Ceramic Singlelayer Capacitors

In accordance with IEC recommendations ceramic capacitors are subdivided into two classes:

- CERAMIC CLASS 1 or low-K capacitors are mainly manufactured of titanium dioxide or magnesium silicate
- CERAMIC CLASS 2 or high-K capacitors contain mostly alkaline titanates

MAIN FEATURES		
	CLASS 1	**CLASS 2**
APPLICATION	For temperature compensation of frequency discriminating circuits and filters, coupling and decoupling in high-frequency circuits where low losses and narrow capacitance tolerances are demanded. As RFI and safety capacitors.	As coupling and decoupling capacitors for such application where higher losses and a reduced capacitance stability are required. As RFI and safety capacitors
PROPERTIES Temperature Dependence Capacitance	High stability of capacitance. Low dissipation factor up to higher frequencies. Defined temperature coefficient of capacitance, positive or negative, linear and reversible. High insulation resistance. No voltage dependence. High long-term stability of electrical values.	High capacitance values with small dimensions. Non-linear dependence of capacitance on temperature.
DC VOLTAGE CAPACITANCE DEPENDENCE	None	Increasing with ε
DISSIPATION FACTOR tan δ	max. $1.5 \cdot 10^{-3}$ (Typical)	max. $25 \cdot 10^{-3}$ (Typical)
INSULATION RESISTANCE	$\geq 1 \cdot 10^{10}$Ohm	$\geq 5 \cdot 10^{9}$Ohm
CAPACITANCE TOLERANCES	< 10pF: ± 0.1pF ± 0.25pF ± 0.5pF ± 1pF ± 2pF ≥ 10pF: ± 1% ± 2% ± 2.5% ± 5% ± 10% ± 20% With very low tolerances (<0.25pF) and where the customer does not exchange reference samples our capacitance standards are binding.	± 10% ± 20% - 20% + 30% - 20% + 50% - 20% + 80%
RATED VOLTAGE	$125V_{DC} \cdots 700_{DC}$	$125V_{DC} \cdots 700_{DC}$ Capacitor stacks up to $19kV_{PEAK}$

PREFERRED VALUES OF CAPACITANCE:

Nominal value series according to IEC 60063 see table on page 3 of this catalog.

The figures given in the table and their decimal multiples or sub-multiples are series or preferred values of capacitance.

CAPACITANCE MEASUREMENTS

The capacitance of all our single-layer capacitors - except where deviations are agreed upon in the ordering procedure - are measured under the following conditions.

MEASURING FREQUENCY

Class 1 capacitors: (1 ± 0.2)MHz or (100 ± 20)kHz

Class 2 capacitors: (1 ± 0.2)kHz (Field strength max. $3V_{RMS}$ per millimeter)

MEASURING VOLTAGE

Class 1 capacitors: $\leq 5.0V_{RMS}$

Class 2 capacitors: $\leq 1.2V_{RMS}$

CLIMATIC CONDITIONS OF MEASUREMENTS

Temperature: (23 ± 3)˚C, for reference measurements (20 ± 1)˚C.

Relative humidity: ≤ 75%

REFERENCE LENGTH OF THE LEADS

2 millimeters from capacitor body. (These conditions are in accordance with IEC - publ. 60384-8, 60384-9)

TEMPERATURE COEFFICIENT OF CLASS 1 CAPACITORS

For cases of practical application requiring a defined and reproducible temperature dependence of capacitance, specific ceramic capacitor materials have been developed with which it is possible to achieve capacitance temperature coefficients (αc) ranging between +100 to - 5600 • 10^{-6}/ºC.

Our ceramic materials are manufactured in accordance with the standard values of Class 1 (NDK).

The αc rated values are determined by capacitance measurements at temperatures of + 20˚C and + 85˚C using the following formula below :

$$\alpha_c = \frac{C2 - C1}{C1 \cdot (\delta 2 - \delta 1)}$$

C1 = capacitance value in pF at 20˚C
C2 = capacitance value in pF at 85˚C
$\delta 1$ = 20˚C
$\delta 2$ = 85˚C

TOLERANCE OF THE TEMPERATURE COEFFICIENT OF CLASS 1 CAPACITORS

Various influences during the manufacturing process of the ceramic dielectric materials may cause deviations from the nominal αc values.

In addition, the relatively higher stray capacitances connected with small capacitance values (below 50pF) modify the αc value.

The permissible deviation of the actual αc values from the nominal ones are comprised within the αc tolerances.

In accordance with EN 130600, we manufacture capacitors with the following αc values and associated tolerances:

Class 1 A = narrowed α_c tolerance
Class 1 B = standard α_c tolerance
Class 1 F = extended α_c tolerance

TOLERANCE OF THE TEMPERATURE COEFFICIENT OF CLASS 1 CAPACITORS

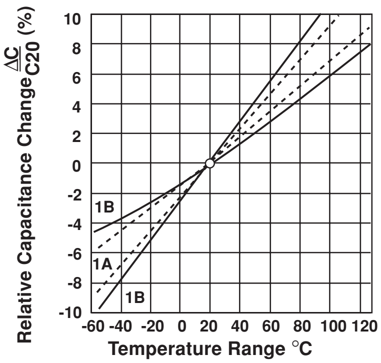
TEMPERATURE COEFFICIENT		α_C TOLERANCE (10^{-6}/°C)									
DESIGNATION	NOMINAL VALUE (10^{-6}/°C)	1 A		1 B					1 F		
		C_N(pF)		C_N(pF)					C_N(pF)		
		15 to 20	> 20	< 3	3 to < 6.2	6.2 to < 10	10 to < 15	≥ 15	< 3	3 to 6.2	> 6.2
P 100	+ 100										
NP 0	± 0										
N 033	- 33	± 20	± 15	+ 250 - 30	+ 120 - 30	+ 60 - 30	+ 40 - 30	± 30			
N 075	- 75										
N 150	- 150										
N 220	- 220										
N 330	- 330	± 40	± 30	+ 250 - 60	+ 125 - 60	+ 90 - 60	+ 70 - 60	± 60			
N 470	- 470										
N 750	- 750	± 80	± 60	+ 250 - 120	± 120	± 120	± 120	± 120			
N 1500	- 1500								+ 500 - 250	+ 500 - 250	± 250
N 2200	- 2200								+ 1000 - 500	± 500	± 500
N 5600	- 5600								+ 1500 - 1000	± 1000	± 1000

PERMISSIBLE RELATIVE CAPACITANCE VARIATION REFERRED TO THE VALUE AT 20°C.

