International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 4, April - 2013

Electical Characteristics Of Metallized Polypropylene Film Capacitor With General Technical Data– Comparative Study

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ABSTRACT:-On invention plastic films it became a revolution by replacing electrolyticcapacitor bymetalized plastic film capacitors. Metallized polypropylenefilm(MPPF) provide high insulation voltage , this feature makes MPPF ideal for applications in high voltage engineering(HVE).The principal objective of the paper is to do about a brief study on Metalized Polypropylene film capacitors by comparativestudy with other metalized plastic films. By graphical study on effects of temperature and humidity across capacitive tolerance(Δc/c) and electrical characteristics of plastic films and proving how polypropylene films are ideal formaking capacitors by studying ESR and dissipation factor by taking general technical data of metalized polypropylene films and values are tabulated . A final purpose of this paper is given to create a method of analysis that how the effect of climatic conditions doesn't make much impact on characteristics of MPPF. Therefore veryideal for precision applications.

Index words :- metalized terepthalate(MKT) ,metalized polypropylene(MKP) ,metalized polyethylene naphthalate (MKN),electrical series resistance(ESR).

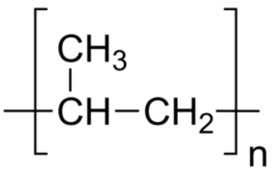
INTRODUCTON

Polypropylene (PP) is a common polymeric material frequently used in diverse industrial applications because of its excellent mechanical properties.

a) Light weight
b) low cost and
c) easy recyclability

Capacitor using it as a dielectric, particularly a biaxially oriented polypropylene film excellent in heat resistance and dielectric properties, less in insulation defects and excellent in the impregnation of an insulating oil into the clearances between film layers and swelling resistance when immersed in the insulatingoil, and a capacitor excellentin dielectric properties, corona resistance, long-term thermal durability and electric current resistance, using the film as dielectric.

Structure of polypropylene



Polypropylene film capacitorsare film capacitors with dielectric made of the thermoplastic, non-polar, organic and partially crystalline polymer material Polypropylene (PP), trade name Treofan, from the family of polyolefin's**.** Polypropylene film is the most-useddielectric film in industrial capacitors and also in power capacitor types. Predictable linear and low capacitance change with operating temperature.

APPLICATION

Suitable foruse in situations where failure of the capacitor could lead to danger of electric shock.Suitable for applications in Class-1 frequency-determining circuits and precision analog applications. Very narrow capacitances. Extremely low dissipation factor.Low moisture absorption, therefore suitable for "naked" designs with no coating. High insulation resistance. Usable in high power applications such as snubber or IGBT. Used also in AC power applications, such as in motors or power factor correction. Very low dielectric losses. Highfrequency and highpower applications such as induction heating. Widely used for safety/EMI suppression, including connection to power supply mains.

GENERAL TECHNICAL DATA

- ***Dielectric***: polypropylene film.
- ***Plates:***metal layer deposited by evaporation undervacuum.

- ***Winding***:Non-inductive type.
- ***Leads***:Tin-plated copper wire.
- ***Plastic case***: PBT material solven resistant &flame ***r***etardant according to UL94V0.
- ***Filling***:Epoxy Resin with flame retardant according to UL94V0.
- ***Marking***: Company logo, capacitor type, capacitance, tolerance, capacitor class, rated voltage, approvals climatic category, passive flammability category, date code.
- ***Operating temperature range***: - 40 to +110 Climatic category: 40/110/56 IEC 60068-1
- ***Related documents***: IEC-60384-14, EN-60384-14 UL-60384-14, CSA-60384-14.

