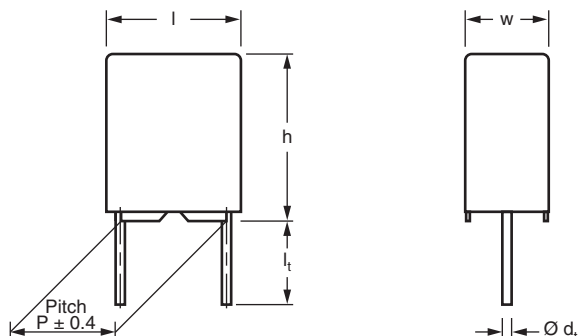


## Interference Suppression Film Capacitors MKT Radial Potted Type



Dimensions in mm

### APPLICATIONS

High stability grade for continuous across the line X2 applications.

See also "Application Note":  
[www.vishay.com/doc?28153](http://www.vishay.com/doc?28153)

### REFERENCE STANDARDS

IEC 60384-14 ed-3 and EN 60384-14  
"IEC 60065 pass. flamm. class C"  
UL 1283  
UL 1414  
CSA-E384-14

### MARKING

C-value; tolerance; rated voltage; sub-class; manufacturer's type; code for dielectric material; manufacturer location; manufacturer's logo; year and week; safety approvals

### DIELECTRIC

Polyester film

### ELECTRODES

Metallized

### CONSTRUCTION

Series construction



### RATED VOLTAGE

AC 310 V; 50 Hz to 60 Hz

### FEATURES

- 15 mm to 37.5 mm lead pitch
- AEC-Q200 qualified for C ≤ 470 nF
- Supplied loose in box, taped on reel
- Compliant to RoHS Directive 2002/95/EC

### PERMISSIBLE DC VOLTAGE

DC 800 V<sub>DC</sub> at 85 °C  
DC 630 V<sub>DC</sub> at 110 °C

### ENCAPSULATION

Plastic case, epoxy resin sealed, flame retardant UL-class 94 V-0

### CLIMATIC TESTING CLASS ACC. TO IEC 60068-1

40/110/56/C

### CAPACITANCE RANGE (E12 SERIES)

E12 series 0.01 µF to 2.2 µF  
Preferred values acc. to E6

### CAPACITANCE TOLERANCE

± 10 %, ± 20 % (± 5 % on request)

### LEADS

Tinned wire

### MAXIMUM APPLICATION TEMPERATURE

110 °C

### DETAIL SPECIFICATION

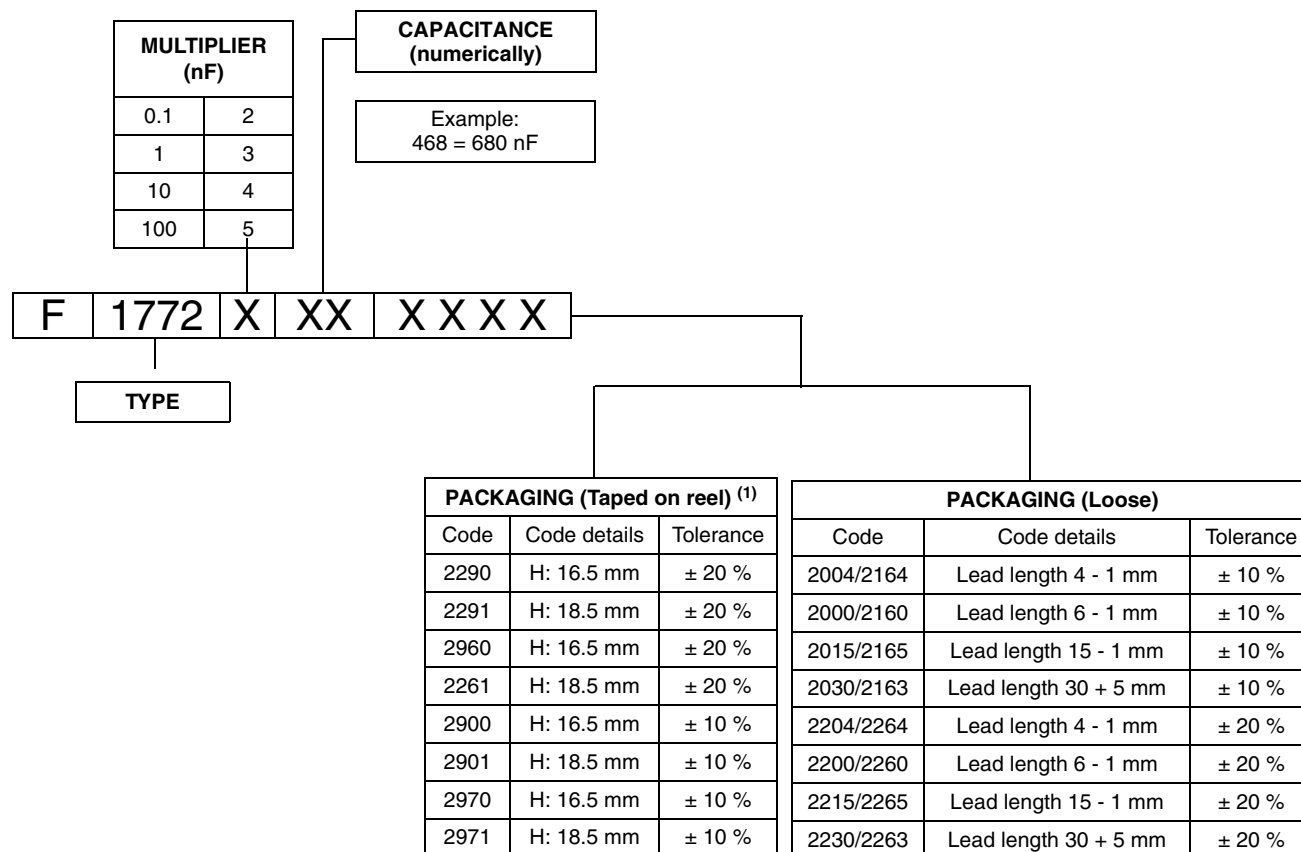
For more detailed data and test requirements contact:  
[RFI@vishay.com](mailto:RFI@vishay.com)



