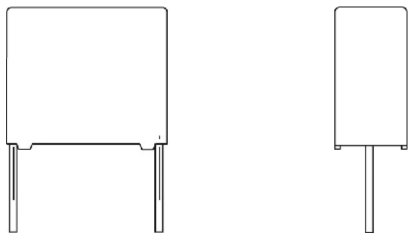
AC and Pulse Metallized Polypropylene Film Capacitors MKP Radial Potted Type



FEATURES

- 5 mm to 52.5 mm lead pitch; 7.5 mm bent back pitch
- Low contact resistance
- Low loss dielectric
- Small dimensions for high density packaging
- Supplied loose in box and taped on reel or ammopack
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

APPLICATIONS

- Where steep pulses occur e.g. SMPS (switch mode power supplies)
- Electronic lighting e.g. ballast
- Motor control circuits
- High frequency and pulse operations
- Deflection circuits in TV-sets (S-correction)
- Loudspeaker crossover networks, storage, filter, timing and sample and hold circuits

QUICK REFERENCE DATA	
Capacitance range (E24 series)	0.00047 µF to 82 µF
Capacitance tolerance	± 5 %
Climatic testing class according to IEC 60068-1	55/110/56
Rated DC temperature	85 °C
Rated AC temperature	85 °C
Maximum application temperature	110 °C
Maximum operating temperature for limited time	125 °C
Reference specifications	IEC 60384-17
Dielectric	Polypropylene film
Electrodes	Metallized
Construction	Mono and internal serial construction
Encapsulation	Flame retardant plastic case and epoxy resin UL-class 94 V-0
Leads	Tinned wire
Marking	C-value; tolerance; rated voltage; manufacturer's type; code for dielectric material; manufacturer location; manufacturer's logo; year and week

Note

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

VOLTAGE RATINGS										
Rated DC voltage	160	250	400	630	850	1000	1250	1600	2000	2500
Rated AC voltage	110	160	200	220	300	350	450	550	700 (1)	900 (2)
Rated peak to peak voltage	310	450	560	620	850	1000	1250	1600	2000	2500

Notes

(1) Rated AC voltage is 600 V_{AC} for pitch ≥ 37.5 mm

(2) Rated AC voltage is 800 V_{AC} for pitch ≥ 37.5 mm

COMPOSITION OF CATALOG NUMBER

1 2 3 4 5 6	7	8 9	10 11 12	13	14	15	16	17	18
M K P 3 8 5	1	4 7	2 5 0	J	F	P	2	T	0

Type (positions 1 to 6)

Multiplier (nF)	
0.01	1
0.1	2
1	3
10	4
100	5
1000	6

Capacitance Code (numerically)

Example		
147	470 pF	0.00047 µF
210	1 nF	0.001 µF
310	10 nF	0.01 µF
410	100 nF	0.1 µF
510	1000 nF	1.0 µF
610	10 000 nF	10.0 µF

Voltage (V_{DC})
016 = 160
025 = 250
040 = 400
063 = 630
085 = 850
100 = 1000
125 = 1250
160 = 1600
200 = 2000
250 = 2500

Tolerance	
J	± 5 %
A	Special tolerance

P_1 (mm)	Pitch Code
5	B
7.5	C
10	D
15	F
22.5	I
27.5	K
37.5	P
52.5	Y

It (mm)	Lead Length Code	Pitch (mm)
3.5 + 1.0/- 0.5	A	≤ 10
3.5 ± 0.3	P	≥ 15
5 ± 1	M	All
25 ± 2	I	All
0: Space holder		

Special Code for Terminal	
2	2 pins
4	4 pins P_2 = 10.2 mm
5	4 pins P_2 = 20.3 mm
(#)	Customized

Packing Code	Packing Style	Remark
B/T	Bulk/loose [(1)]	Excluding bent back
R	Tape and reel; (H: 16 mm; 500 mm)	For bent back only
Z	Tape and reel; (H: 16 mm; 356 mm)	For bent back only
H	Ammo (H: 16 mm)	For bent back only
W	Tape and reel (H: 18.5 mm; 500 mm)	Pitch 5 mm to 22.5 mm
G	Ammo (H: 18.5 mm)	Pitch ≤ 10 mm

Special
0 = Standard
Other = Special

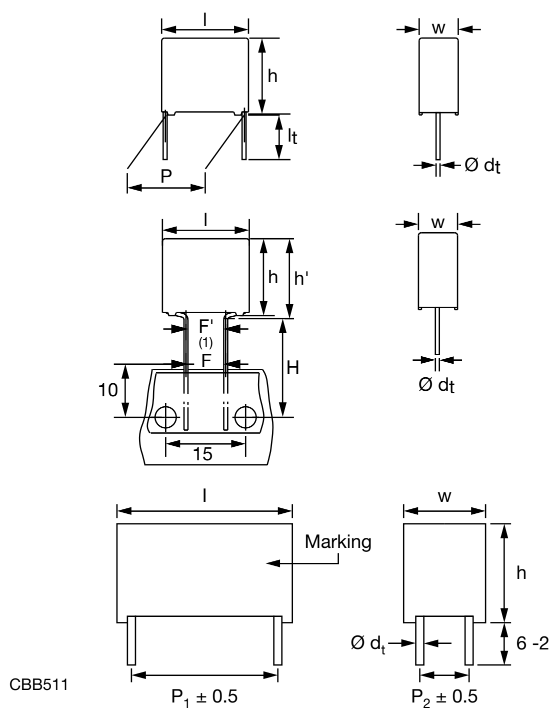
Notes

- For detailed tape specifications refer to packaging information www.vishay.com/doc?28139

(1) Packaging will be bulk for all capacitors with pitch ≤ 15 mm and such with long leads (> 5 mm). Capacitors with short leads up to 5 mm and pitch > 15 mm will be in tray and asking code will be “T”.

ELECTRICAL DATA (For Detailed Ratings go to www.vishay.com/doc?28182)	
U_{RDC} (V)	CAP. (µF)
160	0.011 min.
	82 max.
250	0.010 min.
	62 max.
400	0.0043 min.
	27 max.
630	0.0015 min.
	15 max.
850	0.001 min.
	10 max.
1000	0.00047 min.
	6.8 max.
1250	0.00047 min.
	5.1 max.
1600	0.00047 min.
	2.7 max.
2000	0.00047 min.
	1.6 max.
2500	0.00047 min.
	0.68 max.

