Film Capacitors

FILM CAPACITORS

Plastic film capacitors are generally subdivided into film/foil capacitors and metalized film capacitors.

FILM / FOIL CAPACITORS

Film / foil capacitors basically consist of two metal foil electrodes that are separated by an insulating plastic film also called dielectric. The terminals are connected to the end-faces of the electrodes by means of welding or soldering.

Main features:
High insulation resistance, excellent current carrying and pulse handling capability and a good capacitance stability.

METALIZED FILM CAPACITORS

The electrodes of metalized film capacitors consist of an extremely thin metal layer (0.02 µm to 0.1 µm) that is vacuum deposited either onto the dielectric film or onto a carrier film. The opposing and extended metalized film layers of the wound capacitor element are connected to one another by flame spraying different metals to the end-faces. The metal spraying process is also known as schooping. The terminals are connected to the end-faces by means of welding or soldering. For the production of metalized film capacitors Vishay film capacitors uses the conventionally wound film.

Main features:
High volume efficiency, self-healing properties

SPECIAL DESIGN CAPACITORS

For high current applications Vishay film capacitors is also able to offer special designs such as capacitors with a heavy edge metalization or a double sided metalization as well as combinations that have a film/foil and a metalized film design in one unit. For high voltage applications it is furthermore possible to offer designs with dual and multiple sections. Depending on the design these capacitors provide low losses, high current and pulse carrying capabilities, high voltages, small dimensions and good self-healing properties.

RFI SUPPRESSION CAPACITORS

There are two main sources of Radio Frequency Interference (RFI). Devices that due to their construction produce RF energy, such as oscillators, radio and TV receivers; and devices that produce a wide spectrum of frequency, due to rapid variations in electrical current intensity, such as switch mode power supplies.

Interference from source to receiver is spread in three ways:

- Along wiring
- By coupling
- By radiation

RFI suppression capacitors are the most effective way to reduce RF energy interference. As its impedance decrease with frequency, it acts as a short-circuit for high-frequencies between the mains terminals and/or between the mains terminals and the ground.

Capacitors for applications between the mains terminals are called X Class capacitors. Capacitors for applications between the terminals and the ground are called Y Class capacitors.

X-Capacitors
For the suppression of symmetrical interference voltage. Capacitors with unlimited capacitance for use where their failure will not lead to the danger of electrical shock on human beings and animals. The capacitor must present a safe end of life behavior.

Y-Capacitors
Capacitors for suppression of asymmetrical interference voltage, and are located between a live wire and a metal case which may be touched. High electrical and mechanical reliability to prevent short-circuits in the capacitors. The capacitance value is limited, in order to reduce the AC current flowing through the capacitor. By following these technical requirements, it is intended that its failure will not lead to the risk of electrical shock, making the device with Y capacitor (in conjunction with other protective measures) safe to human beings and animals.

For detailed information, we refer to www.vishay.com/doc?28153.

SELF-HEALING

Self-healing, also known as clearing, is the removal of a defect caused by pinholes, film flaws or external voltage transients. The heat generated by the arcing during a breakdown, evaporates the extremely thin metalization of the film around the point of failure, thereby removing and isolating the short circuit conditions. On Segmented Film Technology Capacitors, the self healing effect is more controlled. The film metalization is made by forming a pattern of segments, which are connected to each other by micro fuses. This limits the healing current and limits the self-healing effect to a well defined section of the film.

The self-healing process requires only µW of power and a defect is normally isolated in less than 10 µs. Extensive and continuous self-healing (e.g. at misapplications) will gradually decrease the capacitance value.

DIELECTRIC MATERIALS

The electrical characteristics of plastic film capacitors are to a great extent dictated by the properties of their dielectric materials. Vishay film capacitors uses the following film materials in their production:

POLYETHYLENE TEREPHTALATE FILM OR POLYESTER FILM (PET)

Polyester film offers a high dielectric constant, and a high dielectric strength. It has further excellent self-healing properties and good temperature stability. The temperature coefficient of the material is positive. Polyester capacitors are regarded as “general purpose capacitors”. They provide the best volume efficiency of all film capacitors at moderate cost and are preferably used for DC applications such as decoupling, blocking, bypassing and noise suppressions.

