

## Low Building Height Metallized Polypropylene DC-Link Film Capacitor - Industrial Grade



### FEATURES

- Slim line, low building height
- Very long useful life time: Up to 100 000 h at  $U_{NDC}$  and 70 °C
- High ripple current capability, low ESR, low ESL
- Temperature range: 105 °C
- Mounting: radial
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**  
**GREEN**  
(5-2008)

### APPLICATIONS

- PV micro inverters
- LED street lighting
- On board chargers (EV/HEV), battery chargers

QUICK REFERENCE DATA	
Rated capacitance range	2 $\mu$ F to 100 $\mu$ F
Capacitance tolerance	5 %
Rated voltage range, $U_{NDC}$	500 V to 1000 V
Climatic testing class	40/105/56
Rated temperature	85 °C
Maximum permissible case temperature	105 °C, observing voltage derating
Maximum applicable peak to peak ripple voltage	0.2 x $U_{NDC}$
Reference standards	IEC 61071, IEC 60068
Dielectric	Polypropylene film
Electrodes	Metallized dielectric capacitor
Construction	Mono construction
Encapsulation	Plastic case sealed with resin; flame retardant
Terminals	Tinned wire
Self inductance ( $L_s$ )	< 1 nH per mm of lead spacing
Withstanding DC voltage between terminals <sup>(1)</sup>	1.5 $U_{NDC}$ for 10 s, cut off current 10 mA, rise time $\leq$ 1000 V/s
Insulation resistance	RC between leads, after 1 min > 10 000 s For $U_{NDC} \leq$ 500 V measuring voltage 100 V For $U_{NDC} >$ 500 V measuring voltage 500 V
Life time expectancy	Useful life time: > 100 000 h at $U_{NDC}$ and 70 °C FIT: < 10 x 10 <sup>-9</sup> /h (10 per 10 <sup>9</sup> component h) at 0.5 x $U_{NDC}$ , 40 °C
Marking	C-value; tolerance; rated voltage; code for dielectric material; code for manufacturing origin; manufacturer's type designation; manufacturer's logo; year and week of manufacture

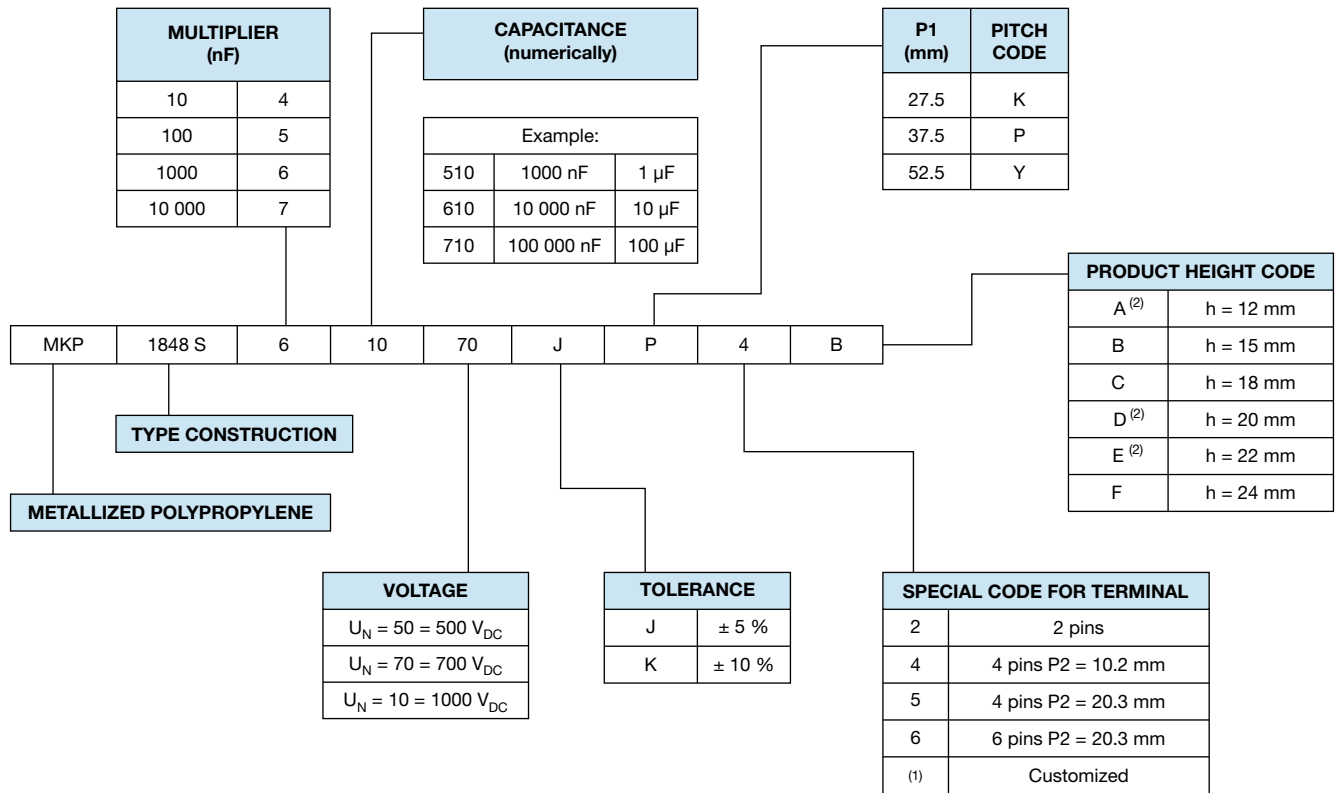
### Notes

- For more detailed data and test requirements, contact [dc-film@vishay.com](mailto:dc-film@vishay.com)
  - For general information like characteristics and definitions used for film capacitors follow the link: [www.vishay.com/doc?28147](http://www.vishay.com/doc?28147)
- <sup>(1)</sup> See document "Voltage Proof Test for Metallized Capacitors" ([www.vishay.com/doc?28169](http://www.vishay.com/doc?28169))