DIMENSIONS in millimeters



Note

- | F-F' | < 0.3 mm
  F = 7.5 mm + 0.6 mm / - 0.1 mm
  Ø dt ± 10 % of standard diameter specified

MOUNTING

Normal Use

The capacitors are designed for mounting on printed-circuit boards. The capacitors packed in bandoliers are designed for mounting on printed-circuit boards by means of automatic insertion machines.
For detailed tape specifications refer to “Packaging Information” www.vishay.com/doc?28139

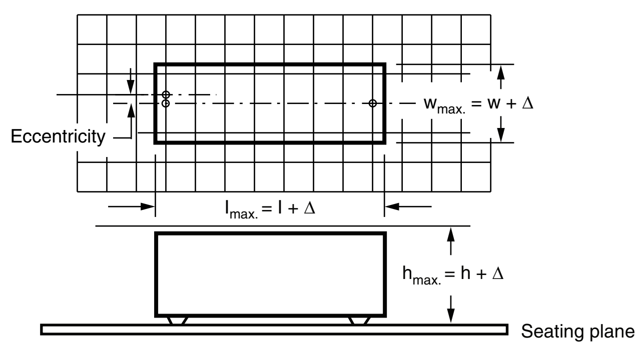
Specific Method of Mounting to Withstand Vibration and Shock

In order to withstand vibration and shock tests, it must be ensured that the stand-off pips are in good contact with the printed-circuit board:

- For original pitch = 15 mm the capacitors shall be mechanically fixed by the leads
- For larger pitches the capacitors shall be mounted in the same way and the body clamped

Space Requirements on Printed-Circuit Board

The maximum length and width of film capacitors is shown in the drawing:
For products with pitch ≤ 15 mm, $\Delta w = \Delta l = 0.3$ mm and $\Delta h = 0.1$ mm
For products with 15 mm < pitch ≤ 27.5 mm, $\Delta w = \Delta l = 0.5$ mm and $\Delta h = 0.1$
For products with pitch = 37.5 mm $\Delta w = \Delta l = 0.7$ mm and $\Delta h = 0.5$ mm
For products with pitch = 52.5 mm, $\Delta w = \Delta l = 1$ mm and $\Delta h = 0.5$ mm
Eccentricity as in drawing. The maximum eccentricity is smaller than or equal to the lead diameter of the product concerned.



SOLDERING CONDITIONS

For general soldering conditions and wave soldering provile we refer to the document “Soldering Conditions Vishay Film Capacitors”: www.vishay.com/doc?28171

STORAGE TEMPERATURE

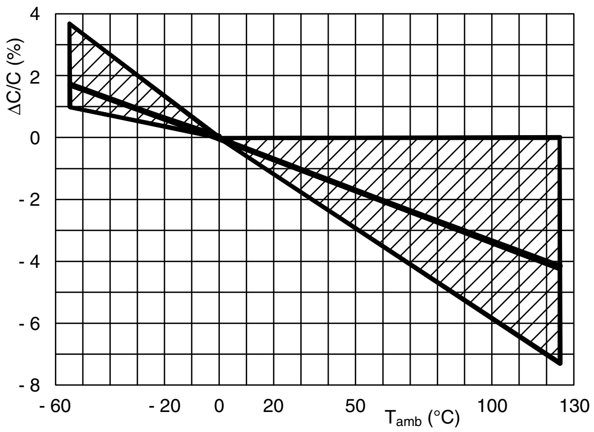
Storage temperature: T_{stg} = -25 °C to +35 °C with RH maximum 75 % without condensation.

RATINGS AND CHARACTERISTICS REFERENCE CONDITIONS

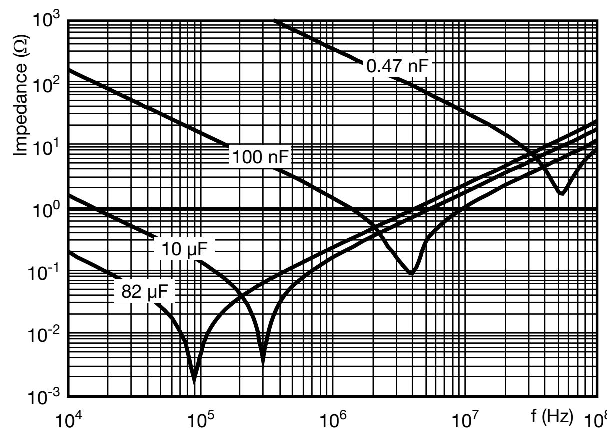
Unless otherwise specified, all electrical values apply to an ambient free temperature of 23 °C ± 1 °C, an atmospheric pressure of 86 kPa to 106 kPa and a relative humidity of 50 % ± 2 %.

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 %.

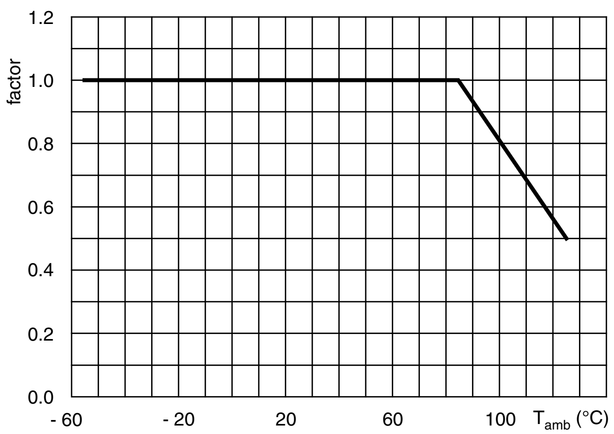
CHARACTERISTICS



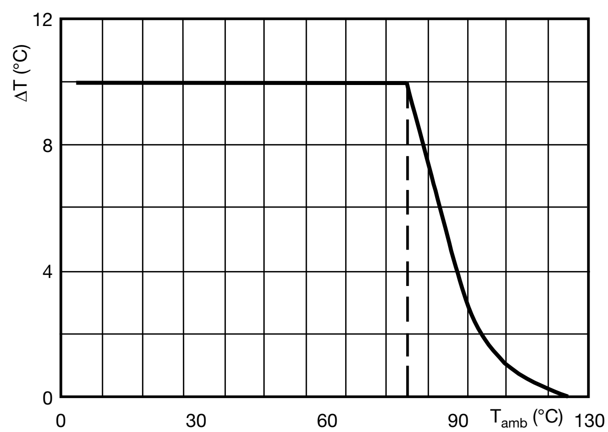
Capacitance as a function of ambient temperature (typical curve)
(1 kHz)



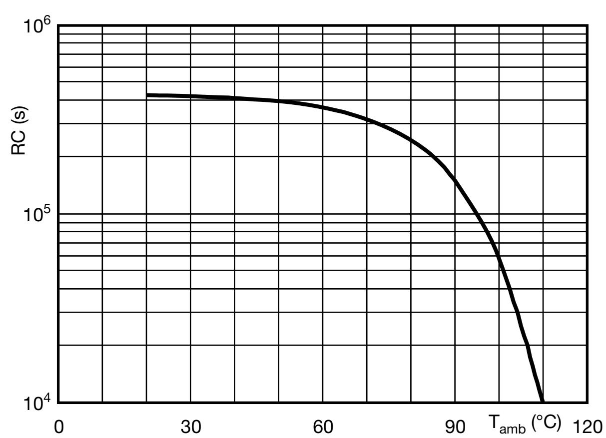
Impedance as a function of frequency (typical curve)