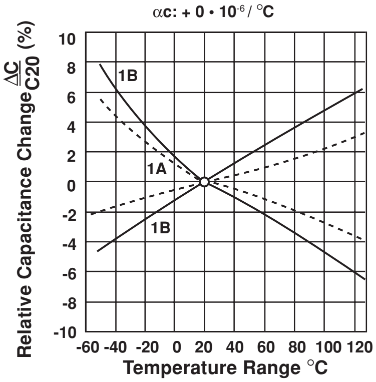
TEMPERATURE COEFFICIENT		PERMISSIBLE RELATIVE CAPACITANCE VARIATION (10^{-3})									
NOMINAL VALUE	TOLERANCE	- 55°C		- 40°C		- 25°C		+ 85°C		+ 125°C	
10^{-6} /°C	10^{-6} /°C	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
+100	15 (1A) 30 (1B)	- 8.63 - 9.75	- 5.90 - 4.10	- 6.90 - 7.80	- 4.76 - 3.38	- 5.18 - 5.85	- 3.60 - 2.61	5.53 4.55	7.48 8.45	8.93 7.35	11.9 13.5
± 0	15 (1A) 30 (1B)	- 1.13 - 2.25	2.67 4.05	- 0.904 - 1.80	2.00 3.09	- 0.678 - 1.35	1.40 2.20	- 0.975 - 1.95	0.975 1.95	- 1.58 - 3.15	1.69 3.23
- 033	15 (1A) 30 (1B)	1.35 0.225	5.65 7.05	1.08 0.180	4.34 5.44	0.810 0.135	3.13 3.93	- 3.12 - 4.10	- 1.17 - 0.195	- 5.04 - 6.62	- 1.75 - 0.291
- 075	15 (1A) 30 (1B)	4.50 3.38	9.65 11.5	3.60 2.70	7.47 8.89	2.70 2.03	5.42 6.43	- 5.85 - 6.83	- 3.90 - 2.93	- 9.45 - 11.0	- 5.74 - 4.25
- 150	15 (1A) 30 (1B)	10.1 9.00	16.9 18.2	8.08 7.20	13.1 14.1	6.06 5.40	9.55 10.3	- 10.7 - 11.7	- 8.78 - 7.80	- 17.3 - 18.9	- 13.1 - 11.5
- 220	30 (1A) 60 (1B)	5.4 14.3	23.2 24.5	12.3 11.4	18.1 19.1	9.24 8.58	13.2 14.0	- 15.3 - 16.3	- 13.3 - 12.4	- 24.7 - 26.3	- 20.2 - 18.9
- 330	30 (1A) 60 (1B)	22.5 20.3	33.4 38.3	18.0 16.2	26.2 29.9	13.5 12.2	19.2 21.8	- 23.4 - 25.4	- 19.5 - 17.7	- 37.8 - 41.0	- 29.5 - 26.7
- 470	60 (1A) 120 (1B)	33.0 30.8	48.5 51.2	26.4 24.6	37.9 40.0	19.8 18.5	27.7 29.3	- 32.5 - 34.5	- 28.6 - 26.7	- 52.5 - 55.7	- 43.2 - 40.5
- 750	15 (1A) 30 (1B)	51.8 47.3	76.5 82.4	41.4 37.8	59.9 64.5	31.1 28.4	43.9 47.3	- 52.7 - 56.6	- 44.9 - 41.0	- 85.1 - 91.4	- 67.8 - 65.6
- 1500	250 (1F)	93.8	161	75.0	126	56.3	92.8	- 114	- 81.3	- 184	- 131
- 2200	500 (1F)	128	248	102	195	76.8	143	- 176	- 111	- 284	- 179
- 5600	1000 (1F)	345	607	276	476	207	350	- 429	- 299	- 693	- 483