DC VOLTAGE RATINGS			
$U_{NDC}$ at 85 °C	500 V	700 V	1000 V
$U_{OPDC}$ at 70 °C	600 V	800 V	1200 V
$U_{OPDC}$ at 105 °C	350 V	500 V	750 V



## COMPOSITION OF CATALOG NUMBER



### Notes

- (1) Tabs terminals or customized terminals are available on request
- (2) Product height on request

DIMENSIONS in millimeters	
<p> <math>P1 \pm 0.5 \text{ mm}</math>  <math>lt = 6 \text{ mm} + 0 \text{ mm} / - 1 \text{ mm}</math> </p>	
<p> <math>P1 \text{ and } P2 \pm 0.5 \text{ mm}</math>  <math>lt = 6 \text{ mm} + 0 \text{ mm} / - 2 \text{ mm}</math> </p>	
<p> <math>P1 \text{ and } P2 \pm 0.5 \text{ mm}</math>  <math>lt = 6 \text{ mm} + 0 \text{ mm} / - 2 \text{ mm}</math> </p>	

**Notes**

- Standard dimension
- $\varnothing dt \pm 10\%$  of standard diameter specified



ELECTRICAL DATA AND ORDERING CODE																
U <sub>NDC</sub> (V)	HEIGHT (mm)	CAP. <sup>(7)</sup> (μF)	DIMENSION <sup>(5)</sup> (mm)			P1 (mm)	P2 (mm)	dV/dt (V/μs)	I <sub>PEAK</sub> (A)	I <sub>RMS</sub> <sup>(2)</sup> (A)		ESR <sup>(3)</sup> (mΩ)		tan δ 10 kHz ( $< 10^{-4}$ ) <sup>(4)</sup>		ORDERING CODE <sup>(1)</sup>
			w	h	l					2 PINS	4 PINS	2 PINS	4 PINS	2 PINS	4 PINS	
500	12	5	24.0	12.0	31.5	27.5	-	30	150	4	-	13	-	60	-	MKP1848S55050JK2A
	15	7	27.0	15.0	31.5	27.5	-	30	210	5	-	10	-	60	-	MKP1848S57050JK2B
		10	27.0	15.0	42.0	37.5	10.2	15	150	5	5	10	7.5	125	110	MKP1848S61050JP*B
		15	33.0	15.0	42.0	37.5	10.2	15	225	6.5	7	7	5	125	110	MKP1848S61550JP*B
		20	33.0	15.0	57.5	52.5	20.3	7	140	6	6.5	9.5	8	250	220	MKP1848S62050JY*B
		30	45.0	15.0	57.5	52.5	20.3	7	210	8.5	9	6.5	5.5	250	220	MKP1848S63050JY*B
		50 <sup>(6)</sup>	62.0	15.0	57.5	52.5	20.3	7	350	-	13.5	-	3.5	-	220	MKP1848S65050JY6B
	18	10	24.0	18.0	42.0	37.5	10.2	15	150	5	5.5	10	7.5	125	110	MKP1848S61050JP*C
		15	27.0	18.0	42.0	37.5	10.2	15	225	6.5	7	6.5	5	125	110	MKP1848S61550JP*C
		20	39.0	18.0	42.0	37.5	10.2	15	300	8.5	9	5	4	125	110	MKP1848S62050JP*C
		30	35.0	18.0	57.5	52.5	20.3	7	210	8	8.5	6.5	5.5	250	220	MKP1848S63050JY*C
		50	50.0	18.0	57.5	52.5	20.3	7	350	-	12.5	-	3.5	250	220	MKP1848S65050JY5C
	24	20	30.0	24.0	42.0	37.5	10.2	15	300	8.5	9	5	4	125	110	MKP1848S62050JP*F
		30	39.0	24.0	42.0	37.5	10.2	15	450	11	12	3.5	2.5	125	110	MKP1848S63050JP*F
		50	39.0	24.0	57.5	52.5	20.3	7	350	11.5	12.5	4	3.5	250	220	MKP1848S65050JY*F
		100 <sup>(6)</sup>	70.0	24.0	57.5	52.5	20.3	7	700	-	22	-	2	-	220	MKP1848S71050JY6F
700	12	3	24.0	12.0	31.5	27.5	-	35	105	3.5	-	14	-	45	-	MKP1848S53070JK2A
	15	5	27.0	15.0	31.5	27.5	-	35	175	5	-	8	-	45	-	MKP1848S55070JK2B
		7	27.0	15.0	42.0	37.5	10.2	17	119	5	5	15	11.5	110	95	MKP1848S57070JP*B
		10	33.0	15.0	42.0	37.5	10.2	17	170	6	6.5	11	8	110	95	MKP1848S61070JP*B
		15	33.0	15.0	57.5	52.5	20.3	8	120	6	6.5	12	10	220	200	MKP1848S61570JY*B
		20	45.0	15.0	57.5	52.5	20.3	8	160	8	8.5	9	7.5	220	200	MKP1848S62070JY*B
		30 <sup>(6)</sup>	62.0	15.0	57.5	52.5	20.3	8	240	-	12	-	5	-	200	MKP1848S63070JY6B
	18	7	24.0	18.0	42.0	37.5	10.2	17	119	5	5	15	11.5	110	95	MKP1848S57070JP*C
		10	27.0	18.0	42.0	37.5	10.2	17	170	6	6.5	11	8	110	95	MKP1848S61070JP*C
		15	39.0	18.0	42.0	37.5	10.2	17	255	8.5	9	7	5.5	110	95	MKP1848S61570JP*C
		20	35.0	18.0	57.5	52.5	20.3	8	160	7.5	8	9	7.5	220	200	MKP1848S62070JY*C
		30	50.0	18.0	57.5	52.5	20.3	8	240	-	11.5	-	5	-	200	MKP1848S63070JY5C
	24	15	30.0	24.0	42.0	37.5	10.2	17	255	8.5	9	7	5.5	110	95	MKP1848S61570JP*F
		20	39.0	24.0	42.0	37.5	10.2	17	340	10.5	11.5	6	4	110	95	MKP1848S62070JP*F
		30	39.0	24.0	57.5	52.5	20.3	8	240	10.5	11	6	5	220	200	MKP1848S63070JY*F
		50 <sup>(6)</sup>	70.0	24.0	57.5	52.5	20.3	8	400	-	18	-	3	-	200	MKP1848S65070JY6F



