DC Film Capacitors
MKT Axial Type

FEATURES

- Supplied loose in box, taped on ammopack or reel
- Material categorization:
  For definitions of compliance please see www.vishay.com/doc?99912

Pb-free
RoHS COMPLIANT
HALOGEN FREE
GREEN (5-2008)

APPLICATIONS

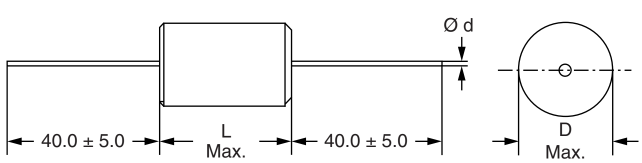
Blocking, bypassing, filtering, timing, coupling and decoupling, interference suppression in low voltage applications.

QUICK REFERENCE DATA	
Capacitance range (E12 series)	470 pF to 22 µF
Capacitance tolerance	± 20 %, ± 10 %, ± 5 %
Climatic testing class according to IEC 60068-1	55/100/56
Maximum application temperature	100 °C
Reference specifications	IEC 60384-2
Dielectric	Polyester film
Electrodes	Metallized
Construction	Mono and internal series construction
Encapsulation	Plastic-wrapped, epoxy resin sealed, flame retardant
Leads	Tinned wire
Marking	C-value; tolerance; rated voltage; manufacturer’s type; code for dielectric material; manufacturer location; manufacturer's logo; year and week
Rated DC voltage	63 V_{DC}, 100 V_{DC}, 250 V_{DC}, 400 V_{DC}, 630 V_{DC}, 1000 V_{DC}
Rated AC voltage	40 V_{AC}, 63 V_{AC}, 160 V_{AC}, 200 V_{AC}, 220 V_{AC}
Pull test on leads	Minimum 20 N in direction of leads according to IEC 60068-2-21
Bent test on leads	2 bends through 90° combined with 10 N tensile strength
Reliability	Operational life > 300 000 h (40 °C/0.5 U_R) Failure rate < 2 FIT (40 °C/0.5 U_R)

Note

- For more detailed data and test requirements, contact dc-film@vishay.com

DIMENSIONS in millimeters



LEAD DIAMETER d	D
0.6	≤ 5.0
0.7	> 5.0 ≤ 7.0
0.8	> 7.0 < 16.5
1.0	≥ 16.5

COMPOSITION OF CATALOG NUMBER

MKT	1813	X	XX	25	X	X
TYPE		MULTIPLIER	CAPACITANCE	Un	TOLERANCE	SPECIAL LETTER FOR TAPED

MULTIPLIER (nF)

0.1	2
1	3
10	4
100	5

CAPACITANCE (numerically)

Example:
468 = 680 nF

Un = 06 = 63 V
Un = 01 = 100 V
Un = 25 = 250 V
Un = 40 = 400 V
Un = 63 = 630 V
Un = 10 = 1000 V

TOLERANCE

4	± 5 %
5	± 10 %
6	± 20 %

SPECIAL LETTER FOR TAPED

	Bulk
R	Reel
G	Ammopack

Note

- For detailed tape specifications refer to “Packaging Information” www.vishay.com/doc?28139 or end of catalog

SPECIFIC REFERENCE DATA

DESCRIPTION	VALUE		
Tangent of loss angle:	at 1 kHz	at 10 kHz	at 100 kHz
C = 0.1 μF	80×10^{-4}	150×10^{-4}	250×10^{-4}
0.1 μF ≤ C = 1.0 μF	80×10^{-4}	150×10^{-4}	-
C ≥ 1.0 μF	100×10^{-4}	-	-

CAPACITOR LENGTH (mm)	MAXIMUM PULSE RISE TIME $(dU/dt)_R$ [V/μs]					
	63 V_{DC}	100 V_{DC}	250 V_{DC}	400 V_{DC}	630 V_{DC}	1000 V_{DC}
11	12	18	32	56	84	-
14	11	13	22	37	66	175
19	7	8	13	21	33	65
26.5	4	5	8	13	19	34
31.5	3	4	6	10	15	25
41.5	2	3	5	7	10	17

If the maximum pulse voltage is less than the rated voltage higher dU/dt values can be permitted.

R between leads, for C ≤ 0.33 μF and U_R ≤ 100 V	> 15 000 MΩ
R between leads, for C ≤ 0.33 μF and U_R > 100 V	> 30 000 MΩ
RC between leads, for C > 0.33 μF and U_R ≤ 100 V	> 5000 s
RC between leads, for C > 0.33 μF and U_R > 100 V	> 10 000 s
R between leads and case, 100 V; (foil method)	> 30 000 MΩ
Withstanding (DC) voltage (cut off current 10 mA); rise time 100 V/s	1.6 x U_{RDC}, 1 min
Maximum application temperature	100 °C

