C
Relative humidity	(93^{+2}_{-3}) %
Test duration	56 days
Test voltage	35 V dc

8.10 Mechanical robustness of the terminals

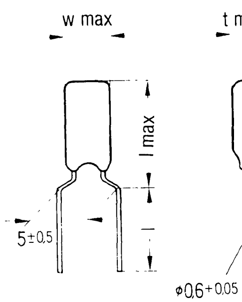
The leads may only be bent in a 1 mm distance to their outlets.
The terminals are in accordance with DIN 40046, part 19, January '78.

Tensile strength test: U_a
leads: 10 N

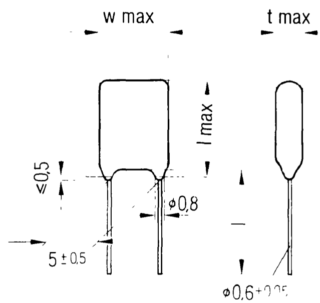
Bending strength of the leads: test: U_b
two bendings in opposite directions;
bending angle 90° each, bending force 5 N

Version
Plastic-encapsulated capacitors (epoxy-dipped)
tinned leads.

Leads (l)
16^{+2} mm lead length ≙ code figure 2
6^{-1} mm lead length ≙ code figure 7



Version B37449–F6223–S*



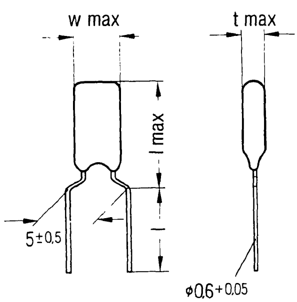
Version B37449 – F6*** – S*
Dimensions in mm

Rated capacitance C_R (pF)	**Ordering code** **Dimensions** *w* x *l* x *t*	
22000	B37449–F6223–S* 5.3 x 9.0 x 2.7	–
33000	–	B37449–F6333–S* 7.3 x 8.0 x 2.7
47000	–	B37449–F6473–S* 7.3 x 8.0 x 2.7
68000	–	B37449–F6683–S* 7.3 x 11 x 2.7
100000	–	B37449–F6104–S* 7.3 x 12 x 2.7

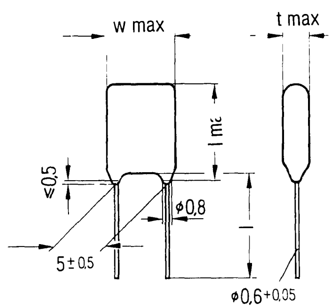
Instead of the * in the ordering code insert the letter for the lead length.

Version
Plastic-encapsulated capacitors (epoxy-dipped)
tinned leads.

Leads (l)
16^{+2} mm lead length ≙ code figure 2
6^{-1} mm lead length ≙ code figure 7



Version B37449-N6103-S*



Version B37449-N6223-S*
Dimensions in mm

Rated capacitance C_R (pF)	**Ordering code** **Dimensions** *w* x *l* x *t*	
10000	B37449-N6103-S* 5.3 x 8.0 x 2.7	–
22000	–	B37449-N6223-S* 7.3 x 8.0 x 2.7

Instead of the * in the ordering code insert the letter for the lead length.

MKV Capacitors

MKV capacitors
are self-healing capacitors comprising tubular mineral oil impregnated low-loss plastic film windings as dielectric and vacuum deposited regenerating paper layers. This paper, used as carrier, does not lie within the electric field. MKV capacitors are particularly suitable for use at high reactive load, i.e. at high capacitance ratings or higher frequencies.

MKP capacitors
are self-healing capacitors comprising tubular low-loss plastic film windings as dielectric and vacuum deposited metal layers. MKP capacitors are preferably used at 50 Hz and voltage ratings up to 450 Vac.

2. Self-healing capability

Heavy current capacitors, which were subject to a final production test at 2.15 times the rated voltage, exhibit only few breakdowns during operation. The physical appearance of the area of isolation resulting from the breakdown, gives rise to the assumption that the breakdowns were caused by overvoltages or voltage peaks.

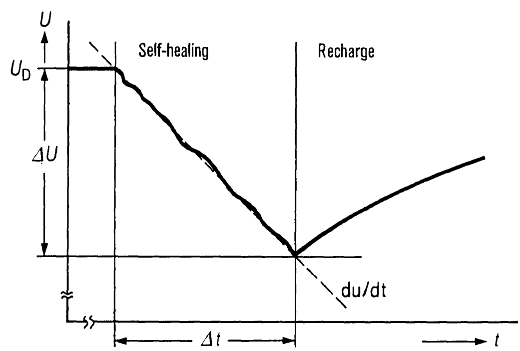


Figure 1
Self-healing procedure

In heavy current supplies, even in mains, voltage peaks up to 3 times the rated supply voltage still frequently occur. These voltage peaks mostly result from switching operations with magnetic parts. Locations of breakdown are weak points, such as included conducting parts, holes in the dielectric, or conductive contaminations, which could not be eliminated at the burnout during the production process.
From oscillograms of the voltage across the capacitor during a breakdown, its characteristics can be derived:

Duration Δt : 1 to 10 µsec
Energy conversion ΔW : 1 to 100 mWsec $\Delta W = C \cdot U_D \cdot \Delta U$
Capacitance variation ΔC: approx. 100 nF

The breakdown is running in a current-limiting way; this means that the breakdown current is automatically interrupted after a few microseconds without the necessity of making the point of breakdown dead.

4. Characteristic data, operating characteristics and test conditions

4.1. Capacitance

4.1.1. Temperature dependence

The capacitance variation over the permitted temperature range (refer to climatic category) is not linear but reversible. Fig. 2 shows the characteristic temperature behavior of the capacitors.

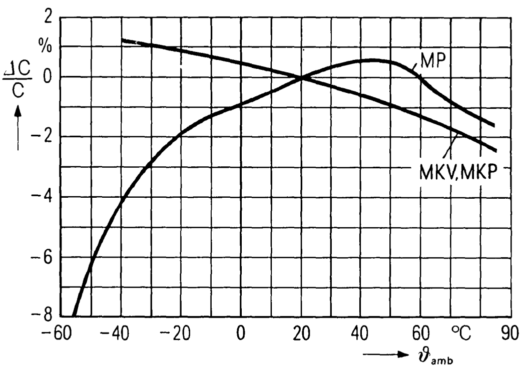


Fig. 2

Relative capacitance variation $\frac{\Delta C}{C}$ versus ambient temperature ϑ_{amb}

4.1.2. Capacitance drift

In addition to reversible changes the capacitance is also subject to irreversible changes, summarized under the term "capacitance drift". This is the sum of all time-dependent irreversible changes of the capacitance during the whole operational life. The capacitance variation is indicated in % of the value at delivery. (Typical value $\pm\frac{1}{3}$%.)

4.2. Voltage loading

4.2.1. MP capacitors for dc application

Rated voltage U_R

The rated voltage U_R is that dc voltage which is indicated on the capacitor. The rated voltage refers to an ambient temperature of 40° C/104° F and serves as base for determining the dielectric design (definition in accordance with DIN 41180).

At continuous operation the capacitor may be loaded with voltages up to the rated voltage within the permitted climatic category and taking the following limit conditions into consideration.

Peak voltage U_p

The peak voltage U_p is the maximum peak voltage, which may be applied to the capacitor for intermittent operation and only occasionally, e.g. at switching processes.
Detailed data are to be found on the data sheets.

Dielectric strength, user's test

The capacitors are designed such that the tests specified in the individual publications may be carried out once by the user without quality reduction.

4.2.2. MKP capacitors for ac application

Rated voltage U_R

The rated voltage U_R is the rms value of the sinusoidal alternating voltage, which is indicated on the capacitor. The rated voltage refers to the maximum temperature limit.

At the nominal kind of operation (continuous or intermittent operation, DB or AB) and at a temperature up to the maximum capacitor temperature $\vartheta_{max.}$, the capacitors may be operated as follows:

with alternating voltage of 1.1 times the rated voltage
with alternating current of 1.3 times the current, which flows through the capacitor at rated sinusoidal voltage and rated frequency.

Operating voltage U_{op} and peak voltage U_p

Figure 5 shows the typical interdependence between operational life L and operating voltage U_{op}, the operational life being the sum of all periods of operation.

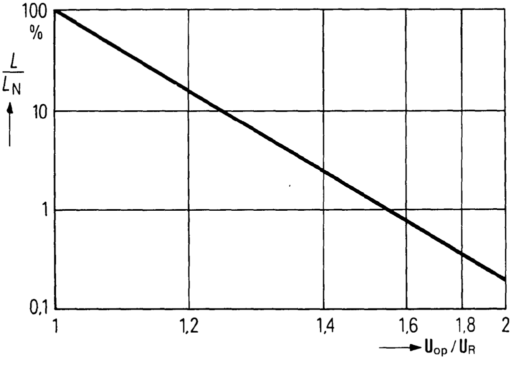


Figure 5
Relative operational life L/L_N
versus relative operating voltage U_{op}/U_R

4.3. Insulation

4.3.1. Self-discharge time constant

The insulation terminal to terminal is indicated according to DIN 41180 as self-discharge time constant

$$\tau = R_{is} \times C \text{ (measured in } M\Omega \times \mu F = s).$$

The insulation resistance is the ratio of dc voltage applied to the current that flows after a certain period of time.

The current flowing after having applied a constant dc voltage is temperature, voltage and time dependent. It is to be understood as the combined charging, self-recharging and leakage current (definition in accordance with VDE 0560, part 1, § 11). In order to determine the limit values the following conditions are to be met. The current is measured 1 minute after the measuring voltage has been applied at $(20 \pm 1)°C/(68 \pm 1.8)°F$ and a relative humidity of less than 65%. Standard voltage is 100 V.

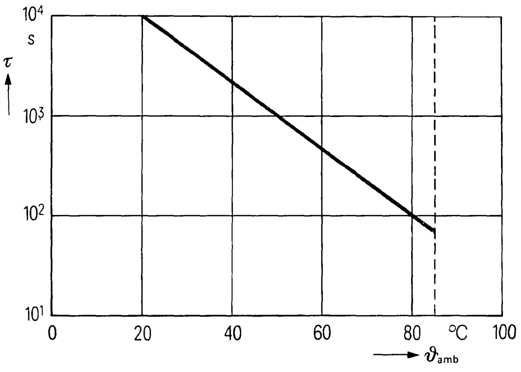


Fig. 6
Self-discharge time constant τ versus ambient temperature ϑ_{amb}

Minimum value to DIN 41180 for MP capacitors for dc application
for $C \leqq 0.33\,\mu F$: 3000 MΩ
for $C > 0.33\,\mu F$: 1000 sec
Minimum values as to VDE 0560 for ac capacitors are not required.

4.3.2. Insulation terminal to case

In case of double-pole, insulated capacitors the average value at delivery of the insulation resistance between the short-circuited terminals and the case amounts to 10 GΩ (measured at 100 Vdc, 20° C/68° F, ≦ 65% relative humidity).

5. Internal heating

When ac capacitors are used, the generated power dissipation results in internal heating. The arising temperature conditions are difficult to be determined in advance (influence of ambient temperature and special cooling conditions, radiation and heat conduction). In cases of doubt, the user should make a type test in order to determine whether the limit temperature indicated upon the capacitor surface has been exceeded or not.

For capacitors for power electronics, the frequency-dependent dissipation factor is indicated on the individual sheets as follows:

$\tan \delta = (\tan \delta_{diel} + \text{const.} \times f)$

The dissipation factor of the polypropylene dielectric is practically constant and independent of temperature throughout the frequency range up to 100 kHz:

$\tan \delta_{diel} \leqq 2 \times 10^{-4}$

5.3. Equivalent series resistance R_{ESR}

The value given in the individual sheets indicates the ohmic part of the equivalent series resistance at resonant frequency. The data are referred to $\vartheta_{amb} = 25°C/77°F$ and were derived from measurements.

5.4. Power loss

The power loss (P_V) is calculated from the reactive power (N) and the dissipation factor for sinusoidal voltages

$P_V = N \times \tan \delta.$

For the non-sinusoidal voltages the frequency-dependent dissipation factor has already to be included into the Fourier analysis

$$P_V = \Sigma \nu \times N_\nu \times \tan \delta_\nu = 2 \pi C \times \Sigma \nu \times U_\nu^2 \times f_\nu \times \tan \delta (f_\nu)$$

For every capacitor for power electronics the individual data sheets contain the frequency dependent dissipation factor and the thermal resistance R_{th}.

The user can thus determine the dissipation and the resulting temperature increase $\Delta \vartheta$ with the aid of Fourier's analysis: $\Delta \vartheta = P_V \cdot R_{th}$. From this temperature increase and the ambient temperature ϑ_{amb}, the dielectric temperature ϑ_{diel} can be derived as:

$\vartheta_{diel} = \vartheta_{amb} + \Delta \vartheta = 85°C/185°F.$

In order to maintain the given operational reliability, the temperature of the dielectric is not allowed to exceed 85° C/185° F.

In every other event, particularly in cases of doubt, we will gladly carry out the calculations for our customers. In this case, it is requested to return an answered questionnaire (see page 46).

5.5. Maximum current $I_{max.}$

Apart from the "thermal limit" for the current carrying capacity, resulting from Fourier's analysis as described in para 5.1. and 5.4., another current limit given by the design of current paths, line cross-sections and connecting elements has to be taken into account. Since this limit value is to be understood as an independent value, the individual data sheets also offer the permitted current value ($I_{max.}$).

Non-sinusoidal voltage loading

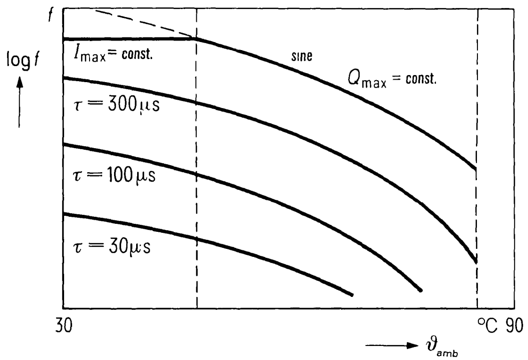


Figure 9
Permissible frequencies

In figure 9, the permissible frequencies are illustrated versus ambient temperature for the rated voltage and the charge exchange time taken as parameter (30, 100, 300 μs) as well as for sine voltages.

6. Ambient temperature ϑ_{amb}

In case of natural cooling the capacitors are cooled by natural air circulation and heat dissipation. The ambient temperature (ϑ_{amb}) is measured in a distance of 30 cm and at ⅔ of the capacitor height. The permissible load is reduced when other components around the capacitor cause a temperature rise.

6.1. Maximum limit temperature ϑ_{max}

The maximum temperature ϑ_{max} is that temperature occurring in the worst case at the hottest spot of the capacitor surface including temperature rise at rated load (definition in accordance with VDE 0560, part 1, § 12).

7. Overload protection

MP and MKV capacitors always have an excess pressure make-and-break fuse, which prevents the capacitor from being blown up, resulting from undue overload or critical phases at the end of its service life. This requirement cannot be met by overcurrent protection, since a self-healing capacitor does not carry any considerable overcurrent; whereas this capacitor type can be disconnected by means of a make-and-break fuse due to its internal pressure caused by the gas produced during the many self-healing processes.

8. Mounting instructions

When capacitors with a make-and-break fuse are mounted, care should be taken not to hinder the elastic elements of the fuse.

This means:
The connecting leads must be sufficiently elastic. The space left above the aluminum capacitor connections must be sufficient and the elastic bottom of tubular case capacitors must be flexible within the beading. The crimps may not be fixed by clamps. When these regulations are taken into account, Siemens capacitors with make-and-break fuses offer maximum reliability for all alternating voltage applications.

Fitting position

Capacitors in aluminum and plastic case may be mounted in any position. For capacitors in big tubular cases upright mounting is mandatory. Horizontal mounting can be permitted after agreement with the manufacturer.

Fixing

The threaded bolts of aluminum and plastic cases up to diameters greater than 60 mm and a height of 154 mm may be used for fixing when the vibration conditions are up to 5 *g*. Larger capacitors are to be fixed, e.g. with ring clips according to B 44031, or connecting rings according to B 44032.

Grounding

Either the threading bolt of aluminum cases or the ground strip at the cover of tubular cases are to be used for grounding in accordance with VDE 0100.

Safety precautions

When MP filter capacitors are used, it is necessary to observe the safety precautions for high voltage capacitors (self-recharging phenomenon and high energy level of high voltage batteries).

9. Mechanical robustness of terminations

The connecting elements meet the requirements of DIN 40046, sheet 19, edition Jan. 70

Test Ua – Tensile	2 kp[1])
Test Ub – Bending	two bends in the opposite direction
Test Uc – Torsion	condition 2 (2 rotations)
Test Ud – Torque of threaded bolts	

[1]) 2 kp ≙ 20 N

11.5. Failure quota α_{AQ}

The failure quota indicates the number of permitted failures per 10^9 component hours.

4th code letter
Failure quota given in failures per 10^9 component hours

K	L	M	N	P	Q
100	300	1000	3000	10 000	30 000

The failure quota is coded in the 4th code letter.

11.6. Load duration (life expectation) t_{BD}

The load duration is the sum of all periods during which voltage is applied (deviating from DIN 40040).

It is identified by the 5th code letter.

5th code letter
Load duration in hours

R	S	T	U	V
100 000	30 000	10 000	3000	1000

11.7. Relative failure rate

The relative failure rate is the ratio of the number of failed to the total number of components and applies to the load duration indicated. It is the product of failure quota and load duration. The value stated in the data sheets is an average value, which was not exceeded during investigations of a sufficiently large number of components.

11.8. Failure criteria

Total failure
- O Short or
- O open circuit

Failure due to variation
Exceeding of the limit values for:
- O Capacitance instability
- O Dissipation factor tan δ

11.9. Example of coding the climatic category

Code letters: H S F/N T

- H — Minimum temperature limit
- S — Maximum temperature limit
- F — Humidity
- N — Failure quota
- T — Load duration

14.3. Cycle duration (SD)

The cycle duration is understood as the sum of operation time and voltage-free intervals at intermittent operation.

14.4. Relative operation time (ED)

The relative operation time is the ratio of operation time to cycle duration, stated as a percentage of the cycle duration.
Example: AB 20% ED; SD 10 hours
means intermittent operation at a cycle duration of 10 hours, where a voltage is applied to the capacitor for 2 hours and the interval lasts 8 hours.

14.5. Short-time operation (KB)

At short-time operation the duty cycle is so short that the steady-state capacitor temperature is not achieved. The voltage-free interval is so long, that the temperature cools down practically to the temperature of the cooling agent.

15. Solder conditions

When the capacitors are subjected to the soldering process, care must be taken that the capacitors are not being damaged by too high heat input. Siemens capacitors meet the following test conditions in accordance with DIN 40046, sheet 18:

Solderability test	275° C ± 10° C/527° F ± 18° F, 2 sec ± 0.5 sec
Heat resistance test	350° C ± 10° C/662° F ± 18° F, 5 sec

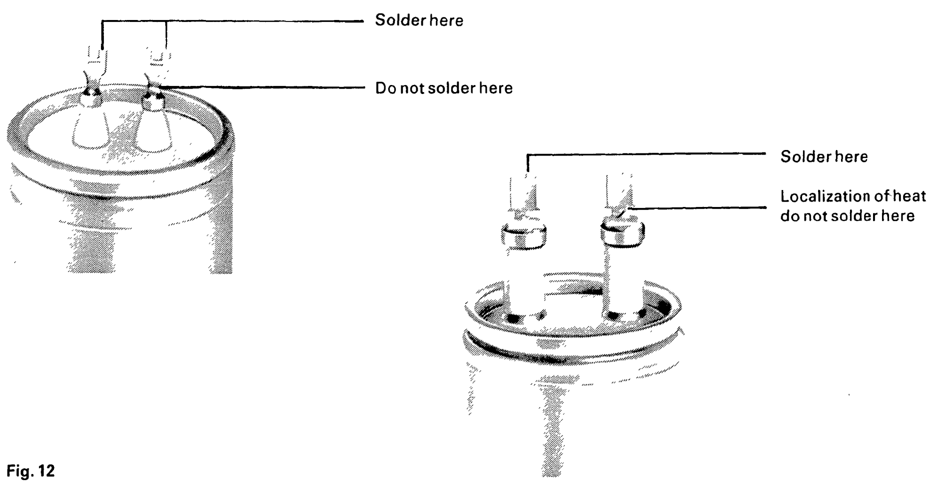


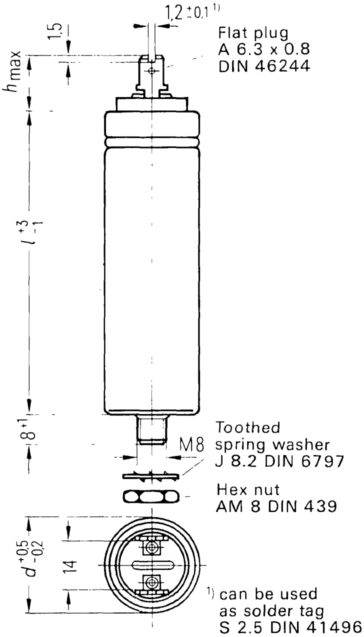
Fig. 12

Too strong connecting leads (> 1 mm dia) must be avoided since the soldering process would require too much heat resulting in dangerous melting of the solder tags (see figure 12).

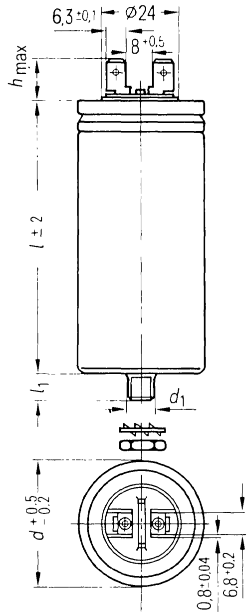
Flat two-pin-plugs, 4.3 mm, are not suited for the soldering of connecting wires.

Design data

Outline drawing a
B 25832-+****-K1
with flat solder plugs 6.3×0.8



Outline drawing b
B 25832-+****-K9
with flat two-pin plugs 6.3×0.8



d	h_{max}
25	16.5
30–45	12

Dimensions in mm

d	h_{max}	l_1	d_1
40; 45	13.5	8	M 8
50–60		12	M12

Capacitor diameter d	≦ 45 mm	≧ 50 mm
Fixing	threaded bolt M 8	threaded bolt M 12
Fixing hole	9.5 mm	14 mm
Max. torque	4 Nm	10 Nm
Fuse	make-and-break fuse	make-and-break fuse
Cross section of connection	1.5 mm^2	1.5 mm^2

Washers and hex nuts for fixing are included in delivery.

DIN climatic category
(DIN 40040) **H S F / M S**

Lower category temperature	ϑ_{min}	**H**	–25°C/+13°F
Upper category temperature	ϑ_{max}	**S**	+70°C/+158°F
Storage temperature range	ϑ_{stg}		–55°C to +70°C –67 to + 158°F
Humidity category		**F**	average relative humidity ≦ 75% 95% for 30 days per year; 85% for the remaining days
Failure quota	α_{AQ}	**M**	1000 failures per 10^9 component hours
Load duration	t_{BD}	**S**	30 000 h

Test data and maximum ratings

Peak voltage	U_p	1100 V	
Voltage rate of rise	$\left(\frac{du}{dt}\right)_{max}$	≦ 10 V/µs	
Test voltage Terminal to terminal	$U_{TERM/TERM}$	900 V; 50 Hz; 2 s	self-healing break-downs may occur
Terminal to case	$U_{TERM/CASE}$	$\leqq 3 \times 10^{-4}$	
Dissipation factor	tan δ	$\leqq 3 \times 10^{-4}$	
Self discharge time constant	$R_{is} \cdot C$	≧ 3000 s	

Rated voltage U_N		330 V ac DB	660 V ac DB
Rated capacitance µF	Tolerance	Ordering code Dimensions d x l / dimensional drawing	
1.5	±6% ≙ A	–	B25833-V6155-A9 40 x 86/a
2.0		–	B25833-V6205-A9 40 x 86/a
2.5		–	B25833-V6255-A9 40 x 86/a
3.0		B25833-V4305-A9 40 x 54/a	B25833-V6305-A9 50 x 86/a
4.0		B25833-V4405-A9 40 x 54/a	B25833-V6405-A9 50 x 86/a
5.0		B25833-V4505-A9 40 x 86/a	B25833-V6505-A9 50 x 86/a
6.0		B25833-V4605-A9 40 x 86/a	B25833-V6605-A9 55 x 86/a
7.0		B25833-V4705-A9 40 x 86/a	B25833-V6705-A9 55 x 86/a
8.0		B25833-V4805-A9 40 x 86/a	B25833-V6805-A9 55 x 86/a
10		B25833-V4106-A9 40 x 86/a	B25833-V6106-A9 60 x 86/a
12		B25833-V4126-A9 50 x 86/a	B25833-V6126-A9 60 x 86/a
15		B25833-V4156-A9 50 x 86/a	B25833-V6156-A9 79 x 95/b
18		B25833-V4186-A9 55 x 86/a	B25833-V6186-A9 79 x 95/b
20		B25833-V4206-A9 55 x 86/a	B25833-V6206-A9 89 x 95/b
25		B25833-V4256-A9 60 x 86/a	–
30		B25833-V4306-A9 79 x 95/b	–
35		B25833-V4356-A9 79 x 95/b	–
40		B25833-V4406-A9 89 x 95/b	–
45		B25833-V4456-A9 89 x 95/b	–
50		B25833-V4506-A9 89 x 95/b	–
60		B25833-V4606-A9 99 x 95/b	–

Service life test (long-term test)

The amount of the ac test voltage (50 Hz, 85°C, 1000 hrs) is determined by the test voltage factor U_{pruf}/U_N. In the table below, this factor is specified as a function of the capacitance for both voltage groups:

Test voltage factor $U_{prüf}/U_N$	U_N = 330 V ac	U_N = 660 V ac
1.50	≦ 6 µF	≦ 1.5 µF
1.41	> 6 µF to 12 µF	> 1.5 µF to 3 µF
1.33	> 12 µF to 24 µF	> 3 µF to 6 µF
1.15	> 24 µF to 36 µF	> 6 µF to 9 µF
1.10	> 36 µF	> 9 µF

Failure criteria:

Capacitance decrease > 2%

Short circuit or cut-off

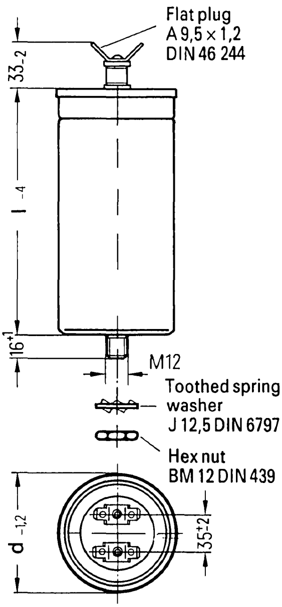
Leakage

Dissipation factor $> 10^{-3}$

Insulation resistance decrease > 50%

Rated Voltage		320 V	400 V	630 V
Rated Capacitance		Dimensions d x l (mm) Dimensional Drawing Ordering Code		
µF	Tolerance	B 25834	B 25834	B 25834
0.1				25 x 48 -J6104-M1 c
0.15				25 x 48 -J6154-M1 c
0.22	± 20% = M			25 x 48 -J6224-M1 c
0.33				25 x 48 -J6334-M1 c
0.47				25 x 48 -B6474-M1 c
0.68			25 x 48 -J4684-M1 c	25 x 48 -B6684-M1 c
1			25 x 48 -B4105-K1 c	30 x 48 -B6105-K1 d
1.5			30 x 48 -B4155-K1 d	35 x 48 -B6155-K1 d
2.2			30 x 48 -B4225-K1 d	30 x 80 -B6225-K1 d
3.3			35 x 48 -B4335-K1 d	35 x 80 -B6335-K1 d
4.7			30 x 80 -B4475-K1 d	40 x 85 -B6475-K9 a
6.8			35 x 80 -B4685-K1 d	50 x 85 -J6685-K9 a
10			40 x 85 -J4106-K9 e	60 x 85 -J6106-K9 a
15	±10% = K		50 x 85 -J4156-K9 e	79 x 104 -B6156-K*) b & e
22			64 x 104 -B4226-K*) b & e	89 x 104 -B6226-K*) b & e
33		60 x 85 -J3336-K9 a	79 x 104 -B4336-K*) b & e	64 x 248 -B6336-K4 b
47		79 x 104 -B3476-K4 b	89 x 104 -B4476-K*) b & e	79 x 248 -B6476-K4 b
68		99 x 104 -B3688-K4 b	64 x 248 -B4686-K4 b	89 x 248 -B6686-K4 b
100		79 x 248 -B3107-K4 b	79 x 248 -B4107-K4 b	
150		79 x 248 -B3157-K4 b	89 x 248 -B4107-K4 b	
220		99 x 248 -B3227-K4 b		

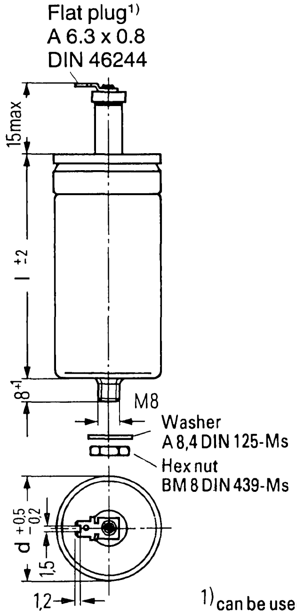
e.



Dimensions in mm

Dimensional Drawing:

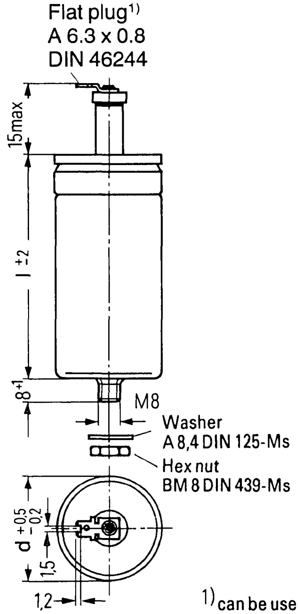
a.



1) can be used as solder tag S 2,5 DIN 41 496

Dimensions in mm

b.



1) can be used as solder tag S 2,5 DIN 41 496

Dimensions in mm

MKP Capacitors – Motor Run

Design:

Self-healing tubular winding capacitor comprising a low loss plastic dielectric (Polypropylene) and vacuum deposited metallized layer.

Case:

The windings are enclosed in tubular aluminum cases with epoxy resin seal.

Connections:

The connections joined to the metallized winding face ends ensure reliable contact. The types are available with flat plug connections and cable connections.

Technical Data:

Climatic Category (in accordance with IEC 68-1)	25/085/21
Operating limit temperature	−25°C . . . +85°C
Maximum permissible voltage (in accordance with IEC 252)	1,1 U_R
Maximum permissible current (in accordance with IEC 252)	1,3 I_R
Self discharge time constant (insulation resistance x capacitance)	r = RC > 3000 MΩ x µF
Operating Frequency	50 . . . 60 Hz
Dissipation Factor (at 120 Hz)	$tg\,\delta < 1 \times 10^{-3}$
Test voltage Terminal/Terminal Terminal/case	 2,0 U_R (2s at 25°C) (self healing breakdowns may occur) 2000V 10s (short circuited terminals x case)
Life Test (in accordance with IEC 252-24)	500h at 85°C 1,25 U_R
Voltage rate of rise $\frac{du}{dt}$ max	10V/µs

Note: Consider U_R (rated voltage) and I_R (rated current) at 60 Hz.

Rated Capacitance µ	Tolerance %	Rated Voltage at 50/60 Hz Volt 370	440
		Dimensions (Ø x L) mm	
4		45 x 55	45 x 55
5		45 x 55	45 x 55
6			
7.5		45 x 62	45 x 74
8.5		45 x 62	
10		45 x 69	45 x 92
12.5		45 x 82	
15		45 x 92	45 x 119
17.5	± 10%*	45 x 107	
20		45 x 119	45 x 170
25		45 x 129	53 x 152
30		45 x 170	53 x 140
35		53 x 129	63.5 x 129
40		53 x 152	63.5 x 152
45		63.5 x 119	63.5 x 170
50		63.5 x 129	63.5 x 200
55		63.5 x 152	63.5 x 200
70			63.5 x 244

* ± 6% Under Special Request.

Ordering Code:

Example: 10 µf 10% 440Vac -7754

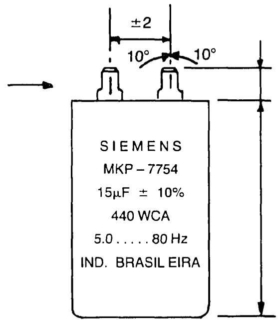
Capacitance — 10 µf

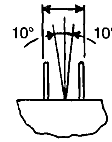
Tolerance — 10%

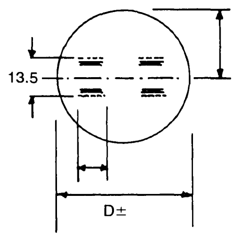
Rated Voltage — 440Vac

Type Code — -7754

Dimensions: Single Capacitance



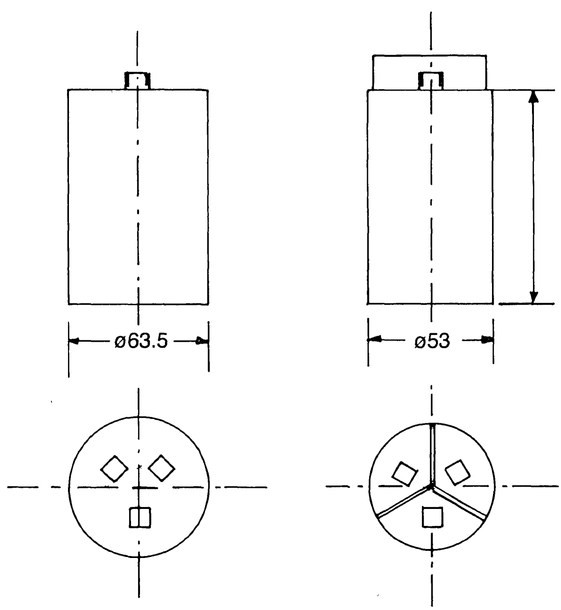




*Permissible Tolerance

Dimensions in mm

Dimensions: Dual Capacitance



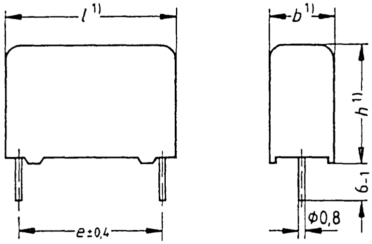
RFI Capacitors

Y capacitors

Rated voltage 250 Vac, 50 Hz

Self-healing capacitors comprising plastic film dielectric; enclosed in rectangular plastic case, epoxy reasin sealed. (Plastic case and seal are flame retardant.) The case is provided with spacers to improve solderability in the solder bath.

The capacitors have parallel leads in the lead spacing and are particularly suitable for PC mounting.



1) max

Dimensions in mm

Technical data

Test voltage	1500 Vac, 2 sec (layer to layer)
Voltage rate of rise (max.)	200 V/µs
Continuous voltage test (type test)	1000 h with 1.7 V_R
Capacitance tolerance	± 10%
Insulation	≧ 30.000 MΩ
DIN climatic category	GPF (−40...+85°C/−40...+185°F, humidity category F)
IEC climatic category	40/85/21
Specifications	As Y capacitors these capacitors comply with VDE 0565-1
Test symbol applied for	0565-1

Types

Rated capacitance	Dimensions *b* x *h* x *l* mm	Lead spacing *e* mm	Approx. weight g	Ordering code
2500 pF (Y)	7 x 13 x 18	15	2	B81121-C-B141
3300 pF (Y)	7 x 13 x 18	15	2	B81121-C-B142
4700 pF (Y)	9 x 14.5 x 18	15	2.2	B81121-C-B143
6800 pF (Y)	7.3 x 16.5 x 27	22.5	4.4	B81121-C-B144
0.01 µF (Y)	7.3 x 16.5 x 27	22.5	4.4	B81121-C-B145
0.015 µF (Y)	8.5 x 18.5 x 27	22.5	5.2	B81121-C-B146
0.022 µF (Y)	10.5 x 19 x 27	22.5	7.5	B81121-C-B147
0.027 µF (Y)	11 x 20.5 x 27	22.5	8.5	B81121-C-B148
0.033 µF (Y)	11.5 x 21 x 32	27.5	10	B81121-C-B149

The information describes the type of component and shall not be considered as assured characteristics.

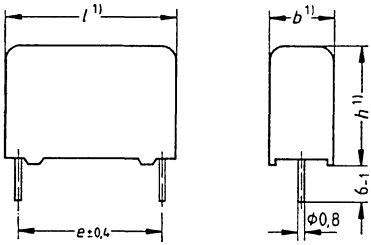
X2 capacitors

Rated voltage 300 Vac

Self-healing, flat capacitor winding comprising polyester dielectric, enclosed in rectangular plastic case with epoxy resin seal. (The plastic case and the eopoxy resin are flame-retardant). The case is provided with spacers to improve solderability in the solder bath.

The capacitors have parallel leads in the lead spacing. Version B is particularly suitable for PC mounting.

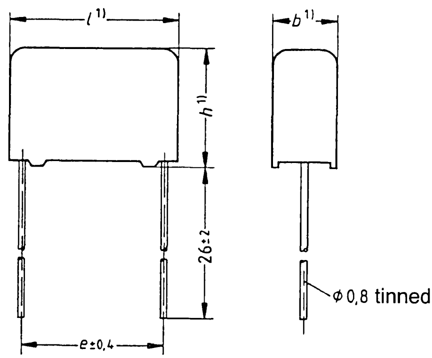
Version B



1) max.

Dimensions in mm

Version C



1) max.

Technical data

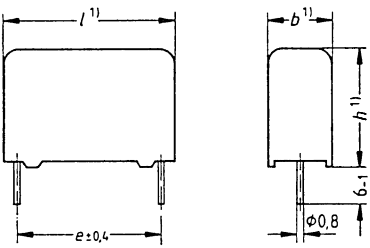
Permissible dc voltage	800 V dc
Test voltage	1300 V dc, 2 sec (layer to layer)
Permissible voltage peaks (max.)	1200 V
Voltage rate of rise (max.)	100 V/µs
Continuous voltage test (type test)	Para. 5.4.18 from VDE 0565, part 1
Capacitance tolerance	± 20%
Insulation	≧ 10.000 sec for C ≧ 0.33 µF ≧ 30.000 MΩ for C ≦ 0.33 µF
DIN climatic category	GPF (−40 to +85°C/−40 to +185°F; humidity category F)
IEC climatic category	40/085/21
Specifications	As X2 capacitors these capacitors comply with IEC 384−14 and VDE 0565−1
Test symbol applied for	565−1

X2 capacitors **Rated voltage 250 Vac, 50...400 Hz**

Self-healing flat capacitor winding comprising polypropylene dielectric, enclosed in rectangular plastic case with epoxy resin seal. (The plastic case and the epoxy resin are flame-retardant.) The case is provided with spacers to improve solderability in the solder bath.

The capacitors have parallel leads in the lead spacing. Version B is particularly suitable for PC mounting.

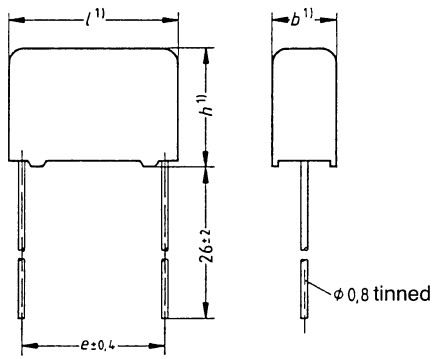
Version B



1) max.

Dimensions in mm

Version C



1) max.

Technical data

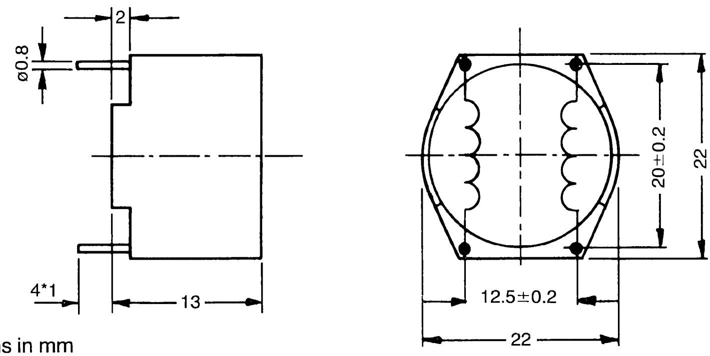
Permissible dc voltage	630 V dc
Test voltage	1200 V dc, 2 sec (layer to layer)
Permissible voltage peaks (max.)	1200 V
Voltage rate of rise (max.)	100 V/µs
Continuous voltage test (type test)	Para. 5.4.18 from VDE 0565 part 1
Capacitance tolerance	± 10%
Insulation	≧ 10,000 sec for C ≧ 0.33 µF ≧ 30,000 MΩ for C ≦ 0.33 µF
DIN climatic category	GPF (–40 to +85°C/–40 to +185°F; humidity category F)
IEC climatic category	40/085/21
Specifications	As X2 capacitors these capacitors comply with IEC 384–14 and VDE 0565–1.
Test symbol applied for	565–1

RFI Chokes

Current-compensated ring core double chokes

Rated voltage 250 V ac
Rated current 0.3 ta 2 A

Ring core chokes with ferrite core, sealed in a plastic can.
The chokes are provided with terminal pins in the lead spacing and are particularly suitable for PC board mounting.
Case and sealing are flame retardant in accordance to UL 94-VO



Dimensions in mm

Technical data

Test voltage	1500 Vac, 2 sec (winding to winding)
Rated current	referred to 50 Hz and +60°C/140°F room temperature
Approx. weight	10 g
Test symbol	565-2

For further details refer to "Technical data on current-compensated ring core chokes".

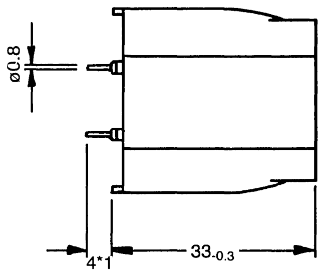
Types

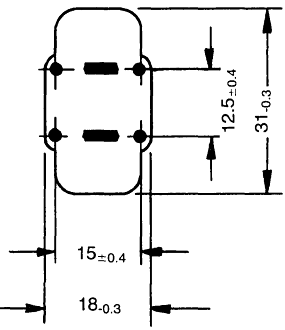
Rated current per winding A	Rated inductance per winding mH	DC resistance per winding (typical value) mΩ	Ordering code
0.3	47	2100	B82722-G2-A3
0.35	27	1700	B82722-G2-C31
0.5	18	1500	B82722-G2-A5
1	5.6	700	B82722-G2-A8
2	2.2	180	B82722-G2-A10

Current-compensated ring core double chokes

Rated voltage 250 Vac
Rated current 0.5 to 4A

Chokes sealed in plastic can with terminal pins in the lead spacing. Can and sealing are flame-retardant in accordance with UL 94 V-O.





Dimensions in mm

Technical data

Test voltage	1500 Vac, 2s, (winding to winding)
Rated current	referred to 50 Hz and +60°/140°F room temperature
Approx. weight	25 g
Test symbol	565-2

Types

Rated current per winding A	Rated inductance per winding mH	DC resistance per winding (typical value) mΩ	Ordering code
0.5	27	1800	B82723-G2-B5*
0.5	39	2000	B82723-G2-A5*
0.65	39	1400	B82723-G2-A6*
0.8	22	1170	B82723-G2-B7
1	12	700	B82723-G2-B8*
1	18	600	B82723-G2-A8*
1.4	27	500	B82723-G2-C82
1.6	10	400	B82723-G2-B9*
2	6.8	200	B82723-G2-B10*
2.5	5.6	160	B82723-G2-B11*
4	3.3	90	B82723-G2-B12*

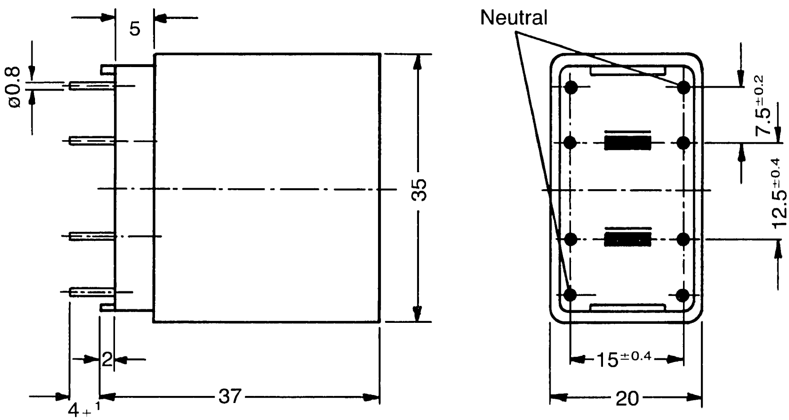
*Marked types additionally have the symbol (Guide Foky 2)

Current-compensated ring core double chokes

Rated voltage 250 Vac
Rated current 0.5 to 4A

Chokes sealed in a plastic can with terminal pins in the lead spacing. Can and sealing are flame-retardant in accordance with UL 94 V-O. A metal can, which can be grounded, is used for shielding.

Interference from the short-range magnetic field throughout the frequency range between 20 kHz and 300 kHz has been lowered by 30 dB.



Dimension in mm

Technical data

Test voltage	1500 V, 2s, (winding to winding) 2500 V, 2s, (winding to case)
Rated current	referred to 50 Hz and +40°C/104°F room temperature
Approx. weight	50 g

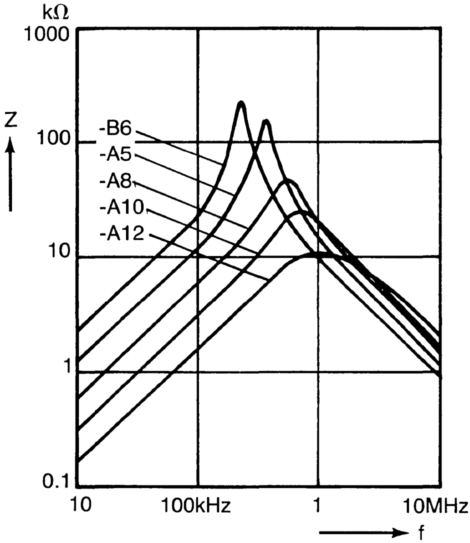
For further details refer to "Technical data on current-compensated ring core chokes".

Types

Rated current per winding A	Rated inductance per winding mH	DC resistance per winding (typical value) mΩ	Ordering code
0.5	39	2000	B82723-G4-A5
0.5	27	1800	B82723-G4-B5
1	12	850	B82723-G4-B8
1.6	10	450	B82723-G4-B9
2	6.8	200	B82723-G4-B10
4	3.3	90	B82723-G4-B12

Impedance Z versus frequency

(measured with windings connected in parallel)

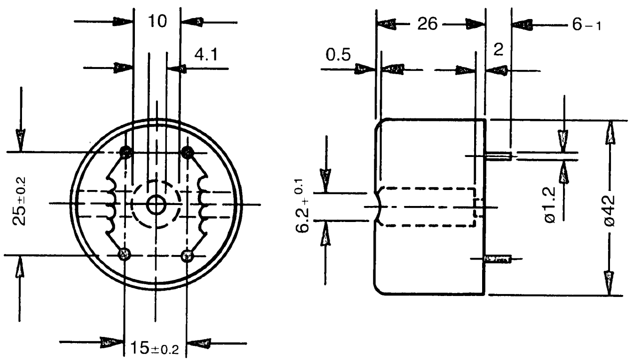


Current-compensated ring core double chokes

Rated voltage 250 Vac
Rated current 1 to 10A

Ring core chokes with ferrite core, sealed in a plastic can. Can and sealing are flame-retardant in accordance with UL 94 V-O.

The chokes are provided with terminal pins, arranged in the lead spacing. They are particularly suitable for PC board mounting.



Dimensions in mm

Technical data

Test voltage	1500 Vac, 2s, (winding to winding)
Rated current	referred to 50 Hz and +60°C/140°F room temperature
Approx. weight	80 g
Test symbol	UL (guide foky 2)

For further details refer to "Technical data on current-compensated ring core chokes".

Types

Rated current per winding A	Rated inductance per winding mH	DC resistance per winding (typical value) mΩ	Ordering code PU: 250
1	33	1000	B82724-G2-A8
1.6	27	560	B82724-G2-A9
2	15	400	B82724-G2-A10
4	6.8	120	B82724-G2-A12
6	3.9	55	B82724-G2-A13
10	1.8	25	B82724-G2-A14

RF Chokes

MCC chokes (**m**ini **c**ylinder **c**ore) and BC chokes (**b**obbin **c**ore) are required for low frequency and high frequency decoupling purposes in signal and control circuits, for the filtering of supply voltages, for use in filter circuits, etc.

Their wide field of application covers electronically controlled household appliances, devices of entertainment electronics, trip computers in vehicles, as well as devices of professional engineering.

Axial, radial, and low-profile choke versions are available to meet these applications. As taped versions they are designed for automatic assembly machines.

MCC-Chokes

Inductance L µH	Tolerance %	Quality at Measuring Frequency Q_{min}	MHz	Rated Current I_N mA	DC-Resistance R_{max} Ω	Resonant Frequency f min. MHz	Ordering No.
0.10		40	25.2	1100	0.11	600	B781*8-T3101-x
0.12		40	25.2	1000	0.12	570	B781*8-T3121-x
0.15	±10	38	25.2	1020	0.13	500	B781*8-T3151-x
0.18	≙K	35	25.2	1000	0.14	460	B781*8-T3181-x
0.22		35	25.2	990	0.16	420	B781*8-T3221-x
0.27		35	25.2	910	0.17	380	B781*8-T3271-x
0.33		35	25.2	830	0.20	330	B781*8-T3331-x
0.39	±20	35	25.2	790	0.22	300	B781*8-T3391-x
0.47	≙M	35	25.2	750	0.25	280	B781*8-T3471-x
0.56		35	25.2	700	0.28	260	B781*8-T3561-x
0.68		35	25.2	530	0.48	240	B781*8-T3681-x
0.82		35	25.2	500	0.55	230	B781*8-T3821-x
1.0		35	25.2	630	0.25	180	B781*8-T1102-K
1.2				610	0.25	170	B781*8-T1122-K
1.5				570	0.30	150	B781*8-T1152-K
1.8		40		540	0.30	130	B781*8-T1182-K
2.2				520	0.35	120	B781*8-T1222-K
2.7	±10			480	0.40	110	B781*8-T1272-K
3.3	≙K	45	7.96	420	0.50	110	B781*8-T1332-K
3.9				400	0.55	100	B781*8-T1392-K
4.7				380	0.65	90	B781*8-T1472-K
5.6				260	1.30	75	B781*8-T1562-K
6.8		50		250	1.45	70	B781*8-T1682-K
8.2				240	1.60	65	B781*8-T1822-K
10				230	1.70	60	B781*8-T1103-x
12		55		190	2.4	50	B781*8-T1123-x
15				185	2.7	45	B781*8-T1153-x
18	±10			175	2.9	40	B781*8-T1183-x
22	≙K			170	3.2	30	B781*8-T1223-x
27				160	3.6	27	B781*8-T1273-x
33			2.52	150	4.1	24	B781*8-T1333-x
39				140	4.5	22	B781*8-T1393-x
47	±5	60		100	8.5	20	B781*8-T1473-x
56	≙J			100	8.8	18	B781*8-T1563-x
68				95	10.0	15	B781*8-T1683-x
82				90	11.5	14	B781*8-T1823-x
100				85	12.5	11	B781*8-T1104-x

*Insert appropriate number: 0 or U for type
0 = taped axial
4 = taped radial

x - Insert appropriate letter for tolerance: K = ± 10%
M = ± 20%

BC-Chokes

Inductance L µH	Tolerance %	Quality at Measuring Frequency Q_{min}	MHz	Rated Current I_N mA	DC-Resistance R_{max} Ω	Resonant Frequency f min. MHz	Ordering No.
1				1200	0.16	205	B781*8-S1102-K
1.2				1150	0.18	185	B781*8-S1122-K
1.5		55		1100	0.20	165	B781*8-S1152-K
1.8				1030	0.22	155	B781*8-S1182-K
2.2				1000	0.25	140	B781*8-S1222-K
2.7	±10%		7.96	940	0.26	125	B781*8-S1272-K
3.3				900	0.29	115	B781*8-S1332-K
3.9	≙ K	60		850	0.31	105	B781*8-S1392-K
4.7				820	0.34	95	B781*8-S1472-K
5.6				780	0.38	85	B781*8-S1562-K
6.8				670	0.51	75	B781*8-S1682-K
8.2		65		690	0.48	50	B781*8-S1812-K
10				680	0.49	35	B781*8-S1103-x
12	±10%	70		650	0.55	30	B781*8-S1123-x
15	≙ K			610	0.60	20	B781*8-S1153-x
18		60		580	0.67	17	B781*8-S1183-x
22				560	0.74	13	B781*8-S1123-x
27	±5%	55	2.52	530	0.83	10	B781*8-S1273-x
33	≙ J			500	0.92	9	B781*8-S1333-x
39		50		470	1.02	8	B781*8-S1393-x
47		45		450	1.10	7.5	B781*8-S1473-J
56				430	1.23	7.0	B781*8-S1563-J
68		40		410	1.35	6.5	B781*8-S1683-J
82		35		390	1.54	6.0	B781*8-S1823-J
100				370	1.7	5.0	B781*8-S1104-J
120				300	2.4	4.5	B781*8-S1124-J
150				280	2.8	4.2	B781*8-S1154-J
180				270	3.0	3.9	B781*8-S1184-J
220		70		250	3.3	3.7	B781*8-S1224-J
270				200	5.7	2.8	B781*8-S1274-J
330			0.796	190	6.4	2.7	B781*8-S1334-J
390	±5%			180	7.0	2.4	B781*8-S1394-J
470	≙ J			170	7.9	2.2	B781*8-S1474-J
580		60		160	8.8	2.0	B781*8-S1564-J
680		55		150	10.0	1.9	B781*8-S1684-J
820				140	12.0	1.6	B781*8-S1824-J
1000				130	14.0	1.6	B781*8-S1105-J
1200		50		115	16.9	1.3	B781*8-S1125-J
1500				100	21.6	1.25	B781*8-S1155-J
1800				95	24.0	1.20	B781*8-S1185-J
2200				80	34.7	1.10	B781*8-S1225-J
2700			0.252	75	40.0	1.00	B781*8-S1275-J
3300		40		62	59.5	0.90	B781*8-S1335-J
3900				59	66.0	0.80	B781*8-S1395-J
4700		35		55	74.0	0.70	B781*8-S1475-J

*Insert appropriate number: 0 or U for type
0 = taped axial
4 = taped radial

x - Insert appropriate letter for tolerance: K = ± 10%
M = ± 20%

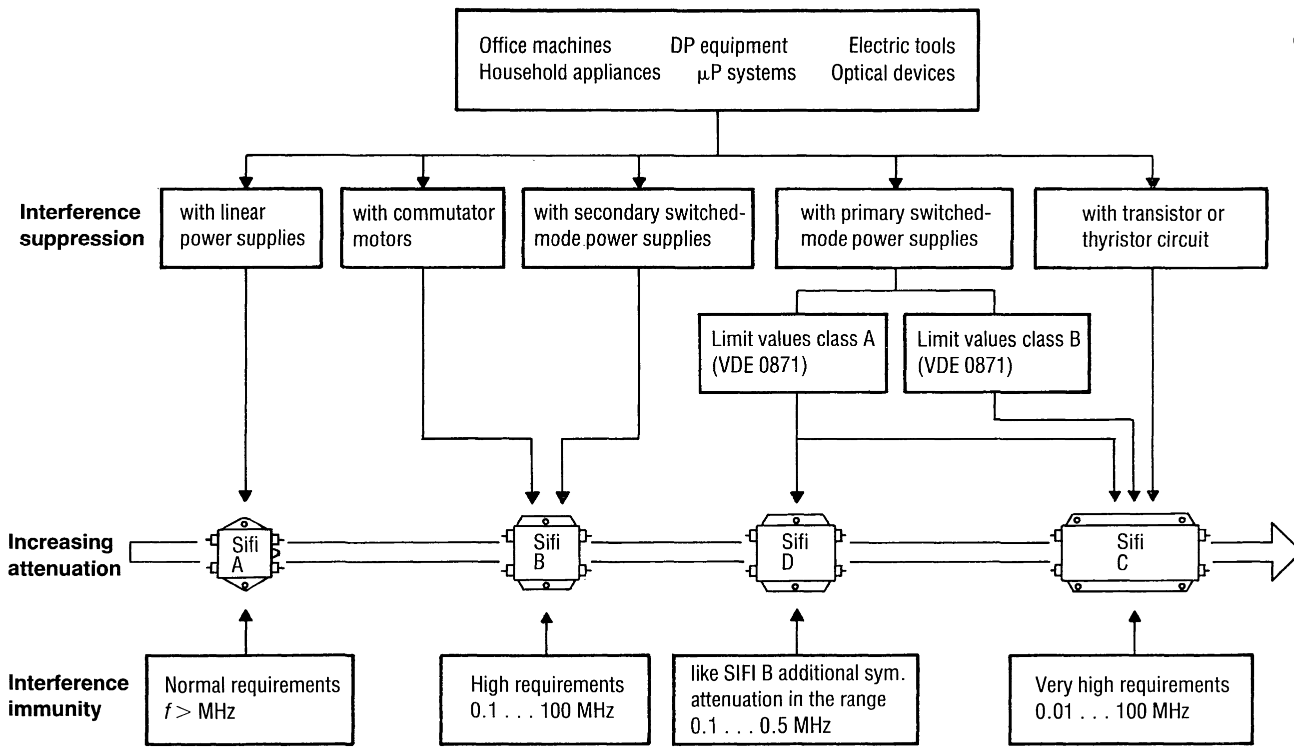
RFI Line Filters

SIFI standard filter series

Application	Four filter series for the solution of EMC problems and for EMI suppression are offered with the new standard filters SIFI B 84 111-A to B 84 114-D. Thus an economic wiring – depending on the required attenuation effect – has been enabled. Filters with one choke SIFI A B84111-A* 10 to * 120 normal attenuation, for rated currents up to 20 A SIFI B B84112-B* 10 to * 120 enhanced attenuation, for rated currents up to 20 A SIFI D B84114-D* 10 to * 110 high attenuation compared to SIFI B, for rated currents up to 10 A Filter with two chokes SIFI C B84113-C* 30 to * 110 very high attenuation
Construction	The components are enclosed in a shielding aluminum case provided with mounting strips and sealed in a self-hardening epoxy resin.
Terminals	Version A and B: flat plugs on both sides 6.3 mm x 0.8 mm (DIN 46244), inserted in insulating lead-throughs. Version K: Thermosetting plug on the line side in accordance with IEC 320/C14 flat plug on the plug side 6.3 mm x 0.8 mm, DIN 46244. Every case is provided with a flat plug 6.3 mm x 0.8 mm, DIN 46244 as safety connector.
Design and symbols	The filters are designed such that they meet the requirements in accordance with VDE 0565T3, UL, CSA, SEV, Semko, Nemko and Demko. The filter series are applied for the corresponding test symbols.
Rated current	The rated current intensity applies to 115 Vac, 50/60 Hz as well as to 250 Vac, 50/60 Hz, i.e. a current reduction in case of application at 250 Vac is not necessary. As the VDE specification 0565T3 is limited to filters up to a rated current of 16 A, the VDE test symbol for both the 20 A filters applies up to 16 A.
Discharge resistors	The discharge resistors are designed in accordance with VDE 0730, i.e. one second after disconnection between device and line, the voltage at the line plug must have dropped to 34 V. The requirements of this VDE specification are the same as those of the corresponding IEC specificaitons (IEC 355 for household appliances, IEC 380 for office machines, and IEC 435 for data processing systems.)

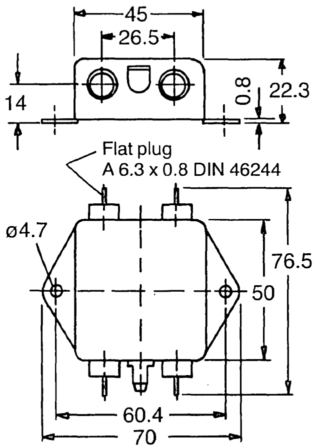
Power Line Filters for Single-Phase Systems

Schematic selection guide for SIFI EMC filters



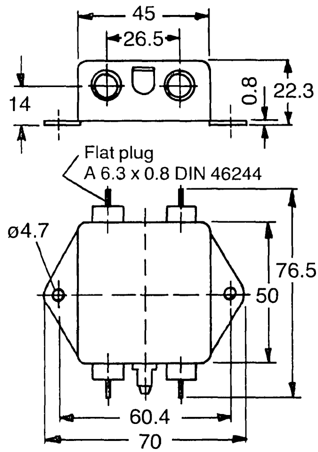
Standard SIFI filter series

Version A

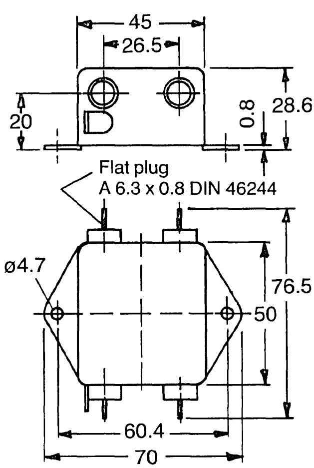


B 84 111-A-A10
B 84 111-A-A20
B 84 111-A-A30

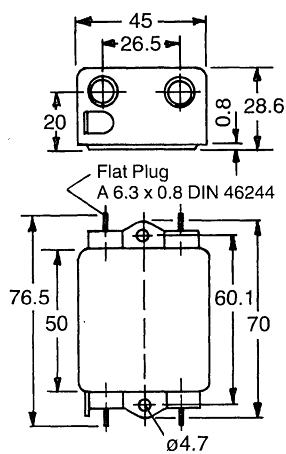
Version B



B 84 111-A-B60
B 84 111-A-B110



B 84 111-A-A60
B 84 111-A-A110

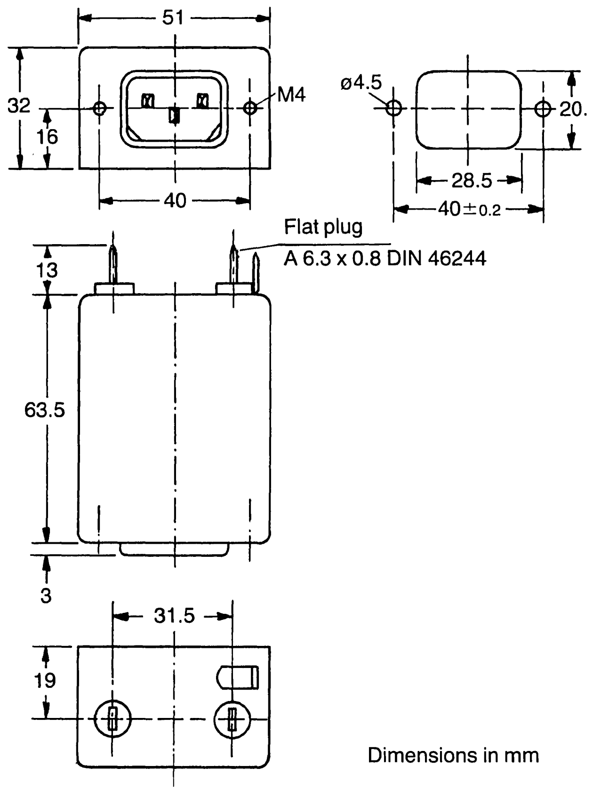


B 84 111-A-B60
B 84 111-A-B110

Dimensions in mm

Standard SIFI filter series

Version K



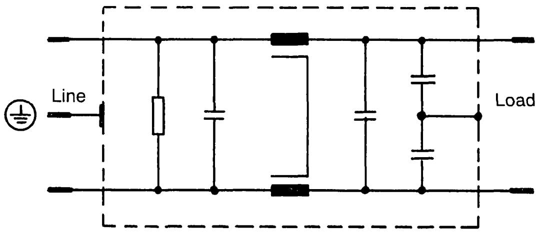
Dimensions in mm

B 84 111-A-K10
B 84 111-A-K30
B 84 111-A-K60

Standard SIFI filter series
SIFI B, enhanced attenuation

Rated voltage 250 Vac
Rated current up to 20 A

Circuit diagram



Technical data

Rated voltage U_R	115/220 V ac, 50/60 Hz
Rated current	referred to 40°C/104°F ambient temperature
Test voltage	1414 V dc; 2 s; conductor to conductor 2700 V dc; 2 s; conductor to ground
Leakage current	<0.5 mA at 250 V ac/50 Hz
DIN climatic category	HPF (−25 to +85°C/−13 to +185°F humidity category F)
Test symbols	VDE, UR, S (Guide FOKY 2) 565-3
Test symbols	CSA, SEMKO, DEMKO, NEMKO applied for

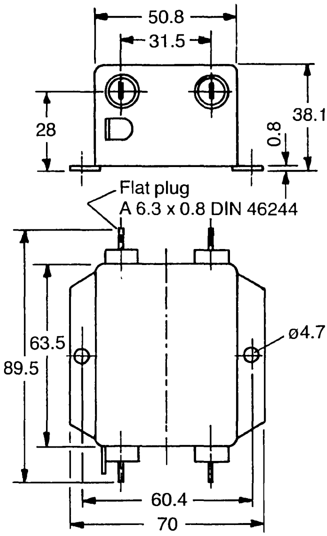
Discharging resistor in accordance with VDE 0730, IEC 355, IEC 380, and IEC 435

Rated current A	Version A[1] Ordering code PU: 20	Approx. weight (g)	Version B Ordering code PU: 20	Approx. weight (g)	Version K Ordering code PU: 20	Approx. weight (g)
1	B 84 112-B-A10	110	B 84 112-B-B10	110	B 84 112-B-K10	140
2	B 84 112-B-A20	110	B 84 112-B-B20	110	–	–
3	B 84 112-B-A30	140	B 84 112-B-B30	140	B 84 112-B-K30	210
6	B 84 112-B-A60	150	B 84 112-B-B60	150	B 84 112-B-K60	210
10	B 84 112-B-A110	200	B 84 112-B-B110	200	–	–
20[2]	B 84 112-B-A120	340	B 84 112-B-B120	340	–	–

[2] UDE approval in accordance to VDE 0565 IT3 only for 16A.

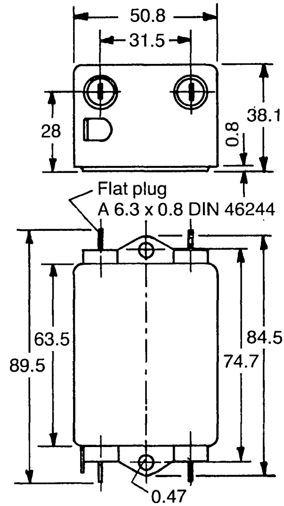
Standard SIFI filter series

Version A



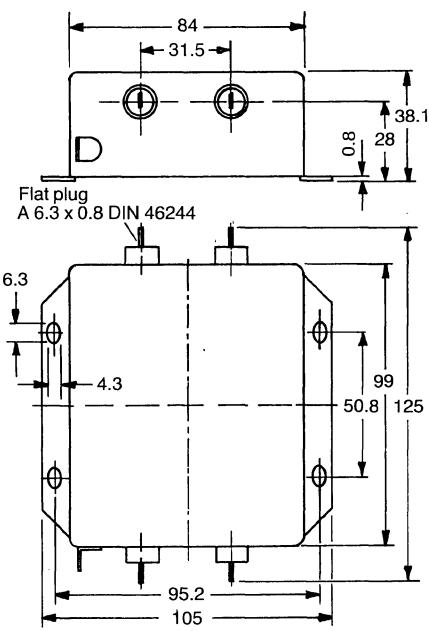
B 84 112-B-A110

Version B

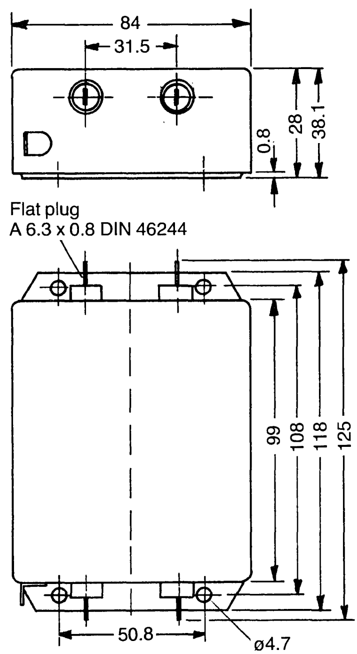


B 84 112-B-B110

Dimensions in mm



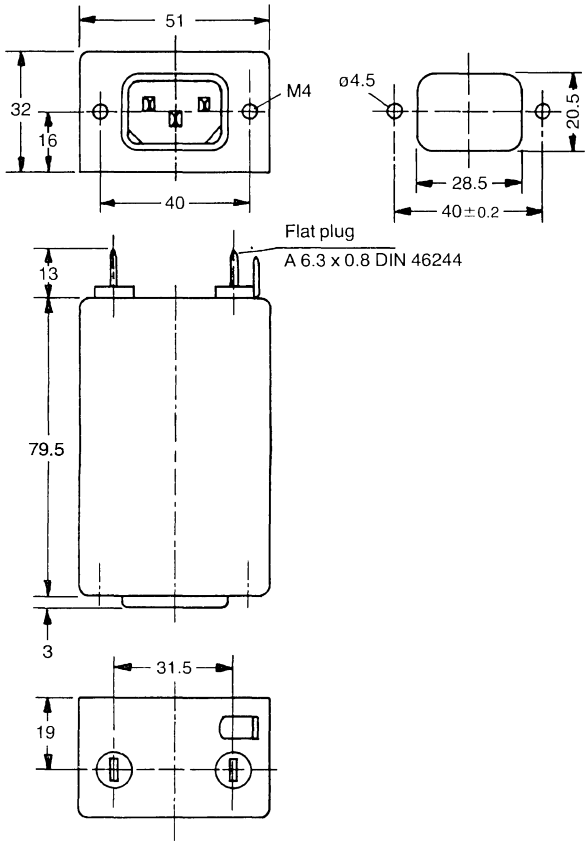
B 84 112-B-A120



B 84 112-B-B120

Standard SIFI filter series

Version K



B 84 112-B-K30
B 84 112-B-K60

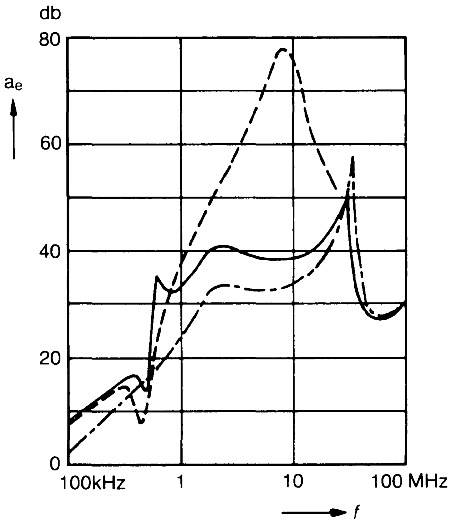
Standard SIFI filter series

Insertion loss (typical values at Z = 50 Ω)

________ Unsymmetric measurement, adjacent arm terminated

\-\-__\-__\-__ asymmetric measurement, both arms in parallel (common mode)

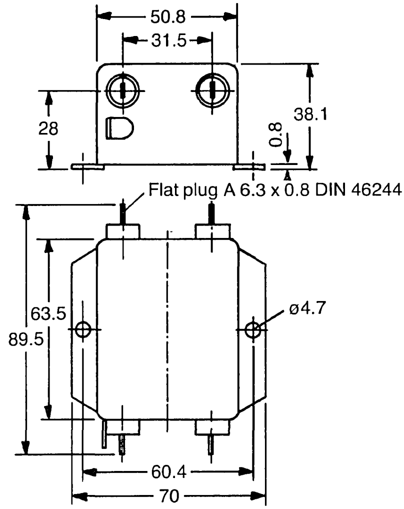
_ _ _ _ _ _ symmetric measurement, (differential mode)



B 84 112-B-A120/-B120

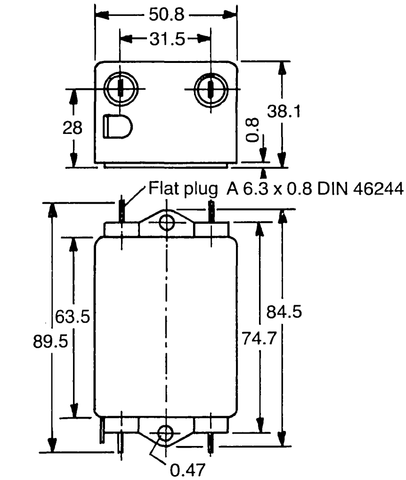
Standard SIFI filter series

Version A

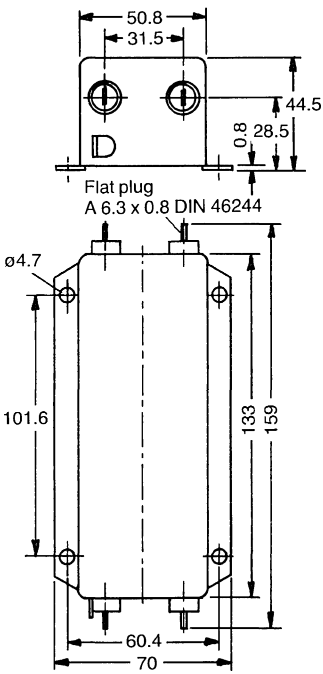


B 84 113-C-A30

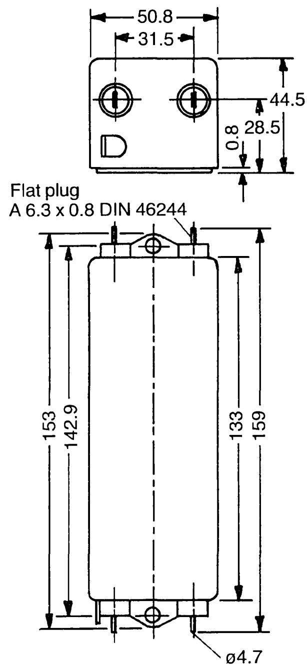
Version B



B 84 113-C-B30



B 84 113-C-A60
B 84 113-C-A110



B 84 113-C-B60
B 84 113-C-B110

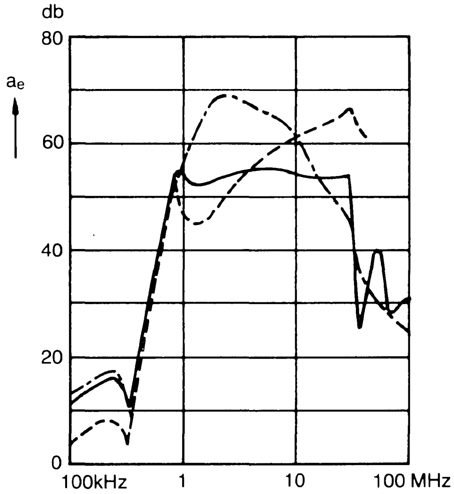
Standard SIFI filter series

Insertion loss (typical values at Z = 50 Ω)

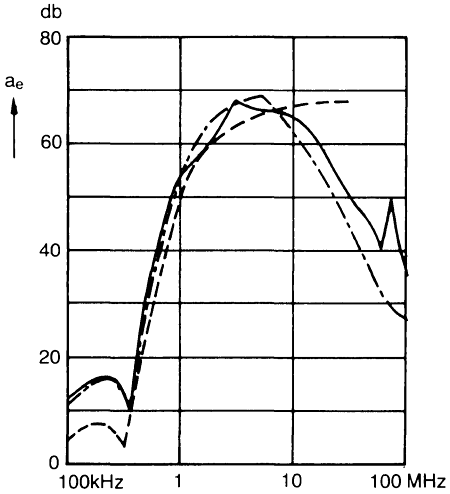
———————— Unsymmetric measurement, adjacent arm terminated

–·–·–·–·– asymmetric measurement, both arms in parallel (common mode)

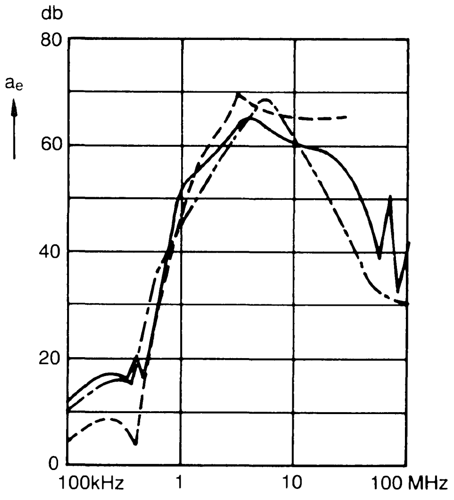
– – – – – – symmetric measurement, (differential mode)



B 84 113-C-A30/-B30/-K30



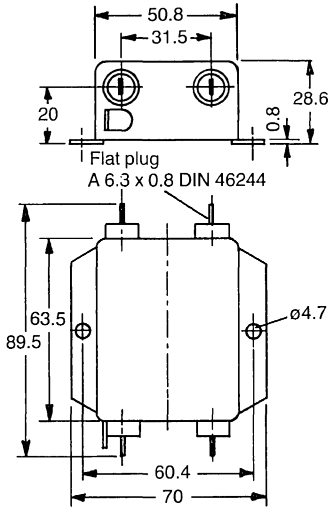
B 84 113-C-A60/-B60



B 84 113-C-A110/-B110

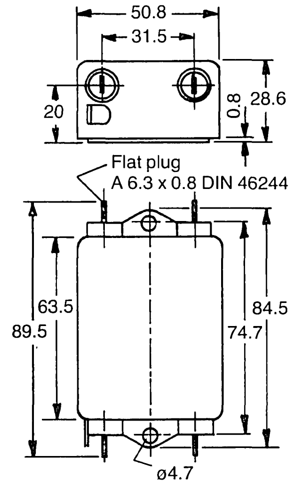
Standard SIFI filter series

Version A



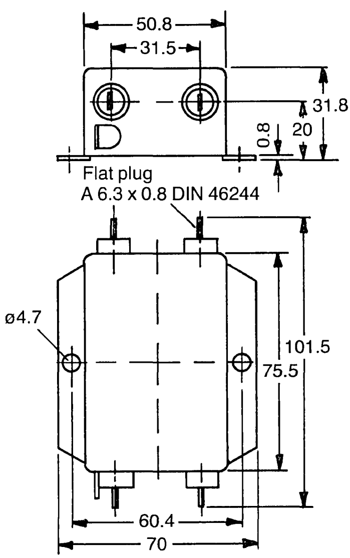
B 84 114-D-A10
B 84 114-D-A20
B 84 114-D-A30