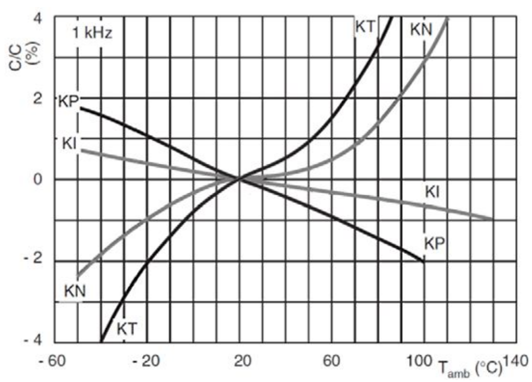
POLYPROPYLENE FILM (PP)

Polypropylene film has superior electrical characteristics.

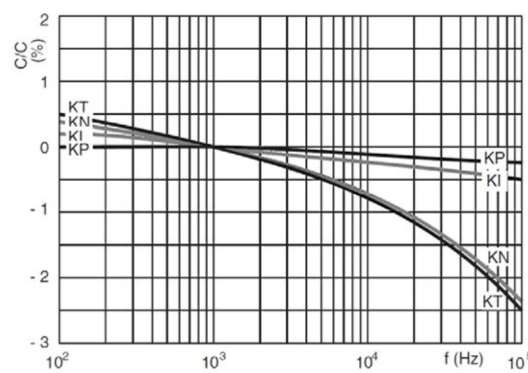
The film features very low dielectric losses, a high insulation resistance, a low dielectric absorption, and a very high dielectric strength. The film provides furthermore an excellent moisture resistance and a very good long-term stability. The temperature coefficient of the material is negative. Polypropylene capacitors are typically used in AC and pulse applications at high frequencies and in DC-Link capacitors. They are further used in switched mode power supplies, electronic ballasts and snubber applications, in frequency discrimination and filter circuits as well as in energy storage, and sample and hold applications.

DIELECTRIC PROPERTIES (TYPICAL VALUES)		
PARAMETER	PET	PP
Relative dielectric constant	3.2	2.2
DF at 1 kHz (tan δ in %)	0.5	0.02
IR (MΩ x μF)	25 000	100 000
Dielectric absorption (%)	0.2	0.05
Capacitance drift - ΔC/C (%)	1.5	0.5
Moisture absorption (%)	0.4	0.01
Maximum temperature (°C)	125	100
TC (ppm/°C)	+400, ± 200	-200, ± 100

CAPACITANCE

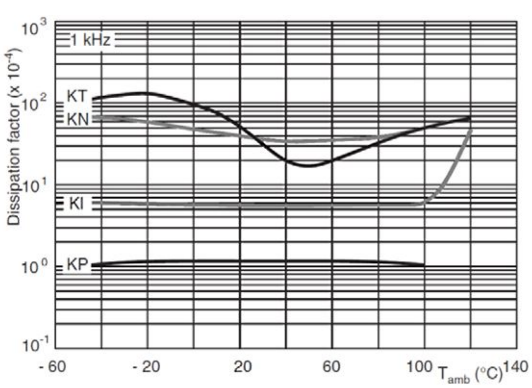


Capacitance change at 1 kHz as function of temperature (typical curve)

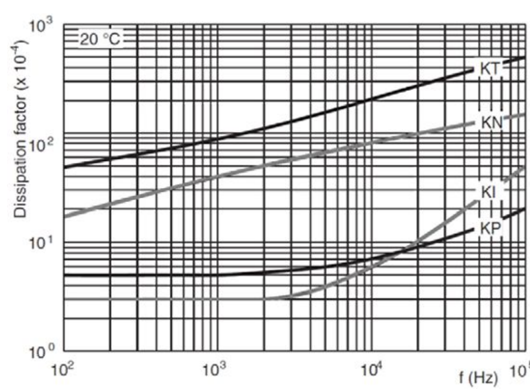


Capacitance change as a function of frequency at room temperature (typical curve)

