What is capacitor

Capacitors are components that have the ability to store electrical energy. This energy is stored in an electrostatic field which is created by electrical charges accumulating on conducting plates placed across an electrical potential and separated by an insulating medium. Capacitance as a value is dependent upon the distance between the conducting plates, the dielectric constant of the insulating medium, and the common area of the conducting plates.

The unit of capacitance is the FARAD A farad of capacitance is a LOT of capacitance. We generally deal in microfarads (mfd.) or nanofarad (nf) or picofarads (pf)

Plastic Film Capacitors

A film type capacitor made from this simple approach would create a large component. To prevent the waste of space the plates are "rolled" together, with an extra layer of dielectric to prevent the plates from touching, which results in a higher capacitance and smaller size.

Film Capacitors come in two standard designs, a film-foil combination where plastic films are interleaved with metal foils that serve as electrodes, or as a Metalized construction where film has aluminum or zinc deposited in it to serve as the electrodes.

There are two basic types of "rolled" construction film- foil capacitors.
One is extended foil type, where foil is extended beyond the dielectric and the connection is made from the extended portion of foil, which are sprayed by metal and then tinned copper wire is soldered or welded. We call such capacitors as NON INDUCTIVE type film capacitors.The other type of "rolled" construction is where connection is made by inserting tinned copper wire and welding it on the metal foil. Such capacitors are called INDUCTIVE type film capacitors. The distance that the electrode foil is indented from the edge of the dielectric is the margin. This margin provides some protection against arc-over and short circuit.

Metalized film construction is different from film-foil in that the foil is replaced with a very thin metallic film which is vacuum deposited on the dielectric. The thickness of the deposited layer is negligible to the foil it replaced, thereby saving more size. All metallised film capacitors are NON INDUCTIVE type.

Final encasement types of film capacitors include dipped epoxy, tape wrapped and epoxy endfilled and in box potted with the epoxy .

Plastic film capacitors are the most versatile of all capacitors. The capacitors have a reputation for outstanding electrical characteristics in severe environmental conditions, high reliability, and stability in long life applications. Being non-polar gives these capacitors predictability in DC or AC applications as well as being stable over a broad temperature range. They have the lowest Dissipation Factor (DF) and Equivalent Series Resistance (ESR) of all capacitor types.

Metallised or film foil capacitors

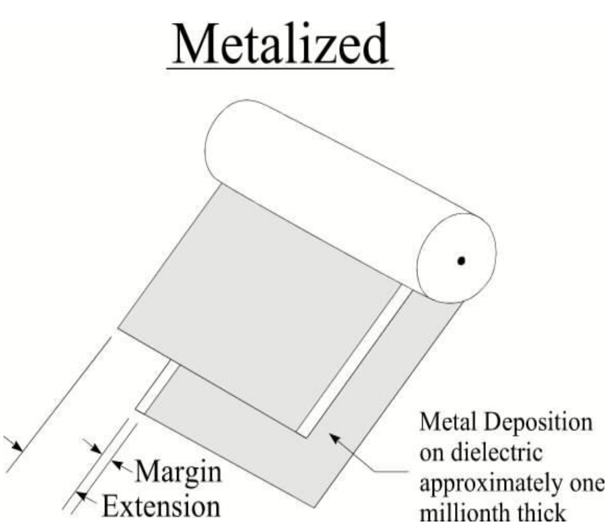
Metalized film capacitors show three advantages where smaller applications are needed due to their smaller size and lower weight. Metalized capacitors also have a built in "healing" property where in the case of voltage stress the film will clear itself and heal the point of damage. Due to this "healing" property most metalized film capacitors are tolerant of over voltage.

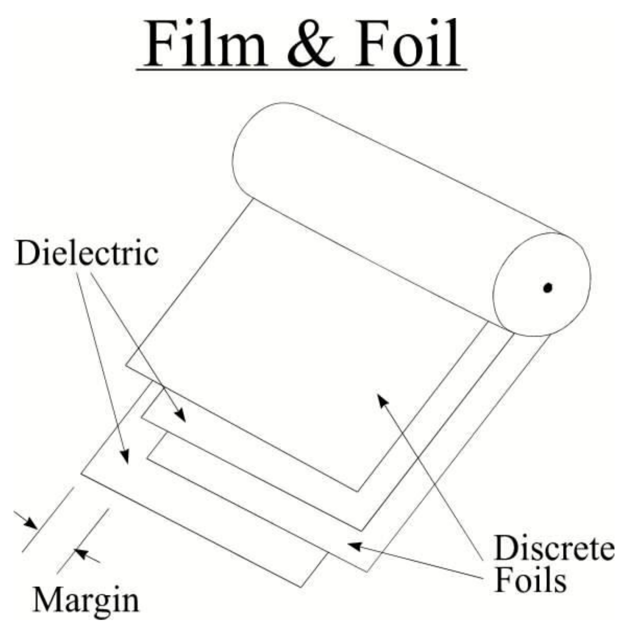
Some film capacitors are "precleared" during manufacturing to blow away pin-holes and weak spots in the dielectric. Metallized film capacitors tend to have a higher ESR than film-foil, however, and somewhat lower insulation resistance. Film-foil capacitors are typically 50-150 % larger in volume than their metallized-film equivalent. Other variations include foil layers separated by metallized layers to get reduced ESR yet still allow for self-healing, and even foil and metallizing in the same electrode layer. In most cases, the idea behind these various constructions is to get the good self-healing of a metallized-film capacitor with the low ESR/high current capacity of film/foil.