Version B

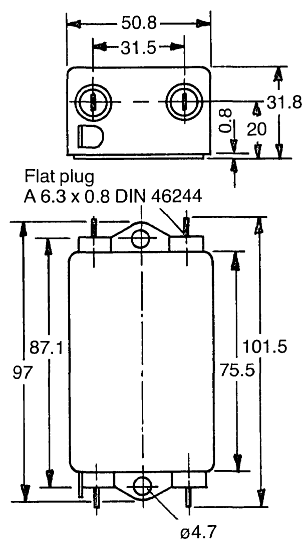


B 84 114-D-B10
B 84 114-D-B20
B 84 114-D-B30

Dimensions in mm



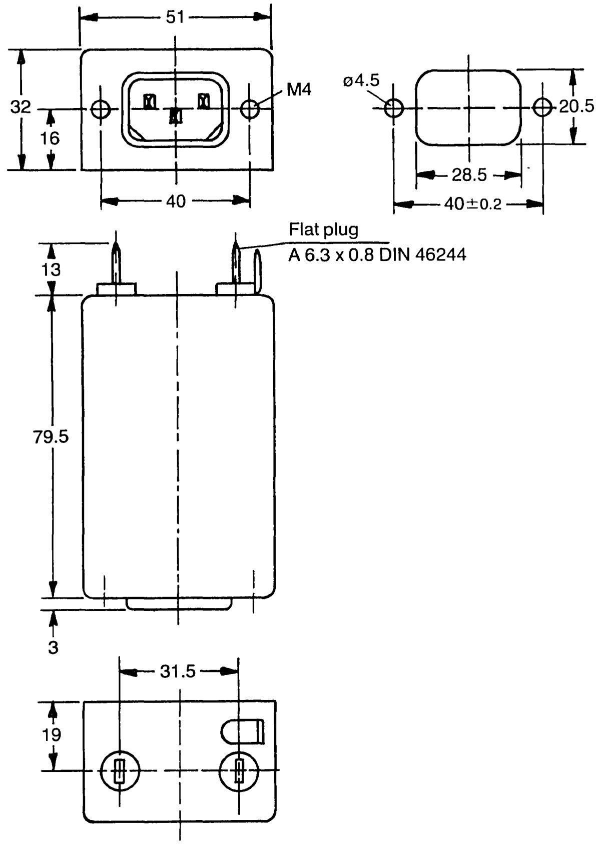
B 84 114-D-A60



B 84 114-D-B60

Standard SIFI filter series

Version K



B 84 114-D-K10
B 84 114-D-K30

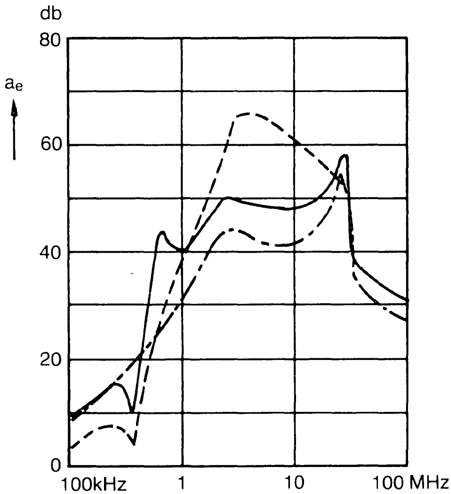
Standard SIFI filter series

Insertion loss (typical values at Z = 50 Ω)

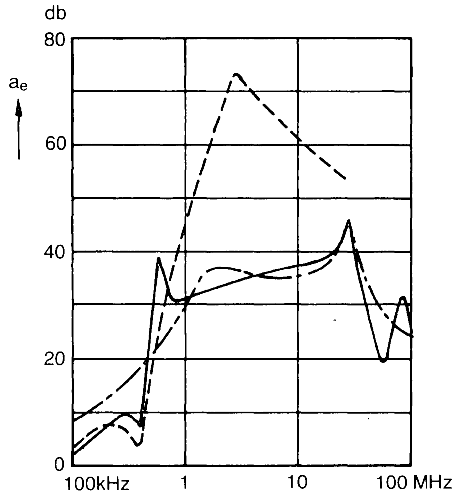
——————— Unsymmetric measurement, adjacent arm terminated

—·——·—·— asymmetric measurement, both arms in parallel (common mode)

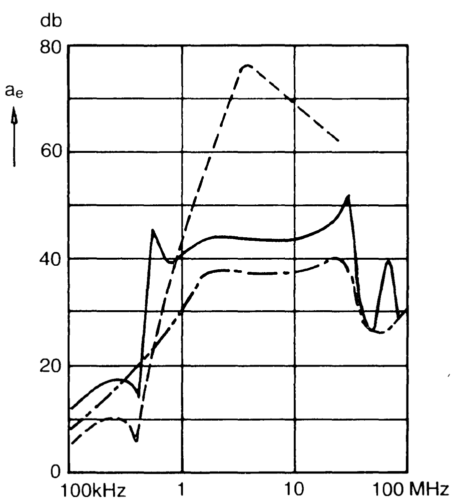
— — — — — — symmetric measurement, (differential mode)



B 84 114-D-A10/-B10/-K10 ——► f
B 84 114-D-A20/-B20
B 84 114-D-A30/-B30/-K30



B 84 114-D-A60/-B60/-K60 ——► f



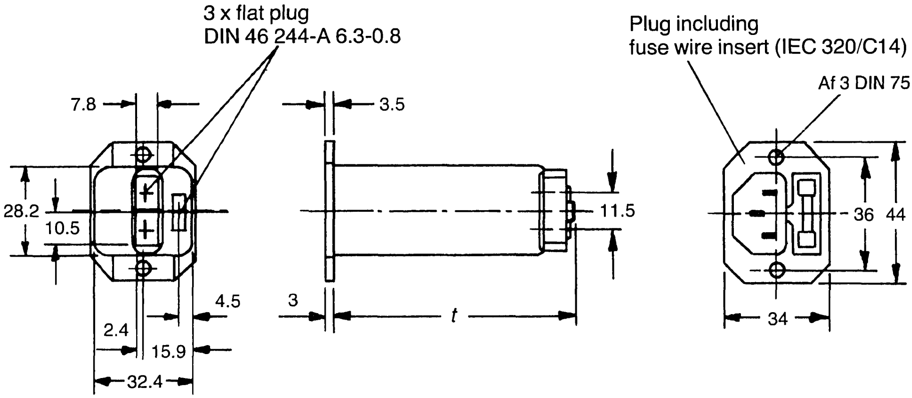
B 84 114-D-A110/-B110 ——► f

Filter with IEC plug and fuse B84103

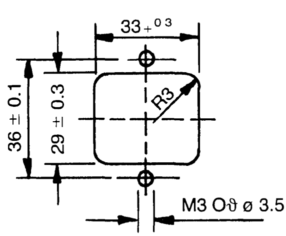
Rated current A	Leakage current* mA	Circuit diagram	Dimension	Approx. weight (g)	Ordering code PU:30
1 2 4 6	<0.34	1	63.5	60	B84103-B2-A10 B84103-B2-A20 B84103-B2-A40 B84103-B2-A60
1 2 4 6	<0.5	2	79	80	B84103-C3-A10 B84103-C3-A20 B84103-C3-A40 B84103-C3-A60

*) at 250 Vac. 50 Hz

Outline drawing



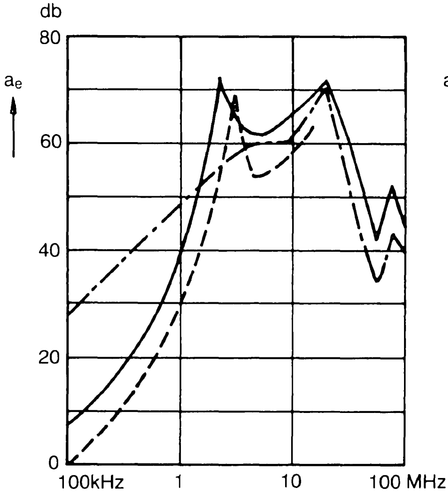
Mounting section



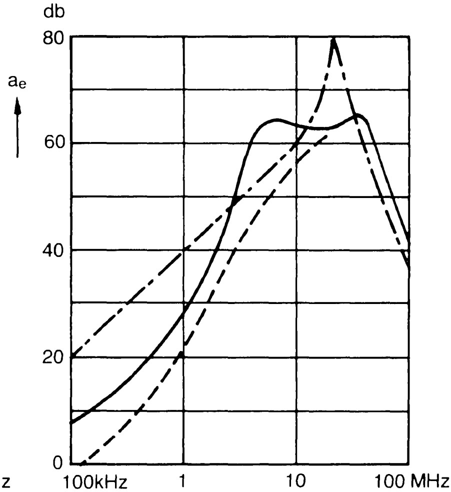
Dimensions in mm

Insertion loss (typical values at $Z = 50\ \Omega$)

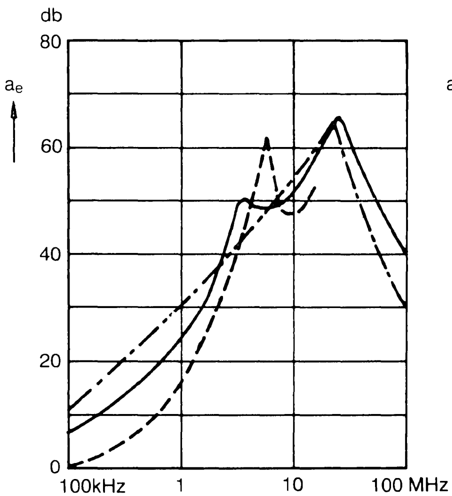
- ——————— Unsymmetric measurement, adjacent arm terminated
- – · – · – · – asymmetric measurement, both arms in parallel (common mode)
- – – – – – – – symmetric measurement, (differential mode)



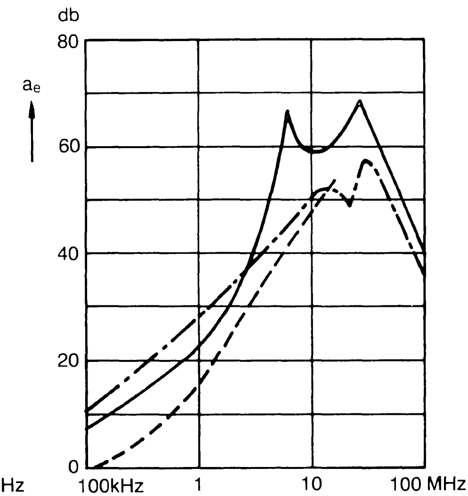
B 84104-A1-A10 → f



B 84104-A1-A20 → f



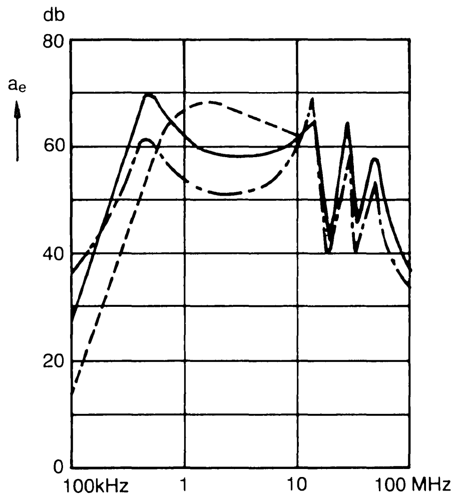
B 84104-A1-A40 → f



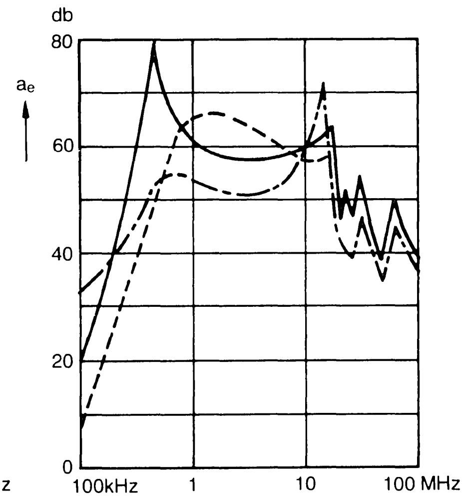
B 84104-A1-A60 → f

Insertion loss (typical values at $Z = 50\ \Omega$)

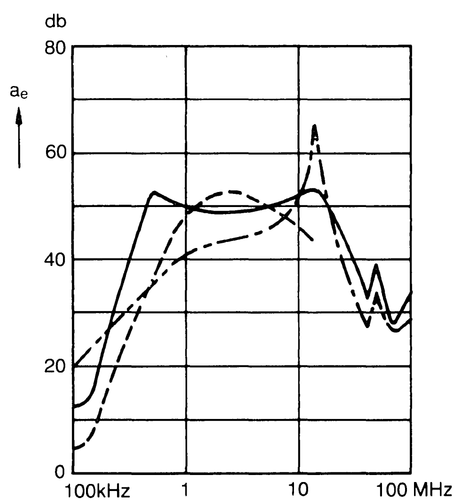
____________ Unsymmetric measurement, adjacent arm terminated
_ . _ . _ . _ asymmetric measurement, both arms in parallel (common mode)
_ _ _ _ _ _ symmetric measurement, (differential mode)



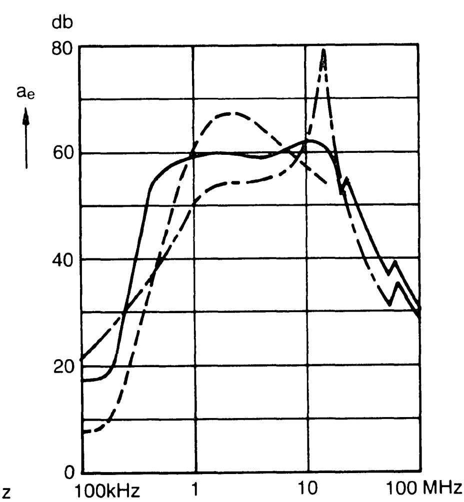
B 84103-C3-A10
B 84104-C3-A10



B 84103-C3-A20
B 84104-C3-A20



B 84103-C3-A40
B 84104-C3-A40

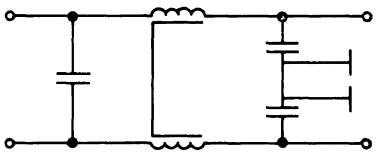


B 84103-C3-A60
B 84104-C3-A60

Filters for printed circuits

Rated voltage 250 Vac
Rated current up to 4 A

Circuit diagram

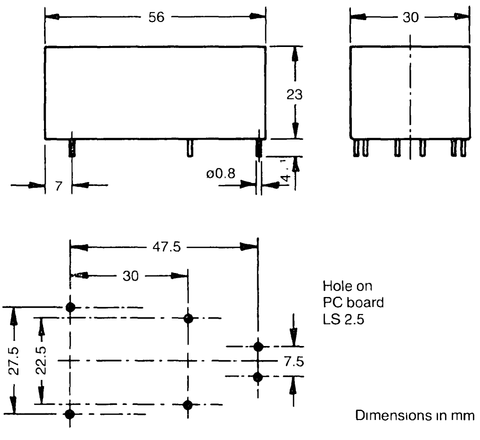


Technical data

Rated voltage	115/250 Vac, 50/60 Hz
Rated current	Referred to +40°C/+104°F ambient temperature +60°C/+140°F for B84110-A-A5
Test voltage	1100 Vdc, 2 s, (line to line) 2700 Vdc, 2 s, (line to ground)
Leakage current	< 0.5 mA
DIN climatic category	HPF (–25 to +85°C/–13 to +185°F humidity category F)
Test symbol	VDE 0565-3 applied for

Rated current A	Leakage current* mA	Approx. weight g	Ordering code PU:75
0.5 1 2 4	<0.5	53	B84110-A-A5 B84110-A-A10 B84110-A-A20 B84110-A-A40

Outline drawing

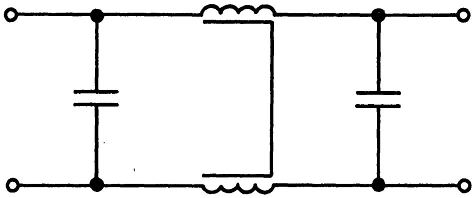


Filter for printed circuits

Rated voltage 250 Vac

Rated current 1.4 A

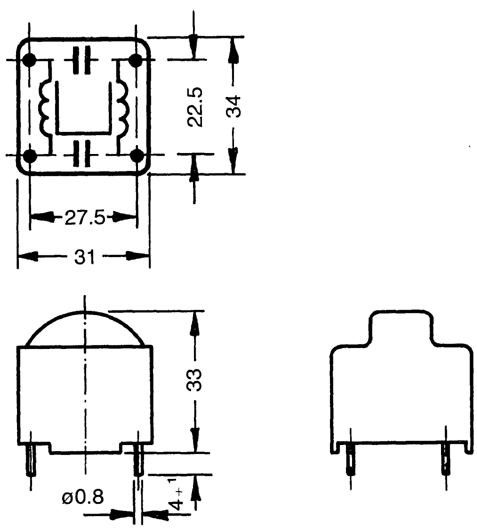
Circuit diagram



Technical data

Rated	250 Vac, 50/60 Hz
Rated current	Reffered to + 40°C/104°F ambient temperature
Test voltage	1100 Vdc, 2 s
DIN climatic category	HPF (–25 to + 85°C/–13 to + 185°F, humidity category F)
Test symbols	 565-3

Rated Current A	Weight ≈ 8	Order No.
1.4	47	B84110-B-A14



PTC Thermistors

General Information

PTC[1] thermistors are resistors made of a doped polycrystalline titanate ceramic material. Within a specific temperature range which is characteristic for the particular type of PTC thermistor, they have a very high positive resistance temperature coefficient (α_R) and a rise in resistance of several powers of 10. This steep rise in resistance is the result of the interaction of semiconductance and ferroelectricity of the titanate ceramic material. Barrier layers are formed at the grain boundaries of the individual crystals of the material, the potential gradient of which and thus the contribution to the overall resistance of the body is heavily dependent on the dielectric constant of the surrounding material. Below Curie point, i.e. in the region of a high dielectric constant, the barrier layers are only weakly developed, and the PTC thermistors have a low resistance. Above Curie point, the dielectric constant drops in accordance with the Curie-Weiss Law. This causes a rapid increase in barrier potential, resulting in the steep rise in resistance.

The effect of this mechanism disguises the weak decrease in resistance with a rise in temperature which basically occurs with all semiconductors due to the "thermal activation" of the charge carriers. This phenomenon which results in a negative temperature coefficient still occurs with PTC thermistors outside the steep resistance rise region.

1. Manufacture and construction

1.1 Manufacture

Mixtures of barium carbonate, strontium oxide, titanium oxide, and other materials whose composition produces the desired electrical characteristics, are ground, mixed, and compressed into discs, sticks, or tubular cases depending upon the application.

These blank bodies are then sintered at high temperatures (between 1000 und 1400°C). Afterwards, they are carefully contacted and provided with connection elements depending upon version.

1.2 Construction

- Contacted PTC thermistor discs or thermistor bodies (without encapsulation), optionally with or without leads.
- Plastic-encapsulated PTC thermistors, radial leads.
- Combined PTC thermistors in a common plastic case connecting lugs in the lead spacing.
- PTC thermistor body, shrunk-sleeve encapsulated and with insulated litz wires.
- PTC thermistor sealed in a glass case, centrally axial leads.
- PTC thermistor in a metal case (screw-in type), single-ended leads.

[1]) PTC: Positive temperature coefficient in accordance with DIN 44080.

Deviation range of PTC thermistor resistance $R_{PTC} = f(\vartheta_{PTC})$
(Tolerance diagram)

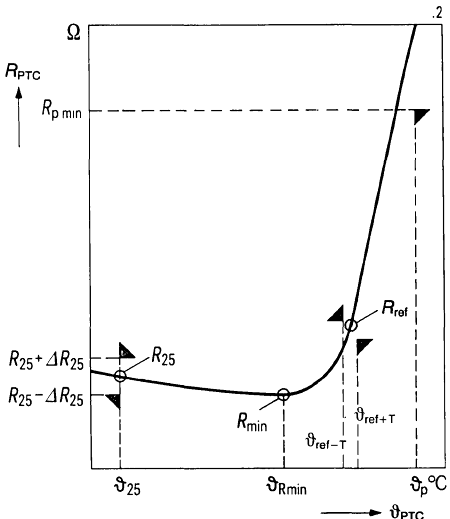


Figure 2

R_{25}	Resistance value at $\vartheta_{amb} = 25°C$ with specified tolerance $\pm\Delta R_{25}$
R_{min}	Resistance value at $\vartheta_{R_{min}}$ with typical value
R_{ref}	Resistance value at ϑ_{ref} with typical value
$\vartheta_{ref}-T$ $\vartheta_{ref}+T$	Reference temperature with specified tolerance $\pm T$
$R_{p_{min}}$	Resistance value at ϑ_p with minimum value

2.3 Minimum resistance R_{min}, initial temperature $\vartheta_{R_{min}}$

The start of the temperature range with a positive temperature coefficient is specified by the temperature $\vartheta_{R_{min}}$. The value of the PTC resistance at this temperature is designated R_{min}. This is the minimum zero load resistance value which the PTC thermistor is able to take.

2.4 Reference resistance R_{ref}, reference temperature ϑ_{ref}

The start of the steep rise in resistance, characterized by the reference temperature ϑ_{ref} which corresponds approximately to the ferroelectric Curie point, is significant for the application. For the individual types of PTC thermistors it is defined as the temperature at which the zero load resistance is equal to the value $R_{ref} = 2 \times R_{min}$. A tolerance of ±5°C is generally permissible. At present, PTC thermistor types are available with the following nominal temperatures: −30°C, ±0°C, +40°C, +60°C, +80°C, +120°C, +160°C, +180°C, and +220°C.

Moreover, PTC thermistors for motor protection are available with "threshold temperatures" between 60°C and 180°C subdivided into steps of 5°C or 10°C. For motor protection purposes, the nominal threshold temperature (ϑ_{NAT}) is defined as the temperature (with a tolerance of ±5°C) at which a change in resistance occurs, causing the appropriate control device to respond.

2.5 Resistance R_p at temperature ϑ_p

This point of the $R_{PTC} = f(\vartheta_{PTC})$ characteristic curve is typical for a resistance in the steep section of the curve. The resistance value R_p is the zero load resistance value at the temperature ϑ_p, and a minimum value is specified for this resistance value.

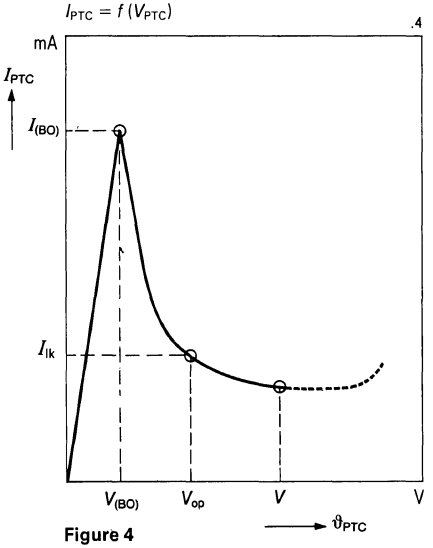
The resistance-temperature characteristic curves specified for the individual types apply to test voltages of $V \leq 1.5V$ in order to minimize the influences of varistor effect and self-heating. When operating with alternating voltage, it has to be observed that owing to the character of the basic material the PTC thermistor is not a purely ohmic resistor but also acts capacitively. Accordingly, the value of R_p, measured as an impedence at ac voltage, decreases with increasing frequency.

2.8 Current-voltage characteristics

The current-voltage characteristic curve shows the relation between current and voltage at a thermally steady state in static air at 25°C if no other temperature is specified.

- The breakover current $I_{(BO)}$ is the current flowing through the PTC thermistor with an applied voltage $V_{(BO)}$, the current at which the electrical power consumed is sufficient to heat the PTC thermistor above reference temperature ϑ_{ref}.
- The leakage current of the PTC thermistor I_{lk} is the current developed at an applied operating voltage V_{op} and at thermal equilibrium.
- The maximum operating voltage V_{max} is the voltage which may be applied continously to the PTC thermistor at the ambient temperature specified in the data sheets in static air and at a stationary high impedance state.

Typical current-voltage characteristic curve
$I_{PTC} = f(V_{PTC})$



$I_{(BO)}$	Breakover current at applied voltage $V_{(BO)}$ (start of current limitation)
I_{lk}	Leakage current at applied voltage V_{op} (when current is balanced)
V_{max}	Maximum operating voltage

Figure 4

2.9 Thermal conductance G_{th}

The thermal conductance is a quotient calculated on the basis of load and associated overtemperature of the PTC thermistor. It is stated in mW/K and is a measure for the load which will increase the steady temperature of the PTC thermistor by 1 K at a specific ambient temperature.

Test U_b: Bending
Two 90 degree bends in opposite directions at a weight of 0.25 kg.

Test U_c: Torsion – degree of severity 2
The lead is bent by 90 degrees at a distance of 6 mm from the PTC thermistor body.
The bending radius of the lead should be approximately 0.75 mm.

3.4 Soldering conditions[1]

PTC thermistors equipped with leads meet the requirements stipulated in the solderability test defined in DIN 40046, sheet 18, test T. When soldering, care must be taken to ensure that no damage occurs as the result of excessive heat input. The following maximum temperatures, maximum times, and minimum distance must be observed.

Dip soldering:	Bath temperature	maximum 260°C
	Soldering time	maximum 4 sec
	Distance from PTC	minimum 6 mm
Iron soldering:	Iron temperature	maximum 360°C
	Soldering time	maximum 2 sec
	Distance from PTC	minimum 6 mm

Should the soldering conditions be more severe, a change in resistance has to be expected.

3.5 Encapsulation and sealing

When encapsulating and sealing the PTC thermistor, please ensure that no mechanical stress will occur (differential thermal expansion during aging and during subsequent operation). When aging, the upper limit temperature of the PTC thermistor must not be exceeded. In order to prevent corrosion of the PTC thermistor contacts, the sealing compound must be chemically neutral. Please consult us if you are in doubt about a particular case.

3.6 Installation conditions

When using PTC thermistors, please ensure that the actual ambient temperature ϑ_{amb} (microclimate) is taken into consideration. Poor heat dissipation may lead to a considerable reduction in loading capacity.

4. Typical applications

The characteristics of the PTC thermistor described in the previous sections make a whole series of application possibilities accessible, the individual requirement of which are taken into account during the design stage.

4.1 PTC thermistors as temperature sensors

The PTC thermistor is operated at a field strength of the order of 1 V/mm. Thus, its resistance is a function of the ambient temperature, as shown in the characteristic curve. Self-heating and the varistor effect may be neglected when PTC thermistors are operated as temperature sensors.

[1]) These soldering conditions only apply to PTC thermistors equipped with leads.

As a result of their thermostat effect, PTC thermistors may also be used when designing low-power heating systems for operation at low voltages or mains voltage if an appropriate size and shape is selected. However, it must be observed that the side surfaces of PTC thermistors are live and that any accumulation of heat on the PTC thermistor surface has to be prevented. By appropriately arranging the elements of the heating system and ensuring that certain elements have a high thermal conductivity, the heat dissipated by the PTC thermistor will be supplied to the system which is to be heated. With a rise in temperature and the associated low level of heat extraction, the PTC thermistor will reduce its power consumption to a low residual value corresponding to the "new" power equilibrium. This will result in a stable final temperature within the heated system.

4.3 PTC thermistors as liquid level-control sensors

A PTC thermistor which is heated by means of field strengths of the order of 10 V/mm reacts to variations in external cooling conditions by changing its power consumption. Thus, at a constant voltage the current consumption is a measure of the respective heat dissipation. With an increase in heat dissipation (i.e. increased cooling), the current of the PTC thermistor will rise as a result of the positive temperature coefficient. The change in current will be particularly large if the PTC thermistor which has been heated in air is now put into a liquid medium where the heat dissipation is considerably higher.

Figure 6 shows the steady current-voltage characteristic curves of a PTC thermistor in both, air and liquid.

Steady current-volltage characteristic curves
$I_{PTC} = f(V_{PTC})$

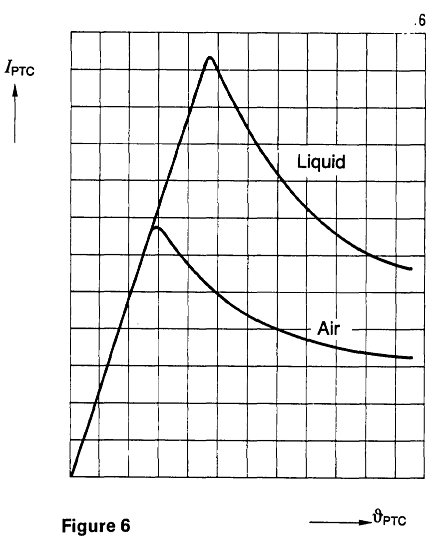


Figure 6

4.5 PTC thermistors as overcurrent protective device

The current-voltage characteristic curve of the PTC thermistor permits application as a short-circuit or overcurrent protective device in special cases. The PTC thermistor is connected in series with the load which is to be protected. During normal operation (refer to figure 7), resistance line 1 will correspond to the load, resulting in operating point A where it crosses the PTC thermistor characteristic curve. Owing to the partially extremely low resistance values, only slight voltage drops will be caused. If a short circuit occurs in the load, shown by resistance line 2, operating point B will result from the PTC thermistor heating and the power consumed by the load will be limited to a permissible, low final value. After the short circuit has been eliminated, the system will automatically return to operating point A.

PTC thermistors with operating voltage ratings up to 550 V are available for a whole range of load protection applications with maximum power ratings of 200 W.

PTC thermistors
as short-circuit or overcurrent protective device $I = f(V)$

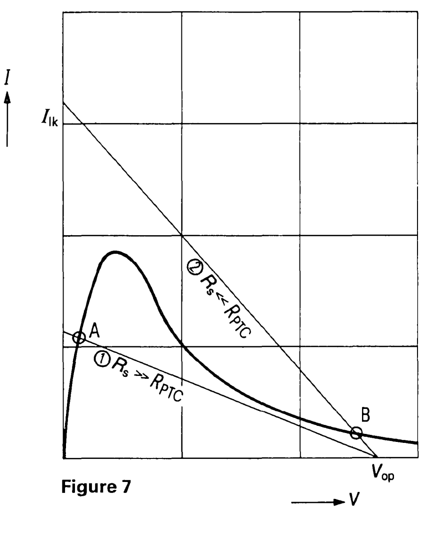


Figure 7

I_{lk} Leakage current

V_{op} Operating voltage

① Resistance line for normal operation

② Resistance line for operation with overcurrent

5.5 Minor defects

In case of a minor defect, the component is entirely operable.
Criteria:

- Bent terminals
- Minor damage to case or component
- Type marking difficult to identify
- Unimportant exceeding of electrical characteristics
- Unimportant exceeding of mechanical characteristics

6. Symbols and terms

α_R	Temperature coefficient	%/K
C_{th}	Thermal capacitance	mJ/K
c	Specific heat of the PTC thermistor material	–
d	Diameter	mm
GND	Ground	–
G_{th}	Thermal conductances	mW/K
δ	Density of the PTC thermistor material	–
ϑ	Temperature	°C
$\Delta\vartheta$	Temperature difference	K
ϑ_{amb}	Ambient temperature	°C
$\vartheta_{case\ max}$	Max. permissible case temperature	°C
$\Delta\vartheta_{ext}$	Tolerance of external temperature	–
ϑ_{max}	Upper category temperature	°C
ϑ_{NAT}	Nominal threshold temperature	°C
ϑ_p	Temperature above the reference temperature ϑ_{ref}	°C
ϑ_{PTC}	Temperature of the PTC thermistor	°C
ϑ_{ref}	Reference temperature (start of the steep resistance rise)	°C
ϑ_{Rmin}	Initial temperature (start of the positive α_R)	°C
ϑ_{stg}	Storage temperature	°C
$\vartheta_{sur\ max}$	Max permissible PTC surface temperature	°C
ϑ_0	PTC thermistor temperature before voltage is applied	°C
$I_{(BO)}$	Breakover current	mA
$\hat{I}_c$	Peak coil current	mA
$I_{c\ in}$	Input peak current, coil side	mA
$\hat{I}_{in}$	Input peak current	mA
I_{lk}	Leakage current of the PTC thermistor	mA
$\hat{I}_{c30}$	Peak leakage current of the PTC thermistor after 30 sec., coil side	mA
$\hat{I}_{c180}$	Peak leakage current of the PTC thermistor after 180 sec., coil side	mA
I_{max}	Max. operating current	A
I_{PTC}	Current of the PTC thermistor	mA
I_R	Rated current	mA
I_{test}	Test current	mA
$I_1 ... I_4$	PTC current at different heat dissipating conditions	mA
PTC	Abbreviation for PTC thermistor	–
P_{dyn}	Dynamic heating power	W
P_i	Initial heating power of the PTC	W
P_{stat}	Stationary final power	W

Overload Protection and Delay Circuits *

* If used as time delay switch, max. 5000 switchings – depending on the load – can be carried out with version B and C.
For a higher number of switchings, clamp contacting (version A) is recommended.

Overload Protection and Delay Circuits 18V to 30V

Application

The PTC thermistors are suitable for automatic short-circuit protection or overcurrent protection. They are used in electronic devices, modules, low-power motors, loudspeakers, circuits, and vehicles (refer to page 49).

Version A

Non-encapsulated PTC thermistors with metallized front ends.

Version C

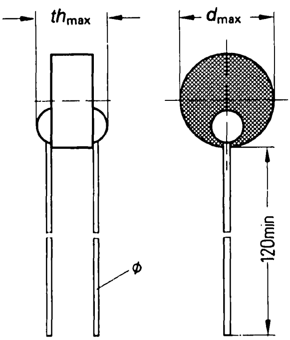
Plastic-encapsulated PTC thermistor with radial leads.

Ordering code	**Q63100–**	**–P450 –A210**	**–P430 –A81**	**–P2390 –C915**	**–P2390 –C935**	**–P2390 –C945**	**Unit**
Operating voltage at ϑ_{amb} = 60°C	V_{max}	18	24	30	30	30	V
Breakover current (typ.)	$I_{(BO)}$	1890	1030	3160	2290	1690	mA
Resistance value at ϑ_{amb} = 25°C	R_{25}	≤1.5	2.4	0.2	0.3	0.45	Ω
Tolerance of R_{25}	ΔR_{25}	–	±20	±25	±25	±25	%
Minimum series resistance at V_{max}	$R_{s\,min}$	0.5	0.5	1.9	2.8	3.4	Ω
Reference temperature (typ.)	ϑ_{ref}	180	160	130	130	130	°C
Leakage current (typ.) at V_{max}	I_{lk}	290	140	220	170	115	mA
Operating current	I_{max}	15	15	15	10	8	A
Temperature coefficient (typ.)	α_R	13	13	15	15	15	%/K
Thermal cooling time constant (typ.)	τ_{th}	90	100	65	55	46	sec
Thermal conductance (typ.)	G_{th}	30	25	35	25	20	mW/K
Thermal capacitance (typ.)	C_{th}	2.7	2.5	2.3	1.4	0.9	J/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	220	200	180	180	180	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	−25	−25	−25	−25	−25	°C
Ground (typ.)	GND	2.0	1.5	3.5	2.4	1.8	g
Dimensions	d_{max}	21	18.5	26	22	17.5	mm
	th_{max}	1.2	1.7	3.5	3.5	3.5	mm
Leads	dia.	–	–	0.8	0.6	0.6	mm

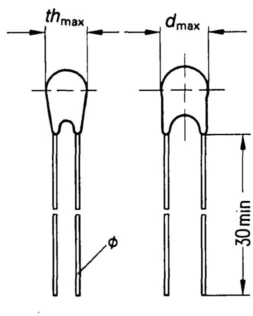
Ordering code	Q63100–	–P2390 –C960	–P2390 –C970	–P2390 –C980	–P2390 –C990	Unit
Operating voltage at ϑ_{amb} = 60°C	V_{max}	80	80	80	80	V
Breakover current (typ.)	$I_{(BO)}$	310	195	110	65	mA
Resistance value at ϑ_{amb} = 25°C	R_{25}	5.6	9.4	25	55	Ω
Tolerance of R_{25}	ΔR_{25}	±25	±25	±25	±25	%
Minimum series resistance at V_{max}	$R_{s\,min}$	15	21	65	85	Ω
Reference temperature (typ.)	ϑ_{ref}	120	120	120	120	°C
Leakage current (typ.) at V_{max}	I_{lk}	25	20	16	12	mA
Operating current	I_{max}	4.3	3.0	1.0	0.7	A
Temperature coefficient (typ.)	α_R	16	16	16	16	%/K
Thermal cooling time constant (typ.)	τ_{th}	28	22	15	12	sec
Thermal conductance (typ.)	G_{th}	13	12	10	7	mW/K
Thermal capacitance (typ.)	C_{th}	0.36	0.26	0.15	0.08	J/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	180	180	180	180	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	−25	−25	−25	−25	°C
Ground (typ.)	GND	0.9	0.6	0.4	0.25	g
Dimensions	d_{max}	11.5	9.0	6.5	4.0	mm
	th_{max}	3.5	3.5	3.5	3.5	mm
Leads	dia.	0.6	0.6	0.6	0.5	mm

Resistance values measured at $I_{test} \leq 1\,mA$.

Version B22



Version C

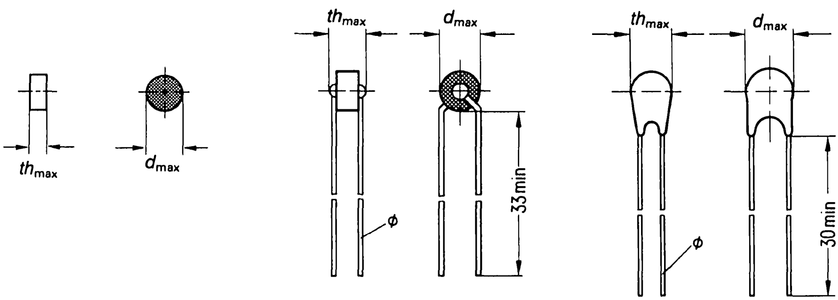


Dimensions in mm

Ordering code	**Q63100– P2390–**	**–C840**	**–C850**	**–C860**	**–C870**	**–C25**	**Unit**
Operating voltage at ϑ_{amb} = 60°C	V_{max}	265	265	265	265	265	Vrms
Breakover current (typ.)	$I_{(BO)}$	420	260	180	130	70	mA
Resistance value at ϑ_{amb} = 25°C	R_{25}	6	10	15	25	80	Ω
Tolerance of R_{25}	ΔR_{25}	±25	±25	±25	±25	±25	%
Minimum series resistance at V_{max}	$R_{s\,min}$	60	113	165	230	1000	Ω
Reference temperature (typ.)	ϑ_{ref}	120	120	120	120	120	°C
Leakage current (typ.) at V_{max}	I_{lk}	15	13	10	9	12	mA
Operating current	I_{max}	4.1	2.2	1.5	1.0	0.4	A
Temperature coefficient (typ.)	α_R	16	16	16	16	16	%/K
Thermal cooling time constant (typ.)	τ_{th}	90	65	50	36	25	sec
Thermal conductance (typ.)	G_{th}	23	16	13	12	10	mW/K
Thermal capacitance (typ.)	C_{th}	2.1	1.0	0.65	0.43	0.25	J/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	180	180	180	180	180	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	−25	−25	−25	−25	−25	°C
Ground (typ.)	GND	3.5	2.0	1.5	1.0	0.5	g
Dimensions	d_{max}	17.5	13.5	11.5	9.0	7.5	mm
	th_{max}	5.5	5.5	5.5	5.5	5.5	mm
Leads	dia.	0.6	0.6	0.6	0.6	0.6	mm

Resistance values measured at $V_{test} \leqslant 1.5V$.

Version A **Version B** **Version C**



Dimensions in mm

Ordering code	**Q63100– P2390–**	**–C884**	**–C885**	**–C886**	**Unit**
Operating voltage at ϑ_{amb} = 60°C	V_{max}	420	550	550	Vrms
Breakover current (typ.)	$I_{(BO)}$	23	16	14	mA
Resistance value at ϑ_{amb} = 25°C	R_{25}	600	1200	1500	Ω
Tolerance of R_{25}	ΔR_{25}	±25	±25	±25	%
Minimum series resistance at V_{max}	$R_{s\,min}$	2500	4000	4000	Ω
Reference temperature (typ.)	ϑ_{ref}	120	115	115	°C
Leakage current (typ.) at V_{max}	I_{lk}	3	3	2	mA
Operating current	I_{max}	0.2	0.1	0.1	A
Temperature coefficient (typ.)	α_R	26	26	26	%/K
Thermal cooling time constant (typ.)	τ_{th}	25	25	25	sec
Thermal conductance (typ.)	G_{th}	10	10	10	mW/K
Thermal capacitance (typ.)	C_{th}	0.25	0.25	0.25	J/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	180	180	180	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	−25	−25	−25	°C
Ground (typ.)	GND	0.6	0.6	0.6	g
Dimensions	d_{max}	6.5	6.5	6.5	mm
	th_{max}	5.5	5.5	5.5	mm
Leads	dia.	0.6	0.6	0.6	mm

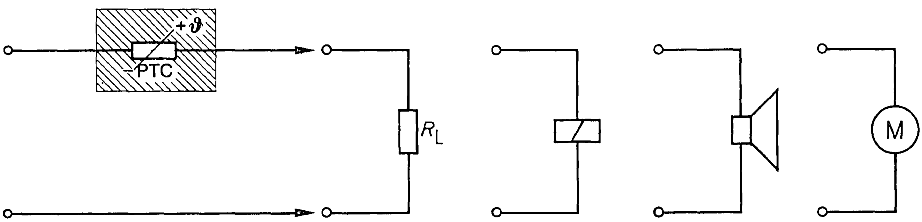
Resistance values measured at $V_{test} \leqslant 1.5$V.

Overload Protection and Delay Circuit Explanation

Functional description

An effective overload protection circuit may be obtained by connecting the suitable type of PTC thermistor in series with the load. During normal operation, the low resistance values R_{25} only cause a slight voltage drop. If, in case of fault, the current increases above the steady maximum current (breakover current $I_{(BO)}$), the PTC thermistor quickly rises in temperature until the reference temperature is reached at which it will rapidly turn high-ohmic and thus limit the current. After the fault has been eliminated, the PTC thermistor is again operable.

Typical circuit design



Calculation for typical applications

An approximate value of the switching time is given by the following equation:

$$t_s \approx \frac{3 \cdot vol \cdot (\vartheta_{ref} - \vartheta_0)}{I_{PTC}^2 \cdot R_0}$$

t_s = Switching time (sec)
vol = Volume of the PTC thermistor (cm^3)
ϑ_{ref} = Reference temperature of the PTC thermistor (°C)
ϑ_0 = Temperature of PTC thermistor before overload (°C)
I_{PTC} = Current through the PTC thermistor during overload (A)
R_0 = Resistance of the PTC thermistor before overload (Ω)

Example

Supply voltage	50V
Rated current of the load	200 mA
Load current during overload	2A
Selected PTC thermistor	Q63100–P2390–C950
	(200 mA < $I_{(BO)}$ < 2A)
(measured)	*d* 12.5 mm, *th* 1.6 mm } vol≈0.2 cm^3
Reference temperature (as specified in data sheet)	120°C
PTC thermistor temperature before overload	40°C
Resistance value of the PTC thermistor before overload	3.5Ω

$$t_s = \frac{3 \cdot 0.2 \cdot (120-40)}{2^2 \cdot 3.5} = 3.4 \text{ sec}$$

Switching time t_s = 3.4 sec

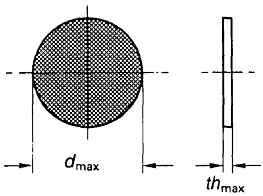
Thermostat Heating Elements

Ordering code	**Q63100–**	**–P350 –A87**	**–P390 –A87**	**–P430 –A87**	**–P450 –A87**	**Unit**
Maximum operating voltage at ϑ_{amb} = 60°C	V_{max}	20	20	20	20	V
Resistance value at ϑ_{amb} = 25°C	R_{25}	6	6	6	6	Ω
Tolerance of R_{25}	ΔR_{25}	±25	±25	±25	±25	%
Minimum series resistance at V_{max}	$R_{s\,min}$	–	–	–	–	Ω
Dynamic heating power[1]	P_{dyn}	22	25	30	33	W
Stationary final power	P_{stat}	1.4	2.1	3.3	4.0	W
Reference temperature (typ.)	ϑ_{ref}	80	120	160	180	°C
Upper category temperature	ϑ_{max}	110	135	180	205	°C
Temperature coefficient (typ.)	α_R	28	29	13	13	%/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	125	125	125	125	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	–25	–25	–25	–25	°C
Ground (typ.)	GND	2.0	2.0	2.0	2.0	g
Dimensions	d_{max}	18.5	18.5	18.5	18.5	mm
	th_{max}	2.2	2.2	2.2	2.2	mm

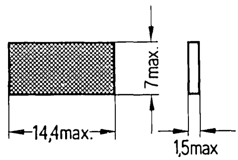
Resistance values measured at $V_{test} \leq 1.5$V.

[1]) Operation after 30 s, at 12V in stagnant water (ϑ_W = 25°C).

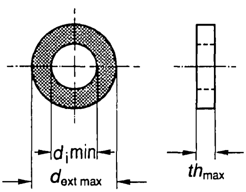
Version A



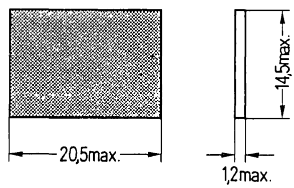
Version R810



Version F



Version R210



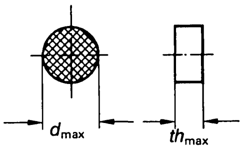
Dimensions in mm

Ordering code	**Q63100–**	**–P450 –R810**	**–P310 –R210**	**–P390 –F222**	**–P430 –F846**	**Unit**
Maximum operating voltage at ϑ_{amb} = 60°C	V_{max}	24	30	26	34	V
Resistance at ϑ_{amb} = 25°C	R_{25}	7	9	15	60	Ω
Tolerance of R_{25}	ΔR_{25}	±30	±35	±35	±35	%
Minimum series resistance at V_{max}	$R_{s\ min}$	0	0	0	0	Ω
Dynamic heating power[1]	P_{dyn}	32	18	10	25	W
Stationary final power	P_{stat}	3.2	0.7	1.5	4.0	W
Reference temperature (typ.)	ϑ_{ref}	180	40	120	160	°C
Upper category temperature	ϑ_{max}	210	90	140	195	°C
Temperature coefficient (typ.)	α_R	13	16	29	13	%/K
Max. permissible storage temperature	$\vartheta_{stg\ max}$	125	125	125	125	°C
Min. permissible storage temperature	$\vartheta_{stg\ min}$	–25	–25	–25	–25	°C
Ground (typ.)	GND	0.5	1.5	0.5	6.6	g
Dimensions	d_{max}	–	–	11.6	24.0	mm
	th_{max}	–	–	2.2	6.5	mm
	$d_{i\ max}$	–	–	6,0	15.9	mm

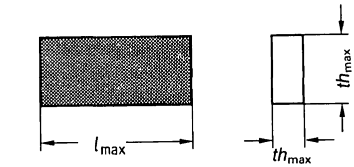
Resistance values measured at $V_{test} \leq 1.5V$.

[1]) Operation after 30 sec, at 12 V in stagnant water (ϑ_W = 25°C).

Version A

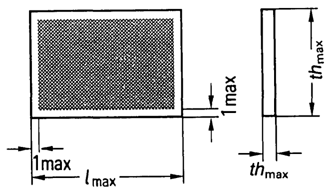


Version R340...R740



Dimensions in mm

Version R290/R291



Ordering code	**Q63100–**	**–P5491 –R290**	**–P5491 –R291**	**–P5491 –R340**	**–P5490 –R440**	**–P5490 –R740**	**Unit**
Maximum operating voltage at ϑ_{amb} = 60°C	V_{max}	265	265	265	265	265	Vrms
Reference value at ϑ_{amb} = 25°C	R_{25}	2	2	1.4	2	2	kΩ
Tolerance of R_{25}	ΔR_{25}	±50	±50	±25	±50	±50	%
Minimum series resistance at V_{max}	$R_{s\,min}$	0	0	0	0	0	Ω
Dynamic heating power[1]	P_{dyn}	250	250	80	50	68	W
Stationary final power	P_{stat}	6.0	6.0	3.8	3.3	4.0	W
Reference temperatur (typ.)	ϑ_{ref}	220	220	220	220	220	°C
Upper category temperature	ϑ_{max}	260	260	260	260	260	°C
Temperature coefficient (typ.)	α_R	16	16	16	16	16	%/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	125	125	125	125	125	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	–25	–25	–25	–25	–25	°C
Ground (typ.)	GND	2.5	2.5	4.0	2.0	3.0	g
Dimensions	d_{max}	1.7	1.7	4.2	4.7	4.7	mm
	th_{max}	20.5	20.5	20.5	15.4	20.5	mm

Resistance values measured at $V_{test} \leq 1.5$V.

[1]) Operation after 30 sec, at 220 V ac in stagnant water (ϑ_w = 25°C).

Questionnaire for Ordering New PTC Thermistors

Questionnaire for Ordering New PTC Thermistors

Parameter	Symbol	Level control sensors	Measuring and regulating sensors Excess temperature protection	Thermostat heating elements	Overload protection Delay circuit	Motor start	Unit
Operating voltage at maximum ambient temperature of .... °C	V						V
PTC thermistor resistance at 25°C with a tolerance of ± ...... %:	R_{25}						Ω
Switching temperature with a tolerance of ± ..... °C and switching resistance	ϑ_{ref}						°C
	R_{ref}						Ω
Maximum operating current	I						A
Turn-off current	I						A
Signal currents in liquid	I_{med}						mA
and air:	I_{air}						mA
Switching time (threshold time)	t_s						s
Heating time	t						s
Heating performance (input peak power)	P						W
Expected requirements/ Price conception	items						

NTC Thermistors

1. General information

NTC thermistos (negative temperature coefficient thermistors) are, in accordance with IEC Publ. 529 and DIN 44070, semiconductor resistors whose resistance values drop as their temperatures increase. Their negative temperature coefficients of the resistance value lie in the range between 3 and 6%/K, thus being approximately ten times greater than those of metals. NTC thermistors consist of polycrystalline mixed oxide ceramics. The conduction mechanism is complex, i.e. either extrinsic conduction or intrinsic conduction may occur. In many cases, the NTCs have a spinell structure and then show valence conduction effects.

1.1 Manufacture

The basic materials are various heavy metal oxides which are mixed in specific proportions. In some cases, oxides or salts of light elements are added in order to stabilize the electrical characteristics or to improve the sintering behavior.

NTC thermistor blanks are principally manufactured in three versions:

- Disc-shaped NTCs are pressed from a granulate of the oxide mixture onto automatic preforming presses.
- Stick-shaped NTCs are extruded: The oxide mixture is plasticized by adding a binder and pressed through a nozzle with high pressure.
- Bead-type NTCs are deposited as drops onto two parallelly strained wires made of a platinum alloy. For this purpose, the oxide mixture is suspended in an epoxy resin.

The blanks are now sintered at high temperatures (between 1000 and 1400°C). That process results in the formation of the crystalline NTC thermistor body.

Discs and sticks are mainly contacted by burning silver paste onto the surface. Contacts for beads are formed by the wires which the beads have been deposited on.

For final assembly, the NTCs are equipped with leads or plugs and, depending on the application, also installed in various types of cases.

This is followed by artificial aging: The use of special methods provides high stability of the electrical values. Before being delivered the electrical and, if necessary for the application, the mechanical and thermal characteristics of the NTCs are checked.

For B values between 2500 K and 5000 K which occur in practical applications, the temperature coefficient at room temperature lies between −2.8 and −5.6%/K.

The approximation for the resistance value-temperature characteristic curve given in equations (1) and (2) will be sufficient for most applications.

Better approximations for precise measurements over a wide temperature range can be obtained by applying various correction formulae. Our experience has shown that the minimum calculation effort is required if only the B value is regarded as temperature-dependent, as in

$$R_T = R_{TO} \times e^{B(\vartheta)\left(\frac{1}{T}-\frac{1}{T_0}\right)} \quad (4)$$

$B(\vartheta) = B\,[1+\beta\,(\vartheta-100)]$

$\beta \quad = 2.5 \times 10^{-4}$ 1/K for $\vartheta > 100$°C

$\beta \quad = 5 \times 10^{-4}$ 1/K for $\vartheta < 100$°C

$To \quad = 298.15$ K ($\triangleq$ 25°C)

ϑ is the temperature in °C, i.e. $T = \vartheta + 273.15$ K.

The characteristic curve of the precision NTC thermistors is calculated with square-law correction elements which are determined empirically.

2.1.2 Tolerance

The resistance value R_R and the B value are subject to manufacturing tolerances. Due to the B tolerance, which describes the varying steepness of the resistance-temperature characteristic, an increase in deviation must be expected at temperatures which lie above or below the rated temperature T_R. The deviation of an NTC from its theoretical characteristic curve is calculated according to equation (5).

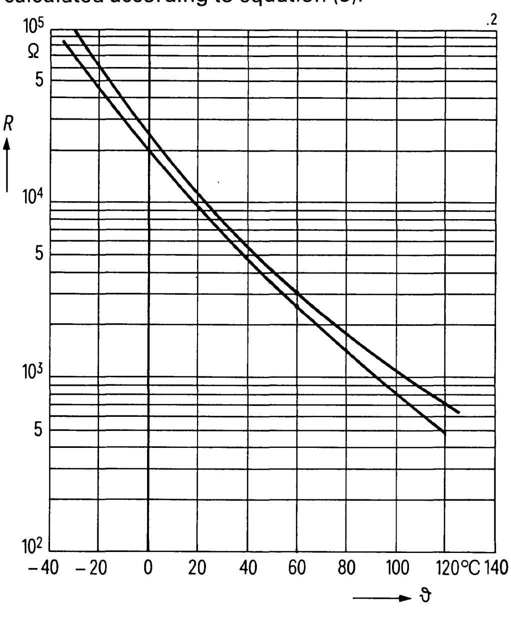


Figure 2
Deviation range of the resistance value (K11/5%/10 kΩ)

2.1.3 Aging

Certain reactions causing a change in resistance value, occur within the polycrystalline NTC thermistor body even at low temperatures. As this variation decays with time, the NTCs are subjected to artificial aging. This considerably improves the long-term stability.

Typical values for the change in resistance value due to aging, are provided by the equation

$$\left(\frac{\Delta R_R}{R_R}\right)t = \left(\frac{\Delta R_R}{R_R}\right)_{10000} \times \left(\frac{t}{10000}\right)^K \quad (6)$$

$\left(\frac{\Delta R_R}{R_R}\right)_t$ Change in resistance value after time t in hours

$\left(\frac{\Delta R_R}{R_R}\right)_{10000}$ Change in resistance value after 10000 hours

K The value for the exponent K lies between 0.3 and 0.5.

With some types, the values specified for the change in resistance after 10000 hours are valid if the NTC thermistor is operated within the permissible temperature range. Should the maximum operating temperature be only 60°C, then the change is generally reduced a factor of 2 to 3.

2.2 Behavior of the NTC thermistor under electrical load

2.2.1 General information

The following formula applies in general to the heating of an NTC thermistor by electric load:

$$P = G_{th}\,(T - T_{amb}) + C_{th} \times \frac{dT}{dt} \quad (7)$$

P Electric power load

G_{th} Thermal conductance of the NTC

T Temperature of the NTC

T_{amb} Ambient temperature

C_{th} Thermal capacitance of the NTC

$\frac{dT}{dt}$ Change in temperature with time

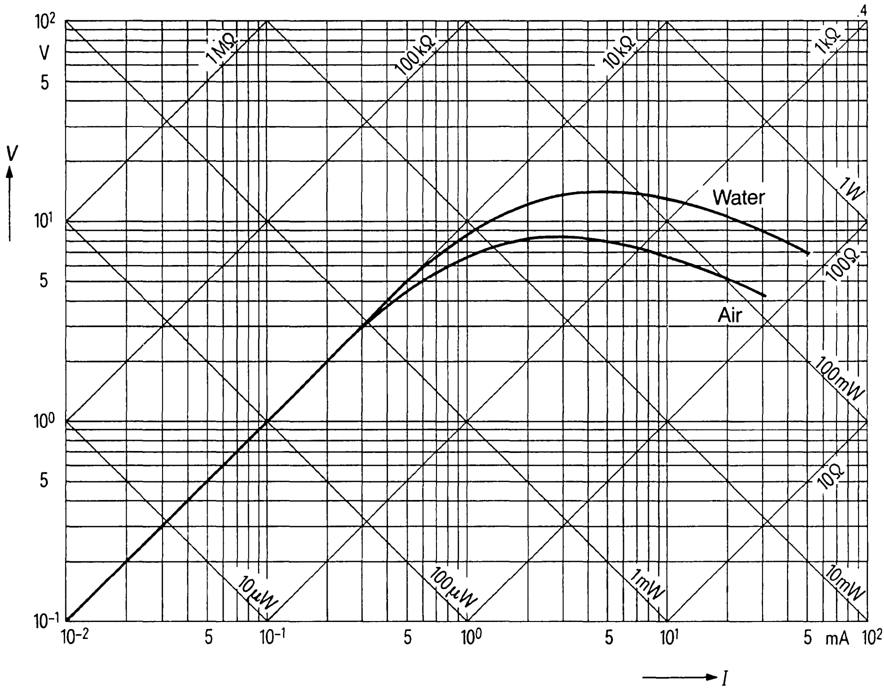


Figure 4
Voltage-current characteristic: M85/10 kΩ
(logarithmic scale)

The voltage-current characteristic curve of an NTC thermistor has three different sections:

1. The straight rise in which the power applied is so low that no noticeable intrinsic heating occurs. In this section, the resistance value of the NTC is only dependent on the ambient temperature.

2. The delayed rise up to the maximum voltage in which the resistance value of the NTC is already noticeably reduced. At the maximum voltage, the relative resistance reduction $\Delta R/R$ – due to heating – is equal to the relative current increase $\Delta I/I$.

3. The falling section, in which the relative resistance reduction is higher than the relative current increase.

The condition for the maximum voltage can be determined from equation (8b) if $\frac{dV}{dT}$ is set equal to 0.

This results in the equation

$$T = \frac{B}{2}\left(1 - \sqrt{1 - \frac{4T_{amb}}{B}}\right) \tag{8c}$$

The corresponding pair of values V_1 and I_1 can then be determined from equations (8a) and (8b).

In case where $B < 4T_{amb}$ (approximately $B < 1200\,K$), there will not be any maximum voltage as the value under the square root sign will become negative.

At an ambient temperature of 25°C and a typical practical B value between 2500 K and 5000 K the maximum voltage lies above the ambient temperature if the NTC temperature amounts to a value between 30 and 50 K.

As shown in equations (8a) and (8b), the NTC thermistor resistance R_T as well as the NTC thermal conductance G_{th} are part of the voltage-current characteristic behavior.
The thermal conductance is not only dependent on size and shape of the NTC and its leads, but also on the medium which surrounds the NTC.

The voltage-current characteristic curves shown in the data sheets are specified for stationary air as surrounding medium. In flowing air or in a liquid, the thermal conductance rises and the voltage-current characteristic curve is displaced towards higher voltage and current values. If the medium is a vacuum, the opposite applies.

The position of the voltage-current characteristic curve can thus indicate the surrounding medium. This results in the possibility of using NTC thermistors as sensors for flow rates of gases and liquids, for vacuum measurements, or for gas analysis.

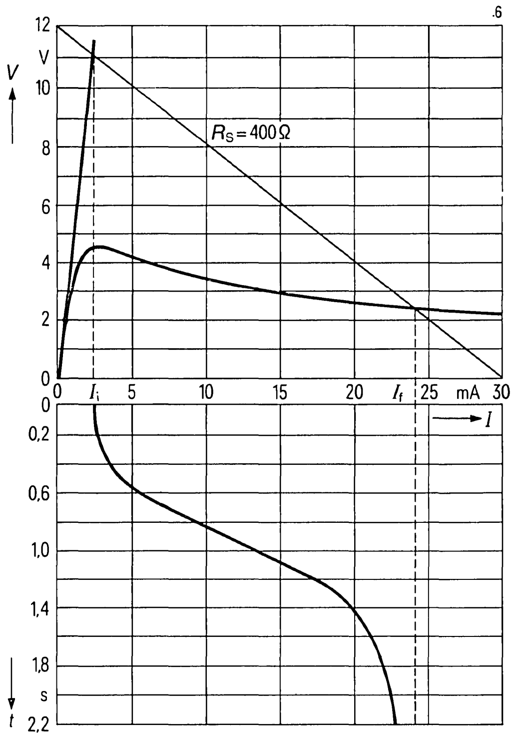


Figure 6
Curren.-time characteristic
(A34-2/30)

2.2.4. Current-time characteristic curve

If an NTC thermistor is connected via a series resistor to a voltage soure and the current is measured versus the time, the result will be the current-time characteristic curve of the NTC.

When the voltage is applied, the thermistor is cold, which means that it has a high resistance and only little current flows. This current heats the NTC and the power applied increases as the NTC thermistor resistance approaches the one of the series resistor. Thereby the rate of current rise becomes steeper and steeper until the NTC thermistor resistance is equal to the one of the series resistor. If the NTC thermistor resistance continues to decrease, the power applied is reduced due to the increasing mismatching, and the current tends to settle at a final value. In this state, the complete power applied is used to maintain the overtemperature.

The behavior of the current-time characteristic curve is of particular importance if the NTC is employed for delaying relay operation or for suppression of current surges.

In the data sheets, current-time characteristic curves are only provided for NTC types which are particularly manufactured for those applications.

3. Application notes

3.1 Application possibilities

Owing to the features and characteristic curves mentioned in section 2, the NTC thermistor has a wide range of possible applications

in chemistry
Calorimetry
Differential-thermometrical titration
Level regulation of liquids, e.g. liquid nitrogen
Measuring the thermal conductivity of gases

in physics
Vakuum measurement
Measuring the flow rates of gases and liquids
Radiometry

in medical science
Measuring the body and skin temperatures
Measuring the flow rates of blood

in temperature regulation of household appliances
Deep freezers
Washing machines
Electric stoves
Heating systems
Air conditioning systems

in vehicles
Measuring the coolant and oil temperatures
Monitoring of exhaust gas temperatures
Glaze warning units

in electric engineering
Delaying the relay operation
Compensation of undesirable temperature variation
Microwave power measurement

The various types of NTC thermistors are divided and designated corresponding to their main application fields. The first letter of the type designation indicates the application according to the following code:

H	High temperature sensors $>200°C$
K; M	Temperature compensation and temperature measurement
A	Relay delay and current surge suppression
R	Regulation of voltages
F	Externally heated NTC thermistors

The two or three figures following the letter indicate the design. After a hyphen or slash follows the characteristic electrical data – in some cases in encoded form.

3.3 Dimensioning notes

3.3.1 Temperature measurement and regulation

Compared with other commercially available temperature sensors, NTC thermistors have considerable advantages in many applications:

a) Owing to the high resistance value, the resistive effects of leads can be neglected. Due to the wide spectrum of various resistance values, the most favorable resistance value can be selected for any application.

b) The high temperature coefficient enables a measuring of temperature differences of 10^{-4} K or less with little effort.

c) The small sizes which are possible for NTCs permit small time constants and thus a rapid response of the sensors. The smallest measuring NTC thermistor in this data book has a diameter of only 0.4 mm.

The tolerances (see also section 2.1.2) can, if necessary, be compensated by resistors connected in series and parallel with the NTC thermistor. This also permits linearization of the resistance-temperature characteristics in accordance with equation (2). The dimensioning of linearization resistors is specified in section 3.3.2. However, any connection of fixed resistors decreases the steepness of the characteristic curve.

NTC thermistors used for temperature measurement purposes should have such a low electrical load that no remarkable heating will occur and the NTC resistance value will be determined only by the ambient temperature.

If an overtemperature ΔT due to intrinsic heating is permitted, then

$$I = \sqrt{\frac{G_{th} \times \Delta T}{R_T}} \qquad (10a)$$

and

$$V = \sqrt{G_{th} \cdot \Delta T \cdot R_T} \qquad (10b)$$

A rule of thumb is the fact that the overtemperature ΔT should be lower than the required measuring accuracy. The thermal conductance G_{th} is normally specified in the NTC data sheets for the case where the NTC thermistor is surrounded by stationary air.

If the NTC is operated in a liquid or if it is installed in a case, the thermal conductance may be increased by a factor of 2 to 5, thus permitting a higher load.

3.3.2 Temperature compensation (linearization)

The electrical load should also in this case be so low that the NTC resistance value is determined only by the ambient temperature. In compensation applications, the distinct nonlinearity of the NTC thermistor characteristic curve is often a problem. However, that characteristic curve can be linearized by connecting a fixed resistor in parallel. The combination of NTC thermistor and parallel resistor has an S-shaped characteristic curve with an inflection point, depending on the temperature.

The steepness of the characteristic curve of this combination is independent of the temperature

$$\frac{dR}{dT} = -\frac{B}{T_{ctr}^2} \times R_{Tctr} \times \frac{1}{\left(1 + \frac{R_{Tctr}}{R_p}\right)^2} \qquad (12)$$

If the value R_{Tctr}/R_p obtained from equation (11) is put into equation (12), then the suitable NTC thermistor resistance for a given $\frac{dR}{dT}$ can be calculated.

The circuit shown in figure 9 can be used for temperature compensation of voltages which are linearly dependent on the temperature.

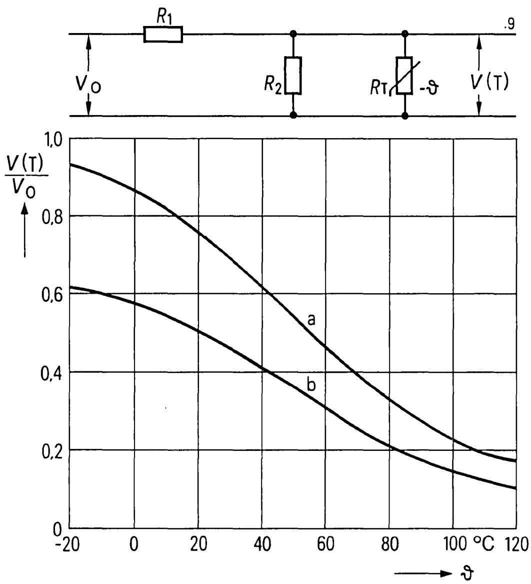


Figure 9
Temperature-dependent voltage divider
a: $R_1 = 3\ \text{k}\Omega$; $R_2 \rightarrow \infty$
b: $R_1 = 4.5\ \text{k}\Omega$; $R_2 = 9\ \text{k}\Omega$
R_T = K11−10 kΩ

In this case, the voltage $V\ (T)$ has an S-shaped behavior and the following applies at the inflection point:

$$R = R_{Tctr} \times \frac{B - 2\,T}{B + 2\,T}$$

where $$R = \frac{R_1 \times R_2}{R_1 + R_2}$$

The voltage variation with temperature is in this case

$$\frac{dV}{dT} = \frac{R_2}{R_1 + R_2} \times V_0 \times -\frac{B}{T^2} \times \frac{R_{Tctr}}{R} \times \frac{1}{\left(1 + \frac{R_T}{R}\right)^2}$$

A parallel connection of relay coil and NTC thermistor is used for delaying the relay release.

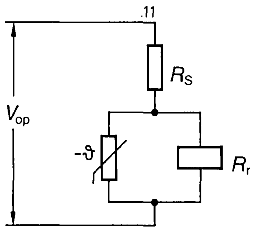


Figure 11
Delay of relay release

In this case, the following dimensioning rules apply:

- With a cold NTC thermistor, the voltage across the coil must be at least 1.5 times the maximum voltage V_1.
- The voltage at which the relay is released should not be less than 1.5 times the rated voltage of the NTC thermistor V_R.

The switching sequence of a relay delayed by means of an NTC thermistor depends on the NTC recovery time. The NTC has to cool down before it can cause a new delay. If it is unloaded for a period of $t = 3 \times \tau_{th}$ (3 times the thermal time constant) between two load operations, then the delay of the second operation is approximately 80 to 90% of the first delay time. It is therefore advisable to short-circuit or disconnect the NTC thermistor by means of additional relay contacts in order to provide the maximum possible time for cooling the NTC (shown as a dashed line in figure 10).

3.3.4 Voltage regulation

NTC thermistors can be used in a manner similar to Z diodes for stabilizing voltages. If a fixed resistor with a value of approximately 1% of the NTC cold resistance is connected in series with the NTC thermistor, an about 10% constant voltage can be picked off across NTC thermistor and series resistor over a current range of 1:10.

Compared with Z diodes, voltage regulation with NTC thermistors has the advantage of no harmonic vibration being generated, and in this way regulation of wide frequency bands is made possible. A distortion factor, which rises with decreasing frequency, does not occur unless frequency values amount to about only 20 Hz, and is caused by the fact that the NTC resistance value is already changed during one half wave.

Version R51 with which voltages of approximately 4 V (R51-4/1/20) and 8 V (R51-8/0.5/10) can be regulated, is especially suitable for that application purpose.

4.2 Quality specifications

In order to characterize the quality of NTC thermistors, the following is indicated:

- Limit values, as well as the deviation of the characteristic data (tolerances)
- Maximum proportions of defective components, so-called AQL values (acceptable quality level), for the values specified in the table below. The principles of statistics must be taken into account when judging the delivery quality.
- A defect exists if a component characteristic does not correspond to the data sheet specifications. The defects are distinguished either according to their type or to their extent.

  Distinction according to the defect types:
  - Defects at cases and terminals
  - Defects in the electrical features

  Distinction according to the defect extent:
  - Total defects: Defects which exclude any functional application
  - Gradual defects: Defects which permit a functional application subject to restrictions
- AQL values:
  The AQL values which apply to the various defects are listed in the table below.

  Defects with respect to deviation values are counted separately.

Defects	AQL value	Remarks
Defects at cases and terminals		
Total defects	0.25%	Total of all defects
Gradual defects	2.5 %	
Defects in the electrical characteristics		
Total defects	0.25%	Total of all defects
Gradual defects		
for characteristics with AQL specification	0.65%	For each defect
	2.5 %	Total of all defects
for characteristics without AQL specification	The deviation of these characteristics are specified such that approximately 2.5% of the product may lie above or below the limits.	

- Incoming inspection
  The examinations carried out by the manufacturer are intended to make an incoming inspection by the user unnecessary. However, should the user nevertheless wish to carry out an incoming inspection, then the application of a random sampling test plan in accordance with the following regulations is recommended:

  VG 95082 and 95083, as well as ABC STD 105
  ASQ random sampling test tables for attribute examination ASQ/AWF1
  (available from Beuth-Vertrieb GmbH, Berlin W15 and Cologne).

5.1 Lower category temperature ϑ_{min}

is defined as the lowest permissible component temperature during operation (without the effects of intrinsic and extrinsic heating, at the moment of turning on).

5.2 Upper category temperature ϑ_{max}

is defined as the maximum permissible temperature which may occur at the hottest point on the component surface (including the effects of intrinsic and extrinsic heating).

5.3 Code letters for category temperatures (in accordance with DIN 40040, 2.73)

The permissible temperature ranges depend on the component version.
The following category temperatures occur:

1st code letter	Lower category temperature
E	− 65°C
F	− 55°C
G	− 40°C
H	− 25°C
J	− 10°C
K	0

2nd code letter	Upper category temperature
A	+400°C
B	+350°C
C	+300°C
D	+250°C
E	+200°C
F	+180°C
G	+170°C
H	+155°C
J	+140°C
K	+125°C
L	+110°C
M	+100°C
N	+ 90°C
P	+ 85°C
Q	+ 80°C
R	+ 75°C
S	+ 70°C
T	+ 65°C
U	+ 60°C
V	+ 55°C
W	+ 50°C
Y	+ 40°C
Z	+ 1000°C

6. Symbols and terms

A	NTC thermistor constant
α_R	Temperature coefficient of the specific resistance
B	*B* value, material constant for determination of the temperature dependence of NTC thermistors
ΔB	Tolerance (of *B* value)
B_{av}	Average *B* value
β	Temperature coefficient of the *B* value
$C_{NTC\text{-}Hh}$	Capacitance between NTC thermistor and heater helix of externally heated NTC thermistors
C_p	Parallel capacitance
C_{th}	Thermal capacitance
d	Diameter
G_{th}	Thermal conductance
G_{thA}	Thermal conductance in air
G_{thC}	Thermal conductance in case of chassis mounting
G_{thW}	Thermal conductance in water
I	Current through the NTC
I_1	Current at the maximum voltage V_1 of the stationary voltage-current characteristic curve
I_f	Final value of current
I_{Hh}	Heater helix current of externally heated NTC thermistors
I_{htM}	Maximum heater current
I_i	Initial current
I_{meas}	Measuring current
$I_{NTC\,M}$	NTC peak current (permissible current for short periods, providing the NTC resistance R_T does not drop below a specific minimum value)
I_R	Rated current
I_{resp}	Response current
$k_{3\,kHz}$	Distortion factor at 3 kHz
$k_{30\,Hz}$	Distortion factor at 30 Hz
L_{ht}	Heater inductance
L_s	Series inductance

t	Time
t_d	Rated value of delay time
Δt_d	Tolerance of delay time
$t_{sold\,M}$	Maximum soldering time
t_t	Test duration
th	Thickness
T	Absolute temperature
ΔT	Temperature difference
T_{amb}	Ambient temperature
T_{ctr}	Temperature at the center of a temperature range
T_i	Initial temperature
T_R	Rated temperature
T_{stg}	Storage temperature
V	Voltage
V_1	Maximum voltage of current-voltage characteristic curve
V_{op}	Operating voltage
V_R	Rated voltage
ΔV_R	Tolerance of the rated voltage
V_{test}	Test voltage
τ	Time constant
τ_{th}	Thermal time constant
τ_{thA}	Thermal time constant in air
τ_{thC}	Thermal time constant in case of chassis mounting
τ_{thW}	Thermal time constant in water
ϑ	Temperature
ϑ_{min}	Lower category temperature
ϑ_{max}	Upper category temperature
ϑ_R	Rated temperature
$\vartheta_{sold\,M}$	Maximum soldering temperature
$\vartheta_{stg\,min}$	Minimum storage temperature
$\vartheta_{stg\,max}$	Maximum storage temperature

Characteristic data

Power rating	at 25°C	P_{25}	650 mW
	at 60°C	P_{60}	470 mW
Rated temperature		ϑ_R	100 °C
Rated resistance		R_R	See resistance-temperature characteristic
Tolerance [1]		ΔR_R	See diagram
B value		B	See resistance-temperature characteristic
Thermal conductance in air		G_{thA}	5 mW/K
Thermal conductance in case of chassis mounting		G_{thC}	30 mW/K
Thermal time constant		τ_{th}	7 s
Thermal capacitance		C_{th}	200 mJ/K

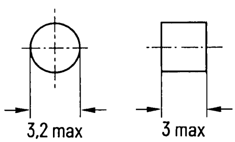
Resistance-temperature characteristic

Type Temperature °C	**K 150/S1/12.5 Ω** Resistance Ω	**K 150/S1/82.5 Ω** Resistance Ω	**K 150/S1/100Ω** Resistance Ω	**K 150/S1/144 Ω** Resistance Ω
−60	8360	14120	9670	235000
−50	4400	8500	6160	113000
−40	2440	5330	4070	57800
−30	1410	3460	2770	31000
−20	848	2310	1940	17400
−10	528	1590	1390	10100
± 0	338	1120	1015	6130
10	223	805	758	3820
20	151	591	575	2440
30	104	441	444	1600
40	73	334	347	1080
50	52.7	257	275	739
60	38.4	200	220	516
70	28.5	158	178	367
80	21.4	126	146	265
90	16.3	102	120	194
100	12.5	82.5	100	144
110	9.8	68.0	84.2	109
120	7.7	56.5	71.4	83.5
130	6.2	47.3	61.0	64.7
140	5.0	39.9	52.5	50.7
150	4.1	33.9	45.4	40.1

[1]) AQL = 0.65%

NTC thermistors with 1.6 kΩ and 2.5 kΩ*)

Application	Temperature measurement with low electrical load
Version	NTC thermistor disc, lapped in a coplanar way
Terminals	Front surface, silver-plated
Marking	None
Quality characteristic	Resistance drift < ±2% after 20000 temperature changes between room temperature and upper category temperature



Weight: approx. 0.2 g
Dimensions in mm

Climatic category **FDF**
in accordance with DIN 40040

Lower category temperature	**F** − 55°C
Upper category temperature	**D** +250°C
Humidity category	**F** Average relative humidity ≤ 75% 95% continuously on 30 days per year 85% occasionally on the remaining days No dew precipitation is permissible

Storage temperatures
Minimum storage temperature $\vartheta_{stg\,min}$ −25°C
Maximum storage temperature $\vartheta_{stg\,max}$ +65°C

Type	Rated resistance	Tolerance	*B* value	Ordering code
K 220/S1/1.6 kΩ	1.6 kΩ	±10%	3560 K	Q63022−K162−S1
K 220/S1/2.5 kΩ	2.5 kΩ	±10%	3560 K	Q63022−K252−S1

*) Other resistance values upon request.