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RELIBILITY TEST METHOD &PERFORMANCE:

Damp heat steady state Test condition *Temperature*: 40±2℃ *Relative humidity*: 93%±2% *Test duration*: 56 days	**Performance** *Dielectric strength*:No dielectric breakdown or flashover at 1500Vac/1 min. *Capacitance change*:≤5% Insulation resistance:≥50% of initial limit
Endurance Test condition *Temperature*: 110°C±2C *Test duration*: 1000 h *Voltage applied*: 1.7VR+1000Vac 0.1s/h	**Performance** *Dielectric strength*:No dielectric breakdown or flashover at 1500Vac/1 min. *Capacitance change*: ≤10% Insulation resistance: ≥50% of initial limit
Resistance to soldering heat Test condition *Solder bath temperature*: 260°C±5°C *Dipping time*: 10s±1s	**Performance** *Capacitance change*: ≤2%

ELECTRICAL CHARACTERISTICS TEST CONDITIONS

- ***Capacitance range***: 1000pF ~ 1.0µF
- ***Capacitance tolerances***: (measured at 1KHZ) .±10%(K); ±20%(M)
- ***Rated Voltage***: 300Vac/1000Vdc;50/60Hz
- ***Dissipation Factor***: tgδ 10-4 at +25°C±5°C

≤ 30 (20 D typical) at 1 kHZ

Insulation Resistance:
Test conditions

- ***Temperature***: 25°C ±5°C
- ***Voltage charge***: 100 Vdc
- ***Charge time***: 1 Min.

Performance

- ***C ≤ 0.33uf*** : ≥1×105 MΩ (typical value . 5x10 5 MΩ)
- ***C > 0.33uF***: ≥30000 s (typical value . 150000 s)
- ***Test Voltage***: at 25°C ±5°C 2500VAC for . (Between terminal) 1 sec+ 5000Vdc for 1sec

CHARACTERITICS OF PPF WHICH MADE IT IDEAL WHEN COMPARED TO OTHER PLASTIC FILMS

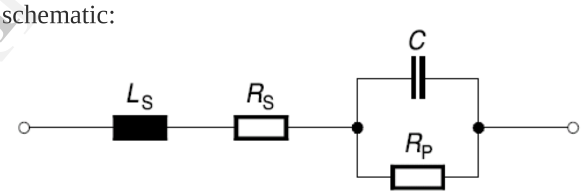
Dielectric		PP	PET	PEN
Dielectric constant(€r)		**2.2**	**3.2**	**3.0**
C drift with time(i_z=Δc/c)	**%**	**3**	**3**	**2**
C Temperature coefficient	**10^-6**	**-250**	**+600**	**+200**
C humiditycoefficient βc(50….95%)	**10^-6/%r.h**	**40..100**	**500..700**	**700..900**
Dissipation factor(1 kHz)		**0.0005**	**0.0050**	**0.0040**
Time constant	**s**	**100000**	**25000**	**25000**
Dielectric absorption	**%**	**.05**	**0.2**	**1.2**

Polyethylene terephthalate (PET)
Polypropylene (PP)
Polyethylene naphthalate (PEN)

ELECTICAL CHARACTERISTICS

EQUIVALENT CIRCUIT DIAGRAM

Any real capacitor can be modelled in following schematic:



Ls– series inductance
Rs– series resistance, due to contacts
C– capacitance
Rp –parallel resistance,due to insulation resistance

Ls, C, Rsare the magnitudes that vary in frequency domain
Rpis the magnitude of insulation resistance measured in DC

CAPACITANCE

RATED CAPACITANCE/MEASURING CONDITIONS

Rated capacitance is the value of capacitor for which it is designed and indicated on it.
Capacitance is measured by standards IEC 60068-1

Measuring conditions	Standard conditions	Referee conditions
Temperature	15…35°C	(23±1)°C
Relative humidity	45…75%	(50±2)%
Ambient atmospheric pressure	86…106kPa	86…106kPa
Frequency	1kHz	1 kHz
Voltage	0.03*Vr(max. 5V)	0.03*Vr(max. 5V)

Prior to being measured capacitor should be maintained at standard temperature and humidity until entire capacitor maintain constant values.

VARIATION OF CAPACITANCE WITH TEMPERATURE

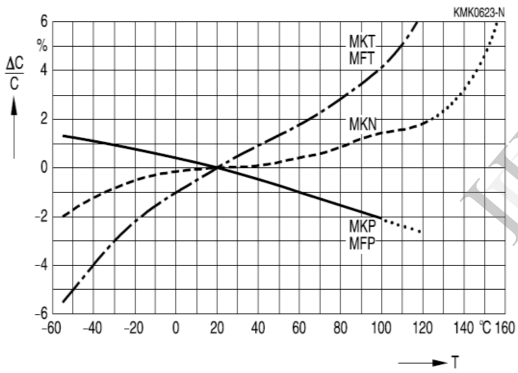
Capacitance will undergo reversible changewithin a range of temperatures between the upperand lower category temperatures. The gradient of the capacitance/temperature curve is given bythe temperature coefficient Δc of the capacitance, which is defined as the average capacitance change, in relation to the capacitance measured at (20 ±2) °C, occurring within the temperaturerange T1 to T2. It is expressed in units of 10-6/K.