CAPACITANCE CHANGE VS. TEMPERATURE OF CLASS 1 CAPACITORS

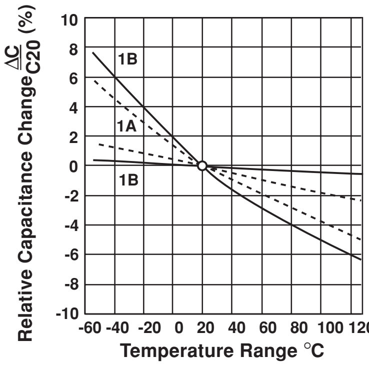
αc: + 100 • 10⁻⁶ / °C



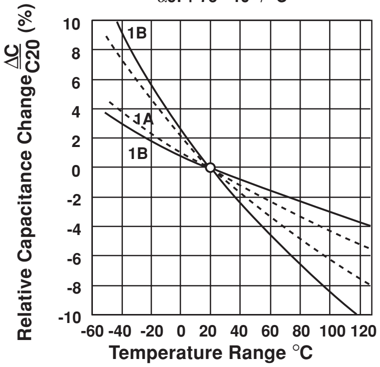
αc: + 0 • 10⁻⁶ / °C



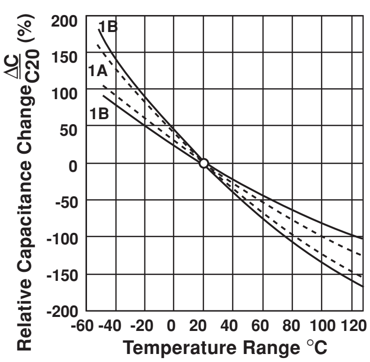
αc: + 30 • 10⁻⁶ / °C



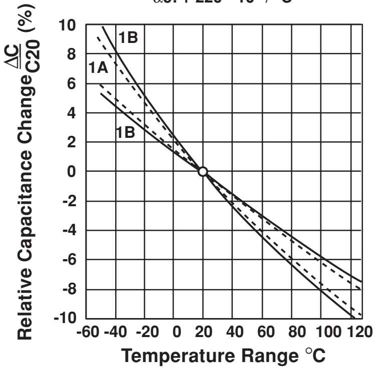
αc: + 75 • 10⁻⁶ / °C



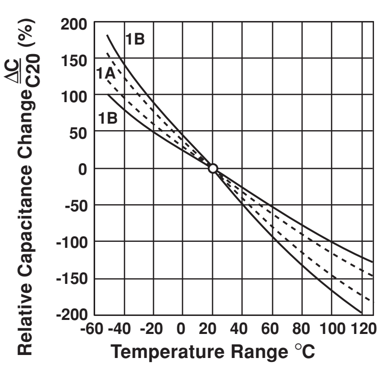
αc: + 150 • 10⁻⁶ / °C



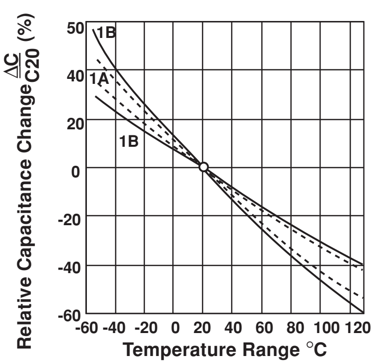
αc: + 220 • 10⁻⁶ / °C



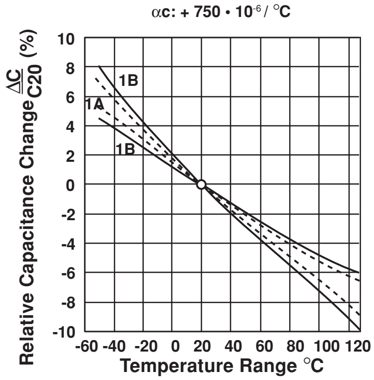
αc: + 330 • 10⁻⁶ / °C



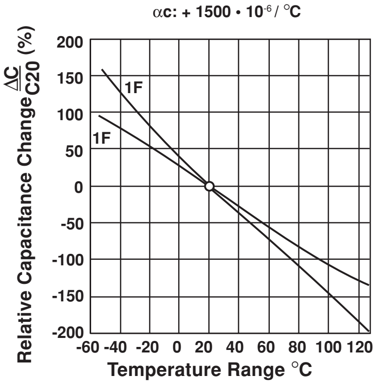
αc: + 470 • 10⁻⁶ / °C



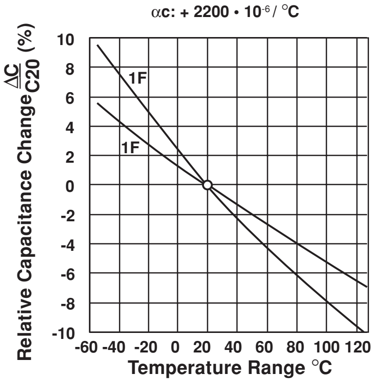
αc: + 750 • 10⁻⁶ / °C



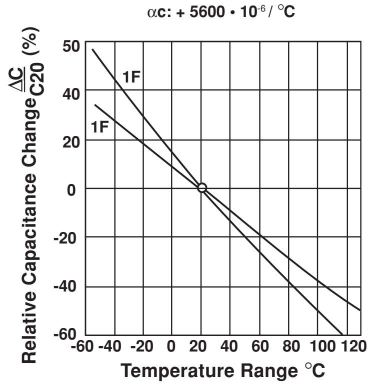
αc: + 1500 • 10⁻⁶ / °C



αc: + 2200 • 10⁻⁶ / °C

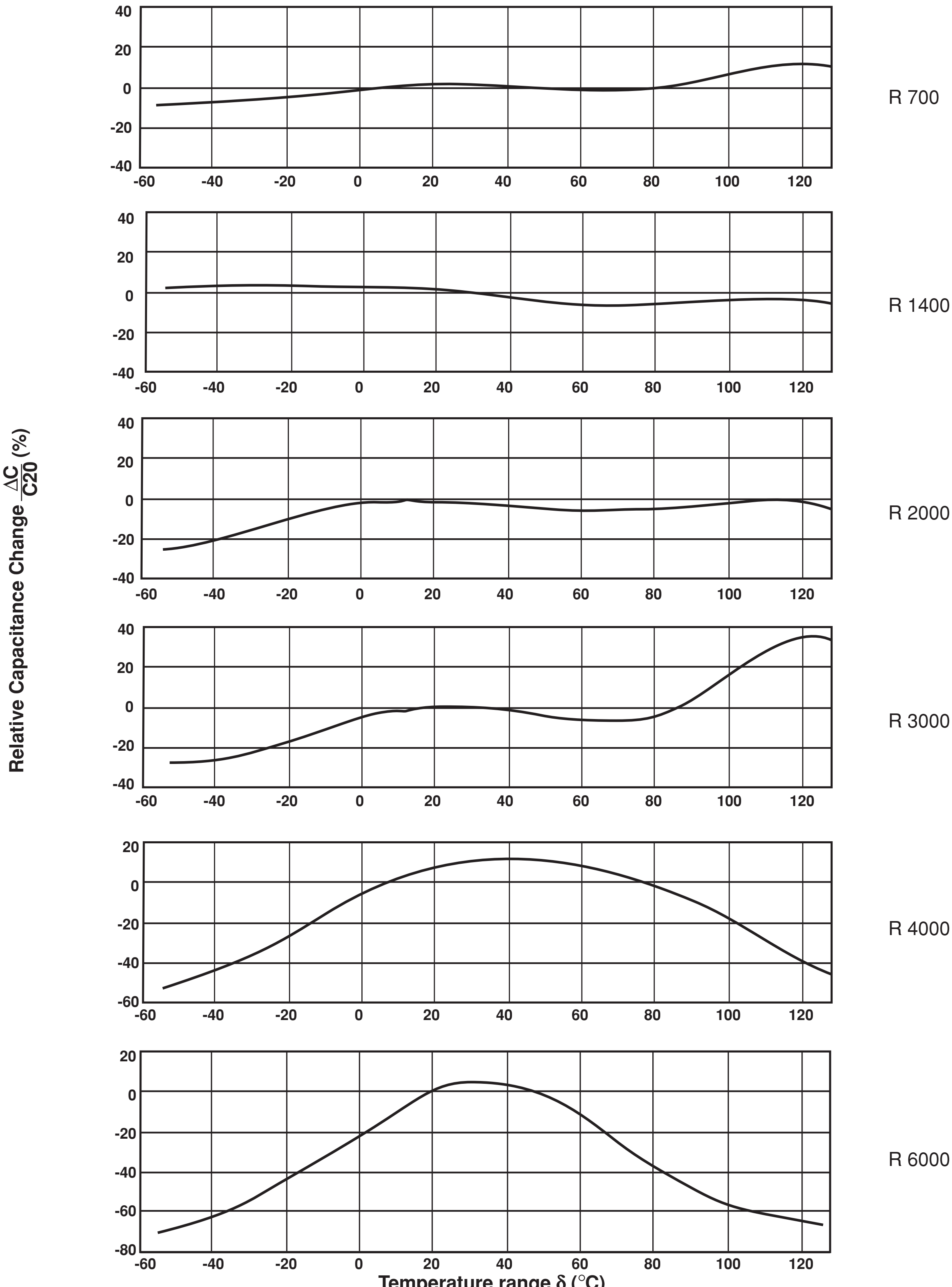


αc: + 5600 • 10⁻⁶ / °C



C20: Capacitance at 20˚C without DC -voltage
Measuring frequency: 1MHz
Measuring voltage: ≥ $5V_{RMS}$

TEMPERATURE DEPENDENCY OF THE CAPACITANCE WITH CLASS 2 CAPACITORS



C20: Capacitance at 20˚C without DC -voltage
Measuring frequency: 1MHz
Measuring voltage: ≥ $5V_{RMS}$

TABLE OF TEMPERATURE CHARACTERISTIC DESIGNATIONS OF CLASS 2 CAPACITORS.

VISHAY DRALORIC CERAMIC TYPE	TEMPERATURE RANGE (˚C)	MAX. CHANGE OF CAPACITANCE VALUE FROM VALUE AT 20 ˚ C		REFERENCE TEMPERATURE CHARACTERISTIC ACCORDING TO IEC 60384-9	REFERENCE TEMPERATURE CHARACTERISTIC ACCORDING TO EIA RS-198
		without DC Voltage	with UR		
R 700, R 1400	- 25 to + 85	± 20%	+ 10 - 15%	2B4	Y5P
	- 55 to + 85	± 20%	+ 10 - 15%	2B4	Y5P
R 2000, R 3000	- 25 to + 85	+ 20 - 30%	+ 20 - 30%	2C4	Y5S
	- 55 to + 85	+ 20 - 30%	+ 20 - 40%	2D2	Y5S
R 4000, R 6000	- 25 to + 85	+ 20 - 55%	+ 20 - 65%	2E4	Y5U
R 4000	- 55 to + 85	+ 20 - 55%	+ 20 - 65%	2E2	X5U

• Marking of the temperature characteristic according IEC 60384-9 resp. EIA RS-198 see General Information.