ELECTRICAL DATA

U_{RDC} (V)	CAP. (µF)	CAPACITANCE CODE	VOLTAGE CODE	V_{AC}	DIMENSIONS D	DIMENSIONS L
63	0.15	415	06	40	5.0	11.0
	0.22	422			5.0	11.0
					-	-
	0.33	433			6.0	14.0
					-	-
	0.47	447			7.0	14.0
					-	-
	0.68	468			6.5	19.0
					-	-
	1.0	510			7.5	19.0
	1.5	515			8.5	19.0
					-	-
	2.2	522			8.5	26.5
					7.5	19.0 (2)
	3.3	533			10.0	26.5
					8.5	19.0 (2)
	4.7	547			11.5	26.5
					-	-
	6.8	568			12.0	31.5
	10.0	610			14.5	31.5
					-	-
	15.0	615			18.0	31.5
	22.0	622			17.5	41.5
100	0.068	368	01	63	5.0	11.0
	0.10	410			5.0	11.0
					-	-
	0.15	415			5.5	11.0
	0.22	422			6.0	14.0
					-	-
	0.33	433			6.0	19.0
					-	-
	0.47	447			6.5	19.0
					-	-
	0.68	468			7.0	19.0
					-	-
	1.0	510			8.5	19.0
	1.5	515			8.0	26.5
					8.0	19.0 (2)
	2.2	522			9.5	26.5
					9.5	19.0 (2)
	3.3	533			11.5	26.5
					-	-
	4.7	547			12.0	31.5
					-	-
	6.8	568			14.0	31.5
	10.0	610			16.5	31.5
					13.5	31.5 (2)
	15.0	615			20.5	31.5

ELECTRICAL DATA						
U_{RDC} (V)	CAP. (µF)	CAPACITANCE CODE	VOLTAGE CODE	V_{AC}	DIMENSIONS	
					D	L
250	0.015	315	25	160	5.0	11.0
	0.022	322			5.0	11.0
	0.033	333			5.0	11.0
	0.047	347			6.0	14.0
	0.068	368			6.0	14.0
	0.10	410			6.0	14.0
					-	-
	0.15	415			7.0	14.0
	0.22	422			7.0	19.0
					-	-
	0.33	433			8.0	19.0
					-	-
	0.47	447			9.0	19.0
					-	-
	0.68	468			8.5	26.5
					9.0	19.0 (2)
	1.0	510			10.0	26.5
	1.5	515			11.0	31.5
					-	-
	2.2	522			13.0	31.5
					-	-
	3.3	533			15.5	31.5
					14.0	26.5 (2)
	4.7	547			15.5	41.5
					14.5	31.5 (2)
	6.8	568			17.5	41.5
	10.0	610			21.0	41.5
					-	-
400	0.0068	268	40	200	5.0	11.0
	0.010	310			5.0	11.0
	0.015	315			6.0	14.0
	0.022	322			6.0	14.0
	0.033	333			6.0	14.0
	0.047	347			7.0	14.0
	0.068	368			8.0	14.0
	0.10	410			7.0	19.0
					-	-
	0.15	415			8.5	19.0
	0.22	422			8.0	26.5
					8.0	19.0 (2)
	0.33	433			9.5	26.5
					9.5	19.0 (2)
	0.47	447			11.0	26.5
					-	-
	0.68	468			11.5	31.5
					-	-
	1.0	510			13.5	31.5
	1.5	515			14.0	41.5
					13.0	31.5 (2)
	2.2	522			16.5	41.5
					-	-

ELECTRICAL DATA

U_{RDC} (V)	CAP. (µF)	CAPACITANCE CODE	VOLTAGE CODE	V_{AC}	DIMENSIONS	
					D	L
630	0.00047	147	63 (1)	220	5.0	11.0
	0.00068	168			5.0	11.0
	0.0010	210			5.0	11.0
	0.0015	215			5.0	11.0
	0.0022	222			5.0	11.0
	0.0033	233			5.0	11.0
	0.0047	247			5.0	11.0
	0.0068	268			6.0	14.0
	0.010	310			6.0	14.0
	0.015	315			6.5	14.0
	0.022	322			7.5	14.0
	0.033	333			6.5	19.0
	0.047	347			7.5	19.0
	0.068	368			8.5	19.0
	0.10	410			10.5	19.0
					9.5	19.0 (2)
	0.15	415			10.0	26.5
	0.22	422			11.5	26.5
					-	-
	0.33	433			13.5	26.5
					-	-
	0.47	447			14.5	31.5
					14.0	26.5 (2)
	0.68	468			14.5	41.5
					-	-
	1.0	510			16.5	41.5
1000	0.0010	210	10 (1)	220	5.5	14.0
	0.0015	215			6.0	14.0
	0.0022	222			6.0	14.0
	0.0033	233			7.0	14.0
	0.0047	247			6.0	19.0
	0.0068	268			6.0	19.0
	0.010	310			6.5	19.0
	0.015	315			7.5	19.0
	0.022	322			9.0	19.0
	0.033	333			10.5	19.0
	0.047	347			12.0	19.0
	0.068	368			11.0	26.5
	0.10	410			13.0	26.5
					-	-
	0.15	415			13.5	31.5
	0.22	422			16.0	31.5
					-	-
	0.33	433			16.0	41.5
					-	-
	0.47	447			19.0	41.5
					-	-

Notes

- Pitch = L + 3.5

(1) Not suitable for mains applications

(2) For the smaller size please add "-M" at the end of the type designation (e.g. MKT1813-510/255-M)