C1 Capacitance measured at temperature T1
C2 Capacitance measured at temperature T2
C3 Reference capacitance measured at (20 ±2) °C

The temperature coefficient is essentially determined by the properties of the dielectric, the capacitor construction and the manufacturing parameters. Polypropylene capacitors have negative temperature coefficients, polyester capacitors have positive temperature coefficients.

Dielectric		PP	PET	PEN
C temperature coefficient αc	10^{-6}/K	-250	+600	+200

Reversible changes of capacitance with temperature are usually expressed as ΔC/Cshows typical temperature chara cteristics of different capacitor styles.



Relative capacitance change ΔC/C vs. temperature T (typical values)

VARIATION OF CAPACITANCE WITH HUMIDITY

The capacitance of a plastic film capacitor will undergo a reversible change of value in relationto any change in the ambient humidity. Depending on thetype of capacitor design, both the dielectric and the effective air gap between the films will react to changes in the ambient humidity,which will thus affect the measured capacitance.The humidity coefficient Δc is defined as the relative capacitance change determined for a 1%change in humidity (at constant temperature).

$\beta_C = 2*(C_2 - C_1)/((C_2+C_2)*(F_2-F_1))$

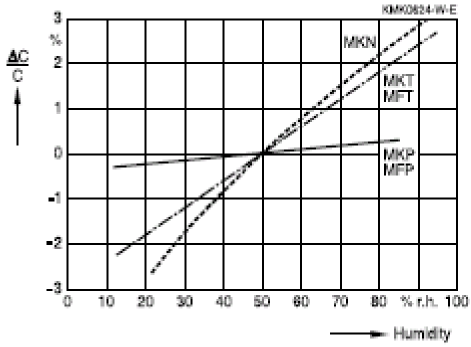
C1 Capacitance at relative humidity F1

C2 Capacitance at relative humidity F2

The values of Δc given in table are valid for a

relative humidity range of 50% to 95%. At relative humidity below 30%, the humidity coefficient is rel atively low. Wide variations are to be expected at relative humidity above 85%.

Figure shows typical capacitance/humidity character istics of different capacitor styles.

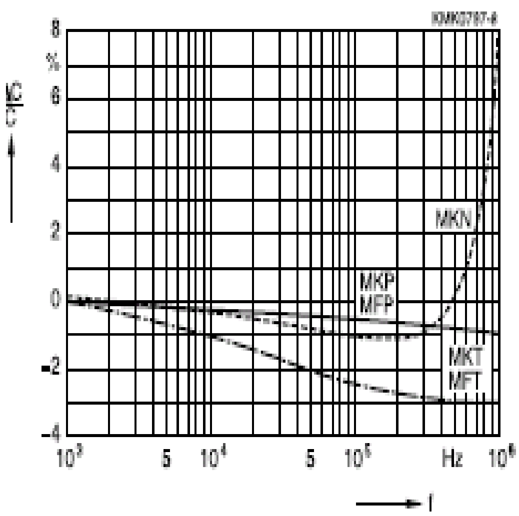


Relative capacitance change ΔC/C vs. relative humid ity (typical values)

VARIATION OF CAPACITANCE WITH FREQUENCY

As figure shows, in polypropylene capacitors (PP MKP, MFP), the capacitance remains virtually unaffected by fr equency up to 1 MHz. In polyester capacitors (PET MKT) and especiallyin PEN capacitors (polyethylene naphthala te, MKN), the effect of frequency is more noticeable.

Dielectric		PP	PET	PEN
C humidity coefficient βc	10/%r.h	40…100	500…700	700..900



Relative capacitance change ΔC/C vs. frequency f (typical exa mple)Additionally, in the vicinity of the natural resonant f requency of the capacitors, selfinductanceleads to an additio nal decrease of impedance.