ELECTRICAL DATA AND ORDERING CODE																
U <sub>NDC</sub> (V)	HEIGHT (mm)	CAP. <sup>(7)</sup> (μF)	DIMENSION <sup>(5)</sup> (mm)			P1 (mm)	P2 (mm)	dV/dt (V/μs)	I <sub>PEAK</sub> (A)	I <sub>RMS</sub> <sup>(2)</sup> (A)		ESR <sup>(3)</sup> (mΩ)		tan δ 10 kHz ( $< 10^{-4}$ ) <sup>(4)</sup>		ORDERING CODE <sup>(1)</sup>
			w	h	l					2 PINS	4 PINS	2 PINS	4 PINS	2 PINS	4 PINS	
1000	12	2	24.0	12.0	31.5	27.5	-	50	100	3	-	16	-	40	-	MKP1848S52010JK2A
		5	27.0	15.0	42.0	37.5	10.2	25	125	4.5	4.5	16	11.5	105	90	MKP1848S55010JP*B
	15	7	33.0	15.0	42.0	37.5	10.2	25	175	5.5	6	12	8	105	90	MKP1848S57010JP*B
		10	33.0	15.0	57.5	52.5	20.3	12	120	5.5	6	13	10	160	140	MKP1848S61010JY*B
		15	45.0	15.0	57.5	52.5	20.3	12	180	7.5	8	9	6.5	160	140	MKP1848S61510JY*B
		20 <sup>(6)</sup>	62.0	15.0	57.5	52.5	20.3	12	240	-	11	-	5	-	140	MKP1848S62010JY6B
		3	24.0	18.0	42.0	37.5	10.2	25	75	3.5	3.5	27	19	105	90	MKP1848S53010JP*C
	18	5	27.0	18.0	42.0	37.5	10.2	25	125	4.5	5	16	11.5	105	90	MKP1848S55010JP*C
		7	39.0	18.0	42.0	37.5	10.2	25	175	6.5	7	12	8	105	90	MKP1848S57010JP*C
		10	39.0	18.0	42.0	37.5	10.2	25	250	7.5	8	8	6	105	90	MKP1848S61010JP*C
		15	50.0	18.0	57.5	52.5	20.3	12	180	-	9	-	6.5	-	140	MKP1848S61510JY5C
		20	50.0	18.0	57.5	52.5	20.3	12	240	-	10	-	5	-	140	MKP1848S62010JY5C
	24	7	30.0	24.0	42.0	37.5	10.2	25	175	6.5	6.5	12	8	105	90	MKP1848S57010JP*F
		10	39.0	24.0	42.0	37.5	10.2	25	250	8.5	9	8	6	105	90	MKP1848S61010JP*F
		15	39.0	24.0	57.5	52.5	20.3	12	180	8	8.5	9	6.5	160	140	MKP1848S61510JY*F
		20	39.0	24.0	57.5	52.5	20.3	12	240	9.5	10	7	5	160	140	MKP1848S62010JY*F
		30 <sup>(6)</sup>	70.0	24.0	57.5	52.5	20.3	12	360	-	15.5	-	4	-	140	MKP1848S63010JY6F

Notes

- (1) Change the \* symbol with special code for the terminals
- (2) Maximum RMS current at 10 kHz, + 85 °C, Δt = + 15 °C, capacitance tolerance ≤ ± 5 %
- (3) Equivalent series resistance typical values at 10 kHz
- (4) Maximum tan δ values
- (5) Standard dimension
- (6) 6 pins
- (7) Intermediate capacitance values available on request