RECOMMENDED PACKAGING				
PACKAGING CODE	TYPE OF PACKAGING	REEL DIAMETER (mm)	ORDERING CODE EXAMPLES	
G	Ammo	-	MKT1813-422-014-G	x
R	Reel	350	MKT1813-422-014-R	x
-	Bulk	-	MKT1813-422-014	x

Note

- Attention: Capacitors with L > 31.5 mm only as bulk available

EXAMPLE OF ORDERING CODE				
TYPE	CAPACITANCE CODE	VOLTAGE CODE	TOLERANCE CODE (1)	PACKAGING CODE
MKT1813	410	06	5	G

Note

(1) **Tolerance codes: 4** = 5 % (J); **5** = 10 % (K); **6** = 20 % (M)

MOUNTING

Normal Use

The capacitors are designed for mounting on printed-circuit boards. The capacitors packed in bandoliers are designed for mounting in printed-circuit boards by means of automatic insertion machines.

For detailed tape specifications refer to packaging information: www.vishay.com/doc?28139 or end of catalog.

Specific Method of Mounting to Withstand Vibration and Shock

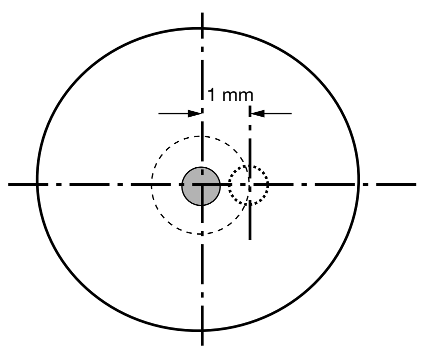
In order to withstand vibration and shock tests, it must be ensured that the capacitor body is in good contact with the printed-circuit board:

- For L ≤ 19 mm capacitors shall be mechanically fixed by the leads.
- For larger pitches the capacitors shall be mounted in the same way and the body clamped.
- The maximum diameter and length of the capacitors are specified in the “Dimensions” table.
- Eccentricity as shown in the drawing below.

Space Requirements on Printed-Circuit Board

The maximum length and width of film capacitors is shown in the drawing:

- Eccentricity as in drawing. The maximum eccentricity is smaller than or equal to the lead diameter of the product concerned.
- Product height with seating plane as given by “IEC 60717” as reference: $h_{max.} \leq h + 0.4$ mm or $h_{max.} \leq h' + 0.4$ mm



Storage Temperature

T_{stg} = - 25 °C to + 35 °C with RH maximum 75 % without condensation

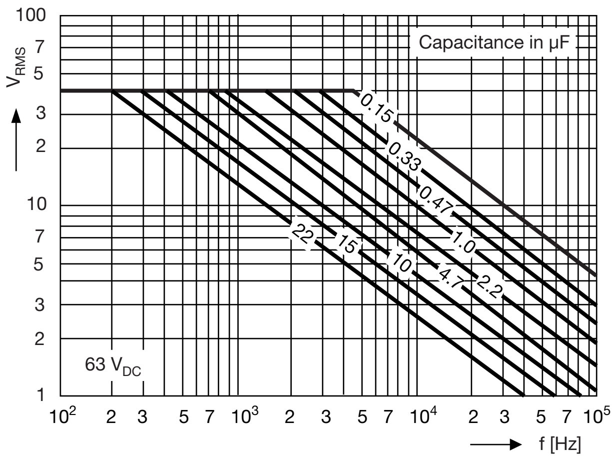
Ratings and Characteristics Reference Conditions

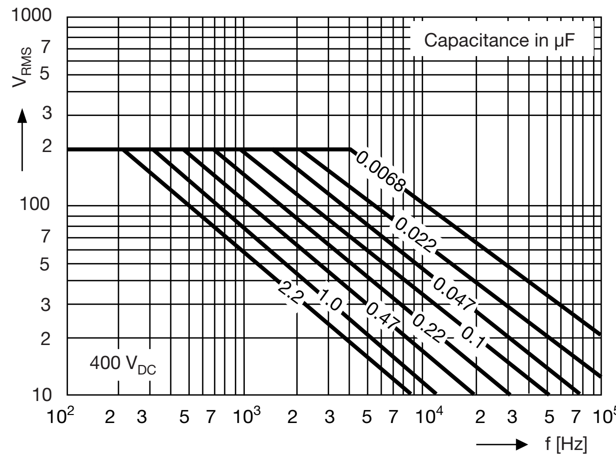
Unless otherwise specified, all electrical values apply to an ambient temperature of 23 °C ± 1 °C, an atmospheric pressure of 86 kPa to 106 kPa and a relative humidity of 50 % ± 2 %.

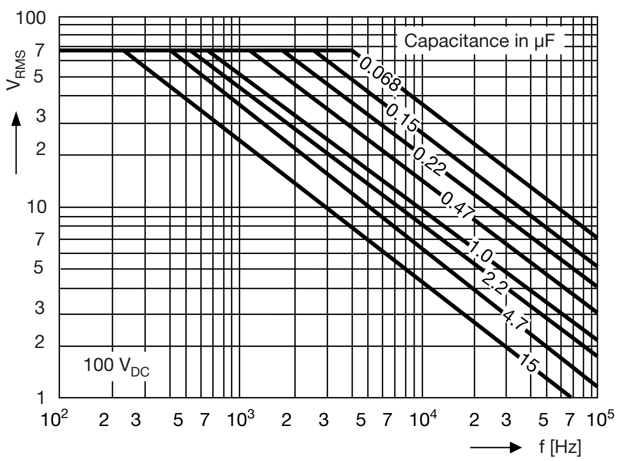
For reference testing, a conditioning period shall be applied over 96 h ± 4 h by heating the products in a circulating air oven at the rated temperature and a relative humidity not exceeding 20 %.