Resistance-temperature characteristic

Type Temperature	**K 220/S1/1.6 kΩ** Resistance	**K 220/S1/2.5 kΩ** Resistance	**K 220/S1/1.6 kΩ** **K 220/S1/2.5 kΩ** Tolerance
−60°C	104.5 kΩ	163.3 kΩ	±30.9%
−50°C	53.6 kΩ	83.8 kΩ	±27.6%
−40°C	29.0 kΩ	45.3 kΩ	±24.5%
−30°C	16.4 kΩ	25.6 kΩ	±21.6%
−20°C	9.65 kΩ	15.08 kΩ	±19.0%
−10°C	5.89 kΩ	9.20 kΩ	±16.5%
± 0°C	3.71 kΩ	5.80 kΩ	±14.2%
10°C	2.41 kΩ	3.76 kΩ	±12.0%
20°C	1.60 kΩ	2.50 kΩ	±10.0%
30°C	1.09 kΩ	1.70 kΩ	±10.0%
40°C	755 Ω	1.18 kΩ	±10.0%
50°C	535 Ω	837 Ω	±10.0%
60°C	386 Ω	603 Ω	±10.0%
70°C	282 Ω	441 Ω	±10.0%
80°C	209 Ω	327 Ω	±10.0%
90°C	157 Ω	246 Ω	±10.0%
100°C	120 Ω	187 Ω	±10.0%
110°C	92.8 Ω	145 Ω	±10.0%
120°C	73.0 Ω	114 Ω	±10.0%
130°C	57.6 Ω	90 Ω	±10.0%
140°C	46.1 Ω	72 Ω	±11.1%
150°C	37.1 Ω	58 Ω	±12.2%
160°C	30.2 Ω	47.3 Ω	±13.2%
180°C	20.5 Ω	32.1 Ω	±15.2%
200°C	14.3 Ω	22.3 Ω	±17.0%
220°C	10.2 Ω	16.0 Ω	±18.6%
240°C	7.5 Ω	11.7 Ω	±20.2%
260°C	5.6 Ω	8.7 Ω	±21.7%

Characteristic data

Power rating at 25°C	P_{25}	1000 mW
at 60°C	P_{60}	500 mW
Rated temperature	ϑ_R	100 °C
Rated resistance	R_R	See table
Tolerance[1]	ΔR_R	±3.5 %
B value	B	See table
Tolerance[1]	ΔB	3.0 %
Thermal conductance in water	G_{thW}	12 mW/K
Thermal time constant in water	τ_{thW}	≤20 mW/s
Insulation resistance	R_{is}	>1000 MΩ
Test voltage	V_{test}	2500 V
Test duration	t_t	1 s

[1]) AQL = 0.65%

NTC Thermistor
Temperature Sensor

K 277

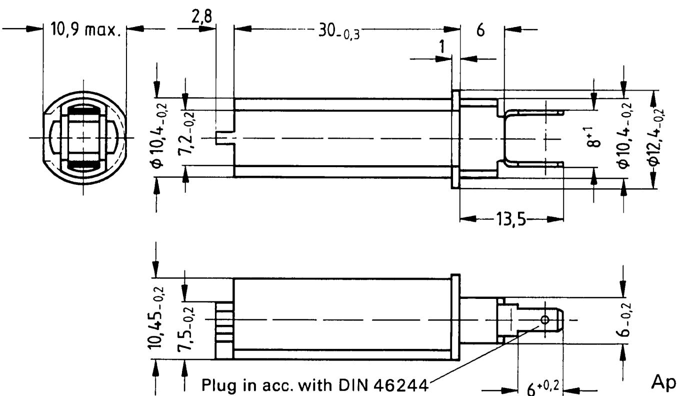
Resistance value 2 kΩ

Application temperature regulation in refrigerators and deep freezers

Version plastic case, sealed

Terminals flat plugs suitable for snap-in receptacle in acc. with DIN 46245 or DIN 46247

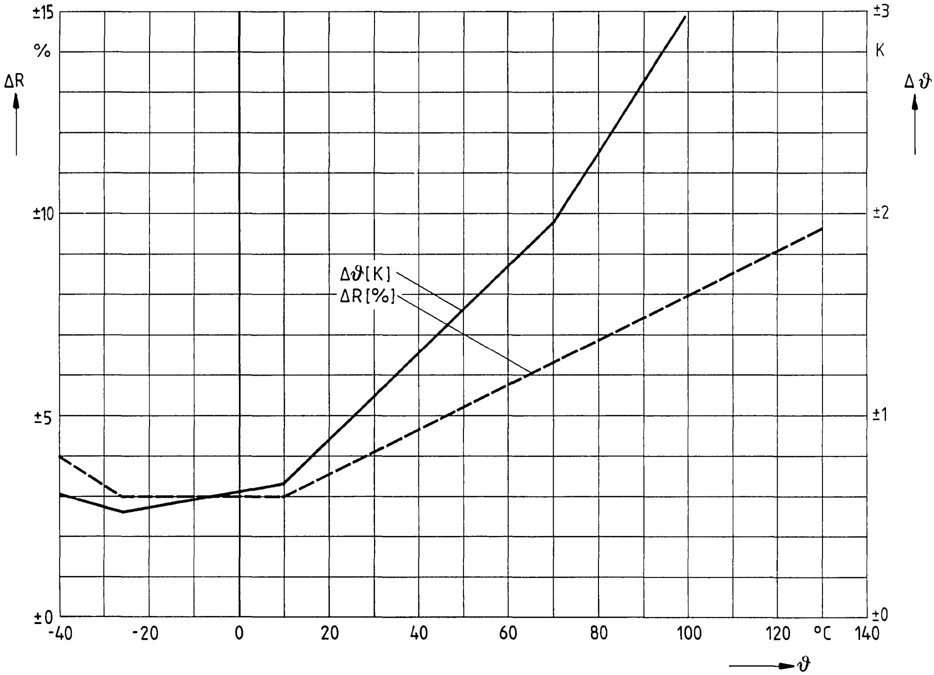
Quality characteristic temperature measuring accuracy $< \pm 1$ K throughout the range −30°C to +10°C



Approx. weight 6 g
Dimensions in mm

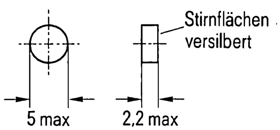
Type	Rated resistance	*B* value	Ordering code
K277/S1/2kΩ	2000 Ω	3560 K	Q63027–K7202–S1

Resistance tolerance and measuring accuracy



NTC thermistors with 17 Ω to 2.3 kΩ

Application	Temperature measurements, e.g. automotive cooling water temperature, oil temperature
Version	NTC thermistor disc, lapped in a coplaner way
Terminals	Front surfaces, silver-plated
Marking	None
Quality characteristic	Resistance drift: <±2% after 20000 temperature changes between room temperature and upper category temperature



Weight: approx. 0.2 g
Dimensions in mm

Climatic category in accordance with DIN 40040	**FHF**
Lower category temperature	**F** − 55°C
Upper category temperature	**H** +155°C
Humidity category	**F** Average relative humidity ≤ 75% 95% continuously on 30 days per year 85% occasionally on the remaining days No dew precipitation is permissible

Storage temperatures

Minimum storage temperature $\vartheta_{stg\ min}$ − 55°C
Maximum storage temperature $\vartheta_{stg\ max}$ + 65°C

Type	Rated resistance	Dimensions d [mm]	th [mm]	Ordering code
M 820/S1/ 17 Ω	17 Ω	5.5 − 1.1	2.0 − 1.4	Q63082−M 17−S1
M 820/S1/ 19 Ω	19 Ω	5.5 − 1.1	2.0 − 1.4	Q63082−M 19−S1
M 820/S1/ 20 Ω	20 Ω	5.5 − 1.1	2.0 − 1.4	Q63082−M 20−S1
M 820/S1/ 21.05 Ω	21.05 Ω	5.1 − 1.1	2.2 − 1.4	Q63082−M 21−S101
M 820/S1/ 30.7 Ω	30.7 Ω	5.5 − 1.1	2.0 − 1.4	Q63082−M310−S1
M 820/S1/ 39.6 Ω	39.6 Ω	5.1 − 1.1	2.2 − 1.4	Q63082−M 39−S106
M 820/S1/ 77 Ω	77 Ω	5.3 ± 0.3	1.3 ± 0.2	Q63082−M770−S1
M 820/S2/ 84.5 Ω	84.5 Ω	5.1 − 0.7	2.4 − 1.6	Q63082−M840−S2
M 820/S1/ 89.5 Ω	89.5 Ω	5.5 − 1.1	2.0 − 1.4	Q63082−M900−S1
M 820/S1/ 92 Ω	92 Ω	5.5 − 1.1	2.0 − 1.4	Q63082−M920−S1
M 820/S1/144 Ω	144 Ω	5.5 − 1.1	2.0 − 1.4	Q63082−M144−S1
M 820/10%/ 2.3 kΩ	2.3 kΩ	5.5 ±0.7	2.2 − 1.4	Q63082−M232−K

Resistance-temperature characteristic

Type	M 820/S1/17Ω	M 820/S1/19Ω	M 820/S1/20Ω	M 820/S1/21.05Ω
Temperature °C	Resistance Ω	Resistance Ω	Resistance Ω	Resistance Ω
−60	11.4 k	12.71 k	13.3 k	40.3 k
−50	5.99 k	6.69 k	7.04 k	19.1 k
−40	3.31 k	3.71 k	3.90 k	9.63 k
−30	1.92 k	2.14 k	2.26 k	5.10 k
−20	1.15 k	1.29 k	1.36 k	2.82 k
−10	717	802	844	1.63 k
± 0	460	514	542	971
10	303	339	357	599
20	205	229	241	379
30	142	158	167	247
40	100	112	117	165
50	71.6	80.1	84.3	112
60	52.3	58.4	61.5	77.6
70	38.7	43.3	45.5	54.8
80	29.1	32.5	34.2	39.3
90	22.1	24.7	26.0	28.5
100	17.0	19.0	20.0	21.0
110	13.3	14.9	15.6	15.8
120	10.5	12.8	12.4	12.1
130	8.4	9.4	9.9	9.3
140	6.8	7.6	8.0	7.3
150	5.5	6.2	6.5	5.7

Resistance-temperature characteristic

Type	M 820/S1/89.5Ω	M 820/S1/92Ω	M 820/S1/144Ω	M 820/10%/2.3 kΩ
Temperature °C	Resistance Ω	Resistance Ω	Resistance Ω	Resistance Ω
−60	73.6 k	75.7 k	235 k	362 k
−50	38.0 k	39.1 k	113 k	167 k
−40	20.6 k	21.2 k	57.8 k	82.0 k
−30	11.7 k	12.1 k	31.0 k	42.5 k
−20	6.94 k	7.14 k	17.4 k	23.0 k
−10	4.26 k	4.37 k	10.1 k	13.0 k
± 0	2.69 k	2.77 k	6.13 k	7.63 k
10	1.75 k	1.80 k	3.82 k	4.62 k
20	1.17 k	1.20 k	2.44 k	2.88 k
30	798	820	1.60 k	1.85 k
40	556	572	1.08 k	1.21 k
50	395	406	739	813
60	285	293	516	556
70	209	215	367	388
80	156	160	265	277
90	117	121	194	197
100	89.5	92.0	144	144
110	69.5	71.4	109	107
120	54.5	56.1	83.4	80.9
130	43.3	44.5	64.7	61.8
140	34.7	35.7	50.7	47.7
150	28.1	28.9	40.1	37.4

Resistance-temperature characteristic

Temperature °C	Resistance kΩ	Temperature °C	Resistance kΩ	Temperature °C	Resistance kΩ	Temperature °C	Resistance kΩ
-40	887.70	2	85.99	44	13.80	86	3.168
-39	833.30	3	81.91	45	13.28	87	3.070
-38	782.70	4	78.04	46	12.77	88	2.975
-37	735.40	5	74.37	47	12.29	89	2.884
-36	691.20	6	70.90	48	11.83		
-35	650.00	7	67.60	49	11.39	90	2.796
-34	611.50	8	64.48			91	2.711
-33	575.50	9	61.52	50	10.97	92	2.629
-32	541.80			51	10.56	93	2.549
-31	510.30	10	58.71	52	10.18	94	2.473
		11	56.04	53	9.805	95	2.399
-30	480.80	12	53.51	54	9.448	96	2.328
-29	453.20	13	51.10	55	9.107	97	2.259
-28	427.30	14	48.82	56	8.779	98	2.193
-27	403.10	15	46.65	57	8.464	99	2.129
-26	380.40	16	44.58	58	8.163		
-25	359.10	17	42.62	59	7.873	100	2.067
-24	339.10	18	40.76			101	2.007
-23	320.30	19	38.98	60	7.595	102	1.949
-22	302.70			61	7.329	103	1.893
-21	286.20	20	37.30	62	7.072	104	1.839
		21	35.69	63	6.826	105	1.787
-20	270.60	22	34.16	64	6.590	106	1.736
-19	256.00	23	32.71	65	6.363	107	1.687
-18	242.30	24	31.32	66	6.145	108	1.640
-17	229.40	25	30.00	67	5.936	109	1.594
-16	217.20	26	28.74	68	5.734		
-15	205.80	27	27.54	69	5.540	110	1.550
-14	195.00	28	26.40			111	1.507
-13	184.80	29	25.31	70	5.354	112	1.465
-12	175.30			71	5.175	113	1.425
-11	166.20	30	24.27	72	5.003	114	1.386
		31	23.28	73	4.837	115	1.349
-10	157.70	32	22.33	74	4.678	116	1.312
-9	149.70	33	21.43	75	4.524	117	1.277
-8	142.10	34	20.57	76	4.376	118	1.243
-7	135.00	35	19.75	77	4.234	119	1.210
-6	128.20	36	18.96	78	4.097	120	1.178
-5	121.90	37	18.21	79	3.965		
-4	115.80	38	17.49				
-3	110.20	39	16.80	80	3.838		
-2	104.80			81	3.716		
-1	99.68	40	16.15	82	3.598		
		41	15.52	83	3.484		
0	94.86	42	14.92	84	3.375		
1	90.31	43	14.35	85	3.269		

Table of Contents

4. Constructional design

4.1. Contacting

The large area metallization over the winding face ends ensures good contact between the layers and the connecting elements. Hence, capacitors with low-inductance, low loss characteristics are obtained.

The capacitors in rectangular plastic cases and the epoxy resin sealed types are provided with spacers in order to improve the solderability in the solder bath. These capacitors are thus particularly suited for use on printed circuit boards.

4.2. Dimensions

The main dimensions stated for MK capacitors are maximum dimensions including the insulating sleeve (for details refer to the individual data sheets).

5. Electrical properties

5.1. Capacitance

5.1.1. Rated capacitance

The capacitance ratings available for the individual capacitor types range from 680 pF to 100 µF. The capacitance values are graded according to the E standard. The actually available values of the E standard (E6, E12, E24, E48, E96) are contained in the individual data sheets.

5.1.2. Tolerances available

MKL capacitors	±20, ±10%
MKT capacitors	±20, ±10, ±5%
MKC capacitors	±20, ±10, ±5%
MKP capacitors	±10, ±5%
MKY capacitors	±5, ±2, ±1%

The rated capacitances and appropriate tolerances are indicated on the individual data sheets. The capacitance tolerances are coded by the following letters (in accordance with IEC recommendation 62/1968):

Code letter	M	K	J	G	F
Capacitance tolerance	±20%	±10%	±5%	±2%	±1%
E standard	E6	E12	E24	E48	E96

5.1.3. Temperature dependence

The variation of the capacitance with respect to the permissible temperature range (see climatic category) is not linear, but reversible.

In the range of −20 to +70 °C, (−4 to +158 °F), however, an approximately linear run of the temperature can be assumed.

5.1.6. Capacitance drift i_z

Apart from reversible changes, the capacitance is also subject to irreversible changes which are summarized under the term "maximum capacitance drift i_z". The values refer to +40 °C/+104 °F and to the load duration stated for each capacitor type on the appropriate data sheets. The values are typical values. For standard type capacitors, the capacitance drift applies to a period of two years. Frequent and large temperature changes within the fringe area of the permissible temperature and relative humidity can cause the stated drift values to rise. In accordance with DIN 44 110 typical values for a storage time of two years are also given. The storage conditions stated under item 3.5.3. are applicable.

5.2. Voltage and current operation

5.2.1. Rated voltage U_R

The rated voltage is the direct operating voltage which may be applied continuously to the terminals of a capacitor at an ambient temperature of 40 °C (104 °F).

When the capacitor is operated within the permissible climatic category, the following limiting conditions are to be taken into account:

5.2.2. Category voltage U_c (at dc operation)

The category voltage U_c is the maximum dc voltage, which may be applied continuously to the capacitor and is dependent upon the ambient temperature. The resulting voltage derating at higher temperatures is covered by outline drawings in the appropriate data sheets (definition in accordance with DIN 44 110).

5.2.3. Category voltage U_c (at ac operation)

The category voltage U_c is referred to 50 Hz which may be applied continuously to the capacitor (see individual types).

When an additional dc voltage is superimposed to the ac voltage, the sum of the applied dc voltage and the amplitude of the ac voltage should not exceed the category voltage U_c.

MK capacitors are generally not intended for technical ac applications. In exceptional cases, references are given to possible operation indicating the permissible rated voltage U_{ac}.

For operation at higher frequencies and for non-sinusoidal ac voltage load see para. 5.2.5.

5.2.4. Peak voltage

The peak voltage is the maximum voltage which may be applied to the capacitor for a short period, e. g. with non-periodic switchings. The peak voltage is particularly specified in individual data sheets.

5.2.6. Pulse handling capability (current carrying capacity)

Our data sheets contain a pulse characteristic k_0 that takes into account the interdependence between the permissible voltage rate of rise U_{pp}/τ and the voltage swing U_{pp}.

The pulse characteristic k_0' that is decisive for the capacitor loading can be calculated for a given application as follows:

For pulse-shaped voltages with straight-line pulse edges (trapezoidal, sawtooth) applies: $k_0' = 2 \times U_{pp}^2/\tau$ [V²/µs]

For spontaneous and short-circuit like discharges and charges applies: $k_0' = U_L^2/RC$ [V²/µs]

The k_0' value determined by the circuit data has to be lower than or at the utmost equal to that k_0' value given for the individual capacitor types.
The k_0' values refer to ambient temperatures of up to 50 °C (122 °F).
k_0 values for higher temperatures are available on request.

Summary of terms used:

Voltage swing (operating voltage)	U_{pp}	[V]
Charging voltage	U_L	[V]
Ohmic resistance in the charging and/or discharging circuit	R	[Ω]
Capacitance of capacitors	C	[µF]
Voltage rise time	τ	[µs]
Permissible pulse characteristic of the capacitor	k_0	[V²/µs]
Pulse characteristic calculated from circuit data	k_0'	[V²/µs]

Calculation example:

Known:
Capacitor B 32510, LS 7.5, U_R = 250 V dc
The corresponding k_0 value is 100,000 V²/µs (refer to page 125).
With a voltage swing of U_{pp} = 100 V, the permissible voltage rate of rise is deduced as:

$$\frac{U_{pp}}{\tau} = \frac{k_0}{2 \times U_{pp}} = \frac{100{,}000\ \text{V}^2/\mu\text{s}}{2 \times 100\ \text{V}} = 500\ \text{V}/\mu\text{s}$$

Typical impedance characteristics of MK capacitors are shown in figure 3, demonstrated on an MKT capacitor. The measuring conditions comply with DIN 41 328, sheet 2.

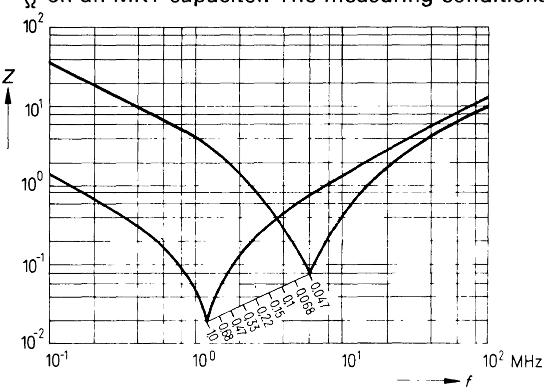


Fig. 3
Impedance Z
versus frequency f

6. Climatic and mechanical characteristics

6.1. Permitted temperature and humidity

The permitted temperature and humidity depend on the individual capacitor types and are identified in accordance with DIN 40 040 as follows:

1st code letter	G	F	–	–
Minimum temperature	−40 °C/ −40 °F	−55 °C/ −67 °F	–	–
2nd code letter	S	P	M	–
Maximum temperature	+70 °C/ +158 °F	+85 °C/ +185 °F	+100 °C/ +212 °F	–
3rd code letter humidity category	G	F (E[3])	D	C
Average relative humidity per year 30 days per year, continuously[1] 60 days per year, continuously for the remaining days, occasionally[2]	≦65% – 85% 75%	≦75% 95% – 85%	≦80% 100% – 90%	≦95% 100% – 100%

6.1.1. Climatic categories in accordance with DIN 40 045 and IEC 68

Metallized film capacitors are graded according to defined climatic categories which result from the climatic conditions according to which the capacitors have been tested. The climatic categories comprise three parameters:
Example:

Climatic category **55/085/56**

Test A: Cold
−55 °C/−67 °F
(in accordance with DIN IEC 68-2-1)

Test B: Dry heat
+85 °C/+185 °F
(in accordance with DIN IEC 68-2-2)

Test C: Damp heat (steady state)
56 days
(in accordance with DIN IEC 68-2-3)

[1] These days should suitably be distributed throughout the year.
[2] Keeping the annual average.
[3] For humidity category E, rare and slight dew precipitation is additionally permitted, e.g. during short openings of outdoor equipment.

Tables 1 and 2 give a selection of solvents which are commercially available at present. Table 3 shows a selection of solvents which are not suited for MK capacitors.

Table 1:
Presently available trifluor trichloroethanes (selection)

Designation	Manufacturer
Freon TF	Du Pont
Frigen 113 TR	Hoechst
Arklone P	ICI
Kaltron 113 MDR	Kali-Chemie
Flugene 113	Rhone-Progil

Table 2:
Presently available solvent mixtures of the components ethyl alcohol, isopropyl alcohol, and trifluor trichloroethane (selection)

Designation	Manufacturer
Freon TE; Freon TP 35; Freon TMS; Freon TES	Du Pont
Frigen 113 TR-E; Frigen 113 TR-P; Frigen 113 TR-M	Hoechst
Arklone A; Arklone F; Arklone L; Arklone K	ICI
Kaltron 113 MDA; Kaltron 113 MDI; Kaltron 113 MDM	Kali-Chemie
Flugene 113 E; Flugene 113 IPA; Flugene 113 M	Rhone-Progil

Table 3:
Presently available solvent mixtures of chlorinated carbons and ketones with fluorized carbons (selection)

Designation	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

6.4 Sealing unprotected MKT film capacitors

The numerous kinds of sealings entail difficulties in indicating the know-how – based on own experiments – for every application. According to our understanding, the following sealing materials are suitable for any application:

Acid-anhydride hardening, non-flexibilized epoxy resins; indifferent, electrically non-conductive hardeners; hardening temperature max. 100 °C (212 °F). A sealing, comprising those elements, has stood our tests and has been utilized in the electronics industry.

6.5. Resistance to vibration

The ability of MK capacitors to withstand specified vibration loads as specified in the DIN standard 40 046, sheet 8, test F_c, partial test B 1 and in the IEC recommendation 68-2-6:

Duration of endurance conditioning	6 hours
Frequency range	10 to 55 Hz
Displacement amplitude	0.75 mm
This vibration load complies with maximum	98.1 m/sec^2 or 10 *g*

Big components have to be fixed by clamps for this test.

6.6. Low air pressure

Test in accordance with DIN 40 046, sheet 13, or the IEC recommendation 68-2-3 providing a degree condition of severity of 44 mbar.

7. Reliability (in accordance with DIN 40 040, Febr. 1973)

The reliability (operational reliability) of a component is determined by the failures expected out of a sufficiently large batch after a defined period of time.

Data on load duration and failure quota is used for characterization.

7.1. Reference reliability of MK capacitors

The reference reliability is the reliability for a particularly defined requirement (reference requirement).

The reference reliability given for MK capacitors, refers to 40 °C (104 °F) and to the annual average humidity admitted for the particular type. Here, the diagrams of apendix 2, DIN 40 040, page 7, are to be taken into account for a reduced relative humidity at temperatures above room temperature.

7.5. Example of coding the climatic category and reliability

Code letters F P C / L R

- Lower category temperature — F
- Upper category temperature — P
- Humidity category — C
- Load duration — R
- Failure quota — L

8. Ordering codes

Siemens has introduced part numbers for all its technical products in order to expedite procedures such as ordering and supplying, by means of data processing equipment. These part numbers clearly identify any deliverable component.

The ordering codes (Siemens part numbers) for MK capacitors are contained on every data sheet. They are in accordance with the Siemens standard SN 01001.

Ordering code example: B 32 510-D 3 104-K

- Type — B 32 510
- Revision status — D
- Rated voltage 3≙250 V dc — 3
- Rated capacitance ($104 \triangleq 10 \times 10^4$ pF = 0.1 µF) — 104
- Capacitance tolerance (K≙±10%) — K

Improvements and technical advance are expressed by changing the code letter for the revision status. It is reserved to deliver MK capacitors with a revision status later than that ordered.

8.1. Marking the capacitors

The capacitance of the capacitors is, in most cases, marked according to DIN 40825.

Examples:

Cap. value	Marking
15 µF	15µ
1.5 µF	1µ5
0.15 µF	µ15

The same thing applies analoguously to "n", i. e. nF.

The date of manufacture is either marked in clear or as date code according to DIN 41314.

Examples for year-month coding:
1982, May: P5
1983, Nov.: RN

Minimum order quantities for taped, axial MK capacitors

Using only small numbers of taped components would be uneconomic as the share of taping and packing expense would increase the costs considerably. Moreover, automatic assembly is only reasonable for larger quantities. We, therefore, determined minimum order quantities for taped MK capacitors, which also correspond to the capacity of the packaging box.

Max. capacitor diameter (mm)	Packaging unit items/box	Kind of packing
5,4	2000	AMMO pack
6,4; 7,4	1300	
8,4; 9,4; 10,7	600	
11,7	500	
12,7; 13,7	300	
15,7; 16,7; 17,7; 18,7	250	

Ordering code for taped, axial MK capacitors

The ordering code (part number) for taped MK capacitors (produced in quantity) is formed by appending a "9" to the code of the untaped components.

Example: untaped capacitor B32110-E1105-M
taped capacitor B32110-E1105-M9

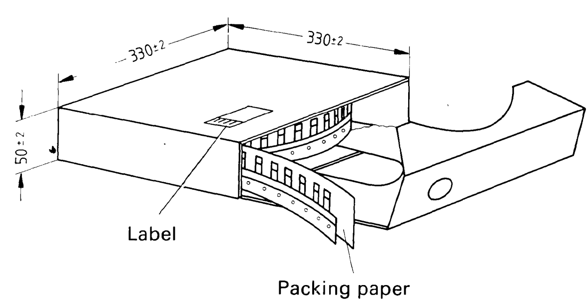
Ordering code

LS mm	Dimens. H or H_0 mm	Cassette packing	Reel packing	AMMO pack
5	H = 18	B32509–T***–+89	B32509–T***–+189	B32509–T***–+289
	H = 16,5	B32509–T***–+69	B32509–T***–+169	B32509–T***–+269
	H = 18	B32529–A***–+89	B32529–A***–+189	B32529–A***–+289
	H = 16,5	B32529–A***–+69	B32529–A***–+169	B32529–A***–+269
	H = 18	B32539–A***–+89	B32539–A***–+189	B32539–A***–+289
	H = 16,5	B32539–A***–+69	B32539–A***–+169	B32539–A***–+269
7,5/5	H_0 = 16	–	B32510–T****–+159	B32510–T****–+259
	H_0 = 16	–	B32520–A****–+159[1]	B32520–A****–+259[1]
	H_0 = 16	–	B32530–A****–+159[1]	B32530–A****–+259[1]
7,5	H = 18	–	B32510–T****–+189	B32510–T****–+289
	H = 16,5		B32510–T****–+169	B32510–T****–+269
	H = 18	B32520–A****–+89[1]	B32520–A****–+189[1]	B32520–A****–+289[1]
	H = 16,5	B32520–A****–+69	B32520–A****–+169	B32520–A****–+269
	H = 18	B32530–A****–+89[1]	B32530–A****–+189[1]	B32530–A****–+289[1]
	H = 16,5	B32530–A****–+69	B32530–A****–+169	B32530–A****–+269

The ordering code digits marked by * or + are to be replaced by the appropriate specifications shown on the corresponding data sheets

Because of the different packing methods it is recommended to contact your nearest Siemens Sales Office or distributor before ordering.

Cassette packing



Dimensions in mm

[1]) available from 1984

Packaging units (minimum order quantities)

B 32509, lead spacing 5 mm

Capacitor[1] C_R/U_R	Minimum order quantity = packaging unit (item) Cassette and reel packing	AMMO pack
4,7 nF/63 V	2000	1900
6,8 nF/63 V	2000	1900
10 nF/63 V	2000	1900
15 nF/63 V	2000	1800
22 nF/63 V	2000	1800
33 nF/63 V	2000	1900
47 nF/63 V	2000	1900
68 nF/63 V	2000	1800
0,1 µF/63 V	2000	1700
0,15 µF/63 V	1600	1400
0,22 µF/63 V	1600	1400
0,33 µF/63 V	1300	1100
0,47 µF/63 V	1000	800

B 32529/B 32539, lead spacing 5 mm

Capacitor[1] C_R/U_R	Minimum order quantity = packaging unit (item) Cassette and reel packing	AMMO pack
4,7 nF/63 V	1900	1700
6,8 nF/63 V	1900	1700
10 nF/63 V	1900	1700
15 nF/63 V	1900	1700
22 nF/63 V	1900	1700
33 nF/63 V	1900	1700
47 nF/63 V	1900	1700
68 nF/63 V	1900	1700
0,1 µF/63 V	1700	1500
0,15 µF/63 V	1400	1300
0,22 µF/63 V	1400	1300
0,33 µF/63 V	800	700
0,47 µF/63 V	800	700

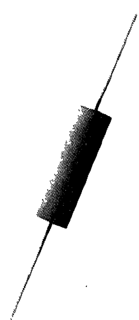
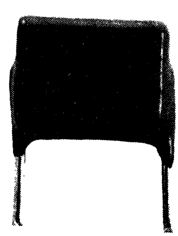
[1]) For dimensions refer to appropriate data sheet.

B 32520/B 32530, lead spacing 7.5/5 or 7.5 mm

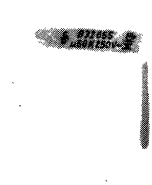
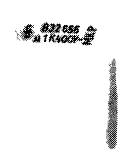
Capacitor[1]) C_R/U_R	Minimum order quantity = packaging unit (item) Cassette and reel packing	AMMO pack
1 nF/400 V		
1,5 nF/400 V		
2,2 nF/400 V		
3,3 nF/400 V		
4,7 nF/400 V		
6,8 nF/400 V		
10 nF/400 V	1300	1100
15 nF/250 V		
22 nF/250 V		
33 nF/250 V		
47 nF/100 V		
68 nF/100 V		
0,1 µF/100 V		
0,15 µF/100 V		

[1]) For dimensions refer to appropriate data sheet.

MKT Capacitors

Type	I 5100	I 5150... I 5154	B 32 560 to B 32 563
Rated capacitance (µF)	0.01 to 6.8	0.01 to 6.8	0.001 to 3.3
Rated voltage (V dc) (V ac)	100 to 630.	100 to 630	100 to 400
DIN climatic category (DIN 40 040)	FMF	GMF	FME/LR
IEC climatic category (IEC 68)	40/100/21	40/100/21	55/100/21
Dimensions *b* × *h* × *l* in mm (inches)	 .236 × .591 to .906 × 1.26	4 × 7.5 × 11 (0.16 × 0.3 × 0.43) to 14 × 24 × 31 (0.55 × 0.95 × 1.22)	2.3 × 7.3 × 9 (0.09 × 0.29 × 0.35) to 10.4 × 17.5 × 24 (0.41 × 0.69 × 0.94
Lead spacing in mm	—	7.5; 10; 15; 22.5; 27.5	7.5; 10; 15; 22.5
Design	Tubular winding with epoxy resin and sealed	Stacked-film epoxy dipped tinned leads	Stacked-film construction; tinned leads, plug-in in the lead spacing
Particular features	Standard version	Standard version	Quality assessed type as to CECC 30 401/007 Form A. Space saving mounting at high packing density.
Figure			

MKP Capacitors

Type	B 32 650	B 32 655	B 32 656
Rated capacitance (μF)	0.0022 to 2.2	0.047 to 1.0	0.0022 to 0.1
Rated voltage U_R AC voltage U ac	400 to 1500 V dc 500 to 1500 V $_{pp}$	630 V dc 250 V ac	1000 V dc 400 V ac
DIN climatic category (DIN 40 040)	GPE	GPE	FPD/LS
IEC climatic category (IEC 68)	40/085/56	40/085/56	55/085/56
Dimensions $b \times h \times l$ in mm (inches)	5.5 × 11 × 18 (0.22 × 0.43 × 0.71) ... 15 × 24.5 × 31.5 (0.59 × 0.96 × 1.24)	5.5 × 11 × 18 (0.22 × 0.43 × 0.71) ... 13.5 × 23 × 31.5 (0.53 × 0.91 × 1.24)	7.3 × 16.5 × 27 (0.29 × 0.65 × 1.06) ... 15 × 24.5 × 31.5 (0.59 × 0.96 × 1.24)
Lead spacing in mm	15; 22.5; 27.5	15; 22.5; 27.5	22.5; 27.5
Design	Wound capacitor with face-end contacts. Built into flame-retardant, epoxy resin sealed plastic case; leads plug-in the lead spacing.		
Particular features	Pulse-proof, for TV, deflection, and high voltage stages, thyristor deflection circuits, etc.	Suitable for mains ac voltage load and pulse circuits	For high reliability applications, in particular suitable for mains ac voltage load and pulse operation
Figure			

Rated voltage U_R		63 V dc	100 V dc				
Lead spacing		**LS 5 mm**	**LS 7.5 mm**	**LS 10 mm**	**LS 15 mm**	**LS 22.5 mm**	**LS 27.5 mm**
Rated capacitance	Tolerance	M; K; J	K; J			M; K; J	
		Dimensions *b* x *h* x *l* and ordering code					
C_R		B32529–	B32520–	B32521–	B32522–	B32523–	B32524–
4700 pF		2.5x6.5x7.5◥ –A472–*					
6800 pF		2.5x6.5x7.5◥ –A682–*					
0.01 µF		2.5x6.5x7.5◥ –A103–*					
0.015 µF		2.5x6.5x7.5◥ –A153–*					
0.022 µF		2.5x6.5x7.5◥ –A223–*					
0.033 µF		2.5x6.5x7.5◥ –A333–*					
0.047 µF		2.5x6.5x7.5◥ –A473–*	4x8.5x10◥ –A1473–*				
0.068 µF		2.5x6.5x7.5◥ –A683–*	4x8.5x10◥ –A1683–*	4x9x13 –A1683–*			
0.1 µF		3x6.5x7.5 –A104–*	4x8.5x10◥ –A1104–*	4x9x13 –A1104–*			
0.15 µF	±20% ≙ M ±10% ≙ K ± 5% ≙ J	3.5x9x7.5 –A154–*	4x8.5x10◥ –A1154–*	4x9x13 –A1154–*			
0.22 µF		3.5x9x7.5 –A224–*		4x9x13 –A1224–*			
0.33 µF		6x10.5x7.5 –A334–*			5.5x11x18 –A1334–*		
0.47 µF		6x10.5x7.5 –A474–*			5.5x11x18 –A1474–*		
0.68 µF					7x13x18 –A1684–*		
1 µF					7x13x18 –A1105–*		
1.5 µF						7.3x16.5x27 –M1155–*	
2.2 µF						8.5x18.5x27 –M1225–*	
3.3 µF						10.5x19x27 –M1335–*	
4.7 µF							11.5x21x31.5 –M1475–*
6.8 µF							13.5x23x31.5 –M1685–*
10 µF							15x24.5x31.5 –M1106–*

* The code letter for the desired tolerance (refer to table) must be inserted in this position.
◥ Shipment for 1983 still in the dimensions: LS 5 = 2.6x6.5x7.5; LS 7.5 = 4x10x10 (B 32535).
▭ Preferred values

Rated voltage U_R		400 V dc				
Lead spacing		LS 7.5 mm	LS 10 mm	LS 15 mm	LS 22.5 mm	LS 27.5 mm
Rated capacitance C_R	Tolerance	K; J			M; K; J	
		Dimensions *b*x*h*x*l* and ordering code				
		B32520–	B32521–	B32522–	B32523–	B32524–
1000 pF	± 20% ≙ M ± 10% ≙ K ± 5% ≙ J	**4x8.5x10 –A6102–*** ◥				
1500 pF		**4x8.5x10 –A6152–*** ◥				
2200 pF		**4x8.5x10 –A6222–*** ◥				
3300 pF		**4x8.5x10 –A6332–*** ◥				
4700 pF		**4x8.5x10 –A6472–*** ◥				
6800 pF		**4x8.5x10 –A6682–*** ◥				
0.01 µF		**4x8.5x10 –A6103–*** ◥	4x9x13 –A6103–*			
0.015 µF			4x9x13 –A6153–*			
0.022 µF			**4x9x13 –A6223–***			
0.033 µF			4x9x13 –A6333–*			
0.047 µF				5.5x11x18 –A6473–*		
0.068 µF				5.5x11x18 –A6683–*		
0.1 µF				**7x13x18 –A6104–***		
0.15 µF				7x13x18 –A6154–*		
0.22 µF					7.3x16.5x27 –M6224–*	
0.33 µF					**8.5x18.5x27 –M6334–***	
0.47 µF					10.5x19x27 –M6474–*	
0.68 µF						11.5x21x31.5 –M6684–*
1 µF						11.5x21x31.5 –M6105–*
1.5 µF						13.5x23x31.5 –M6155–*

* The code letter for the desired tolerance (refer to table) must be inserted in this position.
◥ Shipment for 1983 still in the dimensions: 4x10x10 (B 32535).
▭ Preferred value

IEC climatic category (DIN 40045 or IEC publication 68-1)	**55/100/56**
Damp heat test (DIN IEC 68-2-3)	**Conditions** Test temperature: +40°C Relative humidity: (93^{+2}_{-3})% Test duration: 56 days **Test criteria** Capacitance change $\frac{\Delta C}{C}$: $\leqq \pm 5$% Dissipation factor change $\Delta \tan \delta$ at 1 kHz: $\leqq 5 \cdot 10^{-3}$ Insulation resistance: $\geqq$ 50% of the minimum value at delivery
Resistance to vibration Test F_C: vibration partial test B1 (DIN 40046, sheet 8 and IEC publ. 68-2-6)	Duration of endurance conditioning: 6 h Frequency range: 10...55 Hz Displacement amplitude: 0.75 mm (conforming to 98.1 m/s² max., or to 10 *g*) At 10 Hz...2 kHz capacitors with LS≧22.5 mm must additionally be fixed at the case.
Resistance to soldering heat[1] Test Tb (DIN IEC 68-2-20)	Solder bath temperature: max. 260°C (500°F) Soldering duration: max. 5 sec Capacitance change $\frac{\Delta C}{C}$: $\leqq \pm 2$%
Resistance to cleansing agents	Refer to Data Book "Metalized Plastic Capacitors" 1982/83, chapter "General Technical Information", page 27.
Maximum capacitance drift i_Z	±3%

Self inductance

Lead spacing (mm)	5	7.5	10	15	22.5	27.5
Self inductance (nH)	≈5	≈8	≈9	≈10	≈20	≈20

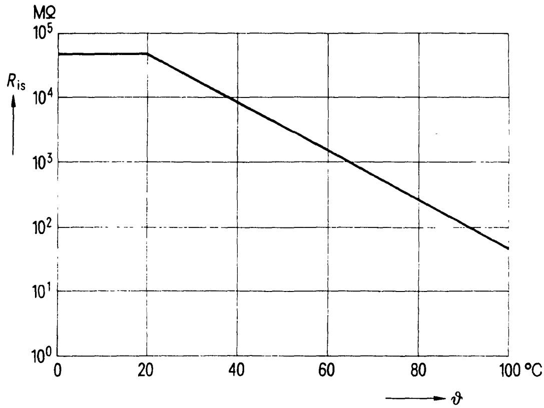
Dissipation factor tan δ measured at 20°C

Upper limits/average production values

	$C_R < 0.1$ µF	$C_R \geqq 0.1...<1$ µF	$C_R \geqq 1$ µF
at 1 kHz	$8/5 \cdot 10^{-3}$	$10/6 \cdot 10^{-3}$	$10/7 \cdot 10^{-3}$
10 kHz	$15/12 \cdot 10^{-3}$	$20/15 \cdot 10^{-3}$	–
100 kHz	$30/18 \cdot 10^{-3}$	–	–

[1]) For soldering recommendations see also Data Book "Metalized Plastic Capacitors" 1982/83, "General Technical Information", section 6.2.

Insulation resistance R_{is}
versus temperature ϑ



Typical values, measured at 20°C and at a relative humidity ≦65%

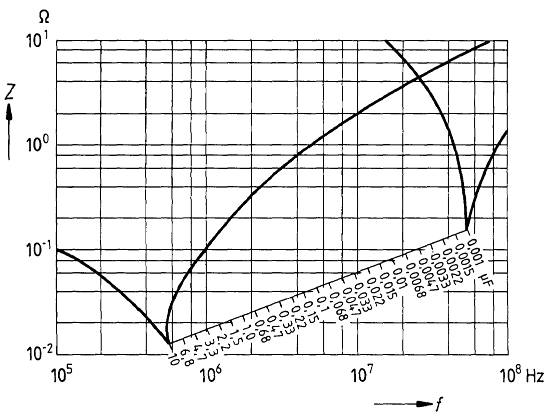
Minimum delivery value[1])

U_R	$C_R \leqq 0.33$ µF	$C_R > 0.33$ µF
≦100 V	3750 MΩ	1250 sec
≧250 V	7500 MΩ	2500 sec

Average delivery value

U_R	$C_R \leqq 0.33$ µF	$C_R > 0.33$ µF
≦100 V	>30000 MΩ	>10000 sec
≧250 V	>75000 MΩ	>25000 sec

Impedance Z
versus frequency f
(typical values)



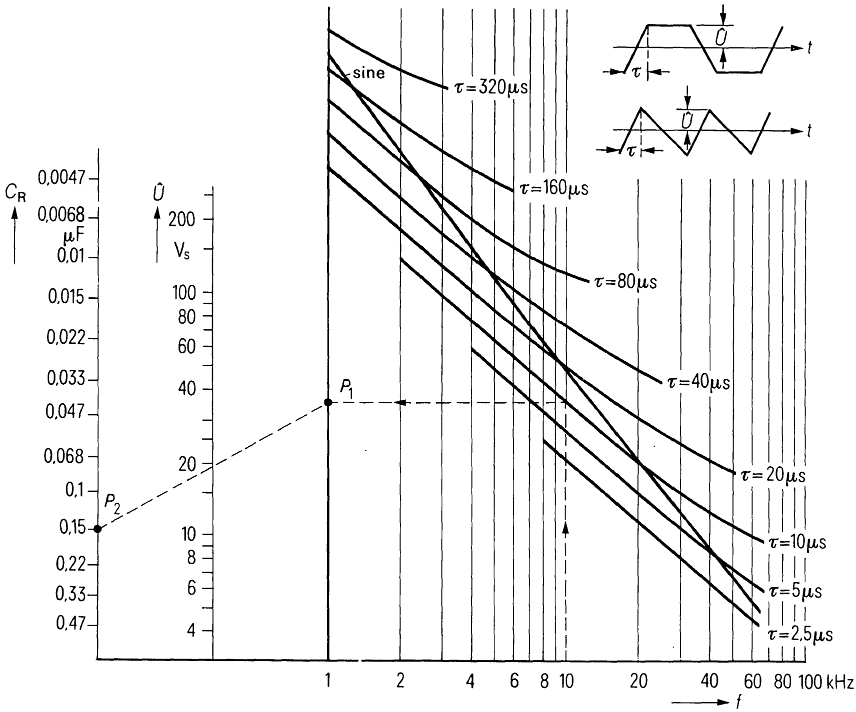
[1]) The indicated values apply at the time of delivery. From time to time during the service life, the insulation may decrease to approx. 10% of the value at the time of delivery, especially if the max. permissible relative humidity of 95% of the humidity category E is applied for a longer period, or if the capacitor is operated close to the upper category temperature.

B 32529, LS 5 mm; U_R = 63 V dc

Nomogram to determine the permissible peak voltage $\hat{U}$

Determine the intersections P_1 and P_2 according to the plotted example. The intersection of the line connecting P_1 with P_2 and the $\hat{U}$ scale gives the maximum permissible peak voltage.

In case of a trapezoidal voltage load, the second harmonic frequency must be considered. For a sinusoidal voltage load, the "sine" characteristic applies.



Example:

f = 10 kHz	(repetition frequency)	}	intersection P_1
τ = 10 µs	(rise time)		
C_R = 0.15 µF	(capacitance)	}	intersection P_2
U_R = 63 V	(rated voltage)		

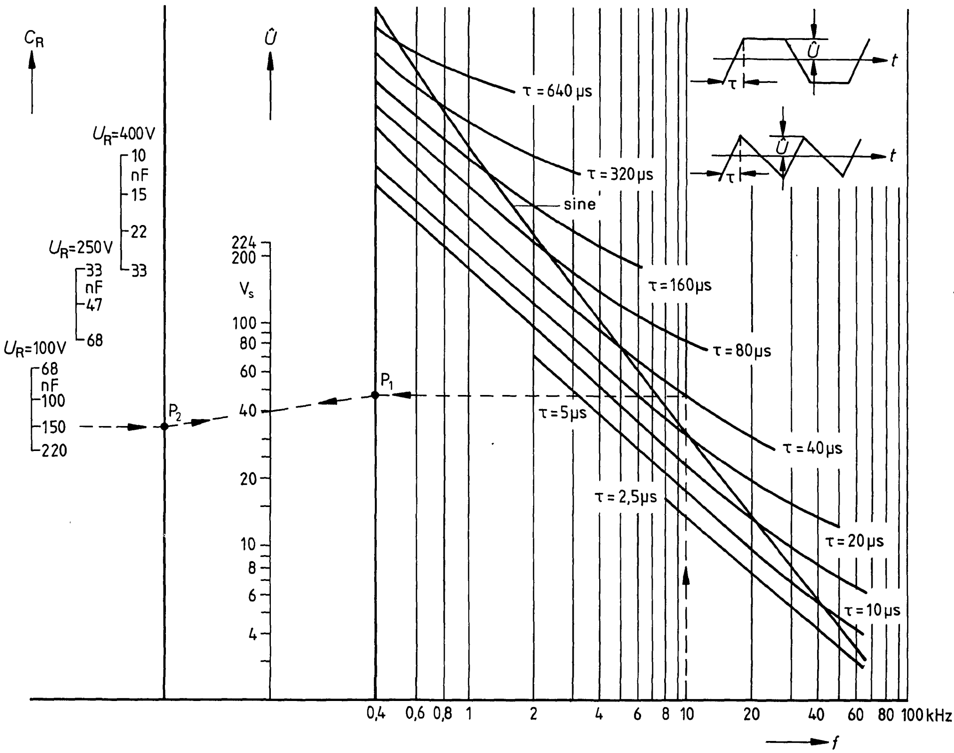
According to the dashed line in the above graph, this results in a max. peak voltage $\hat{U}$ of approx. 19 V.

B 32521, LS 10 mm

Nomogram to determine the permissible peak voltage $\hat{U}$

Determine the intersections P_1 and P_2 according to the plotted example. The intersection of the line connecting P_1 with P_2 and the $\hat{U}$ scale gives the maximum permissible peak voltage.

In case of a trapezoidal voltage load with two steep edges, the second harmonic frequency must be considered. For a sinusoidal voltage load, the "sine" characteristic applies.



Example:

f = 10 kHz	(repetition frequency)	}	intersection P_1
τ = 40 µs	(rise time)		
C_R = 150 nF	(capacitance)	}	intersection P_2
U_R = 100 V	(rated voltage)		

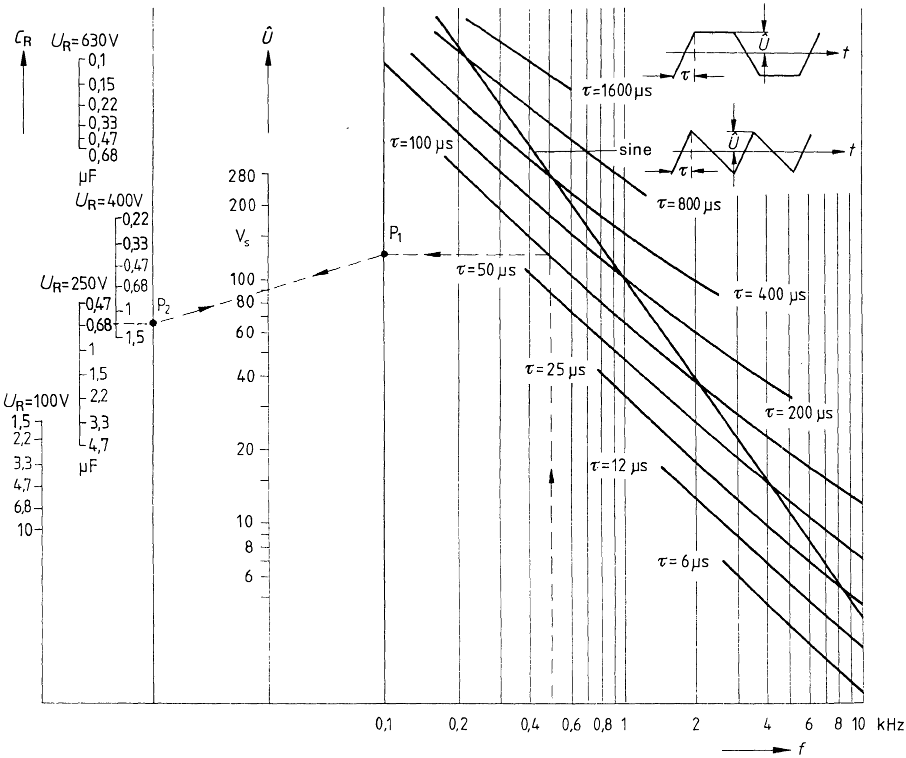
According to the dashed line in the above graph, this results in a max. peak voltage $\hat{U}$ of approx. 40 V.

B 32523, LS 22.5 mm
B 32524, LS 27.5 mm

Nomogram to determine the permissible peak voltage $\hat{U}$

Determine the intersections P_1 and P_2 according to the plotted example. The intersection of the line connecting P_1 with P_2 and the $\hat{U}$ scale gives the maximum permissible peak voltage.

In case of a trapezoidal voltage load with two steep edges, the second harmonic frequency must be considered. For a sinusoidal voltage load, the "sine" characteristic applies.



Example:

f	= 0.5 kHz	(repetition frequency)	intersection P_1
τ	= 100 μs	(rise time)	
C_R	= 0.68 μF	(capacitance)	intersection P_2
U_R	= 250 V	(rated voltage)	

According to the dashed line in the above graph, this results in a max. peak voltage $\hat{U}$ of approx. 90 V.

For loads at frequencies > 10 kHz, please contact us.

MKT Stacked-Film Capacitors

Rated voltage U_R		100 Vdc				250 Vdc	
Rated capacitance	Tolerance	LS 7.5 mm	LS 10 mm	LS 15 mm	LS 22.5 mm	LS 7.5 mm	LS 10 mm
		Dimensions *b x h x l* Ordering code					
C_R		B32560–	B32561–	B32562–	B32563–	B32560–	B32561–
1000 pF	± 5%≙J ±10%≙K						
1500 pF							
2200 pF							
3300 pF							
4700 pF							
6800 pF							
0,01 µF							
0,015 µF						2,3x7,3x9 –D3153–*	
0,022 µF						2,3x7,3x9 –D3223–*	3,2x6,6x11,5 –D3223–*
0,033 µF						2,5x7,3x9 –D3333–*	3,3x6,6x11,5 –D3333–*
0,047 µF						2,9x7,4x9 –D3473–*	3,1x6,6x11,5 –D3473–*
0,068 µF		2,4x8,1x9 –D1683–*				3,6x8,1x9 –D3683–*	3,1x6,6x11,5 –D3683–*
0,1 µF		2,7x8,1x9 –D1104–*				4x10,1x9 –D3104–*	3,6x7,4x11,5 –D3104–*
0,15 µF		3,4x8,1x9 –D1154–*					4,3x8,5x11,5 –D3154–
0,22 µF		4,4x8,0x9 –D1224–*	3,4x7,2x11,5 –D1224–*				5,0x10,1x11,5 –D3224–*
0,33 µF		5,5x8,8x9 –D1334–*	4,2x8,1x11,5 –D1334–*				
0,47 µF		5,5x12,5x9 –D1474–*	5,4x8,1x11,5 –D1474–*	4x6,9x16,5 –D1474–*			
0,68 µF		8x11,4x9 –D1684–*	7,2x8,2x11,5 –D1684–*	5x7,3x16,5 –D1684–*			
1 µF			8,5x9,8x11,5 –D1105–*	5,5x9,2x16,5 –E1105–*			
1,5 µF				7x10,5x16,5 –E1155–*			
2,2 µF				8,5x12,3x16,5 –E1225–*	6,4x11,3x24 –D1225–*		
3,3 µF					7,7x13,4x24 –D1335–*		

* Here, the requested tolerance ±10%≙K or ±5%≙J must be inserted ☐ Preferred values.

IEC climatic category (DIN 40 045, or IEC publication 68-1)	**55/100/21** [1]
Damp heat test in accordance with DIN IEC 68-2-3	**Conditions** Test temperature: + 40 °C/+ 104 °F Relative humidity: $(93 {}^{+2}_{-3})$% Test duration: 21 days **Test criteria** Capacitance change $\frac{\Delta C}{C}$ $\leqq \pm 5\%$ Dissipation factor change Δ tan δ: $\leqq 3 \times 10^{-3}$ at 1 kHz; $\leqq 5 \times 10^{-3}$ at 10 kHz Insulation resistance: $\geqq$ 50% of the minimum value at delivery
Resistance to vibration Test F_c: Vibration partial test B 1 in accordance with DIN 40 046, sheet 8 and IEC publication 68-2-6	Load duration: 6 hours Frequency range: 10 to 55 Hz Displacement amplitude: 0.75 mm (conforming to max. 98.1 m/s² or to 10 *g*)
Resistance to soldering heat [2] Test Tb in accordance with DIN IEC 68-2-20	Temperature of the solder bath max. 260 °C (500 °F) Soldering duration max. 5 sec Test criterion: Capacitance change $\frac{\Delta C}{C}$ $\leqq \pm 2\%$
Resistance to cleansing agents	Refer to section "General Technical Information", page 27
Sealing compound	Refer to para. 6.4. in section "General Technical Information", page 30
Max. capacitance drift i_Z	± 3%

Self inductance

Lead spacing (mm)	7.5	10	15	22.5
Self inductance (approx. nH)	5	6	7	9

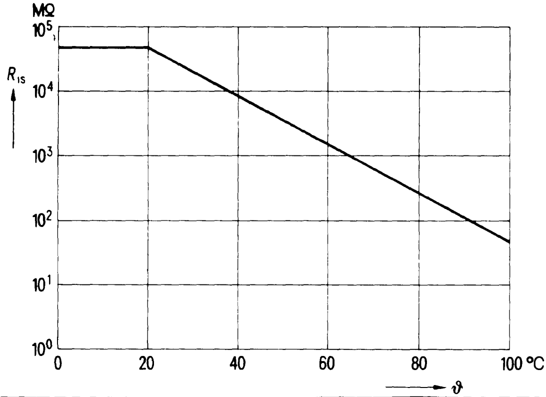
Dissipation factor tan δ measured at 20 °C/68 °F

Maximum values / Average values

	$C_R < 0.1$ µF	$C_R \geqq 0.1$ µF	$C_R > 1$ µF
at 1 kHz	$8/5 \times 10^{-3}$	$8/5 \times 10^{-3}$	$10/6 \times 10^{-3}$
10 kHz	$15/12 \times 10^{-3}$	$15/12 \times 10^{-3}$	–
100 kHz	$30/18 \times 10^{-3}$	–	–

1) The test criteria are also kept at a humidity load of 56 days.
2) For solder recommendations refer to "General Technical Information", para 6.2., page 27

Insulation resistance R_{is}
versus
temperature ϑ



Insulation resistance R_{is}[1)]
or time constant τ,
respectively

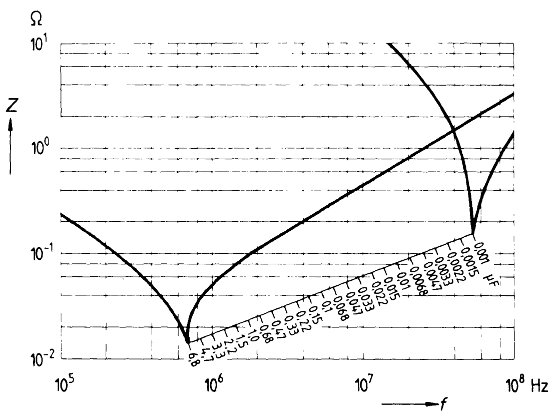
Minimum value

U_R	$C_R \leqq 0.33$ µF	$C_R > 0.33$ µF
100 V	3 000 MΩ	1 000 s
≧250 V	7 500 MΩ	2 500 s

Average value

U_R	$C_R \leqq 0.33$ µF	$C_R > 0.33$ µF
100 V	>30 000 MΩ	>10 000 s
≧250 V	>75 000 MΩ	>25 000 s

Impedance Z
versus frequency f
(typical values)

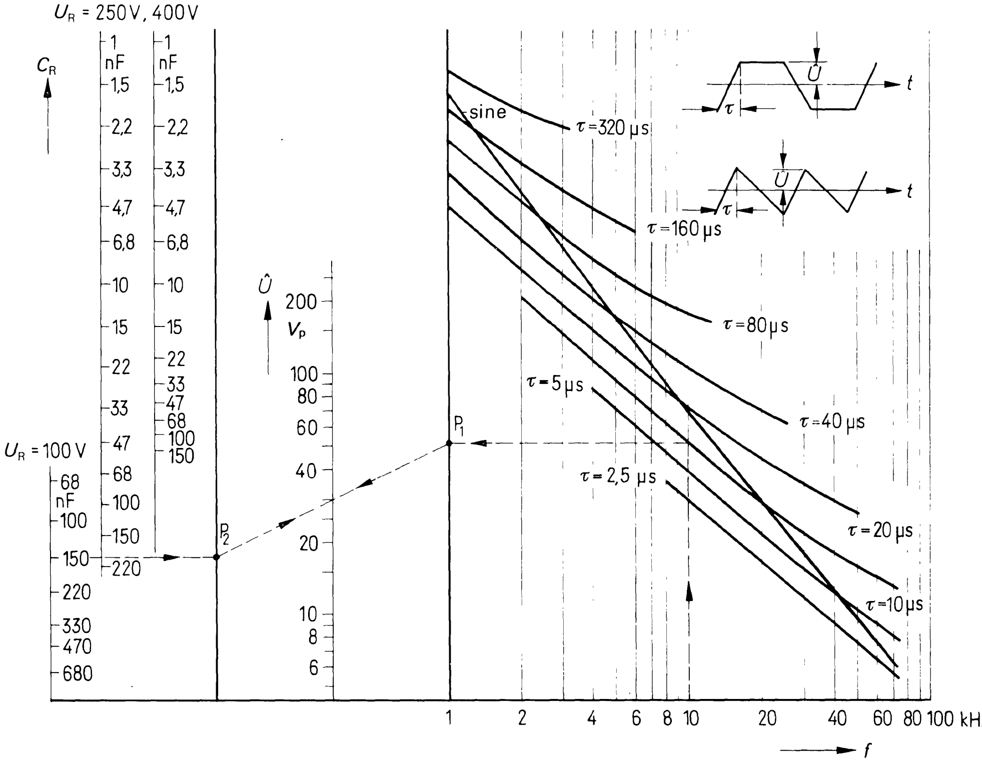


1) The indicated values are applicable at the time of delivery. During operational life the insulation may decrease for a short period to about 10% of the values at the time of delivery especially when the max. permissible humidity of 95% is applied for a long period, or when the capacitor is operated close to the upper category temperature.

B 32 560, lead spacing = 7.5 mm

Nomogram for determining the permissible peak voltage $\hat{U}$

Determine points of intersection P_1 and P_2 in accordance with the example plotted. The line of communication P_1, P_2 yields the maximum possible peak voltage.
In case of trapezoidal voltage load with two steep edges, the second harmonic frequency has to be taken into account. With sinusoidal voltage load the "sine" characteristic applies.



Example given:

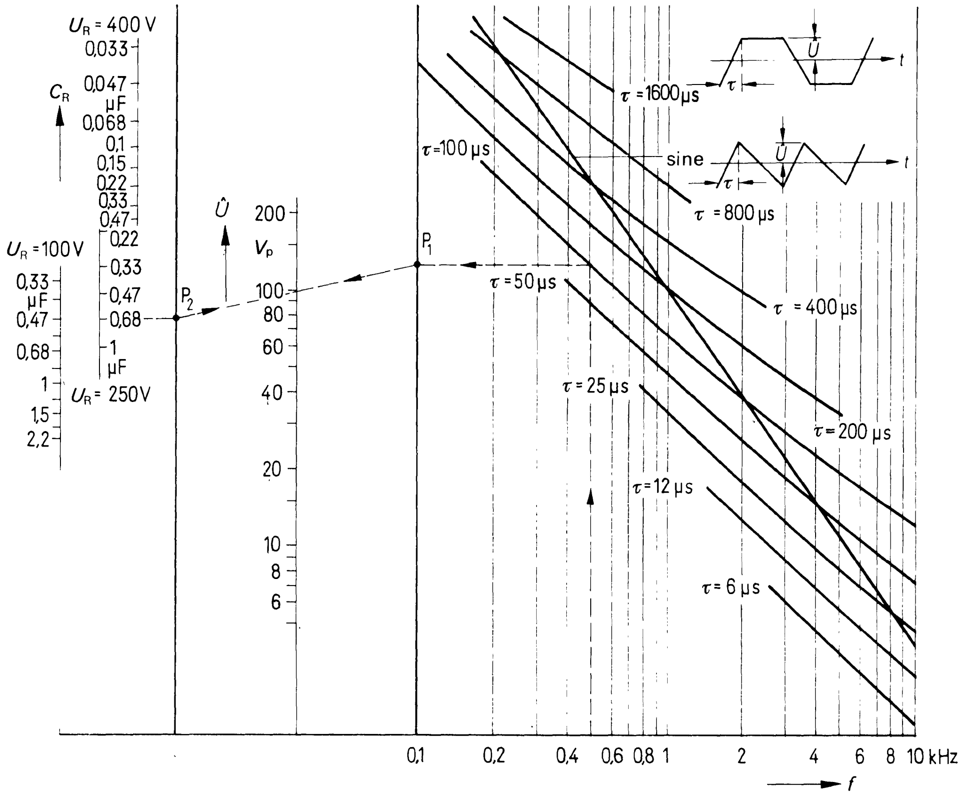
f = 10 kHz	(repetition frequency)	}	Point of intersection P_1
τ = 10 µs	(rise time)		
C_R = 150 nF	(capacitance)	}	Point of intersection P_2
U_R = 100 V	(rated voltage)		

According to the dashed line on the graph above this gives a max. peak voltage $\hat{U}$ of about 30 V.

B 32 562, lead spacing = 15 mm

Nomogram for determining the permissible peak voltage $\hat{U}$

Determine points of intersection P_1 and P_2 in accordance with the example plotted. The line of communication P_1, P_2 yields the maximum possible peak voltage.
In case of trapezoidal voltage load with two steep edges, the second harmonic frequency has to be taken into account. With sinusoidal voltage load the "sine" characteristic applies.



Example given:

f	= 0.5 kHz	(repetition frequency)	Point of intersection P_1
τ	= 100 µs	(rise time)	
C_R	= 0.68 µF	(capacitance)	Point of intersection P_2
U_R	= 250 V	(rated voltage)	

According to the dashed line on the graph above this gives a max. peak voltage $\hat{U}$ of about 100 V.

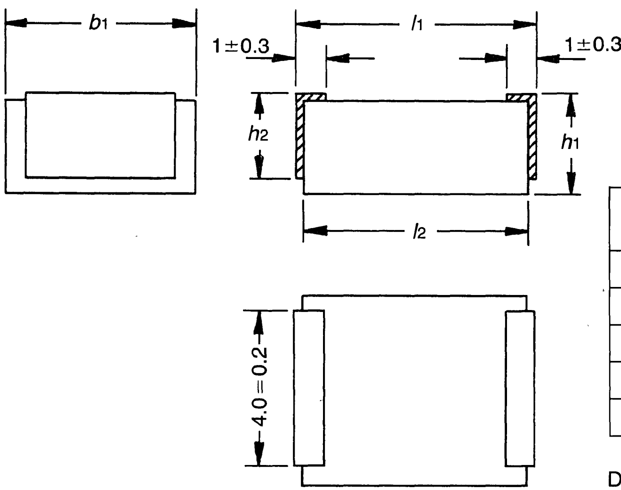
PRELIMINARY

Preliminary data

MKT capacitors, chip version, U_R = 50 V dc

Self-healing capacitor with polyethyleneterephthalat dielectric; encapsulated in a flame-retardant rectangular plastic case (in accordance with UL 94 V-O)

These capacitors are also available on continuous tape. For taping specifications and ordering information refer to data sheet B 32071 (in preparation).



l_1 max	b_1 max	h_1 max	l_2 max	h_2 max
6.8	5.0	2.8	6.5	2.4
7.3	5.4	3.3	7.0	2.9

Dimensions in mm

Rated capacitance C_R µF	**Tolerance**	**Dimensions (max.) $l_1 \times b_1 \times h_1$** mm	**Ordering code**
0.01		6.8x5.0x2.8	B 32595-A9103-M
0.015		6.8x5.0x2.8	B 32595-A9153-M
0.022		6.8x5.0x2.8	B 32595-A9223-M
0.033	±20% = M	6.8x5.0x2.8	B 32595-A9333-M
0.047		6.8x5.0x2.8	B 32595-A9473-M
0.068		6.8x5.0x2.8	B 32595-A9683-M
0.1		6.8x5.0x2.8	B 32595-A9104-M
0.15		7.3x5.4x3.3	B 32595-A9154-M
0.22		7.3x5.4x3.3	B 32595-A9224-M

Metalized Polyester Capacitors

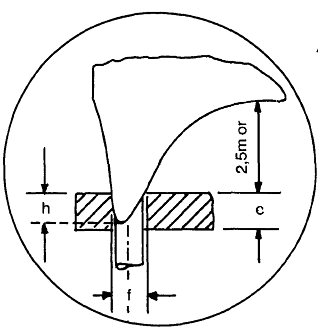
I 5150–
I 5154

Stacked layer construction. Self-healing capacitor with polyester as dielectric. Epoxy resin dipped. Radial tinned copper leads.

d (mm)	ø (mm)	L (mm)
7.5	0.6	11
10	0.8	13
15	0.8	18

*15mm available under request

Detail of meniscus:

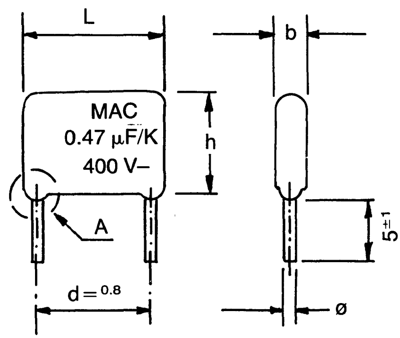


PC Board Thickness	C = 1 mm	C = 1.5 mm
Hole Diameter	F = 1 mm	F = 1.5 mm
Maximum penetration	h ≤ 0.8 mm	h ≤ 1.3 mm

Ordering code

Example: 0.47 / 10 / 100 / 515x

- Rated capacitance (0.47)
- Tolerance (10)
- Rated Voltage (U_R) (100)
- Code (515)
- 0 = L.S. 7.5 mm (x)
  - 1 = L.S. 10 mm
  - 2 = L.S. 15 mm
  - 3 = L.S. 22.5 mm
  - 4 = L.S. 27.5 mm



Dimension Table

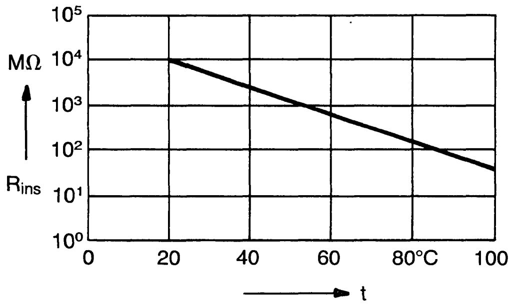
Rated voltage		**100 V dc**				
L.S.		7.5mm	10mm	15mm	22.5mm	27.5mm
Rated Capacitance uF	Tol. (%)	MAXIMUM DIMENSION b x h x l (mm)				
		5150	5151	5152	5153	5154
0.01		4 x 7.5x11				
0.012		4 x 8 x11				
0.015		4 x 9 x11				
0.018		4 x 9 x11				
0.022		4 x 9.5x11				
0.027		4.5x 9.5x11				
0.033		4.5x 9.5x11				
0.039	± 5	4.5x 9.5x11				
0.047	(J)	4.5x 9.5x11				
0.056		4.5x 9.5x11				
0.068		4.5x 9.5x11				
0.082		4.5x 9.5x11				
0.1		4.5x 9.5x11				
0.12		5 x10 x11				
0.15	± 10	5 x10 x11				
0.18	(K)	5 x10 x11	5 x 8.5x13			
0.22		6 x10 x11	5.5x 9 x13			
0.27		6.5x10 x11	5.5x10.5x13			
0.33		7 x11 x11	5.5x10.5x13			
0.39		7.5x11 x11	6 x10.5x13			
0.47		7.5x15 x11	6.5x10.5x13	6 x 9 x18		
0.56		8 x15 x11	7 x10.5x13	6 x 9 x18		
0.68		9.5x15 x11	8 x10.5x13	6.5x 9.5x18		
0.82				6.5x 9.5x18		
1.0			9.5x12 x13	6.5x11.5x18		
1.2				8 x11.5x18		
1.5					8.5x13x26	
1.8					9 x14x26	
2.2					9.5x15x26	
2.7					10.5x17x26	
3.3					11.5x20x26	
3.9						12 x20 x31
4.7						13 x21 x31
5.6						13.5x21.5x31
6.8						14 x22 x31

Dimension Table

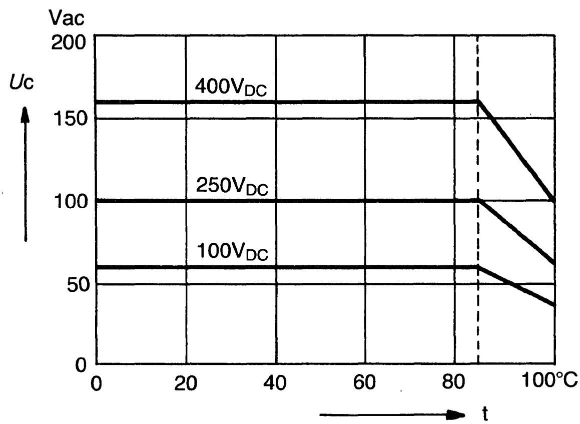
Rated Voltage		**400 V**				
L.S.		7.5mm	10mm	15mm	22.5mm	27.5mm
Rated Capacitance uF	Tol. (%)	MAXIMUM DIMENSION b x h x l (mm)				
		5150	5151	5152	5153	5154
6800 pF		4 x8 x11				
8200 pF		4 x8.5x11				
0.01		4.5x9.5x11	5 x8 x13			
0.012			5 x8 x13			
0.015			5 x8 x13			
0.018			5 x8 x13			
0.022			5 x8 x13			
0.027			5 x8.5x13			
0.033			5 x9 x13			
0.039	± 5		5.5x9 x13			
0.047	(J)		5.5x9.5x13			
0.056			6.5x9.5x13			
0.068				6 x 8.5x18		
0.082				6 x 8.5x18		
0.1				6 x10 x18		
0.12				7. x10.5x18		
0.15	± 10			7 x10.5x18		
0.18	(K)			8 x10.5x18		
0.22				8.5x10.5x18	9 x14 x26	
0.27					9.5x14.5x26	
0.33					9.5x16 x26	
0.39					10 x17 x26	
0.47				11 x16.5x18	10.5x20 x26	
0.56						11 x20x31
0.68						11 x21x31
0.82						11.5x21x31
1.0						13 x22x31

Insulation resistance
as a function of temperature
(Typical values, measured at 25°C)

U_R	$C \leqslant 0.33\,\mu F$	$C > 0.33\,\mu F$
100 V	> 15000 MΩ	5000 s
250 V 400 V	> 30000 MΩ	> 10000 s

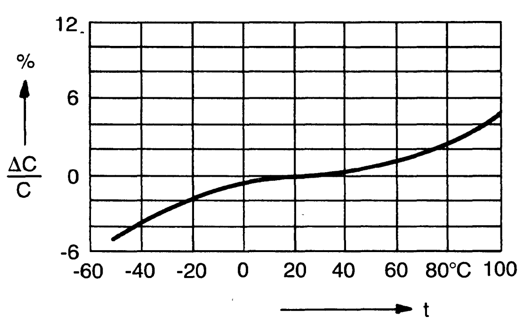


Category voltage *U*c
at ac/dc operation
as a function of temperature t
(50 Hz ac operation)



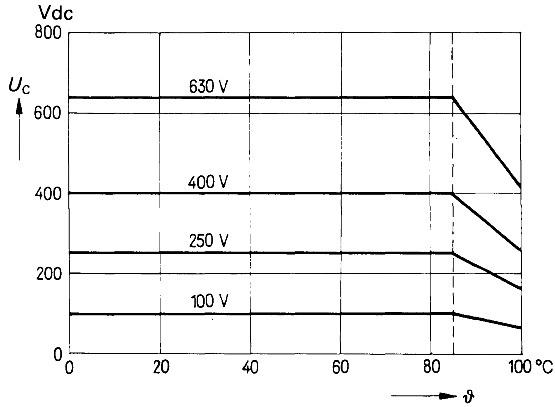
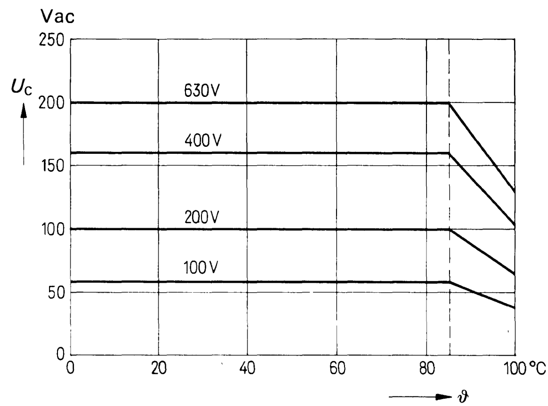
max. 2000 hours 1.25 x *U*c

Reversible capacitance change $\frac{\Delta C}{C}$
as a function of temperature at 1 kHz
(Typical values)



Rated voltage		100 Vdc	250 Vdc	400 Vdc	630 Vdc
Rated capacitance		Dimensions $b \times h \times l$			
µF	Tolerance	Ordering code			
0,01		–	–	–	4,5 × 8 × 14 B32231-C8103-*
0,015		–	–	–	4,5 × 8 × 14 B32231-C8153-*
0,022		–	–	4,5 × 7,5 × 14 B32231-C6223-*	5 × 8,5 × 14 B32231-C8223-*
0,033		–	–	4,5 × 7,5 × 14 B 32231-C6333-*	4,5 × 8 × 19 B32231-C8333-*
0,047		–	4,5 × 8,5 × 14 B32231-A3473-*	4,5 × 8 × 19 B32231-C6473-*	5 × 10,5 × 19 B32231-C8473-*
0,068		–	5,5 × 9 × 14 B32231-A3683-*	4,5 × 8 × 19 B32231-C6683-*	6 × 12 × 19 B32231-C8683-*
0,1		–	4,5 × 8,5 × 14 B32231-A3104-*	5,5 × 8,5 × 19 B32231-C6104-*	5 × 12,5 × 26,5 B32231-C8104-*
0,15		4,5 × 8 × 14 B32231-A1154-*	4,5×8×19 B32231-A3154-*	6,5 × 10 × 19 B32231-C6154-*	6,5 × 14 × 26,5 B32231-C8154-*
0,22	± 20% ≙ M (± 10% ≙ K)[1)]	5 × 9 × 14 B32231-A1224-*	4,5×10×19 B32231-A3224-*	5 × 12 × 26,5 B32231-C6224-*	7,5 × 16,5 × 26,5 B32231-C8224-*
0,33		4,5 × 8,5 × 19 B32231-A1334-*	6×10,5× B32231-S3334-*	6 × 13,5 × 26,5 B32231-C6334-*	9 × 16,5 × 32 B32231-J8334-*
0,47		5 × 9 × 19 B32231-A1474-*	4,5 × 11,5 × 26,5 B32231-A3474-*	7 × 16 × 26,5 B32231-C6474-*	11 × 18,5 × 32 B32231-J8474-*
0,68		6 × 10 × 19 B32231-A1684-*	6 × × 26,5 B32231-A3684-*	8 × 15,5 × 32 B32231-J6684-*	–
1		7,5×11×19 B32231-A1105-*	6,5×16×26,5 B32231-A3105-*	10,5 × 17,5 × 32 B32231-J6105-*	–
1,5		6 × 13 × 26,5 B32231-A1155-*	8 × 16 × 32 B32231-J3155-*	8,5 × 24 × 44 B32231-C6155-*	–
2,2		7 × 15,5 × 26,5 B32231-A1225-*	9,5 × 18 × 32 B32231-J3225-*	10 × 25,5 × 44 B32231-C6225-*	–
3,3		9,5 × 16,5 × 26,5 B32231-A1335-*	10,5 × 22 × 32 B32231-J3335-*	14 × 29 × 44 B32231-C6335-*	–
4,7		9 × 18 × 32 B32231-A1475-*	10×25×44 B32231-A3475-*	17,5 × 32,5 × 44 B32231-C6475-*	–
6,8		12,5 × 20 × 32 B32231-A1685-*	12,5×27,5×44 B32231-A3685-*	–	–
10		13,5 × 25 × 32 B32231-A1106-*	16,5×31×44 B32231-A3106-*	–	–

* When ordering, the code letter for the requested tolerance must be substituted for *.
Closer capacitance tolerance available upon request.

Category voltage U_C at dc operation versus ambient temperature ϑ	
2,000 hours at 85 °C/185 °F for milliseconds (e. g. switchings)	$1.25 \times U_C$ $1.50 \times U_C$
Category voltage U_C[1)2)] at ac operation versus ambient temperature ϑ	
for milliseconds (e. g. switchings)	$1.50 \times U_C$

1) The sum of the dc voltage and the peak value of an ac voltage superimposed on the dc voltage shall not exceed the rated voltage.

2) Capacitors of the 630 Vdc series can be used as 250 Vac mains parallel capacitors if it is ensured that voltage peaks occasionally occurring during operation do not exceed peaks of 1000 V.