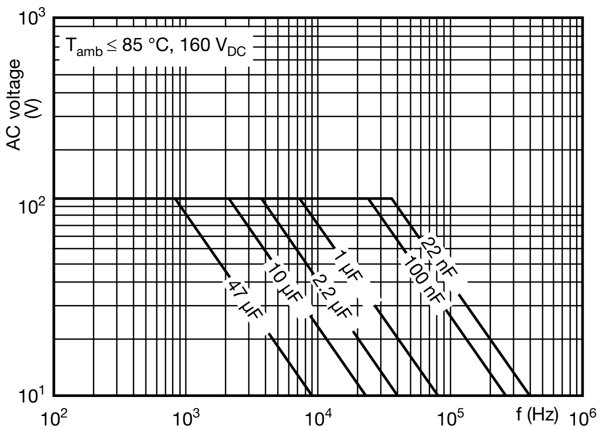
Max. DC and AC voltage as function of temperature



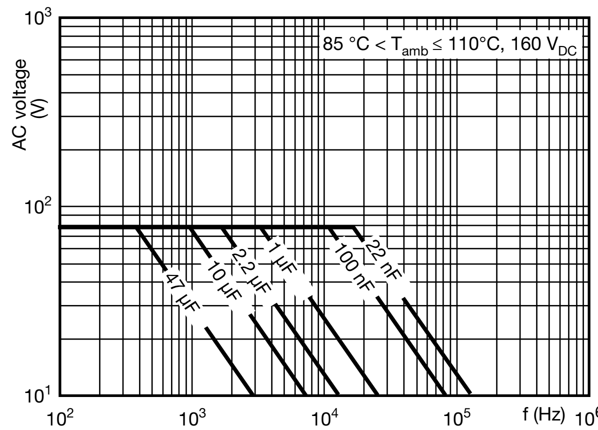
Maximum allowed component temperature rise (ΔT)
as a function of ambient temperature (T_{amb})



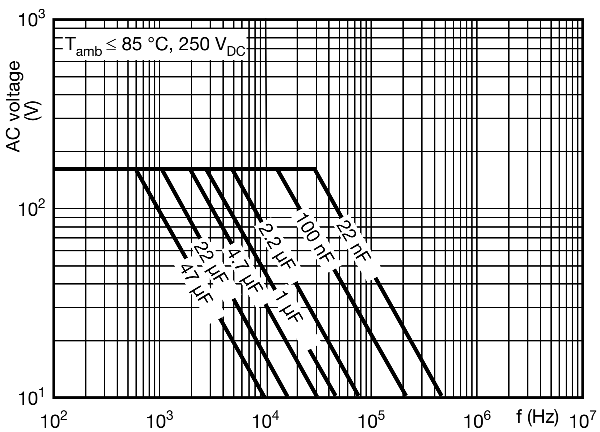
Insulation resistance as a function of ambient temperature
(typical curve)



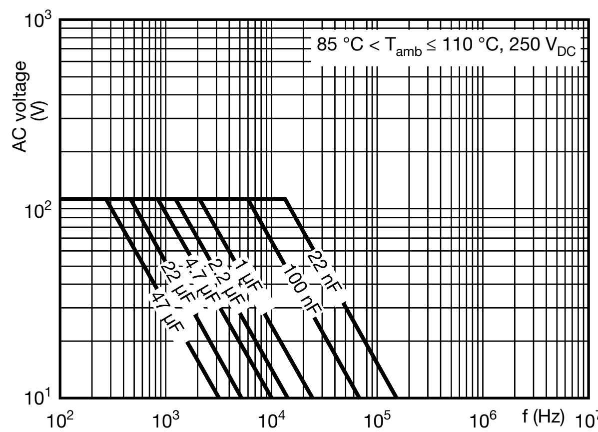
Max. RMS voltage as function of frequency (160 V)



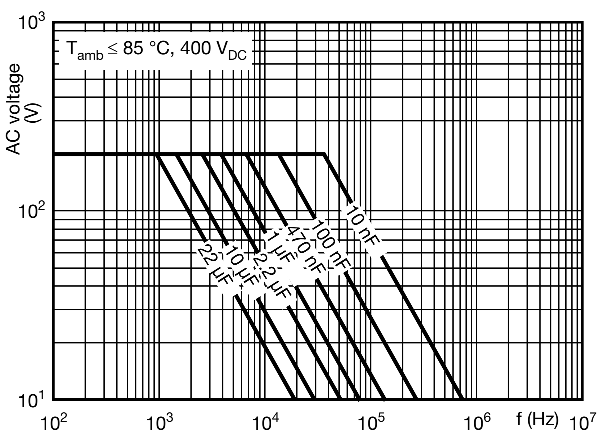
Max. RMS voltage as function of frequency (160 V)



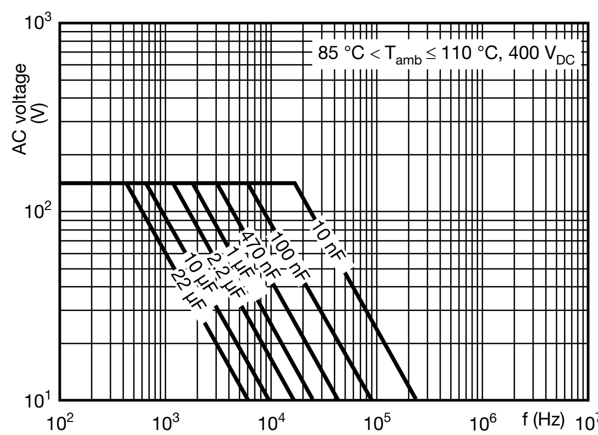
Max. RMS voltage as function of frequency (250 V)



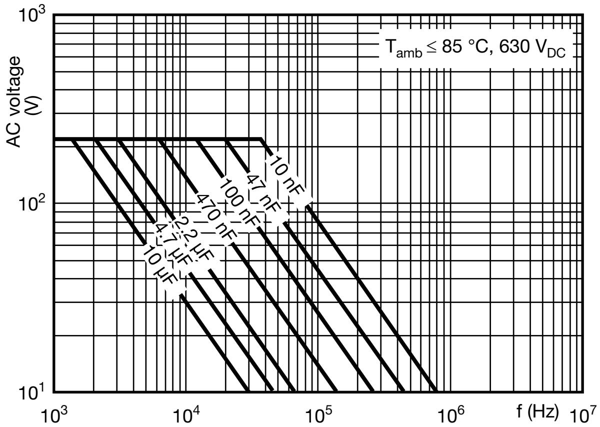
Max. RMS voltage as function of frequency (250 V)