# Vishay BCcomponents Interference Suppression Film Capacitors

## MKT Radial Potted Type

### COMPOSITION OF CATALOG NUMBER



#### Notes

- For detailed tape specifications refer to "Packaging Information" [www.vishay.com/doc?28139](http://www.vishay.com/doc?28139)

<sup>(1)</sup> Taped on reel pitch ≥ 27.5 mm is not available

### SPECIFIC REFERENCE DATA

DESCRIPTION	VALUE
Rated AC voltage ( $U_{RAC}$ )	310 V
Permissible DC voltage ( $U_{RDC}$ )	630 V
Tangent of loss angle	$\leq 100 \times 10^{-4}$ at 1 kHz
Rated voltage pulse slope at $(dU/dt)_R$ 435 $V_{DC}$	100 V/ $\mu$ s
R between leads, for $C \leq 0.33 \mu F$ at 100 V; 1 min	$> 15\,000\,M\Omega$
RC between leads, $C > 0.33 \mu F$ at 100 V; 1 min	$> 5000\,s$
R between leads and case; 100 V; 1 min	$> 30\,000\,M\Omega$
Withstanding (DC) voltage (cut off current 10 mA) <sup>(1)</sup> ; rise time $\leq 1000\,V/s$	
$C \leq 0.47 \mu F$	2200 V; for 1 min
$C > 0.47 \mu F$	2150 V; for 1 min
Withstanding (AC) voltage between leads and case	2120 V; 1 min
Maximum application temperature	110 °C

#### Note

<sup>(1)</sup> See "Voltage Proof Test for Metalized Film Capacitors": [www.vishay.com/doc?28139](http://www.vishay.com/doc?28139)