CAPACITANCE “AGEING” OF CERAMIC CAPACITORS

Following the final heat treatment, all class 2 ceramic capacitors reduce their capacitance value approximation wise according to a logarithmic law due to their special crystaline construction. This change is called “ageing”. If the capacitors are heat treated for example when soldering, the capacity increases again to a higher value and the ageing process begins again. (note: the level of this de-ageing is dependant on the temperature and the duration of the heat, an almost complete de-ageing is achieved at 150˚C in one hour; these conditions also form the basis for reference measurements when testing). The capacitance change per time decade (ageing constant) differs for the various types of ceramic but typical values can be taken from the table below.

CERAMIC DIELECTRIC	R 700	R 1400	R 2000	R 3000	R 4000	R 6000
AGEING CONSTANT (k)	- 1%	- 2%	- 2%	- 1%	- 4%	- 4%

$$k = \frac{100 \cdot (C_{t1} - C_{t2})}{C_{t1} \cdot \log_{10} (t1 / t2)}$$

$$C_{t2} = C_{t1} \cdot (1 - \frac{k}{100} \cdot \log_{10} [t1 / t2])$$

t1, t2 = measuring time point (h)
C_{t1} , C_{t2} = capacitance values for the times t1, t2
k = ageing constant (%)

REFERENCE MEASUREMENT:

Due to ageing it is neccessary to quote an age for reference measurements which can be related to the capacitance with fixed tolerance. According to EN 130700 this time period is 1000 hours.

If the shelf-life of the capacitor is known, the capacitance for t = 1000h can be calculated with the ageing constant.

In order to avoid the influence of the ageing, it is important to de-age the capacitors before stress-testing.

The following procedure is adopted (see also EN 130700) :

De-ageing at 150˚C, 1hour
Storage for 24 hours at normal climate temperature
Initial measurement
Stress
De-ageing at 150˚C, 1hour
Storage for 24 hours at normal climate temperature
Final measurement

RATED VOLTAGE (U_R)

The rated voltage U_R is the highest permissible value of the sum of d.c voltage and the peak value of the alternating voltage applied to the capacitor at any temperature within the permissible temperature range. This voltage is indicated in the data sheets for every capacitor type with the upper limit for the r.m.s value of the alternating voltage added.

The max. power loss (Pv_{max}) and the max. reactive current (I_{max}) should also be taken into consideration.

DIELECTRIC STRENGTH AND TEST CONDITIONS

The test of dielectric strength is carried out as a 100% measurement.

The test may be repeated only once by the user, e.g. to prevent too frequent preloading of the dielectric.

Test Voltage:	**Direct Voltage**	
Value of Test Voltage	Rated Voltage ≤ 330V:	Test Voltage = 3 • U_R
	Rated Voltage > 330V:	Test Voltage = 1.5 • U_R + $500V_{DC}$
	Rated Voltage 400V / 500V:	Test Voltage = $1250V_{DC}$
	Rated Voltage 700V:	Test Voltage = $1550V_{DC}$
Charge / Discharge Current:	max. 50mA	
Duration:	(1 ± 0.2) s	
Temperature:	+ 15˚C to + 35˚C	
Relative Humidity:	≤ 75%	

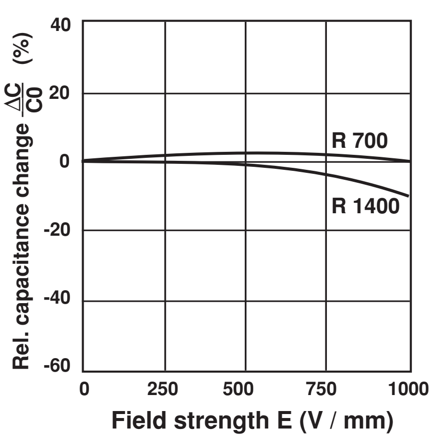
CAPACITANCE INDEPENDANCE OF FREQUENCY

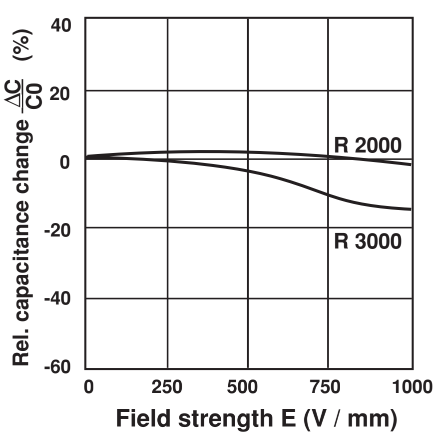
In ceramic capacitors of Class 1 and 2, the capacitance is practically independent of the frequency. If however, a capacitor is operated near its 1st self resonance (series resonance), the self inductance causes a decrease of the impedance between the connecting points, which is equivalent to a capacitance increase.

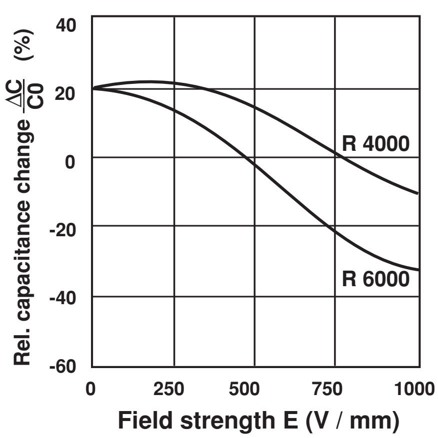
DC - VOLTAGE DEPENDENCY OF CAPACITANCE (TYPICAL VALUES)

The capacitance of Class 1 capacitors scarcely changes when DC bias voltage is applied.

The curves below show the relative variation of Capacitance vs. Field strength E of Class 2 capacitors (Typical values, voltage referred to thickness of ceramic dielectric).







C_0: Capacitance without DC voltage
Measuring Frequency: 1kHz
Temperature: (23 ± 3)°C
Measuring Voltage: ≤ $1.5V_{RMS}$

A.C. VOLTAGE LOAD (GENERAL)

The permissible a.c. load of a ceramic capacitor depends on the following characteristics and data:

Permissible field strength in the ceramic material

Dissipation factor of the ceramic material

Permissible RF current

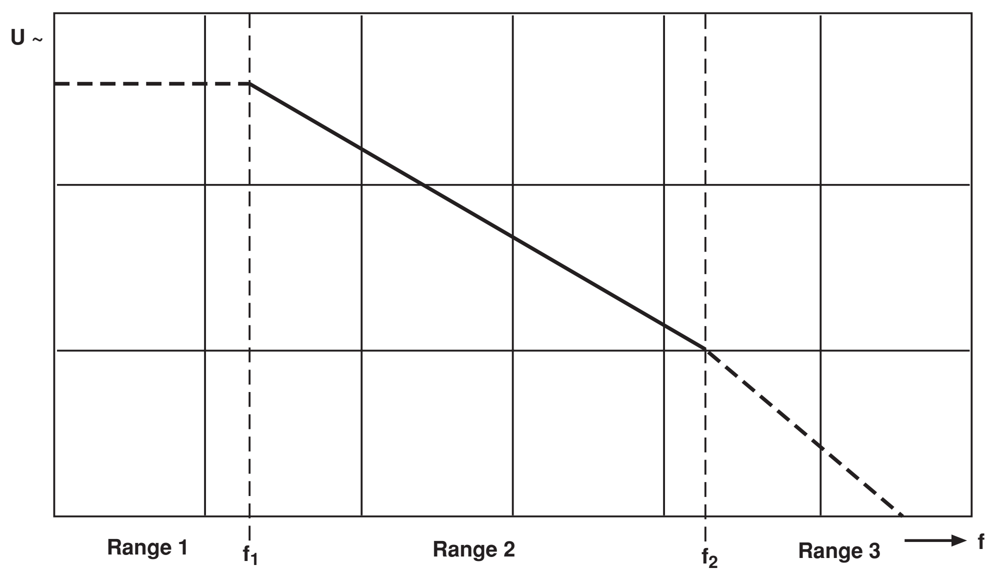
Style
Dimensions of external surface } thermal resistance towards the environment