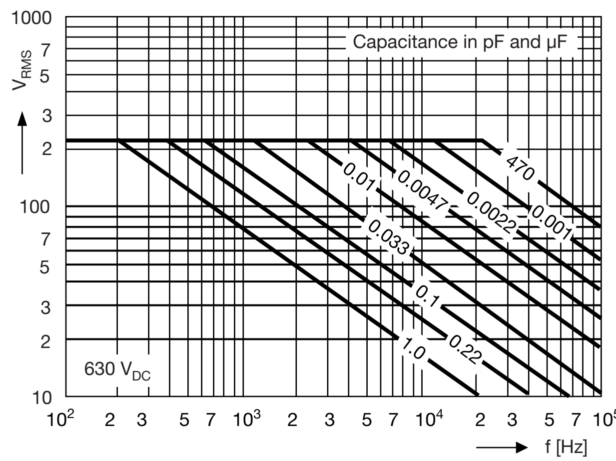
CHARACTERISTICS

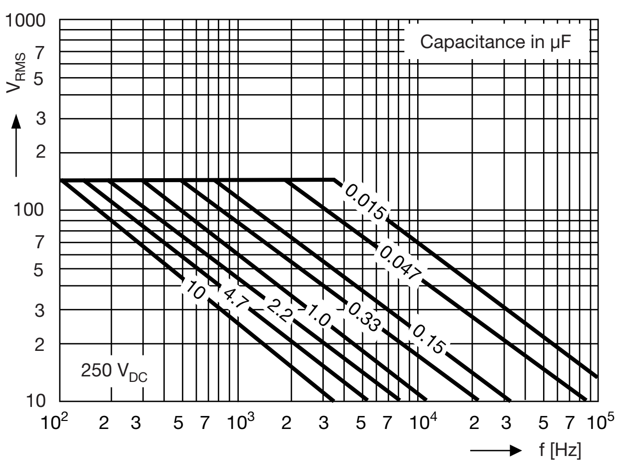
PERMISSIBLE AC VOLTAGE VS. FREQUENCY

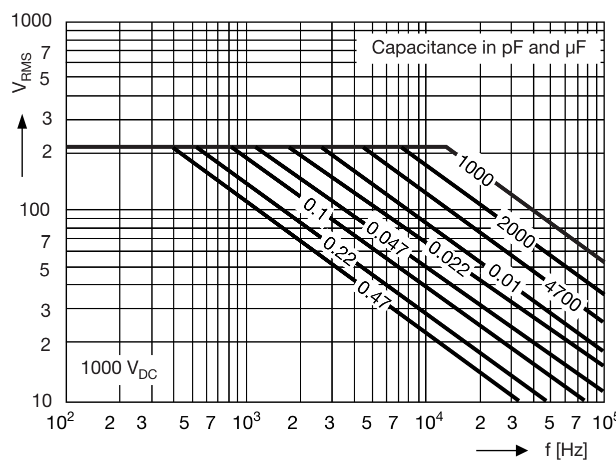




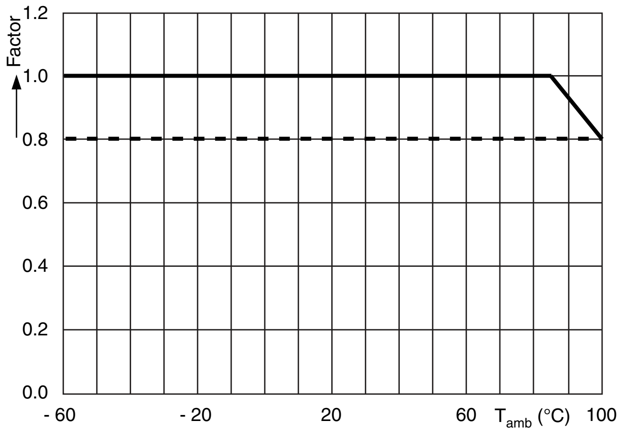




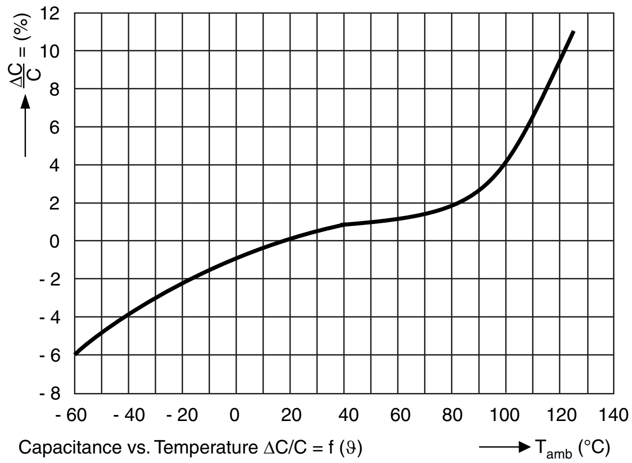




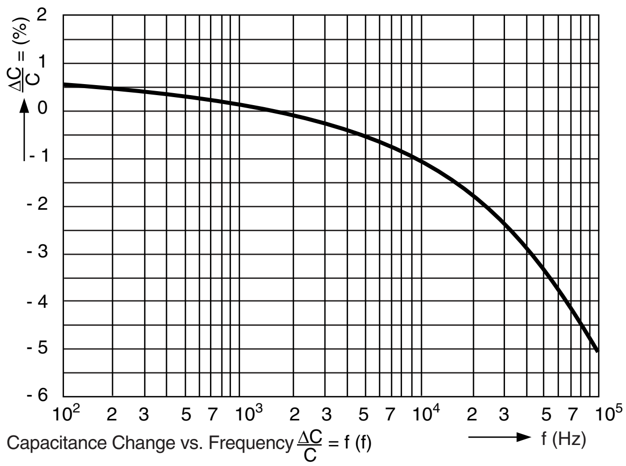
CHARACTERISTICS



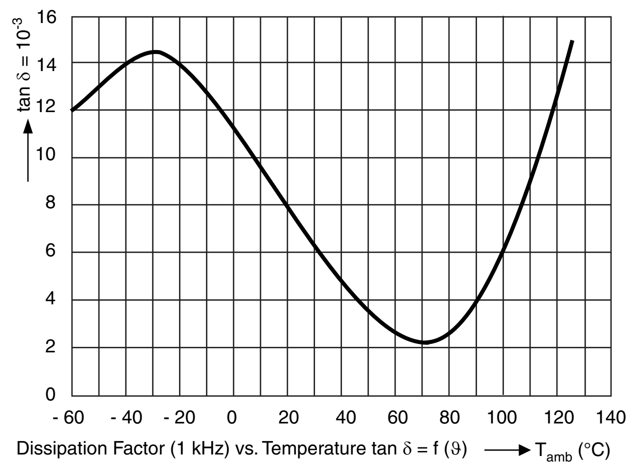
Nominal voltage (AC and DC) as a function of temperature