DISSIPATION FACTOR

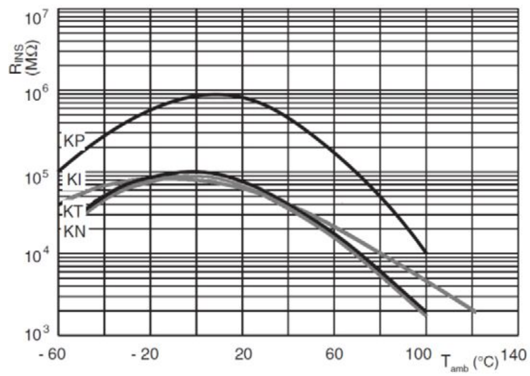


Dissipation factor as function of temperature (typical curve)



Dissipation factor as a function of frequency at room temperature (typical curve)

INSULATION RESISTANCE



Insulation resistance as a function of temperature (typical curve)

Notes

- Dielectrics according to IEC 60062:
  KT = Polyethylene terephthalate (PET)
  KP = Polypropylene (PP)
  KI = Polyphenylene sulfide (PPS)
  KN = Polyethylene naphtalate (PEN)
- Polyethylene terephthalate (PETP) and polyethylene naphtalate (PEN) films are generally used in general purpose capacitors for applications typically with small bias DC voltages and/or small AC voltages at low frequencies.
- Polyethylene terephthalate (PETP) has as its most important property, high capacitance per volume due to its high dielectric constant and availability in thin gauges.
- Polyethylene naphtalate (PEN) is used when a higher temperature resistance is required compared to PET.
- Polyphenylene sulfide (KI) film can be used in applications where high temperature is needed eventually in combination with low dissipation factor.
- Polypropylene (KP) films are used in high frequency or high voltage applications due to their very low dissipation factor and high dielectric strength. These films are used in AC and pulse capacitors and interference suppression capacitors for mains applications.
- Typical properties as functions of temperature or frequency are illustrated in the following chapters: “Capacitance”, “Dissipation factor”, and “Insulation resistance”.

DEFINITIONS

The following definitions apply to both film/foil capacitors and metalized film capacitors.

RATED VOLTAGE (U_R)

The rated voltage is the voltage for which the capacitor is designed. It is defined as the maximum DC (U_R) or AC (U_{RAC}) voltage or the pulse voltage that may continuously be applied to the terminals of a capacitor up to an operating temperature of + 85 °C. The rated voltage is dependent upon the property of the dielectric material, the film thickness and the operating temperature. Above + 85 °C, but without exceeding the maximum temperature, the rated voltage has to be derated in accordance to the dielectric material used.

TEST VOLTAGE OR DIELECTRIC STRENGTH

The test voltage of a capacitor is higher than the rated DC voltage and may only be applied for a limited time. The dielectric strength is measured between the electrodes with a test voltage of 1.5 x U_{NDC} for 10 s, at metalized film capacitors and of 2 x U_{NDC} at film/foil capacitors for typically 2 s. The occurrence of self-healing or clearing-effects during the application of the test voltage is permitted for metalized film capacitors.

AC VOLTAGE

The AC voltage ratings refer to clean sinusoidal voltages without transients. The capacitors must not, therefore, be operated in mains applications (e.g. across the line). This applies also to capacitors that are rated with AC voltages ≥ 250 V_{AC}. Capacitors especially designed for mains operations (X and Y capacitors) are listed as “RFI Capacitors”. For operations in the higher frequency range, the applied AC voltage has to be derated. The derated AC voltages are provided in the graphs “Permissible AC Voltage Versus Frequency” on the capacitor datasheet. The calculations of the graphs are based on the assumption that the temperature rise measured on the surface of the capacitor under working conditions does not exceed 10 °C.

$$P = U_{RMS}^2 \times \omega \times C \times \tan \delta$$

P - Dissipation power (W)
ω - Angular frequency (rads/s)
C - Capacitance (F)
tan δ - Dissipation factor at frequency (f)

$$\Delta T = \frac{P \times 1000}{A \times \alpha} = \frac{P \times 1000}{G}$$

ΔT - Temperature rise (°C)
A - Surface area of the capacitor (cm^2)
α - Heat transfer coeff. [mW/(°C x cm^2)]
(α = 0.96 for plastic boxes with a smooth surface)
G - Component heat conductivity (displayed in datasheet)

Heat coefficient for the capacitor is presented in datasheet for ΔT calculation.
For critical applications, please forward your voltage and current waveforms (worst case conditions) for our capacitor proposal.