Frequency and distortion curve of the RF voltage

Ambient temperature

For every capacitor three frequency ranges are to be distinguished for a.c. permissible voltage. The formulae giving the permissible effective voltage and the limits of the ranges are stated in the following diagram (referred to as a sinusiodal a.c. voltage):

$$U_1 = \frac{U_R}{\sqrt{2}} \qquad U_2 = \sqrt{\frac{Qmax}{2\,\pi \cdot f \cdot C}} \qquad U_3 = \frac{Imax}{2\,\pi \cdot f \cdot C}$$



U in V_{RMS}
I in A_{RMS}
Q in VA_r
C in F

$$f_1 = \frac{Qmax}{2\,\pi \cdot U_1^2 \cdot C} \qquad f_2 = \frac{Imax^2}{2\,\pi \cdot Qmax \cdot C}$$

Range 1: In the low - frequency range the voltage U_1 is limited by the permissible field strength and is generally $U_R / \sqrt{2}$.
See specification on the relevant data sheet.

Range 2: Above the frequency limit f_1 the voltage U_2 is limited by the permissible reactive power Q_{max}.

Range 3: Above the frequency limit f_2 the voltage U_3 is limited by the permissible reactive power I_{max}.

PERMISSIBLE POWER LOSS (P_{VMAX}) AND REACTIVE CURRENTS (I_{MAX})

TUBULAR CAPACITORS								
SIZE	I_{MAX} (A_{RMS})	Pv_{MAX} (mW)	SIZE	I_{MAX} (A_{RMS})	P_{VMAX} (mW)	SIZE	I_{MAX} (A_{RMS})	Pv_{MAX} (mW)
0205	0.5	15	0310	0.5	50	0416	0.75	100
0207	0.5	20	0312	0.5	60	0420	0.75	135
0208	0.5	24	0314	0.5	70	0425	0.75	170
0209	0.5	27	0316	0.5	80	0430	0.75	200
0210	0.5	30	0320	0.5	100	0440	0.75	270
0211	0.5	33	0325	0.5	125			
0212	0.5	36	0330	0.5	150			
0213	0.5	39						
0214	0.5	42						
0216	0.5	48						
0220	0.5	60						

• For the values of Ceramic feed-through capacitors & filters see the relevant data sheets.

PERMISSIBLE REACTIVE POWER (P_{BMAX})

tan δ (10^{-3})	0.5	0.8	1.5	2	2.5	5	10	12	25	50	100
Dissipated Power P_{Vmax} (mW)	Reactive Power P_{Bmax} (VA)										
6	12	7.5	4.0	3.0	2.4	1.2	0.6	0.5	0.24	0.12	0.06
10	20	12.5	6.7	5.0	4.0	2.0	1.0	0.83	0.4	0.2	0.1
13	26	16.3	8.7	6.5	5.2	2.6	1.3	1.1	0.52	0.26	0.13
18	36	22.5	12	9.0	7.2	3.6	1.8	1.5	0.72	0.36	0.18
20	40	25	13.3	10	8.0	4.0	2.0	1.7	0.8	0.4	0.2
24	48	28.8	16	12	9.5	4.8	2.4	2.0	0.95	0.48	0.24
27	54	33.7	18	13.5	10.8	5.4	2.7	2.2	1.1	0.54	0.27
30	60	37.6	20	15	12	6.0	3.0	2.5	1.2	0.6	0.3
36	72	45	24	18	14	7.2	3.6	3.0	1.4	0.72	0.36
42	84	52.5	28	21	17	8.4	4.2	3.5	1.7	0.84	0.42
48	96	60	32	24	19	9.6	4.8	4.0	1.9	0.96	0.48
50	100	62.5	33	25	20	10	5	4.2	2.0	1.0	0.5
60	120	75	40	30	24	12	6.0	5.0	2.4	1.2	0.6
70	140	87.5	47	35	28	14	7.0	5.8	2.8	1.4	0.7
75	150	94	50	37.5	30	15	7.5	6.2	3.0	1.5	0.75
80	160	100	53	40	32	16	8.0	6.7	3.2	1.6	0.8
100	200	125	67	50	40	20	10	8.3	4.0	2.0	1.0
120	240	150	80	60	48	24	12	10	4.8	2.4	1.2
125	250	156	83	63	50	25	12.5	10	5.0	2.5	1.25
135	270	169	90	68	54	27	13.5	11	5.4	2.7	1.35
140	280	175	93	70	56	28	14	12	5.6	2.8	1.4
150	300	188	100	75	60	30	15	13	6.0	3.0	1.5
160	320	200	107	80	64	32	16	13	6.4	3.2	1.6
170	340	213	113	85	68	34	17	14	6.8	3.4	1.7
200	400	250	133	100	80	40	20	17	8.0	4.0	2.0
270	540	337	180	135	108	54	27	22	11	5.4	2.7
300	600	375	200	150	120	60	30	25	12	6.0	3.0
340	680	425	226	170	136	68	34	28	14	6.8	3.4

The above values for dissipated power P_{Vmax} refer to a temperature rise of 30˚C and apply to an ambient temperature of 55˚C. For other ambient temperature δ_u between 55˚C and 85˚C the limiting values for P_V and P_B may be computed from the formulae below:

$$P_{V_{\delta_u}} = \frac{85 - \delta_A}{30} \cdot P_{Vmax}$$

$$P_{B_{\delta_u}} = \frac{85 - \delta_A}{30} \cdot P_{Bmax}$$

DISSIPATION FACTOR: LIMITING AND AVERAGE VALUES

CLASS	CERAMIC DIELECTRIC	AVERAGE VALUES tan δ (10^{-3})	LIMITING tan δ (10^{-3})
1	P 100	0.4	≤ 1.0
	NP 0	0.4	
	N 033	0.4	
	N 075	0.4	
	N 150	0.4	
	N 220	0.5	
	N 330	0.5	
	N 470	0.5	
	N 750	0.5	
	N 1500	0.5	
	N 2200 N 5600	1.0	≤ 1.5

CLASS	CERAMIC DIELECTRIC	AVERAGE VALUES tan δ (10^{-3})	LIMITING tan δ (10^{-3})
2	R 700	12	≤ 25
	R 1400	10	
	R 2000	11	
	R 3000	11	
	R 4000	12	
	R 6000	15	

The AVERAGE VALUES of the table for dissipation refer to capacitances above 50pF and are values averaged from systematic sample measurements of several years on all types of capacitors.