**Interference Suppression Film Capacitors  
MKT Radial Potted Type****Vishay BCcomponents****C-tol. = ± 10 %**

CAPACITANCE (µF)	PITCH (mm)	DIMENSIONS w x h x l MAX. (mm)	MASS <sup>(3)</sup> (g)	SPQ (pieces) SHORT LEAD	ORDERING CODE <sup>(1)(2)</sup>
<b>d<sub>t</sub> = 0.60 mm ± 0.06 mm</b>					
0.010	15	5.0 x 11.0 x 17.5	1.4	750	F177231020..
0.012	15	5.0 x 11.0 x 17.5	1.4	750	F177231220..
0.015	15	5.0 x 11.0 x 17.5	1.4	750	F177231520..
0.018	15	5.0 x 11.0 x 17.5	1.4	750	F177231820..
0.022	15	5.0 x 11.0 x 17.5	1.4	750	F177232220..
0.027	15	5.0 x 11.0 x 17.5	1.4	750	F177232720..
0.033	15	5.0 x 11.0 x 17.5	1.4	750	F177233320..
0.039	15	6.0 x 12.0 x 17.5	2.0	500	F177233920..
0.047	15	6.0 x 12.0 x 17.5	2.0	500	F177234720..
0.056	15	6.0 x 12.0 x 17.5	2.0	500	F177235620..
<b>d<sub>t</sub> = 0.80 mm ± 0.08 mm</b>					
0.068	15	7.0 x 13.5 x 17.5	2.4	450	F177236820..
0.082	15	8.5 x 15.0 x 17.5	2.7	300	F177238220..
0.10	15	8.5 x 15.0 x 17.5	2.7	325	F177241020..
0.12	15	8.5 x 15.0 x 17.5	2.7	300	F177241220..
0.15	15	8.5 x 15.0 x 17.5	2.7	300	F1772415216.
0.15	22.5	7.0 x 16.5 x 26.0	4.1	235	F177241520..
0.18	22.5	7.0 x 16.5 x 26.0	4.1	235	F177241820..
0.22	15	10.0 x 16.5 x 17.5	3.0	235	F1772422216.
0.22	22.5	8.5 x 18.0 x 26.0	4.6	200	F177242220..
0.27	22.5	10.0 x 19.5 x 26.0	6.7	170	F177242720..
0.33	15	13.5 x 22.5 x 18.0	5.5	185	F1772433216.
0.33	22.5	10.0 x 19.5 x 26.0	6.7	170	F177243320..
0.39	27.5	11.0 x 21.0 x 31.0	9.1	125	F177243920..
0.47	22.5	12.0 x 22.0 x 26.0	13.0	110	F17724472160
0.47	27.5	11.0 x 21.0 x 31.0	9.1	125	F177244720..
0.56	27.5	11.0 x 21.0 x 31.0	9.1	125	F177245620..
0.68	22.5	15.5 x 26.5 x 26.5	13.5	110	F1772468216.
0.68	27.5	13.0 x 23.0 x 31.0	12.9	110	F177246820..
0.82	27.5	13.0 x 23.0 x 31.0	12.9	110	F177248220..
1.0	22.5	15.5 x 26.5 x 26.5	13.5	110	F1772510216.
1.0	27.5	15.0 x 25.0 x 31.5	15.0	100	F177251020..
1.2	37.5	14.5 x 24.5 x 41.5	18.9	80	F177251220..
1.5	27.5	18.0 x 28.0 x 31.0	19.0	85	F1772515216.
1.5	37.5	15.5 x 28.5 x 41.5	24.0	70	F177251520..
1.8	37.5	15.5 x 28.5 x 41.5	24.0	70	F177251820..
2.2	27.5	21.0 x 31.0 x 31.0	28.0	70	F1772522216.
2.2	37.5	18.0 x 32.5 x 41.5	31.6	60	F177252220..

**Notes**

<sup>(1)</sup> These capacitors can be delivered on continuous tape and reel.

The ordering code is:

F1772-...-2900 at H = 16.5 mm

F1772-...-2901 at H = 18.5 mm

F1772-...-2970 at H = 16.5 mm

F1772-...-2971 at H = 18.5 mm

<sup>(2)</sup> Further information about packaging quantities with different lead length and/or taped versions, see document “Packaging Quantities”  
[www.vishay.com/doc?27608](http://www.vishay.com/doc?27608)

<sup>(3)</sup> Weight for short lead product only

• SPQ = Standard Packing Quantity

• For detailed tape specifications refer to packaging information: [www.vishay.com/doc?28139](http://www.vishay.com/doc?28139)