PACKAGING INFORMATION						
U <sub>NDC</sub> (V)	HEIGHT (mm)	CAP. <sup>(1)</sup> (μF)	Ø dt	ORDERING CODE <sup>(1)</sup>	MASS (g)	SPQ <sup>(3)</sup> (pcs)
500	12	5	0.8	MKP1848S55050JK2A	7	99
		7	0.8	MKP1848S57050JK2B	10.5	90
	15	10	1.0	MKP1848S61050JP*B	14	70
		15	1.0	MKP1848S61550JP*B	18.5	56
		20	1.2	MKP1848S62050JY*B	22.5	40
		30	1.2	MKP1848S63050JY*B	31.5	30
		50 <sup>(2)</sup>	1.2	MKP1848S65050JY6B	43	20
	18	10	1.0	MKP1848S61050JP*C	15	77
		15	1.0	MKP1848S61550JP*C	15.5	70
		20	1.0	MKP1848S62050JP*C	25	49
		30	1.2	MKP1848S63050JY*C	30.5	40
		50	1.2	MKP1848S65050JY5C	41.5	25
	24	20	1.0	MKP1848S62050JP*F	25	63
		30	1.0	MKP1848S63050JP*F	32	49
		50	1.2	MKP1848S65050JY*F	41.5	40
		100 <sup>(2)</sup>	1.2	MKP1848S71050JY6F	78	20



PACKAGING INFORMATION						
U <sub>NDC</sub> (V)	HEIGHT (mm)	CAP. <sup>(1)</sup> (µF)	Ø dt	ORDERING CODE <sup>(1)</sup>	MASS (g)	SPQ <sup>(3)</sup> (pcs)
700	12	3	0.8	MKP1848S53070JK2A	6.5	99
	15	5	0.8	MKP1848S55070JK2B	9	90
		7	1.0	MKP1848S57070JP*B	12.5	70
		10	1.0	MKP1848S61070JP*B	16	56
		15	1.2	MKP1848S61570JY*B	21.5	40
		20	1.2	MKP1848S62070JY*B	32.5	30
		30 <sup>(2)</sup>	1.2	MKP1848S63070JY6B	43	20
	18	7	1.0	MKP1848S57070JP*C	13	77
		10	1.0	MKP1848S61070JP*C	15.5	70
		15	1.0	MKP1848S61570JP*C	22	49
		20	1.2	MKP1848S62070JY*C	29.5	40
		30	1.2	MKP1848S62570JY5C	41.5	25
	24	15	1.0	MKP1848S61570JP*F	21	63
		20	1.0	MKP1848S62070JP*F	28.5	49
		30	1.2	MKP1848S63070JY*F	39.5	40
		50 <sup>(2)</sup>	1.2	MKP1848S65070JY6F	83	20
1000	12	2	0.8	MKP1848S52010JK2A	11	99
	15	5	1.0	MKP1848S55010JP*B	13	70
		7	1.0	MKP1848S57010JP*B	16.5	56
		10	1.2	MKP1848S61010JY*B	21.5	40
		15	1.2	MKP1848S61510JY*B	30	30
		20 <sup>(2)</sup>	1.2	MKP1848S62010JY6B	45	20
	18	3	1.0	MKP1848S53010JP*C	16.5	77
		5	1.0	MKP1848S55010JP*C	16	70
		7	1.0	MKP1848S57010JP*C	25.5	49
		10	1.0	MKP1848S61010JP*C	21.5	49
		15	1.2	MKP1848S61510JY5C	43.5	25
		20	1.2	MKP1848S62010JY5C	43.5	25
	24	7	1.0	MKP1848S57010JP*F	25	63
		10	1.0	MKP1848S61010JP*F	33	49
		15	1.2	MKP1848S61510JY*F	45.5	40
		20	1.2	MKP1848S62010JY*F	39	40
		30 <sup>(2)</sup>	1.2	MKP1848S63010JY6F	87	20

Notes

- (1) Intermediate capacitance values available on request
- (2) 6 pins
- (3) SPQ = Standard Packing Quantity

## CONSTRUCTION DESCRIPTION

Low inductive wound cell elements of metallized polypropylene film, potted with resin in a flame retardant case.

## SPECIFIC METHOD OF MOUNTING TO WITHSTAND VIBRATION AND SHOCK

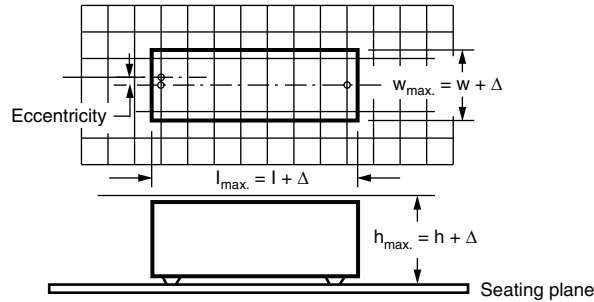
The capacitor unit is designed for mounting on a printed circuit board. In order to withstand vibration and shock tests, it must be insured that the stand-off pips are in good contact with the printed circuit board. The capacitors shall be mechanically fixed by the leads and the body clamped.

## SPACE REQUIREMENTS ON PRINTED-CIRCUIT BOARD FOR 2 PINS PRODUCTS

For the maximum product dimensions and maximum space requirements for length ( $l_{max.}$ ), width ( $w_{max.}$ ) and height ( $h_{max.}$ ) following tolerances must be taken in account in the envelopment of the components as shown in the drawings below.