MAXIMUM APPLICABLE PEAK TO PEAK RIPPLE VOLTAGE

When an AC voltage is superimposed to a DC voltage, the sum of both the DC voltage (U_{DC}) and the peak value of the AC voltage (U_{pk}) must not exceed the rated DC voltage (U_R) of the capacitor.

$$U_R \geq U_{DC} + U_{pk}$$

PULSE VOLTAGE

The RMS value of a pulse voltage ($U_{RMS(pulse)}$) must not exceed the rated AC voltage U_{RAC}.

$$U_{RAC} \geq U_{RMS(pulse)}$$

The peak value of the pulse voltage (U_{pk}) must not exceed the rated DC voltage.

$$U_R \geq U_{pk}$$

NOMINAL CAPACITANCE (C_N)

The nominal capacitance is defined as the capacitive part of an equivalent series circuit consisting of capacitance and equivalent series resistance (ESR). C_N is the capacitance for which the capacitor is designed. It's value is typically measured at a frequency of 1 kHz ± 20 %, at voltage of 0.03 x U_{RDC} (max. 5 V_{AC}) and a temperature of 20 °C.

The capacitance tolerance indicates the acceptable deviation from the rated capacitance at 20 °C. Since the dielectric constant of plastic film is frequency dependent, the capacitance value will decrease with increasing frequency. High relative humidity may increase the capacitance value. Capacitance changes due to moisture are reversible.

CAPACITANCE DRIFT (LONG TERM STABILITY)

In addition to reversible changes the capacitance of a capacitor is also subject to irreversible changes also known as capacitance drift. The capacitance drift is dependent upon the dielectric material. The drift decreases gradually over the time. Frequent and extreme temperature changes may accelerate the process.

TEMPERATURE COEFFICIENT (TC)

The temperature coefficient is the average capacitance change over a specified temperature range. It indicates how much the capacitance changes referred to 20 °C, if the temperature changes by 1 °C. The TC is typically expressed in ppm/°C (parts per million per °C). Depending upon the dielectric material the TC can either be positive, or negative.

$$TC = \frac{C_2 - C_1}{C_{20} \times (T_1 - T_2)}$$

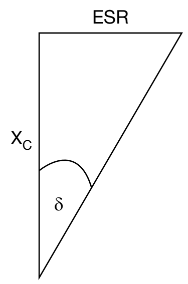
C_1 - Capacitance at temperature T_1

C_2 - Capacitance at temperature T_2

C_{20} - Reference capacitance at 20 °C ± 2 °C

DISSIPATION FACTOR (tan δ)

The dissipation factor (tan δ) is the ratio of the ESR to the capacitive reactance X_C (series capacitance) or the active power to the reactive power at a sinusoidal voltage of a specified frequency.



The tan δ reflects the polarization losses of the dielectric film and the losses caused by the contact resistance (terminals - schooping - electrodes) of the capacitor. Parallel losses can, due to the high insulation resistance of film capacitors, be neglected. The tan δ is temperature and frequency dependent.

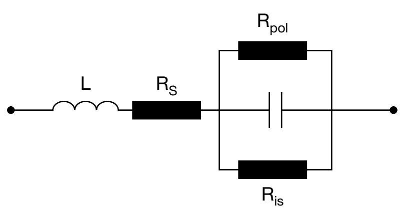
$$\tan\delta = \frac{ESR}{X_C}$$

The reciprocal value of tan δ is also known as Q-factor.

$$Q = \frac{1}{\tan\delta}$$

EQUIVALENT SERIES RESISTANCE (ESR)

The ESR is the ohmic part of an equivalent series circuit. Its value assumes all losses to be represented by a single resistance in series with the idealized capacitor.



