

DIELECTRIC MATERIALS

The electrical characteristics of a plastic film capacitor are to a great extent dictated by the properties of the dielectric materials used.

Polyester (PE) Film

has higher dielectric losses, as a result, is generally suitable for applications at frequencies 10KHz or less.

It has higher dielectric constant, thus, it can produce high capacitance values in smaller package sizes.

It also has wider working temperature range than other common used dielectric materials.

PE film capacitors are regarded as “general purpose capacitors”, providing the best volume efficiency of all film capacitors at moderate cost and preferably used for DC applications, such as decoupling, by-passing, blocking, and noise suppressions.

Polypropylene (PP) Film

has relatively low dissipation factor and dielectric loss, as a result, is suitable for applications of high voltage, high frequency and high pulse current.

It has rather narrow working temperature range, a lower dielectric constant and a negative temperature coefficient.

PP film capacitors are typically used in AC and pulse applications at high frequency, such as Flyback tuning and correction.

They are furthermore used in switching power supplies and snubber applications, in frequency discrimination and filter circuits, as well as in energy storage and sample & hold applications.

Dielectric Properties (Typical Values)

PARAMETER	Dielectric Constant @25°C/50Hz	Minimum Thickness (micron)	Max. Working Temperature (°C)	D.F. at 1 KHz (%)	Insulation Resistance (MΩ • uF)	Moisture Absorption % in weight	Temperature Coefficient (ppm / °C)
PE	3.2	1	125	0.5	25,000	0.4	+400 ± 200
PP	2.2	4	105	0.02	100,000	0.01	- 200 ± 100

FILM CAPACITORS

Plastic film capacitors are generally subdivided into film / foil capacitors and metallized 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 either the surface of the electrodes (usually inductive type) or the endfaces of the electrodes (non-inductive type). Film / foil capacitors provide high dielectric strength, excellent current-carrying and pulse-handling capability and capacitance stability.

Metallized Film Capacitors

The electrodes of a metallized film capacitor consist of an extremely thin aluminum layer (thickness from 0.02um to 0.1um) that is vacuum deposited either onto the dielectric film or onto a carrier film. The dielectric materials, currently used in capacitors, range from 0.9um to 20um thickness. The endfaces of a wound capacitor element are sprayed with some solder materials, and then respectively connected with one terminal by means of welding or soldering. These capacitors provide high volume efficiency and self-healing properties.

Self-healing Properties of Metallized Film Capacitor

Self-healing 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 metallization of the film around the point of failure, thereby removing and isolating the short circuit conditions.

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

Rated Voltage (V_R)

The rated voltage is the voltage for which a capacitor is designed. It is defined as the maximum DC or AC (RMS) voltage or pulse voltage that may be applied continuously 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 below the maximum temperature, the rated voltage has to be derated in accordance to the dielectric material used.

Test Voltage or Dielectric Strength (V_T)

The V_T of a capacitor is higher than the V_R and may only be applied for a limited time. The dielectric strength is measured between the electrodes. The time applied is typically two seconds. The occurrence of self-healing during the application of the test voltage is permitted for metallized film capacitors.

AC Voltage (V_{AC})

The AC voltage rating in this catalogue refer to clean sinusoidal voltages without transients. The capacitors in this catalogue, except MPX type, must, therefore not be operated in main applications (e.g. Across the line). For operations in a higher frequency range, the applied AC voltage has to be derated. The derated V_{AC} are provided in the graphs "Permissible AC Voltage vs Frequency Curves" of this catalogue.

Pulse Voltage

The RMS value of a pulse voltage (V_{RMS}) must not exceed the rated AC voltage ($V_{R(AC)}$) of the capacitor.

$$V_{R(AC)} \geq V_{RMS}$$

The peak value of the pulse voltage (V_{o-p}) must not exceed the rated DC voltage ($V_{R(DC)}$) of the capacitor.

$$V_{R(DC)} \geq V_{o-p}$$

Superimposed AC Voltage

When a AC voltage is superimposed to a DC voltage, The sum of both the DC voltage (V_{DC}) and the peak value of the AC voltage (V_{o-p}) must not exceed the rated DC voltage ($V_{R(DC)}$) of the capacitor.

$$V_{R(DC)} \geq V_{DC} + V_{o-p}$$

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.

Maximum Temperature (T_{max})

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

Minimum Temperature (T_{min})

The minimum temperature or lower category temperature is the lowest temperature at which a capacitor may still be operated.

Rated Capacitance (C_R)

The rated capacitance is defined as the capacitive part of an equivalent series circuit consisting of capacitance and equivalent series resistance (ESR).

C_R is the capacitance for which the capacitor is designed. Its value is typically measured at a voltage of 1 V_{RMS} maximum, a frequency of 1 KHz $\pm 20\%$, and a temperature of +20°C. The capacitance tolerance indicates the acceptable deviation from the C_R at +20°C. As 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. And the capacitance changes due to moisture are reversible.

Capacitance Drift (Longterm Stability)

In addition to reversible changes, the capacitance of a capacitor is also subject to irreversible changes (also known as "drift"). The drift is dependent upon the dielectric material. The drift decrease gradually over the time. Frequent and extreme temperature changes may increase the drift value.

Temperature Coefficient (TC)

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

$$TC = \frac{(C_2 - C_1) \times 1,000,000}{C_{20} \times (T_2 - T_1)} \text{ (ppm / } ^\circ\text{C)}$$

C_1 = capacitance at temperature T_1 (μF)

C_2 = capacitance at temperature T_2 (μF)

C_{20} = reference capacitance at +20 $\pm 2^\circ\text{C}$ (μF)

Dissipation Factor (DF) ($\tan\delta$)

The dissipation factor, also known as “ $\tan\delta$ ”, 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 DF reflects the polarization losses of the dielectric film and the losses caused by the contact resistances of the capacitor. Parallel losses due to the insulation resistance of film capacitors can be neglected.