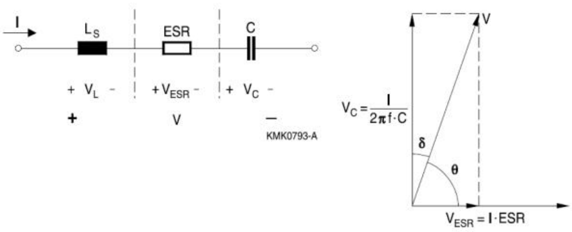
VARIATION OF CAPACITANCE WITH TIME

In addition to the changes described, the capacitance of a c apacitor is also subjected to irreversible changes known as dr ift iz = ΔC/C . The values stated for capacitance drift (see tabl e below) are maximum values and refer to a twoyear period an d a temperature up to 40 °C. Here thereversible effects of tem perature changes (βc and changes in relative humidity (αc) are not takeninto consideration.

Drift is stabilized over time and thus provides the long-term stability of capacitance. However, itmay exceed the sp ecified values if a capacitor is subjected to frequent,large temperaturechanges in the vicinity of the upper category temper ature and relative humidity limits.

ESR AND DISSIPATION FACTOR

Under an AC voltage signal of specified frequency, the equivalent circuit diagram can be simplified to a series connection of the capacitance C, an **equivalent series resista nce(ESR)** and the series inductance LS.Simplified capacitor model for AC. Complex voltage calculation.For frequencies well below the natural resonant frequency (LS, VL), due to the ESR the phaseshift between voltage and current is slightly less than90°. The difference between the phase angle θ and 90° is the defect angle δ, which is measured through the **dissipation factor tan** δ, i.e.the ratio of the equivalent series resistance ESR to the capacitive reactance XC = 1/2πf C.



It can easily be deduced that the dissipation factor is a lso the ratio of effective power (i.e. powerdissipation) to reactive power. Power dissipation can be express ed as a function of the voltageVESR across the equi valent series resistance ESR, or the current I through it:

Tanδ=ESR·2Πf·C

$P=V^2_{ESR}/ESR = ESR*I^2$

Since

$V^2_{ESR} = (ESR^2/ESR^2+(1/2\Pi f*C)^2)*V^2$

and since for film capacitors tan δ = 2πf C ESR<<0. 1

$V^2_{ESR} = ESR^2*(2\Pi f*C)^2*V^2$

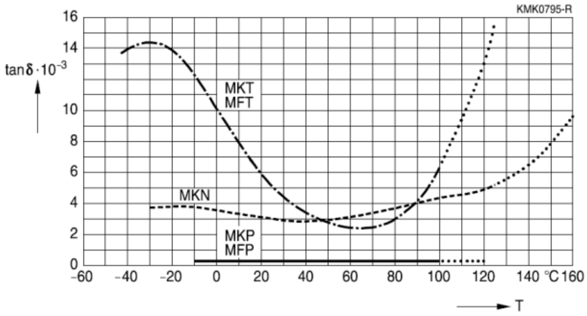
the power can be expressed as

$P=2\Pi f*C*Tan\delta*V^2$ or $P=(2\Pi f*C)^2*ESR*V^2$

Both ESR and tan δ are important because they dictate the **power dissipation** of a capacitor andthus its **self-heating**.

Variation of dissipation factor with temperature, h umidity and voltage The dissipation factor of capacit ors with a polypropylene dielectric is largely unaffec ted by temperature, whereas polyester capacitors sho w a characteristic dissipation factor minimum at app rox. 80 °C (at 1 kHz).

Dielectric	PP	PET	PEN
Capacitance drift ir (typical values)	3%	3%	2%



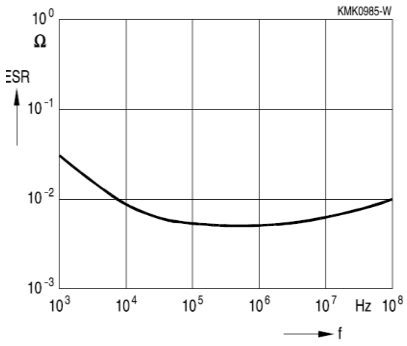
Dissipation factor tan δ vs. temperature T for f = 1 k Hz (typical values)