- For products with pitch = 27.5 mm,  $\Delta w = \Delta l = 0.5$  mm, and  $\Delta h = 0.5$  mm
- 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,  $\Delta w = \Delta l = 1.0$  mm and,  $\Delta h = 0.5$  mm

Eccentricity defined as in drawing. The maximum eccentricity is smaller than or equal to the lead diameter of the product concerned.



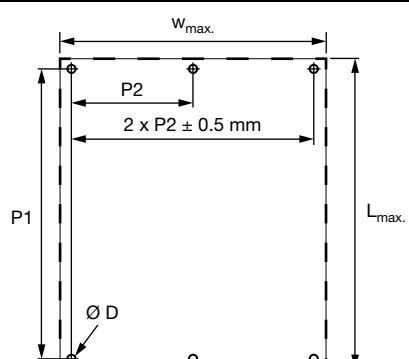
For the minimum product dimensions for length ( $l_{min.}$ ), width ( $w_{min.}$ ) and height ( $h_{min.}$ ) following tolerances of the components are valid:

$$l_{min.} = l - \Delta l, w_{min.} = w - \Delta w \text{ and } h_{min.} = h - \Delta h$$

- For products with pitch = 27.5 mm,  $\Delta l = 1.0$  mm and  $\Delta w = \Delta h = 0.5$  mm
- For products with pitch = 37.5 mm,  $\Delta l = 1.0$  mm and  $\Delta w = \Delta h = 1.0$  mm
- For products with pitch = 52.5 mm,  $\Delta l = 1.5$  mm and  $\Delta w = \Delta h = 1.0$  mm

## SPACE REQUIREMENTS ON PRINTED-CIRCUIT BOARD FOR MULTIPLE PINS PRODUCTS

The product height with seating plane as given by "IEC 60717" as reference:  $h_{max.} = h$ . The maximum length and width of film capacitors is shown in the figure.

DIMENSIONS in millimeters				
				
P1	L <sub>max.</sub>	W <sub>max.</sub>	Ø D	H
37.5	$l + 1.5$	$w + 1.8$	1.5	$h + 0.5$
52.5	$l + 1.8$	$w + 2.0$	1.7	$h + 0.5$



**SOLDERING CONDITIONS**

For general soldering conditions and wave soldering profile we refer to the document “Soldering Conditions Vishay Film Capacitors”: [www.vishay.com/doc?28171](http://www.vishay.com/doc?28171)

**STORAGE TEMPERATURE**

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

**RATINGS AND CHARACTERISTICS REFERENCE CONDITIONS**

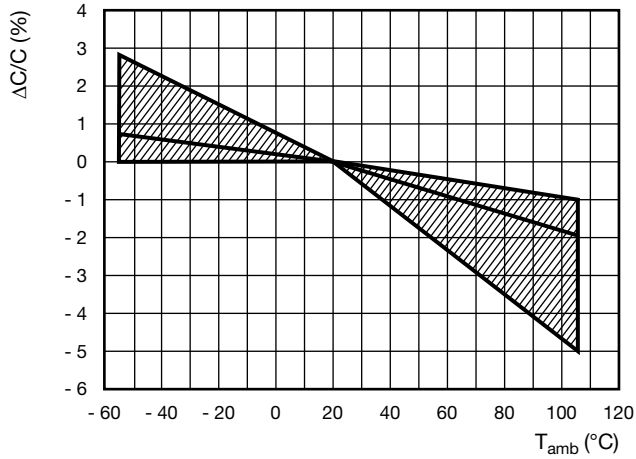
Unless otherwise specified, all electrical values apply to an ambient temperature of  $23\text{ °C} \pm 1\text{ °C}$ , an atmospheric pressure of 86 kPa to 106 kPa and a relative humidity of  $50\% \pm 2\%$ .