The LIMITING VALUES are the values used as requirements in all our tests. They apply to capacitance values above 50pF.

If for certain capacitor styles different tan δ limits should apply they are stated in the relevant data sheets.

DISSIPATION FACTOR: LIMITING VALUES AT LOW CAPACITANCE

The electrical field in a ceramic capacitor acts not only in the dielectric but also in the coating. With capacitance values below 50pF, the latter portion of the field causes an increase of the dissipation factor. For class 1 capacitors in the range of 5 to 50pF, tan δ limits according to the formulae specified in EN 130600 or IEC 60384 apply:

$$\tan\delta = \left(\frac{15}{C} + 0.7\right) \cdot 10^{-3}$$

(C = nominal capacitance in pF)

For feed through capacitors with screw terminals and class 1 dielectric, the following tan δ limiting values apply:

$$C > 50\text{pF}: \tan\delta \leq 1.5 \cdot 10^{-3}$$

$$C > 5 \text{ to } 50\text{pF}: \tan\delta \leq \left(\frac{22.5}{C} + 1.05\right) \cdot 10^{-3}$$

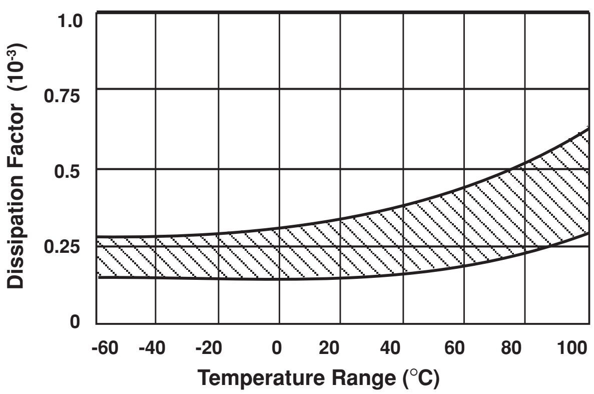
DISSIPATION FACTOR: MEASURING CONDITIONS

	CLASS 1 CAPACITORS	CLASS 2 CAPACITORS
Measuring Frequency		
C < 100pF	100kHz*	100kHz*
C ≥ 100pF ... 1000pF	100kHz*	1kHz*
C > 1000pF	1kHz*	1kHz*
Measuring Voltage	≤ $5.0V_{RMS}$	≤ $1.2V_{RMS}$**
Temperature	(23 ± 3)˚C	
Relative Humidity	≤ 75%	

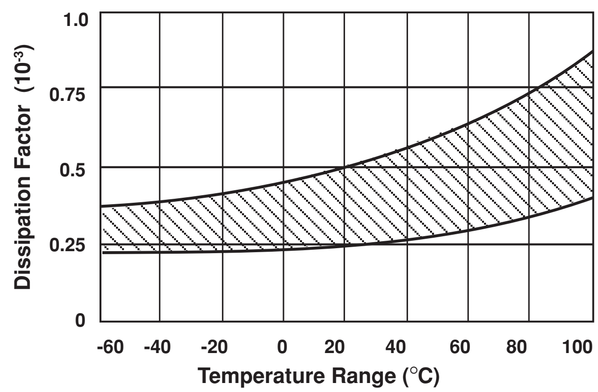
* Reference measuring at 1MHz
** or $3V_{RMS}$ / mm, whichever is lowest

TEMPERATURE DEPENDENCY OF DISSIPATION FACTOR (TYPICAL VALUES)

P 100 to N 150



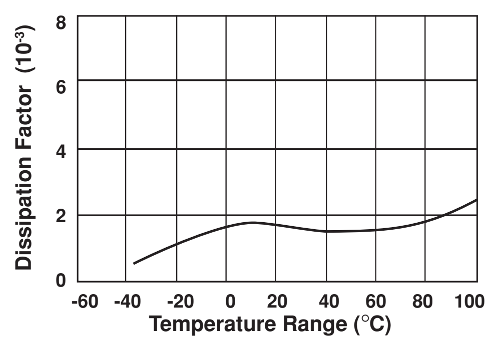
N 220 to N 2200



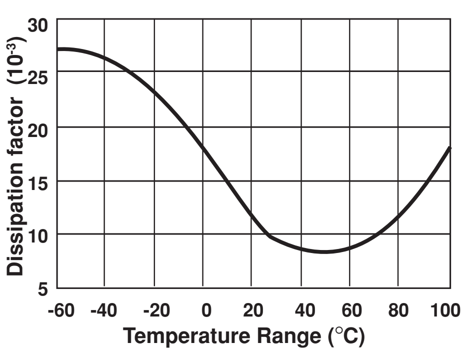
Measuring frequency:
Class 1 : 1MHz
Class 2 : 1kHz