The ESR comprises the polarization losses of the dielectric material (R_{pol}), the losses caused by the resistance of the leads, termination and electrodes (R_S) and the insulation resistance (R_{is}).

$$ESR = \frac{\tan\delta}{\omega \times C}$$

INSULATION RESISTANCE (R_{is}) AND TIME CONSTANT (τ)

The R_{is} is the ratio of an applied DC voltage to the resulting leakage current (flowing through the dielectric and over its body surface) after the initial charging current has ceased. The R_{is} is typically measured after one minute. ± 5 s at 20 °C and a relative humidity of 50 % ± 2 %.

$$R_{is} = \frac{U_{DC}}{I_{leack}}(\Omega)$$

The insulation resistance is determined by the property and the quality of the dielectric material and the capacitor's construction. The R_{is} decreases with increasing temperature. A high relative humidity may decrease the insulation resistance. R_{is} changes due to moisture are reversible. The R_{is} is shown as time constant (τ). It is the product of insulation resistance and capacitance and is expressed in seconds.

$$\tau = R_{is} \times C$$

INDUCTANCE (L)

The inductance of a capacitor depends upon the geometric design of the capacitor element and the length and the thickness of the contacting terminals. All Vishay film capacitors have an extended metalized film or foil construction and exhibit thus a very low inductance. The inductance of radial leaded capacitor types are typically measured with 2 mm long lead wires. Typical values are less than 1.0 nH per mm of lead length.

RESONANT FREQUENCY (f_r)

The resonant frequency is a function of the capacitance and the inductance of a capacitor. At resonant frequency the capacitive reactance equals the inductive reactance ($l/\omega C = \omega L$). At its lowest point of the resonant curve only the ohmic value is effective, this means the impedance equals the ESR. Above the resonate frequency the inductive part of the capacitor prevails.

IMPEDANCE (Z)

The impedance Z is the magnitude of the vectorial sum of ESR and the capacitive reactance X_C in an equivalent series circuit under consideration of the series inductance L.

$$Z = \sqrt{ESR^2 + \left(\omega L - \frac{l}{\omega C}\right)^2}$$

The impedance is typically measured on capacitors (radial types) having 2 mm long leads.

DIELECTRIC ABSORPTION (DA)

The DA depends upon the dielectric material and is a measure of the reluctance of a dielectric to discharge completely. After a fully charged capacitor is discharged the residual charge (recovery voltage) is expressed as a percentage of the initial charge. DA measurements are normally performed in accordance to IEC 60384-1.

$$DA = 100 \times \frac{U_1}{U_2}(\%)$$

U_1 - Recovery Voltage

U_2 - Charging Voltage

AMBIENT TEMPERATURE (T_{amb})

The ambient temperature is the temperature in the immediate surrounding of the capacitor. It is identical to the surface temperature of an unloaded capacitor. At pulse or AC load operations the surface temperature may, due to an internal temperature increase, rise above the ambient temperature.

MAXIMUM TEMPERATURE ($T_{max.}$)

The maximum temperature or upper category temperature is the highest temperature at which a capacitor may still be operated. At pulse or AC load operations, the sum of the ambient temperature (T_{amb}) and the temperature increase (ΔT) caused by the load conditions, must not exceed the maximum temperature ($T_{max.}$).

$$T_{max.} \geq T_{amb} + \Delta T$$

CLIMATIC CATEGORY

The climatic category indicates the climatic conditions which the capacitor may be operated. According to IEC 60068-1 the climatic category is expressed by a three group coding e.g. 55/100/56.

- The first group indicates the lower category temperature (- 55 °C).
- The second group the upper category temperature (+ 100 °C).
- The third group indicates the number of days (56) which the capacitor can withstand within specified limits if exposed to a relative humidity of 95 % and a temperature of + 40 °C.

(IEC 60068-1)

PULSE RISE TIME (du/dt)

The pulse rise time indicates the ability of a capacitor to withstand fast voltage changes and hence high current peaks. The du/dt value, expressed in volts per µs (V/µs), represents the steepest voltage gradient of the pulse (rise or fall time). Its value is dependent upon the properties of the dielectric material, the film thickness and the capacitor's construction. If the applied pulse (U_{pulse}) voltage is lower than the rated voltage (U_R) higher pulse rise times are permitted.

$$du/dt_{(max.)} = (du/dt) \times \frac{U_R}{U_{pulse}}$$

du/dt = Datasheet value.