# Vishay BCcomponents Interference Suppression Film Capacitors MKT Radial Potted Type

C-tol. = ± 20 %

CAPACITANCE (μF)	PITCH (mm)	DIMENSIONS w x h x l MAX. (mm)	MASS (g)	SPQ (pieces) SHORT LEAD	ORDERING CODE <sup>(1)(2)</sup>
<b>d<sub>t</sub> = 0.60 mm ± 0.06 mm</b>					
0.01	15	5.0 x 11.0 x 17.5	1.4	750	F177231022..
0.015	15	5.0 x 11.0 x 17.5	1.4	750	F177231522..
0.022	15	5.0 x 11.0 x 17.5	1.4	750	F177232222..
0.033	15	5.0 x 11.0 x 17.5	1.4	750	F177233322..
0.047	15	5.0 x 11.0 x 17.5	1.4	750	F177234722..
0.068	15	6.0 x 12.0 x 17.5	2.0	600	F177236822..
0.10	15	6.0 x 12.0 x 17.5	2.0	600	F177241022..
<b>d<sub>t</sub> = 0.80 mm ± 0.08 mm</b>					
0.15	15	8.5 x 15.0 x 17.5	2.7	325	F1772415226..
0.15	22.5	6.0 x 15.5 x 26.0	3.3	260	F177241522...
0.22	15	10.0 x 16.5 x 17.5	4.5	300	F1772422226..
0.22	22.5	7.0 x 16.5 x 26.0	4.1	235	F177242222...
0.33	15	13.5 x 22.5 x 18.0	5.5	185	F1772433226..
0.33	22.5	8.5 x 18.0 x 26.0	5.3	190	F177243322..
0.47	22.5	10.0 x 19.5 x 26.0	6.7	170	F1772447226..
0.47	27.5	9.0 x 19.0 x 31.5	6.8	160	F177244722..
0.68	22.5	12.0 x 22.0 x 26.0	13.4	110	F1772468226..
0.68	27.5	11.0 x 21.0 x 31.0	12.9	125	F177246822..
1.0	22.5	15.5 x 26.5 x 26.5	13.5	110	F1772510226..
1.0	27.5	15.0 x 25.0 x 31.5	15.0	100	F177251022..
1.5	27.5	18.0 x 28.0 x 31.5	19.0	85	F1772515226..
1.5	37.5	14.5 x 24.5 x 41.5	18.9	80	F177251522..
2.2	27.5	21.0 x 31.0 x 31.0	28.0	70	F1772522226..
2.2	37.5	15.5 x 28.5 x 41.5	24.0	70	F177252222..

**Notes**

(1) These capacitors can be delivered on continuous tape and reel

The ordering code is:

F 1772-...-2290 at H = 16.5 mm

F 1772-...-2291 at H = 18.5 mm

F 1772-...-2960 at H = 16.5 mm




F 1772-...-2961 at H = 18.5 mm

(2) Further information about packing quantities with different lead length and/or taped versions, see document "Packing Quantities"

[www.vishay.com/docs?27608](http://www.vishay.com/docs?27608)

• SPQ = Standard Packing Quantity

• For detailed tape specifications refer to Packaging Information: [www.vishay.com/doc?28139](http://www.vishay.com/doc?28139)**APPROVALS**

SAFETY APPROVALS X2	VOLTAGE	VALUE	FILE NUMBERS
EN 60384-14 (ENEC) (= IEC 60384-14 ed 3)	310 V <sub>AC</sub>	0.01 - 2.2 μF X2	40005079
UL 1414	250 V <sub>AC</sub>	0.01 - 1.0 μF X2	E 100682
UL 1283	250 V <sub>AC</sub>	0.01 - 2.2 μF X2	E 76297
CSA-E 384-14	310 V <sub>AC</sub>	0.01 - 2.2 μF X2	2127723
CB TEST-CERTIFICATE	310 V <sub>AC</sub>	0.01 - 2.2 μF X2	DE 1-40110/A1
The ENEC-approval together with the CB-Certificate replace all national marks of the following countries (they have already signed the ENEC-Agreement): Austria; Belgium; Czech. Republic; Denmark; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Luxembourg; Netherlands; Norway; Portugal; Slovenian; Spain; Sweden; Switzerland and United Kingdom.			
  			

## 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".

### Specific Method of Mounting to Withstand Vibration and Shock

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

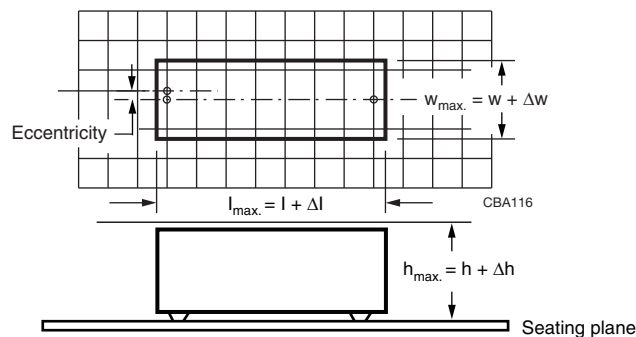
- For pitches  $\leq 15$  mm capacitors shall be mechanically fixed by the leads
- For larger pitches the capacitors shall be mounted in the same way and the body clamped

### Space Requirements on Printed Circuit Board

The maximum space for length ( $l_{max.}$ ), width ( $w_{max.}$ ) and height ( $h_{max.}$ ) of film capacitors to take in account on the printed circuit board is shown in the drawings.