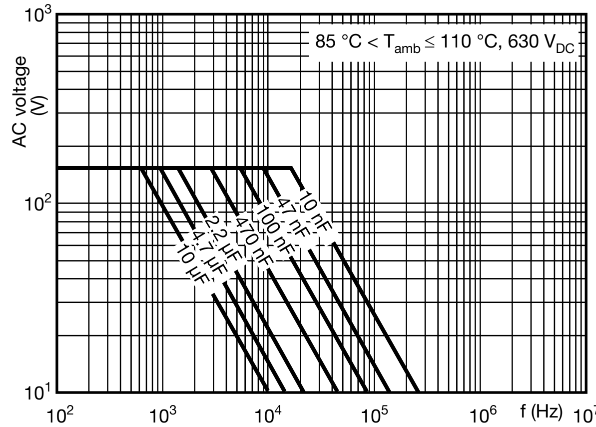
Max. RMS voltage as function of frequency (400 V)



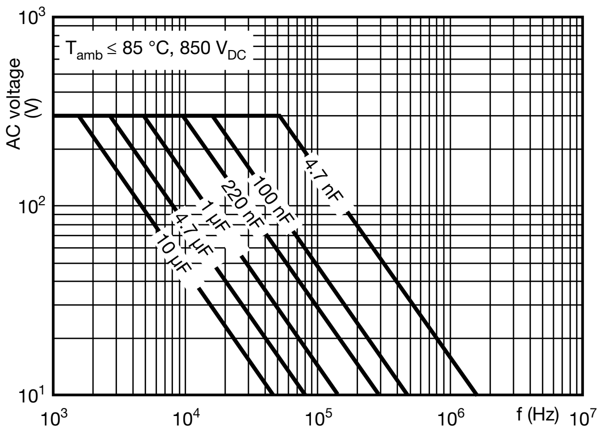
Max. RMS voltage as function of frequency (400 V)



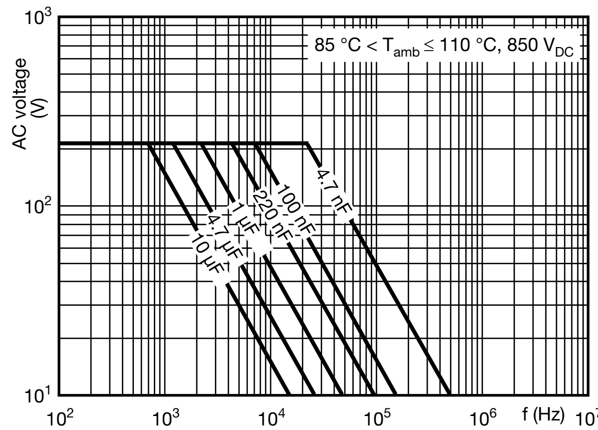
Max. RMS voltage as function of frequency (630 V)



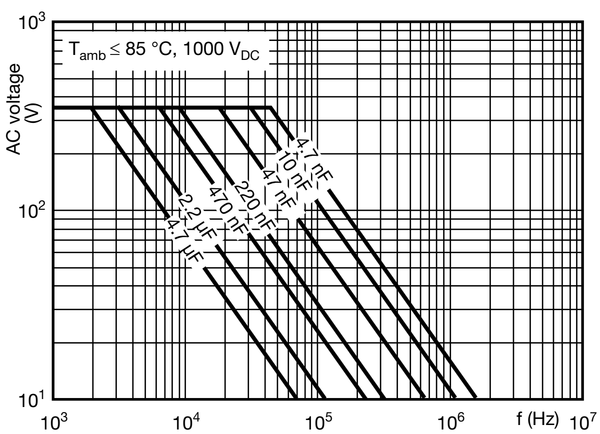
Max. RMS voltage as function of frequency (630 V)



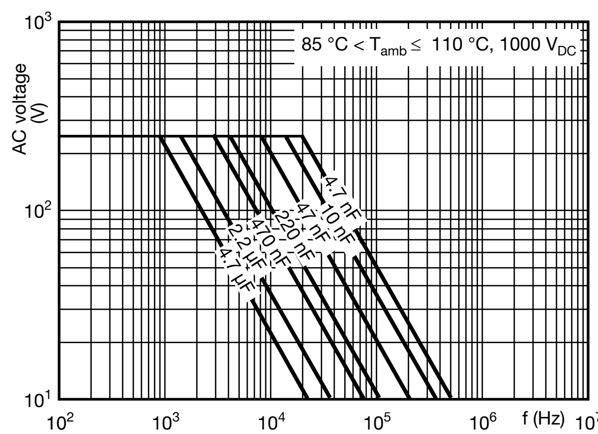
Max RMS voltage as function of frequency (850 V)



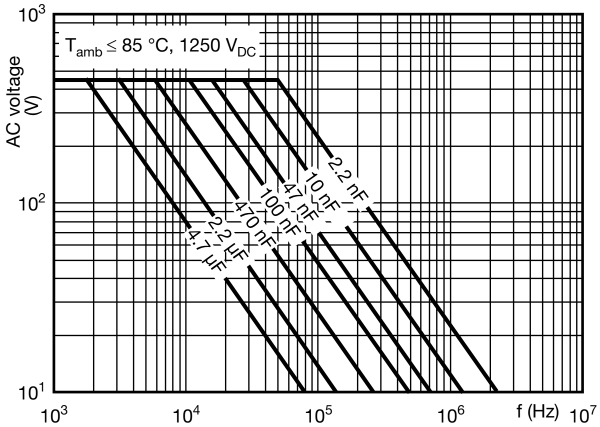
Max. RMS voltage as function of frequency (850 V)



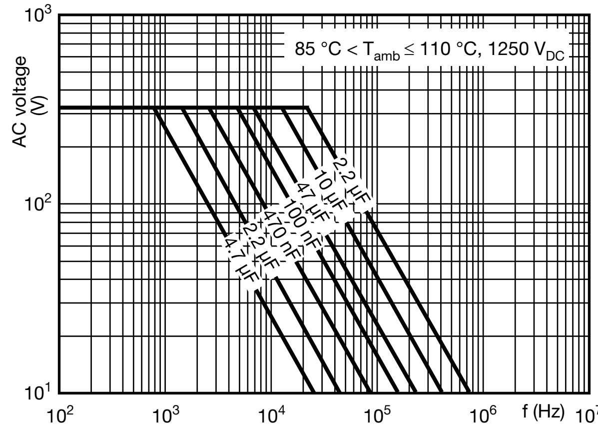
Max. RMS voltage as function of frequency (1000 V)