Measuring voltage:
Class 1 : ≤ $5V_{RMS}$
Class 2 : ≤ $1.2V_{RMS}$

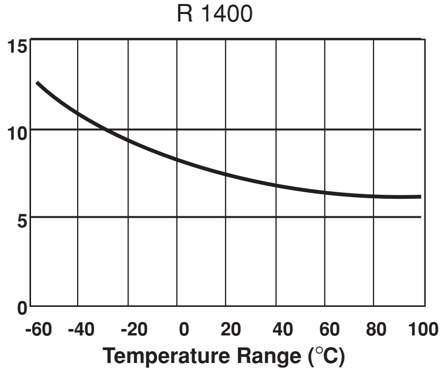
N 5600



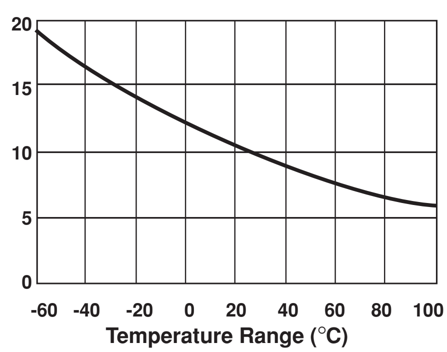
R 700



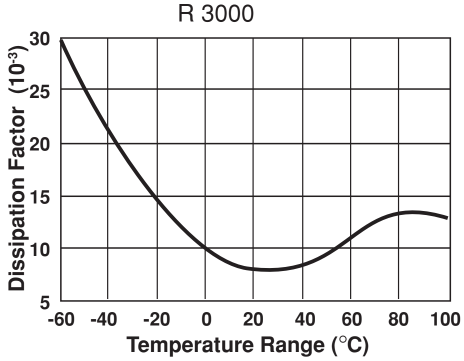
R 1400



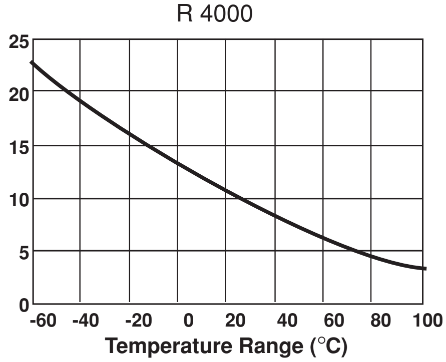
R 2000



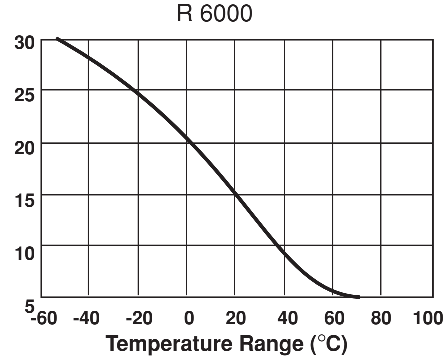
R 3000



R 4000



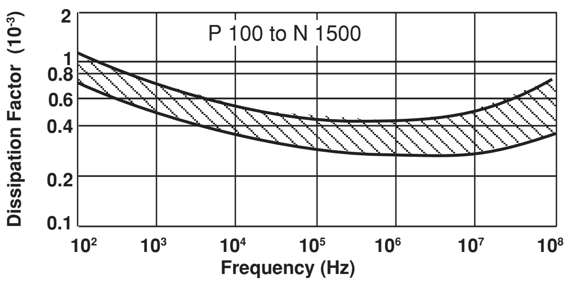
R 6000

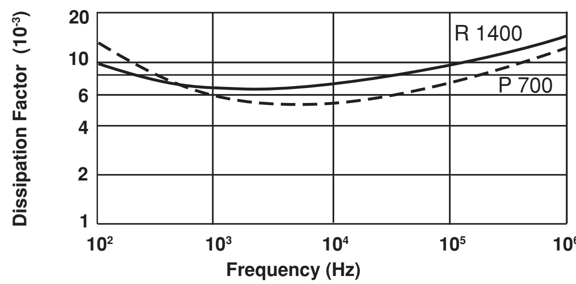


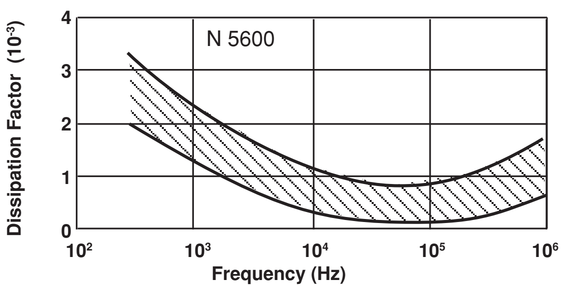
FREQUENCY DEPENDENCY OF DISSIPATION FACTOR (TYPICAL VALUES)

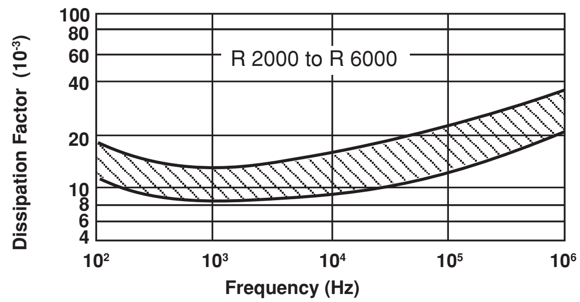
Class 1 Capacitors
Measuring voltage : ≦ $5V_{RMS}$
Measuring temperature : (23 ± 3)°C

Class 2 Capacitors
Measuring voltage : ≦ $1.2V_{RMS}$
Measuring temperature : (23 ± 3)°C









INSULATION RESISTANCE

The insulation resistance is the d.c. resistance of a capacitor, resulting under the conditions specified below, from the bulk resistivity of the dielectric material and the surface resistance. Within the range of the permissible operating temperatures, the bulk resistance of ceramic dielectrics is extremely high so that mainly the surface resistance is measured.

	CLASS 1 CAPACITORS	CLASS 2 CAPACITORS
Limiting Values of the Insulation Resistance	min. $1 \cdot 10^{10}$Ohm	min. $5 \cdot 10^{9}$Ohm

INSULATION RESISTANCE : MEASURING CONDITIONS

Measuring Voltage	Rated Voltage ≤ 100V: U_R
	Rated Voltage > 100V: $100V_{DC}$
Duration	(60 ± 5)s
Temperature	(23 ± 3)˚C
Relative Humidity	≤ 75%

The measurement of insulation resistance is non-destructive.

For tubular capacitor sets (connection in parallel) it should be noted that the resulting value must be divided by the number of tubes connected in parallel.

RESONANT FREQUENCIES FOR SMALL CERAMIC CAPACITORS

At higher frequencies, the inductance of the capacitor causes SELF RESONANCES which may effect the dimensioning of the circuit. In addition, impedance of the capacitors decreases closely below the resonant frequency. The effect of this resonancy equals an increase in capacitance.

Above a resonant frequency the inductive impedance increases. If necessary, the decrease has to be considered when determining the HF load.

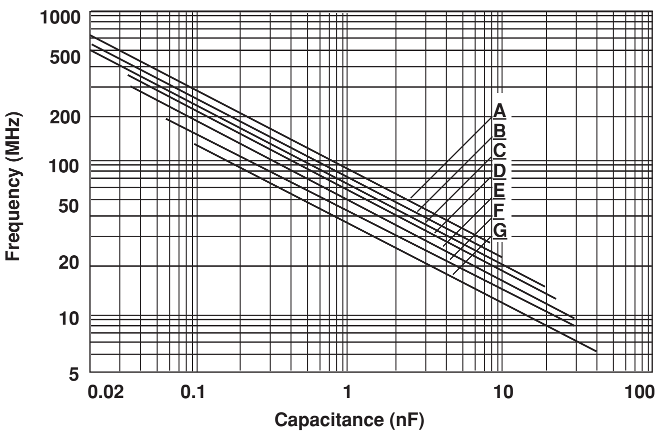
The self-inductance of ceramic capacitors is dependant on their specific dimensons, in which the inductance of the leads is a significant factor.

Due to the influence of the capacitors shape only an inaccurate calculation of the self-resonance is possible.

We have determined the resonant frequencies of our capacitors as a function of capacitance by numerous measurements. The results are shown in the graphs below.

SELF-RESONANT FREQUENCY AS A FUNCTION OF CAPACITANCE

Tubular Capacitors



GRAPH	CAPACITOR SIZE
A	R... 0210, 0310
B	R...0212, 0214, 0312, 0314
C	R... 0216, 0316, 0416
D	R... 0202,00320, 0420
E	R...0325, 0425
F	R... 03030, 04030
G	R... 0440

SHORT-TERM STABILITY (KzK)

During operating a ceramic capacitor the capacitance value may change for short periods of time. These changes are normally of no importance and can only be noticed with very sensitive measuring devices. For higher requirements e.g. in commercial applications, we can supply tubular capacitors, the inconsistancy of which has been reduced to a minimum.

There are three grades of capacitors with guaranteed short-term stability:

Short term-stability Grade 4 capacitance variations $\leq 1 \cdot 10^{-4}$
Short term-stability Grade 5 capacitance variations $\leq 1 \cdot 10^{-5}$ (of normal capacitance value)
Short term-stability Grade 6 capacitance variations $\leq 1 \cdot 10^{-6}$

The required short-term stability grade is guaranteed if the permissible operating voltage as stated on the data sheet is not exceeded.
Short term stability measuring frequency: 1MHz (see EN 130600 or IEC 60384).