$U = f(T_A)$, $T_{LL} \leq T_A \leq T_{UL}$



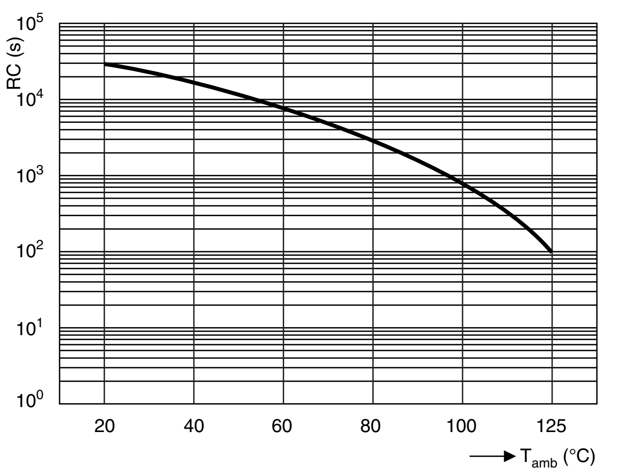
Capacitance as a function of temperature
$\Delta C/C = f(T_A)$, $T_{LL} \leq T_A \leq T_{UL}$



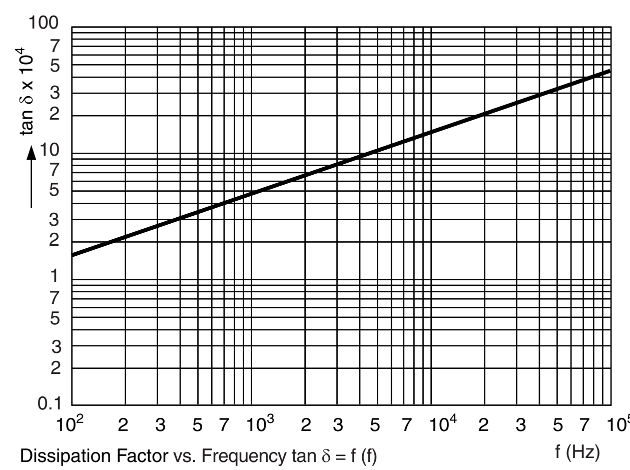
Capacitance as function of frequency
$\Delta C/C = f(f)$, 100 Hz $\leq f \leq$ 1 MHz



Dissipation factor as function of temperature
$\Delta\tan\delta/\tan\delta = f(T_A)$, $T_{LL} \leq T_A \leq T_{UL}$