Pulse handling capability (voltage rate of rise U_{pp}/τ and pulse characteristic k_0).
Maximum permissible voltage change per time unit with non-sinusoidal voltage load (pulse, sawtooth).

Rated voltage U_R		Capacitor length 14 mm	19 mm	26.5 mm	32 mm	44 mm
100 Vdc	U_{pp}/τ k_0	6 V/µs 1 200 V²/µs	3 V/µs 600 V²/µs	2 V/µs 400 V²/µs	1.5 V/µs 300 V²/µs	–
250 Vdc	U_{pp}/τ k_0	10 V/µs 5 000 V²/µs	5 V/µs 2 500 V²/µs	3 V/µs 1 500 V²/µs	2.5 V/µs 1 250 V²/µs	2 V/µs 1 000 V²/µs
400 Vdc	U_{pp}/τ k_0	14 V/µs 11 200 V²/µs	7 V/µs 5 600 V²/µs	4 V/µs 3 200 V²/µs	3 V/µs 2 400 V²/µs	2.5 V/µs 2 000 V²/µs
630 Vdc	U_{pp}/τ k_0	20 V/µs 25 000 V²/µs	10 V/µs 12 600 V²/µs	7 V/µs 8 800 V²/µs	5 V/µs 6 300 V²/µs	–

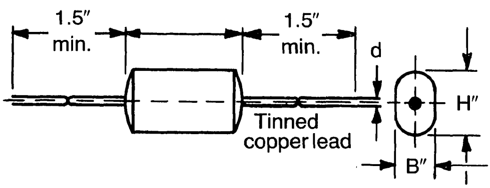
For a voltage swing $U_{pp} < U_R$ the value of the permissible voltage rate of rise U_{pp}/τ can be multiplied by the factor U_R/U_{pp}. The data of the nomogram must be accounted for periodic pulses. See also calculation example in section "General Technical Information", para 5.2.6, page 24.

AC power handling capability at higher frequencies

The maximum permissible peak voltage $\hat{U}$ for sinusoidal and non-sinusoidal voltage load (pulse, sawtooth, trapezoidal voltages) can be obtained from the nomogram, where the following limit values $\hat{U}_l$ are not allowed to be exceeded.

Rated voltage U_R	100 V	250 V	400 V	630 V
Limit voltage $\hat{U}_l$	84 V	140 V	224 V	280 V

Metallized polyester dielectric.
Self-healing capacitor.
Polyester tape as insulation.
Epoxy resin closed face ends.
Axial copper leads.



Ordering Code:

Example: 5200 .22/20/250

Type Number — 5200
Capacitance (μF) — .22
Tolerance (± %) — 20
Voltage (V dc) — 250

Capacity ≤ 1.0 μF

B max	≤ .236	> .236
AWG (d)	22	20

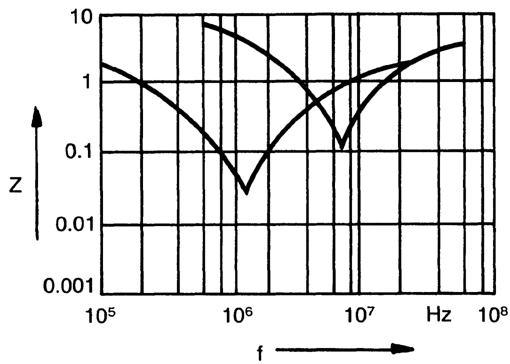
Capacity > 1.0 μF

L max	≤ 1.15
AWG (d)	20

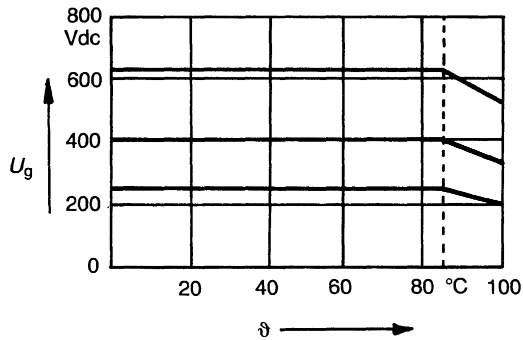
Nom. Cap.		Maximum Dimensions (Inches)		
μF	Tol.	250V	400V	630V
0.01				.197x.315x.591
0.015				.197x.315x.591
0.022				.217x.374x.591
0.033			.197x.374x.591	.197x.315x.787
0.047		.217x.335x.591	.197x.354x.591	.217x.413x.787
0.068		.236x.374x.591	.197x.374x.787	.236x.472x.787
0.1		.236x.394x.591	.197x.374x.787	.256x.433x1.10
0.15		.217x.354x.787	.256x.394x.787	.256x.551x1.10
0.22		.217x.354x.787	.197x.472x1.10	.295x.689x1.10
0.33		.217x.394x.787	.236x.571x1.10	.354x.709x1.26
0.47		.235x.472x.787	.256x.630x1.10	.433x.906x1.26
0.68	± 10%	.236x.472x1.08	.315x.768x1.26	
1.0	and	.276x.650x1.08	.413x.807x1.26	
1.5	± 20%	.315x.787x1.24	.374x.846x1.65	
2.2		.374x.787x1.24		
3.3		.472x.954x1.24		

Self Inductance: 20 nH (for 3 mm lead length at both ends)

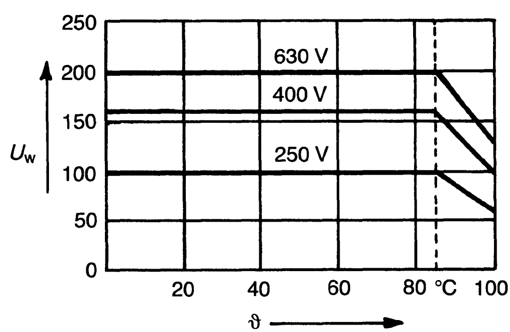
Impedance *Z*:
as a function of frequency f
(typical values)



Category Voltage U_c:
at dc operation versus rated temperature. The 1.25 U_c is permissible until a total of 2,000 hours at 85°C.



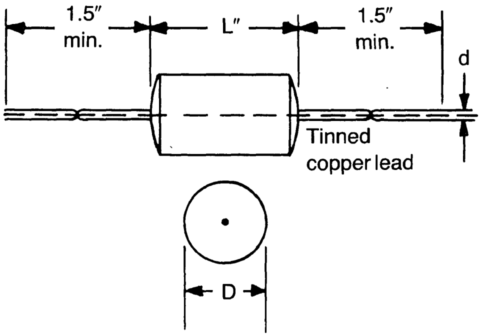
Category Voltage U_w:*
at dc operation versus rated temperature.



Peaks of 1.5 U_w during miliseconds are allowed.

*When an oc voltage is superimposed on a dc voltage, the sum of the dc voltage and the amplitude of the oc voltage shall not exceed the rated voltage.

Metallized polyester dielectric.
Self-healing capacitor.
Polyester tape coating.
Epoxy resin closing face ends.
Axial tinned leads.



Ordering Code:

Example: I 5100 .22/10/250

Type Number
Capacitance (µF)
Tolerance (± %)
Voltage (V dc)

D	d
⩽ .512	.032
> .512	.039

Type 5100

Nom. Cap		Maximum Dimensions (Inches) D x L			
µF	Tol.	100V	250V	400V	630V
.01					.295x.591
.022				.315x.591	.315x.591
.033				.276x.591	.276x.787
.047			.276x.591	.315x.591	.315x.787
.068			.315x.591	.335x.591	.374x.787
.1		.236x.591	.295x.591	.295x.787	.433x.787
.15		.295x.591	.276x.787	.354x.787	.394x1.14
.22		.295x.787	.295x.787	.315x1.14	.453x1.14
.33	± 10%	.354x.591	.295x1.14	.374x1.14	.512x1.26
.47		.295x.787	.335x1.14	.453x1.14	.630x1.26
.68		.335x.787	.394x1.14	.492x1.26	.748x1.26
1.0		.433x.787	.433x1.26	.591x1.26	.906x1.26
1.5		.354x1.14	.492x1.26		
2.2		.433x1.14	.591x1.26		
3.3		.472x1.26			
4.7		.571x1.26			
6.8		.689x1.26			

Dissipation Factor:
tg δ d (measured at 20°C)

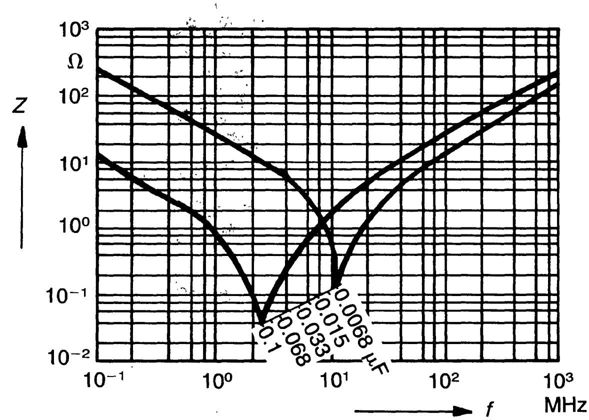
	C < 0,1 µF	C ≥ 0,1 µF	C > 1 µF
1 kHz	8 x 10-3	8 x 10-3	10 x 10-3
10 kHz	15 x 10-3	15 x 10-3	–
100 kHz	30 x 10-3	–	–

Operational Life: 100-000 hours
failure percentage ≤ 3%
(indicative value)

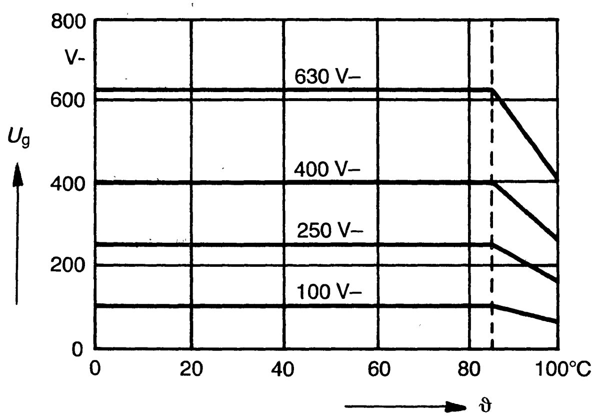
Failure Criteria: short or open-circuit
Capacitance change $\frac{\Delta C}{C}$
Insulation resistence
dissipation factor – tg δ
> 2x max. limit value

Self Inductance: 20 nH (for 3mm lead length at both ends)

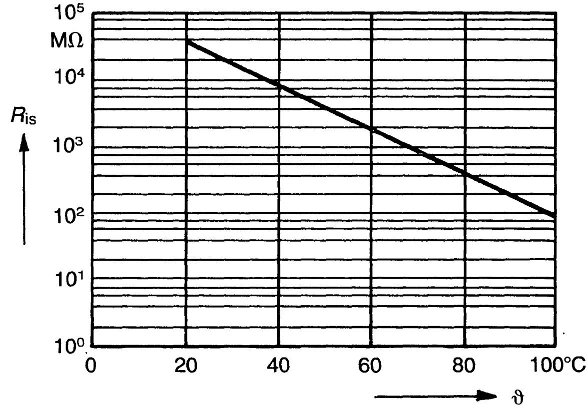
Impedance *Z*:
as a function of frequency f
(typical values)



Category Voltage U_g:
at dc operation versus ambient temperature. The 1.25 U_g is permissible until a total of 2,000 hours at 40°C. Peaks of 1.5 U_g for miliseconds are permissible.



Insulation Resistance:
versus temperature
(time constant τ)



Delivery value at 20°C	
Minimal Value*	for $U_n = 100$ Vdc
for C ≤ 0.33 µF	15.000 MΩ
for C > 0.33 µF	5.000s
Average Value	for U_n 250 Vdc
for C ≤ 0.33 µF	30.000 MΩ
for C > 0.33 µF	10.000s

*The values above indicated are valid until the delivery date. During the usage of the components, as the time goes by, the insulation can grow less to 10% of the rated value, especially when it is submitted to a maximum permissible humidity of 85% for a long time.

Pulse handling capability:

Maximum permissible voltage change per time unit with non-sinusoidal voltage load (pulse, sawtooth).

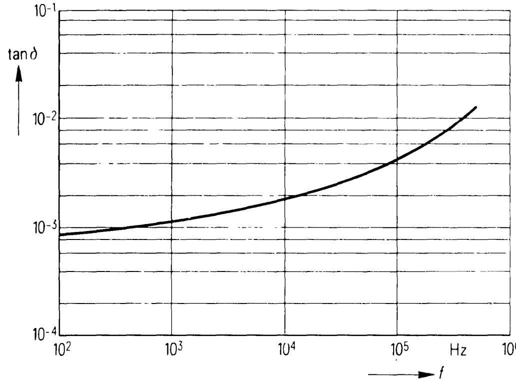
Rated Voltage	**Capacitor Length**			
Rate of Rise U_{pp} in V/µs	**17 mm**	**22 mm**	**31 mm**	**33 mm**
100 V	3	2	2	1.5
250 Vdc	10	6	5	3
400 Vdc	14	8	7	4.5
630 Vdc	20	12	10	6

Rated voltage U_R		250 Vdc	
Rated capacitance µF	Tolerance	LS 7.5 mm	LS 10 mm
		Dimensions $b \times h \times l$ (mm) Ordering code	
0.001	±10%≙K	2.6×7.3×9 B 32540-C 3102-K	
0.0015		2.6×7.3×9 B 32540-C 3152-K	
0.0022		2.5×7.3×9 B 32540-C 3222-K	
0.0033		2.3×7.3×9 B 32540-C 3332-K	
0.0047		2.3×7.3×9 B 32540-C 3472-K	
0.0068		2.7×7.3×9 B 32540-C 3682-K	
0.01	± 5%≙J ±10%≙K	2.3×7.3×9 B 32540-C 3103-*	3.2×6.6×11.5 B 32541-C 3103-*
0.015		2.9×7.3×9 B 32540-C 3153-*	3.2×6.6×11.5 B 32541-C 3153-*
0.022		2.6×7.3×9 B 32540-C 3223-*	3.2×6.6×11.5 B 32541-C 3223-*
0.033		2.6×7.3×9 B 32540-C 3333-*	3.7×6.6×11.5 B 32541-C 3333-*
0.047		3.2×7.3×9 B 32540-C 3473-*	3.2×6.6×11.5 B 32541-C 3473-*
0.068		3.5×9.1×9 B 32540-C 3683-*	3.2×6.6×11.5 B 32541-C 3683-*
0.1		3.9×11.5×9 B 32540-C 3104-*	3.5×8.3×11.5 B 32541-C 3104-*
0.15			4.2×9.6×11.5 B 32541-C 3154-*
0.22			4.9×11.5×11.5 B 32541-C 3224-*
0.33			6.7×11.5×11.5 B 32541-C 3334-*
0.47			9.1×11.5×11.5 B 32541-C 3474-*

* When ordering, the code letter for the requested tolerance must be substituted for *.

Dissipation factor tan δ
versus frequency *f*

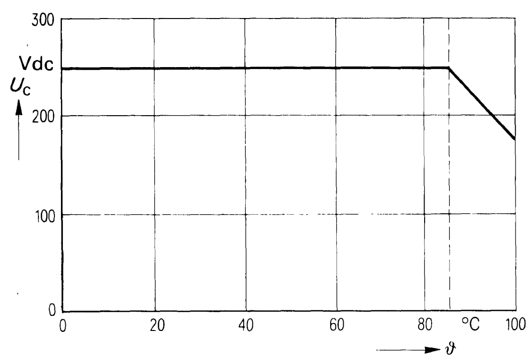
average values
measured at 23 °C (73.4 °F)
and $C \leqq 0.1$ µF



Maximum values

3×10^{-3}	at 1 kHz
10×10^{-3}	at 10 kHz

Category voltage U_C
at dc operation
versus ambient
temperature ϑ



max. 2,000 hours	$1.25 \times U_C$
for milliseconds (e. g. switchings)	$1.50 \times U_C$

Insulation[1)] (Insulation resistance or time constant)	for $C \leqq 0.33$ μF	for $C > 0.33$ μF
Minimum value at delivery	7 500 MΩ	2 500 sec
Average value at delivery	> 75 000 MΩ	> 25 000 sec

Pulse handling capability (voltage rate of rise U_{pp}/τ and pulse characteristic k_o). Maximum permissible voltage change per time unit at non-sinusoidal voltage load (pulse, sawtooth).

		B 32 540 (LS 7.5)	B 32 541 (LS 10)
Voltage rate of rise	U_{pp}/τ	200 V/μs	150 V/μs
Pulse characteristic	k_o	100 000 V²/μs	75 000 V²/μs

For a voltage swing $U_{pp} < U_R$ the value of the permissible voltage rate of rise U_{pp}/τ can be multiplied by the factor U_R/U_{pp}. For periodic pulse load the data of the nomogram is to be taken into account. See also calculation example in section "General Technical Information", para 5.2.6, page 24.

AC power handling capability at higher frequencies

The maximum permissible peak voltage $\hat{U}$ for sinusoidal and non-sinusoidal voltage load (pulse sawtooth, trapezoidal voltages) can be obtained from the nomogram.

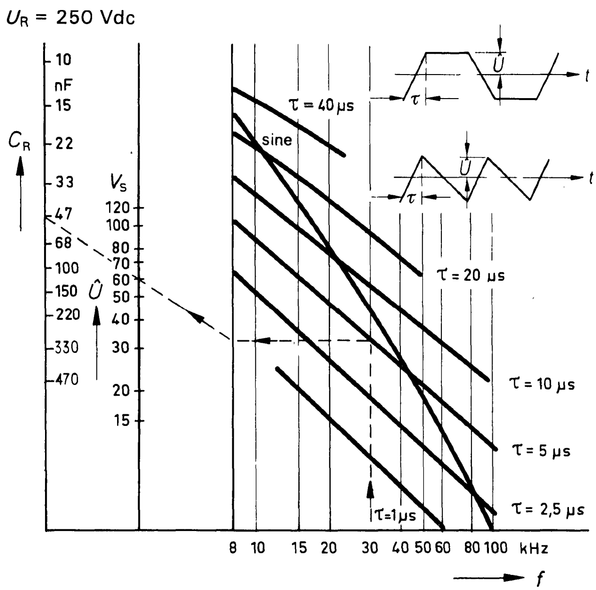
The limit voltage $\hat{U}_l$ = 140 V is not allowed to be exceeded.

1) The indicated values are applicable at the time of delivery. During operational life the insulation may decrease for a short period to about 10% of the values at the time of delivery, especially when the maximum permissible humidity of 95% is applied for a long period, or when the capacitor is operated close to the upper category temperature.

B 32 541, lead spacing = 10 mm

Nomogram for determining the permissible peak voltage $\hat{U}$

The nomogram is based on 10 °C (18 °F) inherent temperature rise of the capacitor; this must be taken into account when considering the permissible max. temperature.
With trapezoidal voltage load the second harmonic frequency must be assumed.



Example given:

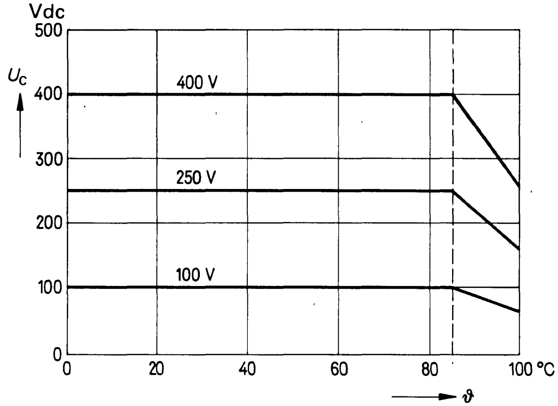
f = 30 kHz (repetition frequency)
τ = 5 µs (rise time)
C_R = 47 nF (capacitance)

According to the dashed line on the graph above this gives a peak voltage $\hat{U}$ of about 60 V.

DIN climatic category (DIN 40 040)	**F M E / L R**
Lower category temperature Upper category temperature Humidity category Failure quota Load duration Relative failure rate	**F** − 55 °C/− 67 °F **M** +100 °C/+212 °F **E** average relative humidity ≦ 75%; 95% for 30 days per year; 85% for the remaining days, occasionally rare, short dew precipitation permitted **L** 300 failures per 10^9 component hours **R** 10^5 h $300 \times 10^{-9} \times 10^5 = 3\%$
Failure criteria Total failure Failure due to variation	 Short or open circuit Capacitance change $\frac{\Delta C}{C}$ $> \pm 10\%$ Dissipation factor tan δ $> 2 \times$ max. limit value Insulation resistance < 150 MΩ
IEC climatic category (DIN 40 045, or IEC publication 68-1) Damp heat test in accordance with DIN IEC 68-2-3	**55/100/21** **Conditions** Test temperature + 40 °C/+ 104 °F Relative humidity $(93 {}^{+2}_{-3})\%$ Test duration 21 days **Test criteria** Capacitance change $\frac{\Delta C}{C}$ $\leqq \pm 5\%$ Dissipation factor change Δ tan δ $\leqq 3 \times 10^{-3}$ at 1 kHz $\leqq 5 \times 10^{-3}$ (at 10 kHz) Insulation resistance ≧ 50% of the minimum value at delivery
Resistance to vibration Test F_c: Vibration partial test B 1 in accordance with DIN 40 046, sheet 8 and IEC publication 68-2-6	Duration of endurance conditioning 6 hours Frequency range 10 to 55 Hz Displacement amplitude 0.75 mm (conforming to max. 10 *g*)
Resistance to soldering heat[1)] Test Tb in accordance with DIN IEC 68-2-20	Temperature of the solder bath max. 260 °C/500 °F Soldering duration max. 5 sec Capacitance change $\frac{\Delta C}{C}$ $\leqq \pm 2\%$
Capacitance drift i_Z (typical value)	± 3%

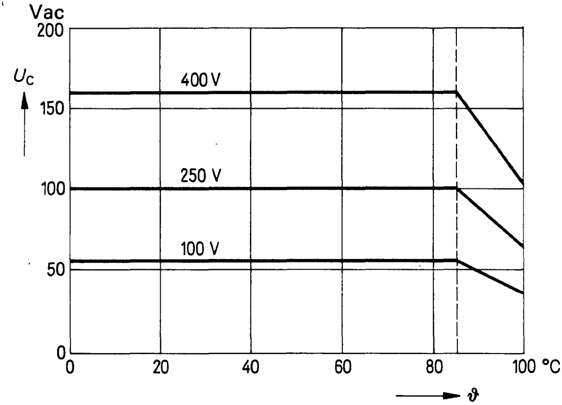
[1)] For solder recommendations also refer to "General Technical Information", para. 6.2., page 27.

Category voltage U_C
at dc operation
versus ambient
temperature ϑ



max. 2,000 hours	$1.25 \times U_C$
for milliseconds (e. g. switchings)	$1.50 \times U_C$

Category voltage U_C[1]
at ac operation
versus ambient
temperature ϑ



for milliseconds (e. g. switchings)	$1.50 \times U_C$

[1] When an ac voltage is superimposed on a dc voltage, the sum of the dc voltage and the amplitude of the ac voltage may not exceed the rated voltage.

Pulse handling capability (voltage rate of rise U_{pp}/τ and pulse characteristic k_O).

Maximum permissible voltage change per time unit at non-sinusoidal voltage load (pulse, sawtooth).

Rated voltage U_R		Pulse handling capability
100 Vdc	U_{pp}/τ k_O	50 V/µs 10000 V²/µs
250 Vdc	U_{pp}/τ k_O	100 V/µs 50000 V²/µs
400 Vdc	U_{pp}/τ k_O	90 V/µs 75000 V²/µs

For a voltage swing $U_{pp} < U_R$ the value of the permissible voltage rate of rise U_{pp}/τ can be multiplied by the factor U_R/U_{pp}. For periodic pulse load the data of the nomogram is to be taken into account. See also calculation example in section "General Technical Information", para 5.2.6, page 24.

AC power handling capability at higher frequencies

The maximum permissible peak voltage $\hat{U}$ for sinusoidal and non-sinusoidal voltages (pulse, sawtooth, trapezoidal voltages) can be obtained from the nomogram. The following limit values $\hat{U}_l$ are not allowed to be exceeded:

Rated voltage U_R	100 V	250 V	400 V
Limit voltage $\hat{U}_l$	85 V	140 V	220 V

Rated voltage U_R DC voltage V_{dc}		400 V dc 500 V_{pp}[1]	1000 V dc 700 V_{pp}	1200 V dc 1200 V_{pp}	1500 V dc 1500 V_{pp}
Rated capacitance C_R[2]	Tolerance	Dimensions $b \times h \times l$ Ordering code			
0.0022 µF	± 5% ≙ J ±10% ≙ K	–	–	–	7,3×16,5×27 B32650–K1222–*
0.0033 µF		–	–	–	7,3×16,5×27 B32650–K1332–*
0.0047 µF		–	–	–	7,3×16,5×27 B32650–K1472–*
0.0068 µF		–	–	–	8,5×18,5×27 B32650–K1682–*
0.01 µF		–	–	–	10,5×19×27 B32650–K1103–*
0.015 µF		–	–	–	11×20,5×27 B32650–K1153–*
0.022 µF		–	7×13×18 B32650–K0223–*	7,3×16,5×27 B32650–K2223–*	11,5×21×31,5 B32650–K1223–*
0.033 µF		–	9×14,5×18 B32650–K0333–*	8,5×18,5×27 B32650–K2333–*	13,5×23×31,5 B32650–K1333–*
0.047 µF		–	7,3×16,5×27 B32650–K0473–*	10,5×19×27 B32650–K2473–*	–
0.068 µF		–	8,5×18,5×27 B32650–K0683–*	11,5×21×31,5 B32650–K2683–*	–
0.1 µF		5,5×11×18 B32650–K4104–*	10,5×19×27 B32650–K0104–*	13,5×23×31,5 B32650–K2104–*	–
0.15 µF		7×13×18 B32650–K4154–*	11×20,5×27 B32650–K0154–*	15×24,5×31,5 B32650–K2154–*	–
0.22 µF		9×14,5×18 B32650K4224–*	13,5×23×31,5 B32650–K0224–*	–	–
0.33 µF		7,3×16,5×27 B32650–K4334–*	15×24,5×31,5 B32650–K0334–*	–	–
0.47 µF		8,5×18,5×27 B32650–K4474–*	–	–	–
0.68 µF		10,5×19×27 B32650–K4684–*	–	–	–
1.0 µF		11,5×21×31,5 B32650–K4105–*	–	–	–
1.5 µF		13,5×23×31,5 B32650–K4155–*	–	–	–
2.2 µF		15×24,5×31,5 B32650–K4225–*	–	–	–

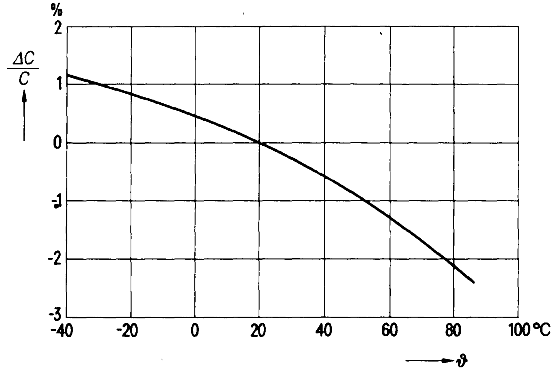
* When ordering, the code letter for the requested tolerance must be substituted for *.
[1] With unipolar pulse load U_{ac} = 400 V_{pp}
[2] Intermediate values upon request

Voltage load

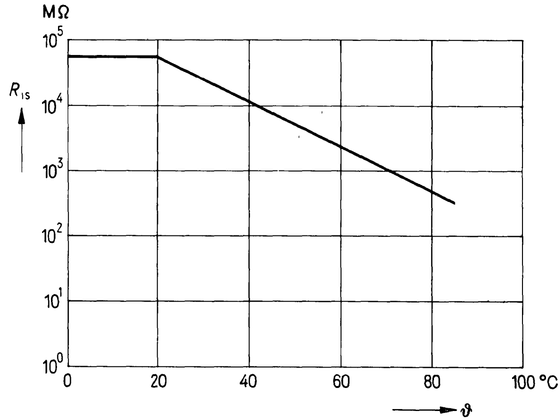
Test voltage U_t	$1.5 \times U_R$
Category voltage U_c	$1.0 \times U_R$

Reversible capacitance change $\frac{\Delta C}{C}$

versus temperature ϑ
at 1 kHz (typical values)



Insulation resistance R_{is}
versus temperature ϑ



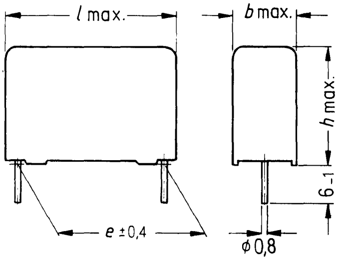
Minimum value[1)]	
for $C \leqq 0.33$ µF	30 000 MΩ
for $C > 0.33$ µF	10 000 s
Average value	
for $C \leqq 0.33$ µF	> 75 000 MΩ
for $C > 0.33$ µF	> 25 000 s

1) The indicated values are applicable at the time of delivery. During operational life the insulation may decrease for a short period to about 10% of the values at the time of delivery, especially when the max. permissible humidity of 95% is applied for a long period, or when the capacitor is operated close to the upper category temperature.

Metallized polypropylene capacitors – standard version

Self-healing wound capacitor with face-end contacts, comprising a polypropylene dielectric. Built into flame-retardant, rectangular plastic case, epoxy resin sealed to ensure resistance to humidity. The capacitor is provided with spacers to improve solderability in the solder bath. Parallel leads; plug-in.

The capacitors are particularly suited for use at mains ac voltage load and in pulse circuits.



Dimensions in mm

l	*e*
18	15
27	22.5
31.5	27.5

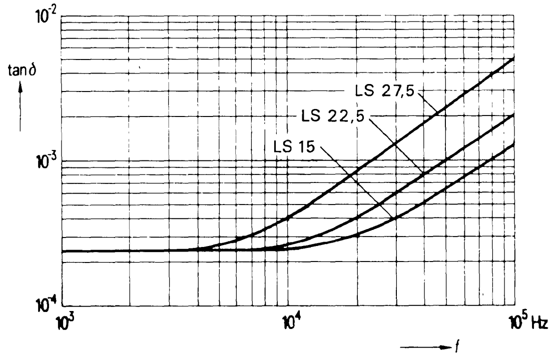
Rated ac voltage U_R up to 1 kHz Perm. dc voltage U		250 Vac 630 Vdc	
Rated capacitance C_R	Tolerance	Dimensions $b \times h \times l$	Ordering code
0.047 µF	± 5% ≙ J[1)] ± 10% ≙ K ± 20% ≙ M	5.5 × 11 × 18	B32655-K6473-*
0.068 µF		7 × 13 × 18	B32655-K6683-*
0.1 µF		9 × 14.5 × 18	B32655-K6104-*
0.15 µF		9 × 14.5 × 18	B32655-K6154-*
0.22 µF		8.5 × 18.5 × 27	B32655-K6224-*
0.33 µF		10.5 × 19 × 27	B32655-K6334-*
0.47 µF		11 × 20.5 × 27	B32655-K6474-*
0.68 µF		11.5 × 21 × 31.5	B32655-K6684-*
1.0 µF		13.5 × 23 × 31.5	B32655-K6105-*

* When ordering, the code letter for the requested tolerance must be substituted for *

1) Upon request

Dissipation factor tan δ
versus frequency *f*
(average values)

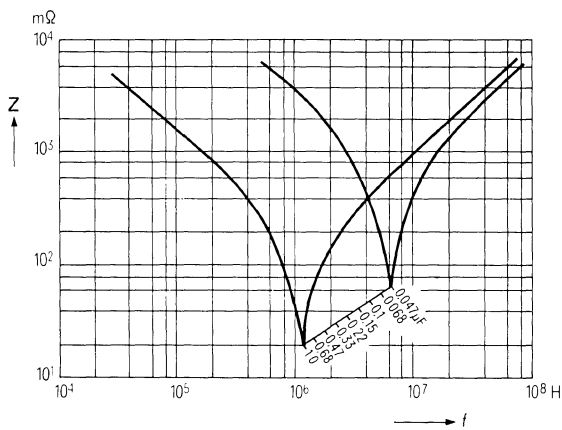
Parameter: Lead spacing



Dissipation factor tan δ measured at 20 °C (68 °F)	Maximum value	Average value
for 1 kHz	0.5×10^{-3}	0.25×10^{-3}
for 10 kHz	1×10^{-3}	0.4×10^{-3}

Self inductance approx. 20 nH

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



Voltage load

Test voltage	U_t	1200 Vdc, 2 s (layer to layer)
Perm. switching peaks	U_p	≦ 1000 V (occasionally)
Category voltage	U_c	250 Vac, 630 Vdc

Pulse handling capability (voltage rate of rise U_{pp}/τ and pulse characteristic k_o)
Maximum permissible voltage change per time unit with non-sinusoidal voltage load (pulse, sawtooth).

Rated voltage U_R	$U_{pp\ perm.}$		Pulse handling capability		
			Capacitor length		
			18 mm	27 mm	31.5 mm
250 Vac	700 V_{pp}	U_{pp}/τ k_o	70 V/µs 1×10^5 $V^2/\mu s$	43 V/µs 0.6×10^5 $V^2/\mu s$	36 V/µs 0.5×10^5 $V^2/\mu s$

For a voltage swing $U_{pp} < U_{pp\ perm}$ the value of the permissible voltage rate of rise U_{pp}/τ can be multiplied by the factor $U_{pp\ perm}/U_{pp}$. See also calculation example in section "General Technical Information", para 5.2.6, page 24.

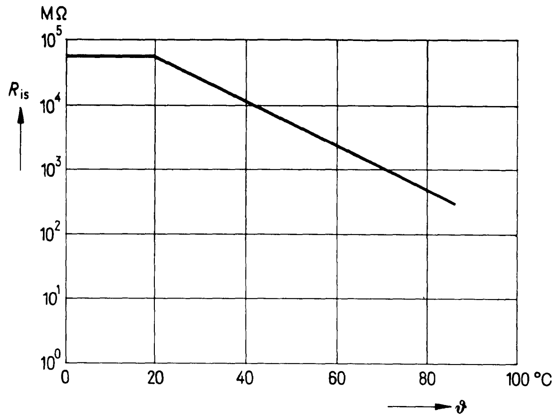
AC power handling capability at higher frequencies

Values upon request; a voltage/time diagram as well as indication of ambient temperature and other operational conditions are requested. Refer also to para. 5.2.5 "Inherent temperature rise, permissible efficiency", page 23.

DIN climatic category (DIN 40 040)	**F P D / L S**
Lower category temperature	**F** −55 °C/− 67 °F
Upper category temperature	**P** +85 °C/+185 °F
Humidity category	**D** average relative humidity ≦ 80%; 100% for 30 days per year, continuously 90% for the remaining days, occasionally
Failure quota	**L** 300 failures per 10^9 component hours
Load duration	**S** 3×10^4 h
Relative failure rate	$300 \times 10^{-9} \times 3 \times 10^4 = 0.9\%$
Reference load	23 °C, ≦ 75% rel. humidity 400 V_{rms}, 10 kHz/for higher load, data upon request
Failure criteria	
Total failure	Short or open circuit
Failure due to variations	Capacitance change $\frac{\Delta C}{C} > \pm 10\%$ Dissipation factor tan δ > 4 × max. values Insulation resistance ≦ 1500 MΩ
IEC climatic category (DIN 40 045, or IEC publication 68-1)	**55/085/56**
Damp heat test in accordance with DIN IEC 68-2-3	**Conditions** Test temperature + 40 °C/104 °F Relative humidity $(93 {}^{+2}_{-3})\%$ Test duration 56 days **Test criteria** Capacitance change $\frac{\Delta C}{C} \leqq \pm 1\%$ Dissipation factor change Δ tan δ ≦ 3×10^{-3} (at 1 kHz) ≦ 5×10^{-3} (at 10 kHz) Insulation resistance ≧ 50% of the minimum value at delivery
Resistance to vibration Test F_c: Vibration partial test B 1 in accordance with DIN 40 046, sheet 8 and IEC publication 68-2-6	Duration of endurance conditioning 6 hours Frequency range 10 to 55 Hz Displacement amplitude 0.75 mm (conforming to max. 98.1 m/s² or 10 *g*)
Resistance to soldering heat[1)] Test Tb in accordance with DIN IEC 68-2-20	Temperature of the solder bath max. 260 °C/500 °F Soldering duration max. 10 sec Capacitance change $\frac{\Delta C}{C} \leqq \pm 2\%$

1) For solder recommendations also refer to "General Technical Information", para. 6.2., page 27.

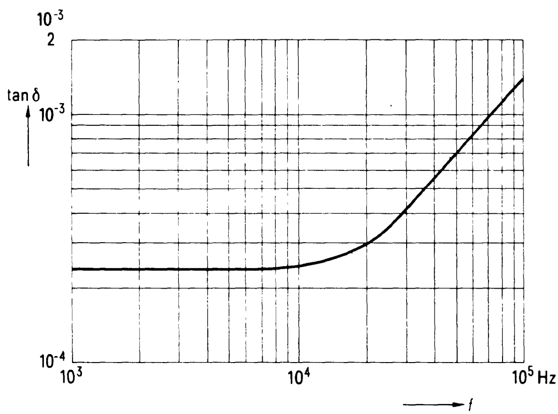
Insulation resistance R_{is}
versus temperature ϑ



Minimum value[1]	30 000 MΩ
Average value	> 75 000 MΩ

Dissipation factor tan δ measured at 20 °C/68 °F	Max. limit values
at 1 kHz	0.5×10^{-3}
at 10 kHz	0.5×10^{-3}
at 100 kHz	2.0×10^{-3} (LS 22.5) or 3.0×10^{-3} (LS 27.5)

Dissipation factor tan δ
versus frequency *f*
(typical values)



[1] The values stated apply at the time of delivery. During operational life the insulation may decrease for a short period to about 10% of the values at the time of delivery, especially when the max. permissible humidity of 100% is applied for a long period, or when the capacitor is operated close to the upper category temperature.

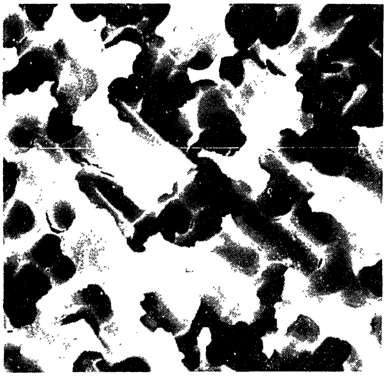


Fig. 1
Etched aluminum foil in an electron micrograph.
Enlargement: 2500 times.

As the oxide layer is forming a voltage dependent resistance, the current rises more than proportional to the applied voltage, as can be seen from fig. 2.

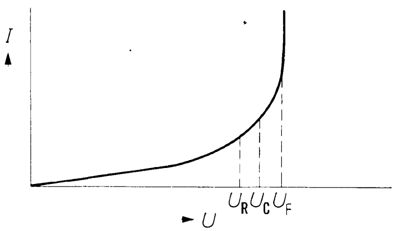


Fig. 2
Current dependence on the voltage of aluminum electrolytic capacitors.

After the forming voltage U_F has been reached, a subsequent forming starts in connection with high generation of gas and heat, a small quantity of which already appears during the strongly curved part of the characteristic. In order to avoid damage of the capacitor, the rated voltage should be applied where the characteristic has its less curved part. The difference between the forming voltage and the operating voltage, the so-called over-anodization, thus determines substantially the operational reliability of the capacitors. Hence, the possibility is given by high over-anodization to build capacitors that are particularly reliable in operation, as required for high reliability purposes (DIN 41 240, type I).
As already mentioned, only the winding method is presently in use for aluminum electrolytic capacitors. The winding contains, in addition to the already described anode, a second aluminum foil, at least equal in size, but not anodized. It serves as a large area current supply for the electrolyte and is normally called "cathode" in spite of the fact that with respect to its function the proper cathode is represented by the electrolyte.
Both foils are separated from each other by paper layers. The paper has to meet different requirements. It serves as carrying agent for the electrolyte – the electrolyte is stored in the pores of the absorbent paper – and as space keeping agent in order to avoid short circuits and to achieve the necessary voltage strength between anode and "cathode".

3. Electrolytic Capacitors – high reliability versions (type I) and standard versions (type II)

High reliability electrolytic capacitors (abbr. DIN designation: type I) feature a high reference reliability (see para. 17). In addition to the possible, far-reaching over-anodization, also other measures are used in order to improve the reliability. The materials used for the construction of aluminum electrolytic capacitors must generally satisfy high requirements as to their purity; for type I capacitors a particularly careful selection is necessary. These efforts influence the case size as well as the price. In IEC publications aluminum electrolytic capacitors for high reliability requirements are identified as "long life grade" (abbr. "LL", formerly "type 1"). Such efforts are not required for capacitors intended for use in the entertainment field, since less reliability is sufficient. The main requirements to be met are here a small size. During the last years a steady size reduction could be achieved, mainly resulting from an increased etching effect. This cannot be permanently continued since reduced foil areas cause the losses to increase. Up to now this disadvantage could be compensated to a large extent by using highly conductive electrolytes. The standard versions of aluminum electrolytic capacitors are designated as type II.
Standard type aluminum electrolytic capacitors are identified in IEC publications as "general purpose grade" (abbr. "GP", formerly "type 2").

4. Specifications

The international specifications for aluminum electrolytic capacitors are given in IEC publication 384-4, which is also available in German as DIN-IEC 384, part 4 (at present only draft). In the future, German specifications will be adapted to these IEC specifications. At the moment, differing principal specifications exist for high reliability and standard electrolytic capacitors which – apart from definitions – mainly contain properties such as temperature range, referred reliability, dissipation factor ratings, impedance, equivalent series resistance, operating and output leakage current, current handling capability etc. Fundamental specifications are:

a) DIN 41 332, sheet 1
Polarized aluminum electrolytic capacitors up to 450 V
Type II (standard versions) with etched anodes
Technical data and test specifications, type IIA

b) DIN 41 332, sheet 10
Polarized aluminum electrolytic capacitors 6.3 to 100 V
Type II (standard versions) with etched anodes
Technical data and test specifications
Supplement for type IIB to DIN 41 332, sheet 1

c) DIN 41 240
Polarized aluminum electrolytic capacitors 6.3 to 450 V
(High reliability versions), technical data and test specifications
Typ IA and IB, etched anode

d) DIN 41 230
Polarized aluminum electrolytic capacitors up to 100 V
Typ IA and IB (high reliability versions), plain anode
Technical data

In addition to the principal DIN specifications there are some type specifications, applying only to a specific type (e.g. axial leaded electrolytic capacitors). The values contained on the type specifications are frequently better than those of the principal standards. The type spec-

5.4 Peak voltage U_p

The peak voltage U_p is the maximum voltage (peak value) which may be applied to the capacitor for short periods only, e.g. up to 5 times for 1 minute during 1 hour, but is not allowed to be exceeded during this period. The peak voltage may not be applied for operational periodic charging and discharging purposes.

The peak voltage U_p is according to DIN specifications
for U_R up to and including 100 V: 1.15 × U_R
for U_R exceeding 100 V: 1.1 × U_R

Siemens aluminum electrolytic capacitors can partly be loaded with considerably higher peak voltage. In this case, details may be found in the data sheets. The reduced operating voltage U_{op} instead of U_R has to be applied to such capacitors for which a derating at ambient temperatures > 85° C/185° F is requested.

5.5 Superimposed alternating voltage

This is the rms value of the alternating voltage which may be applied to the capacitor in addition to the direct voltage. The peak value of the resulting waveform voltage should not exceed the rated voltage. No voltage of reversed polarity with a peak value higher than 2 V may occur (exception: non-polarized electrolytic capacitors).

5.6 Superimposed alternating current

The superimposed alternating current is the rms value of the alternating current, which may be applied to the capacitor. It is so much higher the larger the capacitor surface (cooling surface) and the lower the dissipation factor tan δ (or the smaller the equivalent series resistance ESR respectively) are. This can result in the necessity to choose a capacitor of a higher voltage series than required for its voltage loading. Moreover, the superimposed alternating current depends on the ambient temperature and up to a certain degree on the frequency of the ac current.
The typical values of the permissible superimposed alternating currents as tabulated in para. 5.6.1 and 5.6.2 apply at a frequency of 100 Hz and the ambient temperature of 85° C/ 185° F. More exact values can be taken in most cases from the individual data sheets.

5.6.2 Permissible superimposed, alternating current for standard aluminum electrolytic capacitors
(typical values for the rms in mA at $\vartheta_{amb} \leqq 85°$ C/185° F and $f = 100$ Hz)

Rated capacitance in µF	Rated voltage in Vdc 6.3	10	16	25	40	63	100	160	250	350	450
0.47						5.2	5.6	6.0	6.4	6.7	7.0
1					7.6	8.4	9.3	10	11	12	13
2.2				11	12	14	16	17	18	19	21
4.7			14	16	19	22	26	28	32	35	38
10	17	20	23	27	31	36	42	48	56	62	68
22	30	35	41	47	55	63	74	85	100	110	120
47	50	58	68	80	95	110	130	150	180	200	220
100	83	100	120	140	160	190	230	270	310	350	390
220	150	170	200	240	280	340	400	480	570	630	700
470	240	290	340	410	490	580	700	840	1000	1100	1200
1 000	400	480	580	700	830	1000	1300	1500	1700	2000	2200
1 500	530	640	770	930	1100	1400	1700	2000	2400	2700	3000
2 200	680	820	1000	1200	1500	1800	2200	2600	3200	3600	4000
3 300	920	1100	1400	1700	2000	2400	2900	3600	4300	4900	5400
4 700	1200	1400	1800	2300	2600	3200	3900	4700	5700		
6 800	1500	1800	2200	2800	3300	4100	4900	6100			
10 000	1900	2300	2700	3200	3800	4600	5500				
15 000	2200	2700	3200	3800	4600	5500	6500				
22 000	2700	3100	3800	4500	5300	6300					
33 000	3200	3800	4500	5300	6400	7600					
47 000	3800	4400	5200	6100	7200						
68 000	4400	5100	6100	7100	8300						
100 000	5200	6100	7200	8200							
150 000	6300	7500	8500								
220 000	7500	9000									

5.6.5 Load with not clearly defined currents or frequencies

When currents or frequencies are applied that cannot be clearly defined, the surface temperature is not allowed to exceed the value given in para. 5.6.4 at any point of the capacitor casing.

5.7 Capacitance

5.7.1 Rated capacitance C_R

The rated capacitance of an electrolytic capacitor is the value which is indicated upon the capacitor. The actual capacitance value may deviate from this value within the tolerance limits indicated on the individual data sheets.

5.7.2 Ac and dc capacitance

The effective capacitance of a capacitor depends on the kind of circuit in which it is operated. The rated capacitance is therefore determined either with ac (ac cap.) for the types IA and IIA or with dc (dc cap.) for the types IB and IIB.
One can differentiate accordingly between:
ac capacitance – important for smoothing and coupling capacitors as well as for AF and RF bridging.
dc capacitance – decisive in capacitors for discharge circuits, e.g. maintaining of time specifications.
The ac capacitance (series capacitance C_r) is the capacitive part of the equivalent circuit. It is determined by measuring with an ac voltage $\leqq$ 0.5 V and depends on the frequency. Therefore, a certain measuring frequency must be agreed upon. In accordance with DIN it is 50 Hz. In other specifications, as IEC, 100 Hz or 120 Hz are required. Because of the temperature dependence a reference temperature has been determined, in accordance with DIN it is 20° C (68° F).
The dc capacitance is the capacitance that has been found out by a single discharge of a capacitor, loaded up to its rated voltage under defined time conditions. Because of the complicated description of the measuring methods, DIN 41 328, sheet 4 (measurement of dc capacitance) should be referred to. It should be mentioned for orientation, that the measurement of the dc capacitance results in a higher capacitance value than the ac capacitance measurement. The factors are about 1.1 to 1.5, where the largest deviations occur with capacitors for low rated voltages.

5.7.5 Capacitance drift

There are different phenomena that can cause a capacitance drift. This is designated as the change with time within the service life, referred to a temperature of +40° C (104° F). The drift is greater at lower than at higher voltages. It is therefore advisable to use capacitors of a higher rated voltage series in critical cases. The drift rises with increasing operating temperature as well as with a continuous, full utilization of the allowed ac load. The permissible drift values for high reliability capacitors in accordance with DIN 41 240 are as follows:

	High reliability versions (type IA)			
Rated voltage V	6.3	10 to 25	40 to 100	> 100
Max.	$^{+15}_{-30}$ %	$^{+10}_{-20}$ %	$^{+10}_{-15}$ %	±10%
Typical values	$^{+8}_{-15}$ %	$^{+5}_{-12}$ %	$^{+5}_{-10}$ %	± 5%

There are no values available in DIN 41 332 for standard version electrolytic capacitors; however, the maximum values tabulated above can be assumed as typical values for standard version capacitors.

5.7.6 Dielectric strength

A capacitance decrease can also result from frequent discharges of the capacitors. Due to a special structure, Siemens aluminum electrolytic capacitors have a high dielectric strength. After 10^6 switchings their capacitance decrease is less than 10%. Generally a switching stress as indicated in DIN 41 240 for long life grade (high reliability) capacitors can be assumed.

5.8 Dissipation factor tan δ

The dissipation factor tan δ is the ratio of the equivalent series resistance to the capacitive reactive part in the equivalent circuit or of efficiency to reactive power at sinusoidal waveform voltages. It is measured at the same arrangement as the series capacitance C_r. For the temperature of 20° C (68° F) the principal standards quote the following maximum dissipation factors:

Rated voltage V		6.3	10	16	25	40	63	100	160	250	350	450
High reliability versions (DIN 41 240)	50 Hz	0.30	0.18	0.15	0.14	0.12	0,10	0,10	0,09	0,08	0,08	0,10
	100 Hz	0.45	0.27	0.22	0.21	0.18	0.15	0.15	0.13	0.12	0.12	0.15
Standard versions (DIN 41 332)	50 Hz	0.25	0.20	0.17	0.15	0.13	0.11	0.10	0.11	0.12	0.13	0.15
	100 Hz	0.37	0.30	0.25	0.22	0.20	0.16	0.15	0.16	0.18	0.20	0.22

Above mentioned values apply to capacitances ≦ 1000 μF. They increase by 0.01 at 50 Hz and by 0.02 at 100 Hz per 1000 μF.

5.9 Equivalent series resistance ESR

This is the resistance part of the equivalent circuit. Like the dissipation factor also the ESR value depends on temperature and frequency. It is related to the dissipation factor tan δ by the formula

$$\text{ESR} = \frac{\tan\delta}{\omega \times C_r}$$

The following table contains the values of the principal specifications in $\Omega \times \mu F$ for the equivalent series resistance reffered to 1 µF at 20° C/68° F.

Rated voltage V		6.3	10	16	25	40	63	100	160	250	350	450
High reliability versions (DIN 41 240)	50 Hz 100 Hz	955 715	570 430	480 350	450 335	380 290	320 240	320 240	285 210	255 190	255 190	320 240
Standard versions (DIN 41 332)	50 Hz 100 Hz	800 590	640 480	540 400	480 350	410 320	350 250	320 240	350 250	380 290	410 320	480 350

Above values apply to capacitances ≦ 1000 µF. They increase by 32 $\Omega \times \mu F$ for each 1000 µF. The equivalent series resistance of an aluminum electrolytic capacitor results from dividing the table value by C_R.
The ESR value obtainable in practice is limited by the resistance part of the joints and the foils, hence the calculated values lower than 0.1 Ω cannot be realized in any case.
The values tabulated above only apply unless those given for the individual types are better.

5.10 Impedance *Z*

The impedance of an electrolytic capacitor is principally determined from the series-connection of the following individual resistances:

1. Effective reactance $1/\omega C$ of the capacitance *C*.
2. Ohmic resistance of the electrolytes and the supply lines.
3. Effective reactance ωL of the inductance of the winding and the supply lines.

The effective reactances, $1/\omega C$ and ωL are actually only dependent on the frequency, whereas the electrolytic resistance is mostly dependent on the temperature, and increases strongly with decreasing temperature.
These characteristics of the individual resistances determine the development of the total resistances of an electrolytic capacitor in dependence on frequency and temperature. The graphs in diagrams 6 and 7 serve as examples. It is evident that the capacitive resistance is preponderant at low frequencies, and decreases with ($X_C = 1/\omega C$) as the frequency increases, until it reaches the order of magnitude of the electrolytic resistance. The relatively constant electrolytic resistance is the deciding factor at further increasing frequencies and changing temperatures (see the 20° C/68° F graph). At still higher frequencies, a resonance minimum is formed, especially at low capacitance values and low temperatures. The inductive resistance of the winding and the supply line then becomes operational and results in an increase of the impedance ($X_L = \omega L$). The electrolytic resistance, increasing with falling temperature, attains higher values by shifting the impedance graph at low temperatures. The lower the temperature, the more this influence is able to act upon lower frequencies.

The values in $\Omega \times \mu F$ tabulated below are in accordance with the principal specification and apply to the impedance, referred to 1 μF at different temperatures:

	Frequency	Climatic category	Temp.	Rated voltage Vdc 6.3	10	16	25	40	63	100	160	250	350	450
High reliability versions (DIN 41 240)	1 kHz	all	+20°C	700	500	350	300	250	200	180	180	190	200	300
		H**	−25°C	15000	10000	6000	4500	3500	2500	2000	2000	2500	5000	10000
		G**	−40°C	30000	20000	12000	9000	7000	5000	4000	4000	–	–	–
		F**	−55°C	30000	20000	12000	9000	7000	5000	4000	4000	5000	10000	–
	10 kHz	all	+20°C	450	300	180	150	120	90	70	60	70	70	100
		H**	−25°C	15000	9000	5000	4000	3100	2100	1600	1600	1700	2600	6000
		G**	−40°C	30000	20000	10000	8000	6000	4000	3000	3000	–	–	–
		F**	−55°C	30000	20000	10000	8000	6000	4000	3000	3000	3400	5200	–
Standard versions (DIN 41 332)	1 kHz	all	+20°C	480	340	300	230	200	175	170	180	190	210	380
		H**	−25°C	4000	2500	1900	1400	1100	900	820	3000	3400	3800	11000
		G**	−40°C	Data only for climatic category G** as provided in the type specifications										
	10 kHz	all	+20°C	240	180	150	120	100	80	70	100	150	170	270
		H**	−25°C	3300	2000	1500	1130	920	730	620	2400	3100	3500	12000
		G**	−40°C	Data only for climatic category G** as provided in the type specifications										

Capacitors should preferably be measured at 10 kHz and capacitors > 1000 μF partly at 1 kHz. The impedance value of an aluminum electrolytic capacitor in Ω can be determined by dividing the table value by C_R. The impedance value obtainable in practice is limited by the resistance part of its contacts and foil resistances; therefore, calculated values below 0.1 cannot be realized in any case.
Siemens electrolytic capacitors often feature better impedance values than given above. These are contained on the individual data sheets.

5.11 Leakage current

Due to the special features of the aluminum oxide layer serving as dielectric, a small current, the so-called leakage current, flows even after applying dc for a longer period.
A low leakage current value is the criterion of a well designed dielectric. The leakage current can thus be considered as a measure for the quality of the capacitor. (Here it should be noted that due to physical reasons about twice the leakage current values occur in non-polarized capacitors.)

5.11.1 Leakage current dependence on time

After having applied a voltage, the leakage current is high at first (starting current), particularly after previous, long voltage-free storage, then it decreases rapidly with increasing working time and attains at last an approximately constant final value (see fig. 8).

The data thus determined apply to U_R and a temperature of 20° C (68° F).
For the operational leakage current dependence on temperature the values, measured at 20° C/68° F must be multiplied by the following factors.

Temperature °C/°F	0/32	20/68	50/122	60/140	70/158	85/185	125/257
Factor (typical values)	0.5	1	4	5	6	10	12.5*)

*) At voltage derating (see individual types)

Operation below the rated voltage results in a substantially lower operational leakage current.

Operating voltage in % of the rated voltage	20	30	40	50	60	70	80	90	100
Typical values in % of the operational leakage current I_{rb}	8	9	10	12	15	20	30	50	100

5.11.5 Output leakage current

Because of the dependence on time and temperature it is necessary to determine reference values for time and temperature when testing the leakage current. In accordance with DIN, the leakage current shall be measured after 5 min with rated voltage. The reference temperature is 20° C/68° F. The maximum values for the output leakage current in µA are determined by the following formulae, where differences are made between various loads of the capacitor.

In accordance with DIN 41240 (high reliability version):

For $C_R \cdot U_R \leqq 1000$ Microcoulomb:

$$I_{ra} = \frac{0.01\ \mu A}{\mu F \cdot V} \cdot C_R \cdot U_R \text{ or } 1\ \mu A \text{ (whichever is the greater)}$$

For $C_R \cdot U_R > 1000$ Microcoulomb:

$$I_{ra} = \frac{0.006\ \mu A}{\mu F \cdot V} \cdot C_R \cdot U_R + 4\ \mu A$$

In accordance with DIN 41332 (standard version):

For $C_R \cdot U_R \leqq 1000$ Microcoulomb:

$$I_{ra} = \frac{0.05\ \mu A}{\mu F \cdot V} \cdot C_R \cdot U_R \text{ or } 5\ \mu A \text{ (whichever is the greater)}$$

For $C_R \cdot U_R > 1000$ Microcoulomb:

$$I_{ra} = \frac{0.03\ \mu A}{\mu F \cdot V} \cdot C_R \cdot U_R + 20\ \mu A$$

Siemens aluminum electrolytic capacitors show better results; generally the following formulae apply (exact values are quoted on the specific data sheet):

High reliability version:

$$I_R \leqq \frac{0.002\ \mu A}{\mu F \cdot V} \cdot C_R \cdot U_R + 4\ \mu A$$

Standard version:

$$I_R \leqq \frac{0.004\ \mu A}{\mu F \cdot V} \cdot C_R \cdot U_R + 20\ \mu A$$

(To non-polarized capacitors twice the values apply.)

6.1 Upper temperature limit

Maximum temperature limits have to be respected for all aluminum electrolytic capacitors, exceeding of these limits can lead to early failure of the capacitor. Therefore, upper temperature limits have been fixed in order to determine the highest allowable ambient temperature for the aluminum electrolytic capacitor at continuous operation. The upper temperature limits are quoted in the temperature range table on the specific data sheet. For many type series of aluminum electrolytic capacitors short exceedings of the temperature are permitted; data thereon can also be found on the data sheet.
As explained in para. 7, service life and reliability highly depend on the capacitor's temperature. Operating the aluminum electrolytic capacitor at the lowest possible temperature is, therefore, recommended, as service life and reliability are thus increased. For the same reason, it is advisable to install the aluminum electrolytic capacitor at positions of low ambient temperature.

6.2 Lower operating temperature limit

Due to the decreasing temperature the conductivity of the electrolyte diminishes which results in an increase of the aluminum electrolytic capacitor's real resistance, thus effecting increasing impedances and dissipation factors (equivalent series resistances, respectively). For most of the aluminum electrolytic capacitor applications these increases can be permitted only up to determined maximum values and it is, therefore, reasonable to determine a lower temperature limit. This is also quoted in the indicated temperature range of the different types.
It has to be emphasized that also the operation below the lower temperature limit does not damage the aluminum electrolytic capacitor. Such applications, where even then the equipment's operability is granted, happen continuously, especially if the capacitor is exposed to ac load. The ac current flowing due to increased equivalent series resistance can heat up the aluminum electrolytic capacitor to such an extent that its capacitive qualities still remain sufficient for the equipment's operability.

6.3 Upper storage temperature

The aluminum electrolytic capacitor may be stored even voltage-free at temperatures up to the upper temperature limit. However, it has to be observed that leakage current stability and service life and reliability, respectively, decrease with increasing temperatures (see para. 17 and 19). In order not to diminish these qualities unnecessarily, the storage temperature should therefore not exceed 40° C/104° F and possibly lie between 0° C/32° F and 25° C/77° F.

6.6.2 IEC climatic category

The IEC climatic category is quoted in three numerical blocks, which can be decoded as the following example shows:

lower temperature limit −25° C/−13° F
upper temperature limit +85° C/+185° F
duration of the IEC tests "damp heat" 56 days
25/085/56

7. Reliability

Indications on the reliability of components are of great importance for the user because information is given on operational reliability and expected service life. Basic information on reliability for components is given in DIN 40040 and DIN 40041. Using this information, it has to be considered that these are statistical figures. They can, therefore, refer only to great batches. The most important definitions are quoted below:

7.1 Load duration

Load duration is the total of operating and intermittent periods, storage, measurement and test time at the user, and the time of transportation.

7.2 Failure

A failure can be stated if the characteristics of a component, faultless at the loading start, change during the load in undue manner.

7.2.1 Total failure

A total failure excludes any operable application of the component. This is indicated in case of short circuit or interruption.

7.2.2 Failures due to variation

As failures due to variation are to be understood deviations exceeding certain limits which in general are still acceptable. The excess of one or more of these limits does not in all cases indicate that the capacitor is the reason for the equipment's failure; instead all depends on the sensitivity of the circuitry.

7.5 Reliability

The term reliability indicates the characteristics of a components batch not exceeding a certain failure rate at a determinated load and load duration.

7.5.1 Reference reliability

The reference reliability is the quoted reliability for a reference load. Generally, the reference load for electrolytic capacitors are the ambient temperature ≦40° C (104° F) and the appropriate permissible load (e.g. rated voltage and the ac voltage appropriate to 40° C (104° F). Indicated therein are each one failure rate and the respective load duration. For reference reliability the appropriate specifications DIN 41240, DIN 41257 and DIN 41332, sheet 1, indicate the values tabulated below.

Aluminum electrolytic capacitors, high reliability versions

Nominal diameter mm	Rated voltage U_R	Reference reliability	
		Relative failure rate	Period of time
≦ 10	6.3 to 25 V 40 to 350 V	10% 10%	30 000 hours 50 000 hours
12 to 25	6.3 to 450 V	10%	100 000 hours
> 25	6.3 to 25 V 40 to 450 V	10% 3%	100 000 hours 100 000 hours

Aluminum electrolytic capacitors, standard versions

Nominal diameter mm	Rated voltage U_R	Reference reliability	
		Relative failure rate	Period of time
≦ 4.5	6.3 to 100 V	10%	10 000 hours
5.8 to 12	6.3 to 25 V 40 to 450 V	5% 3%	10 000 hours 10 000 hours
14 to 25	6.3 to 450 V	3%	10 000 hours
> 25	6.3 to 450 V	5%	10 000 hours

If Siemens electrolytic capacitors exhibit better values, this is indicated in the specific data sheets.

7.7 Failure criteria

The failure rates pertinent to reference reliability and operational life include total failures as well as failures due to variations. As already explained in para. 7.2.1, a total failure of the aluminum electrolytic capacitor must be stated in case of short or open circuit. In order to determine the operational life the following criteria of failures due to variation are indicated on specification DIN 41240 and DIN 41332, sheet 1:

		High reliability version	Standard version
Increase in the tan δ values to the adjacent factor of the initial limit value		3	
Falling short of the rated capacitance			
at U_R up to 6.3 V	by	40 %	50 %
at U_R from 10 to 25 V	by	30 %	40 %
at U_R from 40 to 100 V	by	25 %	30 %
at U_R from 160 to 450 V	by	20 %	30 %
Exceeding of the rated capacitance		1.5 × (plus tolerance)	
Increase of the impedance to the adjacent factor of the initial limit value:			
at $U_R \leqq 25$ V by the factor		4	
at $U_R > 25$ V by the factor		3	
Leakage current		The initial limit value must not be exceeded. (Notice re-anodization according to para. 5.11.5.)	

This definition of failures due to variation describes deviations from electrical values exceeding a certain, generally still permissible limit. The excess of one or even more of these limits does not necessarily mean that the capacitor will cause a breakdown of the device; all depends on the sensitivity of the circuitry.

8. References for use

It is intended to draw your attention to a draft specification, published in July 1973 under the number DIN 41123, that contains references for use of aluminum and tantalum electrolytic capacitors. The most important points dealt with, are: safety requirements, protective measures, fitting in devices with inherent heating, damage due to excess pressure, danger of fire, series or parallel connection of electrolytic capacitors.

Solvents containing halogen may cause the following damages to the aluminum electrolytic capacitors: The insulating foil can be dissolved or affected, thus providing only insufficient insulating capability. The sealings of the capacitors can swell up such that the solvents can get into the inner part of the electrolytic capacitor, there resulting in corrosion and premature failure of the component. The following list contains a collection of critical halogen hydrocarbons partially in pure form, partially mixed with other solvents, that are frequently applied as cleaning agents in the electrical industry.
Trichlorotriethane fluoride (trade name e.g. Freon, Kaltron, Frigene)
Trichloroethylene
Trichloroethane (trade name e.g. Chlorothene, Wacker 3 × 1)
Tetrachloroethylene (trade name e.g. Per)
Methylene chloride
Chloroform
Carbon tetrachloride

The following solvents are recommended as cleaning agents for electrolytic capacitors:
Methanol
Ethanol (alcohol)
Propanol
Isopropanol
Isobutanol
Petroleum ether

When using the listed solvents the appropriate safety precautious (e.g. because of toxicity, combustibility, explosion hazard) are to be taken.

8.4 Operating electrolytes

Operating electrolytes partly contain noxious substances. Therefore when handling aluminum electrolytic capacitors the following has to be observed:

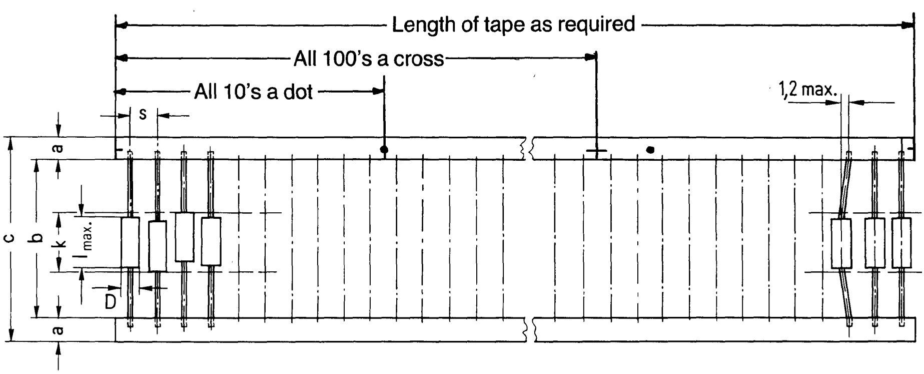
a) Leaked out electrolyte possibly should not be brought in contact with skin or eyes.
b) Skin parts moistened by electrolyte must immediately be washed under running water. Eyes should be washed by means of rinsing for 10 minutes with ample water. In case of continuing pain, a doctor has to be consulted.
c) Respiration of electrolyte vapors and/or fog has to be avoided. Work places and rooms should be well ventilated.
d) Clothes contaminated by electrolyte have to be taken off and washed with water.

1. General Information

Components with axial leads are particularly suitable for automatic assembly. We therefore offer the appropriate electrolytic capacitors with rated diameters of up to 16 mm also packaged on continuous tape. Up to now taping was carried out in accordance with regulations given by DIN 40810 (February 1964). In the meantime an international agreement has been achieved on the way of taping. Thereon the specification draft IEC 52 (Central Office) 133, edition February 1977, was published, which has also been adopted into the German DIN-IEC 52.133, November 1977.

The taping of our electrolytic capacitors will be changed in accordance with IEC regulations. Accordingly the components will be taped in such a manner that identical poles are turned to the same side of the tape, while one tape on the positive pole's side is colored red. The wire ends do not overlap the tape. Depending on the capacitor's dimension the tapes will be delivered on reels or in meandering folding, packaged in parcels.

2. Dimensions and tolerances



	Rated diameter D mm	Taping step spacing s mm	Tolerance above 10 steps Δs mm	Width of tape a mm	Tape spacing b mm	Body location k	Packaging
Al electrolytic capacitor	3.2	5 ± 0.5	±2	6 ± 1	73 ± 2	l_{max} + 1.4 mm	Coil + parcel
	4.5...8.5	10 ± 0.5					
	10...14	15 ± 0.5	± 3				Meandering folding + parcel
	16	20 ± 1	± 4				
Tantalum electrolytic capacitor	3.4...4.7	5 ± 0.5	± 2	6 ± 1	63 ± 2	l_{max} + 1.4 mm	Coil + parcel
	7.3...8.9	10 ± 0.5			73 ± 2		

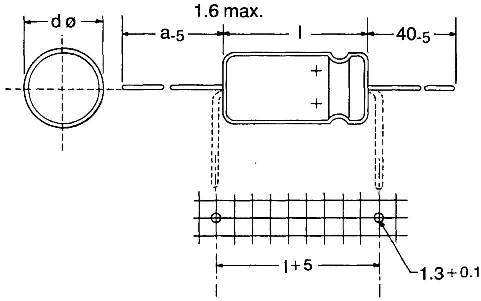
4. Ordering code for taped components

For taping the following electrolytic capacitor types are suitable:

Al electrolytic capacitors		Ta electrolytic capacitors
B 41 010	B 41 588	B 45 170
B 41 020	B 43 050	B 45 176
B 41 283	B 43 283	B 45 178
B 41 313	B 43 588	

The ordering code (part number) for taped electrolytic capacitors, manufactured in quantity, will be formed by adding a "9" to the code number of the untaped component. Example:

untaped capacitor B 41 010-B4108-T
taped capacitor B 41 010-B4108-T9



d x l	$d_{max.}$ x $l_{max.}$ with insulation	a
14x30	14,5x30,5	
16x30	16,5x30,5	55
18x35	18,5x35,5	40
20x40	20,5x40,5	40
25x40	25,5x40,5	

Dimensions in mm

Pretreatment:

The measurements takes place after rated voltage has been applied to the capacitor for 30 minutes. Using a series resistor of 1,000 Ω. After the voltage is applied the capacitor must be stabilized for 24-48 hours at rated temperature.

CR (μF)	UR (Up) (V)	Dissapation Factor tg. δ. max. 120 HZ +20/+25°C	Capacitance Tolerance 120 HZ +20/+25°C (%)	ESR 120 HZ +20/ +25°C Ω	Leakage Current IR-max. (5 min. +20/ +25°C (uA)	Ripple Current IN-max. (85°C 120 HZ (mA)	Basic Dimensions (mm) D (ø)	L	Weights (g)
2200	6,3	0.27		0,18	280	800	14	30	6,5
4700	(7,3)	0,31		0,10	595	960	18	35	12,
10000		0,43		0,06	1263	1100	20	40	16,
2200	10	0,22		0,15	443	850	14	30	6,5
10000	(11,5)	0,38		0,06	2003	1350	25	40	21,
2200	16	0,19		0,13	707	1000	16	30	9,
4700	(18,5)	0,23		0,07	1507	1500	20	40	16,
1000	25	0,15		0,22	503	740	14	30	6,5
2200	(29)	0,17		0,11	1103	1200	20	40	16,
4700		0,21	−10	0,07	2353	1600	25	40	21,
1000	40	0,12		0,17	803	1020	18	35	12,
2200	46	0,14		0,09	1763	1500	25	40	21,
470	68	0,10	+50	0,31	595	760	18	35	12,
1000	(72,5)	0,10		0,15	1263	1200	20	40	16,
220	100	0,10		0,67	443	460	16	30	9,
470	(115)	0,10		0,31	943	850	20	40	16,
47	160	0,20	=T	6,27	245	140	14	30	6,5
100	(176)	0,20		2,95	500	250	18	35	12,
220		0,20		1,34	1076	440	25	40	21,
22	250	0,20		13,4	185	95	14	30	6,5
100	(275)	0,20		2,95	770	280	20	40	16,
10	350	0,20		29,5	125	65	14	30	6,5
22	(385)	0,20		13,4	251	100	16	30	9,
47		0,20		6,27	513	170	18	35	12,
100		0,20		2,95	1070	310	25	40	21,

Electrolytic capacitor with etched electrodes encapsulated in a tubular aluminum can with external insulation.

This series has been developed with a wide range of high C.V. density units which is available in axial leaded where negative pole is connected on the can.

Ordering Code:

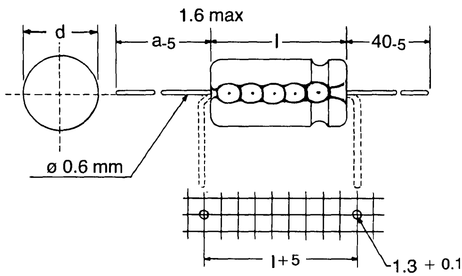
Example: 1000 / 10 – 82049

Rated Capacitance (μF) — 1000

Rated Voltage (V dc) — 10

Code — 82049

End Sealed — 82046



Ø ≤ 5.8 mm

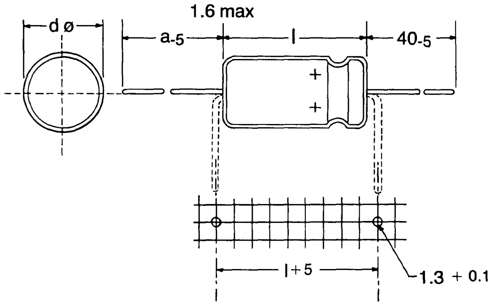
Dimensions

Ordering Code	d x l	d_{max} x l_{max} (w/insulation)	ø terminal	a
80049	4,5 x 11	4,9 x 12,5	0,6	40
	5,8 x 11	6,2 x 12,5		
81049	6,5 x 17,5	7 x 18		
	8,5 x 17,5	9 x 18		
	10 x 25	10,5 x 25,5		50
	12 x 30	12,5 x 30,5	0,8	55
82049	14 x 30	14,5 x 30,5		
	16 x 30	16,5 x 30,5		
	18 x 35	18,5 x 35,5		
	18 x 40	18,5 x 40,5		65
	20 x 40	20,5 x 40,5		
	25 x 40	25,5 x 40,5		

Rated Volt. U_N (V)	6.3	10	16	25	40	50	63	100	160	250	350
Rated Capacitance	Rated dimension d x l mm										
µF											
0.1											
0.15											
0.22											
0.33											
0.47											
0.68											
1											
1.5											
2.2											
3.3											
4.7											
6.8											
10											
15											14.5x30.5
22										14.5x30.5	14.5x30.5
33										14.5x30.5	16.5x30.5
47									14.5x30.5	16.5x30.5	18.5x35.5
68									16.5x30.5	18.5x35.5	
100									16.5x30.5	18.5x40.5	
150									18.5x40.5		
220								16.5x30.5	20.5x40.5		
330							14.5x30.5	18.5x35.5			
470						14.5x30.5	16.5x30.5	18.5x40.5			
680					14.5x30.5	16.5x30.5	18.5x40.5	20.5x40.5			
1000				14.5x30.5	16.5x30.5	18.5x35.5	18.5x40.5	25.5x40.5			
1500			14.5x30.5	16.5x30.5	18.5x35.5	18.5x40.4	20.5x40.5				
2200		14.5x30.5	16.5x30.5	18.5x35.5	18.5x40.5	20.5x40.5	25.5x40.5				
3300		16.5x30.5	18.5x35.5	18.5x40.5							
4700	16.5x30.5	18.5x35.5	18.5x40.5	25.5x40.5							
6800	18.5x35.5	18.5x40.5	20.5x40.5								
10000	18.5x40.5	20.5x40.5									

U_N U_P (V)	C_N (µF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5[1], +20/25°C) (µA)	Dissipation Factor – tgd máx. (120 Hz, +20/ +25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions	
						D (ø)	L
	4,7		3,0	0,15	52,9	4.9	12.5
	6,8		3,0	0,15	36,6	4.9	12.5
	10		3,0	0,15	24,9	4.9	12.5
	15		3,7	0,15	16,6	6.2	12.5
	22		5,5	0,15	11,3	6.2	12.5
	33		8,2	0,15	7,5	7	18
	47		11,7	0,15	5,3	7	18
	68		17,0	0,15	3,7	7	18
25	100		25,0	0,15	2,5	9	18
	220		55,0	0,15	1,1	9	18
(28,7)	330		82,5	0,15	0,8	10.5	25.5
	470		117,5	0,15	0,5	10.5	25.5
	680		170,0	0,15	0,4	12.5	30.5
	1000		250,0	0,15	0,2	14.5	30.5
	1500		375,0	0,15	0,2	16.5	30.5
	2200		550,0	0,17	0,1	18.5	35.5
	3300		825,0	0,19	0,1	18.5	40.5
	4700		1175,0	0,21	0,1	25.5	40.5
		± 20					
	4,7		3,0	0,12	42,3	4.9	12.5
	6,8		3,0	0,12	29,3	6.2	12.5
	10		4,0	0,12	19,9	6.2	12.5
	22		8,8	0,12	9,0	7	18
	100		40,0	0,12	2,0	9	18
	150		60,0	0,12	1,3	9	18
40	220		88,0	0,12	0,9	10.5	25.5
	330		132,0	0,12	0,6	12.5	30.5
(46)	470		188,0	0,12	0,4	12.5	30.5
	680		272,0	0,12	0,3	14.5	30.5
	1000		400,0	0,12	0,2	16.5	30.5
	1500		600,0	0,12	0,1	18.5	35.5
	2200		880,0	0,14	0,1	18.5	40.5
	2,2		3,0	0,10	75,4	4.9	12.5
	3,3		3,0	0,10	50,2	4.9	12.5
	4,7		3,0	0,10	35,3	6.2	12.5
	6,8		3,4	0,10	24,4	6.2	12.5
	15		7,5	0,10	11,1	7	18
50	33		16,5	0,10	5,0	9	18
	47		23,5	0,10	3,5	9	18
(57,5)	150		75,0	0,10	1,1	10.5	25.5
	220		110,0	0,10	0,8	12.5	30.5
	470		235,0	0,10	0,4	14.5	30.5
	680		340,0	0,10	0,2	16.5	30.5
	1000		500,0	0,10	0,2	18.5	35.5
	1500		750,0	0,10	0,1	18.5	40.5
	2200		1100,0	0,12	0,1	20.5	40.5

U_N U_P (V)	C_N (μF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5[1], +20/25°C) (μA)	Dissipation Factor – tgd máx. (120 Hz, +20/ +25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions	
						D (ø)	L
	2,2		3,5	0,16	120,6	7	18
	6,8		10,9	0,16	39,0	9	18
	15		24,0	0,16	17,7	10.5	25.5
160	22		35,2	0,16	12,1	10.5	25.5
	33		52,8	0,16	8,0	12.5	30.5
(176)	47		75,2	0,16	5,6	14.5	30.5
	68		108,8	0,16	3,9	16.5	30.5
	100		160,0	0,16	2,7	16.5	30.5
	150		240,0	0,16	1,8	18.5	40.5
	220		352,0	0,16	1,2	20.5	40.5
	1		3,0	0,18	298,4		
	1,5		3,8	0,18	198,9		
	2,2		5,5	0,18	135,6		
	3,3		8,3	0,18	90,4		
250	4,7		11,8	0,18	63,5		
	6,8		17,0	0,18	43,9	10.5	25.5
(275)	10		25,0	0,18	29,8	10.5	25.5
	22		55,0	0,18	13,6	14.5	30.5
	33		82,5	0,18	9,0	14.5	30.5
	47	± 20	117,5	0,18	6,3	18.5	35.5
	68		170,0	0,18	4,4	18.5	40.5
	0,47		3,0	0,20	705,5		
	0,68		3,0	0,20	487,6		
	1		3,5	0,20	331,6		
	1,5		5,3	0,20	221,0		
	2,2		7,7	0,20	150,7		
350	3,3		11,6	0,20	100,5	10.5	25.5
	4,7		16,5	0,20	70,5	10.5	25.5
(385)	6,8		23,8	0,20	48,8	12.5	30.5
	10		35,0	0,20	33,2	12.5	30.5
	15		52,5	0,20	22,1	14.5	30.5
	22		77,0	0,20	15,1	14.5	30.5
	33		115,5	0,20	10,0	16.5	30.5
	47		164,5	0,20	7,1	18.5	35.5



d x l	$d_{max.}$ x $l_{max.}$ (with insulation)	ø Lead	Cathode Lead Length (a)
6,5 x 17.5	7 x 18	0,6	40
8,5 x 17,5	9 x 18	0,6	
10 x 25	10,5 x 25,5		50
12 x 30	12,5 x 30,5	0,8	55

Dimensions in mm

Pretreatment:

The measurements takes place after rated voltage has been applied to the capacitor for 30 minutes. Using a series resistor of 1,000 Ω. After the voltage is applied the capacitor must be stabilized for 24-48 hours at rated temperature.