- For products with pitch  $\leq 15$  mm,  $\Delta w = \Delta l = 0.3$  mm;  $\Delta h = 0.1$  mm
- For products with  $15 \text{ mm} < \text{pitch} \leq 27.5$  mm,  $\Delta w = \Delta l = 0.5$  mm;  $\Delta h = 0.1$  mm
- For products with pitch = 37.5 mm,  $\Delta w = \Delta l = 0.7$  mm;  $\Delta h = 0.5$  mm

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



## SOLDERING CONDITIONS

For general soldering conditions and wave soldering profile, we refer to the application note:

“Soldering Guidelines for Film Capacitors”: [www.vishay.com/doc?28171](http://www.vishay.com/doc?28171)

### Storage Temperature

- Storage temperature:  $T_{stg} = -25$  °C to  $+40$  °C with RH maximum 80 % without condensation

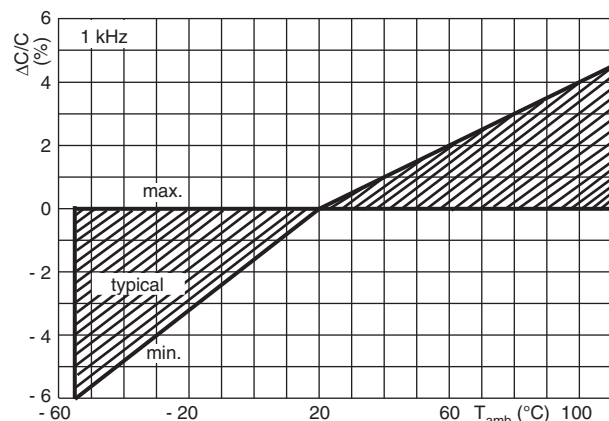
### Ratings and Characteristics Reference Conditions

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

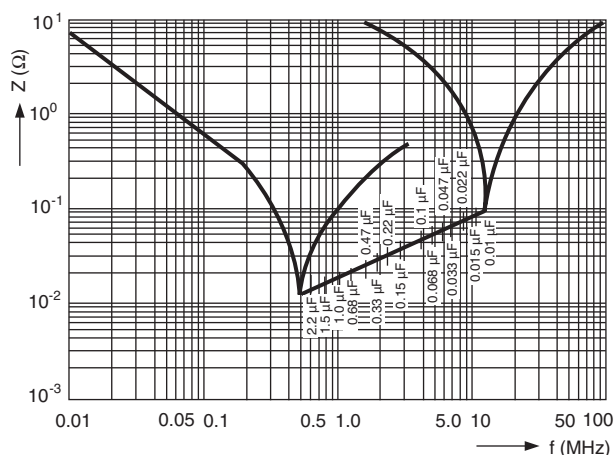
For reference testing, a conditioning period shall be applied over  $96$  h  $\pm 4$  h by heating the products in a circulating air oven at the rated temperature and a relative humidity not exceeding 20 %.

**CHARACTERISTICS**

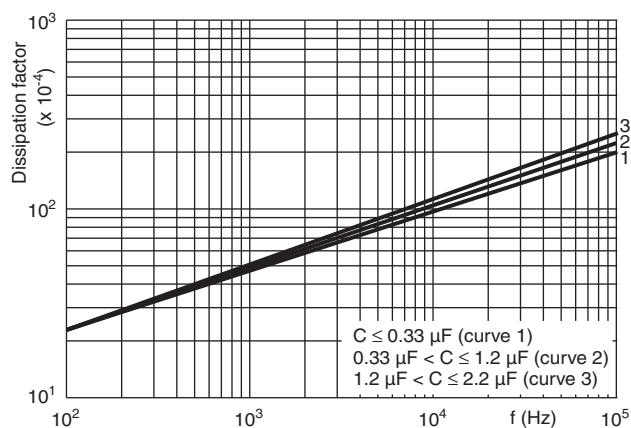
Capacitance as a function of ambient temperature (typical curve)