COMPONENT CLIMATIC CATEGORY

According to IEC 60068-1 the climatic category is described by a three set code.
For details see General Information

SOLDERING

SOLDERING SPECIFICATIONS

Soldering test for capacitors with leads: (according to IEC 60068-2-20, solder bath method).		
	SOLDERABILITY	**RESISTANCE TO SOLDERING HEAT**
Soldering Temperature	(235 ± 5)˚C	(260 ± 5)˚C
Soldering Duration	(2 ± 0.5) sec.	(10 ± 1) sec.
Distance from Component Body	≥ 2mm	≥ 5mm

SOLDERING RECOMMENDATIONS

Mounting of the component should be achieved using SN 60/40 or silver bearing SN62/36/2AG solder, whereby solder wire, cream or preforms are accceptable. Only a mildly active, resin flux should be used.

We recommend the use of a heat sink adjacent to the component body if possible.

As ceramic capacitors are very sensitive to rapid changes in temperature (Themal shock) a pre-heat and post-heat cycle is strongly recommended.

Both the component and ground plate should be heated up to 120°C (Heat must not be applied directly to the ceramic body and the temperature on the component surface should not be allowed to increase faster than 100°C per minute).

After the pre-heat cycle the mounting plate temperature should be raised to achieve solder flow. The solder flow state should be maintained for a minimum period (recommendation: less than 5s) and the tip temperature should be maintained for a minimum period (recommendation: less than 5s) and the tip temperature should be as low as possible (max. 260°C)

The assembly should be allowed to cool at a rate not exceeding 100°C per minute.

CLEANING

The components should be cleaned immediately following the soldering operation with vapor degreasers.

SOLVENT RESISTANCE

The coating and marking of the capacitors are resistant to the following test method:

IEC 60068-2-45 (Method XA).

MOUNTING

We do not recommend modifying the lead terminals, e.g. bending or cropping. This action could break the coating or crack the ceramic insert. If however, the lead must be modified in this way, we recommend to support the lead with a clamping fixture next to the coating.

RELIABILITY

By careful control of the manufacturing process stages, the quality of the product is maintained at the highest possible level. To obtain data on the reliability of our ceramic capacitors, many long-term tests under increased temperature and voltage conditions have been carried out in our laboratories.

Based on the results of these tests, the following can be stated:

Reference conditions:	Ambient temperature:	(40 ± 2)˚C
	Relative humidity:	(60 ± 2)%
	Electrical stress:	50% rated voltage (U_R)
Failure criteria:	Short circuit ($R \leq 10^{-5}\Omega$) or open circuit	
Failure tests:	Class 1 capacitors: $\lambda = 2 \times 10^{-9}\ h^{-1}$	
	Class 2 capacitors: $\lambda = 5 \times 10^{-9}\ h^{-1}$	

By derating the voltage load, greatly increased reliability can be predicted.

Temperature, up to the maximum category temperature, is not believed to significantly affect the reliability.

MARKING

Unless otherwise indicated in the data sheet, the following designations will be used

1. NOMINAL CAPACITANCE

The nominal value of capacitance is marked PICOFARAD (pF). The designation is omitted in this case or in NANOFARAD (nF) which is indicated by 'n' following the numbers. On small capacitor sizes an abbreviated marking is used.
Examples are shown in the table below.

EXAMPLES OF ABBREVIATED DESIGNATION	
0.68pF	p 6 8
5pF	5 p 0
22pF	2 2 p
150pF	n 1 5
1nF	1 n 0
15nF	1 5 n

2. CAPACITANCE TOLERANCE

The capacitance tolerance is marked in pF (nominal capacitances less than 10pF) or in %. Besides marking the tolerances in clear it may be marked with a code letter. See tables below.

CODE LETTER	CAPACITANCE TOLERANCES	
	<10 pF: (pF)	≥ 10pF: (%)
B	± 0.1	-
C	± 0.25	-
D	± 0.5	± 0.5
F	± 1	± 1
G	± 2	± 2.0
H	-	± 2.5
J	-	± 5

CODE LETTER	CAPACITANCE TOLERANCES	
	<10 pF: (pF)	≥ 10pF: (%)
K	-	± 10
M	-	± 20
R	-	- 20 + 30
S	-	- 20 + 50
Z	-	- 20 + 80

3. TEMPERATURE CHARACTERISTIC

The temperature coefficient and the temperature characteristic is marked by one or two colour dots. In exceptional cases letters may be used. See tables below

CLASS 1			
CERAMIC	AC (10^{-6}/ °C)	COLOUR DOTS	CODE LETTER
P 100	+ 100	red / violet	A
NP 0	± 0	black	C
N 033	- 33	brown	H
N 075	- 75	red	L
N 150	- 150	orange	P
N 220	- 220	yellow	R
N 330	- 330	green	S
N 470	- 470	blue	T
N 750	- 750	violet	U
N 1500	- 1500	orange / orange	V
N 2200	- 2200	yellow / orange	K
N 3300	- 3300	green / orange	L
N 5600	- 5600	blue / orange	M

CLASS 2		
CERAMIC	CHARACTERISTICS	COLOUR DOTS
R 700	2 B 4	red
R 1400	2 B 4	red / yellow
R 2000	2 C 4	yellow
R 3000	2 C 4	yellow / green
R 4000	2 E 4	blue
R 6000	2 E 4	blue

4. RATED VOLTAGE

The voltage (DC or AC value) is marked fully or using a code letter. The marking of voltage is omitted on 400V types.

TYPE DESIGNATION

1ST LETTER	SHAPE	TUBULAR & STACK
	G	capacitor stack (disc)
	M	tubular capacitor set
	R	tubular capacitor
2ND LETTER	TYPE OF LEADS / TERMINALS	
	D	straight leads
	F	solder lugs
	Z	special type
3RD LETTER	ARRANGEMENT OF LEADS	
	E	parallel, tangential, short
	L	parallel, tangential, long
	M	radial, long
	P	parallel, radial, long
	Q	tangential, long
	R	parallel, radial, short
	W	at an angle
	Z	special type
4TH LETTER	SURFACE	
	K	solderably varnished
	L	completely laquered
	M	partially laquered
	Q	not laquered
	T	completely resin coated and impregnated
	Z	special type

1ST LETTER	SHAPE	FEED-THROUGH CAPACITOR
	D	Feed-through, tubular case
2ND LETTER	TYPE OF FEED-THROUGH CONDUCTOR	
	D	straight lead
	E	bare electrodes
	U	lead with eyelet
	Z	special type
3RD LETTER	TYPE OF OUTER TERMINAL	
	E	bare electrodes
	L	metallic disc, solderable
	M	threaded
	N	metallic sleeve, solderable
	Z	special type
4TH LETTER	SURFACE	
	K	solderable varnished
	L	completely laquered
	Q	not laquered
	Z	special type

ORDERING INFORMATION

RDLT	0314	400V_{DC}	56pF	± 20%	N 750
TYPE DESIGNATION	SIZE (Nominal diameter and length of the component)	RATED VOLTAGE	CAPACITANCE VALUE	TOLERANCE	CERAMIC DIELECTRIC