CR (μF)	UR (Up) (V)	Dissapation Factor tg. δ. max. 120 HZ +20/+25°C	Capacitance Tolerance 120 HZ +20/+25°C (%)	ESR 120 HZ +20/ +25°C Ω	Leakage Current IR-max. (5 min. +20/ +25°C (uA)	Ripple Current IN-max. (85°C 120 HZ (mA)	Basic Dimensions (mm)		Weights (g)
							D (ø)	L	
470	6,3	0,25		0,78	62	250	8,5	17,5	1,7
1000	(7,3)	0,25		0,37	129	450	10	25	3,2
100	10	0,20		2,95	23	110	6,5	17,5	1,4
	(11,5)								
220	16	0,17		1,14	73	210	8,5	17,5	1,7
470	(18,5)	0,17		0,53	153	370	10	25	3,2
1000		0,17		0,25	323	650	12	30	5,2
47	25	0,15		4,70	26	90	6,5	17,5	1,4
100	(29)	0,15	−10	2,21	53	150	8,5	17,5	1,7
470		0,15		0,47	238	470	12	30	5,2
22	40	0,12		8,04	20	70	6,5	17,5	1,4
220	(46)	0,12		0,73	179	300	10	25	3,2
470		0,12	+50	0,15	379	530	12	30	5,2
10	63	0,10		14,74	15	50	6,5	17,5	1,4
47	(72,5)	0,10		2,82	62	130	8,5	17,5	1,7
100		0,10		1,47	129	220	10	25	3,2
220		0,10	=T	0,67	280	400	12	30	5,2
4,7	100	0,10		31,35	12	35	6,5	17,5	1,4
10	(115)	0,10		14,74	23	60	8,5	17,5	1,7
22		0,10		6,70	47	85	8,5	17,5	1,7
47		0,10		3,14	97	155	10	25	3,2
100		0,10		1,47	203	270	12	30	5,2
2,2	160	0,20		133,97	30	15	6,5	17,5	1,4
22	(176)	0,20		13,4	125	75	10	25	3,2
1	250	0,20		249,73	27	10	6,5	17,5	1,4
2,2	(275)	0,20		133,97	36	20	8,5	17,5	1,7
4,7		0,20		62,71	55	30	8,5	17,5	1,7
10		0,20		29,47	95	50	10	25	3,2
1	350	0,20		249,73	30	15	8,5	17,5	1,7
2,2	(385)	0,20		133,97	43	20	8,5	17,5	1,7
4,7		0,20		62,71	69	35	10	25	3,2

Electrolytic capacitor with etched electrodes encapsulated in a tubular aluminum can with external insulation.

This series has been developed with a wide range of high C.V. density units which is available in axial leaded where negative pole is connected on the can.

Ordering Code:

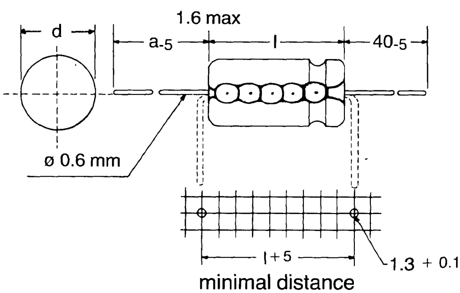
Example: 1000 / 10 – 81049

Rated Capacitance (μF) — 1000

Rated Voltage (V dc) — 10

Code — 81049

End Sealed — 81046



ø ≤ 5.8 mm

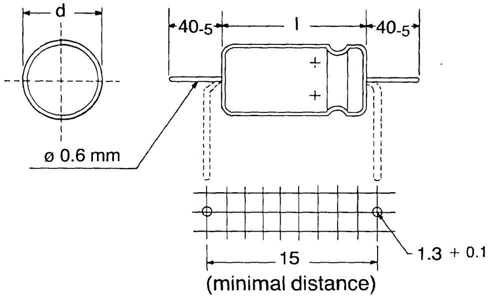
Dimensions

Ordering Code	d x 1	d_{max} x l_{max} (w/insulation)	ø terminal	a
80049	4,5 x 11	4,9 x 12,5	0,6	40^{-5}
	5,8 x 11	6,2 x 12,5		
81049	6,5 x 17,5	7 x 18		
	8,5 x 17,5	9 x 18		
	10 x 25	10,5 x 25,5		50^{-5}
	12 x 30	12,5 x 30,5	0,8	55^{-5}
82049	14 x 30	14,5 x 30,5		
	16 x 30	16,5 x 30,5		
	18 x 35	18,5 x 35,5		
	18 x 40	18,5 x 40,5		65^{-5}
	20 x 40	20,5 x 40,5		
	25 x 40	25,5 x 40,5		

Rated Volt. U_N (V)	6.3	10	16	25	40	50	63	100	160	250	350
Rated Capacitance	Rated dimensions d x 1 mm Code										
µF											
0.1											
0.15											
0.22											
0.33											
0.47											7x18
0.68											7x18
1										7x18	9x18
1.5										7x18	9x18
2.2									7x18	9x18	9x18
3.3								7x18		9x18	10.5x25.5
4.7								7x18		9x18	10.5x25.5
6.8							7x18	7x18	9x18	10.5x25.5	12.5x30.5
10							7x18	9x18		10.5x25.5	12.5x30.5
15						7x18				10.5x25.5	
22					7x18		9x18	9x18	10.5x25.5		
33				7x18		9x18	9x18	10.5x25.5	12.5x30.5		
47				7x18		9x18	9x18	10.5x25.5			
68				7x18			9x18	10.5x25.5			
100		7x18	7x18	9x18	9x18		10.5x25.5	12.5x30.5			
150			7x18		9x18	10.5x25.5		12.5x30.5			
220	7x18		9x18	9x18	10.5x25.5	12.5x30.5	12.5x30.5				
330		9x18		10.5x25.5	12.5x30.5						
470	9x18		10.5x25.5	10.5x25.5	12.5x30.5						
680	9x18		10.5x25.5	12.5x30.5							
1000		10.5x25.5	12.5x30.5								
1500		12.5x30.5									
2200											
3300											

U_N U_P (V)	C_N (µF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5^1, +20/25°C) (µA)	Dissipation Factor – tgd máx. (120 Hz, +20/ +25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions D (ø)	L
	4,7		3,0	0,15	52,9	4.9	12.5
	6,8		3,0	0,15	36,6	4.9	12.5
	10		3,0	0,15	24,9	4.9	12.5
	15		3,7	0,15	16,6	6.2	12.5
	22		5,5	0,15	11,3	6.2	12.5
	33		8,2	0,15	7,5	7	18
	47		11,7	0,15	5,3	7	18
	68		17,0	0,15	3,7	7	18
25	100		25,0	0,15	2,5	9	18
	220		55,0	0,15	1,1	9	18
(28,7)	330		82,5	0,15	0,8	10.5	25.5
	470		117,5	0,15	0,5	10.5	25.5
	680		170,0	0,15	0,4	12.5	30.5
	1000		250,0	0,15	0,2	14.5	30.5
	1500		375,0	0,15	0,2	16.5	30.5
	2200		550,0	0,17	0,1	18.5	35.5
	3300		825,0	0,19	0,1	18.5	40.5
	4700		1175,0	0,21	0,1	25.5	40.5
		± 20					
	4,7		3,0	0,12	42,3	4.9	12.5
	6,8		3,0	0,12	29,3	6.2	12.5
	10		4,0	0,12	19,9	6.2	12.5
	22		8,8	0,12	9,0	7	18
	100		40,0	0,12	2,0	9	18
	150		60,0	0,12	1,3	9	18
40	220		88,0	0,12	0,9	10.5	25.5
	330		132,0	0,12	0,6	12.5	30.5
(46)	470		188,0	0,12	0,4	12.5	30.5
	680		272,0	0,12	0,3	14.5	30.5
	1000		400,0	0,12	0,2	16.5	30.5
	1500		600,0	0,12	0,1	18.5	35.5
	2200		880,0	0,14	0,1	18.5	40.5
	2,2		3,0	0,10	75,4	4.9	12.5
	3,3		3,0	0,10	50,2	4.9	12.5
	4,7		3,0	0,10	35,3	6.2	12.5
	6,8		3,4	0,10	24,4	6.2	12.5
	15		7,5	0,10	11,1	7	18
50	33		16,5	0,10	5,0	9	18
	47		23,5	0,10	3,5	9	18
(57,5)	150		75,0	0,10	1,1	10.5	25.5
	220		110,0	0,10	0,8	12.5	30.5
	470		235,0	0,10	0,4	14.5	30.5
	680		340,0	0,10	0,2	16.5	30.5
	1000		500,0	0,10	0,2	18.5	35.5
	1500		750,0	0,10	0,1	18.5	40.5
	2200		1100,0	0,12	0,1	20.5	40.5

U_N U_P (V)	C_N (µF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5[1], +20/25°C) (µA)	Dissipation Factor – tgd máx. (120 Hz, +20/ +25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions D (ø)	Dimensions L
	2,2		3,5	0,16	120,6	7	18
	6,8		10,9	0,16	39,0	9	18
	15		24,0	0,16	17,7	10.5	25.5
160	22		35,2	0,16	12,1	10.5	25.5
	33		52,8	0,16	8,0	12.5	30.5
(176)	47		75,2	0,16	5,6	14.5	30.5
	68		108,8	0,16	3,9	16.5	30.5
	100		160,0	0,16	2,7	16.5	30.5
	150		240,0	0,16	1,8	18.5	40.5
	220		352,0	0,16	1,2	20.5	40.5
	1		3,0	0,18	298,4		
	1,5		3,8	0,18	198,9		
	2,2		5,5	0,18	135,6		
	3,3		8,3	0,18	90,4		
250	4,7		11,8	0,18	63,5		
	6,8		17,0	0,18	43,9	10.5	25.5
(275)	10		25,0	0,18	29,8	10.5	25.5
	22		55,0	0,18	13,6	14.5	30.5
	33		82,5	0,18	9,0	14.5	30.5
	47	± 20	117,5	0,18	6,3	18.5	35.5
	68		170,0	0,18	4,4	18.5	40.5
	0,47		3,0	0,20	705,5		
	0,68		3,0	0,20	487,6		
	1		3,5	0,20	331,6		
	1,5		5,3	0,20	221,0		
	2,2		7,7	0,20	150,7		
350	3,3		11,6	0,20	100,5	10.5	25.5
	4,7		16,5	0,20	70,5	10.5	25.5
(385)	6,8		23,8	0,20	48,8	12.5	30.5
	10		35,0	0,20	33,2	12.5	30.5
	15		52,5	0,20	22,1	14.5	30.5
	22		77,0	0,20	15,1	14.5	30.5
	33		115,5	0,20	10,0	16.5	30.5
	47		164,5	0,20	7,1	18.5	35.5



d x l	$d_{max.}$ x $l_{max.}$ (with insulation)
4.5 x 11	4.9 x 12.5
5.8 x 11	6.2 x 12.5

Dimensions in mm

Pretreatment:

Measurement takes place after rated voltage has been applied to the capacitor for 30 minutes. After that, the capacitor must be stabilized for 24 to 48 hours at rated temperature.

CR (μF)	UR (Up) (V)	Dissapation Factor tg. δ. max. 120 HZ +20/+25°C	Capacitance Tolerance 120 HZ +20/+25°C (%)	ESR 120 HZ +20/ +25°C Ω	Leakage Current IR-max. (5 min. +20/ +25°C (uA)	Ripple Current IN-max. (85°C 120 HZ (mA)	Basic Dimensions (mm) D (ø)	L	Weights
22	16	0.17		11.4	10	39	4.5	11	0.45g
47	(18.5)	0.17		5.33	18	66	5.8	11	0.70g
10	25	0.15	−10	22.1	8	28	4.5	11	0.45g
22	(29)	0.15		10.0	14	48	5.8	11	0.70g
4,7	40	0.12		37.63	7	22	4.5	11	0.45g
10	(46)	0.12		11.68	11	36	5.8	11	0.70g
			+100						
2,2	63	0.10		66.98	6	16	4.5	11	0.45g
4,7	(72,5)	0.10		31.35	9	27	5.8	11	0.70g
0.47	100	0.10		313.5	4	8	4.5	11	0.45g
1	(115)	0.10		147.3	5	11	4.5	11	0.45g
2.2		0.10		66.98	8	19	5.8	11	0.70g

Electrolytic capacitor with etched electrodes encapsulated in a tubular aluminum can with external insulation.

This series has been developed with a wide range of high C.V. density units which is available in axial leaded where negative pole is connected on the can.

Ordering Code:

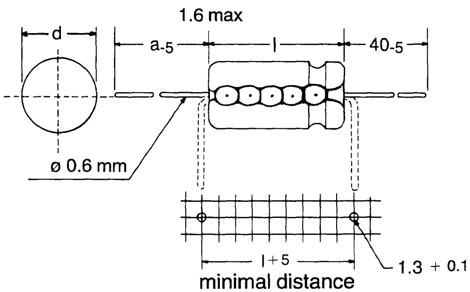
Example: 1000 / 10 – 80049

Rated Capacitance (µF) — 1000

Rated Voltage (V dc) — 10

Code — 80049

End Sealed — 80046



ø ≤ 5.8 mm

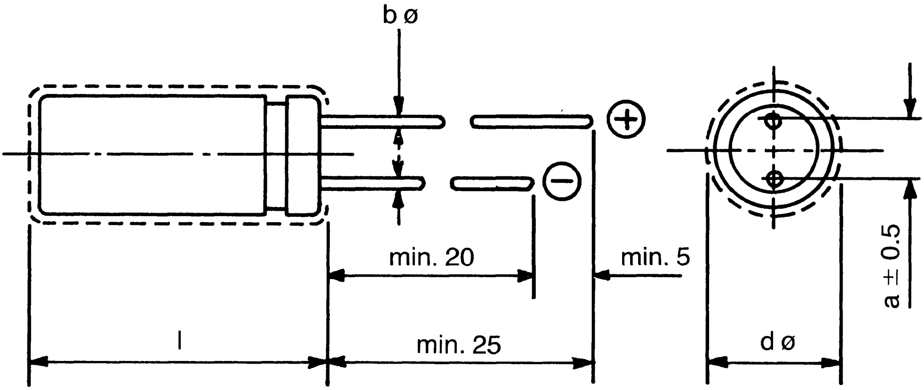
Dimensions

<table>
<tr><th>Ordering Code</th><th>d x 1</th><th>d_{max} x l_{max} (w/insulation)</th><th>ø terminal</th><th>a</th></tr>
<tr><td rowspan="2">80049</td><td>4,5 x 11</td><td>4,9 x 12,5</td><td rowspan="5">0,6</td><td rowspan="4">40⁻⁵</td></tr>
<tr><td>5,8 x 11</td><td>6,2 x 12,5</td></tr>
<tr><td rowspan="4">81049</td><td>6,5 x 17,5</td><td>7 x 18</td></tr>
<tr><td>8,5 x 17,5</td><td>9 x 18</td></tr>
<tr><td>10 x 25</td><td>10,5 x 25,5</td><td>50⁻⁵</td></tr>
<tr><td>12 x 30</td><td>12,5 x 30,5</td><td rowspan="7">0,8</td><td rowspan="4">55⁻⁵</td></tr>
<tr><td rowspan="6">82049</td><td>14 x 30</td><td>14,5 x 30,5</td></tr>
<tr><td>16 x 30</td><td>16,5 x 30,5</td></tr>
<tr><td>18 x 35</td><td>18,5 x 35,5</td></tr>
<tr><td>18 x 40</td><td>18,5 x 40,5</td><td rowspan="3">65⁻⁵</td></tr>
<tr><td>20 x 40</td><td>20,5 x 40,5</td></tr>
<tr><td>25 x 40</td><td>25,5 x 40,5</td></tr>
</table>

Rated Volt. U_N (V)	6.3	10	16	25	40	50	63	100	160	250	350
Rated Capacitance	Rated dimensions d x 1 mm Code										
μF											
0.1								4.9x12.5			
0.15								4.9x12.5			
0.22								4.9x12.5			
0.33								4.9x12.5			
0.47								4.9x12.5			
0.68								4.9x12.5			
1								4.9x12.5			
1.5							4.9x12.5	6.2x12.5			
2.2						4.9x12.5	4.9x12.5	6.2x12.5			
3.3						4.9x12.5	6.2x12.5				
4.7				4.9x12.5	4.9x12.5	6.2x12.5	6.2x12.5				
6.8				4.9x12.5	6.2x12.5	6.2x12.5					
10				4.9x12.5	6.2x12.5						
15			4.9x12.5	6.2x12.5							
22			4.9x12.5	6.2x12.5							
33	4.9x12.5		6.2x12.5								
47		6.2x12.5	6.2x12.5								
68		6.2x12.5									
100	6.2x12.5										
150											
220											
330											
470											
680											
1000											
1500											
2200											
3300											

U_N U_P (V)	C_N (μF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5[1], +20/25°C) (μA)	Dissipation Factor – tgd máx. (120 Hz, +20/ +25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions D (ø)	Dimensions L
	4,7		3,0	0,15	52,9	4.9	12.5
	6,8		3,0	0,15	36,6	4.9	12.5
	10		3,0	0,15	24,9	4.9	12.5
	15		3,7	0,15	16,6	6.2	12.5
	22		5,5	0,15	11,3	6.2	12.5
	33		8,2	0,15	7,5	7	18
	47		11,7	0,15	5,3	7	18
	68		17,0	0,15	3,7	7	18
25	100		25,0	0,15	2,5	9	18
	220		55,0	0,15	1,1	9	18
(28,7)	330		82,5	0,15	0,8	10.5	25.5
	470		117,5	0,15	0,5	10.5	25.5
	680		170,0	0,15	0,4	12.5	30.5
	1000		250,0	0,15	0,2	14.5	30.5
	1500		375,0	0,15	0,2	16.5	30.5
	2200		550,0	0,17	0,1	18.5	35.5
	3300		825,0	0,19	0,1	18.5	40.5
	4700		1175,0	0,21	0,1	25.5	40.5
		± 20					
	4,7		3,0	0,12	42,3	4.9	12.5
	6,8		3,0	0,12	29,3	6.2	12.5
	10		4,0	0,12	19,9	6.2	12.5
	22		8,8	0,12	9,0	7	18
	100		40,0	0,12	2,0	9	18
	150		60,0	0,12	1,3	9	18
40	220		88,0	0,12	0,9	10.5	25.5
	330		132,0	0,12	0,6	12.5	30.5
(46)	470		188,0	0,12	0,4	12.5	30.5
	680		272,0	0,12	0,3	14.5	30.5
	1000		400,0	0,12	0,2	16.5	30.5
	1500		600,0	0,12	0,1	18.5	35.5
	2200		880,0	0,14	0,1	18.5	40.5
	2,2		3,0	0,10	75,4	4.9	12.5
	3,3		3,0	0,10	50,2	4.9	12.5
	4,7		3,0	0,10	35,3	6.2	12.5
	6,8		3,4	0,10	24,4	6.2	12.5
	15		7,5	0,10	11,1	7	18
50	33		16,5	0,10	5,0	9	18
	47		23,5	0,10	3,5	9	18
(57,5)	150		75,0	0,10	1,1	10.5	25.5
	220		110,0	0,10	0,8	12.5	30.5
	470		235,0	0,10	0,4	14.5	30.5
	680		340,0	0,10	0,2	16.5	30.5
	1000		500,0	0,10	0,2	18.5	35.5
	1500		750,0	0,10	0,1	18.5	40.5
	2200		1100,0	0,12	0,1	20.5	40.5

U_N U_P (V)	C_N (µF)	Tol. Cap. (%)	Leakage Current $-I_r$ máx. (5^1, +20/25°C) (µA)	Dissipation Factor – tgd máx. (120 Hz, +20/+25°C)	ESR max. (120 Hz, +20/25°C) (Ω)	Dimensions D (ø)	Dimensions L
	2,2		3,5	0,16	120,6	7	18
	6,8		10,9	0,16	39,0	9	18
	15		24,0	0,16	17,7	10.5	25.5
160	22		35,2	0,16	12,1	10.5	25.5
	33		52,8	0,16	8,0	12.5	30.5
(176)	47		75,2	0,16	5,6	14.5	30.5
	68		108,8	0,16	3,9	16.5	30.5
	100		160,0	0,16	2,7	16.5	30.5
	150		240,0	0,16	1,8	18.5	40.5
	220		352,0	0,16	1,2	20.5	40.5
	1		3,0	0,18	298,4		
	1,5		3,8	0,18	198,9		
	2,2		5,5	0,18	135,6		
	3,3		8,3	0,18	90,4		
250	4,7		11,8	0,18	63,5		
	6,8		17,0	0,18	43,9	10.5	25.5
(275)	10		25,0	0,18	29,8	10.5	25.5
	22		55,0	0,18	13,6	14.5	30.5
	33		82,5	0,18	9,0	14.5	30.5
	47	± 20	117,5	0,18	6,3	18.5	35.5
	68		170,0	0,18	4,4	18.5	40.5
	0,47		3,0	0,20	705,5		
	0,68		3,0	0,20	487,6		
	1		3,5	0,20	331,6		
	1,5		5,3	0,20	221,0		
	2,2		7,7	0,20	150,7		
350	3,3		11,6	0,20	100,5	10.5	25.5
	4,7		16,5	0,20	70,5	10.5	25.5
(385)	6,8		23,8	0,20	48,8	12.5	30.5
	10		35,0	0,20	33,2	12.5	30.5
	15		52,5	0,20	22,1	14.5	30.5
	22		77,0	0,20	15,1	14.5	30.5
	33		115,5	0,20	10,0	16.5	30.5
	47		164,5	0,20	7,1	18.5	35.5



d x l	$d_{max.}$ x $l_{max.}$ (with insulation)	a	b
5 x 11	5,5 x 12	2,0	0,5
6,3 x 11	6,8 x 12	2,5	
8 x 12,5	8,5 x 13,5	3,5	
10 x 12,5	10,5 x 13,5	5,0	0,6
10 x 20	10,5 x 21	5,0	
12,5 x 25	13 x 26	5,0	
16 x 25	16,5 x 26	7,5	0,8
16 x 31,5	16,5 x 32,5	7,5	
18 x 31,5	18,5 x 32,5	7,5	

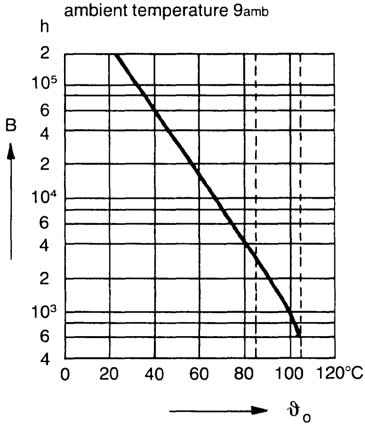
Dimensions in mm

Pretreatment:

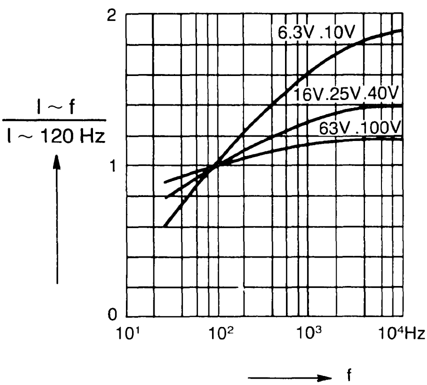
The measurement takes place after rated voltage has been applied to the capacitor for 30 minutes, using a series resistor of 1,000 Ω. After the voltage is applied, the capacitor must be stabilized for 24-48 hours at rated temperature.

CR (μF)	UR (Up) (V)	Dissapation Factor tg. δ. max. 120 HZ +20/+25°C	Capacitance Tolerance 120 HZ +20/+25°C (%)	ESR 120 HZ +20/ +25°C Ω	Leakage Current IR-max. (5 min. +20/ +25°C (uA))	Ripple Current IN-max. (85°C 120 HZ (mA))	Basic Dimensions (mm) D (ø)	L	Weights
47	6.3	0.25		7.84	9	50	5	11	0.45g
100	(7.3)	0.25		3.68	16	90	6.3	11	0.55g
220		0.25		1.67	31	150	8	12.5	1.00g
470		0.25		0.78	62	240	10	12.5	1.50g
1000		0.25		0.37	129	410	10	20	2.30g
2200		0.27		0.18	280	730	12.5	25	4.00g
4700		0.31		0.10	595	960	16	31.5	8.00g
2200	10	0.22		0.15	443	850	16	25	7.00g
4700	(11.5)	0.26		0.08	943	1100	18	31.5	10.0g
22	16	0.17		11.4	10	40	5	11	0.45g
47	(18.5)	0.17		5.33	18	70	6.3	11	0.55g
100		0.17		2.50	35	120	8	12.5	1.00g
220		0.17		1.14	73	200	10	12.5	1.50g
470		0.17		0.53	153	350	10	20	2.30g
1000		0.17		0.25	323	620	12.5	25	4.00g
2200		0.19		0.13	707	1000	16	31.5	8.00g
10	25	0.15		22.1	8	30	5	11	0.45g
22	(29)	0.15		10.0	14	50	6.3	11	0.55g
47		0.15		4.70	27	90	8	12.5	1.00g
100		0.15		2.21	53	140	10	12.5	1.50g
220		0.15		1.00	113	250	10	20	2.30g
470		0.15		0.47	238	450	12.5	25	4.00g
1000		0.15		0.22	503	750	16	25	7.00g
2200		0.17		0.11	1103	1200	18	31.5	10.0g
4.7	40	0.12		37.63	7	23	5	11	0.45g
10	(46)	0.12		17.68	11	40	6.3	11	0.55g
22		0.12		8.04	21	70	8	12.5	1.00g
47		0.12		3.76	41	110	10	12.5	1.50g
470		0.12		0.37	379	570	16	25	7.00g
1000		0.12		0.17	803	910	16	31.5	8.00g
2.2	63	0.10		67.0	6	17	5	11	0.45g
4.7	(72.5)	0.10		31.35	9	30	6.3	11	0.55g
10		0.10		14.74	16	50	8	12.5	1.00g
22		0.10		6.70	31	80	10	12.5	1.50g
100		0.10		1.47	129	210	10	20	2.30g
220		0.10		0.67	280	380	12.5	25	4.00g
470		0.10		0.31	595	680	31.5	8.00g	

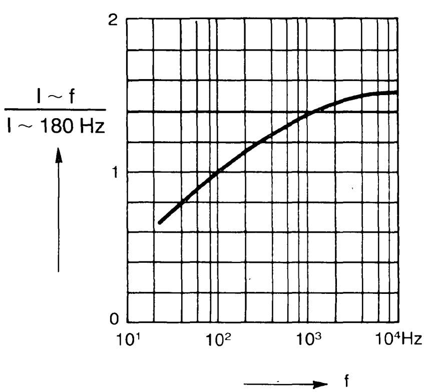
Load duration B versus ambient temperature ϑ_{amb}

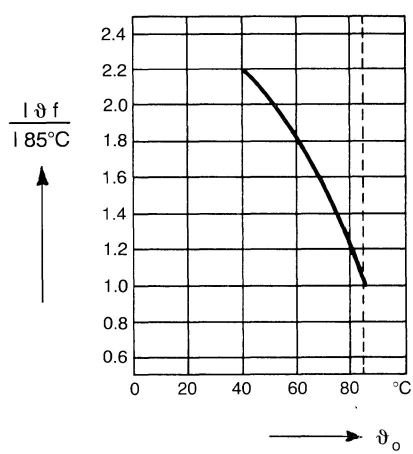


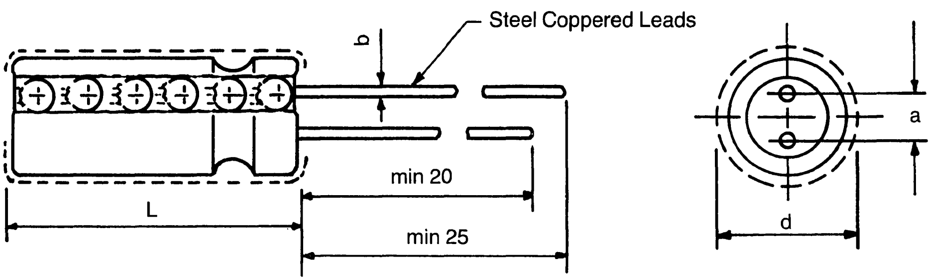
Life Expectancy



Ripple Current







d x l	$d_{max.}$ x $l_{max.}$ (with insulation)	a	b
5 x 11	5.5 x 12	2	0.5
6.3 x 11	6.8 x 12	2.5	0.5
8 x 12.5	8.5 x 13.5	3.5	0.5
10 x 12.5	10.5 x 13.5	5	0.6
10 x 20	10.5 x 21	5	0.6
12.5 x 25	13 x 26	5	0.6
16 x 25	16.5 x 26	7.5	0.8
16 x 31.5	16.5 x 32.5	7.5	0.8
18 x 31.5	18.5 x 32.5	7.5	0.8

Dimensions in mm

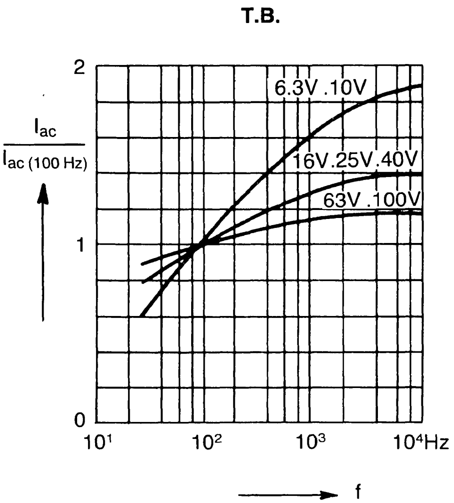
Pretreatment:

The measurements takes place after rated voltage has been applied to the capacitor for 30 minutes. Using a series resistor of 1,000 Ω. After the voltage is applied the capacitor must be stabilized for 24-48 hours at rated temperature.

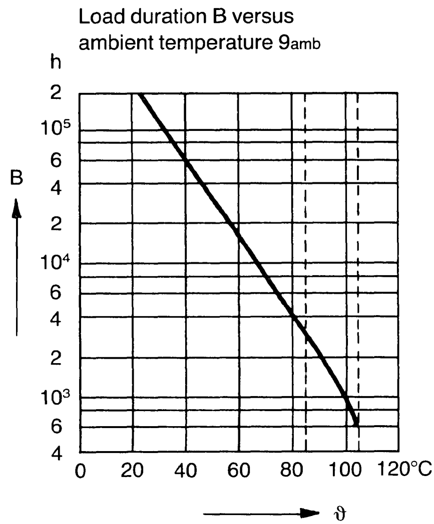
CR (μF)	UR (Up) (V)	Dissapation Factor tg. δ. max. 120 HZ +20/+25°C	Capacitance Tolerance 120 HZ +20/+25°C (%)	ESR 120 HZ +20/ +25°C Ω	Leakage Current IR-max. (5 min. +20/ +25°C (uA)	Ripple Current IN-max. (85°C 120 HZ (mA)	Basic Dimensions (mm) D (ø)	L	Weights
100		0.25		4.15		75	5	11	0.45g
150		0.25		2.76		100	6.3	11	0.55g
330		0.25		1.26		180	8	12.5	1.00g
2200	6.3	0.27		0.21		730	12.5	25	4.00g
3300	(7.3)	0.29		0.15		850	16	25	7.00g
4700		0.31		0.11		960	16	31.5	8.00g
6800		0.35		0.09		1050	18	31.5	10.0g
47		0.20		7.06		55	5	11	0.45g
68		0.20		4.88		70	5	11	0.45g
100		0.20		3.32		95	6.3	11	0.55g
220		0.20		1.51		170	8	12.5	1.00g
330		0.20		1.00		230	10	12.5	1.50g
470		0.20		0.71		270	10	12.5	1.50g
1000	10	0.20		0.33		460	10	20	2.30g
1500	(11.5)	0.20		0.22		700	12.5	25	4.00g
2200		0.22		0.166		850	16	25	7.00g
3300		0.24		0.12		950	16	31.5	8.00g
4700		0.26	±20	0.09		1100	18	31.5	10.0g
33		0.17		3.54		50	5	11	0.45g
68		0.17		4.15		85	6.3	11	0.55g
100		0.17		2.82		120	8	12.5	1.00g
150		0.17		1.88		150	8	12.5	1.00g
220		0.17		1.28		200	10	12.5	1.50g
470		0.17		0.60		350	10	20	2.30g
680		0.17		0.41		420	10	20	2.30g
1000	16	0.17		0.28		620	12.5	25	4.00g
1500	(18.4)	0.17		0.19		860	16	25	7.00g
2200		0.19		0.14		990	16	25	7.00g
3300		0.21		0.11		1200	18	31.5	10.0g

CR (μF)	UR (Up) (V)	Dissapation Factor tg. δ. max. 120 HZ +20/+25°C	Capacitance Tolerance 120 HZ +20/+25°C (%)	ESR 120 HZ +20/ +25°C Ω	Leakage Current IR-max. (5 min. +20/ +25°C (uA)	Ripple Current IN-max. (85°C 120 HZ (mA)	Basic Dimensions (mm) D (ø)	L	Weights
4.7		35.9		0.10		25	5	11	0.45g
6.8		24.6		0.10		30	5	11	0.45g
10		16.6		0.10		41	6.3	11	0.55g
15		11		0.10		50	6.3	11	0.55g
22		7.53		0.10		75	8	12.5	1.00g
33		5.02		0.10		90	8	12.5	1.00g
47		3.53		0.10		120	10	12.5	1.50g
100	63	1.66		0.10		210	10	20	2.30g
220	(72.5)	0.75		0.10		380	12.5	25	4.00g
330		0.50		0.10		470	12.5	25	4.00g
470		0.36		0.10		630	16	25	7.00g
680		0.24		0.10		890	18	31.5	10.0g
0.1		1326		0.08		4	5	11	0.45g
0.15		884		0.08		5	5	11	0.45g
0.22		602		0.08		6	5	11	0.45g
0.33		402		0.08		7	5	11	0.45g
0.47		282		0.08		9	5	11	0.45g
0.68		195	±20	0.08		11	5	11	0.45g
1		133		0.08		13	5	11	0.45g
1.5		88		0.08		16	5	11	0.45g
2.2		62.4		0.08		19	5	11	0.45g
3.3		40		0.08		23	5	11	0.45g
4.7		28		0.08		32	6.3	11	0.55g
6.8		19		0.08		38	6.3	11	0.55g
10		13.3		0.08		55	8	12.5	1.00g
15	100	8.84		0.08		70	8	12.5	1.00g
22	(115)	6.03		0.08		95	10	12.5	1.50g
33		4.02		0.08		115	10	12.5	1.50g
47		2.82		0.08		160	10	20	2.30g
68		1.95		0.08		190	10	20	2.30g
100		1.33		0.08		290	12.5	25	4.00g
150		0.88		0.08		350	12.5	25	4.00g
220		0.60		0.08		480	16	25	7.00g
330		0.40		0.08		650	16	31.5	8.00g
470		0.28		0.08		820	18	31.5	10.00g

Ripple Current X Frequency

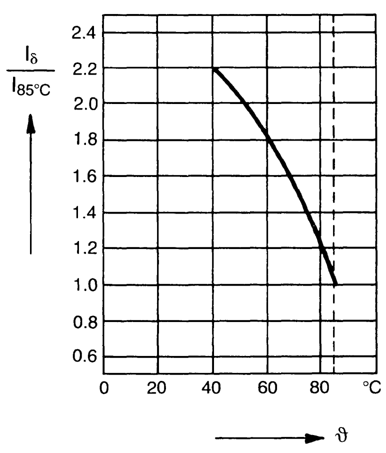


Life Expectancy X Temperature



Relative failure rate ≤ 1%
(during load duration)

Typical value for the relation
total failure/failure due to variation 10/90



Variation of
max. Ripple
Current as
a function
of temperature.

Rated Voltage Surage Voltage		10V/13V	16V/20V	25V/32V	63V/79V
Capacity μF	Tol.	Maximum Dimensions = D x L mm/inches			
0.1					5.5x12 .217x.472
0.15					5.5x12 .217x.472
0.22					5.5x12 .217x.472
0.33					5.5x12 .217x.472
0.47					5.5x12 .217x.472
0.68					5.5x12 .217x.472
1.0	±20%				5.5x12 .217x.472
1.5					5.5x12 .217x.472
2.2					5.5x12 .217x.472
3.3				5.5x12 .217x.472	6.8x12 .268x.531
4.7				5.5x12 .217x.472	6.8x12 .268x.581
6.8			5.5x12 .217x.472	6.8x12 .268x.531	8.5x13.5 .335x.581
10.0			5.5x12 .217x.472	6.8x12 .268x.531	8.5x13.5 .335x.581
15.0			5.5x12 .217x.472	6.8x12 .268x.531	
22.0			6.8x12 .268x.531	8.5x13.5 .335x.581	
33.0			6.8x12 .268x.531	8.5x13.5 .335x.581	
47.0		6.8x12 .268x.531	8.5x13.5 .335x.581		
100.0		8.5x13.5 .335x.581			

U_N (V)	C_R (F)	Cap. Tol. (120 Hz/ +20°C)	Dissipation Factor tgδ max (120 Hz/ +20°C)	Z max 100kHz/ 20°C (Ω)	Leakage Current IR max (5 min, + 20°C) (μA)	Ripple Current IN rms max (85°C, 10 to 100kHz (mA)	Basic Dimensions mm	
							D (Ø)	L
10	1000		0.10	0.09	22.0	1950	16	31.5
	2200		0.12	0.06	46.0	2800	18	31.5
16	100		0.08	0.25	5.2	500	10	20
	220		0.08	0.17	9.0	900	12.5	25
	330		0.08	0.17	12.6	900	12.5	25
	470		0.08	0.10	17.0	1250	16	25
	1000		0.08	0.06	34.0	2200	18	31.5
	2200		0.10	0.05	72.4	2800	18	35
25	47		0.06	0.25	4.4	500	10	20
	220		0.06	0.10	13.0	1250	16	25
	330		0.06	0.09	18.5	1600	16	31.5
	470	+20%	0.06	0.06	25.5	2200	18	31.5
	1000	≡ M	0.06	0.05	52.0	3000	18	35
40	33		0.06	0.25	4.7	500	10	20
	100		0.06	0.17	10.0	900	12.5	25
	220		0.06	0.09	19.6	1350	16	31.5
	330		0.06	0.06	28.4	2200	18	31.5
	470		0.06	0.05	39.6	3000	18	35
63	22		0.05	0.25	4.8	650	12.5	25
	33		0.05	0.17	6.2	650	12.5	25
	47		0.05	0.17	7.9	700	12.5	25
	100		0.05	0.09	14.6	1350	16	31,5
	220		0.05	0.06	29.8	2300	18	31.5

Life test

Conditions: 2000h/85°C/U_R or 1000h/95°C/U_R or 500/105°C/U_R

Evaluation:
|ΔC/C| ≤ 20% of value initially measured
tg∂ ≤ 2 times the initial limit
I_R ≤ than the initial limit
Z ≤2 times the initial limit

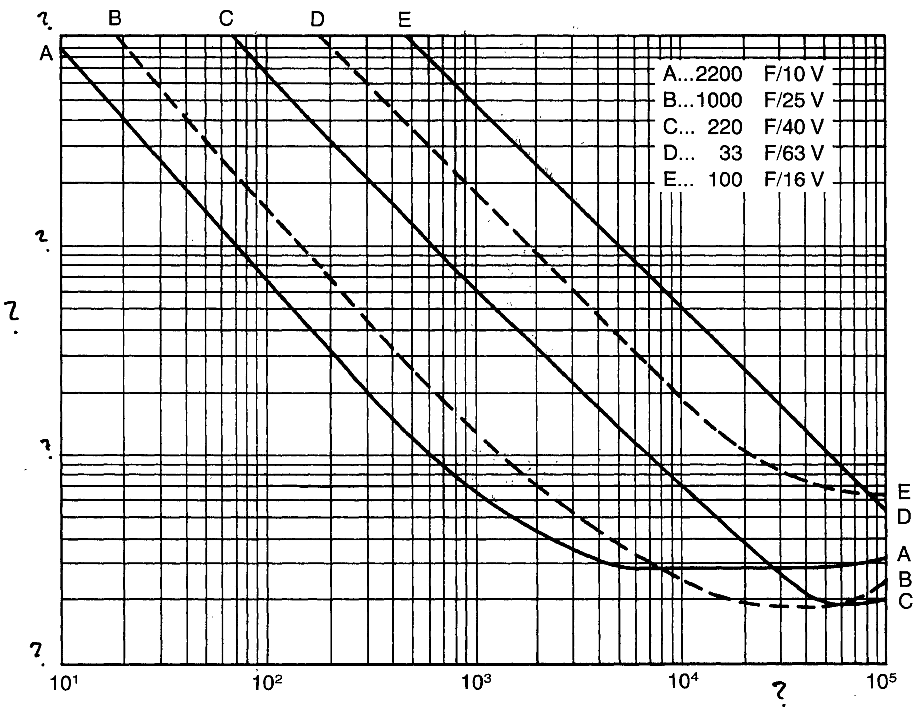
Storage test

Conditions: 1000h/85°C/OV

Evaluation:
|ΔC/C| ≤ 20% of value initially measured
tg∂ ≤ 2 times the initial limit
I_R ≤ than the initial limit
Z ≤2 times the initial limit

Pre-treatment Measurement takes place after the rated voltage has been applied to the capacitor for 30 minutes, using a resistor of 1000Ω. After that, the capacitor must be stabilized for 24 to 48 hours at rated temperature.

Typical values – impedance x frequency



The climatic categories for electrical components in accordance with DIN 40 040, para. 3, designate the minimum and maximum category temperatures as well as the humidity category of the component by three subsequent code letters (see page 43). The capacitors dealt with in this data book are assigned to both the groups:

STYROFLEX capacitors (maximum category temperature 70 °C/158 °F)
Polypropylene capacitors (max. category temperature 85 °C/185 °F)

according to the summary of types, i.e. at first, the unprotected types and at last the protected or sealed types are quoted.

2.1. STYROFLEX capacitors (maximum category temperature 70 °C/158 °F

2.1.1. Unprotected standard capacitors, meeting normal climatic requirements (humidity category G) page 55

Standard capacitors are used in large quantities for all electronic apparatus and equipment, where close capacitance tolerances, a low dissipation factor tan δ, and high capacitance stability are required.

Whereas all other STYROFLEX and polypropylene capacitors are tubular winding performances, this group also includes flat winding versions, such as B31112 and B31113.

2.1.2. Unprotected high reliability capacitors throughout normal climatic requirements (humidity category G) page 69

High reliability capacitors are used for all apparatus and equipment of high operational reliability and long service life expectancy.

Apart from tests for capacitance and dielectric strength the capacitors are subjected to severer test conditions regarding insulation resistance and dissipation factor. In addition, these capacitors have an improved capacitance drift i_z characteristic due to a pre-treatment with temperature cycles throughout the total temperature range.

Some of the high reliability types are available for two different minimum category temperatures.

2.1.3. Protected high reliability capacitors in plastic case, meeting medium climatic requirements (humidity category E) page 81

The face-contacted wound unit of the high reliability capacitors, encapsulated in epoxy resin sealed plastic cases, are additionally protected against moisture, thus meeting high humidity requirements, (humidity category E). They are, moreover, outstanding for low losses.

2.1.4. Sealed high reliability capacitors, meeting high climatic requirements (humidity category C) page 87

The windings of sealed capacitors are not subject to humidity influences of the environmental conditions. The capacitance is humidity independent. Moreover, improved values particularly for load duration and failure quota are obtained. The insulation performance, especially at increased moisture, is mainly determined by the feed-throughs and their surface leakage paths. Parallel resistances arising because of dew precipitation or hoarfrost cause a decrease in the insulation resistance or an increased dissipation factor.

Special details of the capacitor terminations are shown in the dimensional drawings on the data sheets. Reliable contact is provided by the foil or lead connections on the capacitor electrodes. They comply with DIN 41380, part 3 and 4, para. 3.8.1., such that a low electrical transfer resistance is guaranteed even at very low voltages.

5. Capacitance

5.1. Rated capacitance C_R and capacitance measurement

The rated capacitance C_R of a capacitor is the value which is indicated upon it.

Unless otherwise stated, the capacitance is measured under the following conditions:

Temperature	15 to 35 °C/59 to 95 °F
Relative humidity	45 to 75%
Air pressure	860 to 1,060 mbar

The capacitance is measured by means of a measuring bridge suitable to measure the series equivalent circuit. The uncertainty in measurement including the harmonic content and interference voltages should not exceed 10% of the deviation allowed for the specimen or 0,1% of the capacitance. The greater value applies; minimum value, however, not below 0,5 pF.

For closely tolerated capacitance ratings, the measured capacitance is translated by means of the temperature coefficient α_c of the relevant type into the reference temperature of 23 °C/73,4 °F.

Preferred measuring frequencies are:

for $C_R \leqq 1{,}000$ pF	100 kHz
for $C_R > 1{,}000$ pF	1 kHz

The measuring voltage shall not exceed 20 V.

For capacitors with electrically disconnected metal case, measurement is performed symmetrically with the case being grounded.

The capacitance mainly depends on the following influences:

Temperature	see para. 5.4., page 33
Humidity	see para. 5.5., page 34
Time	see para. 5.7. and para. 5.8., page 35 and 36.

In cases of doubt, the capacitance shall be measured in accordance with DIN specification 40046, part 2, November 1974, after pretreatment acc. to table 3, at the conditions of table 5, as follows:

(23 ± 1) °C (73,4 ± 1,8) °F; (50 ± 2) % relative humidity (860 to 1060) mbar.

5.2. Rated capacitance C_R, E series and tolerances

The ranges of rated capacitances C_R and tolerances available are indicated for each capacitor type. For all capacitors > 10 pF, preferred series are indicated, i.e. the E series complying with DIN 41426 and IEC publication 63 (1963).

E 6	E 12	E 24	E 48	E 96	E 192	E 6	E 12	E 24	E 48	E 96	E 192
			316	316	316						
					320		560	560			
				324	324				562	562	562
					328						569
330	330	330								576	576
			332	332	332						583
					336				590	590	590
				340	340						597
					344					604	604
			348	348	348						612
					352				619	619	619
				357	357			620			
			360								626
					361					634	634
			365	365	365						642
					370				649	649	649
				374	374						657
					379					665	665
			383	383	383						673
					388	680	680	680			
	390	390							681	681	681
				392	392						690
					397					698	698
			402	402	402						706
					407				715	715	715
				412	412						723
					417					732	732
			422	422	422						741
					427			750	750	750	750
		430									759
				432	432					768	768
					437						777
			442	442	442				787	787	787
					448						796
				453	453					806	806
					459						816
			464	464	464		820	820			
					470				825	825	825
470	470	470									835
				475	475					845	845
					481						856
			487	487	487				866	866	866
					493						876
				499	499					887	887
					505						898
		510							909	909	909
			511	511	511			910			
					517						920
				523	523					931	931
					530						942
			536	536	536				953	953	953
					542						965
				549	549					976	976
					556						988

2nd Example:

A capacitance of 78,712 pF has been calculated for a coupling capacitor. A capacitance tolerance of ± 10% is adequate for this application. The next E values of the E 24 series are 75,000 and 82,000 pF. The value 75,000 pF with the tolerance of ± 5% meets the tolerance requirement of ± 10% for the above stated, calculated value.

5.4. Temperature dependence of the capacitance, temperature coefficient α_c

The temperature coefficient α_c is defined in accordance with DIN 41380, part 3 and 4, para 2.7.4. (edition 2.78) as follows:

$$\alpha_c = \frac{C_2 - C_1}{C_3 \cdot (\vartheta_2 - \vartheta_1)}$$

C_1 = capacitance at temperature ϑ_1
C_2 = capacitance at temperature ϑ_2
C_3 = reference capacitance at (25 ± 10)°C/(77 ± 18)°F

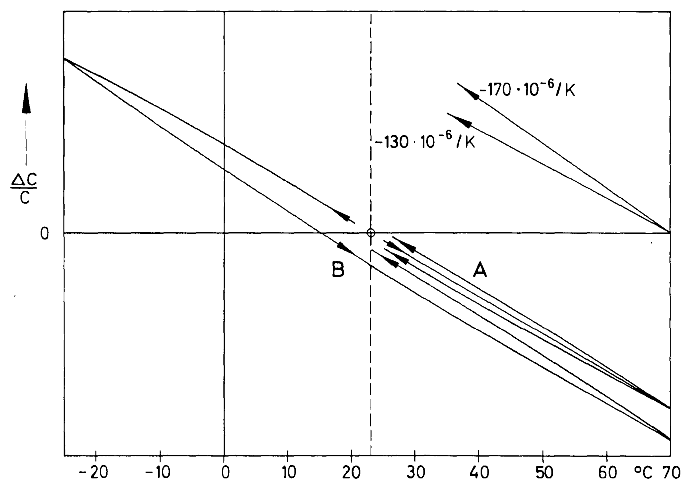
} uniform data in 10^{-6}/K

The temperature coefficient is mainly determined by the characteristics of the dielectric film, the capacitor design and the deviation due to the production process.

The measuring conditions are contained in DIN 41380, part 3, para. 5.4.3.1. and part 4 para. 5.3.3.1.

The stated values are typical values.

Capacitance change versus temperature for a "pre-aged" STYROFLEX capacitor



The point of regression of a temperature cycle between room temperature and the maximum limit temperature (curve A) can lie above or below the point of origin.

A temperature curve from 23 °C (73,4 °F) via −25 °C (−13 °F) to +70 °C (+158 °F) and back to room temperature is plotted in curve B. The compensation error is the difference between the original capacitance value and the value after passing the temperature cycle. The more frequently the positive part of the temperature range has been passed, the closer the point of regression and the point of origin can be approached.

In accordance with humidity diffusion the moisturing and drying process is time-dependent, the time constant being between approx. ½ day (e.g. for 7 and 10 hours for unprotected types) and several weeks (e.g. for protected capacitors).

The capacitance of sealed capacitors is not subject to influences of moisture.

5.6. Frequency dependence of capacitance

The capacitance of the capacitors is practically independent of frequency. Closely below the self resonant characteristic of the capacitors (see para. 9) the self inductance causes and additional decrease in impedance. It's effect is like an increase in capacitance (see also equivalent circuit diagram, para. 6).

5.7. Capacitance drift i_z

The drift values

$$|i_z| = \frac{\Delta C}{C}$$

stated for the individual capacitor types are typical values. They are indicated in pF in per cent of the rated capacitance and mostly with an additive part. The vertical lines on the right and left hand position of i_z means that absolute values are dealt with, i.e. the values can be positive or negative. The drift values are valid for rated capacitances > 100 pF. The reversible influences of temperature and humidity variations α_c and β_c are not contained in the i_z value.

The values are referred to +40 °C/+104 °F and to the load duration of the climatic category stated on the data sheets (in most cases 100,000 hours; see para. 16.4.). No load duration is indicated for standard type capacitors; in this case, the capacitance drift is referenced to a period of 2 years. Frequent and large temperature changes at the upper category of the permitted temperature and relative humidity may increase the indicated drift values.

If one capacitance value is available with two different rated voltages U_R, the capacitor type being the same, the winding with the higher rated voltage generally shows a more favorable drift since its dielectric volume part is higher.

The drift which is caused by operation at changing temperatures, has been improved by determined temperature cycles performed during the manufacturing process. Number and temperature limit values are dependent on type and climatic category.

If the lower category temperature of STYROFLEX or polypropylene capacitors lies above the lowest transport temperature of −40°C/−40°F, then falling below the minimum category temperature ϑ_{min} may cause the following capacitance changes:

Minimum category temperature		Capacitance change
ϑ_{min}	Code letter	
−10 °C/+14 °F	J	±(0,3%+0,2 pF)
−25 °C/−13 °F	H	±(0,2%+0,2 pF)

6.2. Temperature and moisture influences

The dissipation factor values can be caused to increase because of influences of moisture, whereas influences of temperature can be neglected.

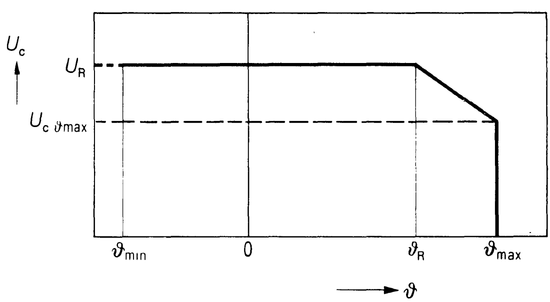
If the capacitor temperature increases when the apparatus starts operation, the capacitor could possibly be dried out resulting in a decreased dissipation factor.

6.3. Voltage dependence

The dissipation factor of STYROFLEX and Polypropylene capacitors is not dependent on voltage.

7. Electrical power rating

The designations and definitions for the voltages permitted for a capacitor are determined in the DIN specification 41380 part 3 and 4 (Febr. 1978) and are explained in the following diagram:



7.1. Rated voltage U_R DIN 45 910, para. 2.2.12.
Rated temperature ϑ_R DIN 45 910, para. 2.2.13.

The rated voltage U_R is the maximum dc voltage which may continuously be applied to the terminals of a capacitor at any temperature between the lower category temperature ϑ_{min} (see para. 7.2.) and the rated temperature ϑ_R.

The rated temperature ϑ_R is the max. permissible ambient temperature, at which the rated voltage U_R may continuously be applied.

The rated voltage U_R and the rated temperature ϑ_R of STYROFLEX capacitors refer to a surface temperature of 40 °C/104 °F, of some other types also to 70 °C/158 °F and those of polypropylene capacitors to 85 °C/185 °F.

The rated voltage U_R of unprotected capacitors can be indicated by an uncoded legend or a color ring on the terminal side of the outer layer according to the following schematic:

Rated voltage U_R	25 V	63 V	160 V	250 V	630 V
Color ring	blue	yellow	red	green	black

Up to the rated temperature ϑ_R, it is I_{max} (maximum rms alternating current); for temperatures above the rated temperature, the following derating factors apply:

Temperature		Derating factor for the maximum rms alternating current I_{max}	
		STYROFLEX	Polypropylene
40 °C/104 °F	Rated temperature ϑ_R	1,0	1,0
50 °C/122 °F 60 °C/140 °F 70 °C/158 °F		0,85 0,7 –	0,9 0,8 0,7
70 °C/158 °F 85 °C/185 °F	Maximum category temperature	0,5 –	– 0,4

7.6. Maximum frequency f_c

The maximum frequency f_c, from which on the category current I_c is the decisive factor – and no longer the permitted alternating voltage – is given in the following equation:

$$f_c = \frac{I_c}{2\pi \cdot C \cdot U_c}$$

8. Insulation resistance R_i

8.1. of unprotected capacitors

The insulation resistance of unprotected capacitors depends on the capacitor temperature and the relative humidity. With increasing temperature and constant absolute humidity, the relative air humidity decreases, the capacitor dries out, and the drying process results in an increased insulation resistance starting at the value given.

Measurement is performed at:

$U_R < 100$ V with 10 ± 1 V
$U_R \geqq 100$ V with 100 ± 15 V.

The data sheets include the insulation resistance R_i which is attained by 98% of the capacitors.

8.2. of sealed capacitors

The insulation resistance of sealed capacitors in metal cases mainly depends on the leakage paths of the feed-throughs used for the terminations. The minimum values of the insulation resistances are contained in the individual capacitor data.

11. Coupling capacitance

For applications, where low capacitance of the outer layer to ground or to adjacent parts (coupling capacitance) is required, unprotected small types are recommended. Moreover, the coupling capacitance can be reduced with construction aids during the assembly of the capacitors.

In order to avoid deviating capacitances, types in metal cases with separate ground connection can be used.

12. Low air pressure

With reduced air pressure the dielectric strength of the insulated feed-throughs of sealed capacitors and connecting elements within the windings of unprotected types is reduced. Unprotected types can be used without voltage derating down to 500 mbar (400 torr) (7 km altitude, above NSL).

13. Vibration

The resistance to vibrations and shocks is defined in accordance with DIN 40046, part 8 (July 1970). For this test, axial-leaded capacitors must be clamped or soldered with 6 mm long straight leads. They are subsequently tested in three orthogonal directions. If not otherwise stated in the individual capacitor data, the vibration is performed in accordance with DIN 40046, sheet 8, and IEC publication 68-2-6, test F_c, vibration, partial test B 1, 3 × 30 min. at 10 to 55 Hz with a displacement amplitude of 0,35 mm, which conforms to a maximum acceleration of 49 m/s^2 (5 *g*).

14. Solder conditions for the user

The plastic dielectric determines the upper category temperature of the capacitors. Heating above this category temperature is of influence on the plastic and hence the electrical data of the capacitor. Undue heating can damage the capacitor.

During every soldering process heat flows into the winding via the leads to be soldered. Care has been taken by design measures to keep the influence of the flowing-in heat on the capacitors as low as possible.

If suitable measures, such as fan cooling (also after the soldering process), increased distance, solder resist materials etc. are provided, a soldering temperature of max. 265 °C/509 °F and a duration of 5 ± 1 sec. will usually be adequate for soldering. A solder duration of max. 3 sec. is recommended for STYROFLEX capacitors with leads directly fed into its active region (B 31110, B 31112, B 31113, and B 31310).

The capacitance of the capacitors can possibly be affected by certain solutions of the fluxing agent.

It is, therefore, recommended:

1. to provide for steam escapage and exhaustion during the soldering process.
2. not to adjust the resonent circuit directly after the soldering process.

Because of their higher category temperature, polypropylene capacitors are less sensitive to temperature requirements during the soldering process.

16. Climatic categories and reference reliability

16.1. Climatic categories in accordance with DIN 40040, Febr. 1973

The climatic category is that range of climatic requirements for which a component was designed. It is coded with three letters as can be seen from the table below. Separated by a slash, two code letters follow for high reliability capacitors indicating the reliability (see para. 16.2.).

1st code letter	Minimum category temperature ϑ_{min}
F	−55 °C/−67 °F
G	−40 °C/−40 °F
H	−25 °C/−13 °F
J	−10 °C/+14 °F

2nd code letter	Maximum category temperature ϑ_{max}
P	85 °C/185 °F
S	70 °C/158 °F

3rd code letter	Limits of relative humidity[1] Max. values: Annual average	for 30 days per year continuously[2]	for 60 days per year continuously[2]	for the remaining days occasionally[3]	Remarks
C	≦95%	100%	–	100%	dew precipitation permitted
R	≦90%	100%	–	95%	
D	≦80%	100%	–	90%	
E	≦75%	95%	–	85%	rare and slight dew precipitation
F	≦75%	95%	–	85%	without dew precipitation
G	≦65%	–	85%	75%	

16.2. Reference reliability

The reliability of a component is determined by the failures probably to be expected after a defined period of time from a sufficiently large batch.

Data on the reference reliability is only given on the appropriate data sheets for high reliability capacitors.

[1]) For reference temperatures see diagram in appendix II of DIN 40040.
[2]) These days should be reasonably distributed throughout the year.
[3]) Keeping the annual average.
[4]) May occur at short openings of apparatus installed outdoors.

16.4. Load duration

The load duration is the sum of: operating times, intermittent periods, storage, measuring and test times (at the user), transport times

The load duration for high reliability STYROFLEX and polypropylene capacitors generally amounts to 10^5 hours (11,4 years). This is defined with the second code letter after the climatic category, i.e. the 5th code letter "R".

16.5. Example for coding the DIN climatic category and reliability

	HSG/LR	
Minimum category temperature ϑ_{min}	**H**	− 25 °C/− 13 °F
Maximum category temperature ϑ_{max}	**S**	+ 70 °C/+ 158 °F
Humidity category:	**G**	
relative humidity		
annual average		≦ 65%
60 days per year		85%
on the remaining days		75%
Failure quota:		
Failures per 10^9 component hours	**L**	300 fit
Load duration:	**R**	10^5 h

16.6. IEC climatic category complying with IEC publication 68-1 and DIN 40045 (Jan. 1969).

The IEC climatic category is indicated by three figures separated by slashes from each other.

Example: **25/070/04**

1st figure negative temperature in degrees Celsius for the cold test (complies with the lower category temperature ϑ_{min}) (2 hours)

2nd figure temperature in degrees Celsius for damp heat test (complies with the upper category temperature ϑ_{max}) (16 hours)

3rd figure Number of days for the humidity test with 92% rel. humidity at 40 °C/104 °F.

The number of days for the duration of the humidity test as indicated in the test category (in accordance with IEC publication 68-1) is determined such that after this period, the change in the electrical values resulting from the influence of humidity, has reached its final state. Prolongation of the humidity test is permissible.

The following preferred groups for STYROFLEX capacitors are quoted in the IEC publication 275:

55/085/56	10/070/21
25/070/56	10/070/04

The permitted category values after the humidity test are indicated on the data sheets. The changes due to humidity are reversible.

19. Standards and instructions

STYROFLEX and polypropylene capacitors are manufactured largely in accordance with international and German specifications. Deviations from DIN 41380, part 3 and 4, are pointed out in the general technical data.

19.1. Fundamental standards

The fundamental international recommandation for STYROFLEX capacitors is the

IEC publ. 384-7	Fixed polystyrene film dielectric direct current capacitors, edition 1978.

The corresponding German standard is:

DIN 41380, part 3	Polystyrene film dielectric capacitors up to 1000 Vdc; technical terms and tests; KS capacitors (edition Feb. 78).

For polypropylene capacitors the

DIN 41380, part 4	Polystyrene film dielectric capacitors up to 1000 Vdc; technical terms and tests; KP capacitors (edition Feb. 78).

Differences in comparison with the IEC publications are marked accordingly.

19.2. Special standards for components

Siemens capacitors in accordance with DIN type specifications are listed on page 23 of the data book.

19.3. Other standards

IEC publ. 68-1 and 3	Basic environmental testing procedures.
CECC 30000, DIN 45910 } Edit. 2	Generic specification: Fixed capacitors (edition July 1976).
VDE 0560, part 1	General regulations on capacitors (edition December 1969).
VDE 0560, part 18	Rules for plastic film capacitors (edition April 1966).
DIN 40040	Applicability classes and reliability figures for components of telecommunications and electronics (edition February 1973).
DIN 40045	Guide lines for the determination of climatic test categories for electrical components of telecommunications systems (edition January 1969).
DIN 40046, part 1 to part 31	Environmental testing for electrical engineering.
DIN 40080 (tentative standard)	Sampling procedures and tables for inspection by attributes (edition 1979)
DIN 40810 (draft)	Packaging of electronic components on continuous tapes (edition March 1974).

22. Part number, ordering code

Siemens has introduced part numbers for all its technical products in order to expedite procedures such as ordering and supplying, by means of data processing equipment. These part numbers are stated on data sheets, in data books, as well as in short form catalogs, thus clearly identifying any deliverable component. In the following paragraphs the construction of part numbers and their 15 digits is explained.

Orders can be settled easier and faster, when the customer indicates the part number. For some types, however, it is impossible, to give complete part numbers in our information materials; however, the coding method is indicated, so that the client can code the part number by himself.

As far as the coding method remains unclear, it is better to place the order uncoded (clear text). Since the coded designation is necessary for the internal settlement, the coding will then be performed by Siemens, so that all types are supplied according to a coded part number.

22.1. Construction of the part number

Digit position	1	2	3	4	5	6		7	8	9	10	11		12	13	14	15
	B						–						–				
	1st block							2nd block						3rd block			

In order to facilitate the legibility, the part number comprising 15 digits, has been separated into 3 blocks of 6, 5 and 4 digits, the blocks being joined by a hyphen. Each of the three blocks begins with a letter, whereas all other digits are Arabic figures. In case of collecting numbers, the letters are indicated with the special sign "+" and figures with "*".

22.2. Digit 1 to 6 (type number)

For passive components, the first block starts with the letter "B". Together with the following 5 figures the first block is to be understood as "type number" or B-number, dividing the passive devices into groups for instance STYROFLEX capacitors, resistors, SIFERRIT material etc.

22.3. Digit 7 (revision status)

In some fields of components, extended technical davelopments often result in improve-revision status, which can be changed for unimportant variations into the next following letter of the alphabet.

In some fields of components, extended technical developments often result in improvements, e.g. smaller dimensions. Some of the users are very interested in this miniaturization and its determination in the part number with respect to new constructions, whereas other users producing mainly unchanged apparatus over many years, also want to apply components with smaller dimensions, but are interested in an unchanged components designation.

Siemens has therefore compromised as follows:

So-called "insignificant" variations which don't impair the previous application, are marked in the 7th digit with a new revision status code letter. A change of the code letter into a letter, late in the alphabet, specifies the component as being able to replace a component marked with a previous code letter.

If only the digit position 13 is held by a figure (except of "0"), position 14 and position 15 must also be designated with "0" or any other value. In case, all positions behind data position 12 are only "0" they will be omitted.

The following apply for coding the capacitance values in the 2nd and 3rd data block:

	Coding: →	Decoding: ←	
6,30 pF =		= 06,30 · 10^0 pF =	– + *060 – +30*
12,50 pF =		= 12,50 · 10^0 pF =	– + *120 – +50*
160 pF =		= 16 · 10^1 pF =	– + *161 – +*
137,50 pF =		= 13,75 · 10^1 pF =	– + *131 – +75*
3,15 nF =	3 150 pF	= 31,50 · 10^2 pF =	– + *312 – +50*
8765 pF =		= 87,65 · 10^2 pF =	– + *872 – +65*
0,01 µF =	10 000 pF	= 10 · 10^3 pF =	– + *103 – +*
45,50 nF =	45 500 pF	= 45,50 · 10^3 pF =	– + *453 – +50*
0,33 µF =	330 000 pF	= 33 · 10^4 pF =	– + *334 – +*

In accordance with the Siemens regulations, a variable figure is marked by a "*", in this case the code figure for the rated voltage (refer to para. 23.4.), and a special code figure (refer to para. 23.6.). A code letter is replaced by "+", coding the 12th data position, the tolerance.

The tolerance code letters available are to be found on page 32, para. 5.2.

22.6. Digit 15 (special versions)

By means of this code figure, different versions or special characteristics of types are distinguished. The meaning of this code figure is stated for the actual types. A 7 in this digit position designates types packaged on continuous tapes; a 6 is provided for capacitors wound on a cylinder (see page 47, para. 19.). If there is not any defined statement to be made in position 15, a "zero" has to appear in position 15.

23. Examples for the compiling of part numbers

A DIN specification for an axial-leaded capacitor of climatic category HSG (−25 °C to +70 °C/−13 °F to +158 °F, high reliability version) is in accordance with para. 9 of the DIN standard 41380, part 3, Feb. 78, set up as follows:

Example of designation:

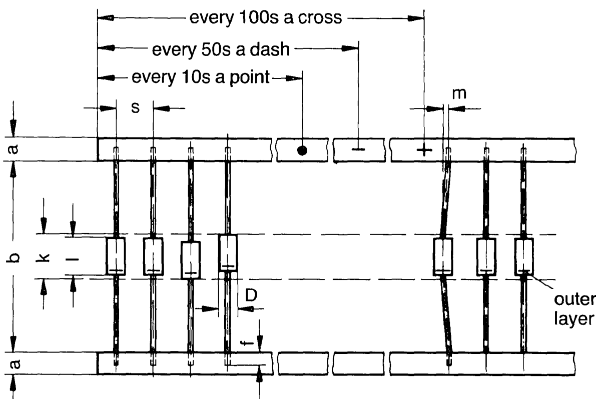
KS capacitor DIN 41343 – A 22600 – 2 – 160 FSG

- DIN 41343: Type specification
- A: Type
- 22600: Rated capacitance in pF or µF
- 2: Capacitance tolerance
- 160: Rated voltage in V
- FSG: Climatic category

General information

We provide taped versions with axial and radial leads tailored to automatic assembly of equipment. Taping of capacitors with axial leads is based on IEC Publication 286-1; taping of types with radial leads is done in accordance with the latest and probably final state of the IEC Standard.

Taping of axial capacitors types:
B 31063, B 31861 . . . 864 as well as B 33062 and B 33063



f = 3,5 min. a = 6,0$_{\pm 0,5}$
m = 1,2 max.

Diameter $D_{max.}$ mm	Standard spacing between capacitors: Spacing s mm	Standard spacing between capacitors: Tolerance over 10 spacing Δs mm
≤ 4,9	5$_{\pm 0,5}$	±1
> 4,9...9,8	10$_{\pm 0,5}$	±2
> 9,8...14,7	15$_{\pm 0,5}$	±3
>14,7...19,0	20$_{\pm 1,0}$	±4

Length $l_{-1,5}$ mm	Body window k mm	Tape spacing $b_{\pm 2}$ mm
11,0...13,5	$l_{max.} + ^{1,4}$	63
16,5; 18,5		68
21,5; 23,5		73
31,5		83

Minimum order quantity

a) Reel packing

Capacitor body diameter $D_{max.}$	Minimum quantity per reel
> 3,9 bis ≤ 4,9	3000
> 4,9 bis ≤ 6,0	1500
> 6,0 bis ≤ 7,0	1250
> 7,0 bis ≤ 8,5	1000
> 8,5 bis ≤ 9,8	800
> 9,8 bis ≤ 11,5	500
> 11,5 bis ≤ 13,0	400
> 13,0 bis ≤ 14,7	300
> 14,7 bis ≤ 19,0	on request

Ordering code: B 31063-B 1223-J6, where “6” means reel packing.

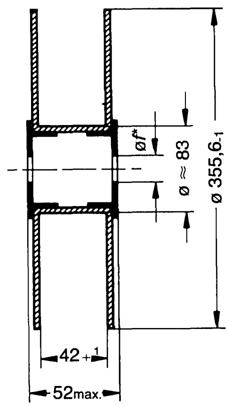
b) Carton packing (AMMO-Pack)

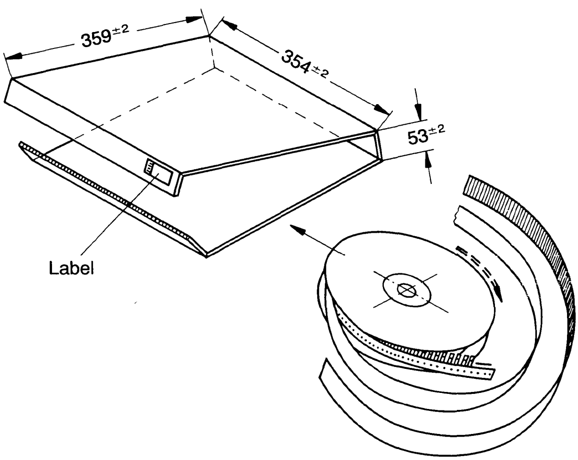
Capacitor body diameter $D_{max.}$	Minimum quantity per carton
> 3,9 bis ≤ 4,9	7000
> 4,9 bis ≤ 6,0	4000
> 6,0 bis ≤ 7,0	3000
> 7,0 bis ≤ 8,5	2000
> 8,5 bis ≤ 9,8	1500
> 9,8 bis ≤ 11,5	1000
> 11,5 bis ≤ 13,0	800
> 13,0 bis ≤ 14,7	600
> 14,7 bis ≤ 19,0	on request

Ordering code: B 33063-B 1332-H7, where “7” means AMMO-Pack

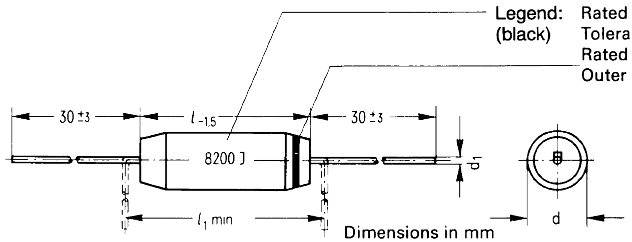
Minimum order quantity
Minimum quantity = 1000 reel

Ordering code: B 33061-Z 1392-H6





*) old: ø f = 16.5 ± 1 mm
new: ø f = 30 ±1 mm



Length $l_{-1.5}$	l_1 min.	d_1
11.5	15	0.6
16.5	20	
21.5	25	0.8
31.5	35	

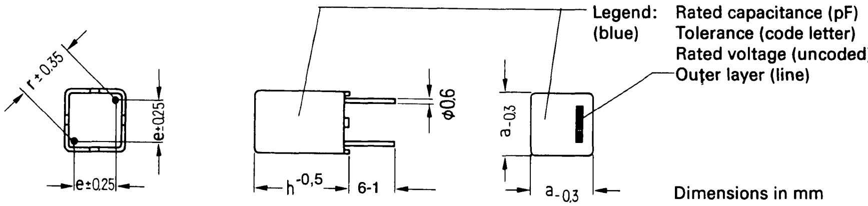
Rated voltage U_R Color ring			**160 V** red	**630 V** black
			Type with coded revision status and rated voltage	
			B31063-B1	B31063-A6
Rated capacitance C_R pF	Tolerance		**Dimensions** dia d_{max} x length l	
2 to <10	±1 pF = F			5.8 x 11.5
10 to 20	±1 pF = F		4.0 x 11.5	5.8 x 11.5
> 20 to 30	±1 pF = F	±5% = J	4.0 x 11.5	5.8 x 11.5
> 30 to 39	±1 pF = F	±5% = J	4.5 x 11.5	5.8 x 11.5
> 39 to 220	±2.5% = H	±5% = J	4.5 x 11.5	5.8 x 11.5
> 220 to 330	±2.5% = H	±5% = J	4.5 x 11.5	6.2 x 11.5
> 330 to 470	±2.5% = H	±5% = J	4.5 x 11.5	6.6 x 11.5
> 470 to 680	±2.5% = H	±5% = J	4.5 x 11.5	7.4 x 11.5
> 680 to 1000	±2.5% = H	±5% = J	4.7 x 11.5	8.5 x 11.5
> 1000 to 1500	±2.5% = H	±5% = J	5.2 x 11.5	7.6 x 21.5
> 1500 to 2200	±2.5% = H	±5% = J	5.8 x 11.5	8.4 x 21.5
> 2200 to 3300	±2.5% = H	±5% = J	6.7 x 11.5	9.5 x 21.5
> 3300 to 4700	±2.5% = H	±5% = J	7.6 x 11.5	10.8 x 21.5
> 4700 to 6800	±2.5% = H	±5% = J	6.9 x 16.5	10.0 x 31.5
> 6800 to 10000	±2.5% = H	±5% = J	8.0 x 16.5	11.5 x 31.5
>10000 to 15000	±2.5% = H	±5% = J	8.8 x 31.5	13.5 x 31.5
>15000 to 22000	±2.5% = H	±5% = J	10.2 x 21.5	
>22000 to 27000	±2.5% = H	±5% = J	11.2 x 21.5	

Ordering code example: B 3 1 0 6 3 - B 1 2 2 3 - J

STYROFLEX capacitor B 31063
22000 pF±5% 160 V HSG or
KS capacitor
DIN 44126-A 22000-5-160 HSG
For ordering information refer to page 51 to 54.

E-series available: E 6, E 12 and E 24 (see page 30).
The E-6 values are preferred values.

The dimensions apply to the greatest capacitance value.
Diameters for lower capacitance values can be interpolated.



Dimensions in mm

Rated voltage U_R	63 V						
Type with code for revision status and rated voltage	Rated capacitance C_R		Dimensions				
	pF	Tolerance	*a*	*h*	*e*	*r*
B31531-B5	100 to 7500	± 2,5% ≙ H ± 1% ≙ F	6,3	10,5	5,08	7,2
	> 7500 to 15 000		7,5	12,5		
	> 15 000 to 33 000		10,0		7,62	10,75
	> 33 000 to **56 000**		12,5		10,16	14,35

Ordering code example:

B 3 1 5 3 1 - B 5 5 6 3 - F

STYROFLEX capacitor B31531 56000 pF± 1% 63 V GSE

For ordering information refer to page 51 to 54.

E-series available: E 24, E 48, and E 96 (see page 30).
The E 24 values are preferred values.