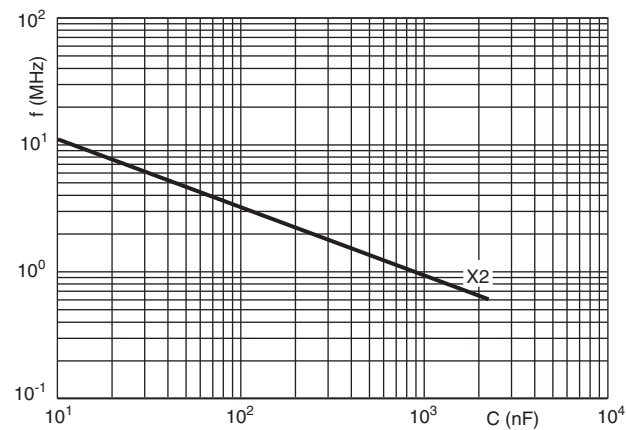
Impedance as a function of frequency (typical curve)



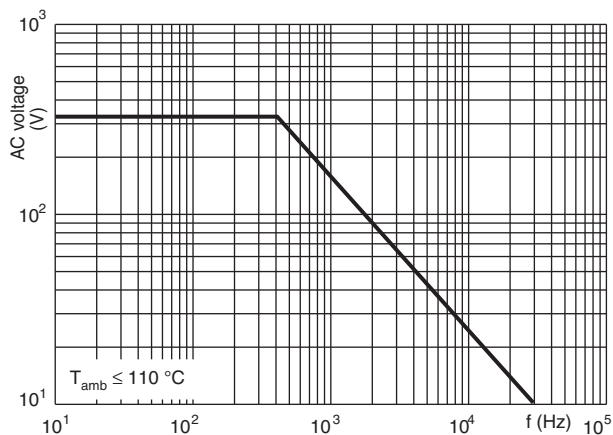
Tangent of loss angle as a function of frequency (typical curve)



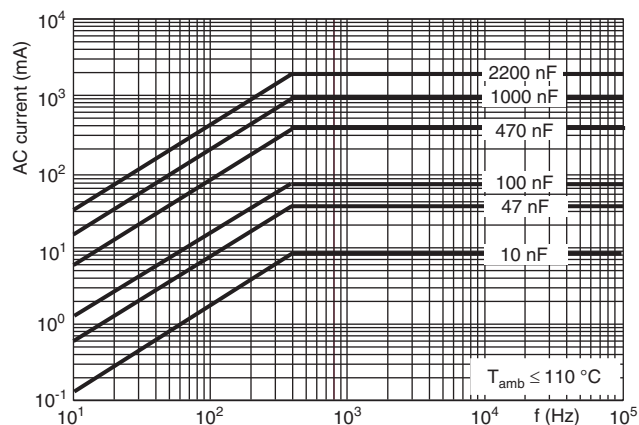
Resonant frequency as a function of capacitance (typical curve)



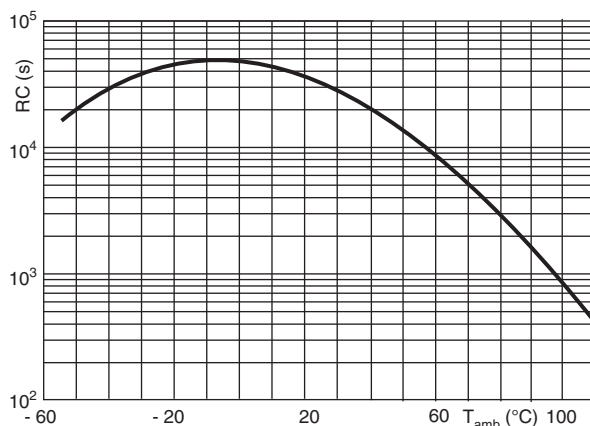
Max. RMS voltage as a function of frequency



Max. RMS current as a function of frequency



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



## APPLICATION NOTES AND LIMITING CONDITIONS

- For X2 electromagnetic interference suppression where a higher stability grade is needed for **continuous across the line applications** (50 Hz/60 Hz) with a maximum mains voltage of 310 V<sub>AC</sub>.
- These capacitors are not intended for continuous pulse application. For these situations capacitors of the AC and pulse programs must be used.
- For series impedance applications we refer to application note: [www.vishay.com/doc?28153](http://www.vishay.com/doc?28153)
- The maximum ambient temperature must not exceed 110 °C.
- Rated voltage pulse slope:  
If the pulse voltage is lower than the rated voltage, the values of the specific reference data can be multiplied by 435 V<sub>DC</sub> and divided by the applied voltage.