Variation of ESR with frequency

From the definition of tan δ, ESR can be expressed as:
ESR=tanδ/2Πf*C

Thus ESR comprises all the phenomena that can con tribute as resistivity, which have been described for t he dissipation factor . Figureshows a general frequenc y response for afilm capacitor:

At very low frequencies, leakage is prevalent (range no t represented).At low frequencies, ESR is dominated by the dielectric losses, decreasing roughly as f^{-1}.
At medium to high frequencies, losses in the conducto rs are dominant and ESR becomes relatively constant.
At very high frequencies (>10 MHz) ESR increases by f due to the skin effect.



ESR vs. frequency for an MKT capacitor

ESR variations with temperature and humidity follow t hose of dissipation factor

Insulation resistance

Measuring conditions

The insulation resistance Rins of a capacitor is a meas ure of its resistivity in DC. Under a stationary DC volt age, a leakage current flows through the dielectric and over the capacitor surfaces.Rins is measured by deter mining the ratio of the applied DC voltage to the res ulting leakage current flowing through the capacitor, once the initial charging current has ceased (typical ly after aperiod of 1 min □5 s).The measuring voltage depends on the rated voltage. It is specified in IEC 60 384-1.

The specified measuring temperature is 20 °C. At othe r temperatures, a correction shall be madeto the measu red value to obtain the equivalent value for 20 °C by multiplying the measured resultby the appropriate corr ection factor.

Measuring temperature in °C	Correction factor(average values) according to the sectional specification		
	MKT,MFT	MKN	MKP,MFP
15	0.79	0.79	0.75
20	1.00	1.00	1.00
23	1.15	1.15	1.25
27	1.38	1.38	1.50
30	1.59	1.59	1.75
35	2.00	2.00	2.00

In case of doubt a referee measurement at 20 °C and (50 ±2)% relative humidity is decisive.

In the data sheets for the individual types, the insulation resistance Rins is given as a minimum as-delivered value and as a limit value attained after the "da mp heat, steady-state" test.

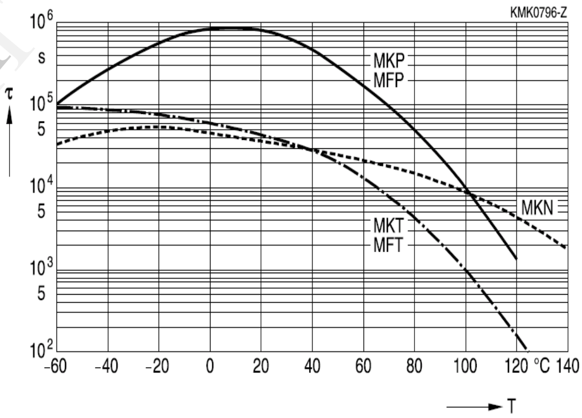
For capacitors with capacitance ratings >0.33 μF the in sulation is given in terms of a **time constant.**

τ = Rins CR (in s)

Factors affecting insulation resistance

As could already be deduced from the correction factor t able, the insulation resistance is affected by temperature , Figure shows the typical behavior of individual types

Rated voltage VR of capacitor	Measuring voltage
10V≤VR<100V	(10±1)V
100V≤VR<500V	(100±15)V
500V≤VR	(500±50)V



Insulation as selfdischarge time constant τ (= Rins · CR) in s (MΩ · μF) vs. temperature T(typical valu es)

Insulation resistance is also affected significantly b y humidity (as humidity increases, insulation resistance decreases).