Aluminum is the most common metal used as the metallization or foil material, as it is hard to beat for cost and reliability

Circuits which require high currents may need a film-foil combination capacitor. The heavy foil of this combination offers low electrical resistance and excellent thermal dissipation preventing internal hot spots and optimizing the circuit efficiency.

Impregnated capacitors are recommended for high voltage circuits where corona may be a problem. Wax is suitable for a lower temperature application. For higher temperature application oil is a suitable impregnant . These capacitors can be either metalized or film-foil combination. Also, series wound units are used to prevent corona.





FILM / FOIL (INDUCTIVE) VS. METALLISED	
Film/Foil Inductive	**Metallised Non-Inductive**
➤ High dv/dt ➤ High IR ➤ Good current carrying capability ➤ Better capacitance stability ➤ Lead connections are made of spot welding on the foil	➤ Smaller in size as compared to film / foil capacitor ➤ High reliability (because of self healing property) ➤ Connections of elements are made by means of metal spraying process and by welding the leads on to the end spray

Typical inductance values @100Khz(in µH)

Capacitance in µFd	PET Film / Foil Inductive	PET Film / Foil Non-inductive	MPET Metallised Non-inductive
0.0033/630V/±10%	-773	-875	-750
0.01/400V/±10%	-251	-240	-246
0.047/630V/±10%	-57	-55	-56
0.1/100V/±10%	-26	-25	-27
0.022/100V/±10%	-11	-10	-12
0.47/100V/±10%	-5	-5	-5

The most commonly used plastics for film capacitors are polyester, and polypropylene.

Polyester:

Polyester is probably the most popular of the film capacitors, at least for board-level applications. Actually, polyester is a generic term for a class of similar polymers, the one used in polyester capacitors being polyethylene terephthalate. Some people call it Mylar capacitors and some as PET. Low cost, small size and the ability to do many things well enough makes it a good choice for many non critical applications. High dissipation factor means it is best used in DC or relatively low-frequency/low-current pulse and AC power applications. Poor temperature drift, dielectric absorption, and leakage relegate it to non-critical analog circuit applications. Polyester has a high temperature drift but can be found layered with polypropylene to flatten the temperature curve (the two go in opposite directions). Polyester capacitors are available to 125C.

Polypropylene:

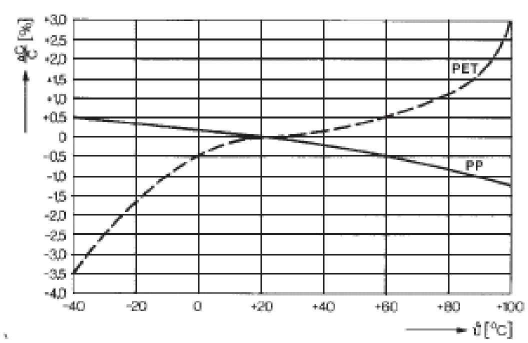
Polypropylene (PP) capacitors are available in a wide range of sizes and voltages, and are used in a wide variety of circuits. PP has a very low dissipation factor over it´s entire temperature range and over a wide frequency range. This makes polypropylene capacitors popular for high-frequency, high-current applications like switching power supplies.

While PPs very low dissipation factor has made it the only viable material for many high-power AC applications, its self-healing properties, critical for reliable high voltage operation, are only fair. impregnation helps make up for these deficiencies however.

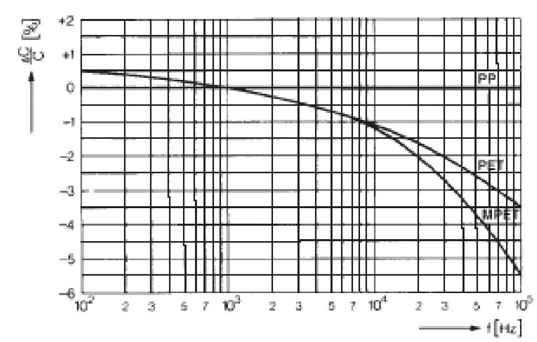
DIELECTRIC COMPARISON

Parameters	Polyester (PET)	Polypropylene (PP)
Dielectric constant 23° C, 1 kHz	3.25	2.2
Dissipation Factor 23° C, 1 kHz	0.005	0.0002
Volume Resistivity 23° C	$10^{18}\,\Omega$ cm	$10^{18}\,\Omega$ cm
Surface Resistivity 23° C, 80% RH	$10^{10}\,\Omega$	$10^{14}\,\Omega$
V / micron	435 V DC	500 V DC