The pulse rise time (du/dt) is tested with values that are 5 to 10 times above the datasheet value.

For film/foil capacitors the applied pulse rise time (du/dt) is not limited. At higher repetition frequencies, however, the heat generated in the capacitor during the pulse operation must not rise by more than 10 °C.

PULSE LOAD AND CURRENT HANDLING CAPABILITY

The pulse load and current handling capability is the load of a non-sinusoidal AC voltage that may be applied to a capacitor. To prevent the capacitor from overheating the following operating parameters have to be considered:

- Maximum pulse voltage (U_{pulse})
- Pulse shape
- Pulse rise or fall time (du/dt)
- Repetition frequency of the pulse
- Ambient temperature
- Heat dissipation (cooling)

The maximum pulse current depends upon the capacitance and the permissible du/dt value.

$$I_{max.} = (du/dt) \times C \ \ (A)$$

For high voltage and high current pulse loads Vishay film capacitors offers also a series of special capacitors. For example capacitors with a heavy-edge or a double-sided metallization and capacitors that combine a film/foil and a metalized film design in one unit.

For critical applications, please forward your voltage and current waveforms (worst case conditions) for our capacitor proposal.

CORONA STARTING VOLTAGE

The corona starting voltage is defined as detectable electrical discharges resulting from the ionization of air on the surface or between the capacitor layers. Its value is dependent upon the internal design of the capacitor element, the dielectric material, and the thickness of the film. The usage of series wound capacitors increases the corona voltage level.

NON-FLAMMABILITY

Non-flammability of capacitors is accomplished by the usage of flame-retardant materials. Non-flammability is periodically checked according to IEC 60384-1 and IEC 60695-2-2. All plastic case materials used comply with UL-class 94 V-0.

GENERAL TEST CONDITIONS

Unless otherwise specified, all electrical data refer to an ambient temperature of + 23 °C, an atmospheric pressure of 86 kPa to 106 kPa and a relative humidity of 45 % to 75 %. For arbitration cases measurements at 20 °C and a relative humidity of 50 % ± 2 % are mandatory.

SOLDERING CONDITIONS

Regarding the resistance to soldering heat and the solderability, our products comply with “IEC 60384-1” and the additional type specifications.

For all capacitors, we refer to the paragraph “Soldering Conditions” in the type specifications.

For more detail, we refer to the document “Soldering Guidelines for Film Capacitors”: www.vishay.com/doc?28171

CATEGORY OF FLAMMABILITY	SEVERITIES FLAME EXPOSURE TIME (s) FOR CAPACITOR VOLUME (V) (mm^3)				MAXIMUM PERMITTED BURNING TIME (s)	ADDITIONAL REQUIREMENTS
	V = 250	250 < V = 500	500 ≤ V = 1750	V > 1750		
A	15	20	60	120	3	Burning droplets or glowing parts falling down shall not ignite the tissue paper.
B	10	20	30	60	10	
C	5	10	20	30	30	

SHELF LIFE OR STORAGE CONDITIONS

Film capacitors should be stored under temperatures conditions from - 25 °C up to 35 °C, with relative humidity maximum of 75 % without condensation.

The following shelf life is applicable:

Parts supplied on tape or bulk:
Minimum shelf life of two years without impairing the electrical parameters.

Parts soldered on a PC board:
Minimum shelf life of 10 years without deterioration of quality.

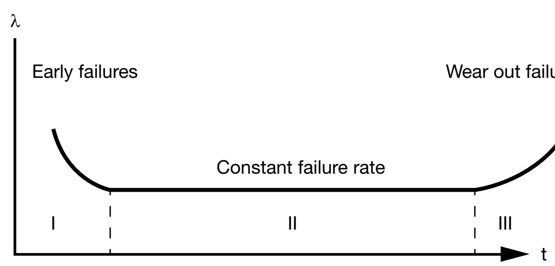
CLEANING PROCEDURE

The influence of high temperatures or vapor accelerates the purifying but also the destructive progress.