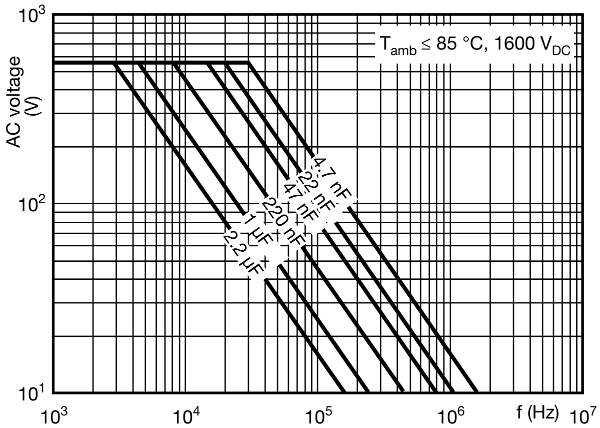
Max. RMS voltage as function of frequency (1000 V)



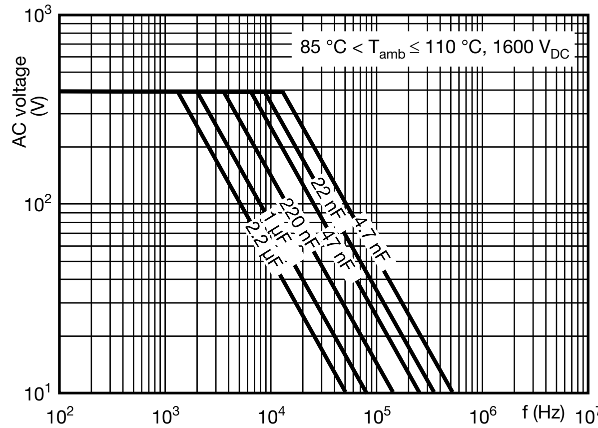
Max. RMS voltage as function of frequency (1250 V)



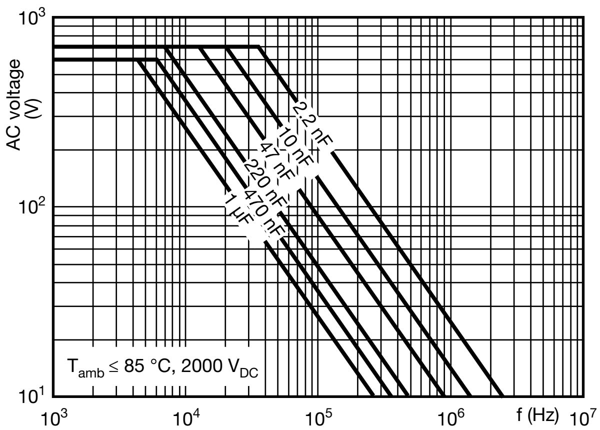
Max. RMS voltage as function of frequency (1250 V)



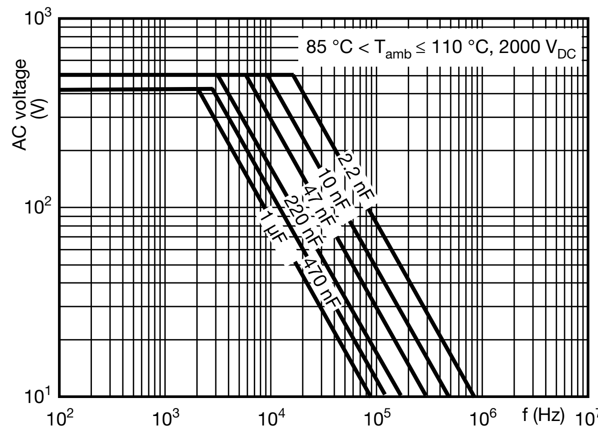
Max. RMS voltage as function of frequency (1600 V)



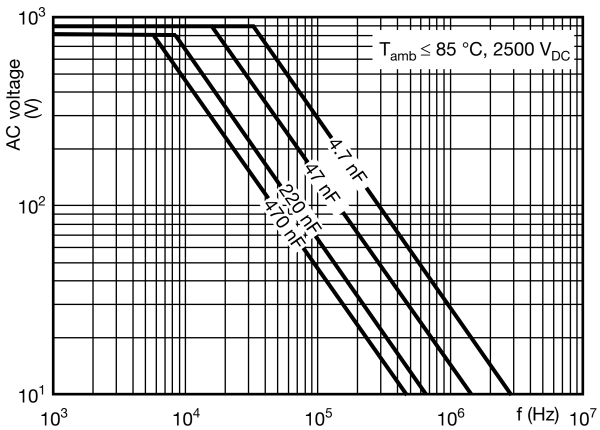
Max. RMS voltage as function of frequency (1600 V)



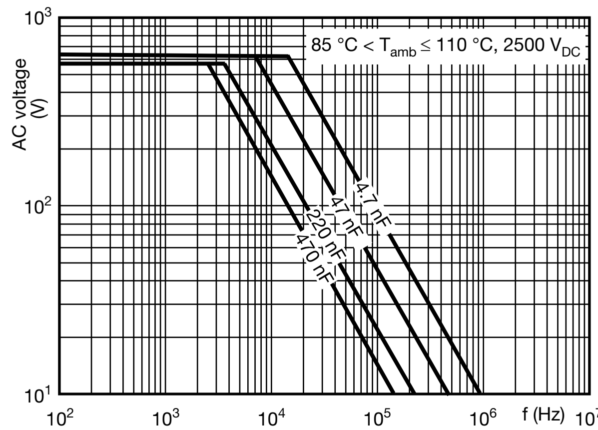
Max. RMS voltage as function of frequency (2000 V)



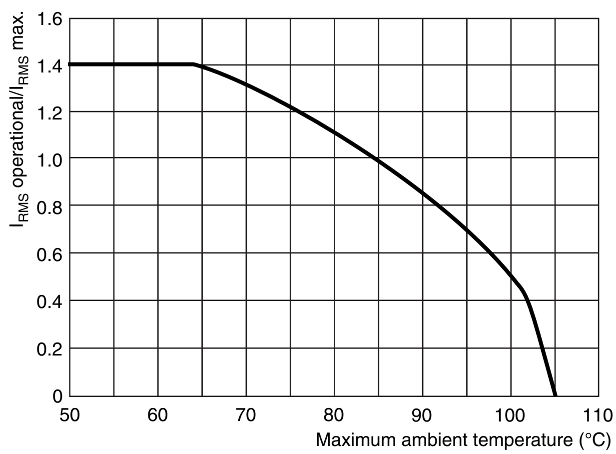
Max. RMS voltage as function of frequency (2000 V)