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

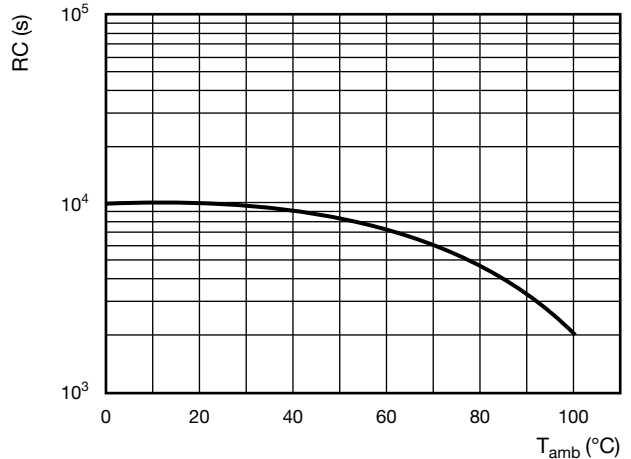




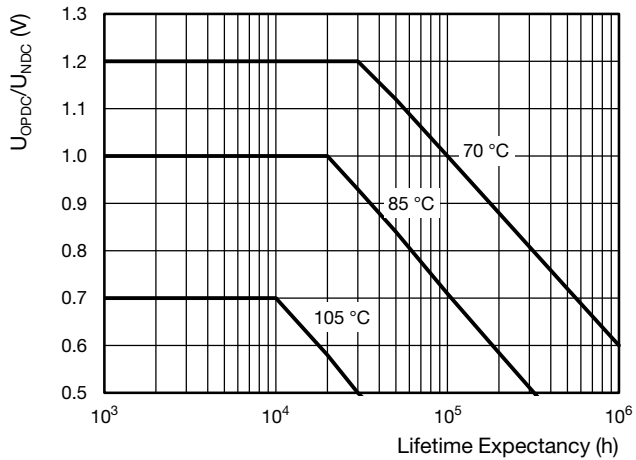
## CHARACTERISTICS



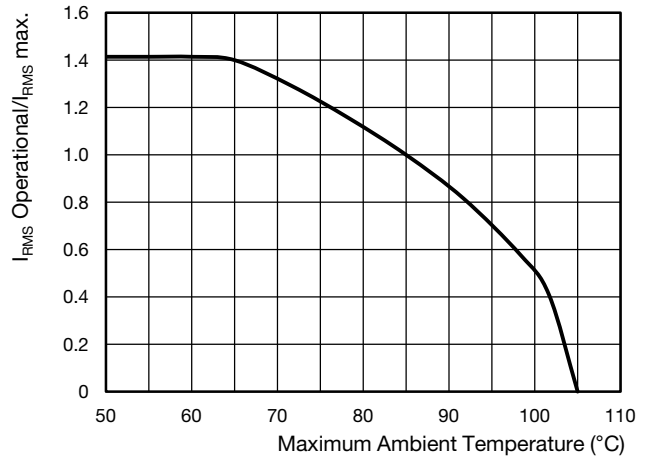
Capacitance as a function of ambient temperature (typical)



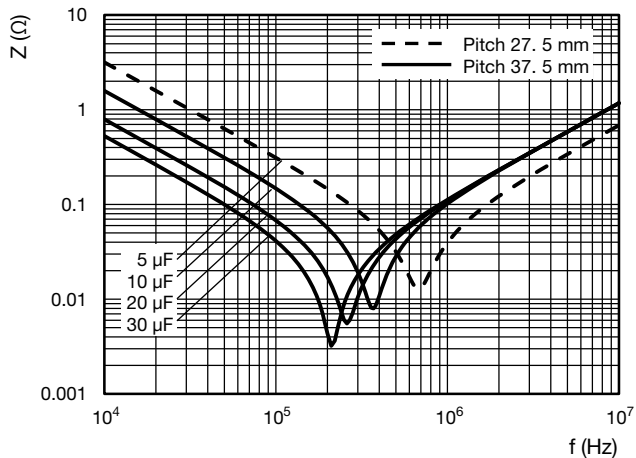
Insulation resistance as a function of ambient temperature (typical)



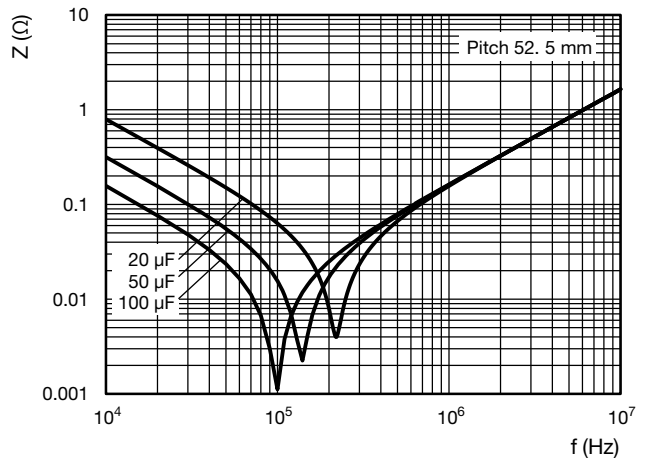
Lifetime expectancy (typical)



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



Impedance vs. Frequency (typical)



Impedance vs. Frequency (typical)

<b>HEAT CONDUCTIVITY</b>			
<b>DIMENSION (mm)</b>			<b>HEAT CONDUCTIVITY (mW/°C)</b>
<b>w</b>	<b>h</b>	<b>l</b>	
24	12	31.5	21.5
27	15	31.5	26
27	15	42	33
33	15	42	38
24	18	42	33.5
27	18	42	36
39	18	42	47
30	24	42	45.5
39	24	42	54.5
33	15	57.5	48.5
45	15	57.5	61.5
62	15	57.5	80
35	18	57.5	55
50	18	57.5	72
39	24	57.5	68
70	24	57.5	106

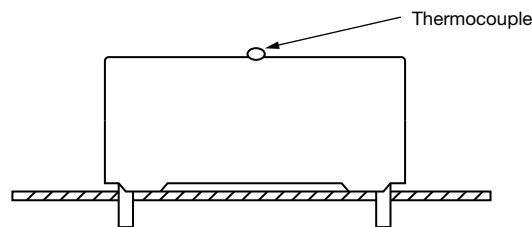
### POWER DISSIPATION AND MAXIMUM COMPONENT TEMPERATURE RISE

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 component temperature rise ( $\Delta T$ ) can be measured or calculated by  $\Delta T = P/G$ :

- $\Delta T = T_{\text{case}} - T_{\text{ambient}} =$  Case temperature rise ( $^{\circ}\text{C}$ ) with a maximum of  $15^{\circ}\text{C}$  at rated temperature.
- $P = I_{\text{RMS}}^2 \times \text{ESR} =$  Power dissipation of the component (mW)
- $G =$  Heat conductivity of the component (mW/ $^{\circ}\text{C}$ )

### MEASURING THE COMPONENT TEMPERATURE



The case temperature is measured in unloaded condition ( $T_{\text{amb}}$ ) and loaded condition ( $T_{\text{C}}$ ).