Please consult Vishay film capacitors if you have doubts about the usage of your cleaning solvent or if the cleaning process exceeds a solvent temperature of 40 °C and a cleaning time of one minute.

BATH TUBE CURVE

It represents the characteristic shape of the failure rate over the operation period. Its course may be divided into three time phases:



I. Early failure phase
II. Application phase
III. Wear-out phase

The failure rate at phase II can be assumed to be constant.

BURN-IN

The burn-in or artificial aging of components is a measure to minimize early failure rates. In the burn-in test the components are generally subjected to an electrical and thermal stress.

FAILURE

A failure means the unacceptable deviation from at least one property of a component that was without a defect at the beginning of its application. There are critical failures (e.g. short or open circuit) and failures caused by exceeding limiting values.

In case of claims the following information will be required by the manufacturer:

- Kind of defect observed
- Occurrence of the defect (e.g. incoming inspection, burnin, reliability test, field)
- Operating conditions
- Date code (on the component)
- Number of pieces rejected
- Lot size
- Lot number (on the label of the box)
- Return defect samples for failure analysis

This information will allow the manufacturer to solve the problem as quick as possible and to initiate the appropriate corrective actions.

FAILURE RATE

The failure rate is expressed in “FIT” (failures in time) and indicates the number of failures per 10^9 component test hours.

1 fit = 1 x 10^{-9}/h (1 failure per 10^9 component hours)

$$\lambda_{ref} = \frac{n}{N \times t_b}$$

n = Number of components tested
N = Number of failures
t_b = Test time in hours

The calculations of the failure rates are based on IEC 61709. The fit ratings provided refer to 40 °C, 0.5 x U_{RDC} and an upper confidence level of 60 %.

The failure criteria is defined as follows:

Critical defect:
Short circuit or open circuit, $\Delta C/C > 50$ %

Defect by the change of limiting values:
$\Delta C/C > 10$ % (MKT)
$\Delta C/C > 5$ % (KP, MKP)
$\Delta \tan \delta > 2$ x initial limit (MKT)
$\Delta \tan \delta > 3$ x initial limit (KP, MKP)
$R_{is} < 0.5$ % (MKT) of initial limit
$R_{is} < 1.5$ % (KP, MKP) of initial limit

FIT ratings of other voltage and temperature conditions can be converted according with IEC 61709 as follows:

VOLTAGE CONVERTION FACTORS (π_U)		
LOAD RATIO (U/U_{rat})	MKT MKP	KT KP
1.00	6.1	11.0
0.75	2.5	3.0
0.50	1.0	1.0
0.25	0.4	0.4
0.10	0.2	0.2

TEMPERATURE CONVERTION FACTORS (π_U)		
TEMPERATURE	KT MKT	KP MKP
≤ 40 °C	1	1
55 °C	2	2
70 °C	5	5
85 °C	12	12
100 °C	33	33
125 °C	350	

$$\lambda = \lambda_{ref} \times \pi_U \times \pi_T$$

FMEA

The “Failure Mode and Effects Analyses” is a method that analyses systematically the potential defects as to their importance, the probability of their occurrence and the probability of detecting them (Pareto Analysis). This analysis is carried out during development and manufacturing. The results are used for a continuous improvement of quality.

TEST INFORMATION

Robustness of leads

Tensile strength of leads (Ua) (load in lead axis direction)
Lead diameter 0.5 mm, 0.6 mm and 0.8 mm:
Load 10 N, 10 s.

Bending (Ub)
Lead diameter 0.5 mm, 0.6 mm and 0.8 mm:
Load 5 N, 4 x 90°.
Lead diameter 1.0 mm:
Load 10 N, 4 x 90°.

Torsion (Uc) (for axial capacitors only)
Severity 1: Three rotations of 360°.
Severity 2: Two rotations of 180°.

Rapid change of temperature (Na)

The rapid change of temperature test is intended to determine the effect on capacitors of a succession of temperature changes and consists of 5 cycles of 30 min at lower category temperature and 30 min at higher category temperature.