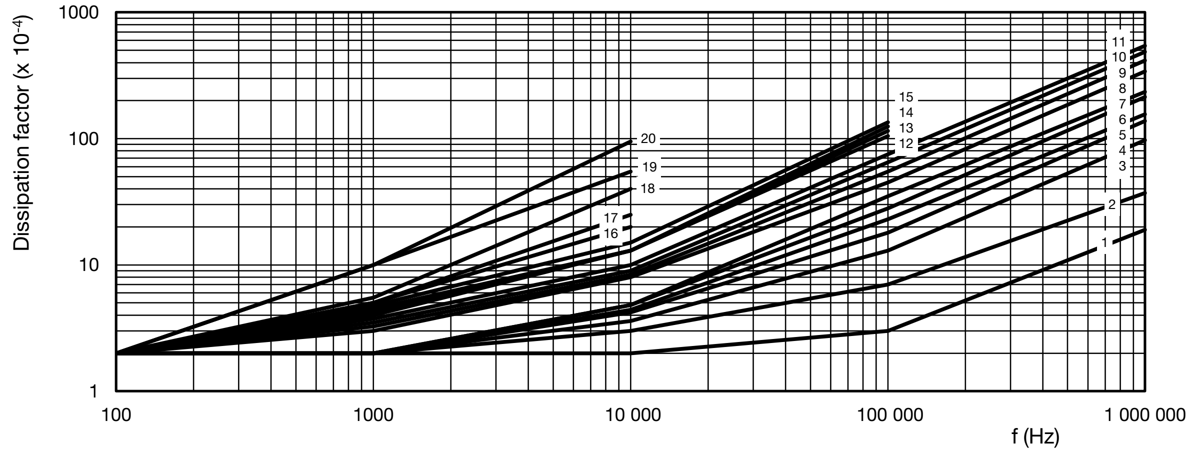
Max. RMS voltage as function of frequency (2500 V)



Max. RMS voltage as function of frequency (2500 V)



Maximum I_{RMS} current in function of the ambient temperature



Tangent of loss angle as a function of frequency (typical curve)

160 V: C ≤ 0.018 µF, curve 1 0.018 < C ≤ 0.12 µF, curve 2 0.12 < C ≤ 0.16 µF, curve 5 0.16 < C ≤ 0.33 µF, curve 6 0.33 < C ≤ 0.47 µF, curve 7 0.47 < C ≤ 0.91 µF, curve 10 0.91 < C ≤ 1.1 µF, curve 11 1.1 < C ≤ 1.6 µF, curve 12 1.6 < C ≤ 2.4 µF, curve 13 2.4 < C ≤ 3 µF, curve 14 3 < C ≤ 5.6 µF, curve 15 5.6 < C ≤ 43 µF, curve 18 43 < C ≤ 82 µF, curve 20	**250 V:** C ≤ 0.043 µF, curve 2 0.043 < C ≤ 0.091 µF, curve 3 0.091 < C ≤ 0.11 µF, curve 5 0.11 < C ≤ 0.43 µF, curve 6 0.33 < C ≤ 0.47 µF, curve 7 0.43 < C ≤ 0.91 µF, curve 10 0.91 < C ≤ 3.3 µF, curve 12 3.3 < C ≤ 5.6 µF, curve 13 5.6 < C ≤ 33 µF, curve 18 33 < C ≤ 62 µF, curve 20	**400 V:** C ≤ 0.010 µF, curve 1 0.010 < C ≤ 0.036 µF, curve 2 0.036 < C ≤ 0.043 µF, curve 3 0.043 < C ≤ 0.18 µF, curve 4 0.18 < C ≤ 0.43 µF, curve 8 0.43 < C ≤ 0.75 µF, curve 10 0.75 < C ≤ 3.0 µF, curve 11 3.3 < C ≤ 15 µF, curve 17 15 < C ≤ 27 µF, curve 19	**630 V:** C ≤ 0.018 µF, curve 1 0.018 < C ≤ 0.024 µF, curve 2 0.024 < C ≤ 0.043 µF, curve 3 0.043 < C ≤ 0.11 µF, curve 4 0.11 < C ≤ 0.24 µF, curve 7 0.24 < C ≤ 2.4 µF, curve 9 2.4 < C ≤ 8.2 µF, curve 16 8.2 < C ≤ 15 µF, curve 19
850 V: C ≤ 0.0091 µF, curve 1 0.0091 < C ≤ 0.051 µF, curve 2 0.051 < C ≤ 0.12 µF, curve 3 0.12 < C ≤ 0.68 µF, curve 4 0.68 < C ≤ 1.3 µF, curve 6	**1000 V:** C ≤ 0.015 µF, curve 1 0.015 < C ≤ 0.056 µF, curve 2 0.056 < C ≤ 0.10 µF, curve 3 0.1 < C ≤ 0.91 µF, curve 4	**1250 V:** C ≤ 0.033 µF, curve 1 0.033 < C ≤ 0.091 µF, curve 2 0.091 < C ≤ 0.68 µF, curve 3	**1600 V:** C ≤ 0.0091 µF, curve 1 0.0091 < C ≤ 0.27 µF, curve 2 0.27 < C ≤ 0.36 µF, curve 3 0.36 < C ≤ 1 µF, curve 5
2000 V: C ≤ 0.018 µF, curve1 0.018 < C ≤ 0.22 µF, curve 2 0.22 < C ≤ 1 µF, curve 4	**2500 V:** C ≤ 0.082 µF, curve1 0.082 < C ≤ 0.39 µF, curve 2 0.39 < C ≤ 0.68 µF, curve 4		

HEAT CONDUCTIVITY (G) AS A FUNCTION OF (ORIGINAL) PITCH AND CAPACITOR BODY THICKNESS IN mW/°C								
W_{max} (mm)	HEAT CONDUCTIVITY (mW/°C)							
	PITCH 5 mm	PITCH 7.5 mm	PITCH 10 mm	PITCH 15 mm	PITCH 22.5 mm	PITCH 27.5 mm	PITCH 37.5 mm	PITCH 52.5 mm
3	-	4	-	-	-	-	-	-
3.5	3	-	-	-	-	-	-	-
4	-	5	6.5	-	-	-	-	-
4.5	4	-	-	-	-	-	-	-
5	-	6	7.5	10	-	-	-	-
6	5.5	7	9	11	19	-	-	-
7	-	-	-	12	21	-	-	-
8.5	-	-	-	16	25	-	-	-
9	-	-	-	-	-	31	-	-
10	-	-	-	18	28	-	-	-
11	-	-	-	-	-	36	-	-
12	-	-	-	-	34	-	-	-
13	-	-	-	-	-	42	-	-
14.5	-	-	-	-	-	-	-	-
15	-	-	-	-	-	48	-	-
18	-	-	-	-	-	57	-	-
18.5	-	-	-	-	-	-	89	-
21	-	-	-	-	-	68	-	-
21.5	-	-	-	-	-	-	102	-
24	-	-	-	-	-	-	116	-
25	-	-	-	-	-	-	-	152
30	-	-	-	-	-	-	134	181
35	-	-	-	-	-	-	-	197

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 air ambient temperature.