Ordering code example

B 33062–B1222–J9

- Type
- Revision status
- Rated voltage
  1 ≙ 160 V dc
  6 ≙ 630 V dc
- Index 9 ≙ taped version.
  If no index figure is indicated, a taped or untaped version can be supplied.
- Capacitance tolerance
  J ≙ ± 5%
- Rated capacitance
  222 ≙ 22 × 10^2 = 2200 pF

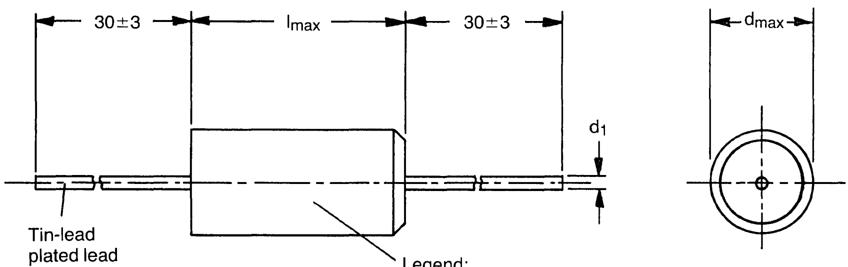
Characteristics

Rated voltage U_R	**160 V dc**	**630 V dc**			
Rated temperature ϑ_R	85°C/185°F	85°C/185°F			
Category voltage U_c (at ϑ_{max})	160 V dc	630 V dc			
Perm. sinusoidal rms ac voltage U_{ac} (at ϑ_R)	65 V	210 V			
l =	**13.5 mm**	**18.5 mm**	**23.5 mm**		
Category current I_c	1.0 A	1.2 A	1.5 A		
DIN climatic category	HPE	Rare and slight dew precipitation permitted			
Lower category temperature	−25°C/−13°F				
Upper category temperature	+85°C/+185°F				
IEC climatic category	25/085/21				
Capacitance change $\Delta C/C$	≦ ± I 0.75% + 0.5 pF I				
Dissipation factor tan δ_F	1.4 times the tabulated value				
Insulation resistance R_{IF} 98%	≧ 5 × 10^4 MΩ				
2%	≧ 10^4 MΩ				
Capacitance drift i_Z	≦ I 0.3% + 0.4 pF I				
Temperature coefficient α_C **of capacitance**	−(100 to 300) × 10^{-6}/K				
Humidity coefficient β_C **of capacitance** for 50 to 95% rel. humidity	+(40 to 100) × 10^{-6} per % rel. humidity				
Dissipation factor tan δ	**≦100 pF**	**...1000 pF**	**...4700 pF**	**...22000 pF**	**>22000 pF**
(in 10^{-3}) ≦ 1 kHz	–	0.2	0.2	0.3	0.5
10 kHz	0.2	0.3	0.3	0.4	0.6
100 kHz	0.3	0.4	0.5	–	–
1000 kHz	0.4	0.7	–	–	–
Insulation resistance R_i 98%	10^5 MΩ				
2%	5 × 10^4 MΩ				
Self-inductance L_s per cm lead and capacitor length	approx. 10 nH				

(cont'd on page 3)

Tubular, axial-leaded capacitor with molded capsule and epoxy end fill.*

The capacitor can be used at temperatures between −40° and +85°C as resonant circuit capacitor in RF, IF and carrier frequency filters (telecommunication) because of its low dissipation factor and sufficiently high stability. Negative temperature coefficient. Best protection against humidity or chemical effects is obtained by the plastic-sealed face ends. Due to an upper category temperature of 85°C (185°F), the capacitor is suitable for use in printed circuits.



Rated capacitance (pF)
Tolerance (code letter)
Rated voltage

Dimensions in mm

Rated voltage U_R 100 V

Type with code for revision status and rated voltage	Rated capacitance C_R pF	Tolerance	Dimensions d	Dimensions l	Dimensions d_1
B33074-A1	100 to 10000			13.0	0.6
	>10000 to 18000	± 5 % = J	6.4		
	>18000 to 33000	± 2.5 % = H		15.0	
	>33000 to 68000	± 1 % = F	8.1		0.8
	>68000 to 100000		9.7	19.0	

Ordering code example

B33074-A1222-J6

Type — B33074

Revision status — A

Rated voltage — 1 = 100 V dc

Rated capacitance — 222 = 22 x 10^2 = 2200 pF

Capacitance tolerance — J = ± %

Index 6 = taped version.

*Enclosure Material: Flame Retardant with UL 94V-0 (1.6 mm) certificate, complying with the enclosure requirement of UL-1414.

Polypropylene Capacitors (KP), unprotected, horizontal

standard versions

Suitable for use in RF and IF filters, at operating voltages of 160 V and 630 V and at ambient temperatures up to +85 °C/+185 °F.

U_R	**160 V**	**630 V**			
ϑ_R	85°C/185°F	85°C/185°F			
U_c at ϑ_{max}	160 V	630 V			
Uac	65 V	210 V			
l =	**11,0 mm**	**16,5 mm**	**21,5 mm**		
I_c	1,0 A	1,2 A	1,5 A		
DIN climatic category	GPE	Rare and slight dew precipitation permitted			
ϑ_{min}	– 40°C/– 40°F				
ϑ_{max}	+ 85°C/+ 185°F				
IEC climatic category	40/085/21				
$\lvert \Delta C/C \rvert$	≦(0,75% + 0,5 pF)				
tan δ_F	1,4 times the tabulated value				
R_{iF} 98%	≧5 · 10^4 MΩ				
2%	≧10^4 MΩ				
i_Z [1]	≦(0,3% + 0,4 pF)				
α_C [1]	–(100 to 300) · 10^{-6}/K				
tan δ	**≦100 pF**	**… 1000 pF**	**… 4700 pF**	**… 22000 pF**	**… 100000 pF**
(in 10^{-3}) ≦ 1 kHz	0,1	0,2	0,2	0,3	0,5
10 kHz	0,2	0,3	0,3	0,4	0,7
100 kHz	0,3	0,4	0,5	–	–
1000 kHz	0,4	0,7	–	–	–
R_i 98%	10^5 MΩ				
2%	10^4 MΩ				

[1] For C_R ≧ 100 pF

Polypropylene Capacitors (KP), protected

in square plastic case, high reliability versions

DIN draft 44 392 in preparation

Epoxy resin sealed plastic case (flame retardant in accordance with VL 94 V-0), of low self inductance (> 680 pF due to face contacting). Particularly suitable for use in RF, IF and carrier frequency filters at ambient temperatures up to +85 °C/+185 °F. Due to their square shape they are ideal for use in combination with RM SIFERRIT cores.

U_R ϑ_R U_c at ϑ_{max} Uac	**63 V** 85 °C/185 °F 63 V 25 V		
I_c	1,0 A		
at U_c at 12 V	FPE/LR 300 fit FPE/ZR 150 fit	Rare and slight dew precipitation permitted	

Resistance to vibration
Test F_c: Vibration
partial test B 1
in accordance with
DIN 40046 sheet 8 (7.70)
and IEC publication 68-2-6
"Vibration", edition 1970

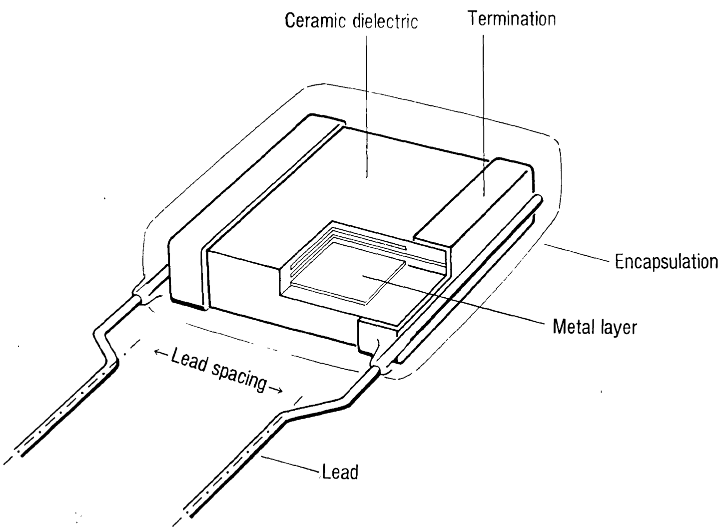
Endurance conditioning:	3 x 120 min.
Frequency range:	10 to 55 Hz
Displacement amplitude:	0,75 mm max. 10 g

ϑ_{min}		-55 °C/-67 °F			
ϑ_{max}		+85 °C/+185 °F			
IEC climatic category		55/085/56			
$\mid \Delta C/C \mid$		≦ (0,75% + 0,75 pF)			
tan δ_F		1,4 times the tabulated value			
R_{iF}	98%	≧ 5 · 10^4 MΩ			
i_z[1]		≦ (0,3% + 0,4 pF)			
α_C[1]		− (80 to 360) · 10^{-6}/K			
tan δ		**≦ 1000 pF**	**... 4700 pF**	**... 22 000 pF**	**... 68 000 pF**
(in 10^{-3})	≦ 1 kHz	0,3	0,3	0,3	0,4
	10 kHz	0,3	0,3	0,4	0,5
	100 kHz	0,4	0,4	–	0,9
	1000 kHz	0,6	–	–	–
R_i	98%	10^5 MΩ			
	2%	5 · 10^4 MΩ			

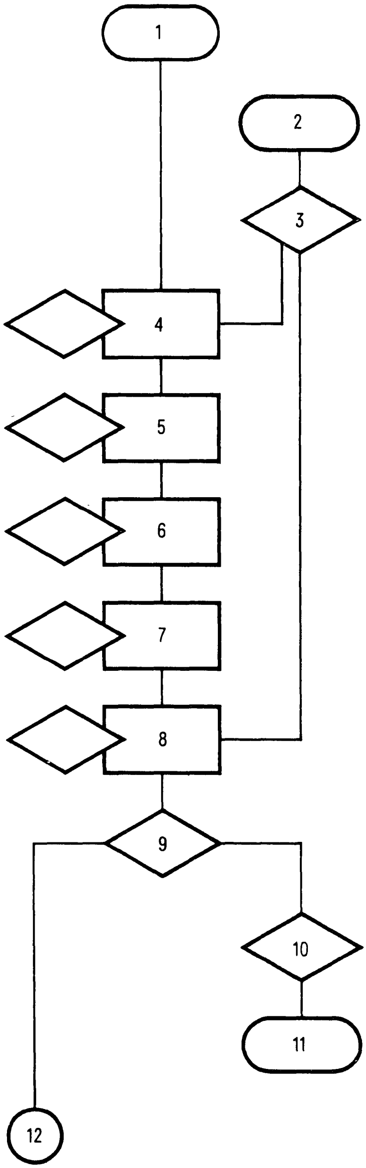
1) For C_R ≧ 680 pF

2.2 Caps

Caps are available with leads brought out in parallel, and epoxy or synthetic resin encapsulation. This type has a spacing bend at each lead in order to exclude dry joints.

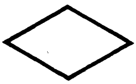
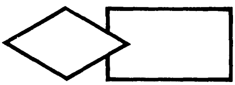


3.2 Chip production



1 Ceramic film storage
2 Incoming raw material
3 Incoming examination
4 Metallization of the ceramic films
5 Stacking the metallized ceramic films
6 Separating the ceramic stacks, checking the electrode position
7 Sintering
8 Contacting the electrodes
9 Electrical test
10 Quality and reliability examination
11 Delivery to shipping warehouse
12 To cap production

Legend

	Production step, process
	Examination, decision
	Production step with process examination
	Start or end of the production process

4.3. X7R chips

Rated capacitance C_R	Rated voltage V_R	EIA standard	Page
100 pF – 22000 pF	50 V dc; 100 V dc	0805	
220 pF – 33000 pF		1005	
1000 pF – 47000 pF		1505	
4700 pF – 100000 pF		1805	
100 pF – 47000 pF		1206	
10000 pF – 180000 pF		1808	
8200 pF – 180000 pF		1210	
33000 pF – 330000 pF		1812	
47000 pF – 680000 pF		2220	

4.4. Z5U chips

Rated capacitance C_R	Rated voltage V_R	EIA standard	Page
1000 pF – 68000 pF	25 V dc; 50 V dc	0805	
1000 pF – 100000 pF		1005	
4700 pF – 150000 pF		1505	
33000 pF – 150000 pF		1805	
10000 pF – 150000 pF		1206	
100000 pF – 470000 pF		1808	
100000 pF – 470000 pF		1210	
100000 pF – 1 μF		1812	
470000 pF – 2.2 μF		2220	

4.7. X7R caps

Rated capacitance C_R	Rated voltage V_R	Dimensions in mm (w x l x t)	Lead spacing	Page
100 pF – 27000 pF 100 pF – 4700 pF	25 V dc, 50 V dc 100 V dc, 200 V dc	5.5 x 5.0 x 2.5	2.5 mm	
27000 pF – 220000 pF 1800 pF – 39000 pF	25 V dc, 50 V dc 100 V dc, 200 V dc	6.5 x 5.0 x 3.2		
100 pF – 27000 pF 100 pF – 4700 pF	25 V dc, 50 V dc 100 V dc, 200 V dc	5.5 x 5.0 x 2.5	5.0 mm	
27000 pF – 220000 pF 1800 pF – 39000 pF	25 V dc, 50 V dc 100 V dc, 200 V dc	6.5 x 5.0 x 3.2		
180000 pF – 1.0 µF 15000 pF – 220000 pF	25 V dc, 50 V dc 100 V dc, 200 V dc	9.0 x 7.5 x 3.8		
820000 pF – 2.2 µF 82000 pF – 470000 pF	25 V dc, 50 V dc 100 V dc, 200 V dc	11.5 x 10.0 x 5.0		
270000 pF – 820000 pF 82000 pF – 120000 pF	50 V dc, 100 V dc 200 V dc	11.5 x 10.0 x 5.0	10 mm	
560000 pF – 2.2 µF 150000 pF – 270000 pF	50 V dc, 100 V dc 200 V dc	14.0 x 12.0 x 5.0		

4.8. Z5U caps

Rated capacitance C_R	Rated voltage V_R	Dimensions in mm (w x l x t)	Lead spacing	Page
1000 pF – 68000 pF 68000 pF – 470000 pF	25 V dc, 50 V dc 25 V dc, 50 V dc	5.5 x 5.0 x 2.5 6.5 x 5.0 x 3.2	2.5 mm	
1000 pF – 68000 pF 68000 pF – 470000 pF 470000 pF – 2.2 µF 2.2 µF – 4.7 µF	25 V dc, 50 V dc 25 V dc, 50 V dc 25 V dc, 50 V dc 25 V dc, 50 V dc	5.5 x 5.0 x 2.5 6.5 x 5.0 x 3.2 9.0 x 7.5 x 3.8 11.5 x 10.0 x 5.0	5.0 mm	
2.2 µF – 4.7 µF	50 V dc	11.5 x 10.0 x 5.0	10 mm	

6. Technical explanation

6.1. Class 1 dielectrics

The dielectric materials are defined in the EIA and MIL standards. They mainly consist of TiO_2 and additives of BaO, La_2O_3, or Nd_2O_5, and have an almost linear temperature coefficient (*TC*).

6.1.1. COG (NPO) capacitors

COG capacitors belong to the class 1 dielectrics. They have a *TC* of $(0 \pm 30) \times 10^{-6}$/K for a temperature range between –55 °C and +125 °C.

These capacitors are applied in circuits where stability and minimum dissipation are required, e. g. in filter and resonant circuits.

Characteristics:

- No capacitance change due to aging
- Minor dissipation $\leqq$ 0.15% (at 1 MHz)
- Negligible capacitance and dissipation factor dependence of voltage and frequency

6.2 Class 2 dielectrics

Dielectric materials with higher permittivity (dielectric constant) require ferroelectric ceramics on a $BaTiO_3$ basis. Their capacitance does not linearly depend on the temperature and their characteristics are less stable.

6.2.1. X7R capacitors

They are mainly suitable for coupling and filtering where no particular requirements as regards stability and dissipation factor are to be met.

Characteristics:

- $\pm$ 15% capacitance change in a temperature range between –55 °C and +125 °C
- Capacitance decrease per time decade approximately 2% (aging)
- Dissipation factor $\leqq 25 \times 10^{-3}$
- High packing density

6.2.2. Z5U capacitors

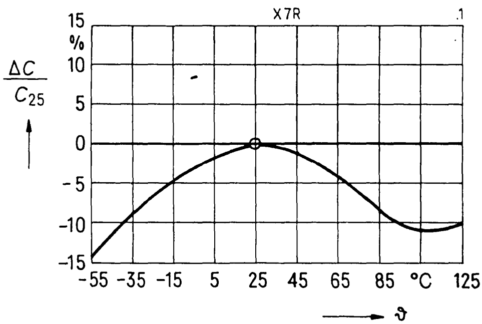
Mainly suitable for coupling and filtering tasks

Characteristics:

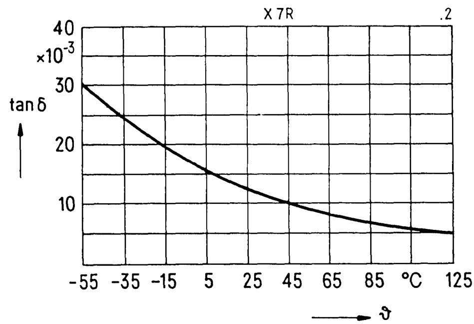
- +22% to –56% capacitance change in a temperature range between +10 °C and +85 °C
- Capacitance decrease per time decade approximately 5% (aging)
- Dissipation factor $\leqq 30 \times 10^{-3}$
- Very high packing density

7.2. Characteristic curves for X7R capacitors

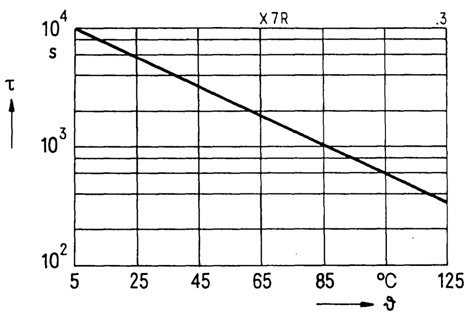
Capacitance change versus temperature
(typical values)



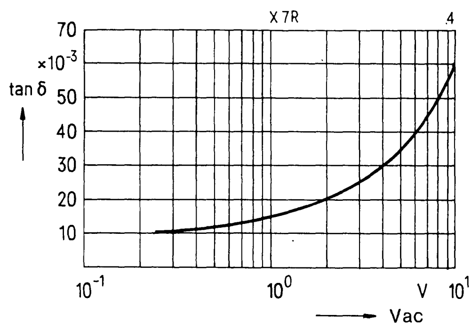
Dissipation factor versus temperature
(typical values)



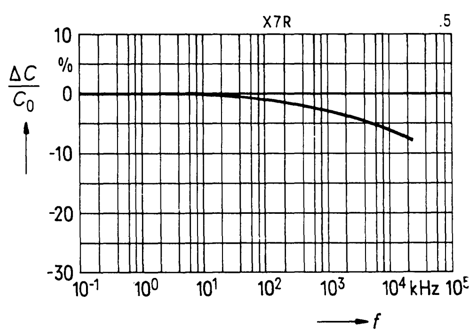
Self-discharge time constant versus temperature
(typical values)



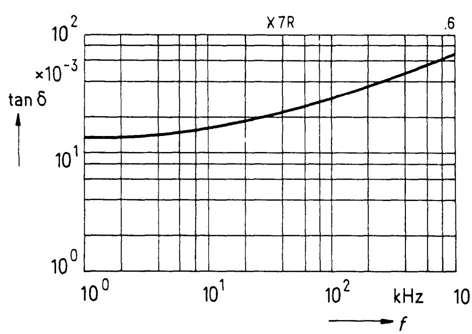
Dissipation factor versus ac voltage
(typical values)



Capacitance change versus frequency
(typical values)

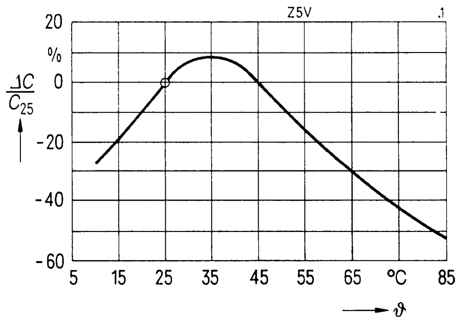


Dissipation factor versus frequency
(typical values)

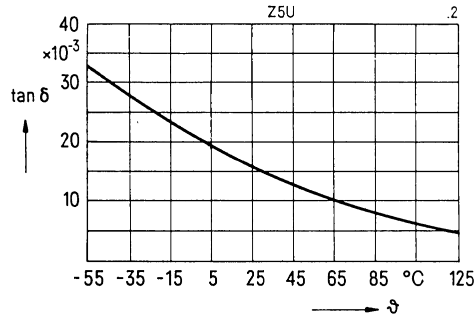


7.3. Characteristic curves for Z5U capacitors

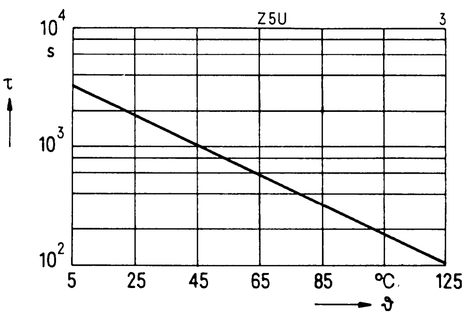
Capacitance change versus temperature
(typical values)



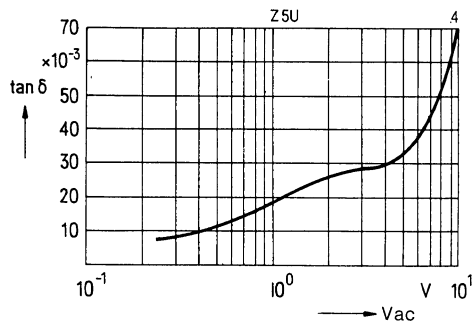
Dissipation factor versus temperature
(typical values)



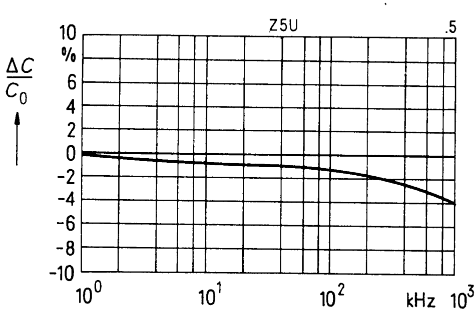
Self-discharge time constant versus temperature
(typical values)



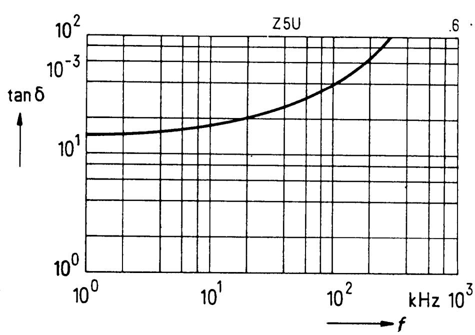
Dissipation factor versus ac voltage
(typical values)



Capacitance change versus frequency
(typical values)



Dissipation factor versus frequency
(typical values)



8. Test and measuring conditions

8.1. Standards

Multilayer ceramic capacitors comply with the MIL specifications MIL-C-39014, MIL-C-11014, MIL-C-55681, and the EIA standard RS-198-B (General Specification for Ceramic Dielectric Capacitors).

8.2 DIN climatic category	**for COG, X7R**	**for Z5U**
(DIN 40040)	**FKF**	**LPF**
Minimum category temperature	**F** – 55 °C	**L** –10 °C
Maximum category temperature	**K** +125 °C	**P** +85 °C
Humidity category	**F** ≦ 75% average relative humidity 15% continuously on 30 days per year 85% occasionally on the remaining days	

8.3. IEC climatic category	**for COG, X7R**	**for Z5U**
(IEC 68, part 1, or DIN 40045)	**55/125/56**	**05/085/56**

8.4. Capacitance

Capacitance measuring conditions comply with MIL-STD-202 E, method 305

Test frequency: (class 1)	1 MHz ± 0.2 MHz for capacitances ≦ 1 000 pF 1 kHz ± 0.2 kHz for capacitance > 1 000 pF
Test frequency: (class2)	1 kHz ± 0.2 kHz
Test voltage:	1 V_{rms} ± 0.2 V for COG, X7R capacitors 0,5 V_{rms} ± 0.1 V for Z5U capacitors
Temperature:	25 °C ± 1 °C

8.5 Dissipation factor

The measuring conditions for the dissipation factor are identical to those of the capacitance.

8.6. Insulation resistance

Measuring conditions comply with MIL-STD-202 E, method 302

Test voltage:	rated voltage
Charging current:	≦ 50 mA
Test duration:	max. 2 min.

In case of capacitance values > 0.33 µF, the time constant of insulation is indicated as $\tau = C \times R_{is}$. Usual units for the time constant: sec, MΩ µF, or ΩF

8.7. Dielectric withstanding voltage test (dielectric strength test)

Test conditions comply with MIL-STD-202 E, method 301

Test voltage:	2.5 x rated voltage
Test duration:	60 sec
Charging current:	≦ 50 mA

X7R: $\leqq \pm 20\%$
$\tan\delta \leqq 50 \times 10^{-3}$
$R_{is} \geqq 2000\ M\Omega$ or $\geqq 50$ sec

Z5U: $\leqq \pm 20\%$
$\tan\delta \leqq 70 \times 10^{-3}$
$R_{is} \geqq 2000\ M\Omega$ or $\geqq 50$ sec (the lower value has to be applied)

8.14. Flammability test

Test conditions comply with MIL-STD-202 E, method 111 A.

Max. permissible time of application of flame: $\leqq$ 15 sec

8.15 Humidity test

Test conditions comply with MIL-STD-202 E, method 103 B, test condition D (constant humidity)

Test temperature:	(40 ± 2) °C	With X7R, and Z5U pretreatment: 1 hr storage at max. category temperature, (24 ± 2)hrs recovery, final measurements; aftertreatment: like pretreatment
Relative humidity:	$(93 {+2 \atop -3})\%$	
Test duration:	56 days	
Test voltage	V_R	

Permissible variation

COG: $\leqq$ 2% or 1 pF (the larger value has to be applied)
$\tan\delta \leqq 2 \times \tan\delta$ limit value
$R_{is} \geqq 2500\ M\Omega$ or 25 sec

X7R: $\leqq \pm 15\%$
$\tan\delta \leqq 50 \times 10^{-3}$
$R_{is} \geqq 1000\ M\Omega$ or $>$ 25 sec (the lower value has to applied)

8.16. Resistance to solvents

Test conditions comply with MIL-STD-202 E, method 215.

8.17. Mechanical robustness of the terminals

The leads may only be bent in a 1 mm distance to their outlets.
They are in accordance with DIN 40046, part 19, January '78.

Tensile strength:	test: U_a leads: 10 N
Bending strength of the leads:	test: U_b two bendings in opposite directions; bending angle 90° each, bending force 5 N

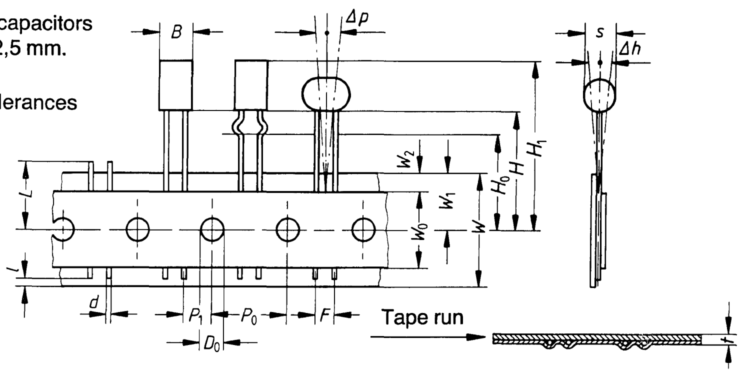
Packaging Ceramic Capacitors on Continuous Tapes

General information

Taped types which are tailored to automatic assembly are available with radial leads in lead spacings 2,5 mm and 5 mm, as well as ceramic chips. Tape packaging is based on the latest, probably final state of the relevant IEC Standard.
Particularly suitable for radial taping are multilayer capacitors (caps) and SIBATIT 50000 capacitors; the latter preferably with crimped leads and in a 5 mm lead spacing.

Taping of ceramic capacitors with lead spacing 2,5 mm.

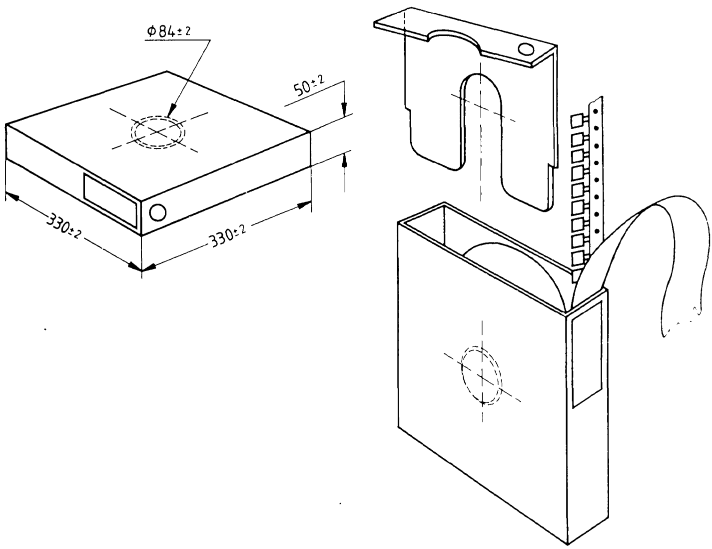
Dimensions and tolerances



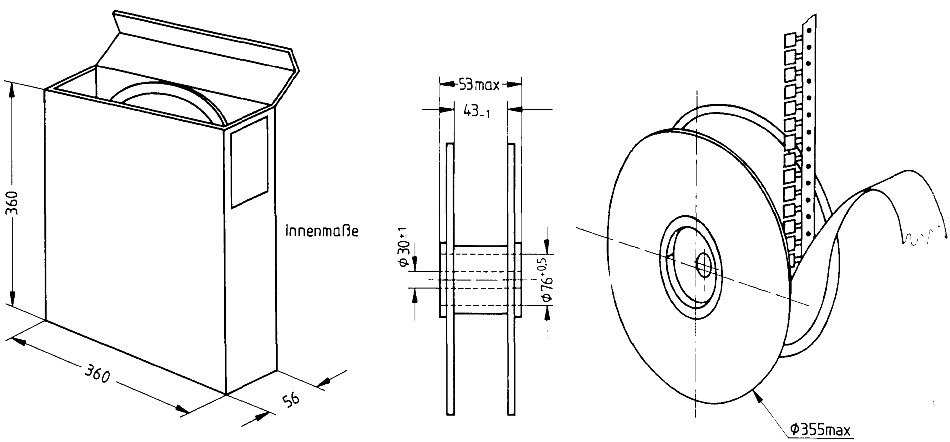
Designation	Symbol	Dimensions in mm Value	Tolerance	Notes
Head width	B	11	max.	
Head thickness	s	3,5	max.	
Lead diameter	d	0,5/0,6	±0,05	
Hole spacing	P_0	12,7	±0,2	± 1 mm/10 hole spacing[1]
Spacing: hole center to lead center	P_1	5,1	±0,7	
Lead spacing	F	2,5	+0,6/−0,1	
Slope of capacitor	Δh	0	±2,0	measured at upper head edge
Slope of capacitor	Δp	0	±1,3	
Base width	W	18	±0,5	
Adhesive width	W_0	5,5	min.	removal force ≥ 5 N
Spacing: hole to upper tape edge	W_1	9	±0,5	
Position of adhesive tape	W_2	3	−2,5	
Spacing: hole center to lower component edge	H	18	+2,0	
Spacing: hole center to kink	H_0	16	±0,5	
Spacing: hole center to upper component edge	H_1	32,2	max.	
Hole diameter	D_0	4	±0,2	
Tape thickness	t	0,7	+0,2	
Projecting length of lead	l	2	±0,5	
Length of cut lead	L	11	max.	

Types of packaging

Cassette packing



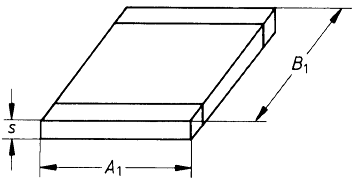
Reel packing



Taping of chip capacitors with rated voltage 50V–

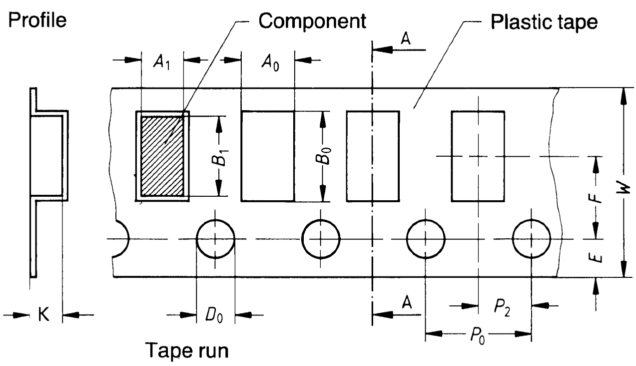
Tin plated terminations in accordance to IEC 40 (secretariat) 458 (draft).

Dimensions and tolerances



Size	$B_1 \times A_1 \times s$	$B_1 \times A_1 \times s$
0805	2,0 x 1,25 x 0,5	2,0 x 1,25 x 1,0
1206	3,2 x 1,60 x 0,5	3,2 x 1,60 x 1,0

Dimensions/Tolerances:
A_1 ± 0,15 mm
B_1 ± 0,2 mm
s ± 0,1 mm



Code	Size	Symbol	Dimensions Value	Dimensions Tolerance
Nest width	0805	A_0	1,6	
	1206		1,9	
Nest length	0805	B_0	2,4	
	1206		3,5	
Nest depth	0805	K	0,8; 1,3	
	1206		0,8; 1,3	
Hole diameter		D_0	1,5	+0,1 −0
Hole spacing		P_0	4,0	±0,1
Spacing: hole center to nest center		P_2	2,0	±0,05
Tape width		W	8,0	±0,3
Spacing: hole center to tape edge		E	1,75	±0,1
Spacing: hole center to nest center		F	3,5	±0,05

Ceramic material COG (NPO)

Rated capacity	EIA standard 0805		EIA standard 1206	
	Chip thickness S±0.1	Ordering code	Chip thickness S±0.1	Ordering code
1,0		B37940-K5010-*61		B37871-K5010-*61
1,2		B37940-K5010-*261		B37871-K5010-*261
1,5		B37940-K5010-*561		B37871-K5010-*561
1,8		B37940-K5010-*861		B37871-K5010-*861
2,2		B37940-K5020-*261		B37871-K5020-*261
2,7		B37940-K5020-*761		B37871-K5020-*761
3,3		B37940-K5030-*361		B37871-K5030-*361
3,9		B37940-K5030-*961		B37871-K5030-*961
4,7		B37940-K5040-*761		B37871-K5040-*761
5,6		B37940-K5050-*661		B37871-K5050-*661
6,8		B37940-K5060-*861		B37871-K5060-*861
8,2		B37940-K5080-*261		B37871-K5080-*261
	0,5 mm		0,5 mm	
10		B37940-K5100-*61		B37871-K5100-*61
12		B37940-K5120-*61		B37871-K5120-*61
15		B37940-K5150-*61		B37871-K5150-*61
18		B37940-K5180-*61		B37871-K5180-*61
22		B37940-K5220-*61		B37871-K5220-*61
27		B37940-K5270-*61		B37871-K5270-*61
33		B37940-K5330-*61		B37871-K5330-*61
39		B37940-K5390-*61		B37871-K5390-*61
47		B37940-K5470-*61		B37871-K5470-*61
56		B37940-K5560-*61		B37871-K5560-*61
68		B37940-K5680-*61		B37871-K5680-*61
82		B37940-K5820-*61		B37871-K5820-*61
100		B37940-K5101-*61		B37871-K5101-*61
120		B37940-K5121-*61		B37871-K5121-*61
150		B37940-K5151-*61		B37871-K5151-*61
180		B37940-K5181-*61		B37871-K5181-*61
220		B37940-K5221-*61		B37871-K5221-*61
270	1,0 mm	B37940-K5271-*61		B37871-K5271-*61
330		B37940-K5331-*61		B37871-K5331-*61
390		B37940-K5391-*61		B37871-K5391-*61
470				B37871-K5471-*61
560				B37871-K5561-*61
680			1,0 mm	B37871-K5681-*61
820				B37871-K5821-*61
1000				B37871-K5102-*61

*Insert letter for capacitance tolerance.

Rated capacitance C_R	4.7 pF to 560 pF
Rated voltage V_R	50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 1
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 30 x 10^{-6}/K
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 1.5 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	C_R $<$ 10 pF $\pm$ 1 pF $\triangleq$ F; $\pm$ 0.5 pF $\triangleq$ D
	C_R $\geqq$ 10 pF $\pm$ 20% $\triangleq$ M; $\pm$ 10% $\triangleq$ K; $\pm$ 5% $\triangleq$ J

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code
100	B37979–N5101–x
120	B37979–N5121–x
150	B37979–N5151–x
180	B37979–N5181–x
220	B37979–N5221–x
270	B37979–N5271–x
330	B37979–N5331–x
390	B37979–N5391–x
470	B37979–N5471–x
560	B37979–N5561–x

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code	C_R (pF)	Ordering code
4,7	B37979–N1040–x7	10	B37979–N1100–x	100	B37979–N1101–x
5,6	B37979–N1050–x6	12	B37979–N1120–x	120	B37979–N1121–x
6,8	B37979–N1060–x8	15	B37979–N1150–x	150	B37979–N1151–x
8,2	B37979–N1080–x2	18	B37979–N1180–x	180	B37979–N1181–x
		22	B37979–N1220–x		
		27	B37979–N1270–x		
		33	B37979–N1330–x		
		39	B37979–N1390–x		
		47	B37979–N1470–x		
		56	B37979–N1560–x		
		68	B37979–N1680–x		
		82	B37979–N1820–x		

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	220 pF to 4700 pF
Rated voltage V_R	50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 1
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 30 x 10^{-6}/K
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 1.5 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% $\triangleq$ M; $\pm$ 10% $\triangleq$ K; $\pm$ 5% $\triangleq$ J

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**	C_R (pF)	**Ordering code**
680	B37986–N5681–x	1000	B37986–N5102–x
820	B37986–N5821–x	1200	B37986–N5122–x
		1500	B37986–N5152–x
		1800	B37986–N5182–x
		2200	B37986–N5222–x
		2700	B37986–N5272–x
		3300	B37986–N5332–x
		3900	B37986–N5392–x
		4700	B37986–N5472–x

Rated voltage V_R = 100 V dc

C_R (pF)	**Ordering code**	C_R (pF)	**Ordering code**
220	B37986–N1221–x	1000	B37986–N1102–x
270	B37986–N1271–x	1200	B37986–N1122–x
330	B37986–N1331–x	1500	B37986–N1152–x
390	B37986–N1391–x		
470	B37986–N1471–x		
560	B37986–N1561–x		
680	B37986–N1681–x		
820	B37986–N1821–x		

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	4.7 pF to 560 pF
Rated voltage V_R	50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 1
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 30 x 10^{-6}/K
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 1.5 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$C_R < 10$ pF $\pm$ 1 pF ≙ F; $\pm$ 0.5 pF ≙ D
	$C_R \geqq 10$ pF $\pm$ 20% ≙ M; $\pm$ 10% ≙ K; $\pm$ 5% ≙ J

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code
100	B37979–G5101–x
120	B37979–G5121–x
150	B37979–G5151–x
180	B37979–G5181–x
220	B37979–G5221–x
270	B37979–G5271–x
330	B37979–G5331–x
390	B37979–G5391–x
470	B37979–G5471–x
560	B37979–G5561–x

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code	C_R (pF)	Ordering code
4,7	B37979–G1040–x7	10	B37979–G1470–x	100	B37979–G1101–x
5,6	B37979–G1050–x6	12	B37979–G1560–x	120	B37979–G1121–x
6,8	B37979–G1060–x8	15	B37979–G1680–x	150	B37979–G1151–x
8,2	B37979–G1080–x2	18	B37979–G1820–x	180	B37979–G1181–x
		22	B37979–G1100–x		
		27	B37979–G1120–x		
		33	B37979–G1150–x		
		39	B37979–G1180–x		
		47	B37979–G1220–x		
		56	B37979–G1270–x		
		68	B37979–G1330–x		
		82	B37979–G1390–x		

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	220 pF to 4700 pF
Rated voltage V_R	50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 1
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 30 x 10^{-6}/K
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 1.5 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% $\triangleq$ M; $\pm$ 10% $\triangleq$ K; $\pm$ 5% $\triangleq$ J

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
680	B37986–G5681–x	1000	B37986–G5102–x
820	B37986–G5821–x	1200	B37986–G5122–x
		1500	B37986–G5152–x
		1800	B37986–G5182–x
		2200	B37986–G5222–x
		2700	B37986–G5272–x
		3300	B37986–G5332–x
		3900	B37986–G5392–x
		4700	B37986–G5472–x

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
220	B37986–G1221–x	1000	B37986–G1102–x
270	B37986–G1271–x	1200	B37986–G1122–x
330	B37986–G1331–x	1500	B37986–G1152–x
390	B37986–G1391–x		
470	B37986–G1471–x		
560	B37986–G1561–x		
680	B37986–G1681–x		
820	B37986–G1821–x		

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	1800 pF to 27000 pF
Rated voltage V_R	50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 1
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 30 x 10^{-6}/K
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 1.5 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K; $\pm$ 5% ≙ J

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
5600	B37983–N5562–x	18000	B37983–N5183–x
6800	B37983–N5682–x	22000	B37983–N5223–x
8200	B37983–N5822–x	27000	B37983–N5273–x
10000	B37983–N5103–x		
12000	B37983–N5123–x		
15000	B37983–N5153–x		

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
1800	B37983–N1182–x	10000	B37983–N1103–x
2200	B37983–N1222–x		
2700	B37983–N1272–x		
3300	B37983–N1332–x		
3900	B37983–N1392–x		
4700	B37983–N1472–x		
5600	B37983–N1562–x		
6800	B37983–N1682–x		
8200	B37983–N1822–x		

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	1 200 pF to 47 000 pF
Rated voltage V_R	50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 1
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 30 x 10^{-6}/K
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 1.5 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K; $\pm$ 5% ≙ J

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**
33000	B37900–N5333–x
39000	B37900–N5393–x
47000	B37900–N5473–x

Rated voltage V_R = 100 V dc

C_R (pF)	**Ordering code**
12000	B37900–N1123–x
15000	B37900–N1153–x
18000	B37900–N1183–x
22000	B37900–N1223–x
27000	B37900–N1273–x

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	220 pF to 22000 pF
Rated voltage V_R	50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 2
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 15%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 25 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^5$ MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
3300	B37981–M5332–x	10000	B37981–M5103–x
3900	B37981–M5392–x	12000	B37981–M5123–x
4700	B37981–M5472–x	15000	B37981–M5153–x
5600	B37981–M5562–x	18000	B37981–M5183–x
6800	B37981–M5682–x	22000	B37981–M5223–x
8200	B37981–M5822–x		

Note: x = Insert appropriate letter for capacitance tolerance.

Body Size 6.5 x 5.0 x 3.2 mm

Rated capacitance C_R	5600 pF to 150000 pF
Rated voltage V_R	25 V dc; 50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 2
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 15%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 25 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^5$ MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
27000	B37987–M5273–x	100000	B37987–M5104–x
33000	B37987–M5333–x	120000	B37987–M5124–x
39000	B37987–M5393–x	150000	B37987–M5154–x
47000	B37987–M5473–x		
56000	B37987–M5563–x		
68000	B37987–M5683–x		
82000	B37987–M5823–x		

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	220 pF to 22000 pF
Rated voltage V_R	25 V dc; 50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 2
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 15%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 25 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^5$ MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
3300	B37981–F5332–x	10000	B37981–F5103–x
3900	B37981–F5392–x	12000	B37981–F5123–x
4700	B37981–F5472–x	15000	B37981–F5153–x
5600	B37981–F5562–x	18000	B37981–F5183–x
6800	B37981–F5682–x	22000	B37981–F5223–x
8200	B37981–F5822–x		

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	5600 pF to 150000 pF
Rated voltage V_R	50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 2
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 15%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 25 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^5$ MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**	C_R (pF)	**Ordering code**
27000	B37987–F5273–x	100000	B37987–F5104–x
33000	B37987–F5333–x	120000	B37987–F5124–x
39000	B37987–F5393–x	150000	B37987–F5154–x
47000	B37987–F5473–x		
56000	B37987–F5563–x		
68000	B37987–F5683–x		
82000	B37987–F5823–x		

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	47000 pF to 680000 pF
Rated voltage V_R	50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 2
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 15%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 25 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**
180000	B37984–M5184–x
220000	B37984–M5224–x
270000	B37984–M5274–x
330000	B37984–M5334–x
390000	B37984–M5394–x
470000	B37984–M5474–x
560000	B37984–M5564–x
680000	B37984–M5684–x

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	220 pF to 1.0 µF
Rated voltage V_R	50 V dc; 100 V dc;
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 2
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 15%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 25 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^5$ MΩ at 25°C
Time constant τ	> 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**	C_R (pF)	**Ordering code**
820000	B37901–M5824–x	1000000	B37901–M5105–x

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	10000 pF to 330000 pF
Rated voltage V_R	25 V dc; 50 V dc
DIN climatic category (DIN 40040)	LPF (+10°C to + 85°C, humidity category F)
IEC climatic category (IEC 68, part 1)	5/085/56
Dielectric	class 2
Temperature range ϑ	+10°C to + 85°C
Capacitance change ΔC	+22/–56%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 30 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^4$ MΩ at 25°C
Time constant τ	$>$ 500 sec at 25°C
Capacitance values available	E 6 series (preferred series)
Capacitance tolerance and code letters	+ 80% to –20% ≙ Z; ± 20% ≙ M

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**
10000	B37982–N5103–x
15000	B37982–N5153–x
22000	B37982–N5223–x
33000	B37982–N5333–x
47000	B37982–N5473–x

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	10000 pF to 330000 pF
Rated voltage V_R	25 V dc; 50 V dc
DIN climatic category (DIN 40040)	LPF (+10°C to + 85°C, humidity category F)
IEC climatic category (IEC 68, part 1)	5/085/56
Dielectric	class 2
Temperature range ϑ	+10°C to + 85°C
Capacitance change ΔC	+22/–56%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 30 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^4$ MΩ at 25°C
Time constant τ	$>$ 500 sec at 25°C
Capacitance values available	E 6 series (preferred series)
Capacitance tolerance and code letters	+ 80% to –20% ≙ Z; ± 20% ≙ M

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**
10000	B37982–G5103–x
15000	B37982–G5153–x
22000	B37982–G5223–x
33000	B37982–G5333–x
47000	B37982–G5473–x

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	470000 pF to 2.2 μF
Rated voltage V_R	50 V dc
DIN climatic category (DIN 40040)	LPF (+10°C to + 85°C, humidity category F)
IEC climatic category (IEC 68, part 1)	5/085/56
Dielectric	class 2
Temperature range ϑ	+10°C to + 85°C
Capacitance change ΔC	+22/–56%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 30 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^4$ MΩ at 25°C
Time constant τ	$>$ 500 sec at 25°C
Capacitance values available	E 6 series (preferred series)
Capacitance tolerance and code letters	+ 80% to –20% ≙ Z; ± 20% ≙ M

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (μF)	Ordering code
470000	B37985–N5474–x	1000000	B37985–N5105–x
680000	B37985–N5684–x	1500000	B37985–N5155–x

Note: x = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	1.0 pF to 560 pF
Rated voltage V_R	50 V dc; 100 V dc
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 1
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 30 x 10^{-6}/K
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 1.5 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	C_R < 10 pF ± 1 pF ≙ F; ± 0.5 pF ≙ D C_R ≧ 10 pF ± 20% ≙ M; ± 10% ≙ K; ± 5% ≙ J

Rated voltage V_R = 50 V dc

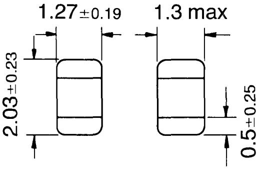
C_R (pF)	Ordering code	C_R (pF)	Ordering code	C_R (pF)	Ordering code
1	B37940–K5010–+1	10	B37940–K5100–+1	100	B37940–K5101–+1
1.2	B37940–K5010–+201	12	B37940–K5120–+1	120	B37940–K5121–+1
1.5	B37940–K5010–+501	15	B37940–K5150–+1	150	B37940–K5151–+1
1.8	B37940–K5010–+801	18	B37940–K5180–+1	180	B37940–K5181–+1
2.2	B37940–K5020–+201	22	B37940–K5220–+1	220	B37940–K5220–+1
2.7	B37940–K5020–+701	27	B37940–K5270–+1	270	B37940–K5271–+1
3.3	B37940–K5030–+301	33	B37940–K5330–+1	330	B37940–K5331–+1
3.9	B37940–K5030–+901	39	B37940–K5390–+1	390	B37940–K5391–+1
4.7	B37940–K5040–+701	47	B37940–K5470–+1	470	B37940–K5471–+1
5.6	B37940–K5050–+601	56	B37940–K5560–+1	560	B37940–K5561–+1
6.8	B37940–K5060–+801	68	B37940–K5680–+1		
8.2	B37940–K5080–+201	82	B37940–K5820–+1		

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
10	B37940–K1100–+1	100	B37940–K1101–+1
12	B37940–K1120–+1	120	B37940–K1121–+1
15	B37940–K1150–+1	150	B37940–K1151–+1
18	B37940–K1180–+1	180	B37940–K1181–+1
22	B37940–K1220–+1	220	B37940–K1221–+1
27	B37940–K1270–+1	270	B37940–K1271–+1
39	B37940–K1390–+1		
47	B37940–K1470–+1		
56	B37940–K1560–+1		
68	B37940–K1680–+1		
82	B37940–K1820–+1		

Note: + = Insert appropriate letter for capacitance tolerance.

EIA standard 0805
B 37940



Rated capacitance C_R	330 pF to 3300 pF
Rated voltage V_R	50 V dc; 100 V dc
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 1
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 30 x 10^{-6}/K
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 1.5 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% $\triangleq$ M; $\pm$ 10% $\triangleq$ K; $\pm$ 5% $\triangleq$ J

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
820	B37949–K5821–+1	1000	B37949–K5102–+1
		1200	B37949–K5122–+1
		1500	B37949–K5152–+1
		1800	B37949–K5182–+1
		2200	B37949–K5222–+1
		2700	B37949–K5272–+1
		3300	B37949–K5332–+1

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
330	B37949–K1331–+1	1000	B37949–K1102–+1
390	B37949–K1391–+1	1200	B37949–K1122–+1
470	B37949–K1471–+1	1500	B37949–K1152–+1
560	B37949–K1561–+1	1800	B37949–K1182–+1
680	B37949–K1681–+1		
820	B37949–K1821–+1		

Note: + = Insert appropriate letter for capacitance tolerance.

Rated capacitance C_R	1500 pF to 10000 pF
Rated voltage V_R	50 V dc; 100 V dc
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 1
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 30 x 10^{-6}/K
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$<$ 1.5 x 10^{-3}
Insulation resistance R_{is}	$>$ 10^5 MΩ at 25°C
Time constant τ	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K; $\pm$ 5% ≙ J

Rated voltage V_R = 50 V dc

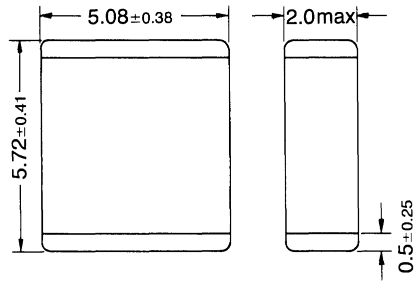
C_R (pF)	Ordering code	C_R (pF)	Ordering code
3300	B37955–K5332–+1	10000	B37955–K5103–+1
3900	B37955–K5392–+1	12000	B37955–K5123–+1
4700	B37955–K5472–+1	15000	B37955–K5153–+1
5600	B37955–K5562–+1		
6800	B37955–K5682–+1		
8200	B37955–K5822–+1		

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
1500	B37955–K1152–+1	10000	B37955–K1103–+1
1800	B37955–K1182–+1		
2200	B37955–K1222–+1		
2700	B37955–K1272–+1		
3300	B37955–K1332–+1		
3900	B37955–K1392–+1		
4700	B37955–K1472–+1		
5600	B37955–K1562–+1		
6800	B37955–K1682–+1		
8200	B37955–K1822–+1		

Note: + = Insert appropriate letter for capacitance tolerance.

EIA standard 2220
B 37955



Rated capacitance C_R	1000 pF to 33000 pF
Rated voltage V_R	50 V dc; 100 V dc
DIN climatic category (DIN 40040)	FKF (–55°C to +125°C, humidity category F)
IEC climatic category (IEC 68, part 1)	55/125/56
Dielectric	class 2
Temperature range ϑ	–55°C to +125°C
Capacitance change ΔC	$\pm$ 15%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 25 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^5$ MΩ at 25°C
Time constant τ.	$>$ 1000 sec at 25°C
Capacitance values available	E 12 series (preferred series)
Capacitance tolerance and code letters	$\pm$ 20% ≙ M; $\pm$ 10% ≙ K

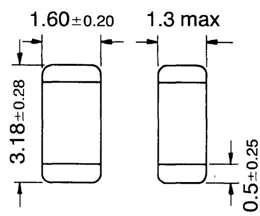
Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
1000	B37872–K5102–+1	10000	B37872–K5103–+1
1200	B37872–K5122–+1	12000	B37872–K5123–+1
1500	B37872–K5152–+1	15000	B37872–K5153–+1
1800	B37872–K5182–+1	18000	B37872–K5183–+1
2200	B37872–K5222–+1	22000	B37872–K5223–+1
2700	B37872–K5272–+1	27000	B37872–K5273–+1
3300	B37872–K5332–+1	33000	B37872–K5333–+1
3900	B37872–K5392–+1		
4700	B37872–K5472–+1		
5600	B37872–K5562–+1		
6800	B37872–K5682–+1		
8200	B37872–K5822–+1		

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
3300	B37872–K1332–+1	10000	B37872–K1103–+1
3900	B37872–K1392–+1		
4700	B37872–K1472–+1		
5600	B37872–K1562–+1		
6800	B37872–K1682–+1		
8200	B37872–K1822–+1		

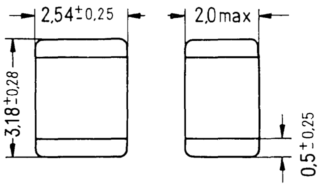
EIA standard 1206
B 37872



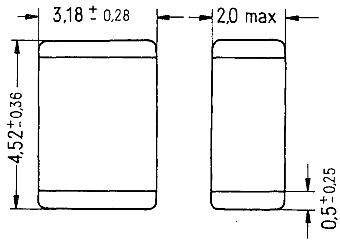
Note: + = Insert appropriate letter for capacitance tolerance.

Version
Chips without leads with silver-palladium terminations

EIA standard 1210
B 37950



EIA standard 1812
B 37953



Dimensions in mm

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code	C_R (pF)	Ordering code
47000	B37953–K5473–+1	0.10 μF	B37953–K5104–+1
56000	B37953–K5563–+1	0.12 μF	B37953–K5124–+1
68000	B37953–K5683–+1	0.15 μF	B37953–K5154–+1
82000	B37953–K5823–+1	0.18 μF	B37953–K5184–+1
		0.22 μF	B37953–K5224–+1
		0.27 μF	B37953–K5274–+1

Rated voltage V_R = 100 V dc

C_R (pF)	Ordering code
33000	B37953–K1333–+1
39000	B37953–K1393–+1
47000	B37953–K1473–+1
56000	B37953–K1563–+1
68000	B37953–K1683–+1
82000	B37953–K1823–+1

Note: + = Insert appropriate letter for capacitance tolerance.

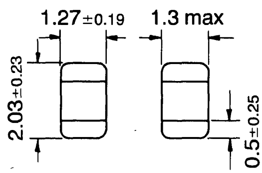
Rated capacitance C_R	10000 pF to 47000 pF
Rated voltage V_R	25 V dc; 50 V dc
DIN climatic category (DIN 40040)	LPF (+10°C to +85°C, humidity category F)
IEC climatic category (IEC 68, part 1)	05/085/56
Dielectric	class 2
Temperature range ϑ	+10°C to + 85°C
Capacitance change ΔC	+22/–56%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 30 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^4$ MΩ at 25°C
Time constant τ	> 500 sec at 25°C
Capacitance values available	E 6 series (preferred series)
Capacitance tolerance and code letters	+80% to –20% ≙ Z; ± 20% ≙ M

Rated voltage V_R = 50 V dc

C_R (pF)	Ordering code
10000	B37942–K6103–+1
15000	B37942–K6153–+1
22000	B37942–K6223–+1
33000	B37942–K6333–+1
47000	B37942–K6473–+1

Note: + = Insert appropriate letter for capacitance tolerance.

EIA standard 0805
B 37942



Rated capacitance C_R	100000 pF to 220000 µF
Rated voltage V_R	25 V dc; 50 V dc
DIN climatic category (DIN 40040)	LPF (+10°C to + 85°C, humidity category F)
IEC climatic category (IEC 68, part 1)	05/085/56
Dielectric	class 2
Temperature range ϑ	+10°C to + 85°C
Capacitance change ΔC	+22/–56%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 30 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^4$ MΩ at 25°C
Time constant τ	$>$ 500 sec at 25°C
Capacitance values available	E 6 series (preferred series)
Capacitance tolerance and code letters	+ 80% to –20% ≙ Z; ± 20% ≙ M

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**
0.1 µF	B37951–K6104–+1
0.15 µF	B37951–K6154–+1
0.22 µF	B37951–K6224–+1

Note: + = Insert appropriate letter for capacitance tolerance.

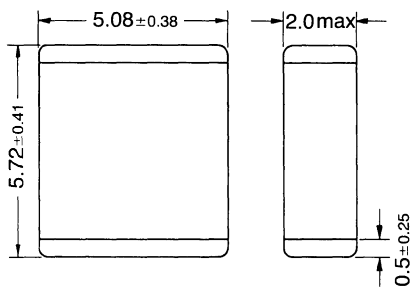
Rated capacitance C_R	470000 pF to 1.5 μF
Rated voltage V_R	25 V dc; 50 V dc
DIN climatic category (DIN 40040)	LPF (+10°C to + 85°C, humidity category F)
IEC climatic category (IEC 68, part 1)	05/085/56
Dielectric	class 2
Temperature range ϑ	+10°C to + 85°C
Capacitance change ΔC	+22/–56%
Voltage test V_{test}	2.5 x V_R
Dissipation factor tan δ	$< 30 \times 10^{-3}$
Insulation resistance R_{is}	$> 10^4$ MΩ at 25°C
Time constant τ	> 500 sec at 25°C
Capacitance values available	E 6 series (preferred series)
Capacitance tolerance and code letters	+ 80% to –20% ≙ Z; ± 20% ≙ M

Rated voltage V_R = 50 V dc

C_R (pF)	**Ordering code**	C_R (μF)	**Ordering code**
0.47 μF	B37957–K6474– + 1	1.0 μF	B37957–K6105– + 1
0.68 μF	B37957–K6684– + 1	1.5 μF	B37957–K6155– + 1

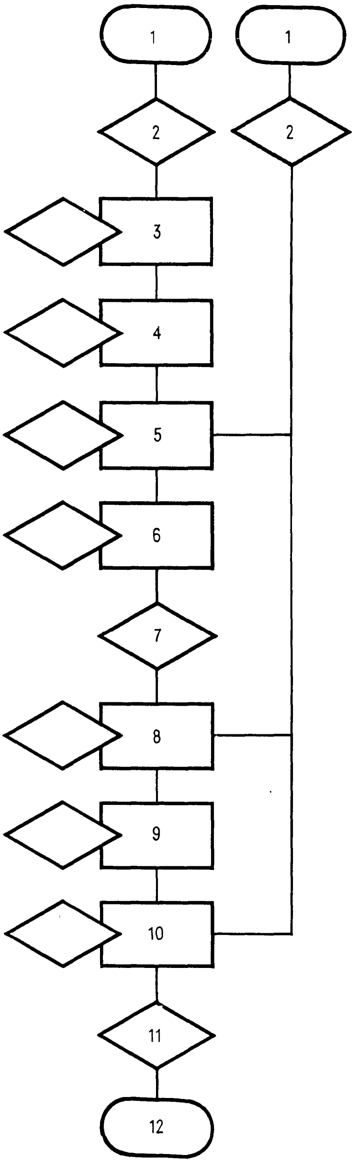
Note: + = Insert appropriate letter for capacitance tolerance.

EIA standard 2220
B 37957



3. Production and examination plan

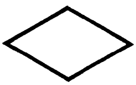
3.1. Dielectric



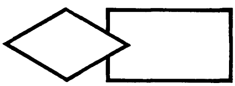
1. Incoming ceramic raw materials
2. Incoming examination of the ceramic raw materials
3. Preliminary grinding
4. Transformation (solid state reaction)
5. Subsequent grinding
6. Homogenizing
7. Release examination
8. Granulating
9. Sintering
10. Metallization
11. Electrical tests
12. Storage

Legend

Production step, process



Examination, decision



Production step with process examination

Start or end of the production process

4. Types available (survey)

SIBATIT 50000 capacitors

Rated capacitance C_R	Rated voltage V_R	Lead spacing	Ordering code	Page
22000 pF to 68000 pF 22000 pF to 100000 pF	63 V dc	2.5 mm 5.0 mm	B37448–F B37449–F	

Low-loss capacitors

Rated capacitance C_R	Rated voltage V_R	Lead spacing	Ordering code	Page
10000 pF, 22000 pF 10000 pF, 22000 pF	63 V dc	2.5 mm 5.0 mm	B37448–N B37449–N	

6.1. Characteristics

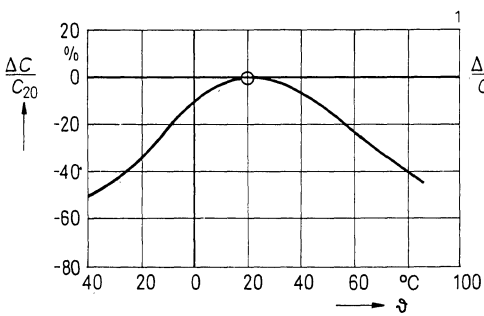
- High dielectric withstanding voltage (dielectric strength)
- Low temperature drift
- Polarity independence
- High volume capacitance

6.2. Screening effect, coupling capacitance

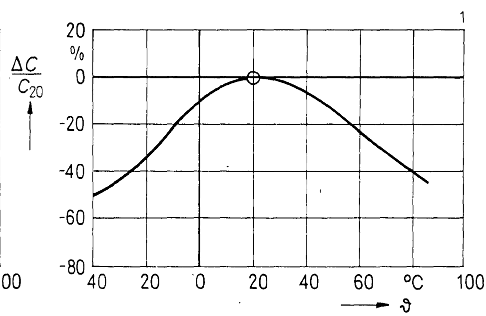
The outer layer of SIBATIT capacitors screens the inner layer and can be identified by means of the external leads. When employing these capacitors in filters and filter circuits the outer layer is recommended, if possible, to be placed where no RF potential exists. This arrangement is to avoid damaging stray capacitance.

7. Characteristic curves

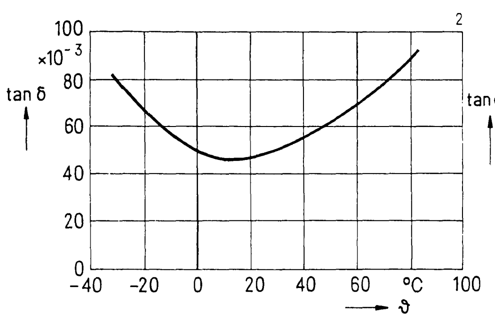
Capacitance values versus temperature
(typical values)



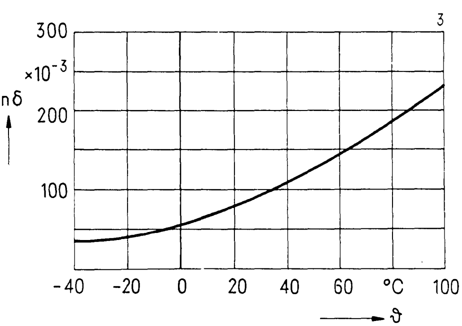
Capacitance change versus temperature
for low-loss capacitors (typical values)



Dissipation factor versus temperature
(typical values)

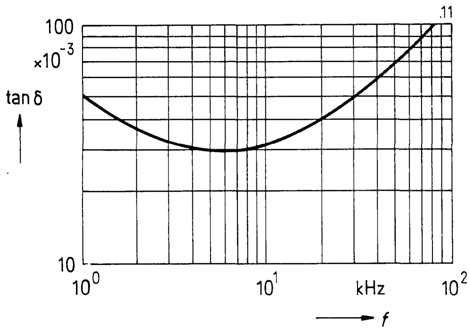


Dissipation factor versus temperature
for low-loss capacitors (typical values)

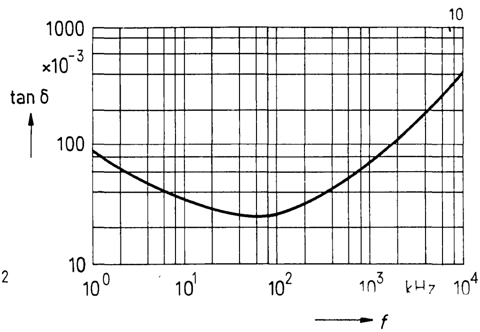


Characteristic curves (cont'd)

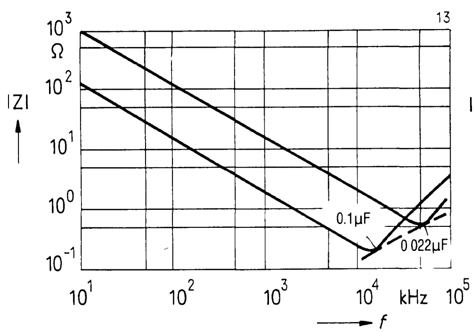
Dissipation factor versus frequency
(typical values)



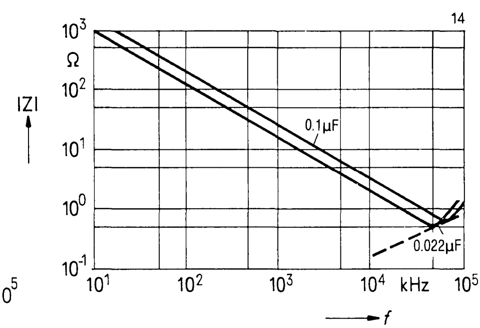
Dissipation factor versus frequency
for low-loss capacitors (typical values)



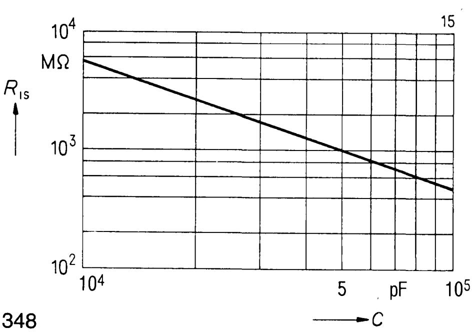
Impedance versus frequency
(typical values)



Impedance versus frequency
for low-loss capacitors (typical values)



Insulation resistance versus capacitance
(typical values)



Failure criteria

Aftertreatment	storage for 24 hrs at room temperature	
Capacitance change	> ± 20% from initial value	
Dissipation factor	> 100 x 10^{-3} (1 kHz)	SIBATIT 50000
Time constant	< 1.25 sec	
Dissipation factor	> 100 x 10^{-3} (100 kHz)	low loss
Insulation resistance	< 10 MΩ	

8.5. Capacitance

Test temperature: 15 to 33 °C
Relative humidity: 45 to 75%
(drying is possible in accordance with DIN 41046, sheet 2)
Test voltage: ≦ 200 mV
Test frequency: 1 kHz ± 0.2 kHz

8.6. Dissipation factor

The test conditions for the dissipation factor equal those of the capacitance.

8.7. Insulation resistance

Test temperature: (20 ± 5) °C
Relative humidity: ≦ 75%
(drying is possible in accordance with DIN 41046, sheet 2)
Test duration: (60 ± 5) sec
Test voltage: (10 ± 1) V dc

In case of high capacitance values, the time constant of insulation ist indicated as $\tau = C \times R_{is}$. Usual units for the time constant: sec, MΩμF, or ΩF

8.8. Dielectric withstanding voltage test (dielectric strength test)

Test voltage: 130 V
Test duration: 1 sec
Charging current: ≦ 50 mA

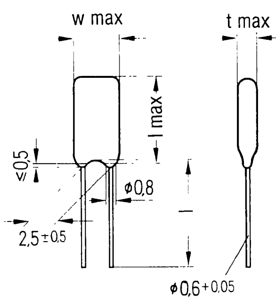
8.9. Solderability

The capacitors comply with the soldering conditions of DIN 40046, sheet 18, or IEC Publication 68–2–20.
The capacitors should not be stored for a long time and without protection.

Soldering temperature: ≦ 260 °C
Immersion duration: ≦ 6 sec

Sufficient heat dissipation has to be provided for short terminals.

Rated capacitance C_R	22000 pF to 100000 pF
Rated voltage V_R	63 V dc
DIN climatic category	GPF
IEC climatic category	40/085/56
Dielectric	class 2
Temperature range ϑ	–40°C to + 85°C
Capacitance change ΔC	+ 20 to – 55%
Voltage test V_{test}	130 V dc
Dissipation factor tan δ	$\leqq$ 50 x 10^{-3} at 1 kHz
Self-discharge time constant τ	$\geqq$ 50 sec
Capacitance tolerance and code letter	+50% to –20% $\triangleq$ S



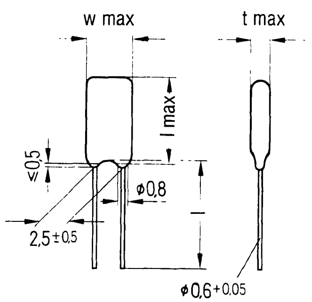
Dimensions in mm

Rated capacitance C_R (pF)	**Ordering code** **Dimensions** *w* x *l* x *t*
22000	B37448–F6223–S* 5.3 x 8.0 x 2.7
33000	B37448–F6333–S* 5.3 x 9.0 x 2.7
47000	B37448–F6473–S* 5.3 x 12 x 2.7
68000	B37448–F6683–S* 5.3 x 14 x 2.7

Instead of the * in the ordering code insert the letter for the lead length.

Low-loss capacitors

Rated capacitance C_R	10000 pF, 22000 pF
Rated voltage V_R	63 V dc
DIN climatic category	GPF
IEC climatic category	40/085/56
Dielectric	class 2
Temperature range ϑ	–40°C to + 85°C
Capacitance change ΔC	+ 20 to – 55%
Voltage test V_{test}	130 V dc
Dissipation factor tan δ	$\leqq$ 50 x 10^{-3} at 100 kHz
Insulation resistance R_{is}	$\geqq$ 10 MΩ
Capacitance tolerance and code letter	+ 50% to –20% ≙ S



Dimensions in mm

Rated capacitance C_R (pF)	**Ordering code** **Dimensions** *w* x *l* x *t*
10000	B37448–N6103–S* 5.3 x 8.0 x 2.7
22000	B37448–N6223–S* 5.3 x 13 x 2.7

Instead of the * in the ordering code insert the letter for the lead length.

The resulting separated area (isolated circle) is highly resistive and voltage proof for any operational requirement of the capacitor. Since time and energy dissipated for the self-healing procedure are extremely low, the capacitor remains fully operable during breakdowns. The potential drop of the capacitors is negligible for all heavy current applications.
The self-healing capability is subject to an upper voltage limit, which depends on the version. For Siemens capacitors, this limit lies above the peak voltages to be expected from mains (approx. three times the rated voltage).
The number of possible breakdowns is virtually unlimited. An actual limit is, however, given by the pressure inside the capacitor during breakdowns (refer also to section 7, overload protection).
Taking application in pulse-sensitive circuits into consideration, MP capacitors for dc application are designed such that under maximum continuous voltage load at the upper category temperature less than 2 self-healing processes will occur per µF throughout the first year. Subsequently, these processes occur less frequently. MP capacitors showing this feature are designated MPJ capacitors in accordance with the regulations of VDE 0560, part 14, and DIN 41180.
The self-healing capability of MP capacitors is not bound to maintaining certain limit conditions (in accordance with DIN 41180 operating voltage: at least 20 V; energy level: at least 2 µWs) since an electro-chemical self-healing process takes place, when the voltage falls below 20 V.

3. Construction

3.1. Contacting

The large area metallization over the winding ends as well as welded or soldered leads ensure reliable contacting between layers and terminations. Moreover, low inductance and low damping characteristics are obtained.

3.1.1. Resistance to surges i/C

The capacitance-specific current (i/C) complies with the voltage variation per time unit ($\mathrm{d}u/\mathrm{d}t$). The maximum value $(\mathrm{d}u/\mathrm{d}t)_{max.}$ of this voltage rate of rise depends on the peak current carrying capacity of the contacting. For relevant data please refer to the specific data sheets. The maximum permissible peak current $\hat{i}$ can be calculated according to the formula:
$\hat{i} = C \times (\mathrm{d}u/\mathrm{d}t)_{max.}$

3.2. Versions

The capacitor windings of MP capacitors for dc application and MKV capacitors for ac application are housed in cases, such as

aluminum cases with axial leads (cartridges)
tubular cases with flat solder plugs
in tubular cases with screw terminals or
heavy duty two-pin flat plugs

A flame-retardent material (e.g. epoxy resin) is used for sealing the capacitor windings of MKP capacitors in plastic cases, such as

tubular cases with or without threaded bolt,
with flat solder plug or cable connection.

Category voltage U_C (at dc operation)

The category voltage U_C is the maximum voltage that may be applied continuously to a capacitor. It is independent of the ambient temperature. Up to the ambient temperature of 40° C/ 104° F U_C equals U_R. At higher ambient temperatures U_C is less than U_R. MP capacitors for dc application may be used at accordingly decreased voltages up to +85° C/185° F (see fig. 3) (definition according to DIN 41180).

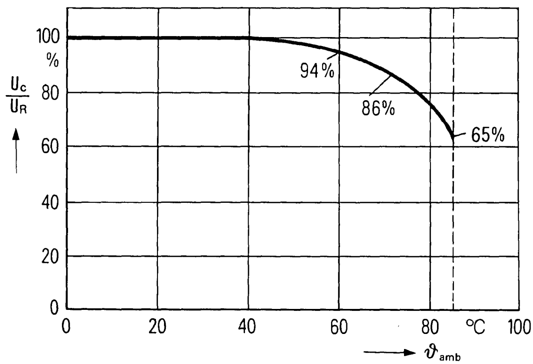


Fig. 3
Relative category voltage U_c/U_R versus ambient temperature ϑ_{amb}

Permissible ac voltages U_{rms}

MP capacitors for dc application are not suitable for use at ac networks. The permissible superimposed ac voltage for capacitors with diameters greater than 100 mm is indicated on the individual data sheet. The ac voltage load permitted for all other MP capacitors for dc application depends on the frequency as is shown in fig. 4. It is not allowed to exceed 200 V. The peak value of a mixed voltage is not allowed to exceed the category voltage U_C.

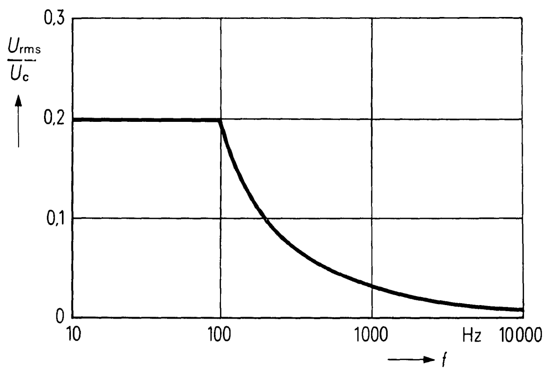


Fig. 4
Relative ac voltage U_{rms}/U_c versus frequency f (according to DIN 41180)

The peak voltage U_p is the maximum peak voltage, which may be applied to the capacitor for intermittent operation and only occasionally, e.g. at switching processes. Peak voltage operation decisively influences the capacitor life.

Resistance to overload

Because of the self-healing characteristic, MKV and MKP capacitors can withstand, without damage, voltage peaks up to 3 times the rated voltage, e.g. during switching processes.

Dielectric strength, user's test

The tests may be repeated once by the user.

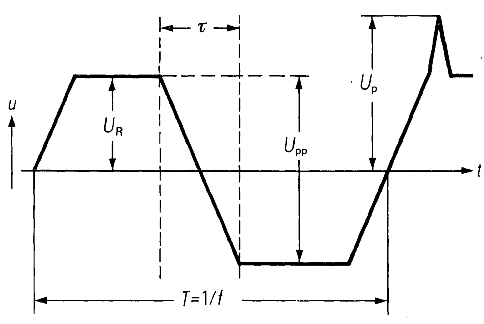
Direct voltage loading

Direct voltage operation is permitted at the level of the rated alternating voltage peak values. Higher voltages on request.

4.2.3. MKV capacitors for power electronics

The rated voltage (U_R) is the peak voltage value which is indicated upon the capacitor.

The peak-to-peak voltage (U_{pp}) is the sum of positive and negative voltage amplitudes at polarity changing load.



Maximum peak voltage U_p

The maximum peak voltage U_p is a measure for the dielectric strength of the capacitor for the dielectric strength of the capacitor without taking into account, however, the load limit with regard to the thermal stability.

Dielectric strength test

The capacitors are designed such that 80 % of the tests, indicated on the data sheets, may be repeated.

Direct voltage loading

Direct voltage operation is permitted at the level of the rated voltage values (U_R). Higher voltages on request.

Important aspects of this test are:

a) The type test must be performed by a device finished or produced in series, and not with a provisional, experimental arrangement.

b) The temperature should not be measured before thermal equilibrium has been achieved, for which occasionally several hours could be necessary.

c) The outer supply lines to the capacitor must be designed such that any heat flow into the capacitor is reliably avoided. It is, therefore, recommended to take care that the choosen design of the supply lines ensures heat removal from the capacitor terminals.

5.1. Reactive power N

The operation-dependent reactive power (N) can be calculated as follows:

a) at sinusoidal alternating voltage operation:

$$N = 2 \times \pi \times C \times U^2 \times f$$

U = rms value of the sinusoidal voltage
f = frequency
C = capacitance

b) at non-sinusoidal alternating voltage load:

Each periodically changing voltage $U(t)$ of any shape of the amplitude results from superposition of sine voltages, whose frequencies are integral multiples (ν) of the basic frequency f (Fourier's analysis). The total reactive power is the sum of the reactive power values of the individual sinusoidal voltages.

$$N = 2 \times \pi \times C \times \sum_{\nu=1}^{\infty} U_\nu^2 \times f_\nu$$

$f_\nu = \nu \times f$ frequency of the νth partial voltage
$U_\nu =$ rms value of the νth partial voltage

5.2. Dissipation factor $\tan\delta$

The dissipation factor is calculated from the dielectric, the layer and supply line losses. These depend on temperature and frequency.

In case of MP capacitors for dc applications these dependencies are negligible.