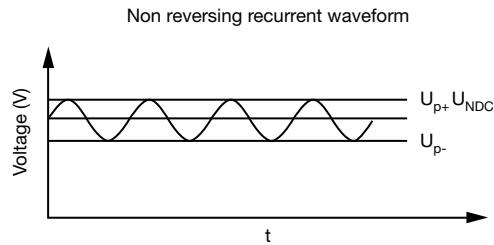
To avoid external thermal radiation or convection, the capacitor must be tested in a closed area, free from air circulation.

**APPLICATION NOTES AND LIMITING CONDITIONS**

These capacitors are not suitable for mains applications as across-the-line capacitors without additional protection. 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 continuous peak voltage ( $U_{p+}$ ) shall not exceed the DC voltage rating ( $U_{NDC}$ )
2. The peak-to-peak ripple voltage ( $U_{pp}$ ) shall not be greater than  $0.2 \times U_{NDC}$



3. 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](mailto:dc-film@vishay.com).
4. The voltage peak slope ( $dU/dt$ ) shall not exceed the pulse slope at the DC voltage rating. If the pulse voltage is lower than the rated DC voltage, the rated voltage pulse slope may be multiplied by  $U_{NDC}$  and divided by the applied voltage.

For all other pulses following equation must be fulfilled:

$$2 \times \int_0^T \left( \frac{dU}{dt} \right)^2 \times dt < U_{NDC} \times \left( \frac{dU}{dt} \right)_{rated}$$

T is the pulse duration

MAXIMUM REPETITIVE PEAK VOLTAGES	
REPETITIVE SURGE VOLTAGE	MAXIMUM DURATION PER DAY
$1.1 \times U_{NDC}$	30 % of on load duration
$1.15 \times U_{NDC}$	30 min
$1.2 \times U_{NDC}$	5 min
$1.3 \times U_{NDC}$	1 min
$1.5 \times U_{NDC}$	110 ms

**Note**

- The capacitor unit may be subjected to the following surge without any significant reduction of lifetime expectancy



INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
<b>ROUTINE TEST - FINAL INSPECTION</b>		
5.14.2-1 External inspection, visual examination		Legible marking as specified
5.14.2-2 Dimensions		See specification drawing
5.3-1 Capacitance	1 kHz at room temperature	See specific reference data
5.3-2 tan $\delta$	1 kHz at room temperature 10 kHz at room temperature	See specific reference data
5.5.1-2 Voltage test between terminals	1.5 x $U_{NDC}$ at $T_{amb}$ Duration: 10 s	No visible damage or puncture No flashover
5.7 Insulation resistance	$U_{NDC} \leq 500$ V measuring voltage 100 V at room temperature $U_{NDC} > 500$ V measuring voltage 500 V at room temperature Duration: 1 min	See specific reference data
<b>TYPE TESTS</b>		
5.14.2 External inspection	Check for finish, marking and overall dimensions	Legible marking and finish as specified Dimensions: See specification drawing
5.14.0 Initial measurements	Capacitance at 1 kHz tan $\delta$ at 10 kHz	
5.14.1-1/4 Robustness of terminations IEC 60068-2-21	Tensile $U_{a1}$ Wire diameter    Section modulus    Load $\leq 0.8$ mm $\leq 0.5$ mm <sup>2</sup> 10 N $\leq 1.25$ mm $\leq 1.2$ mm <sup>2</sup> 20 N Duration: 10 s $\pm$ 1 s Bending, $U_b$ method 1 Wire diameter    Section modulus    Load $\leq 0.8$ mm $\leq 0.5$ mm <sup>2</sup> 10 N $\leq 1.25$ mm $\leq 1.2$ mm <sup>2</sup> 20 N 4 x 90°, duration: 2 s to 3 s/bend	
5.14.1-6 Resistance to soldering heat IEC 60068-2-20	No pre-drying, method 1A Solder bath: 260 °C $\pm$ 5 °C Duration: 10 s $\pm$ 1 s	
5.14.4 Final measurements	Capacitance tan $\delta$	$ \Delta C/C  \leq 0.5$ % Increase of tan $\delta \leq 0.0050$ compared to the values measured in 5.14.0
5.14.0 Initial measurements	Capacitance at 1 kHz tan $\delta$ at 10 kHz	
5.14.3-1 Vibration IEC 60068-2-6	10 Hz to 55 Hz; amplitude $\pm 0.35$ mm or acceleration 98 m/s <sup>2</sup> Test duration: 10 frequency cycles 3 axes offset from each other by 90° 1 octave/min Visual examination	No visible damage



INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
5.14.3-2 Shock or impact IEC 60068-2-6  5.14.4 Final measurements	Pulse shape: half sine Acceleration: 490 m/s <sup>2</sup> Duration of pulse: 11 ms Visual examination  Capacitance tan δ	No visible damage  $ \Delta C/C  \leq 0.5\%$ Increase of tan δ ≤ 0.0050 compared to the values measured in 5.14.0
5.5.3-1 Initial measurements  5.5.3-2 Voltage test between terminals  5.5.3-3 Final measurements	Capacitance at 1 kHz tan δ at 10 kHz R insulation  1.5 x U <sub>NDC</sub> at T <sub>amb</sub> Duration: 60 s  Capacitance tan δ R insulation	$ \Delta C/C  \leq 0.5\%$ Increase of tan δ ≤ 0.0050 R insulation ≤ 50 % of specified values
5.9-1 Initial measurements  5.9-2 Surge discharge test  5.9-2 Voltage test between terminals  5.9-3 Final measurements	Capacitance at 1 kHz tan δ at 10 kHz  1.1 x U <sub>NDC</sub> Number of discharges: 5 Time lapse: every 2 min (10 min total)  Within 5 min after the surge discharge test Duration: 60 s 1.5 x U <sub>NDC</sub> at T <sub>amb</sub>  Capacitance tan δ at 10 kHz	$ \Delta C/C  \leq 1.0\%$ tan δ ≤ 1.2 x initial tan δ + 0.0001 compared to the values measured in 5.9-1
5.11-1 Initial measurements  5.11-2 Self healing test  5.11-3 Final measurements	Capacitance at 1 kHz tan δ at 10 kHz  1.5 x U <sub>NDC</sub> Duration: 10 s Number of clearings ≤ 5 Clearing = Voltage drop of 5 % increase the voltage at 100 V/s till 5 clearings occur with a max. of 2.5 x U <sub>NDC</sub> for a duration of 10 s  Capacitance tan δ	$ \Delta C/C  \leq 0.5\%$ tan δ ≤ 1.2 x initial tan δ + 0.0001 compared to the values measured in 5.11-1



INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
5.13-0 Initial measurements  5.13-1 Change of temperature according to IEC 60682-2-14  5.13-2 Damp heat steady state according to IEC 60682-2-78  5.5.3-2 Voltage test between terminals  5.13-3 Final measurements	Capacitance at 1 kHz tan δ at 10 kHz  Test Nb T <sub>max.</sub> = 85 °C T <sub>min.</sub> = - 40 °C Transition time: 1 h, equivalent to 1 °C/min 5 cycles  Test Ca T <sub>max.</sub> = 40 °C + 2 °C RH = 93 % ± 3 % Duration: 56 days  1.5 x U <sub>NDC</sub> at ambient temperature Duration: 60 s  Visual examination  Capacitance tan δ at 1 V <sub>RMS</sub> 10 kHz	No puncturing or flashover Self healing punctures are permitted  $ \Delta C/C  \leq 2.0 \%$ Increase of tan δ ≤ 0.0150 compared to the values measured in 5.13-0
5.10.0 Initial measurements  5.10-1 Thermal stability test under overload conditions  5.10-2 Final measurements	Capacitance at 1 kHz tan δ at 10 kHz  Natural cooling T <sub>amb</sub> ± 5 °C $1.21 \times P_{max.} = (U_2/2) \times W_2 \times C \times \tan \delta =$ $1.21 \times (I_{max.}^2/W_2 \times C) \times \tan \delta$ with $W_2 = 2 \times p \times f_2$ for I <sub>max.</sub> (see specific reference data) f <sub>2</sub> = 10 kHz Duration: 48 h  Measure the temperature every 1.5 h during the last 6 h	Temperature rise ≤ 1 °C $ \Delta C/C  \leq 2.0 \%$ Increase of tan δ ≤ 1.2 x initial δ + 0.0150
5.12 Resonance frequency measurement	Impedance analyser at T <sub>amb</sub>	< 0.9 times the value as specified in typical curve "Resonant frequency" of this specification



INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
5.15-0 Initial measurements  5.15-1 Endurance test between terminals  5.15-2 Final measurement	Capacitance at 1 kHz tan $\delta$ at 10 kHz  Sequence: 1.3 x U <sub>NDC</sub> at 85 °C 1.3 x U <sub>OPDC</sub> at 105 °C  Duration: 500 h  1000 x discharge at 1.4 x I <sub>peak</sub> (maximum respective peak current in continuous operation)  1.3 x U <sub>NDC</sub> at 85 °C 1.3 x U <sub>OPDC</sub> at 105 °C  Duration: 500 h	          $ \Delta C/C  \leq 3.0 \%$ Increase of tan $\delta \leq 0.0150$ compared to the values measured in 5.15-0
5.16.3-0 Initial measurements  5.16.3-1 Destruction test sequence High DC voltage test  High AC voltage test  5.16.3-2 Final measurements	Capacitance at 1 kHz  T <sub>max.</sub> = 85 °C Product enveloped with cheese cloth 3 x U <sub>NDC</sub> for DC voltage until repetitive product healings occur Duration = 15 min  AC RMS voltage = U <sub>NDC</sub> /2 $\sqrt{2}$ with minimum of 250 V <sub>AC</sub> Duration = 5 min Repeat destruction sequence 3 x  Visual examination	          Audible healings or check healings with oscilloscope          No puncturing, flashover or burning of the cheese cloth Self healing punctures are permitted

**Note**

- Sub-clause numbers of tests and performance requirements refer to the “Sectional Specification, IEC-publication 61071”



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