## INSPECTION REQUIREMENTS

### General Notes:

Sub-clause numbers of tests and performance requirements refer to the “Sectional Specification, Publication IEC 60384-14 ed 3 and Specific Reference Data”.

### Group C Inspection Requirements

SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
<b>SUB-GROUP C1A PART OF SAMPLE OF SUB-GROUP C1</b>		
4.1 Dimensions (detail)  Initial measurements	Capacitance Tangent of loss angle: For C ≤ 1 μF at 10 kHz For C > 1 μF at 1 kHz	As specified in chapter “General Data” of this specification
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	No pre-drying Method: 1A Solder bath: 280 °C ± 5 °C Duration: 10 s	

# Vishay BCcomponents Interference Suppression Film Capacitors

## MKT Radial Potted Type

SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
<b>SUB-GROUP C1A PART OF SAMPLE OF SUB-GROUP C1</b>		
4.19 Component solvent resistance	Isopropylalcohol at room temperature Method: 2 Immersion time: 5 ± 0.5 min Recovery time: Min. 1 h, max. 2 h	No visible damage Legible marking  $ \Delta C/C  \leq 5\%$ of the value measured initially  Increase of $\tan \delta$ $\leq 0.008$ for: $C \leq 1 \mu F$ or $\leq 0.005$ for: $C > 1 \mu F$ Compared to values measured initially As specified in section "Insulation Resistance" of this specification
4.4.2 Final measurements	Visual examination	
	Capacitance	
	Tangent of loss angle	
	Insulation resistance	
<b>SUB-GROUP C1B PART OF SAMPLE OF SUB-GROUP C1</b>		
Initial measurements	Capacitance Tangent of loss angle: For $C \leq 1 \mu F$ at 10 kHz For $C > 1 \mu F$ at 1 kHz	No visible damage Legible marking
4.20 Solvent resistance of the marking	Isopropylalcohol at room temperature Method: 1 Rubbing material: Cotton wool Immersion time: 5 min ± 0.5 min	
4.6 Rapid change of temperature	$\theta A = -40^\circ C$ $\theta B = +110^\circ C$ 5 cycles Duration $t = 30$ min	
4.6.1 Inspection	Visual examination	
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/s <sup>2</sup> (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/s <sup>2</sup> Duration of pulse: 11 ms	
4.9.2 Final measurements	Visual examination	
	Capacitance	No visible damage  $ \Delta C/C  \leq 5\%$ of the value measured initially  Increase of $\tan \delta$ $\leq 0.008$ for: $C \leq 1 \mu F$ or $\leq 0.005$ for: $C > 1 \mu F$ Compared to values measured initially As specified in section "Specific Reference" of this specification
	Tangent of loss angle	
	Insulation resistance	