The DF is temperature and frequency dependent.

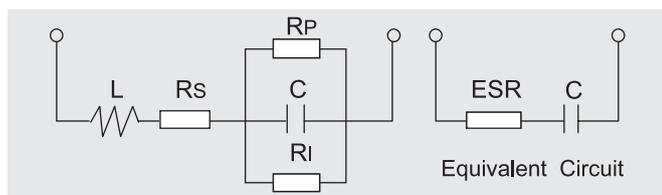
$$DF = \tan\delta = \frac{ESR}{X_C}$$

The reciprocal value of DF 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 consists of the polarization losses of the dielectric material (R_p), the insulation resistance (R_i) and the losses caused by resistance of the leads, termination and electrodes (R_s).

$$ESR = \frac{\tan\delta}{2\pi f C} \text{ (} \Omega \text{)}$$

Insulation Resistance (R_i) and Time Constant (t)

The insulation resistance is the ratio of an applied DC voltage to the resulting leakage current (I_L), flowing through the dielectric and over its body surface after the initial charging current has ceased.

The R_i is typically measured after 60 ± 5 sec. At $+20^\circ\text{C}$ and a relative humidity (R.H.) of $50 \pm 2\%$.

$$R_i = \frac{V_{DC}}{I_L} \text{ (} \Omega \text{)}$$

The R_i depends upon the property and the quality of the dielectric material and the capacitor's construction. The R_i decreases with increasing temperature and / or increasing humidity. R_i changes due to moisture are reversible. For capacitors with high C values, the R_i is shown as time constant (t). It is the product of R_i and capacitance and is expressed in second Or $M\Omega \cdot \mu\text{F}$.

$$t = R_i \times C \text{ (} M\Omega \cdot \mu\text{F } \text{)}$$

Inductance (L)

The inductance of a capacitor is dependent upon the geometric design of the capacitor element and the length and the thickness of the contacting terminals. Typical inductance values of radial leaded capacitor types are $1.0 \text{ nH} / 1 \text{ mm}$ lead length.

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 .

$$Z = \sqrt{ESR^2 + (\omega L - 1/\omega C)^2}$$

Dissipation Power (PD)

$$PD = V_{RMS}^2 \times 2\pi f C \times \tan\delta \times 1000 \text{ (mW)}$$

PD = dissipation power (mW)

V_{RMS} = applied RMS voltage (V)

f = frequency (Hz)

C = capacitance (F)

$\tan\delta$ = dissipation factor at frequency f

Resonant Frequency (f_R)

The f_R is a function of the capacitance C and the inductance L of a capacitor. At resonant frequency, the capacitive reactance equals the inductive reactance ($1/\omega C = \omega L$). At its lowest point of the resonant curve, only ohmic value is effective, and the impedance Z equals the ESR. Above the f_R , the inductive part of the capacitor prevails.

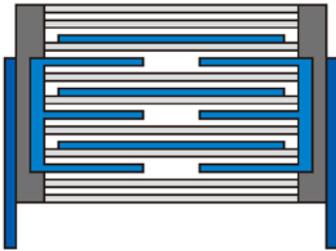
Pulse Rise Time (dv / dt)

The pulse rise time indicates the ability of a capacitor to withstand rapid voltage changes and hence high current peaks. The dv / dt value, expressed in $V / \mu\text{s}$, represents the steepest voltage gradient of the pulse (rise or fall time). The dv / dt value depends upon the properties of the dielectric material, the film thickness and the capacitor's construction. For film-foil capacitors the applied dv / dt is not limited, if the temperature rise caused by the pulse load is still under its limit.

Pulse Load and Current Handling Capability

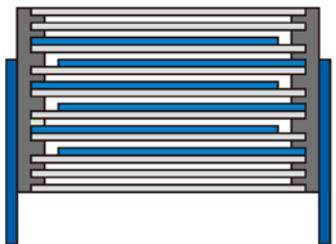
To prevent a capacitor from overheating, the following factors of applied pulse load have to be considered: maximum pulse voltage (V_{p-p}), pulse shape, dv / dt , frequency, pulse current, T_{amb} and cooling conditions.

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



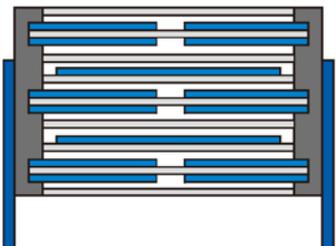
METALLIZED FILM & FILM-FOIL DESIGN
(INTERNAL SERIES)

MPPS, PPSB, SFE, SFW, SFV



EXTENDED METALLIZED FILM DESIGN

DMPE, MPEM, MPEB, TMPE, FMPE
MPP, MPH, MPHT, MPPB, MPH
TMPP, TMPE, MPX2, SPB, DPB, DPE
DPK, DPG, DPJ, DPM, FPB, FPE, FPW
FPV, APB, APW, APN, APT, APM



METALLIZED FILM & DOUBLE SIDE
METALLIZED DESIGN
(INTERNAL DESIGN)

MPLB, SLB, SLE, SLW, SLV

Waveform							
RMS Value	$\frac{V_{o-p}}{\sqrt{2}}$	$V_{o-p} \sqrt{\frac{t}{2T}}$	$\frac{V_{o-p}}{\sqrt{2}}$	$\frac{V_{o-p}}{\sqrt{3}}$	$V_{o-p} \sqrt{\frac{t}{3T}}$	V_{o-p}	$V_{o-p} \sqrt{\frac{t}{T}}$