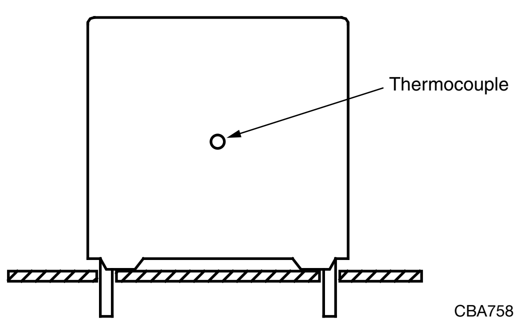
The power dissipation can be calculated according type detail specification "HQN-384-01/101: Technical information film capacitors with the typical tgd of the curves.".

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

For capacitors connected in parallel, normally the proof voltage and possibly the rated voltage must be reduced. For information depending of the capacitance value and the number of parallel connections contact: dc-film@vishay.com

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 thanthe maximum (U_{p-p}) 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 U_{RDC} 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
4. The maximum component surface temperature rise must be lower than the limits (see graph “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 < $T_{amb} \leq$ 110 °C**	**110 °C < $T_{amb} \leq$ 125 °C**
Maximum continuous RMS voltage	U_{RAC}	0.7 x U_{RAC}	0.5 x U_{RAC}
Maximum temporary RMS-over voltage (< 24 h)	1.25 x U_{RAC}	0.875 x U_{RAC}	0.625 x U_{RAC}
Maximum peak voltage (V_{o-p}) (< 2 s)	1.6 x U_{RDC}	1.1 x U_{RDC}	0.8 x U_{RDC}

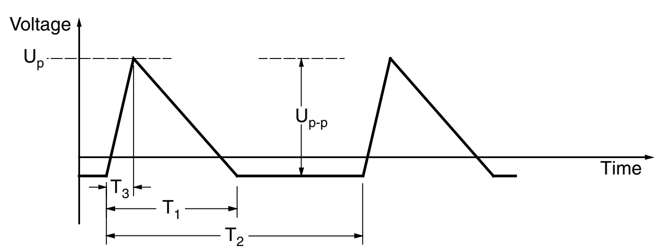
EXAMPLE

C = 4n7 - 1600 V used for the voltage signal shown in next drawing.
U_{p-p} = 1000 V; U_p = 900 V; T_1 = 12 µs; T_2 = 64 µs; T_3 = 4 µs
The ambient temperature is 80 °C. In case of failure, the oscillation is blocked.

Checking the conditions:

1. The peak voltage U_p = 900 V is lower than 1600 V_{DC}
2. The peak-to-peak voltage 1000 V is lower than $2\sqrt{2}$ x 550 V_{AC} = 1600 U_{p-p}
3. The voltage pulse slope (dU/dt) = 1000 V/4 µs = 250 V/µs
   This is lower than 4000 V/µs (see specific reference data for each version)
4. The dissipated power is 35 mW as calculated with fourier terms and typical tgd.
   The temperature rise for Wmax. = 6 mm and pitch = 15 mm will be 35 mW/9 mW/°C = 3.9 °C
   This is lower than 10 °C temperature rise at 80 °C, according graph.
5. Oscillation is blocked
6. Not applicable

VOLTAGE SIGNAL



INSPECTION REQUIREMENTS

General Notes

Sub-clause numbers of tests and performance requirements refer to the “Sectional Specification, Publication IEC 60384-17 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: C ≤ 1 µF at 100 kHz 1 µF < C ≤ 10 µF at 10 kHz C > 10 µF at 1 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: 1 A 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	$\|\Delta C/C\| \leq 1$ % of the value measured initially.
	Tangent of loss angle	Increase of tan δ: ≤ 0.0005 for: C ≤ 100 nF at 100 kHz ≤ 0.0010 for: 100 nF < C ≤ 470 nF at 100 kHz ≤ 0.0015 for: 470 nF < C ≤ 1 µF at 100 kHz ≤ 0.0015 for: 1 µF < C ≤ 10 µF at 10 kHz ≤ 0.0015 for: C > 10 µF at 1 kHz Compared to values measured in 4.3.1
4.6.1 Initial measurements	Capacitance Tangent of loss angle: C ≤ 1 µF at 100 kHz 1 µF < C ≤ 10 µF at 10 kHz C >10 µF at 1 kHz	
4.15 Solvent resistance of the marking	Isopropylalcohol at room temperature Method: 1 Rubbing material: cotton wool Immersion time: 5 min ± 0.5 min	No visible damage Legible marking
4.6 Rapid change of temperature	θ A = -55 °C θ B = +110 °C 5 cycles Duration t = 30 min	

GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	**CONDITIONS**	**PERFORMANCE REQUIREMENTS**
SUB-GROUP C1A PART OF SAMPLE OF SUB-GROUP C1		
4.7. Vibration	Visual examination Mounting: see section “Mounting” for more information 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.	No visible damage
4.7.2 Final inspection	Visual examination	
4.9 Shock	Mounting: see section “Mounting” for more information Pulse shape: half sine Acceleration: 490 m/s² Duration of pulse: 11 ms	
4.9.3 Final measurements	Visual examination	No visible damage
	Capacitance	$\vert\Delta C/C\vert \leq 2$ % of the value measured in 4.6.1.
	Tangent of loss angle	Increase of tan δ: $\leq$ 0.0005 for: C $\leq$ 100 nF at 100 kHz $\leq$ 0.0010 for: 100 nF < C $\leq$ 470 nF at 100 kHz $\leq$ 0.0015 for: 470 nF < C $\leq$ 1 µF at 100 kHz $\leq$ 0.0015 for: 1 µF < C $\leq$ 10 µF at 10 kHz $\leq$ 0.0015 for: C > 10 µF at 1 kHz 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 +110 °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 test chamber	No breakdown or flashover
	Visual examination	No visible damage Legible marking
	Capacitance	$\vert\Delta C/C\vert \leq 2$ % of the value measured in 4.4.2 or 4.9.3
	Tangent of loss angle	Increase of tan δ: $\leq$ 0.0005 for: C $\leq$ 100 nF at 100 kHz $\leq$ 0.0010 for: 100 nF < C $\leq$ 470 nF at 100 kHz $\leq$ 0.0015 for: 470 nF < C $\leq$ 1 µF at 100 kHz $\leq$ 0.0015 for: 1 µF <C $\leq$ 10 µF at 10 kHz $\leq$ 0.0015 for: C >10 µF at 1 kHz 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.

GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	**CONDITIONS**	**PERFORMANCE REQUIREMENTS**
SUB-GROUP C2		
4.11 Damp heat steady state	56 days; 40 °C; 90 % to 95 % RH no load	
4.11.1 Initial measurements	Capacitance Tangent of loss angle at 1 kHz	
4.11.3 Final measurements	Voltage proof = U_{RDC} for 1 min within 15 min after removal from test chamber	No breakdown or flashover
	Visual examination	No visible damage Legible marking
	Capacitance	$\|\Delta C/C\| \leq 2$ % of the value measured in 4.11.1.
	Tangent of loss angle	Increase of tan δ $\leq$ 0.0005 for: C $\leq$ 100 nF at 100 kHz $\leq$ 0.0010 for: 100 nF < C $\leq$ 470 nF at 100 kHz $\leq$ 0.0015 for: 470 nF < C $\leq$ 1 µF at 100 kHz $\leq$ 0.0015 for: 1 µF < C $\leq$ 10 µF at 10 kHz $\leq$ 0.0015 for: C >10 µF at 1 kHz Compared to values measured in 4.11.1.
	Insulation resistance	$\geq$ 50 % of values specified in section "Insulation resistance" of this specification
SUB-GROUP C3A		
4.12.1 Endurance	Duration: 2000 h Temperature: 85 °C Voltage: 1.25 x U_{RAC} V_{RMS}, 50 Hz or Duration: 2000 h Temperature: 110 °C Voltage: 0.875 x U_{RAC} V_{RMS}, 50 Hz	
4.12.1.1 Initial measurements	Capacitance Tangent of loss angle C $\leq$ 1 µF at 100 kHz 1 µF < C $\leq$ 10 µF at 10 kHz C > 10 µF at 1 kHz	
4.12.1.3 Final measurements	Visual examination	No visible damage Legible marking
	Capacitance	$\|\Delta C/C\| \leq 5$ % for C > 10 nF $\|\Delta C/C\| \leq 8$ % for C $\leq$ 10 nF Compared to values measured in 4.12.1.1
	Tangent of loss angle	Increase of tan δ: $\leq$ 0.0005 for: C $\leq$ 100 nF at 100 kHz $\leq$ 0.0010 for: 100 nF < C $\leq$ 470 nF at 100 kHz $\leq$ 0.0015 for: 470 nF < C $\leq$ 1 µF at 100 kHz $\leq$ 0.0015 for 1 µF < C $\leq$ 10 µF at 10 kHz $\leq$ 0.0015 for: C > 10 µF at 1 kHz Compared to values measured in 4.12.1.1
	Insulation resistance	$\geq$ 50 % of values specified in section "Insulation resistance" of this specification.

GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	**CONDITIONS**	**PERFORMANCE REQUIREMENTS**
SUB-GROUP C3B		
4.12.2 Endurance test at 50 Hz alternating voltage	Duration: 500 h Voltage: 1.25 x U_{RDC} 110 °C	
4.12.2.1 Initial measurements	0.625 x U_{RAC} at 125 °C Capacitance Tangent of loss angle: C ≤ 1 µF at 100 kHz 1 µF < C ≤ 10 µF at 10 kHz C > 10 µF at 1 kHz	
4.12.2.3 Final measurements	Visual examination	No visible damage Legible marking
	Capacitance	I∆C/CI ≤ 10 % + 100 pF compared to values measured in 4.12.2.1
	Tangent of loss angle	Increase of tan δ: ≤ 0.0005 for: C ≤ 100 nF at 100 kHz ≤ 0.0010 for: 100 nF < C ≤ 470 nF at 100 kHz ≤ 0.0015 for: 470 nF < C ≤ 1 µF at 100 kHz ≤ 0.0015 for: 1 µF < C ≤ 10 µF at 10 kHz ≤ 0.0015 for: C >10 µF at 1 kHz Compared to values measured in 4.12.2.1
	Insulation resistance	≥ 50 % of values specified in section "Insulation Resistance" of this specification.
SUB-GROUP C4		
4.2.6 Temperature characteristics Initial measurements Intermediate measurements	Capacitance Capacitance at -55 °C Capacitance at 20 °C Capacitance at +125 °C	For -55 °C to +20 °C: +1 % ≤ I∆C/CI ≤ 3.75 % or for 20 °C to 105 °C: -7.5 % ≤ I∆C/CI ≤ 0 %
Final measurements	Capacitance	As specified in section "Capacitance" of this specification
	Insulation resistance	As specified in section "Insulation Resistance" of this specification
4.13 Charge and discharge	10 000 cycles Charged to U_{RDC} discharge resistance: $R = \frac{U_{RDC}}{2.5 \times C\,(dU/dt)}$	
4.13.1 Initial measurements	Capacitance Tangent of loss angle: C ≤ 1 µF at 100 kHz 1 µF < C ≤ 1 µF at 10 kHz C > 10 µF at 1 kHz	
4.13.3 Final measurements	Capacitance	I∆C/CI ≤ 1 % compared to values measured in 4.13.1.
	Tangent of loss angle	Increase of tan δ: ≤ 0.0005 for: C ≤ 100 nF or ≤ 0.001 for: 100 nF < C ≤ 470 nF or ≤ 0.0015 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.

GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	**CONDITIONS**	**PERFORMANCE REQUIREMENTS**
SUB-GROUP ADD1		
A.1 Ignition of lamp test Only for 1600 V and 2000 V series (Cap. value < 33 nF)	Capacitance	
A.1.1 Initial measurements	Tangent of loss angle at 100 kHz Temperature: 85 °C	
A.1.2 Ignition of lamp test	10 000 cycles: 1 s ON 29 s OFF: Frequency: 60 kHz Voltage: 1600 V type: 2800 V_{pp}2000 V type: 3000 V_{pp}	
A.1.3 Final measurements	Visual examination	No visible damage
	Capacitance	$\lvert\Delta C/C\rvert \leq 5$ % of the value measured in A.1.1
	Tangent of loss angle	Increase of tan δ: ≤ 0.0005 for: C ≤ 100 nF at 100 kHz ≤ 0.0010 for: 100 nF < C ≤ 470 nF at 100 kHz ≤ 0.0015 for: 470 nF < C ≤ 1 μF at 100 kHz ≤ 0.0015 for: 1 μF < C ≤ 10 μF at 10 kHz ≤ 0.0015 for: C >10 μF at 1 kHz Compared to values measured in A.1.1
	Insulation resistance	≥ 50 % of values specified in section "Insulation Resistance" of this specification

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