Dry heat (Ba)

This test determines the ability of the capacitors to be used or stored at high temperature. The standard test is 16 h at upper category temperature.

Damp heat cyclic (Db)

This test determines the suitability of capacitors for use and storage under conditions of high humidity when combined with cyclic temperature changes and, in general, producing condensation on the surface of the capacitor. One cycle consists of 24 h exposure to 55 °C and 95 % to 100 % relative humidity (RH).

Cold (Aa)

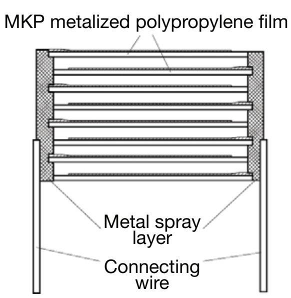
This test determines the ability of the capacitors to be used or stored at low temperature. The standard test is 2 h at the lower category temperature.

Damp heat steady state (Ca)

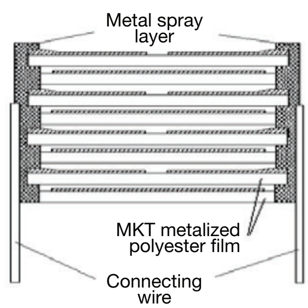
This test determines the suitability of capacitors for use and storage under conditions of high humidity. The test is primarily intended to permit observation of the effects of high humidity at constant temperature over a specified period.

The capacitors are exposed to a damp heat environment, which is maintained at a temperature of 40 °C and an RH of 90 % to 95 % for the number of days specified by the third set of digits of the climatic category code.

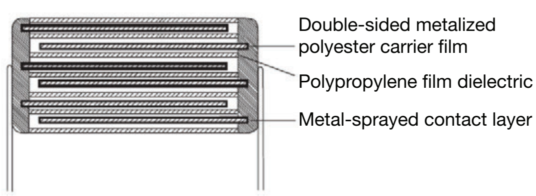
FILM CAPACITORS



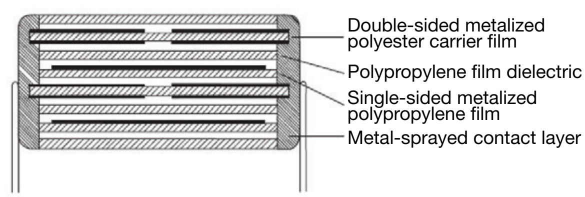
MKP1848
Extended Metalized Film Design



F1772-2
Extended metalized film with internal series connection design

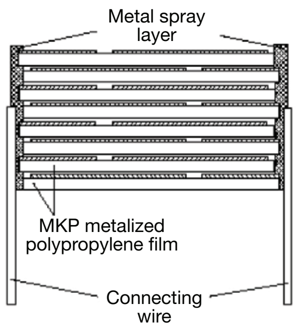


MMKP383 (250 V to 630 V)
Extended double-sided metalized film design

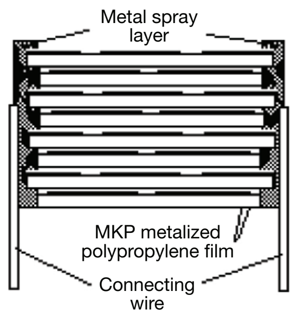


MMKP383 (1000 V to 1400 V)
Extended double-sided metalized film with internal series connection design

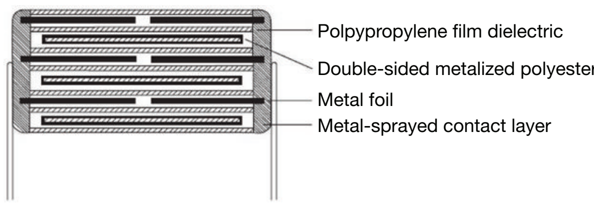
For technical questions, contact: dc-film@vishay.com



MKP385 (1600 V to 2000 V)
Extended metalized film with internal series connections (3 sections) design



MKP385 (2500 V) Extended metalized film with internal series connections (4 sections) design



KP1836
Extended foil design with internal series connection and double-sided metalized carrier film