In accordance with DIN 41180 the following limit values are specified:

Rated capacitance C_R	Dissipation factor $\tan\delta$	Measuring frequency f_R
$\leqq$ 10 µF	$12 \cdot 10^{-3}$	1000 Hz
> 10 µF to 32 µF	$7 \cdot 10^{-3}$	50 Hz
> 32 µF to 64 µF	$8 \cdot 10^{-3}$	50 Hz

Siemens MP capacitors for dc application meet these requirements.

Sinusoidal voltage loading

The sinusoidal voltage loading versus frequency f can be divided into 3 sections.

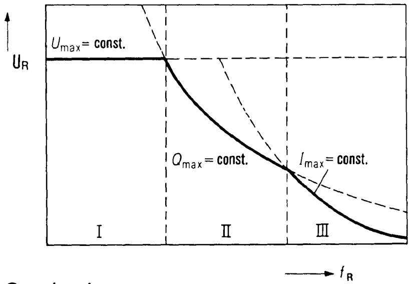


Figure 7
Permitted sinusoidal voltages

Section I
Limitation through voltage strength of the dielectric.

Section II
Limitation through inherent heating resulting from internal losses at natural cooling (frequency dependent).

Section III
Limitation through the current carrying capability of the supply lines (see limit values, rms current: I_{max}.. These curves are individually plotted for ambient temperatures ϑ_{amb}, such as 30° C/86° F, 40° C/104° F, 50° C/122° F, 60° C/140° F, 70° C/158° F, 80° C/176° F.

Explanations for the graphs of the specific types

Permissible frequency f versus ambient temperature ϑ_{amb} and voltage waveform.

The curves according to figure 9 reveal the permissible operating frequencies f versus ambient temperature ϑ_{amb} at natural cooling. The limitation is given by the heating of the capacitors resulting from internal losses. The waveform of the voltage at a uniform rated voltage U_R = peak voltage is taken as parameter. The characteristic forms shown are:

Sine wave
Trapezoidal wave with a charge exchange time τ of 300 µs
Trapezoidal wave with a charge exchange time τ of 100 µs
Trapezoidal wave with a charge exchange time τ of 30 µs

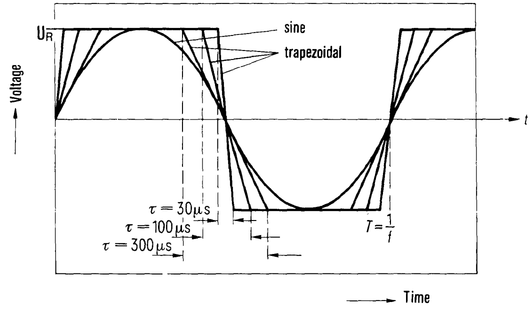


Figure 8
Voltage waveforms

7.1. Switch-off systems

7.1.1. Capacitors in aluminum cases

The wound unit of the capacitor (1) is held in the case by a winding crimp (2) and a holding disc (3). The break wire (4, part of the fuse) is soldered to the break point (5) at the bottom edge of the wound unit. The break wire is tightened to one of the two feed-throughs (6) in the cover (7) of the case. The cover itself rests on the cover crimp (8). Both crimps are folded causing the case to be elongated by about 8 mm when the crimps open, thereby breaking the wire and cutting off the capacitor winding from the current source.
The basic construction of the capacitor case with make-and-break fuse is shown in figure 10.

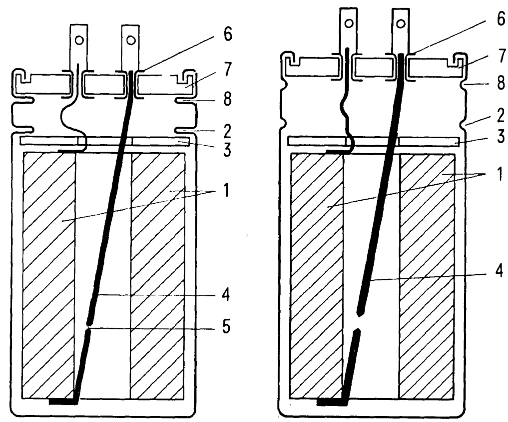


Fig. 10

1 Wound unit of the capacitor
2 Winding crimp
3 Holding disc
4 Break wire
5 Break point
6 Feed-through
7 Case cover
8 Cover crimp

7.1.2. Capacitors in steel cases

Apart from the shown make-and-break fuse for aluminum case capacitors, a second safety device for capacitors with high rated currents has been developed. Fig. 11 shows this device for capacitors in steel cases. The function of the crimps has been taken over by the case bottom, formed as an operating diaphragm which will be pushed out under operation.

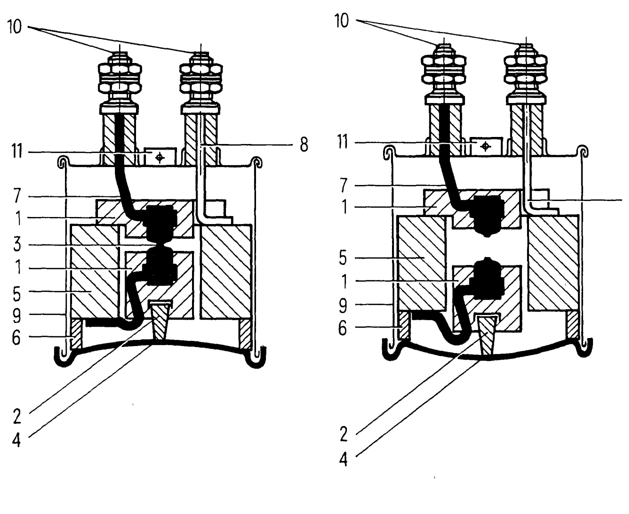


Fig. 11
1 Insulating stretching device
2 Stretching tape
3 Break point
4 Case bottom (operating diaphragm)
5 Wound unit
6 Winding support
7 Protected supply line to the winding
8 Unprotected supply line to the winding
9 Case
10 Double-pin connection
11 Case connection

10. Self-inductance

The self-inductance of MP or MKV capacitors results from inductances of the leads and the winding. The self-inductance is particularly low, because of a special contacting method (large area metallization joining all windings). Hence the resonant frequency is accordingly high.

11. Climatic requirements

11.1. Permitted temperature and humidity

The permitted temperature and humidity depend on the individual types and are indicated in accordance with DIN 40040 as follows:

1st code letter	J	H	G	F
Minimum operating temperature limit	−10° C +14° F	−25° C −13° F	−40° C −40° F	−55° C −67° F
2nd code letter	**S**		**P**	
Maximum operating temperature limit	+70° C/158° F		+85° C/185° F	
3rd code letter	**F**	**E**[3]	**C**	
Average relative humidity 30 days per year, continuously[1] for the remaining days, occasionally[2]	≦ 75% 95% 85%	≦ 75% 95% 85%	≦ 95% – 100%	

11.2. Damp heat test (long-term test)

The capacitors for power electronics meet the test C of the DIN specification 40046, sheet 5.

Capacitors for high climatic requirements (climatic category C)
Condition 4: (40 ± 2)° C/(104 ± 3.6)° F (92^{+3}_{-2}) % relative humidity 56 days

Capacitors for medium climatic requirements (climatic category F)
Condition 5: (40 ± 2)° C/(104 ± 3.6)° F (92^{+3}_{-2}) % relative humidity 21 days

11.3. Reliability (in accordance with DIN 40040, Febr. 1973)

The reliability (operational reliability) of a component is determined by the failures expected out of a sufficiently large batch after a defined period of time. In the explanations of DIN 40040 the previous term "operational reliability" has been replaced by "reference reliability". The reference reliability is given by the failure quota and the appropriate load duration.

11.4. Reference reliability

The reference reliability is the reliability for a particularly defined stress (reference stress). The reference reliability indicated on the data sheets refers to the indicated climatic category.

[1]) These days should suitably be distributed throughout the year.
[2]) Keeping the annual average.
[3]) Contrary to the humidity category F, rare and slight dew precipitation (e.g. during short openings of equipment installed outdoors) is permitted throughout humidity category E.

12. Mechanical requirements

12.1. Vibration resistance

The resistance to vibration of MP, MKV, and MKP capacitors ≦ 60 mm in diameters and ≦ 160 mm in height complies with DIN 40046, sheet 8, test F_C, partial test B 1 and IEC 68-2-6 for the following conditions:

Duration of endurance conditioning	6 h
Frequency range	10 to 55 Hz
Displacement amplitude	0.75 mm
corresponding to max.	98.1 m/s² or 10 *g*, resp.

This data applies to the individual capacitor.
Because of the possible influence of fixing and the connections on the resonant properties, it is necessary to check the stability during vibration load in the built-in state.

Independent of this, it is recommended that the capacitors not be located where the vibrating amplitudes in strongly vibrating appliances reach their maximum.

Data on larger capacitors only upon request.

12.2. Shock test

In accordance with DIN 40046, sheet 7, and IEC publication 68-2-6, test E. Data upon request.

13. Low air pressure

Storage ability at low air pressure

Capacitors for high climatic requirements (climatic category C):
max. altitude 20,000 m ≙ 40 mbar
Capacitors for medium climatic requirements (climatic category F):
max. altitude 8,500 m ≙ 300 mbar

Operational low air pressure

in accordance with IEC 68-2-13 test N and DIN 40046, sheet 13, test M. Data upon request.

14. Kinds of operation

The voltages indicated on the data sheets are referred to so-called kinds of operation. Nominal kinds of operation (in accordance with VDE 0560, part 8, para. 15) are:

14.1. Continuous operation (DB)

The period of operation lasts until a steady-state capacitor temperature is achieved and maintained over a long period.

14.2. Intermittent operation (AB)

Periods of operation are followed – preferably in regular sequences – by intervals during which the capacitor is free of voltage. The intervals may be so short that the capacitor does not cool down to the temperature of the surrounding cooling agent.

Preliminary edition

Design

Self-healing, tubular winding capacitors comprising an impregnated low loss plastic dielectric and metal paper electrodes.

Case

The windings are enclosed in tubular metal cases and sealed with plastic covers and rubber rings or scarf joints, respectively.

Terminals

The terminals, joined to the metallized winding face ends, ensure reliable contact. The capacitors are available with two different kinds of terminals:
Version -K1 with simple, solderable 6.3 flat plug; version-K9 with 6.3 flat two-pin plugs.

Ground connection and mounting

The threaded bolt (marked for grounding in accordance with DIN 40011, sheet 1) provides ground connection in accordance with VDE 0100 and may be used for fixing the capacitor, provided the vibration does not exceed 5 *g*.

Overload protection and mounting instructions

The capacitors are provided with an excess pressure make-and-break fuse, which interrupts the current supply when electrical or thermal overloads occur. When this fuse operates, the capacitor length extends up to 8 mm; this space must be left above capacitor.

General technical information

Refer to data book 1979/80 "Capacitors for Power Electronics", page 23.

Application

Damping in accordance with VDE 0560-12 (E).
Resonant circuit capacitors suitable e. g. for magnetic voltage stabilizers.

Ordering codes

For capacitor dimensions and ordering codes refer to the table on page 3.

Types available

Rated capacitance C_R µF	Tolerance	Rated voltage U_R	Dimensions $d \times l$ (mm) Outline drawing	Ordering code
1			25 x 48/a	B25832-J4105-K1
1.5			25 x 80/a	B25832-A4155-K1
1.6			30 x 48/a	B25832-J4165-K1
2			30 x 48/a	B25832-J4205-K1
2.2			25 x 80/a	B25832-A4225-K1
2.5			35 x 48/a	B25832-J4255-K1
3			25 x 80/a	B25832-A4305-K1
3			35 x 48/a	B25832-J4305-K1
3.3			25 x 80/a	B25832-A4335-K1
4			30 x 80/a	B25832-A4405-K1
4.7			30 x 80/a	B25832-A4475-K1
5			30 x 80/a	B25832-A4505-K1
6	± 10% ≙ K	450 Vac DB[1])	45 x 48/a	B25832-J4605-K1
6.8			35 x 80/a	B25832-A4685-K1
7			35 x 80/a	B25832-A4705-K1
8			40 x 85/b	B25832-A4805-K9
10			40 x 85/b	B25832-A4106-K9
12			45 x 85/b	B25832-A4126-K9
14			50 x 85/b	B25832-A4146-K9
15			50 x 85/b	B25832-A4156-K9
16			50 x 85/b	B25832-A4166-K9
20			55 x 85/b	B25832-A4206-K9
22			60 x 85/b	B25832-A4226-K9
25			60 x 85/b	B25832-A4256-K9
25			45 x 155/b	B25832-S4256-K9
30			50 x 155/b	B25832-A4306-K9
33			50 x 155/b	B25832-A4336-K9
47			60 x 155/b	B25832-A4476-K9
50			60 x 155/b	B25832-A4506-K9

For further voltage series (330 Vac and 660 Vac) refer to the data sheet B25833-V.

[1]) DB = continuous operation

Design: Self-healing capacitors for ac application comprising metal paper electrodes and a low-loss plastic film as dielectric. The tubular windings are oil-impregnated and have contact-proof front surface metallization.

Case: The windings are built into tubular metal cases with tightly folded rings.

Connection: Two flat two-pin plugs (see dimensional drawings).

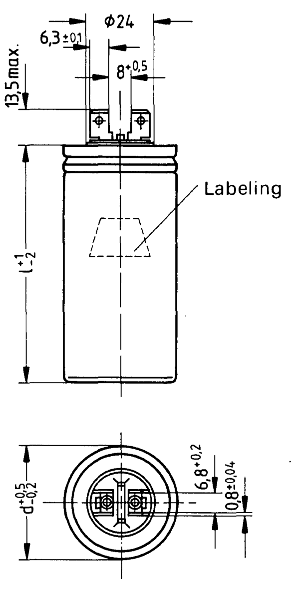
Overload protection: The capacitors are provided with an excess pressure make-and-break fuse which cuts off the current supply in case of electrical or thermal overload. Upon fuse operation the capacitor case expands up to 8 mm; this space has to be kept vacant above the capacitor.

General technical information: Refer to data book 1979/80 "Capacitors for Power Electronics", page 23.

Application: Damping in accordance with VDE 0560-12 (E). Resonant circuit capacitors suitable e. g. for magnetic voltage stabilizers.

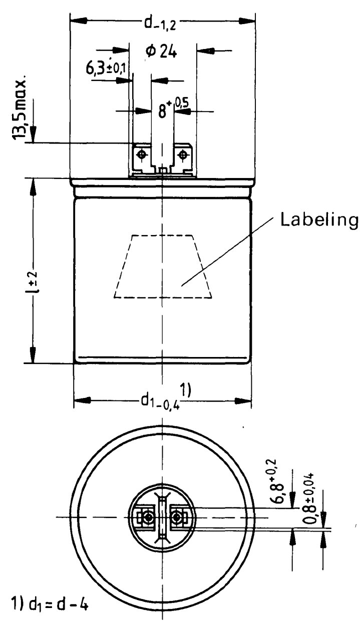
For capacitor dimensions and ordering codes refer to table on page (2). For capacitors of voltage group 450 V ac, refer to data sheet B 25 832.

Dimensional drawing a



Dimensions in mm

Dimensional drawing b



1) $d_1 = d - 4$

Climatic category

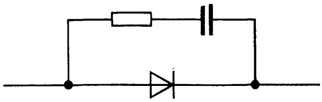
Climatic category in accordance with DIN 40040			**H P F / M S**
Min category temperature	ϑ_{min}	**H**	−25°C
Max. category temperature	ϑ_{max}	**P**	+85°C
Storage temperature range	ϑ_{stg}		−55°C to +85°C
Humidity category		**F**	Average relative humidity ≦ 75%; 95% on 30 days per year; 85% on the remaining days
Failure quota	α_{AQ}	**M**	1000 failures per 10^9 component hours
Load duration	t_{BD}	**S**	30 000 hrs
Failure rate			$1000 \times 10^{-9} \times 3 \times 10^4 = 3\%$

Characteristics

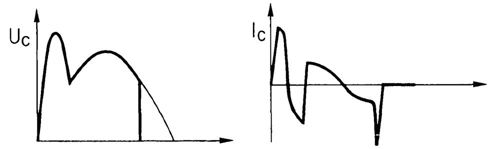
Rated voltage, sinusoidal	U_N	**330 V**	**660 V**
Peak voltage, occasionally	u_{max}	1000 V	2000 V
Voltage rate of rise	$\left(\frac{du}{dt}\right)_{max}$	≦ 10 V/μs	≦ 20 V/μs
Rated frequency	f_N	50 to 60 Hz	50 to 60 Hz
Voltage waveform		Slight deviations from the sinusoidal waveform are permitted. In cases of doubt please furnish a voltage oscillogram for a harmonic analysis.	

Test data

AC test voltage, terminal to terminal		710 V; 50 Hz; 2 sec	1420 V; 50 Hz; 2 sec
AC test voltage, terminal to case		2500 V; 50 Hz; 2 sec	3000 V; 50 Hz; 2 sec
Dissipation factor measured at U_N; f_N; 20°C	tan δ	$< 5 \times 10^{-4}$	$< 5 \times 10^{-4}$
Self-discharge time constant measured at 100 V; 1 min; 20°C	τ	> 3000 sec	> 3000 sec



Circuit diagram

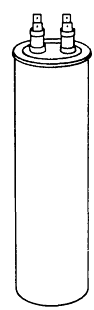
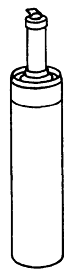


Voltage and current characteristic

Damping capacitors are ac capacitors that are connected in parallel with semiconductor components to suppress or attenuate undesired voltage peaks. The capacitors are periodically charged and/or discharged, whereby the peak value of the ocurring current substantially exceeds the rms value.

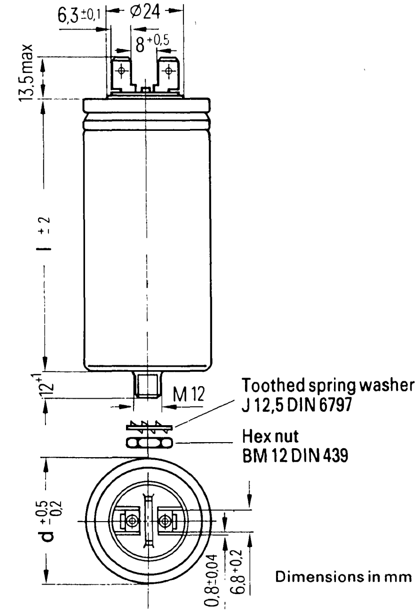
Damping capacitors are in addition to the sine-halfwave voltage load subject to periodic voltage peaks from the carrier storage effect and to harmonics in case of phase control circuits.

Main features: high voltage stability
high peak current carrying capacity
reliability

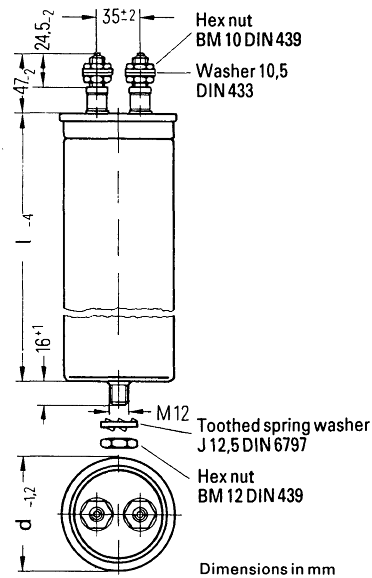
Type	Capacitance	Rated voltage[1])	
B 25834	33µ...220µF 0.68µF...150µF 0.1µ...68µ	320 V 400 V 630 V	
B 25835	0.1 to 4.7µF	850 V to 3000 V	

Dimensional Drawing

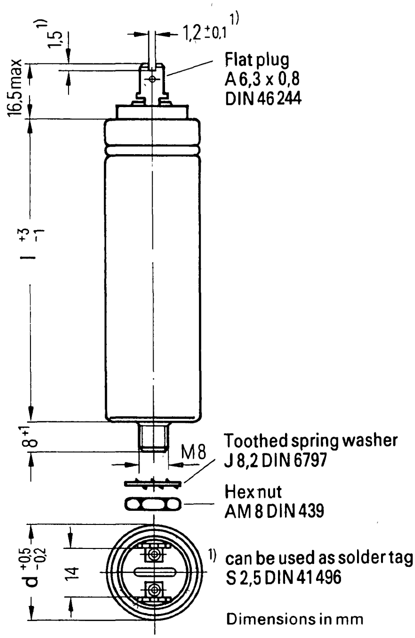
a.



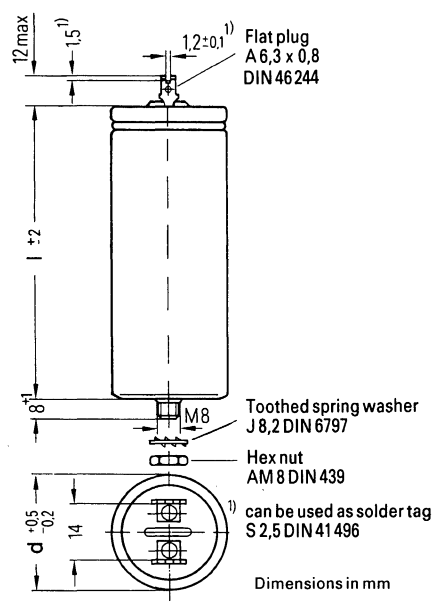
b.



c.



d.



Damping capacitors

Summary of types

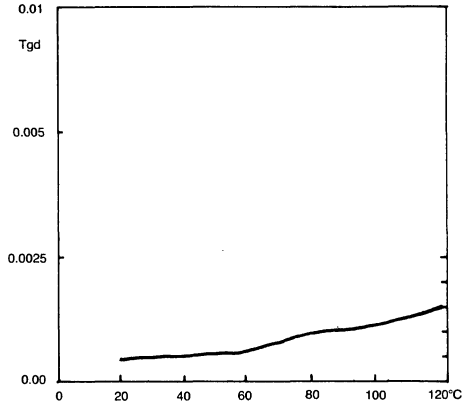
AC-Voltage		630	1000	1500	2200
Rated voltage U_R		850V	1400V	2100V	3000V
Rated capacitance C_R		Dimensions d x l(mm) Ordering code			
µF	Tolerance	B 25835-	B 25835-	B 25835-	B 25835-
0.1	±10% = K		25 x 69 -K0104-K7		35 x 130 -K2104-K7
0.22	±10% = K	25 x 56 -K6224-K7	25 x 69 -K0224-K7		35 x 130 -K2224-K7
0.33	±10% = K	25 x 56 -K6334-K7	25 x 94 -K0334-K7		50 x 130 -K2334-K7
0.47	±10% = K	25 x 56 -K6474-K7	30 x 94 -K0474-K7	35 x 130 -K1474-K7	50 x 130 -K2474-K7
0.68	±10% = K	30 x 56 -K6684-K7	30 x 94 -K0684-K7	35 x 130 -K1684-K7	60 x 130 -K2684-K7
1.0	±10% = K	30 x 56 -K6105-K7	35 x 94 -K0105-K7	45 x 130 -K1105-K7	
2.2	±10% = K	45 x 56 -K6225-K7	50 x 94 -K0225-K7	60 x 130 -K1225-K7	
4.7	±10% = K	60 x 56 -K6475-K7			

Ordering Example

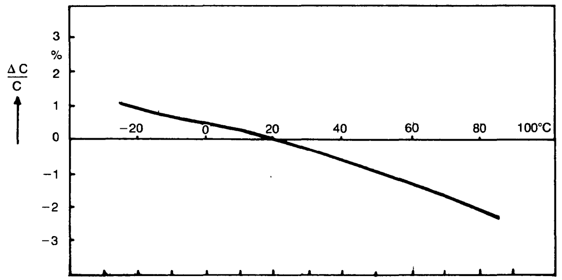
0,1, µF ± 10% 3000V = B 25835-K 2104-K7

Electrical Performance as a Function of Temperature:

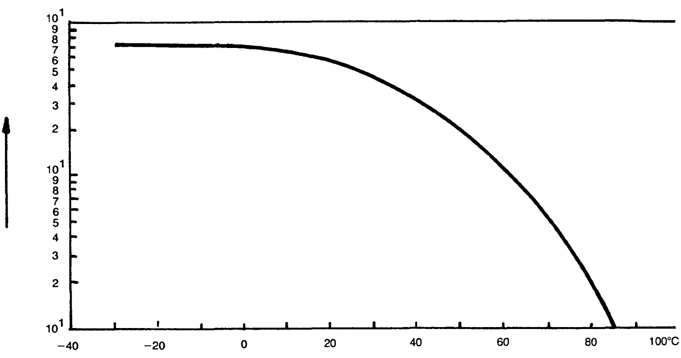
1. (tg) Dissipation Factor as a Function of Temperature



2. Reversible Capacitance Change $\frac{\Delta C}{C}$ as a Function of Temperature



3. Insulation Resistance as a Function of Temperature



Rated Capacitance µ	Tolerance %	Rated Voltage at 50/60 Hz 370 Dimensions (Ø x L) mm
15 + 4	−3	53 x 115
15 + 5	+6	53 x 115
15 + 7.5		53 x 115
15 + 12.5		53 x 123
20 + 4		53 x 133
20 + 5		53 x 133
25 + 4		63.5 x 124
25 + 5		63.5 x 124
25 + 7.5		63.5 x 124
25 + 10		63.5 x 124
25 + 12.5		63.5 x 124
30 + 4		63.5 x 133
30 + 5		63.5 x 133
30 + 7.5		63.5 x 133
30 + 10		63.5 x 133
35 + 4		63.5 x 148
35 + 5		63.5 x 148
35 + 7.5		63.5 x 148
35 + 12.5		63.5 x 148
40 + 4		63.5 x 100
40 + 5		63.5 x 160
40 + 7.5		63.5 x 160
40 + 10		63.5 x 160
45 + 4		63.5 x 160
45 + 5		63.5 x 160
45 + 7.5		63.5 x 160
45 + 10		63.5 x 160
50 + 5		63.5 x 170
50 + 10		63.5 x 170

Ordering Code: 30 + 10/370/7754

Example: 30 + 10µf 370v 7754

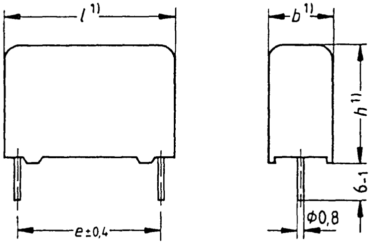
Capacitance — 30 + 10µf

Rated Voltage — 370v

Type Code — 7754

X2 capacitors **Rated voltage 400 Vac, 50...1000 Hz**

Self-healing capacitor with plastic films as dielectric; enclosed in rectangular plastic case with epoxy resin seal. (The plastic case and the epoxy resin are flame-retardant.) The case is provided with spacers to improve solderability in the solder bath.
The capacitors have parallel leads in the lead spacing and are particularly suitable for PC mounting.



1) max.
Dimensions in mm

Technical data

Permissible dc voltage	1000 V dc
Test voltage	1800 V dc, 2 sec (layer to layer)
also permitted	750 Vac, 50 Hz, 1 min
Permissible voltage peaks (max.)	1600 V
Voltage rate of rise (max.)	200 V/µs
Life test (type test)	in acc. with VDE 0565 part 1
Capacitance tolerance	± 10%
Insulation	≧ 30,000 MΩ
DIN climatic category	GPF (−40 to +85°C/−40 to +185°F; humidity category F)
IEC climatic category	40/085/21
Specifications	As X2 capacitors these capacitors comply with IEC 384-14 and VDE 0565-1.

Types

Rated capacitance µF	Dimensions $b \times h \times l$ mm	Lead spacing e mm	Approx. weight g	Ordering code
0.01 (X2)	7 x 13 x 18	15	2	B81121-C-B92
0.022 (X2)	9 x 14.5 x 18	15	2.2	B81121-C-B93
0.033 (X2)	7.3 x 16.5 x 27	22.5	4.4	B81121-C-B94
0.047 (X2)	8.5 x 18.5 x 27	22.5	5.2	B81121-C-B95
0.068 (X2)	10.5 x 19 x 27	22.5	7.5	B81121-C-B96
0.1 (X2)	11 x 20.5 x 27	22.5	8.5	B81121-C-B97
0.15 (X2)	11.5 x 21 x 31.5	27.5	10	B81121-C-B98
0.22 (X2)	15 x 24.5 x 31.5	27.5	15.4	B81121-C-B99
0.33 (X2)	18 x 27.5 x 31.5	27.5	20.8	B81121-C-B100

The information describes the type of component and shall not be considered as assured characteristics

Types

Rated capacitance µF	Dimensions $b \times h \times l$ mm	Lead spacing e mm	Approx. weight g	Ordering code[1]
0.022	5.5 x 11 x 18	15	1.5	B81121-C-*104
0.033	7 x 13 x 18	15	2.0	B81121-C-*105
0.047	9 x 14.5 x 18	15	2.2	B81121-C-*106
0.068	9 x 14.5 x 18	15	2.2	B81121-C-*107
0.1	9 x 17.5 x 18	15	5	B81121-C-D108[3]
0.1	9 x 17.5 x 18	15	5	B81121-C-E108[4]
0.15	8.5 x 18.5 x 27	22.5	5.2	B81121-C-*109
0.22	10.5 x 19 x 27	22.5	7.5	B81121-C-*110
0.33	11.5 x 21 x 31.5	27.5	10	B81121-C-*111
0.47	13.5 x 23 x 31.5	27.5	14	B81121-C-*112
0.68	15 x 24.5 x 31.5	27.5	16	B81121-C-*113
1.0	18 x 27.5 x 31.5	27.5	20	B81121-C-*114[2]

[1]) When ordering, quote the code letter of the lead length required (see dimensional drawings).
B = short leads
C = long leads

[2]) Without sev approval

[3]) Short lead length

[4]) Long lead length

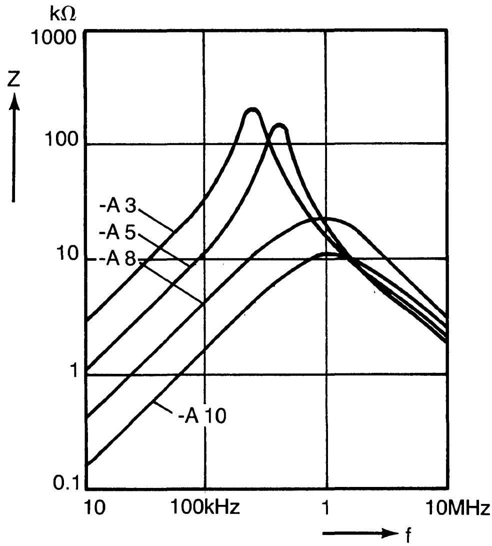
Types

Rated capacitance µF	Dimensions $b \times h \times l$ mm	Lead spacing e mm	Approx. weight g	Ordering code[1])
0.022	5.5 x 11 x 18	15	1.5	B81121-C-*121
0.033	5.5 x 11 x 18	15	2.0	B81121-C-*122
0.047	7 x 13 x 18	15	2.3	B81121-C-*123
0.068	9 x 14.5 x 18	15	3.2	B81121-C-*124
0.1	9 x 14.5 x 18	15	3.2	B81121-C-*125
0.15	8.5 x 18.5 x 27	22.5	5.2	B81121-C-*126
0.22	10.5 x 19 x 27	22.5	6.5	B81121-C-*127
0.33	11 x 20.5 x 27	22.5	7.0	B81121-C-*128
0.47	11.5 x 21 x 31.5	27.5	10	B81121-C-*129
0.68	13.5 x 23 x 31.5	27.5	12	B81121-C-*130
1.0	18 x 27.5 x 31.5	27.5	19	B81121-C-*132

[1]) When ordering, quote the code letter of the lead length required (see dimensional drawings).
B = short leads
C = long leads

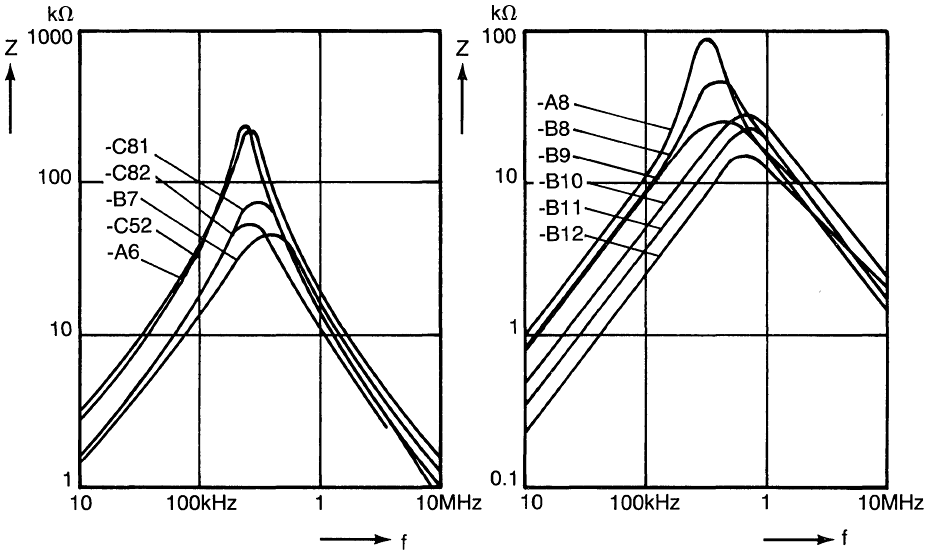
Impedanze A. versus frequency f

(measured with windings connected in parallel)



Impedance Z versus frequency f

(measured with windings connected in parallel)

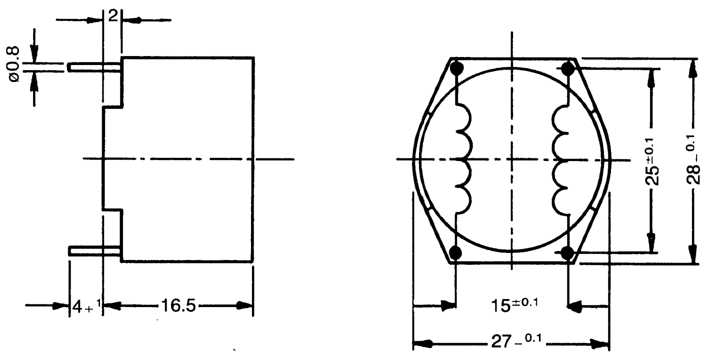


Current-compensated ring core double chokes

Rated voltage 250 Vac
Rated current 0.5 to 4A

Ring core chokes with ferrite core, sealed in a plastic can. Can and sealing are flame-retardant in accordance with UL 94 V-O.

The chokes are provided with terminal pins in the lead spacing and are particularly suitable for PC board mounting.



Dimensions in mm

Technical data

Test voltage	1500 Vac, 2s, (winding to winding)
Rated current	referred to 50 Hz and +60°C/140°F room temperature
Approx. weight	15 g
Test symbol	 565-2

For further details refer to "Technical data on current-compensated ring core chokes".

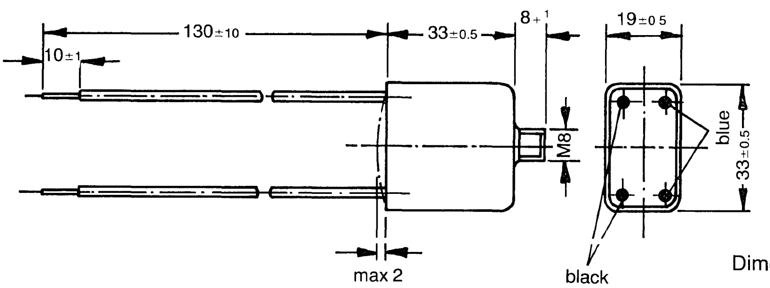
Types

Rated current per winding A	Rated inductance per winding mH	DC resistance per winding (typical value) mΩ	Ordering code
0.5	22	1600	B82723-G5-A5
0.6	39	1100	B82723-G5-B6
1	10	600	B82723-G5-A8
2	5.6	160	B82723-G5-A10
4	2.7	60	B82723-G5-A12

Current-compensated ring core double chokes incl. shielding

Rated voltage 250 Vac
Rated current 1 to 6A

Chokes, enclosed in aluminium case, epoxy resin sealed. A threaded stud at the bottom of the case is provided for mounting.
Single-ended fine litz-wire lines.



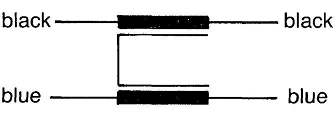
Dimensions in mm

Technical data

Test voltage	1500 V, 2s, (winding to winding)
	2500 V, 2s, (winding to case)
Rated current	referred to 50 Hz and +60°C/140°F room temperature
Approx. weight	50 g

For further details refer to "Technical data on current-compensated ring core chokes".

Circuit



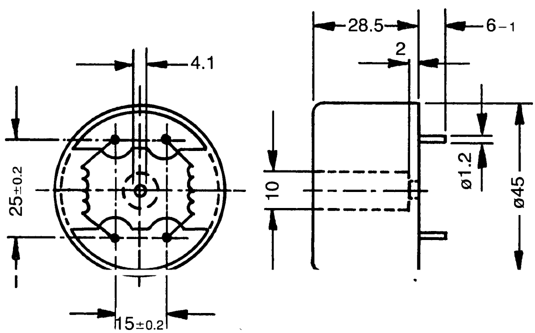
Types

Rated current per winding A	Rated inductance per winding mH	DC resistance per winding (typical value) mΩ	Connections cross section/ material	Ordering code PU: 50
1	12	700		B82723-E1-A8
1.6	10	450		B82723-E1-A9
2	6.8	200	0.75 mm²/NYFAFw	B82723-E1-A10
4	3.3	90		B82723-E1-A12
6	1.5	40		B82723-E1-A13

Current-compensated ring core double chokes

Rated voltage 250 Vac
Rated current 1 to 10A

Ring core chokes with ferrite core, sealed in plastic can. An aluminum can is used for shielding. The chokes are provided with terminal pins in the lead spacing and are particularly suitable for PC board mounting.



Dimensions in mm

Technical data

Test voltage	1500 Vac, 2s, (winding to winding) 2500 Vac, 2s, (winding to case)
Rated current	referred to 50 Hz and +60°C/140°F room temperature
Approx. weight	100 g

For further details refer to "Technical data on current-compensated ring core chokes".

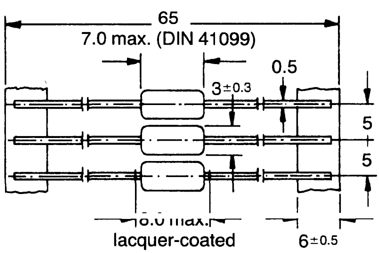
Types

Rated current per winding A	Rated inductance per winding mH	DC resistance per winding (typical value) mΩ	Ordering code PU: 200
1	33	1000	B82724-G4-A8
1.6	27	560	B82724-G4-A9
2	15	400	B82724-G4-A10
4	6.8	120	B82724-G4-A12
6	3.9	55	B82724-G4-A13
10	1.8	25	B82724-G4-A14

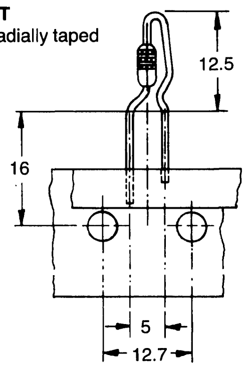
Construction:

MCC and BC chokes are wound on the approved SIFERRIT cylinder cores or on SIFERRIT drum cores. The mechanically rigid plastic encapsulation is unaffected by the usual cleaning agents (e.g. Freon) and flame-retardant in accordance with the UL 94 V-0 regulation. Color coding is done by rings in accordance with IEC publication 62-1974. The stand-off version can be supplied with the bent lead insulated down to PC board level.

B78108-T
taped



B78148-T
central-radially taped



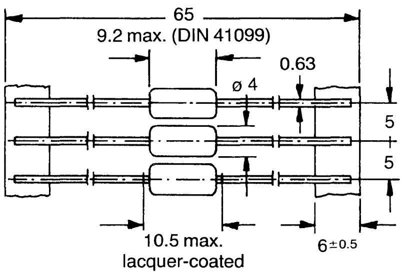
Dimensions in mm

Technical Data:

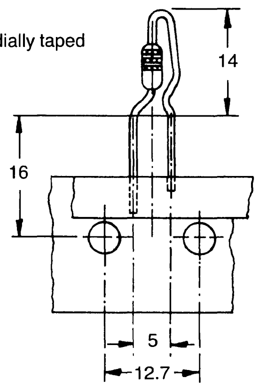
Inductance:	0.1 ... 100µH Measuring Frequency 1 MHZ for L ≤ 10µH 10 KHZ for L > 10µH
Rated Current:	at 40°C
DC-Resistant:	at 20°C
Climate Category:	
At DIN:	FKF (−55°C to +125°C)
At IEC:	55/125/56
Solderability:	+260°C, 10 sec.
Tensile Strength of the Leads:	≥20N.

BC (**b**obbin **c**ore) chokes, are RF-chokes, wound on a special SIFERRIT cylinder core. The mechanically rigid plastic encapsulation is unaffected by the usual cleaning agents and flame-retardant in accordance with UL 94-V-0. Color coding is done by rings in accordance with IEC publication 62-1974. The stand of version can be supplied with the bent lead insulated down to PC board level.

B78108-S
taped



B78148-S
central-radially taped



Dimensions in mm

Technical Data:

Inductance:	0.1 . . . 4700μH Measuring Frequency 1 MHZ for L ≤ 10μH 10 KHZ for L > 10μH
Rated Current:	at 40°C
DC-Resistant:	at 20°C
Climate Category:	
At DIN:	FKF (− 55°C to + 125°C)
At IEC:	55/125/56
Solderability:	+ 260°C, 10 sec.
Tensile Strength of the Leads:	≥20N.

Leakage current	As voltage-dependent dielectrics are used for the Y capacitors, a leakage current of 0.5 mA per arm is ensured at 250 V, 50 Hz.
Attenuation	The ability of attenuating unsymmetric interference as well as symmetric interference voltage part is an important factor for a powerful EMI suppression. Particularly the filter series B, C, and D ensure a high, symmetric suppression effect already from 150 kHz on due to a suitable selection of the component.

Other technical data

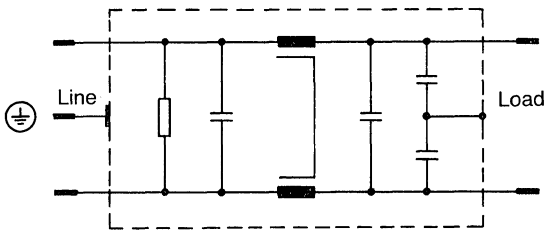
Rated voltage	71-13 to +185°F 115/220 V ac, 50/60 Hz
Rated current	referred to 40°C ambient temperature
Test voltage	1414 V dc; 2 s; conductor to conductor 2700 V dc; 2 s; conductor to ground
Leakage current	≤0.5 mA at 250 V ac/50 Hz

DIN climatic category HPF (−25 to +85°C humidity category F)

Standard SIFI filter series
SIFI A, normal, attenuation

Rated voltage 250 Vac
Rated current up to 20 A

Circuit diagram



Technical

Rated voltage U_R	115/220 V ac, 50/60 Hz
Rated current	referred to 40°C/104°F ambient temperature
Test voltage	1414 V dc; 2 s; conductor to conductor 2700 V dc; 2 s; conductor to ground
Leakage current	<0.5 mA at 250 V ac/50 Hz
DIN climatic category	HPF (−25 to +85°C/−13 to +185°F, humidity category F)
Test symbols	(Guide FOKY 2) 565-3
Test symbols	CSA, SEMKO, DEMKO, NEMKO applied for

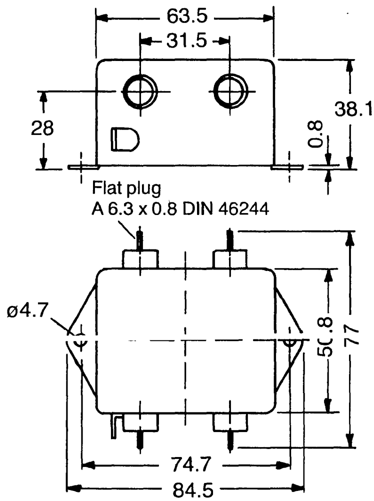
Discharging resistor in accordance with VDE 0730, IEC 355, IEC 380, and IEC 435

Rated current A	Version A[1] Ordering code PU: 20	Version A[1] Approx. weight (g)	Version B Ordering code PU: 20	Version B Approx. weight (g)	Version K Ordering code PU: 20	Version K Approx. weight (g)
1	B 84 111-A-A10	80	–	–	B 84 111-A-K10	140
2	B 84 111-A-A20	80	–	–	–	–
3	B 84 111-A-A30	80	–	–	B 84 111-A-K30	140
6	B 84 111-A-A60	110	B 84 111-A-B60	110	B 84 111-A-K60	140
10	B 84 111-A-A110	120	B 84 111-A-B110	120	–	–
20[2]	B 84 111-A-A120	210	B 84 111-A-B120	210	–	–

[2]UDE approval in accordance to VDE 0565 IT3 only for 16A.

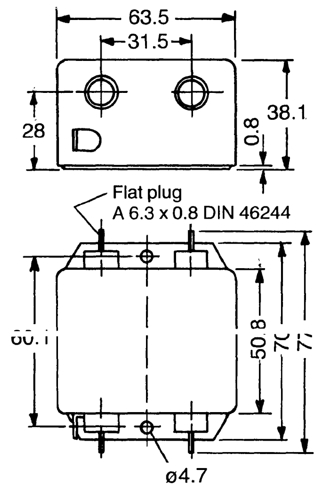
Standard SIFI filter series

Version A



B 84 111-A-A120

Version B



B 84 111-A-B120

Dimensions in mm

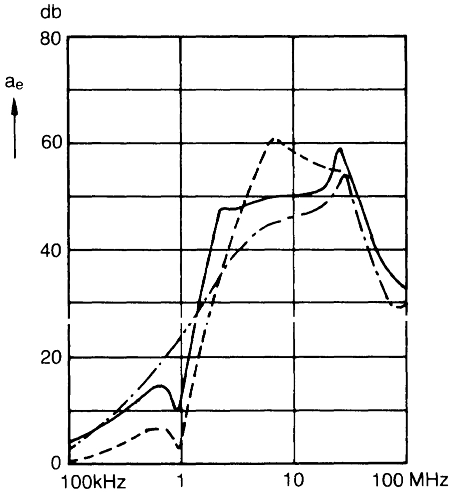
Standard SIFI filter series

Insertion loss (typical values at $Z = 50\ \Omega$)

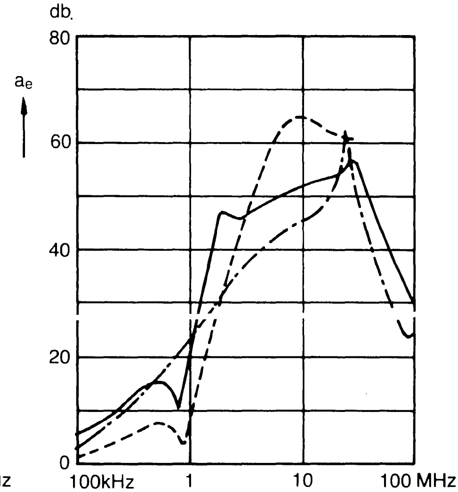
———————— Unsymmetric measurement, adjacent arm terminated

–·—·—·— asymmetric measurement, both arms in parallel (common mode)

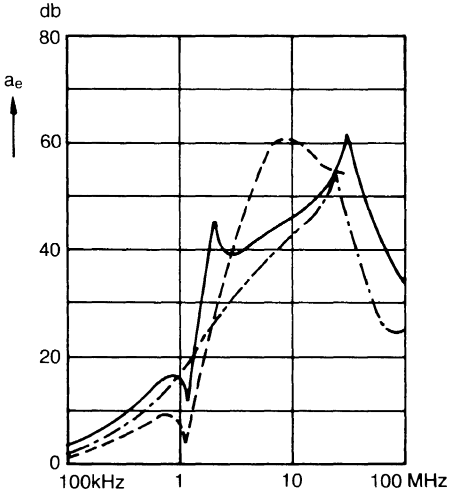
– – – – – – – symmetric measurement, (differential mode)



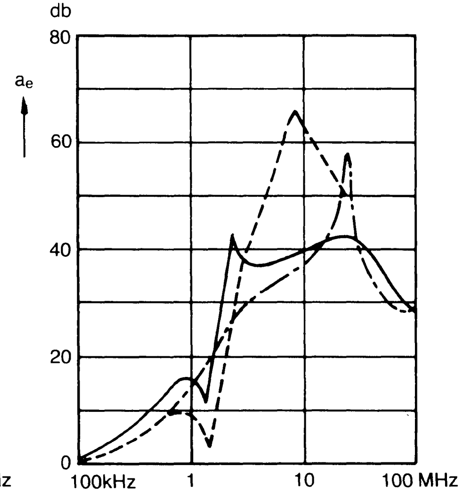
B 84 111-A-A10/-K10 ——► f
B 84 111-A-A20
B 84 111-A-A30/-K30



B 84 111-A60/-B60/-K60 ——► f



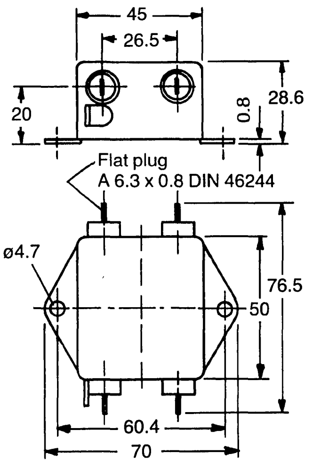
B 84 111-A-A110/-B110 ——► f



B 84 111-A-A120/-B120 ——► f

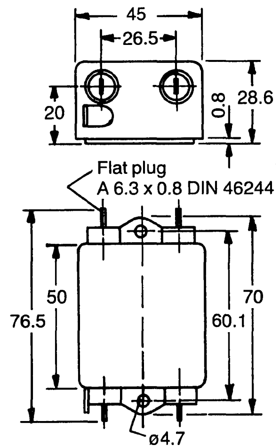
Standard SIFI filter series

Version A

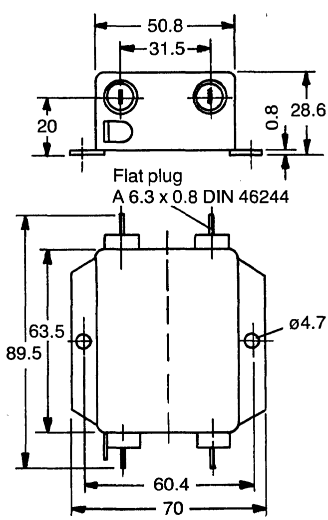


B 84 112-B-A10
B 84 112-B-A20

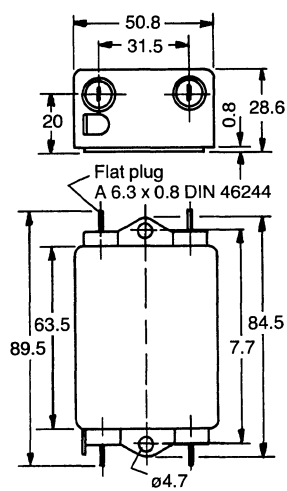
Version B



B 84 112-B-B10
B 84 112-B-B20



B 84 112-B-A30
B 84 112-B-A60

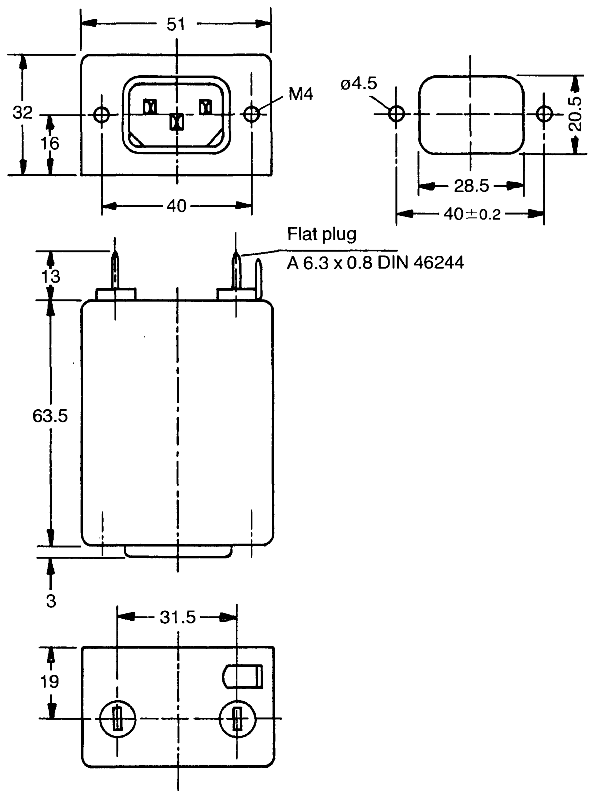


B 84 112-B-B30
B 84 112-B-B60

Dimensions in mm

Standard SIFI filter series

Version K

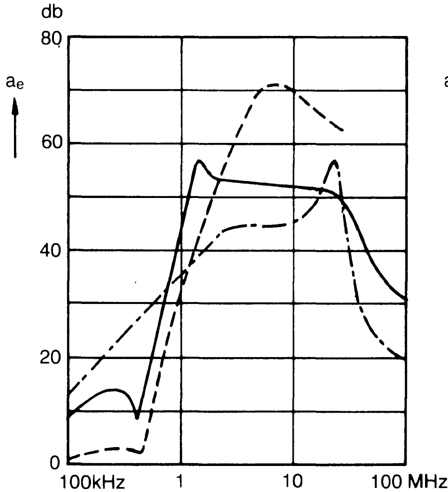


B 84 112-B-K10

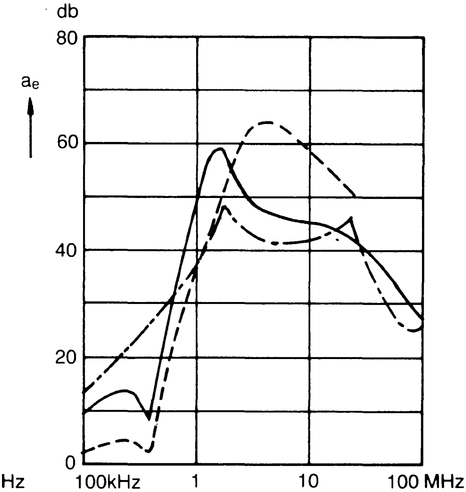
Standard SIFI filter series

Insertion loss (typical values at Z = 50 Ω)

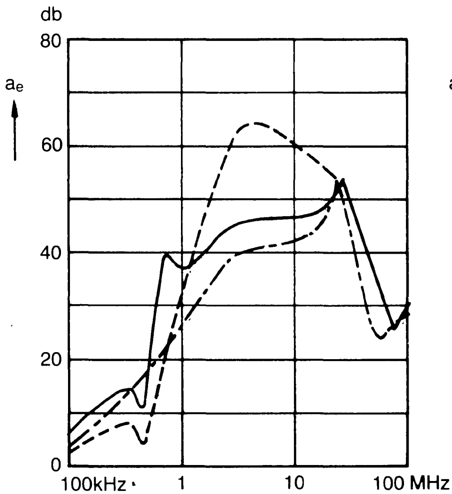
———————— Unsymmetric measurement, adjacent arm terminated
-·—·—·— asymmetric measurement, both arms in parallel (common mode)
— — — — — symmetric measurement, (differential mode)



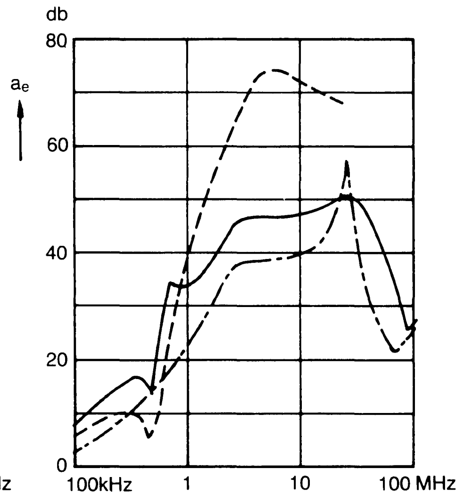
B 84 112-B-A10/-B10/-K10 → f
B 84 112-B-A20/-B20



B 84 112-B-A30/-B30/-K30 → f



B 84 112-A60/-B60/-K60 → f

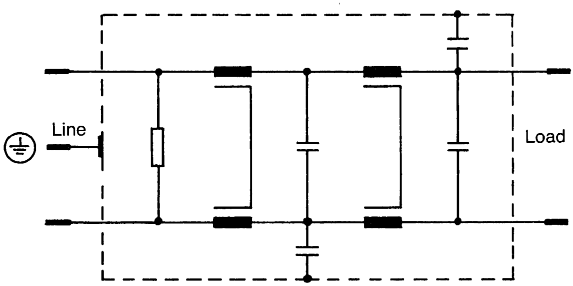


B 84 112-A110/-B110 → f

Standard SIFI filter series
SIFI C, very high attenuation

Rated voltage 250 Vac
Rated current up to 10 A

Circuit diagram



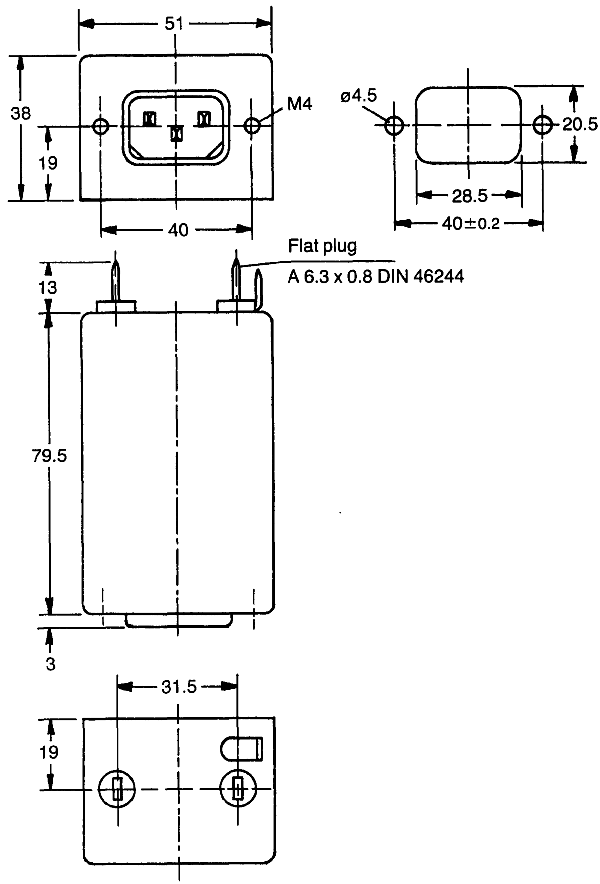
Technical data

Rated voltage *U*R	115/220 V ac, 50/60 Hz
Rated current	referred to 40°C/104°F ambient temperature
Test voltage	1414 V dc; 2 s; conductor to conductor 2700 V dc; 2 s; conductor to ground
Leakage current	<0.5 mA at 250 V ac/50 Hz
DIN climatic category	HPF (−25 to +85°C 0565-3 humidity category F)
Test symbols	VDE 0565-3, UR, S (Guide FOKY 2)
Test symbols	CSA, SEMKO, DEMKO, NEMKO, applied for
Discharging resistor	in accordance with VDE 0730, IEC 355, IEC 380, and IEC 435

Rated current A	Version A[1)] Ordering code PU: 20	Version A[1)] Approx. weight (g)	Version B Ordering code PU: 20	Version B Approx. weight (g)	Version K Ordering code PU: 20	Version K Approx. weight (g)
3	B 84 113-C-A30	210	B 84 113-C-B30	210	B 84 113-C-K30	270
6	B 84 113-C-A60	510	B 84 113-C-B60	510	–	–
10	B 84 113-C-A110	690	B 84 113-C-B110	690	–	–

Standard SIFI filter series

Version K

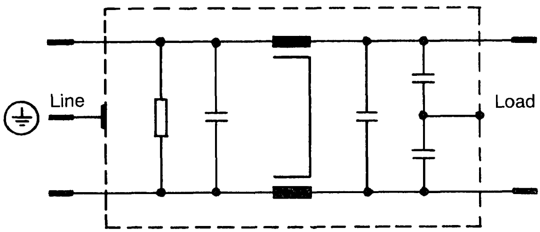


B 84 113-C-K30

Standard SIFI filter series
SIFI D, High attenuation

Rated voltage 250 Vac
Rated current up to 10 A

Circuit diagram



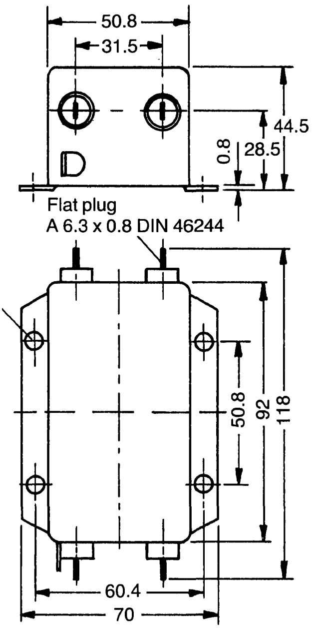
Technical data

Rated voltage *U*R	115/220 V ac, 50/60 Hz
Rated current	referred to 40°C/104°F ambient temperature
Test voltage	1414 V dc; 2 s; conductor to conductor 2700 V dc; 2 s; conductor to ground
Leakage current	<0.5 mA at 250 V ac/50 Hz
DIN climatic category	HPF (−25 to +85°C/−13 to +185°F, humidity category F)
Test symbols	VDE 0565-3, UR, S (Guide FOKY 2)
Test symbols	CSA, SEMKO, DEMKO, NEMKO, applied for
Discharging resistor	in accordance with VDE 0730, IEC 355, IEC 380, and IEC 435

Rated current A	Version A[1)] Ordering code PU: 20	Version A[1)] Approx. weight (g)	Version B Ordering code PU: 20	Version B Approx. weight (g)	Version K Ordering code PU: 20	Version K Approx. weight (g)
1	B 84 114-D-A10	150	B 84 114-D-B10	150	B 84 114-D-K10	210
2	B 84 114-D-A20	150	B 84 114-D-B20	150	–	–
3	B 84 114-D-A30	150	B 84 114-D-B30	150	B 84 114-D-K30	210
6	B 84 114-D-A60	230	B 84 114-D-B60	230	B 84 114-D-K60	290
10	B 84 114-D-A110	420	B 84 114-D-B110	420	–	–

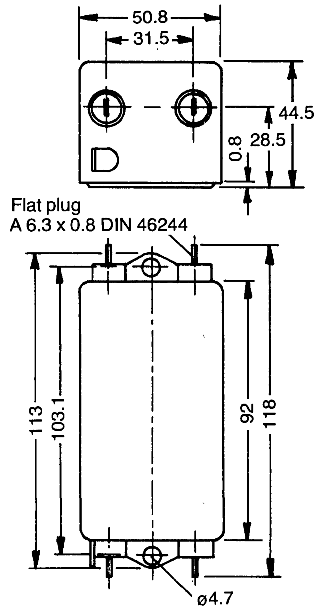
Standard SIFI filter series

Version A



B 84 114-D-A110

Version B

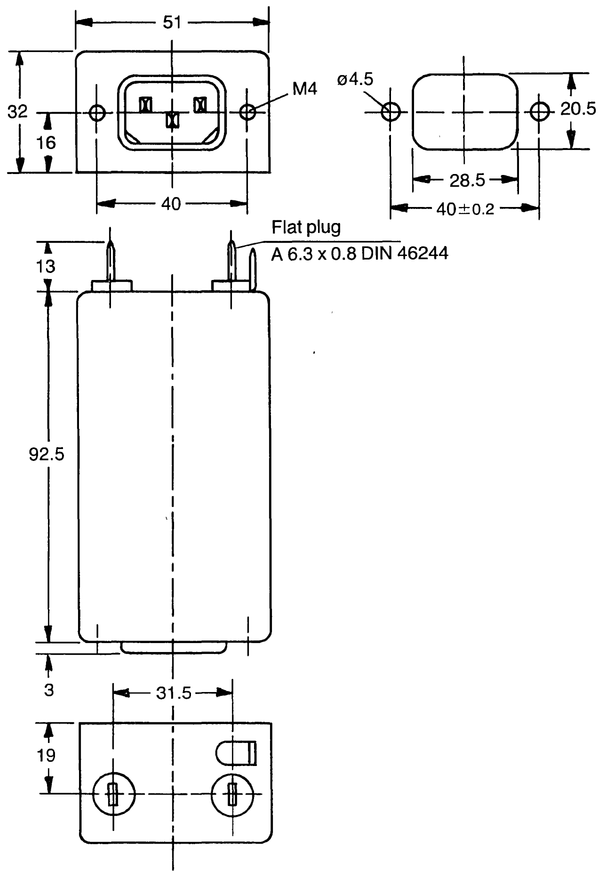


B 84 114-D-B110

Dimensions in mm

Standard SIFI filter series

Version K



B 84 114-D-K60

Filter with EIC plug

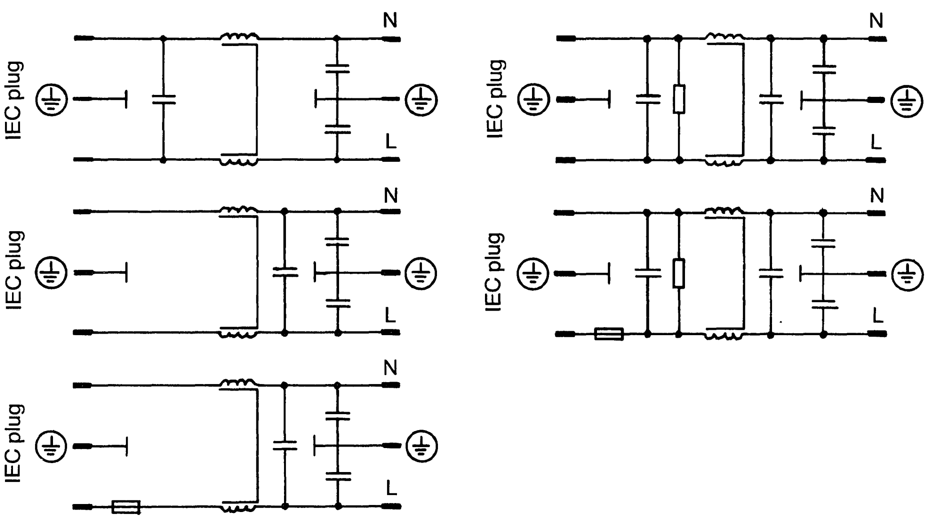
Rated voltage 250 V ~
Rated current up to 6 A

Series of filters having an integrated plug in accordance with IEC 320 with and without device protection are available for use in desk calculators, office machines, medical equipment and other electronic devices.

Relating to electromagnetic compatibility, the filters can be mounted at the best suitable assembly location directly at the interface of line and device.

The application of these filters results in reducing the interference level generated in the devices as well as in an efficient protection against interference from the power line.

Circuit diagrams



Technical data

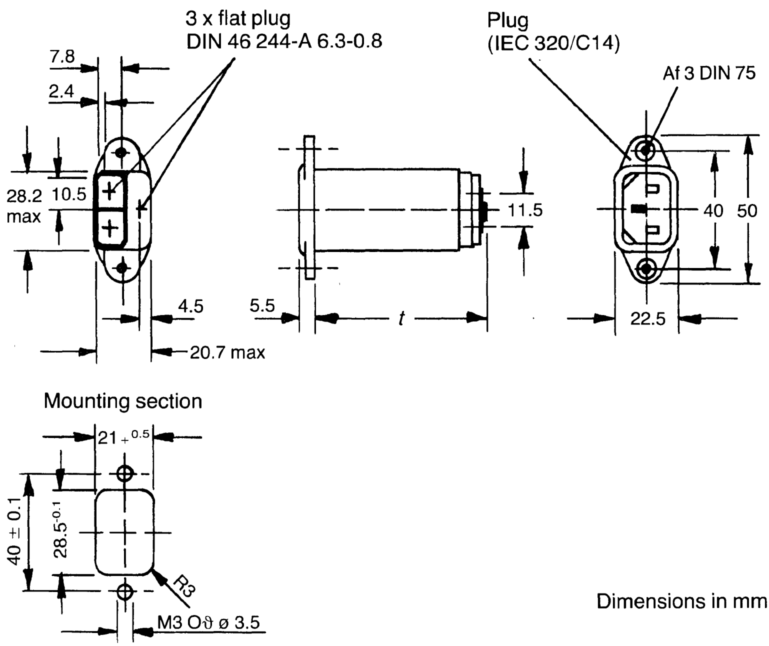
Rated voltage	115/250 Vac, 50/60 Hz
Rated current	Referred to 40°C/104°F ambient temperature
Test voltage	1414 Vdc, 2 s (line to line) 2700 Vdc, 2 s (line to ground)
DIN climatic category	HPF (–25 to + 85°C/–13 to + 185°F humidity category F)
Test symbols	VDE 0565-3, UL, CSA, SEV, SEMKO, DEMKO, NEMKO applied for
Discharging resistor	in accordance with VDE 0730, IEC 355, IEC 380 and IEC 435

Filter with IEC plug and fuse B84104

Rated current A	Leakage current* mA	Circuit diagram	Dimension	Approx. weight (g)	Ordering code PU:30
1 2 4 6	<0.34	3	51	50	B84104-A1-A10 B84104-A1-A20 B84104-A1-A40 B84104-A1-A60
1 2 4 6	<0.34	4	61	60	B84104-B2-A10 B84104-B2-A20 B84104-B2-A40 B84104-B2-A60
1 2 4 6	<0.5	5	76	80	B84104-C3-A10 B84104-C3-A20 B84104-C3-A40 B84104-C3-A60

*) at 250 Vac. 50 Hz

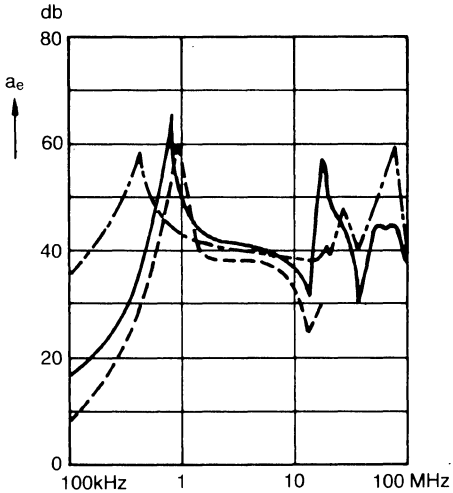
Outline drawing



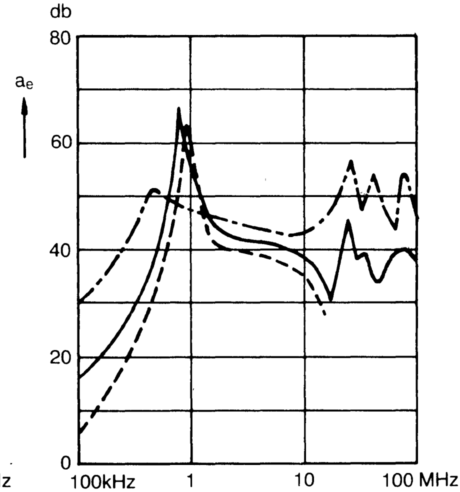
Dimensions in mm

Insertion loss (typical values at $Z = 50\ \Omega$)

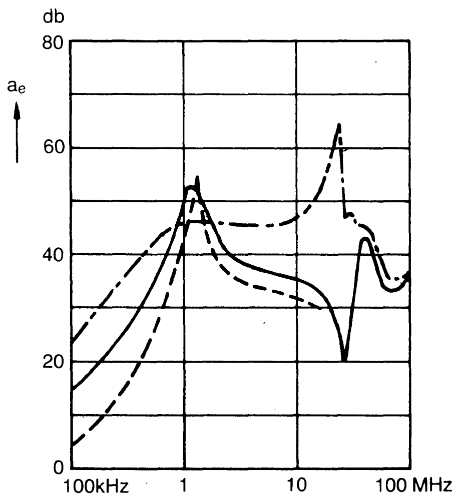
——————— Unsymmetric measurement, adjacent arm terminated
— — —— - —- — asymmetric measurement, both arms in parallel (common mode)
— — — — — — — symmetric measurement, (differential mode)



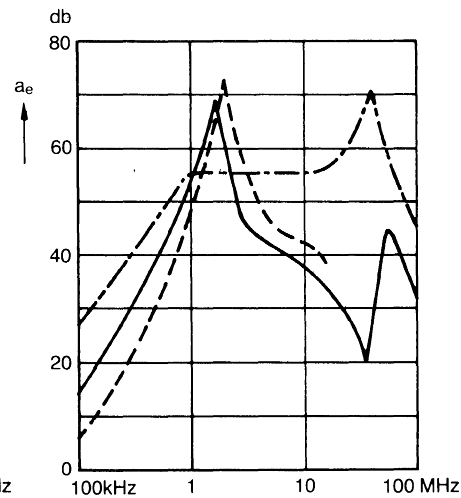
B 84103-B2-A10 ——► f
B 84104-B2-A10



B 84103-B2-A20 ——► f
B 84104-B2-A20



B 84103-B2-A40 ——► f
B 84104-B2-A40



B 84103-B2-A60 ——► f
B 84104-B2-A60

General technical information

State-of-the-art data and signal transmission methods – particularly in terminal systems – allow symmetrical data processing on simple unshielded multi-wire lines at a speed of up to several 100 K bits/second.

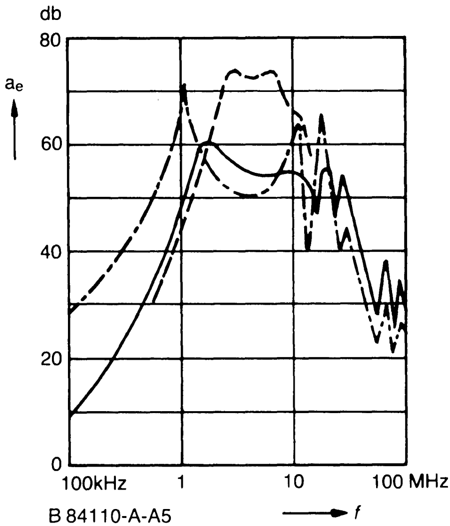
In order to keep this technology alive even under the regulations of RFI suppression as well as from the EMC point of view, highly symmetric suppression chokes and filters have been developed.

Insertion loss (typical values at $Z = 50\ \Omega$)

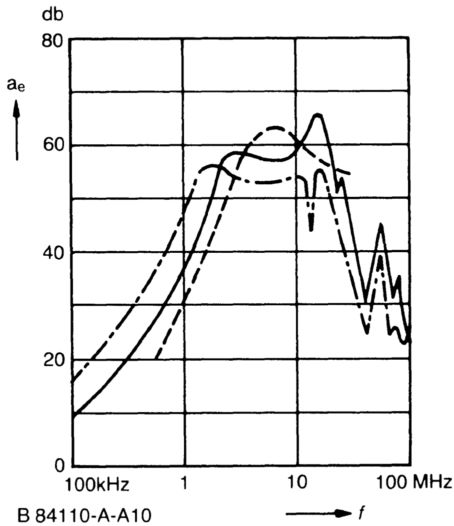
——————— Unsymmetric measurement, adjacent arm terminated

–·—·—·— asymmetric measurement, both arms in parallel (common mode)

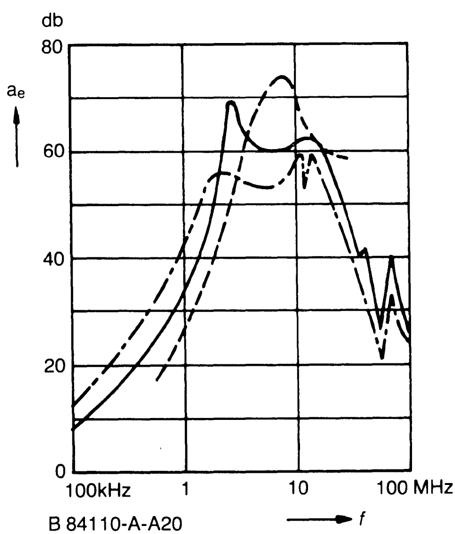
– – – – – – symmetric measurement, (differential mode)



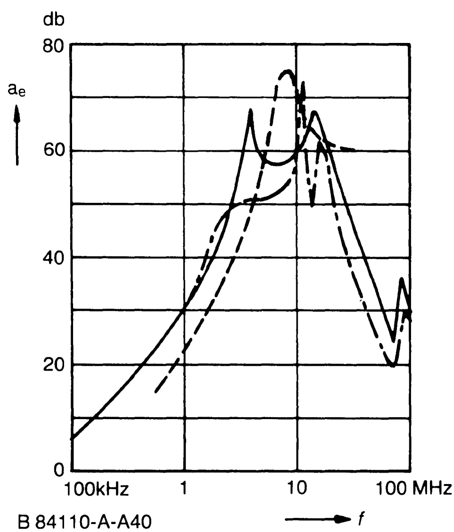
B 84110-A-A5



B 84110-A-A10



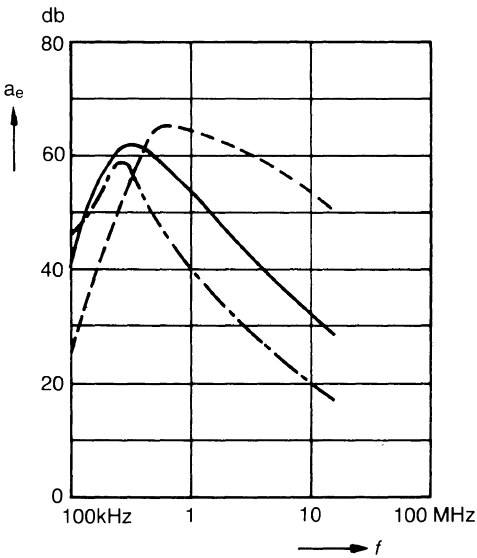
B 84110-A-A20



B 84110-A-A40

Insertion loss (typical values at $Z = 50\ \Omega$)

——————— Unsymmetric measurement, adjacent arm terminated
–·——–——·— asymmetric measurement, both arms in parallel (common mode)
– ––––––– symmetric measurement, (differential mode)



1.3 Dimensions

The principal dimensions of PTC thermistors are specified as limit values. For detailed information, please refer to the special data sheets.

2. Characteristic electrical values

2.1 Zero load resistance R_ϑ

The zero load resistance value R_ϑ is the resistance value measured at a given temperature ϑ, whereby the electrical load is kept so small that no noticeable change in the resistance value occurs if the load is reduced to any value required.

For test voltages, please refer to the special data sheets.