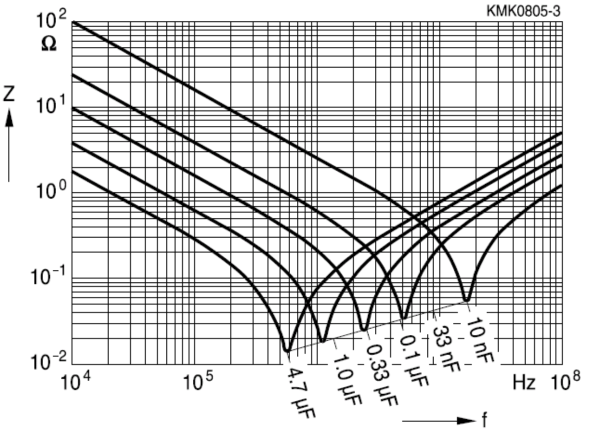
Self-inductance

The selfinductance or series inductance LS of a film ca pacitor is due to the magnetic field createdby the curre ntin the film metallization and the connections. It is t hus determined by the windingstructure, thegeometric design and the length and thickness of the contact path s. As far as possible, all capacitors described in this dat a book are constructed with lowinductance bifilar elect rodecurrent paths or extendedfoil contacts,and thus fe ature very low inductance. A general rule fordeducin g LS states that the maximum value is 1 nH per mm of lead length and capacitor length.LS can also be calc ulated from the resonant frequency.

Impedance, resonant frequency

The impedance Z represents the component's opposition to current flow and is both resistive andreactive in nature. It is thus of particular importance in AC and ripple current filtering.From the capacitor model in figure , Z is defined as the magnitude of the vectorial sum of ESRand the total reactance (inductive reactance minus capacitive reactance):

$$Z=(ESR^2+(2\Pi f\cdot Ls-1/2\Pi f\cdot C)^2)^{1/2}$$

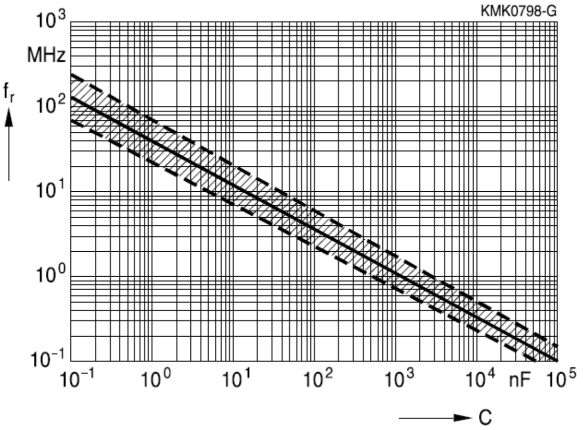


Typical impedance characteristics of film capacitors

At low frequencies, the capacitive reactance XC = 1/2πf C prevails, whereas at very high frequencies the inductive reactance XL = 2πf LS is dominant. When capacitive reactance equals inductive reactance, natural resonance occurs. At this point the reactances cancel each other out andimpedance equals ESR. The natural resonant frequency therefore given by:

$$f_{res=1/2\Pi*\sqrt{C*Ls}}$$

The frequency range of natural resonance (also termed selfresonance) as a function of capacitance can be read off the following diagram



Resonant frequency fresversus capacitance C(typical values)

RESULT

The temperature and frequency dependenciesof electrical parameters for polypropylene film capacitors are very low, the PP capacitors have a linear, negative temperature coefficient of capacitance of ±2,5 % within their temperature range. Therefore, polypropylene film capacitors are suitable for applications in first class frequency-determining circuits, filters, oscillator circuits, audio circuits, and timers. They are also useful for compensation of inductive coils in precision filter applications, and for high-frequency applications.

In addition, PP film capacitors have the lowest dielectric absorption capacity, it makes them suitable for applications such as VCO timing capacitors, sample-and-hold and audio circuits.They are available for these precisionapplicationsin very narrow capacitance tolerances.
The dissipation factor of PP film capacitors is smaller than that of other film capacitors. Due to the low and very stable dissipation factor over a wide temperature and frequency range, even at very high frequencies, and their high dielectric strength of 650 V/µm, PP film capacitors can be used in metalized and in film/foil versions as capacitors for pulse applications, such as CRT-scan deflection circuits, or as so-called "snubber" capacitors, or in IGBT applications. In addition, polypropylene film capacitors are used in AC power applications, such as motor run capacitors or PFC capacitors.

Conclusion

During a few decades, polypropylene all-film power capacitors impregnated with fluids madefrom biodegradable and non-toxic vegetable oils are of interestamong researchers world-wide. There are four electrical properties of model capacitors which are taken into considerations; capacitance, withstand voltage.

ACKNOWLEDGMENT

We arethankful to Authoritiesat VITUniversity
for their continuous encouragement in using facilities and field work studies.

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