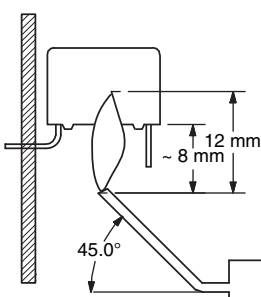


**Interference Suppression Film Capacitors  
MKT Radial Potted Type****Vishay BCcomponents**

SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
<b>SUB-GROUP C1 COMBINED SAMPLE OF SPECIMENS OF SUB-GROUPS C1A AND C1B</b>		
4.11 Climatic sequence	Capacitance	
4.11.1 Initial measurements	Measured in 4.4.2 and 4.9.2 Tangent of loss angle Measured initially in C1A and C1B	
4.11.2 Dry heat	Temperature: 110 °C Duration: 16 h	
4.11.3 Damp heat cyclic Test Db, first cycle		
4.11.4 Cold	Temperature: - 40 °C Duration: 2 h	
4.11.5 Damp heat cyclic Test Db, remaining cycles		
4.11.6 Final measurements	Visual examination  Capacitance  Tangent of loss angle   Voltage proof 1350 V <sub>DC</sub> 1 min between terminations Insulation resistance	No visible damage Legible marking $ \Delta C/C  \leq 5\%$ of the value measured in 4.11.1  Increase of $\tan \delta$ $\leq 0.008$ for: $C \leq 1 \mu\text{F}$ or $\leq 0.005$ for: $C > 1 \mu\text{F}$ Compared to values measured in 4.11.1 No permanent breakdown or flash-over  $\geq 50\%$ of values specified in section "Insulation Resistance" of this specification
<b>SUB-GROUP C2</b>		
4.12 Damp heat steady state	56 days, 40 °C, 90 % to 95 % RH No load	
4.12.1 Initial measurements	Capacitance Tangent of loss angle: 1 kHz	
4.12.3 Final measurements	Visual examination  Capacitance  Tangent of loss angle   Voltage proof 1350 V <sub>DC</sub> ; 1 min between terminations Insulation resistance	No visible damage Legible marking $ \Delta C/C  \leq 5\%$ of the value measured in 4.12.1  Increase of $\tan \delta$ $\leq 0.008$ for: $C \leq 1 \mu\text{F}$ or $\leq 0.005$ for: $C > 1 \mu\text{F}$ Compared to values measured in 4.12.1 No permanent breakdown or flash-over  $\geq 50\%$ of values specified in section "Insulation Resistance" of this specification
<b>SUB-GROUP C3</b>		
4.13.1 Initial measurements	Capacitance Tangent of loss angle: For $C \leq 1 \mu\text{F}$ at 10 kHz For $C > 1 \mu\text{F}$ at 1 kHz	
4.13 Impulse voltage	3 successive impulses, full wave, peak voltage: X2: 2.5 kV for $C \leq 1 \mu\text{F}$ X2: 2.5 kV/ $\sqrt{C}$ for $C > 1 \mu\text{F}$ Max. 24 pulses	No self healing breakdowns or flash-over

Vishay BCcomponents Interference Suppression Film Capacitors  
MKT Radial Potted Type

SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
<b>SUB-GROUP C3</b>		
4.14 Endurance	Duration: 1000 h 1.25 x U <sub>RAC</sub> at 110 °C Once in every hour the voltage is increased to 1000 V (RMS) for 0.1 s via resistor of 47 Ω ± 5 %	
4.14.7 Final measurements	Visual examination  Capacitance  Tangent of loss angle  Voltage proof 1350 V <sub>DC</sub> ; 1 min between terminations 2120 V <sub>AC</sub> ; 1 min between terminations and case  Insulation resistance	No visible damage Legible marking   ΔC/C  ≤ 5 % compared to values measured in 4.13.1  Increase of tan δ ≤ 0.008 for: C ≤ 1 μF or ≤ 0.005 for: C > 1 μF Compared to values measured in 4.13.1  No permanent breakdown or flash-over  ≥ 50 % of values specified in section "Insulation Resistance" of this specification
<b>SUB-GROUP C4</b>		
4.15 Charge and discharge	10 000 cycles Charged to 435 V <sub>DC</sub> Discharge resistance: $R = \frac{435 \text{ V}_{DC}}{1.5 \times C(dU/dt)}$	
4.15.1 Initial measurements	Capacitance Tangent of loss angle: For C ≤ 1 μF at 10 kHz For C > 1 μF at 1 kHz	
4.13.3 Final measurements	Capacitance  Tangent of loss angle  Insulation resistance	ΔC/C  ≤ 10 % compared to values measured in 4.15.1  Increase of tan δ ≤ 0.008 for: C ≤ 1 μF or ≤ 0.005 for: C > 1 μF Compared to values measured in 4.15.1  ≥ 50 % of values specified in section "Insulation Resistance" of this specification
<b>SUB-GROUP C5</b>		
4.16 Radio frequency characteristic	Resonance frequency	≥ 0.9 times the value as specified in section "Resonant Frequency" of this specification.

SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
<b>SUB-GROUP C6</b>		
4.17 Passive flammability Class C	<p>Bore of gas jet: <math>\varnothing 0.5</math> mm  Fuel: Butane  Test duration for actual volume V in mm<sup>3</sup>:  <math>V \leq 250</math>: 5 s  <math>250 &lt; V \leq 500</math>: 10 s  <math>500 &lt; V \leq 1750</math>: 20 s  <math>V &gt; 1750</math>: 30 s  One flame application</p> 	After removing test flame from capacitor, the capacitor must not continue to burn for more than 30 s. No burning particle must drop from the sample
<b>SUB-GROUP C7</b>		
4.18 Active flammability	20 cycles of 2.5 kV discharges on the test capacitor connected to $U_{RAC}$	The cheese cloth around the capacitors shall not burn with a flame No electrical measurements are required



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