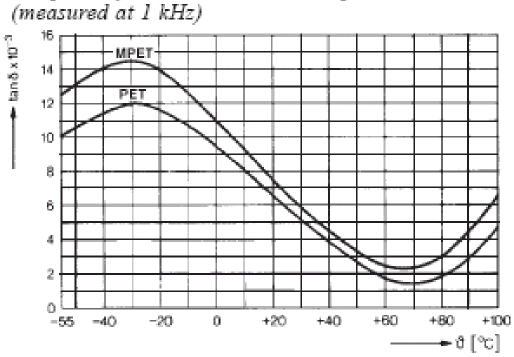
Capacitance change ΔC/C versus Temperature θ



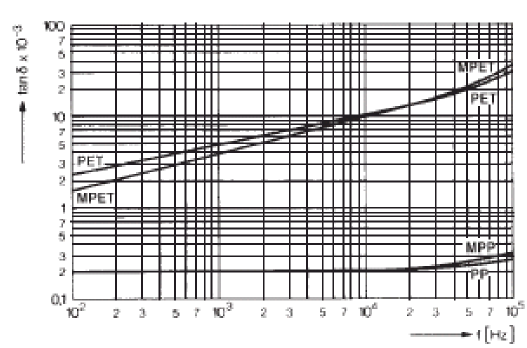
Capacitance change ΔC/C versus Frequency f



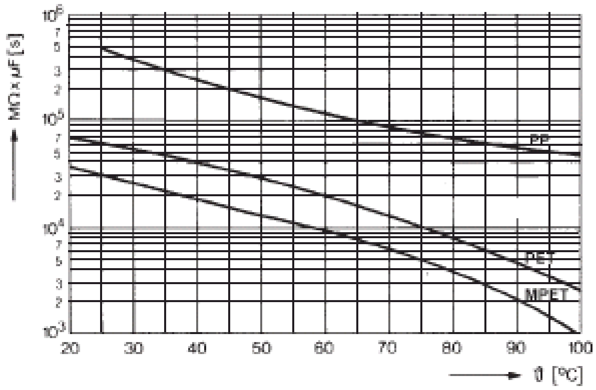
Dissipation factor tan δ versus Temperature θ (measured at 1 kHz)



Dissipation factor tan δ versus Frequency f.



Time constant τ versus Temperature θ



<u>Technical Terms</u>

- Rated Capacitance CR : The designed capacitance value, usually marked on the capacitor.

- Capacitance Tolerance : Admitted capacitance deviation from the rated capacitance at 20°C

- Rated Voltage UR : The maximum direct voltage or the maximum rms alternating voltage or the peak value of a pulse voltage which may be continuously applied to a capacitor at any temperature between the lower category temperature and the rated temperature.

- Category Voltage UC : The maximum voltage which may be continuously applied to a capacitor at its upper category temperature.

- Climatic category : The climatic category which the capacitor belongs to is expressed in numbers(standard IEC60068-1:example 55/85/21). The first number represents the lower category temperature; the second number represents the upper category temperature; the third number represents the number of days relevant to the damp heat test.

- Rated Temperature : The maximum ambient temperature at which the rated voltage may be continuously applied

- Upper Category Temperature : The designed maximum ambient temperature at which the capacitor can continuously operate.

- Temperature coefficient of capacitance : The change rate of capacitance with temperature measured over a specified range of temperature. It is normally expressed in parts per million per Celsius degree (10-6/ °C)

- Dissipation Factor : The ratio between the resistive and the reactive part of the impedance of the capacitor submitted to a sinusoidal voltage of specified frequency.

- Insulation Resistance/Time Constant : It is expressed in MO¸ measured after a minute of charge under a specified voltage.

- The time constant is expressed with the following formula : T= RC (s)
  The time constant of a capacitor equals to the product of the insulation resistance and the capacitance in value.

Caution

- Normally, values higher than the rated voltage may cause a breakdown of the capacitor dielectric and damage the capacitor. Metallized capacitors have self-healing properties and the application of voltages higher than rated voltage will not cause an immediate short circuit. But the insulation resistance will drop with the charge time goes on, the leak current will increase gradually. The capacitor may lead to smoke or fire due to the heat produced and the breakdown of the capacitor

- If a capacitor marked D.C. is used as an A.C. capacitor, the maximum working voltage is limited by the heat produced or by discharges. The maximum working voltage converted to AC voltage depends on different types of the capacitors. For more details, please contact us.

- When a capacitor is used at high frequency, the self-healing may cause breakdown of the capacitor due to the aging of the dielectric. So the rated voltage should be decreased at high frequency. And also, the ambient temperature and the self-temperature rise should both be taken into account. If the capacitor is subject to rms or pulse currents higher than those admitted, make sure the operating temperature (ambient temperature plus self temperature rise)will not exceed the rated upper temperature.

- The capacitor has a large charge and discharge current due to the low internal impedance of it. The capacitor will deteriorate and breakdown when the current exceeds the permissible value. The permissible current can be categorized into pulse current (peak value) and continuous current (rms value) depending on different breakdown style. Make sure the operating current does not exceed the permissible value.

- Generally, the permissible pulse current is the product of dv/dt and the capacitance. The permissible rms current varies with dielectric, operating frequency and end spray. So the upper dv/dt value is low in metallized capacitors. For more details, please contact us.