2.2 Resistance-temperature characteristics

The typical resistance pattern at zero load versus the PTC thermistor temperature $R_{PTC} = f(\vartheta_{PTC})$ is shown in the diagram below:

Typical resistance-temperature characteristic curve

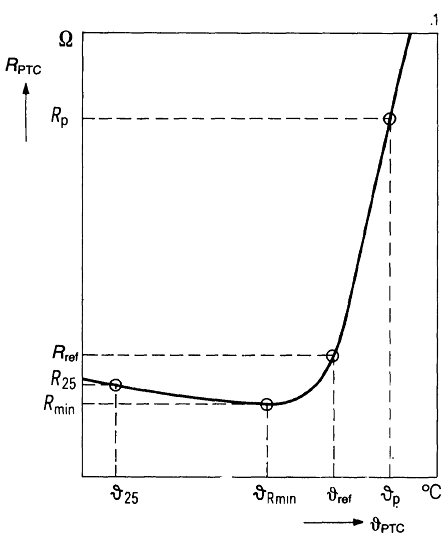


Figure 1

$\vartheta_{R_{min}}$	Initial temperature (start of the positive α_R)
R_{min}	Minimum resistance (resistance value at $\vartheta_{R_{min}}$)
ϑ_{ref}	Reference temperature (start of the steep resistance rise)
R_{ref}	Reference resistance (resistance value at ϑ_{ref})
ϑ_p	Temperature above the reference temperature ϑ_{ref}
R_p	Resistance in the range of steep rise (resistance value at ϑ_p)
R_{25}	PTC thermistor resistance (resistance value at ϑ_{25})

2.6 Temperature coefficient α_R

The temperature coefficient α_R of the PTC resistance is defined at each point of the characteristic curve by the relation:

$$\alpha_R(\vartheta) = \frac{1}{R}\,\frac{dR\vartheta}{d\vartheta} = \frac{d}{d\vartheta}\,(I_N\, R_\vartheta)$$

In the range of the steep rise in resistance between R_{ref} and R_p, α_R may be regarded as being approximately constant. The following relation then applies:

$$R_{ref} \leqslant R_1, R_2 \leqslant R_p\colon\ \alpha_R = \frac{I_N\,(R_2/R_1)}{\vartheta_2 - \vartheta_1}$$

Within this temperature range, the reverse relation can equally be applied:

$R_2 = R_1 \cdot e\ \alpha_R\ (\vartheta 2 - \vartheta 1)$

For the individual types, the specified values of α_R relate only to the temperature range of the steep resistance rise which is most important in practical applications.

2.7 Voltage and frequency dependence of the resistance

In addition to being dependent on the temperature, the resistance is also dependent upon the field strength. This "varistor effect" is caused by the basically existing field strength dependence of the barrier layer resistance. This phenomenon is mainly appearing with PTC thermistors when they have a high impedence, i.e. when the barrier layers are fully developed. The varistor effect reduces the maximum achievable resistance value and the value of α_R.

PTC thermistor $R_{PTC} = f(\vartheta_{PTC})$
versus temperature and frequency

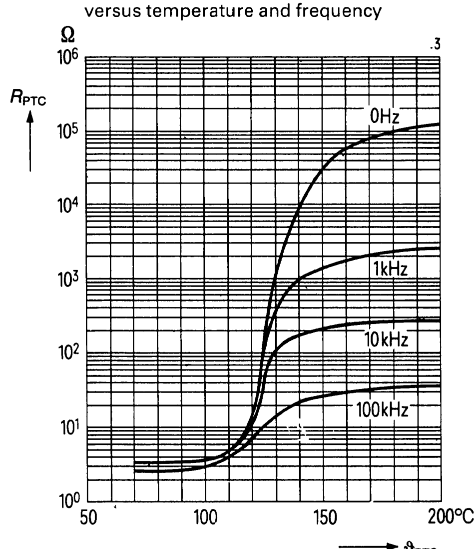


Figure 3

2.10 Thermal capacitance C_{th}

The thermal capacitance is the amount of heat required to increase the mean PTC thermistor temperature by 1 K. The unit of thermal capacitance is J/K.

2.11 Thermal cooling time constant τ_{th}

The thermal cooling time constant is the time taken for the mean temperature of the PTC thermistor at zero load to change by 63.2% of the difference between initial temperature and final temperature.

2.12 Thermal threshold time t_a, operating turn-off time $t_{op\,off}$

The term "thermal threshold time" was created in accordance with the DIN Draft Standard concerning "thermal machine protection", for PTC thermistor sensor in conjunction with the corresponding control devices used for excess temperature protection of electrical machines and motors. This time is the period taken for the PTC thermistor to respond and reach the resistance value at which the control device turns off.

The thermal threshold time is stated in the special data sheets.

The operating turn-off time $t_{op\,off}$ is a value of the thermal threshold time occurring in practical application and it enables a classification of the PTC thermistor versions.

3. Permissible climatic and mechanical stress

3.1 Upper category temperature ϑ_{max} and maximum permissible PTC surface temperature $\vartheta_{sur\,max}$

The upper category temperature (it corresponds to the maximum surface temperature) is the maximum temperature which the PTC thermistor can take at its surface owing to electrical and thermal loading.

3.2 Ambient temperature ϑ_{amb} and storage temperature ϑ_{stg}

The ambient temperature and storage temperature are the temperatures in the direct environment of the PTC thermistor. These temperatures are identical to the surface temperature of the PTC thermistor at zero load and thermal equilibrium at the intended place of application.

3.3 Robustness of terminations

The terminations meet the requirements in accordance with DIN 40046, sheet 19, test U. They may only be bent at a minimum distance of 4 mm from the soldered joint on the PTC thermistor body or 4 mm from the point at which they leave their feed-throughs. During that procedure, any mechanical load must be removed from the wire at the point of the lead outlet. The bending radius must be at least 0.75 mm.

Test U_a: Tensile
Lead diameter ≤ 0.5 mm = 5 N
> 0.5 mm = 10 N

There is thus a clear relationship between PTC resistance and temperature. Under those conditions, the PTC thermistor is able to carry out measuring and regulating tasks in the region of the steep rise in resistance. The most important application in this respect is protecting electrical machines from excess temperatures. A range of PTC thermistors with operating temperature ratings of between 60 and 180°C is available for this purpose.

4.2 PTC thermistors as self-regulating thermostats

If a PTC thermistor is exposed to a field strength of the order of 10 V/mm it will experience a rise in temperature above its reference temperature. This results in a balanced temperature which is almost independent of the ambient temperature. Owing to its positive temperature coefficient, the power consumption of the PTC thermistor will increase with a drop in temperature and, conversely, will decrease with an increase in temperature. This thermostat effect results in a temperature stabilization with stabilization factors ($\Delta\vartheta/\Delta\vartheta_{ext}$) between 5 and 10 in a room which is enclosed by PTC thermistors. Even with regard to changes of the operating voltage, the stabilization mechanism will be effective. If the operating voltage increases, the PTC thermistor initially consumes correspondingly more power, but, as a result, its temperature increases and thus the current becomes stabilized at a lower level. The performance (and thus the temperature) in the voltage range in question is therefore not proportional to the square of the voltage, as it is the case with an ohmic resistance, but rather is proportional to a considerably smaller power of the voltage which may be estimated at an exponent of 0.1 ($P = V^{0.1}$). In other words: the power consumed is virtually independent of the voltage within a wide voltage range.

Performance of PTC thermistor
$P = f(t)$ versus time

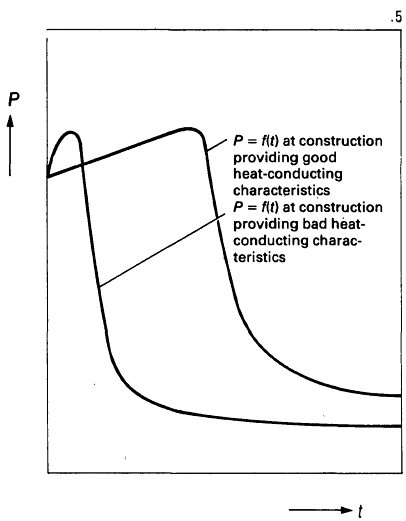


Figure 5

Schematic construction of a thermostat
Construction providing good heat-conducting characteristics with **symmetrical** heat dissipation to ensure optimum heating performance

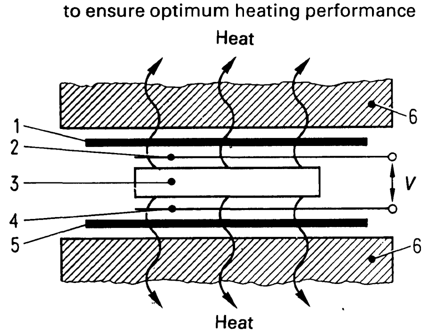


Figure 5a

1;5 Insulation (heat-conductive)
2;4 Electrode foil
3 PTC thermistor
6 Medium to be heated

If ambient conditions remain constant, the current-voltage characteristic curve approximates a hyperbola since the power comsumed between approximately 6 and 30 V/mm is almost independent of the voltage. Various "hyperbolas of equal power" apply to various ambient conditions. On this basis, it is possible to define whether the PTC thermistor is operating in air or liquid, and whether the surrounding medium is stationary or flowing.

4.4 PTC thermistors as switching elements in delay circuits

If a voltage is applied to a PTC thermistor in order to heat it above reference temperature, the time taken to reach the reference temperature and the high resistance state will depend upon the initial power. By appropriately selecting the voltage, series resistance, size of the PTC thermistor, reference temperature, and heat capacity it is possible to vary the "switching time" within wide limits. The following equation serves as an approximation for t_s:

$$t_s = \frac{c \cdot \delta \cdot \mathrm{vol}\,(\vartheta_{ref} - \vartheta_0)}{P_i}$$

t_s = Switching time [sec]
c = Specific heat of the PTC thermistor material $\frac{W \cdot s}{K \cdot g}$
δ = Density of the PTC thermistor material [g/cm^3]
vol = Volume of the PTC thermistor [cm^3]
ϑ_{ref} = Reference temperature of the PTC thermistor [°C]
ϑ_0 = PTC thermistor temperature before voltage is applied [°C]
P_i = Initial heating power of the PTC thermistor [W]

An approximate value of the heat power developed in the PTC thermistor until the reference temperature is reached is given by the following equation:

$$P_i \approx \frac{V^2 \cdot R_0}{(R_s + R_0)^2}$$

V = Operating voltage [V]
R_0 = PTC resistance value before voltage is applied [Ω]
R_s = Value of the series resistance [Ω].

The product of $c \cdot \delta$ is with our PTC thermistor material approximately 3 W · s/K · cm^3, thus resulting in:

$$t_s \approx \frac{3 \cdot \mathrm{vol} \cdot (\vartheta_{ref} - \vartheta_0)\,(R_s + R_0)^2}{V^2 \cdot R_0}$$

After the time t_s which starts when applying the voltage $V-$ has passed, the network of PTC thermistor and series resistor, which by comparison has a low resistance when being cold, will have reached a value of approximately 100 times the previous resistance and the current will have reduced by the same factor.

Application examples of delay circuits:

- Degaussing of color picture tubes
- Delay of relay circuits
- Control of the auxiliary starting phase of ac motors

5. Quality specifications

A production lot of components is not released until a hundred percentage test and an additional random sampling test (before delivery to the customer) have been carried out. The slipping through of defective components is statistically described by the so-called **AQL** values (acceptable quality level). Since the defective production batches are again subject to a hundred percentage test, the rejection rate will be as small as possible, that the actual number of defective components delivered lies clearly below the AQL values which we specify. For random sampling tests carried out by the user, we recommed to observe the random sampling test plans below, and to consider the acceptance characteristic curves corresponding to the random sample amount:
MIL 105 D, DIN 40080.
The principles of statistics have to be applied when judging the quality of the components delivered.

5.1 Quality of components delivered

The quality of components delivered is specified by the AQL values as follows:

Defect type		Defect type		Max. possible defects
Defects in cases and leads	AQL	Electrical defects	AQL	ΣAQL
Hundred percent defect	0.25	Hundred percent defect	0.25	0.25
Major defect	1.5	Major defect	0.65	1.5
Minor defect	2.5	Minor defect	1.5	2.5

5.2 Definition of the defects

For each defect class, for which an AQL value has been determined, only the number of defective units (defective in respect of one or more characteristics within this defect class) is taken into account, i. e. a defective component is counted only once.

5.3 Hundred percent defects (decisive defects)

In case of a hundred percent defect, any functional application of the component is impossible or at least considerably impaired.
Criteria:

- Short circuit
- Contact break
- Serious discrepancy in characteristics
- Broken leads
- Broken cases
- Incorrect type marking

5.4 Major defects

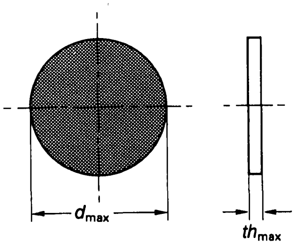
In case of a major defect, the serviceability of the component is noticeably impaired.
Criteria:

- Considerable exceeding of electrical characteristics
- Considerable exceeding of mechanical characteristics

Exceeding these characteristics does not lead to hundred percent defects.

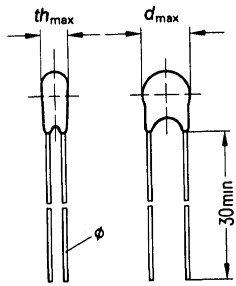
R_{c25}	Resistance value of the PTC on the coil side at ϑ_{amb} = 25°C	Ω
R_{l25}	Resistance value of the PTC on the line side at ϑ_{amb} = 25°C	Ω
R_L	Load resistance	Ω
R_{min}	Resistance value at ϑ_{Rmin} (minimum resistance)	Ω
R_p	Resistance value at ϑ_p	Ω
$R_{p\,min}$	Min. occurring resistance at ϑ_p	Ω
R_{PTC}	PTC thermistor resistance	Ω
R_{ref}	Reference resistance	Ω
R_s	Series resistance	Ω
$R_{s\,max}$	Max. permissible series resistance	Ω
$R_{s\,min}$	Min. permissible series resistance	Ω
R_{ϑ}	Resistance value at temperature ϑ	Ω
R_0	PTC resistance value before voltage is applied	Ω
R_{25}	Resistance value at ϑ_{amb} = 25°C	Ω
ΔR_{25}	Tolerance of R_{25}	–
T	Tolerance	–
th	Thickness	mm
t	Time	sec
t_a	Thermal threshold time	sec
$t_{op\,off}$	Operating turn-off time	sec
t_s	Switching time	sec
τ_{th}	Thermal cooling time constant	sec
vol	Volume of PTC thermistor	cm^3
$V_{(BO)}$	Breakover voltage	V, Vrms
$V_{(BR)}$	Breakdown voltage	V, Vrms
V_{max}	Maximum operating voltage	V, Vrms
V_{op}	Operating voltage	V, Vrms
V_{PTC}	PTC thermistor voltage	V, Vrms
V_R	Rated voltage	V, Vrms
V_{test}	Test voltage – terminals/case	V, Vrms

Version A



Dimensions in mm

Version C



Ordering code	**Q63100– P2390–**	**–C955**	**–C965**	**–C975**	**–C985**	**–C995**	**Unit**
Operating voltage at ϑ_{amb} = 60°C	V_{max}	30	30	30	30	30	V
Breakover current (typ.)	$I_{(BO)}$	1060	805	610	320	160	mA
Resistance value at ϑ_{amb} = 25°C	R_{25}	0.8	1.2	1.8	4.6	13	Ω
Tolerance of R_{25}	ΔR_{25}	±25	±25	±25	±25	±25	%
Minimum series resistance at V_{max}	$R_{s\,min}$	4.8	6.1	8.7	26	34	Ω
Reference temperature (typ.)	ϑ_{ref}	130	130	130	130	130	°C
Leakage current (typ.) at V_{max}	I_{lk}	80	70	60	45	25	mA
Operating current	I_{max}	5.5	4.3	3.0	1.0	0.7	A
Temperature coefficient (typ.)	α_R	15	15	15	15	15	%/K
Thermal cooling time constant (typ.)	τ_{th}	36	28	22	15	12	sec
Thermal conductance (typ.)	G_{th}	15	13	12	10	7	mW/K
Thermal capacitance (typ.)	C_{th}	0.54	0.36	0.26	0.15	0.08	J/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	180	180	180	180	180	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	−25	−25	−25	−25	−25	°C
Ground (typ.)	GND	1.5	0.9	0.6	0.4	0.25	g
Dimensions	d_{max}	13.5	11.5	9.0	6.5	4.0	mm
	th_{max}	3.5	3.5	3.5	3.5	3.5	mm
Leads	dia.	0.6	0.6	0.6	0.6	0.5	mm

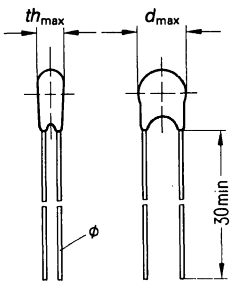
Resistance values measured at $I_{test} \leq 1$mA.

Application

The PTC thermistors are suitable for automatic short-circuit protection or overcurrent protection. They are used in electronic devices, modules, low-power motors, loudspeakers, circuits, and vehicles (refer to page 49).

Version

Plastic-encapsulated PTC thermistors with radial leads.



Dimensions in mm

Ordering code	**Q63100–**	**–P2390 –C910**	**–P2390 –C930**	**–P2390 –C940**	**–P2390 –C950**	**Unit**
Operating voltage at ϑ_{amb} = 60°C	V_{max}	80	80	80	80	V
Breakover current (typ.)	$I_{(BO)}$	1305	865	630	400	mA
Resistance value at ϑ_{amb} = 25°C	R_{25}	0.9	1.65	2.3	3.7	Ω
Tolerance of R_{25}	ΔR_{25}	±25	±25	±25	±25	%
Minimum series resistance at V_{max}	$R_{s\,min}$	5.0	7.0	8.5	12.0	Ω
Reference temperature (typ.)	ϑ_{ref}	120	120	120	120	°C
Leakage current (typ.) at V_{max}	I_{lk}	65	50	40	30	mA
Operating current	I_{max}	15	10	8	5.5	A
Temperature coefficient (typ.)	α_R	16	16	16	16	%/K
Thermal cooling time constant (typ.)	τ_{th}	65	55	46	36	sec
Thermal conductance (typ.)	G_{th}	35	25	20	15	mW/K
Thermal capacitance (typ.)	C_{th}	2.3	1.4	0.9	0.54	J/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	180	180	180	180	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	−25	−25	−25	−25	°C
Ground (typ.)	GND	3.5	2.4	1.8	1.5	g
Dimensions	d_{max}	26	22	17.5	13.5	mm
	th_{max}	3.5	3.5	3.5	3.5	mm
Leads	dia.	0.8	0.6	0.6	0.6	mm

Overload Protection and Delay Circuits
130V ac to 265V ac

Application

The PTC thermistors are suitable for automatic short-circuit protection or overcurrent protection. They are used in electronic devices, modules, relay coils, circuits, and household appliances (refer to page 49).

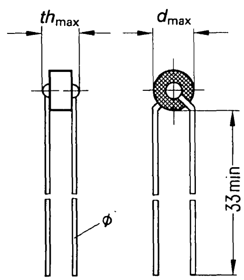
Version B

Non-encapsulated PTC thermistors with radial leads.

Version C

Plastic-encapsulated PTC thermistors with radial leads.

Version B26



Dimensions in mm

Ordering code	**Q63100–**	**–P2390 –B26**	**–P2390 –C26**	**–P350 –B22**	**–P2390 –C810**	**–P2390 –C830**	**Unit**
Operating voltage at ϑ_{amb} = 60°C	V_{max}	130	130	250	265	265	Vrms
Breakover current (typ.)	$I_{(BO)}$	140	140	110	820	580	mA
Resistance value at ϑ_{amb} = 25°C	R_{25}	31	31	60	2.6	3.7	Ω
Tolerance of R_{25}	ΔR_{25}	±20	±20	$\pm^{40}_{25}$	±25	±25	%
Minimum series resistance at V_{max}	$R_{s\,min}$	130	130	40	25	36	Ω
Reference temperature (typ.)	ϑ_{ref}	120	120	80	120	120	°C
Leakage current (typ.) at V_{max}	I_{lk}	15	15	10	25	20	mA
Operating current	I_{max}	1.0	1.0	4.0	10	7	A
Temperature coefficient (typ.)	α_R	16	16	28	16	16	%/K
Thermal cooling time constante (typ.)	τ_{th}	–	36	80	135	110	sec
Thermal conductance (typ.)	G_{th}	–	12	24	36	27	mW/K
Thermal capacitance (typ.)	C_{th}	–	0,43	1.9	4.9	3.0	J/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	180	180	180	180	180	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	−25	−25	−25	−25	−25	°C
Ground (typ.)	GND	1.0	1.0	4.0	8	5	g
Dimensions	d_{max}	8.0	9.6	13	26	22	mm
	th_{max}	4.7	5.7	9.7	5.5	5.5	mm
Leads	dia.	0.6	0.6	0.63	0.8	0.6	mm

Overload Protection and Delay Circuits
18V to 30V

Application

The PTC thermistors are suitable for automatic short-circuit protections or overcurrent protection. They are used in electronic devices, modules, relay coils, circuits, and household appliances (refer to page 49).

Version A

Non-encapsulated PTC thermistors with metallized front ends.

Version B

Non-encapsulated PTC thermistors with radial leads.

Version C

Plastic-encapsulated PTC thermistors with radial leads.

Ordering code	**Q63100– P2390–**	**–A25**	**–B25**	**–C880**	**–C883**	**–C890**	**Unit**
Operating voltage at ϑ_{amb} = 60°C	V_{max}	265	265	265	265	265	Vrms
Breakover current (typ.)	$I_{(BO)}$	70	70	67	50	37	mA
Resistance value at ϑ_{amb} = 25°C	R_{25}	80	80	70	120	150	Ω
Tolerance of R_{25}	ΔR_{25}	±25	±25	±25	±25	±25	%
Minimum series resistance at V_{max}	R_{smin}	1000	1000	620	600	2300	Ω
Reference temperature (typ.)	ϑ_{ref}	120	120	120	120	120	°C
Leakage current (typ.) at V_{max}	I_{lk}	12	12	6	5	5	mA
Operating current	I_{max}	0.4	0.4	0.4	0.4	0.1	A
Temperature coefficient (typ.)	α_R	16	16	16	20	16	%/K
Thermal cooling time constant (typ.)	τ_{th}	–	–	25	25	13	sec
Thermal conductance (typ.)	G_{th}	–	–	10	10	8	mW/K
Thermal capacitance (typ.)	C_{th}	–	–	0.25	0.25	0.10	J/K
Max. permissible storage temperature	$\vartheta_{stg\ max}$	180	180	180	180	180	°C
Min. permissible storage temperature	$\vartheta_{stg\ min}$	−25	−25	−25	−25	−25	°C
Ground (typ.)	GND	0.5	0.5	0.6	0.6	0.3	g
Dimension	d_{max}	5.5	5.5	6.5	6.5	4.0	mm
	th_{max}	2.5	4.5	5.5	5.5	5.5	mm
Leads	dia.	–	0.6	0.6	0.6	0.5	mm

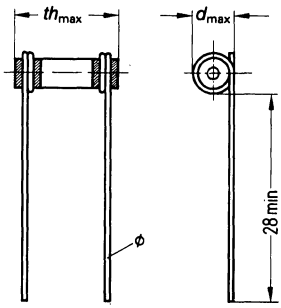
Overload Protection and Delay Circuits
250V ac to 550V ac

Application

The PTC thermistors are suitable for automatic short-circuit protection or overcurrent protection. They are used in electronic devices, modules, relay coils, circuits, and household appliances (refer to page 49).

Version

Non-encapsulated PTC thermistors with radial leads.



Dimensions in mm

Ordering code	**Q63100–**	**–P330 –B402**	**–P5330 –B405**	**–P5330 –B406**	**Unit**
Operating voltage at ϑ_{amb} = 60°C	V_{max}	250[1]	420[1]	550[1]	Vrms
Breakover current (typ.)	$I_{(BO)}$	7	6	4	mA
Resistance value at ϑ_{amb} = 25°C	R_{25}	2000	3500	6250	Ω
Tolerance of R_{25}	ΔR_{25}	±20	±16	±20	%
Minimum series resistance at V_{max}	R_{smin}	0	0	0	Ω
Reference temperature (typ.)	ϑ_{ref}	60	60	60	°C
Leakage current (typ.) at V_{max}	I_{lk}	1.5	1.0	1.0	mA
Operating current	I_{max}	0.3	0.3	0.3	A
Temperature coefficient (typ.)	α_R	20	20	20	%/K
Thermal cooling time constant (typ.)	τ_{th}	20	25	25	sec
Thermal conductance (typ.)	G_{th}	5	6	6	mW/K
Thermal capacitance (typ.)	C_{th}	0.1	0.15	0.15	J/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	180	180	180	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	−25	−25	−25	°C
Ground (typ.)	GND	1.0	1.5	1.5	g
Dimensions	d_{max}	5.5	5.5	5.5	mm
	th_{max}	14	17	17	mm
Leads	dia.	0.5	0.5	0.5	mm

Resistance values measured at $V_{test} \leq 1.5V$.

[1]) Operating voltage at ϑ_{amb} = 40°C

Thermostat Heating Elements
18V; 20V

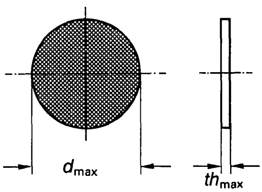
Application

Owing to their thermostat effect, the PTC thermistors are mainly intended for fulfilling temperature stablization tasks.

Due to their size and shape, they are particularly suitable for the design of low-power heating systems operating at low voltages (refer to page 98).

Version A

PTC thermistor disc with metallized front ends.



Dimensions in mm

Ordering code	**Q63100–**	**–P450 –A210**	**–P460 –A31**	**–P310 –A87**	**–P330 –A87**	**Unit**
Maximum operating voltage at $\vartheta_{amb} = 60°C$	V_{max}	18	18	20	20	V
Resistance value ati $\vartheta_{amb} = 25°C$	R_{25}	≤1.5	2.5	6	6	Ω
Tolerance of R_{25}	ΔR_{25}	–	±30	±25	±25	%
Minimum series resistance at V_{max}	$R_{s\,min}$	–	–	–	–	Ω
Dynamic heating power[1]	P_{dyn}	115	80	12	17	W
Stationary final power	P_{stat}	4.8	4.0	0.9	1.0	W
Reference temperature (typ.)	ϑ_{ref}	180	190	40	60	°C
Upper category temperature	ϑ_{max}	230	230	95	105	°C
Temperature coefficient (typ.)	α_R	13	11	16	20	%/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	125	125	125	125	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	–25	–25	–25	–25	°C
Ground (typ.)	GND	2.0	1	2.0	2.0	g
Dimensions	d_{max}	21.0	14.3	18.5	18.5	mm
	th_{max}	1.2	1.1	2.2	2.2	mm

Thermostat Heating Elements
24V to 34V

Application

Owing to their thermostat effect, the PTC thermistors are mainly intended for fulfilling temperature stablization tasks.

Due to their size and shape, they are particularly suitable for the design of low-power heating systems operating at low voltages (refer to page 98).

Version A

PTC thermistor disc with metallized front ends.

Version F

PTC thermistor ring with metallized front ends.

Version R

Plate and block-type PTC thermistors with metallized side surfaces.

Ordering code	**Q63100–**	**–P430 –A81**	**–P350 –A67**	**–P390 –A67**	**–P430 –A67**	**–P450 –A67**	**Unit**
Maximum operating voltage at ϑ_{amb} = 60°C	V_{max}	24	30	30	30	30	V
Resistance value at ϑ_{amb} = 25°C	R_{25}	2.4	8	8	8	8	Ω
Tolerance of R_{25}	ΔR_{25}	±20	±50	±50	±50	±50	%
Minimum series resistance at V_{max}	$R_{s\,min}$	0	0	0	0	0	Ω
Dynamic heating power[1]	P_{dyn}	70	15	18	22	35	W
Stationary final power	P_{stat}	3.6	1.1	1.8	2.6	2.9	W
Reference temperature (typ.)	ϑ_{ref}	160	80	120	160	180	°C
Upper category temperature	ϑ_{max}	200	125	145	185	225	°C
Temperature coefficient (typ.)	α_R	13	28	29	13	13	%/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	125	125	125	125	125	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	–25	–25	–25	–25	–25	°C
Ground (typ.)	GND	1.5	1	1	1	1	g
Dimensions	d_{max}	18.5	12.0	12.0	12.0	12.0	mm
	th_{max}	1.7	2.0	2.0	2.0	2.0	mm

Thermostat Heating Elements
265V ac

Application

Owing to their thermostat effect, the PTC thermistors are mainly intended for fulfilling temperature stablization tasks.

Due to their size and shape, they are particularly suitable for the design of low-power heating systems operating at mains voltage (refer to page 98).

Version A

PTC thermistor disc with metallized front ends.

Version R

Plate and block-type PTC thermistors with metallized side surfaces.

Ordering code	**Q63100–**	**–P3440 –A68**	**–P5490 –A54**	**–P5490 –A98**	**Unit**
Maximum operating voltage at ϑ_{amb} = 60°C	V_{max}	265	265	265	Vrms
Resistance value at ϑ_{amb} = 25°C	R_{25}	2	2	4	kΩ
Tolerance of R_{25}	ΔR_{25}	±50	$\pm^{100}_{50}$	±50	%
Minimum series resistance at V_{max}	$R_{s\,min}$	0	0	0	Ω
Dynamic heating power[1)]	P_{dyn}	55	45	20	W
Stationary final power	P_{stat}	2.8	3.4	3.3	W
Reference temperature (typ.)	ϑ_{ref}	170	220	220	°C
Upper category temperature	ϑ_{max}	210	260	260	°C
Temperature coefficient (typ.)	α_R	16	16	16	%/K
Max. permissible storage temperature	$\vartheta_{stg\,max}$	125	125	125	°C
Min. permissible storage temperature	$\vartheta_{stg\,min}$	–25	–25	–25	°C
Ground (typ.)	GND	15	0.8	0.4	g
Dimensions	d_{max}	12.3	8.2	5.5	mm
	th_{max}	3.0	3.1	3.1	mm

"Dynamic" and "stationary" heating power

The electrical powers converted in the PTC thermistor are fundamental as regards the design of a particular heating system. However, these values are considerably influenced by the construction of the heating system. By specifying P_{dyn} and P_{stat} it is possible to differentiate between the individual version of PTC thermistors.

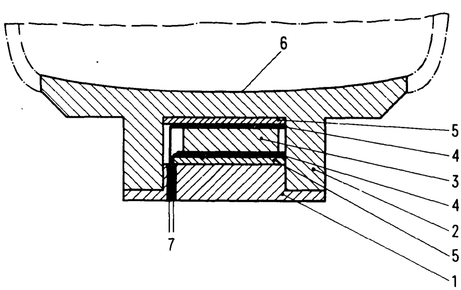
P_{dyn}: Electrical power converted in the PTC thermistor after turning on.

P_{stat}: Stationary final power after completion of the heating process.

Functional description

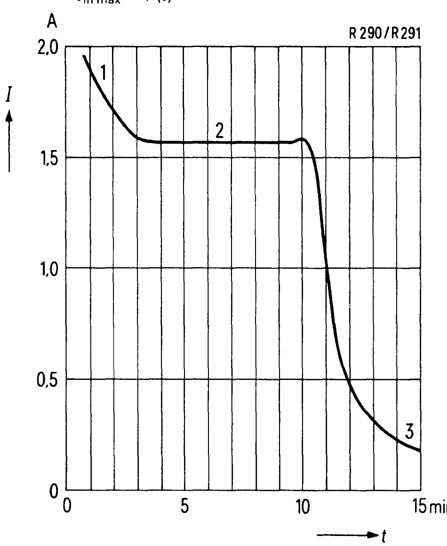
Owing to the thermostat effect and the design of the heating system which shows good heat conducting characteristics, the heat dissipated by the PTC thermistor is used to boil the water after turning on (1). The power equilibrium which results due to the high degree of heat extraction, causes the system to operate at a constant high heating power until all the water has boiled away (2). After this, the PTC thermistor reduces its power consumption until it remains steady at a final value 10 times less than the previous one (3).

Schematic construction of a heating for low-power appliances, e.g. egg boiler



1, 2 Metal parts for guidance of heat
3 PTC thermistor
4 Metal foils (electrodes)
5 Insulation – heat-conductive
6 Evaporating tray
7 Connecting cable

Input peak current versus time
$I_{in\,max} = f(t)$



1 Turning on (heating up)
2 Boiling (evaporating)
3 Boiling finished
Dry operation (equilibrating)

Questionnaire for Ordering New PTC Thermistors

PTC thermistors for special applications

The variety of possible applications for PTC thermistors extends well beyond the individual applications stated in the data sheets. The PTC thermistors listed in the tables only constitute a part of the range of the types available and are intended to provide a survey of basic PTC thermistor characteristics which may be varied widely depending upon manufacturing conditions. This ensures that PTC thermistors can be precisely matched to the requirements of each particular application.

Thus, if you have not found the "PTC thermistor" for your particular new applications please complete the enclosed technical questionnaire and send it to the following address:

Siemens Aktiengesellschaft
Unternehmensbereich Bauelemente
Vertrieb/Abteilung: BV Wid
Balanstraße 73
D-8000 München 80

Our application laboratory will give you help and advice. The more detailed the specifications that you give, the more quickly we will be able to find an appropriate solution.

For dimensional drawings

General Technical Information

2. Electrical characteristics

2.1 Behavior of an NTC thermistor without load

2.1.1 Resistance value – temperature characteristic curve

The following equation is a good approximation for showing the dependence of the NTC resistance value on the temperature:

$$R_T = A \times e^{\frac{B}{T}} \qquad (1)$$

or, after conversion

$$R_T = R_R \times e^{B\left(\frac{1}{T} - \frac{1}{T_R}\right)} \qquad (2)$$

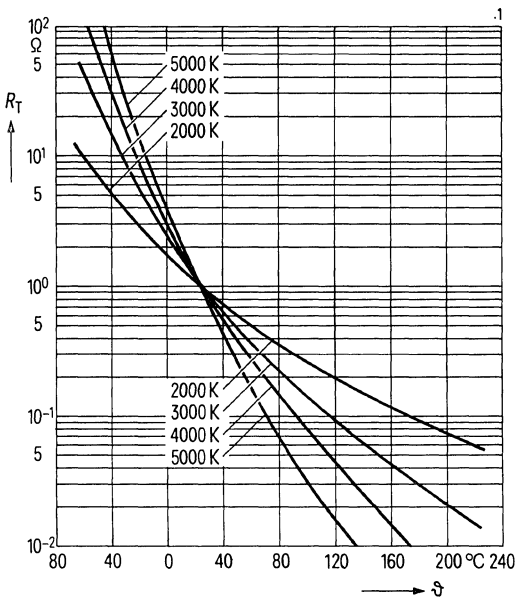


Figure 1
Resistance – temperature characteristics (parameter = B)

R_T	NTC thermistor resistance value at temperature T in K
R_R	NTC thermistor resistance value at temperature T_R in K
A	Constant with the dimension Ω
B	Material constant of the NTC thermistor with the dimension K, the "B value"
T	Temperature in K

The temperature coefficient of an NTC thermistor results from the equations (1) or (2) as follows.

$$\alpha_R = \frac{1}{R_t} \times \frac{dR_T}{dT} = -\frac{B}{T^2} \qquad (3)$$

$$\left|\frac{\Delta R_T}{R_T}\right| = \left|\frac{\Delta R_R}{R_R}\right| + \left|\frac{\Delta B}{B}\ ln\ \frac{R_T}{R_R}\right| \tag{5}$$

$\frac{\Delta R_T}{R_T}$ is the maximum deviation of the resistance value at temperature T.

$\frac{\Delta R_R}{R_R}$ is the tolerance at the rated temperature T_R.

$\frac{\Delta B}{B}$ is the permissible deviation of the B value.

The resistance deviation thus consists of the basic tolerance of the rated resistance, and a temperature-dependent component which includes the tolerance of the B value.

For example, the maximum resistance deviation expected in type K11/5%/10k is
at 20°C : 10 kΩ±5%;
at 120°C : 0.6 kΩ±19%.

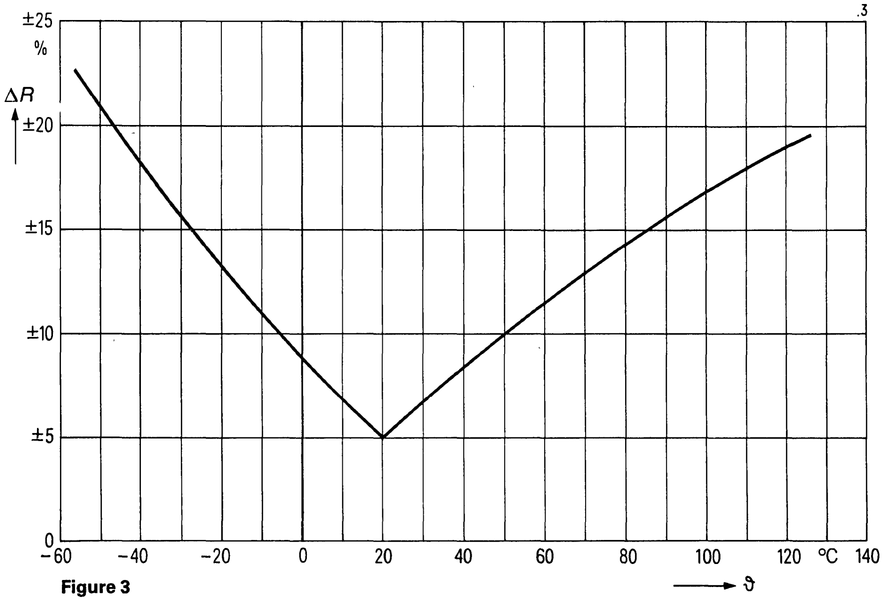


Figure 3
Deviation range of the resistance value
(K11/5%/10 kΩ)

In the case of the precision NTC thermistors M841, M843, M846, M847, M867, an extremely close resistance tolerance over a wide temperature range is achieved by special selection of the NTC compound, by special production methods, and by individual adjustment.

2.2.2 Voltage-current characteristic curve

If a constant electric power is supplied to the NTC thermistor, then its temperature will first vary considerably, but the rate of change decreases with time. After a certain period, a steady state is reached in which the power applied is dissipated into the environment by thermal conduction or thermal radiation.

In this case, $\frac{dT}{dt}$ in equation (7) becomes 0; this results in

$$P = G_{th} \times (T - T_{amb}) \tag{8}$$

$$I^2 \times R_T = G_{th} \times (T - T_{amb})$$

$$\frac{V^2}{R_T} = G_{th} \times (T - T_{amb})$$

and with

$$R_T = A \times e^{\frac{B}{T}}$$

$$I = \sqrt{\frac{G_{th}\,(T - T_{amb})}{A \times e^{\frac{B}{T}}}} \tag{8a}$$

$$V = \sqrt{G_{th}\,(T - T_{amb}) \times A \times e^{\frac{B}{T}}} \tag{8b}$$

in the parameter description of the voltage-current characteristic curve, whereby R_T is the (temperature-dependent) resistance value of the NTC thermistor.

If the voltage values obtained at a constant temperature are plotted versus the current, then the result will be the voltage-current characteristic curve of the NTC thermistor. Equations (8a) and (8b) are the parameter description of that characteristic curve, with the aid of which it is possible to calculate the voltage-current characteristic curves of various ambient temperatures or to draw them graphically in a double logarithmic coordinate system. [In this case, the curves of equal power (P = const.) and the curves of equal resistance value (R = const.) become straight lines at an angle of 45°.]

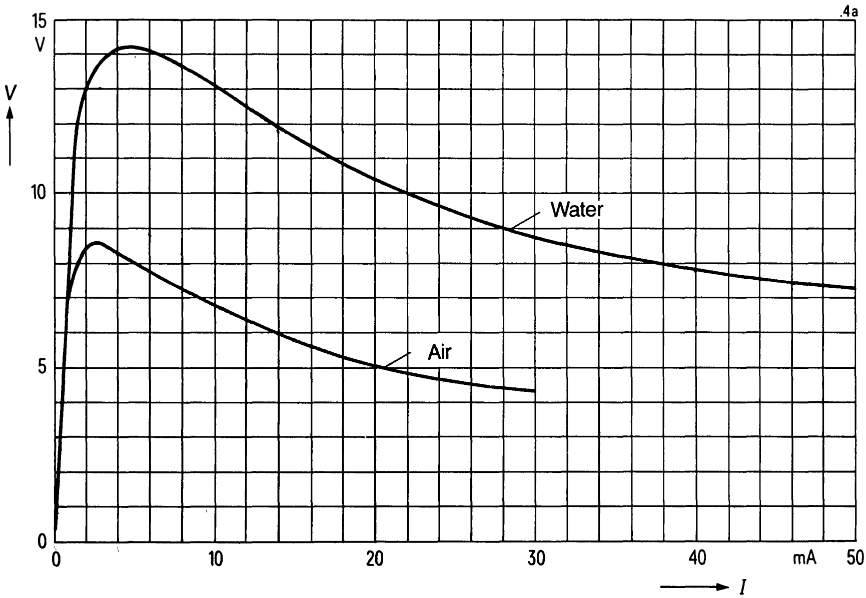


Figure 4a
Voltage-current characteristic: M85/10 kΩ
(linear scale)

2.2.3 Thermal time constant τ_{th}

If the electric load is disconnected from an NTC thermistor, then equation (7) changes to

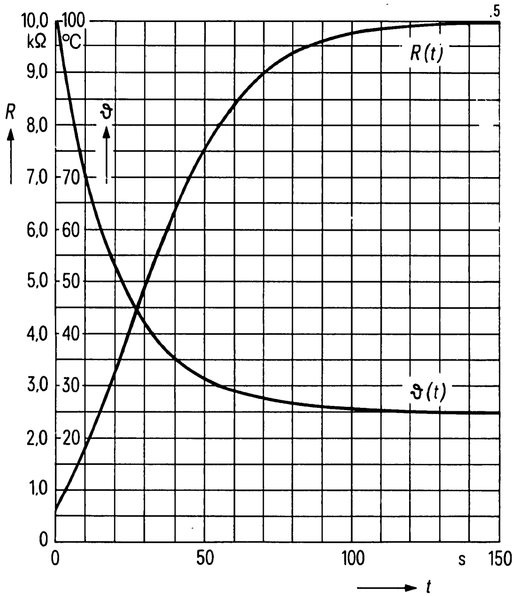


Figure 5
Resistance-time characteristic
(K164/10 kΩ)

$$G_{th}\,(T - T_{amb}) + C_{th} \times \frac{dT}{dt} = 0$$

This equation can be integrated and results in

$$(T - T_{amb}) = (T_i - T_{amb}) \times e^{-\frac{t}{\tau_{th}}} \qquad (9)$$

T_i Initial temperature of the NTC
T_{amb} Ambient temperature

$\tau_{th} = \frac{C_{th}}{G_{th}}$, the thermal time constant of the NTC

With the aid of equation (4) for $R\,(\vartheta)$, the resistance-time characteristic curve can be calculated.
Example: K164 (figure 5)

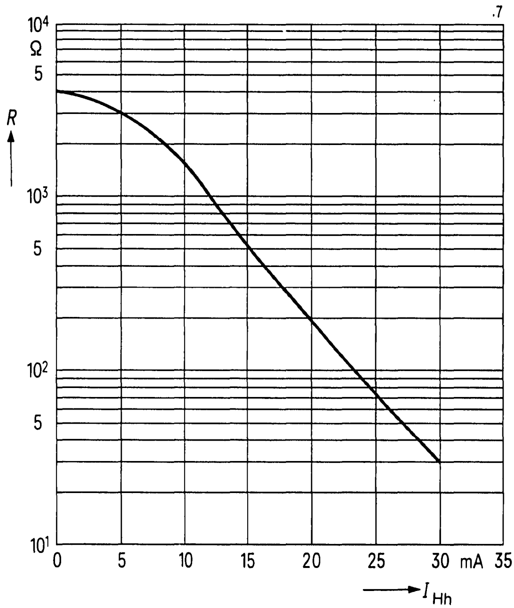


Figure 7
Resistance value-heater current characteristic (F75-34/14u)

2.3 Externally heated NTC thermistors

Externally heated NTCs consist of a bead-shaped NTC thermistor onto which the glass carrier of a heater helix is melted. With the help of that glass carrier, the heater is electrically isolated from the NTC, but it still has a good thermal contact with the latter. A current flowing through the heater helix controls the NTC thermistor resistance.

Externally heated NTC thermistors are mainly used for level regulation in carrier frequency systems and generally as current-dependent, controllable resistors in measuring and regulating systems.

3.2 Installation notes

3.2.1 Soldering

In accordance with DIN 44070, the following maximum temperatures and times must be observed when soldering at the NTC thermistor leads.

Dip soldering
Bath temperature 260°C – soldering time 4 s

Iron soldering
Iron temperature 360°C – soldering time 2 s

Unless otherwise specified, soldering should not be carried out less than 6mm away from the NTC body. If the soldering conditions are more severe, resistance changes must be expected. In the case of NTC thermistors without leads, soldering is only possible with certain restrictions. Due to the temperature shock when the hot solder is applied, fine cracks may occur in the ceramic body and result in resistance changes.

In order to prevent removal of the silver layer from the ceramic disc during soldering, solders with silver additives or solders with low tin contents should be used.

3.2.2 Mechanical stress on the leads

Twisting (torsion) of the leads by an angle of 180° is only permissible if the distance from the NTC body is at least 6mm.

It is not permitted to bend the leads directly at the NTC body.

The wire may be bent at a minimum distance of twice the wire diameter +2mm from the NTC body. The bending radius must at least be 0,75mm. Bending of the solder tags or plug pins is not permissible.

3.2.3 Encapsulation and sealing

If NTC thermistors are to be encapsulated or sealed, care must be taken that no mechanical stresses are transferred to the NTC. A method which has proved successful is to encapsulate the NTC with a silicon rubber compound before sealing it with epoxy resins.

In order to prevent a corrosion of the NTC contacts, the sealing compound must be chemically neutral.

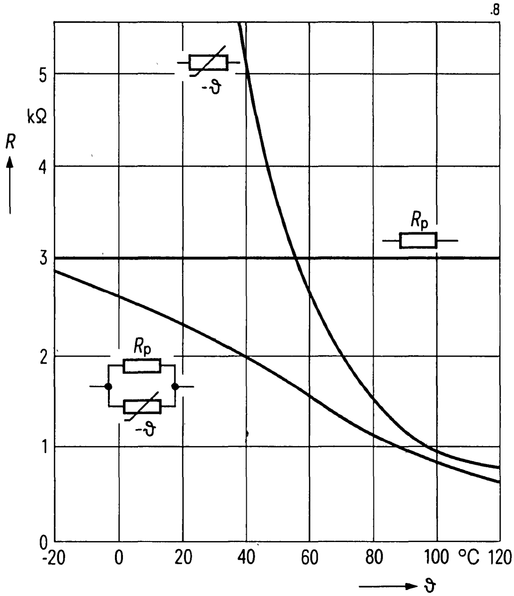


Figure 8
Linearization of the characteristic curve by a parallel resistor; $R_p = 3\ k\Omega$ (K11/10 kΩ)

The best linearization is obtained by placing that inflection point in the center of the operation temperature range. The resistance value of the parallel resistor is then

$$R_p = R_{Tctr} \times \frac{B - T_{ctr}}{B + 2T_{ctr}} \tag{11}$$

R_{Tctr} NTC thermistor resistance at the center temperature T_{ctr}

B B value of the NTC thermistor

Any required voltage variations can be adjusted by means of the division ratio $\frac{R_2}{R + R_2}$, but a possible loading of the voltage divider must be taken into account. The resistance of the load takes effect as reduction of R_2.

3.3.3 Relay delay

Type series A34 has been predominantly developed for delaying relay operation. Those NTC thermistors permit relay starting and delay times in the range between 0.1 s and several seconds. However, the delay time t_d depends considerably on the supply voltage V_{op}, approximately

$$t_d \backsim \frac{1}{V_{op}^2} \text{ to } \frac{1}{V_{op}^3},$$

and in addition, it is temperature-dependent. Its temperature coefficient is approximately half that of the NTC thermistor if the following dimensioning rules are observed.

As shown in figure 10, a series connection of NTC thermistor and relay coil is used for delaying the relay start.

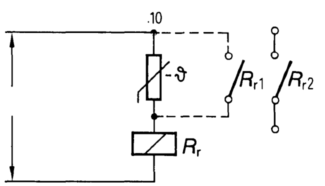


Figure 10
Delay of relay start

When the voltage V_{op} is connected, the current through the relay coil will be limited to a fraction of the relay response current by the high resistance of the cold NTC thermistor. The NTC intrinsic heating causes the NTC resistance value to drop, and the current rises until response current I_{resp} of the relay is reached. The following rules should be observed when dimensioning delay circuits with NTC thermistors (see figure 6).

- The supply voltage V_{op} should be at least 1.5 times and at most 6 times the maximum voltage V_1 of the NTC voltage-current characteristic curve.
- The supply voltage V_{op} should be at least 1.5 times, but if possible, be twice the average relay starting voltage.
- The maximum response current I_{resp} of the relay must not exceed 0.8 times the resulting final current value I_f.
- The stationary final current I_f must not be greater than the continuous operating current I_R specified in the data sheets. Should the NTC thermistor be short-circuited or disconnected after the relay has been started, both, I_{resp} and I_f, may be greater than I_R provided that the maximum current $I_{NTC\,M}$ will not be exceeded.

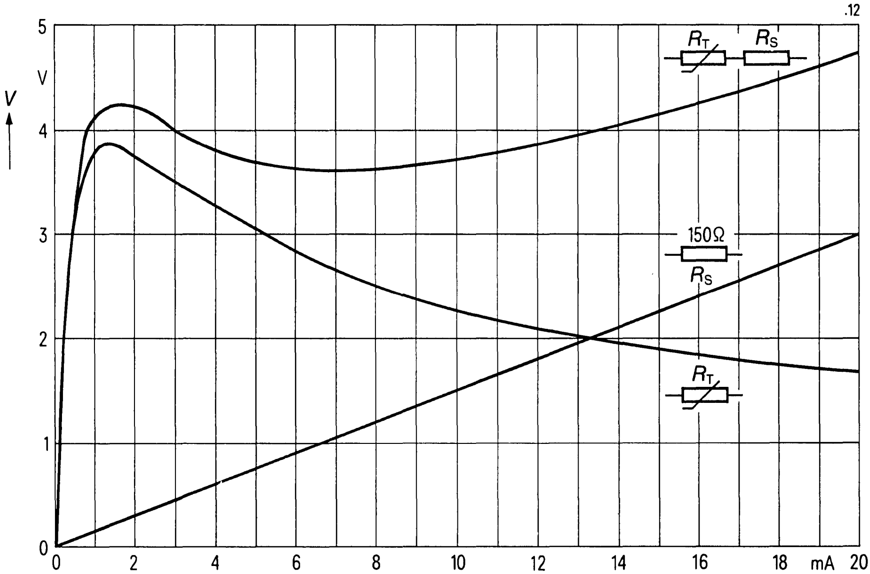


Figure 12
Voltage regulation
(R51-4/1/20)

3.3.5. Parallel connection of NTC thermistors

Parallel connection of two or more NTC thermistors is only possible as long as the heating due to electrical loading is negligible. As soon as the NTC thermistors are driven into the negative section of the voltage-current characteristic curve, the NTC with the lowest resistance value will carry most of the current, is thus heated even more, and will finally carry the complete current amount.

4. Explanation of technical data

4.1. Rated or reference temperature

The terms used in the following technical data for NTC thermistors largely comply with DIN 44070 "Thermistors, NTC Technical Terms and Tests".

The temperature at which the rated resistance value is specified, is for historical reasons mostly 20°C. Conversion to 25°C would result in unusual resistance values if interchangeability with the original types is to be ensured.

As nowadays the reference temperature of 25°C is also used, this technical data introduces a rated temperature at which the rated resistance value is specified; this being a deviation from the standard. The rated resistance values specified in the technical data are no-load resistance values, i.e. the resistance value is measured with such little electrical load that a further reduction of the load would result in not more than a 0.1% change of the resistance value.

4.3 Matching pairs

Matching pairs of some NTC thermistor types are supplied upon request.

The two NTCs which are packed together, deviate in their rated resistances and B values only by a specified amount from the common average value.

Two pairing conditions are offered:

Matching pair P1 $\frac{R_R - R_{av}}{R_{av}} \leqslant \pm 2.5\%$

$\frac{B - B_{av}}{B_{av}} \leqslant \pm 2\%$

Matching pair P2 $\frac{R_R - R_{av}}{R_{av}} \leqslant \pm 1.5\%$

$\frac{B - B_{av}}{B_{av}} \leqslant \pm 1\%$

Thereby, $R_{av} = \frac{R_{R1} + R_{R2}}{2}$ $B_{av} = \frac{B_1 + B_2}{2}$

R_{R1} and B_1 are rated resistance and B value of the one NTC thermistor, R_{R2} and B_2 rated resistance and the B value of the other NTC thermistor.

5. Climatic categories in accordance with DIN 40040

In this data book, the climatic category is specified for each version concerned. The upper and lower category temperatures can be found in table I. Table II provides information on the humdity category.

Climatic categories are formed in accordance with DIN 40040, 2.73.
In compliance with this standard, the coding of climatic categories comprises three letters:

1. Code letter for lower category temperature
2. Code letter for upper category temperature
3. Code letter for permissible humidity category

Example for the formation of climatic categories with code letters: **F K F**

Lower category temperature	– 55°C	F
Upper category temperature	+125°C	K
Humidity category		
Annual average	75%	F
Max. values for 30 days per year	95%	
No dew precipitation is permissible		

5.4 Code letters for humidity categories (in accordance with DIN 40040, 2.73)

3rd code letter	Limits of the relative humidity[1]			e.g. suitable for the following environmental component climates
	Relative humidity		Dew precipi-tation	
	Annual average	Maximum value		
R[3]	≤90%	100%	yes	Equipment installed outside or in outdoor rooms; in cold, moderate, or subtropical climatic areas; also in unheated rooms which are not too damp.
D[3]	≤80%	100% for 30 days[2] per year	yes	Equipment in outdoor rooms and in medium moist rooms; in unheated rooms without major additional moisture sources, in moderate and cold climatic areas. Equipment installed outside in warm-dry climatic areas, if $\overline{U_{\overline{mon}}}$ = 75%[5] in the month with the most moisture.
E[4]	≤75%	95% for 30 days[2] per year	seldom and slight	Equipment installed in warm-dry climatic areas in outdoor and indoor rooms, if $\overline{U_{\overline{mon}}}$ = 70%[5] in the month with the most moisture. Operated equipment in rooms endangered by moisture, e.g. workshops, in cold, moderate, and warm-dry climatic areas. Non-operated equipment in moderate rooms endangered by moisture, in moderate and cold climatic areas; seldom and slight short-term dew precipitation is permissible.
F[4]	≤75%	95% for 30 days[2] per year	no	Like category E, but dew precipitation is not permitted.

[1] Specifications refer to the environmental component climate.
[2] Those days should be distributed throughout the year in a natural way.
[3] The values specified apply to all temperatures within the upper and lower category temperatures (permissible temperature range). Particularly for climatic areas with additional moisture sources.
[4] The values specified for the relative humidity refer to components in ambient temperature. In case of higher temperatures, the relative humidity decreases in accordance with DIN 40040, supplement I.
[5] $\overline{U_{\overline{mon}}}$ is the monthly average value of the relative humidity, which has been ascertained over a period of many years.

NTC	Abbreviation for negative temperature coefficient thermistor
P	Power
P_{25}	Power rating at 25°C
P_{60}	Power rating at 60°C
P_{100}	Power rating at 100°C
P_{max}	Peak NTC power rating (permissible power dissipation for short periods, providing the NTC thermistor resistance R_T does not drop below a specific value)
R	Resistance
R_{20}	Resistance at 20°C
R_{25}	Resistance at 25°C
R_{80}	Resistance at 80°C
R_{130}	Resistance at 130°C
R_{-30}	Resistance at −30°C
R_{av}	Average resistance
R_{ba}	Series of basic resistance values
ΔR_{ba}	Permissible deviation of the basic resistance values
R_{Hh}	Resistance of the heater helix of externally heated NTC thermistors
ΔR_{Hh}	Tolerance of the resistance of heater helix
R_{hot}	Resistance of the hot NTC thermistor
R_{is}	Insulation resistance
R_{min}	Hot resistance (minimum value for continuous operation)
R_p	Value of parallel resistance
R_r	Relay resistance
R_R	Rated resistance
ΔR_R	Tolerance of the rated resistance
$\Delta R_{10.}$	Maximum change of the rated resistance after 10000 hours
R_S	Series resistance
R_T	NTC thermistor resistance at temperature T
R_{Tctr}	NTC thermistor resistance at temperature T_{ctr}
ΔR_T	Deviation of the resistance value from the ideal characteristic curve
$(\Delta R_T)_t$	Expected resistance change after time t

NTC thermistors with 12.5 Ω to 144 Ω

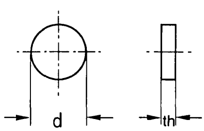
Application Temperature measurement, e.g. automotive cooling water temperature, oil temperature

Version NTC thermistor disc, lapped in a coplanar way

Terminals Front surfaces, silver-plated

Marking None

Quality characteristic Resistance drift: < ±2% after 20000 temperature changes between room temperature and upper category temperature



Weight: approx. 0.3 g
Dimensions in mm

Climatic category in accordance with DIN 40040 — **FHF**

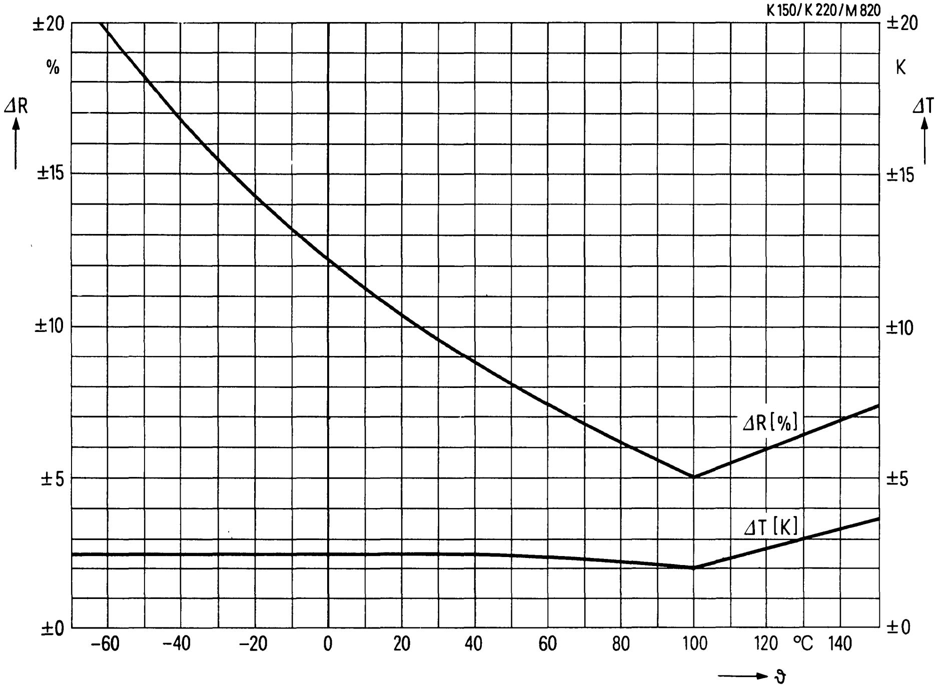
Lower category temperature **F** − 55°C
Upper category temperature **H** +155°C
Humidity category **F** Average relative humidity ⩽ 75%
95% continuously on 30 days per year
85% occasionally on the remaining days
No dew precipitation is permissible

Storage temperatures

Minimum storage temperature $\vartheta_{stg\ min}$ −25°C
Maximum storage temperature $\vartheta_{stg\ max}$ +65°C

Type	Rated resistance	Dimensions d [mm]	th [mm]	Ordering code
K 150/S1/12.5 Ω	12.5 Ω	7.7 −1.0	2.0 ± 0.5	Q63015−K9120−S1
K 150/S1/82.5 Ω	82.5 Ω	7.3 − 1.0	2.0 − 1.0	Q63015−K9820−S1
K 150/S1/100 Ω	100 Ω	7.3 − 1.0	2.0 − 1.0	Q63015−K9101−S1
K 150/S1/144 Ω	144 Ω	6.9 ± 0.4	1.4 ± 0.3	Q63015−K9141−S1

Permissible deviation of the resistance-temperature measurement error



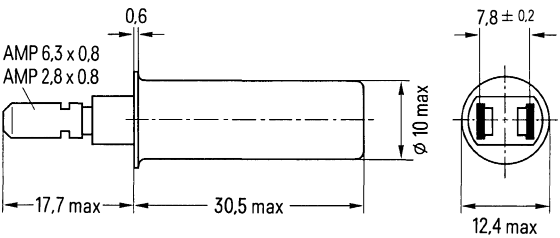
Characteristic data

Type	K 220/S1	1.6 kΩ	2.5 kΩ	Unit
Power rating at 25°C	P_{25}	220	220	mW
at 60°C	P_{60}	180	180	mW
Rated temperature	ϑ_R	20	20	°C
Rated resistance	R_R	1.6	2.5 k	Ω
Tolerance [1]	ΔR_R	±10	±10	%
Resistance at 130°C	R_{130}	58	90	%
Tolerance of R_{130} [1]	ΔR_{130}	±10	±10	Ω
B value	B	3560	3560	K
Tolerance [1]	ΔB	See resistance-temperature characteristic		
Thermal conductance in air	G_{thA}	1	1	mW/K
in case of chassis mounting	G_{thC}	approx. 6	approx. 6	mW/K
Thermal time constant	τ_{th}	approx. 5	approx. 5	s
Thermal capacitance	C_{th}	30	30	mJ/K

[1]) AQL = 0.65%

NTC thermistors with 330 Ω and 950 Ω

Application Temperature monitoring, measurement, and regulation of liquids
Version Stainless steel case, insulated terminals
Terminals Flat plugs 2.8 × 0.8 mm or 6.3×0.8 mm in accordance with DIN
Marking Red color dot ≙ 950 Ω
Quality characteristic Temperature measuring accuracy:
< ±1.5 K in the range between 25°C and 100°C



Weight: approx. 8.0 g
Dimensions in mm

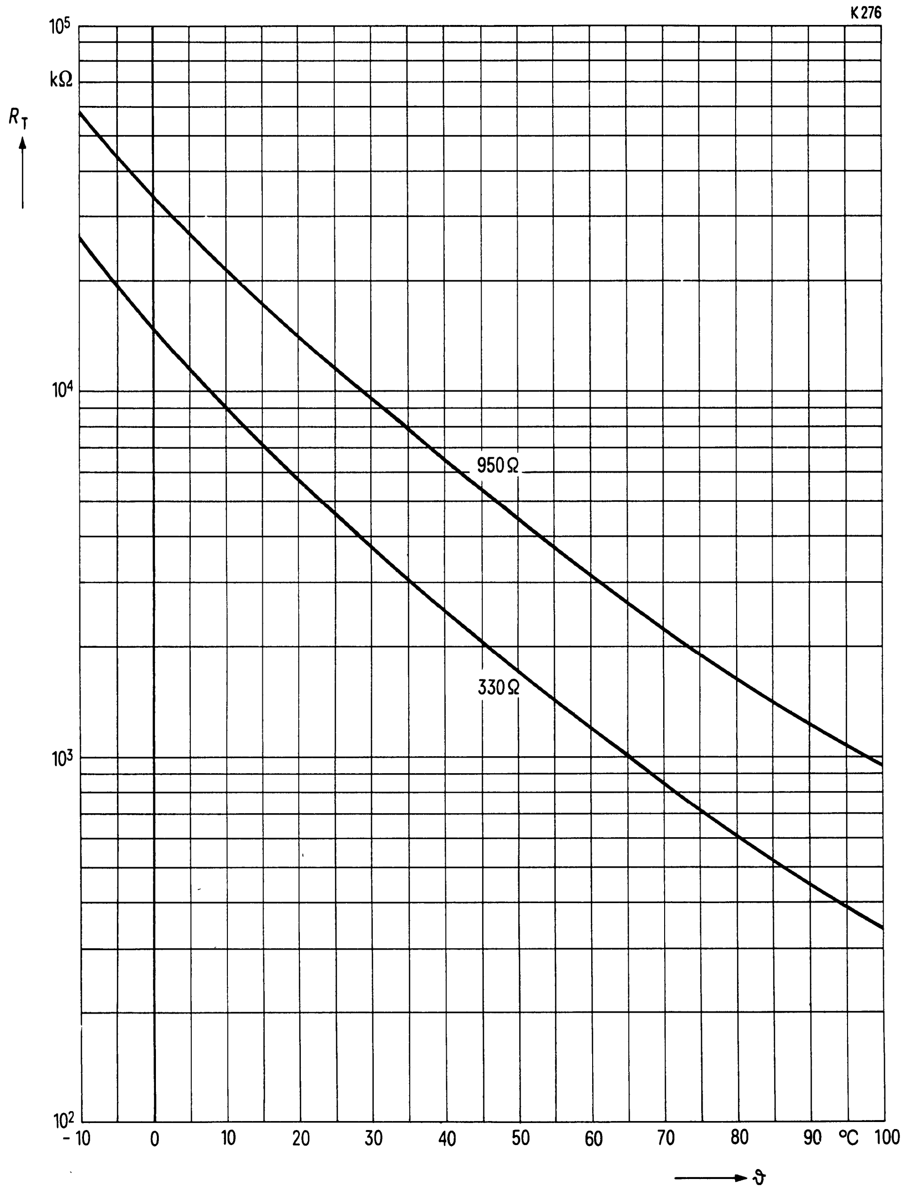
Climatic category **IME**
in accordance with DIN 40040

Lower category temperature **I** − 10°C
Upper category temperature **M** +100°C
Humidity category **E** Average relative humidity ⩽ 75%
95% continuously on 30 days per year
85% occasionally on the remaining days
Seldom and slight dew precipitation is permissible

Storage temperatures
Minimum storage temperature $\vartheta_{stg\ min}$ −10°C
Maximum storage temperature $\vartheta_{stg\ max}$ +65°C

Type	Rated resistance	*B* value	Flat plug	Ordering code
K 276/S2/330 Ω/2.8	330 Ω	3940	2.8 × 0.8	Q63027−K6331−S228
K 276/S2/330 Ω/6.3	330 Ω	3940	6.3 × 0.8	Q63027−K6331−S263
K 276/S2/950 Ω/2.8	950 Ω	3760	2.8 × 0.8	Q63027−K6951−S228
K 276/S2/950 Ω/6.3	950 Ω	3760	6.3 × 0.8	Q63027−K6951−S263

NTC thermistor resistance $R_T = f(\vartheta)$
versus NTC thermistor temperature



DIN climatic category (DIN 40 040) — G K E

Lower category temperature	**G**	−40°C
Upper category temperature	**K**	+125°C
Humidity category	**E**	average relative humidity ≦ 75% 95% on 30 days per year, continuously; 85% on the remaining days, occasionally rare, short-time dew precipitation permitted

Storage temperature

Minimum storage temperature	$\vartheta_{stg\ min.}$	−25°C
Maximum storage temperature	$\vartheta_{stg\ max.}$	+65°C

Characteristic data

Power rating at 25°C	P_{25}	900 mW [1]
Rated temperature	ϑ_R	5°C
Rated resistance	R_R	2 kΩ
Tolerance	ΔR_R	refer to page 3
B value	B	approx. 3560 K
Thermal conductance (in static air)	G_{thA}	> 12 mW/K
Thermal time constant (in static air)	τ_{th}	130 s
Recommended measuring load		< 5 mW
Insulation resistance	R_{is}	> 1 MΩ
Test voltage	V_{test}	1500 V
Test duration	t_t	1 s

[1]) Not for temperature measuring purposes. Refer to "recommended measuring load".

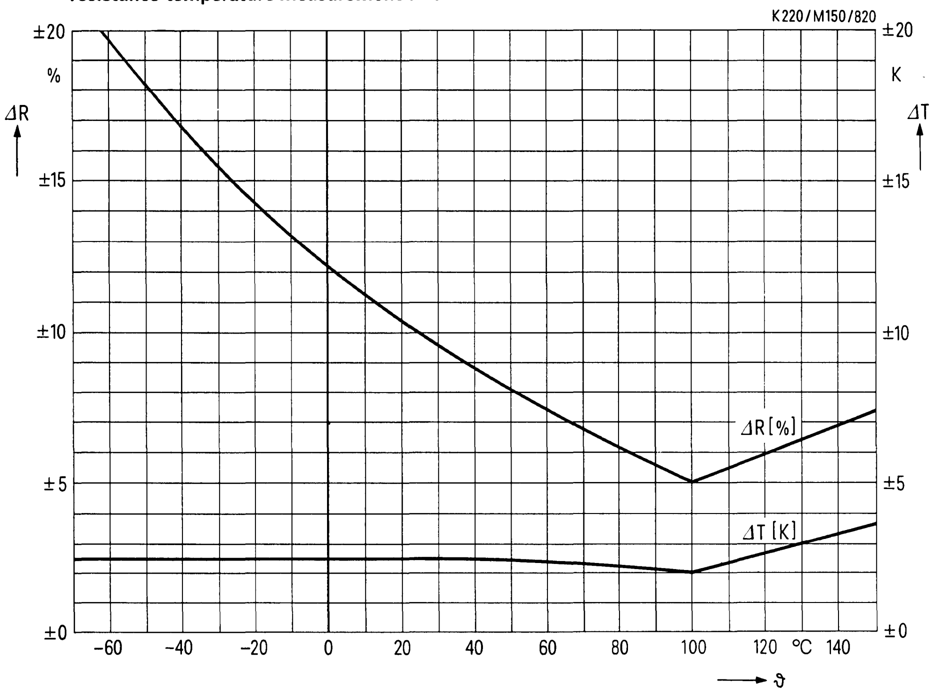
Resistance-temperature characteristic

Temperature °C	Resistance Ω	Temperature °C	Resistance Ω	Temperature °C	Resistance Ω	Temperature °C	Resistance Ω
−40	20 750	2	2287.00	44	430.10	86	114.80
−39	19 530	3	2187.00	45	415.30	87	111.60
−38	18 380	4	2091.00	46	401.10	88	108.60
−37	17 310	5	2000.00	47	387.50	89	105.60
−36	16 310	6	1914.00	48	374.40		
−35	15 380	7	1831.00	49	361.80	90	102.70
−34	14 500	8	1753.00			91	99.89
−33	13 690	9	1679.00	50	349.70	92	97.18
−32	12 920			51	338.00	93	94.56
−31	12 200	10	1608.00	52	326.80	94	92.02
		11	1541.00	53	316.10	95	89.56
−30	11 530	12	1477.00	54	305.70	96	87.18
−29	10 900	13	1416.00	55	295.80	97	84.87
−28	10 300	14	1357.00	56	286.20	98	82.63
−27	9 747	15	1302.00	57	276.90	99	80.46
−26	9 224	16	1249.00	58	268.10		
−25	8 733	17	1199.00	59	259.50	100	78.36
−24	8 271	18	1150.00			101	76.32
−23	7 837	19	1105.00	60	251.30	102	74.35
−22	7 429			61	243.30	103	72.43
−21	7 044	20	1061.00	62	235.70	104	70.57
		21	1019.00	63	228.30	105	68.77
−20	6 682	22	979.00	64	221.20	106	67.03
−19	6 341	23	940.80	65	214.40	107	65.33
−18	6 020	24	904.40	66	207.80	108	63.68
−17	5 717	25	869.60	67	201.40	109	62.09
−16	5 431	26	836.30	68	195.30		
−15	5 162	27	804.50	69	189.40	110	60.54
−14	4 908	28	774.00			111	59.03
−13	4 667	29	744.90	70	183.70	112	57.57
−12	4 440			71	178.10	113	56.15
−11	4 226	30	717.10	72	172.80	114	54.78
		31	690.40	73	167.70	115	53.44
−10	4 023	32	664.90	74	162.70	116	52.14
−9	3 831	33	640.40	75	157.90	117	50.88
−8	3 650	34	617.00	76	153.30	118	49.65
−7	3 479	35	594.60	77	148.90	119	48.46
−6	3 316	36	573.10	78	144.50	120	47.30
−5	3 162	37	552.50	79	140.40		
−4	3 016	38	532.80			121	46.18
−3	2 878	39	513.80	80	136.30	122	45.08
−2	2 747			81	132.40	123	44.02
−1	2 623	40	495.70	82	128.70	124	42.99
		41	478.20	83	125.00	125	41.98
0	2 505	42	461.50	84	121.50		
1	2 394	43	445.50	85	118.10		

Characteristic data

Power rating	at 25°C	P_{25}	400 mW
	at 60°C	P_{60}	300 mW
Rated temperature		ϑ_R	+100 °C
Rated resistance		R_R	See resistance-temperature characteristic
Tolerance [1]		ΔR_R	See diagram
B value		B	See resistance-temperature characteristic
Thermal conductance in air		G_{thA}	3 mW/K
in case of chassis mounting		G_{thC}	approx. 20 mW/K
Thermal time constant		τ_{th}	approx. 30 s
Thermal capacitance		C_{th}	100 mJ/K

Permissible deviation of the resistance-temperature measurement error



[1]) AQL = 0.65%

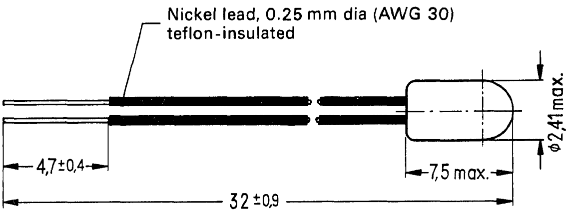
Resistance-temperature characteristic

Type	M 820/S1/30.7Ω	M 820/S1/39.6Ω	M 820/S1/77Ω	M 820/S2/84.5Ω
Temperature °C	Resistance Ω	Resistance Ω	Resistance Ω	Resistance Ω
−60	84.5 k	71.3 k	67.1 k	69.5 k
−50	38.7 k	34.1 k	34.4 k	35.9 k
−40	18.8 k	17.2 k	18.6 k	19.5 k
−30	9.68 k	9.17 k	10.5 k	11.1 k
−20	5.21 k	5.10 k	6.20 k	6.55 k
−10	2.93 k	2.96 k	3.79 k	4.02 k
± 0	1.70 k	1.77 k	2.39 k	2.54 k
10	1.03 k	1.10 k	1.55 k	1.65 k
20	637	698	1.03 k	1.10 k
30	406	456	670	753
40	265	305	486	525
50	177	208	344	373
60	120	144	248	269
70	83.7	102	181	198
80	59.1	73.5	135	147
90	42.3	53.6	101	111
100	30.7	39.6	77.0	84.5
110	22.8	29.8	59.7	65.6
120	17.2	22.8	46.8	51.5
130	13.1	17.6	37.0	40.9
140	10.1	13.8	29.6	32.8
150	7.8	10.9	23.9	26.5

NTC Thermistor Miniature Sensor

M 861

Resistance value	30 kΩ
Application	miniature thermistor for high-accuracy temperature measurement throughout the range −40°C to +120°C
Version	epoxy resin coated thermistor
Terminals	0.25 mm dia leads, teflon encapsulated nickel wire
Quality characteristic	high stability due to special aging, dielectric strength: 200 V dc voltage



Approx. weight 0.1 g

Dimensions in mm

DIN climatic category (DIN 40 040)	**G K C**	
Lower category temperature	**G**	−40°C
Upper category temperature	**K**	+125°C
Humidity category	**C**	average relative humidity ≦ 95% max. value 100%, including dew precipitation

Storage temperatures

Minimum storage temperature	$\vartheta_{stg\ min.}$	−25°C
Maximum storage temperature	$\vartheta_{stg\ max.}$	+65°C

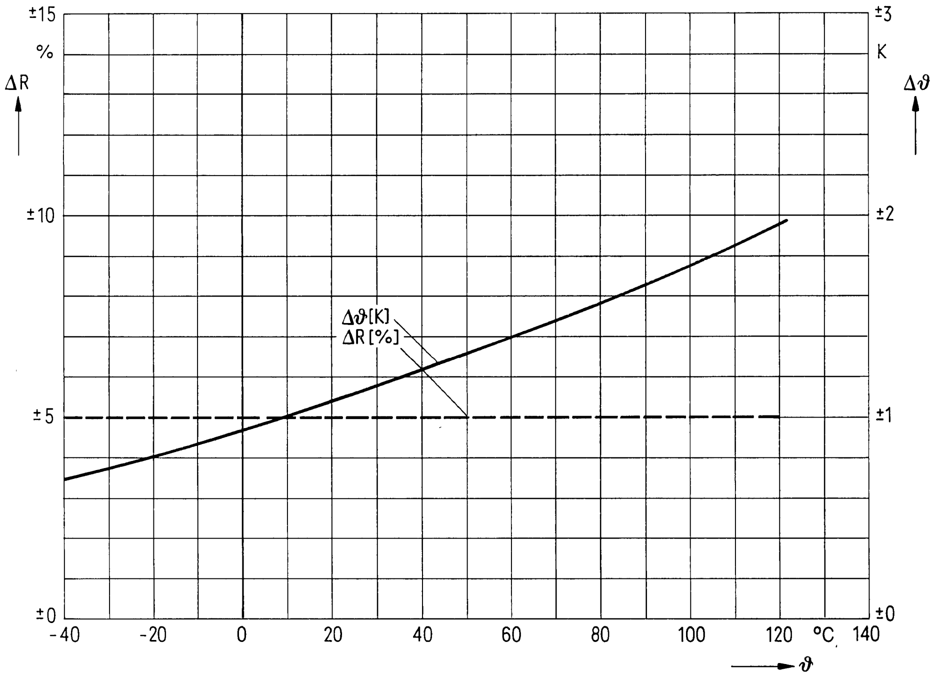
Characteristic data

Power rating at 25°C	P_{25}	140 mW
Rated temperature	ϑ_R	25°C
Rated resistance	R_R	30 kΩ
Tolerance [1]	ΔR_R	±5%
B value	B	3970 K
Thermal conductance in air	G_{thA}	1.4 mW/K
Thermal time constant	τ_{th}	< 20 s

Type	Rated resistance	*B* value	Ordering code
M861/S1/30 kΩ	30 kΩ	3970 K	Q63086–M1303–S1

[1] AQL = 0.65%

Resistance tolerance and measuring accuracy



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