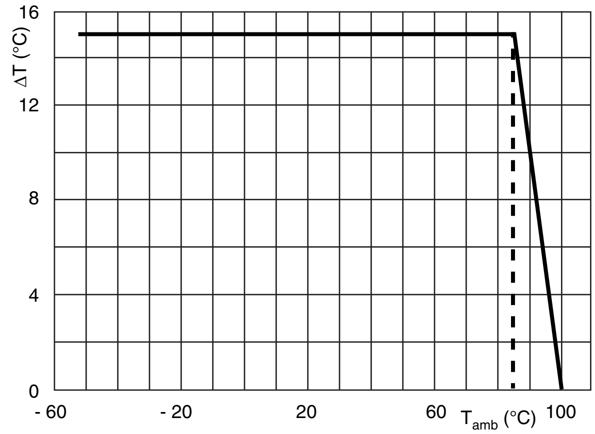


Insulation resistance as a function of temperature
$R_{is} = f(T_A)$, $T_{LL} \leq T_A \leq T_{UL}$



Dissipation factor as a function of frequency
$\Delta\tan\delta/\tan\delta = f(f)$, 100 Hz $\leq f \leq$ 1 MHz_L

CHARACTERISTICS



Maximum allowed component temperature rise (ΔT) as a function of the ambient temperature (T_{amb})

HEAT CONDUCTIVITY (G) AS A FUNCTION OF (ORIGINAL) PITCH AND CAPACITOR BODY THICKNESS IN mW/°C

$D_{max.}$ (mm)	HEAT CONDUCTIVITY (mW/°C)					
	L = 11 mm	L = 14 mm	L = 19 mm	L = 26.5 mm	L = 31.5 mm	L = 41.5 mm
5.0	2	-	-	-	-	-
5.5	2	3	-	-	-	-
6.0	-	3	4	-	-	-
6.5	-	3	5	-	-	-
7.0	-	4	5	-	-	-
7.5	-	-	6	-	-	-
8.0	-	4	-	8	-	-
8.5	-	-	6	9	-	-
9.0	-	-	7	-	-	-
9.5	-	-	-	10	-	-
10.0	-	-	-	11	-	-
10.5	-	-	8	-	-	-
11.0	-	-	-	12	14	-
11.5	-	-	-	13	15	-
12.0	-	-	9	-	16	-
12.5	-	-	-	-	-	-
13.0	-	-	-	14	17	-
13.5	-	-	-	15	18	-
14.0	-	-	-	16	19	-
14.5	-	-	-	-	19	-
15.0	-	-	-	-	-	-
15.5	-	-	-	-	21	-
16.0	-	-	-	-	-	29
16.5	-	-	-	-	22	30
17.0	-	-	-	-	-	-
17.5	-	-	-	-	-	31
18.0	-	-	-	-	24	-
18.5	-	-	-	-	-	-
19.0	-	-	-	-	-	34
20.0	-	-	-	-	-	-
20.5	-	-	-	-	28	-
21.0	-	-	-	-	-	38

POWER DISSIPATION AND MAXIMUM COMPONENT TEMPERATURE RISE

The power dissipation must be limited in order not to exceed the maximum allowed component temperature rise as a function of the free ambient temperature.

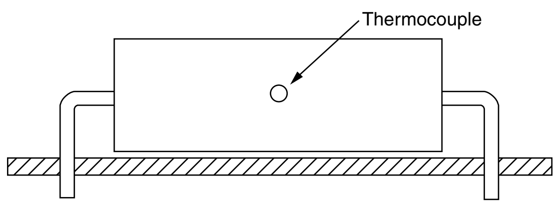
The power dissipation can be calculated according type detail specification "HQN-384-01/101: Technical Information Film Capacitors".

The component temperature rise (ΔT) can be measured (see section "Measuring the component temperature" for more details) or calculated by $\Delta T = P/G$:

- ΔT = Component temperature rise (°C)
- P = Power dissipation of the component (mW)
- G = Heat conductivity of the component (mW/°C)

MEASURING THE COMPONENT TEMPERATURE

A thermocouple must be attached to the capacitor body as in:



The temperature is measured in unloaded (T_{amb}) and maximum loaded condition (T_C).

The temperature rise is given by $\Delta T = T_C - T_{amb}$.

To avoid radiation or convection, the capacitor should be tested in a wind-free box.

APPLICATION NOTE AND LIMITING CONDITIONS

These capacitors are not suitable for mains applications as across-the-line capacitors without additional protection, as described hereunder. These mains applications are strictly regulated in safety standards and therefore electromagnetic interference suppression capacitors conforming the standards must be used.

To select the capacitor for a certain application, the following conditions must be checked:

1. The peak voltage (U_P) shall not be greater than the rated DC voltage (U_{RDC})
2. The peak-to-peak voltage (U_{P-P}) shall not be greater than $2\sqrt{2} \times U_{RAC}$ to avoid the ionization inception level
3. The voltage peak slope (dU/dt) shall not exceed the rated voltage pulse slope in an RC-circuit at rated voltage and without ringing. If the pulse voltage is lower than the rated DC voltage, the rated voltage pulse slope may be multiplied by URdc and divided by the applied voltage.
   For all other pulses following equation must be fulfilled:
   $$2 \times \int_0^T \left(\frac{dU}{dt}\right)^2 \times dt < U_{RDC} \times \left(\frac{dU}{dt}\right)_{rated}$$
   T is the pulse duration.
   The rated voltage pulse slope is valid for ambient temperatures up to 85 °C. For higher temperatures a derating factor of 3 % per K shall be applied.
4. The maximum component surface temperature rise must be lower than the limits (see figure "Max. allowed component temperature rise").
5. Since in circuits used at voltages over 280 V peak-to-peak the risk for an intrinsically active flammability after a capacitor breakdown (short circuit) increases, it is recommended that the power to the component is limited to 100 times the values mentioned in the table "Heat Conductivity".
6. When using these capacitors as across-the-line capacitor in the input filter for mains applications or as series connected with an impedance to the mains the applicant must guarantee that the following conditions are fulfilled in any case (spikes and surge voltages from the mains included).

VOLTAGE CONDITIONS FOR 6 ABOVE		
ALLOWED VOLTAGES	**$T_{amb} \leq 85$ °C**	**85 °C < $T_{amb} \leq 100$ °C**
Maximum continuous RMS voltage	U_{RAC}	0.8 x U_{RAC}
Maximum temperature RMS-overvoltage (< 24 h)	1.25 x U_{RAC}	U_{RAC}
Maximum peak voltage (V_{O-P}) (< 2 s)	1.6 x U_{RDC}	1.3 x U_{RDC}

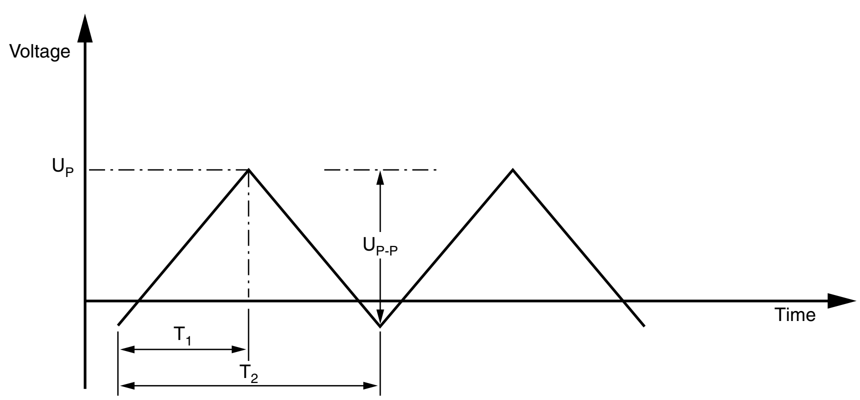
Example

C = 3300 nF - 100 V used for the voltage signal shown in next figure.
U_{P-P} = 80 V; U_P = 70 V; T_1 = 0.5 ms; T_2 = 1 ms
The ambient temperature is 35 °C

Checking conditions:

1. The peak voltage U_P = 70 V is lower than 100 V_{DC}
2. The peak-to-peak voltage 80 V is lower than $2\sqrt{2}$ x 63 V_{AC} = 178 U_{P-P}
3. The voltage pulse slope (dU/dt) = 80 V/500 µs = 0.16 V/µs
   This is lower than 8 V/µs (see "Specific Reference Data" for each version)
4. The dissipated power is 60 mW as calculated with fourier terms
   The temperature rise for $W_{max.}$ = 11.5 mm and pitch = 26.5 mm will be 60 mW/13 mW/°C = 4.6 °C
   This is lower than 15 °C temperature rise at 35 °C, according figure "Maximum allowed component temperature rise"
5. Not applicable
6. Not applicable

Voltage Signal



INSPECTION REQUIREMENTS

General Notes

Sub-clause numbers of tests and performance requirements refer to the "Sectional Specification, Publication IEC 60384-2 and Specific Reference Data".

GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	**CONDITIONS**	**PERFORMANCE REQUIREMENTS**
SUB-GROUP C1A PART OF SAMPLE OF SUB-GROUP C1		
4.1 Dimensions (detail)		As specified in Chapters "General data" of this specification
4.3.1 Initial measurements	Capacitance Tangent of loss angle: For C ≤ 470 nF at 100 kHz or for C > 470 nF at 10 kHz	
4.3 Robustness of terminations	Tensile: Load 10 N; 10 s Bending: Load 5 N; 4 x 90°	No visible damage
4.4 Resistance to soldering heat	Method: 1A Solder bath: 280 °C ± 5 °C Duration: 10 s	
4.14 Component solvent resistance	Isopropylalcohol at room temperature Method: 2 Immersion time: 5 min ± 0.5 min Recovery time: Min. 1 h, max. 2 h	
4.4.2 Final measurements	Visual examination	No visible damage Legible marking
	Capacitance	$\lvert\Delta C/C\rvert \leq 2$ % of the value measured initially
	Tangent of loss angle	Increase of tan δ ≤ 0.005 for: C ≤ 100 nF or ≤ 0.010 for: 100 nF < C ≤ 220 nF or ≤ 0.015 for: 220 nF < C ≤ 470 nF and ≤ 0.003 for: C > 470 nF Compared to values measured in 4.3.1
SUB-GROUP C1B PART OF SAMPLE OF SUB-GROUP C1		
4.6.1 Initial measurements	Capacitance Tangent of loss angle: For C ≤ 470 nF at 100 kHz or for C > 470 nF at 10 kHz	
4.6 Rapid change of temperature	θA = - 55 °C θB = + 100 °C 5 cycles Duration t = 30 min	
	Visual examination	No visible damage
4.7 Vibration	Mounting: See section "Mounting" of this specification Procedure B4 Frequency range: 10 Hz to 55 Hz Amplitude: 0.75 mm or Acceleration 98 m/s² (whichever is less severe) Total duration 6 h	
4.7.2 Final inspection	Visual examination	No visible damage

GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	**CONDITIONS**	**PERFORMANCE REQUIREMENTS**
SUB-GROUP C1B PART OF SAMPLE OF SUB-GROUP C1		
4.9 Shock	Mounting: See section "Mounting" of this specification Pulse shape: Half sine Acceleration: 490 m/s² Duration of pulse: 11 ms	
4.9.3 Final measurements	Visual examination	No visible damage
	Capacitance	$\lvert\Delta C/C\rvert \leq$ 3 % of the value measured in 4.6.1
	Tangent of loss angle	Increase of tan δ $\leq$ 0.005 for: C $\leq$ 100 nF or $\leq$ 0.010 for: 100 nF < C $\leq$ 220 nF or $\leq$ 0.015 for: 220 nF < C $\leq$ 470 nF and $\leq$ 0.003 for: C > 470 nF Compared to values measured in 4.6.1
	Insulation resistance	As specified in section "Insulation Resistance" of this specification
SUB-GROUP C1 COMBINED SAMPLE OF SPECIMENS OF SUB-GROUPS C1A AND C1B		
4.10 Climatic sequence		
4.10.2 Dry heat	Temperature: + 100 °C Duration: 16 h	
4.10.3 Damp heat cyclic Test Db, first cycle		
4.10.4 Cold	Temperature: - 55 °C Duration: 2 h	
4.10.6 Damp heat cyclic Test Db, remaining cycles		
4.10.6.2 Final measurements	Voltage proof = U_{RDC} for 1 min within 15 min after removal from testchamber	No breakdown of flash-over
	Visual examination	No visible damage Legible marking
	Capacitance	$\lvert\Delta C/C\rvert \leq$ 5 % of the value measured in 4.4.2 or 4.9.3
	Tangent of loss angle	Increase of tan δ $\leq$ 0.007 for: C $\leq$ 100 nF or $\leq$ 0.010 for: 100 nF < C $\leq$ 220 nF or $\leq$ 0.015 for: 220 nF < C $\leq$ 470 nF and $\leq$ 0.005 for: C > 470 nF Compared to values measured in 4.3.1 or 4.6.1
	Insulation resistance	$\geq$ 50 % of values specified in section "Insulation resistance" of this specification
SUB-GROUP C2		
4.11 Damp heat steady state	56 days, 40 °C, 90 % to 95 % RH	
4.11.1 Initial measurements	Capacitance Tangent of loss angle at 1 kHz	

GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	**CONDITIONS**	**PERFORMANCE REQUIREMENTS**
SUB-GROUP C2		
4.11.3 Final measurements	Voltage proof = U_{RDC} for 1 min within 15 min after removal from testchamber	No breakdown of flash-over
	Visual examination	No visible damage Legible marking
	Capacitance	$\lvert\Delta C/C\rvert \leq 5$ % of the value measured in 4.11.1
	Tangent of loss angle	Increase of tan $\delta \leq 0.005$ Compared to values measured in 4.11.1
	Insulation resistance	≥ 50 % of values specified in section "Insulation resistance" of this specification
SUB-GROUP C3		
4.12 Endurance	Duration: 2000 h 1.25 x U_{RDC} at 85 °C 1.0 x U_{RDC} at 100 °C	
4.12.1 Initial measurements	Capacitance Tangent of loss angle: For C $\leq$ 470 nF at 100 kHz or for C > 470 nF at 10 kHz	
4.12.5 Final measurements	Visual examination	No visible damage Legible marking
	Capacitance	$\lvert\Delta C/C\rvert \leq 5$ % compared to values measured in 4.12.1
	Tangent of loss angle	Increase of tan δ ≤ 0.005 for: C $\leq$ 100 nF or ≤ 0.010 for: 100 nF < C $\leq$ 220 nF or ≤ 0.015 for: 220 nF < C $\leq$ 470 nF and ≤ 0.003 for: C > 470 nF Compared to values measured in 4.12.1
	Insulation resistance	≥ 50 % of values specified in section "Insulation resistance" of this specification
SUB-GROUP C4		
4.13 Charge and discharge	10 000 cycles Charged to U_{RDC} Discharge resistance: $R = \frac{U_R}{C \times 2.5 \times (dU/dt)_R}$	
4.13.1 Initial measurements	Capacitance Tangent of loss angle: For C $\leq$ 470 nF at 100 kHz or for C > 470 nF at 10 kHz	
4.13.3 Final measurements	Capacitance	$\lvert\Delta C/C\rvert \leq 3$ % compared to values measured in 4.13.1
	Tangent of loss angle	Increase of tan δ ≤ 0.005 for: C $\leq$ 100 nF or ≤ 0.010 for: 100 nF < C $\leq$ 220 nF or ≤ 0.015 for: 220 nF < C $\leq$ 470 nF and ≤ 0.003 for: C > 470 nF Compared to values measured in 4.13.1
	Insulation resistance	≥ 50 % of values specified in section "Insulation resistance" of this specification

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