Suppressor film capacitor Highlight and Application in Series with the main

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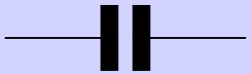
Paola Bettacchi - Product Manager

- **Film capacitor : main features and performances**
- **Process flow charts**
- **Self-healing and corona effect**
- **International Standards**
- **Application in series/parallel with the main**

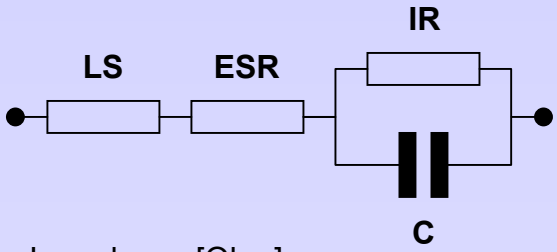
FILM CAPACITORS GENERAL INFORMATION

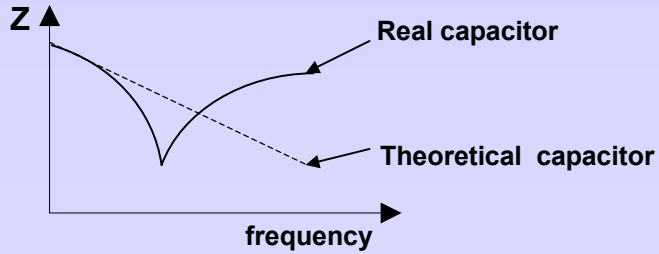
MAIN CAPACITORS PARAMETER SYMBOLS



Theoretical capacitor symbol

REAL CAPACITOR equivalent circuit





Z = Impedance [Ohm]
LS = Total series due to the armature and the leads of the capacitor
ESR = Total series resistance due to armature, to the leads and to the connection
IR = Insulation resistance
C = Capacitance

LS = $L_L + L_W$ (L_L = Inductance of the leads ; L_W = Inductance of winding)

ESR = $R_L + R_C + R_W$ (R_L = Resistance of leads ; R_C = Resistance of contacts ; R_W = Resistance of winding)

QUALITY OF CAPACITORS

THEORETICAL

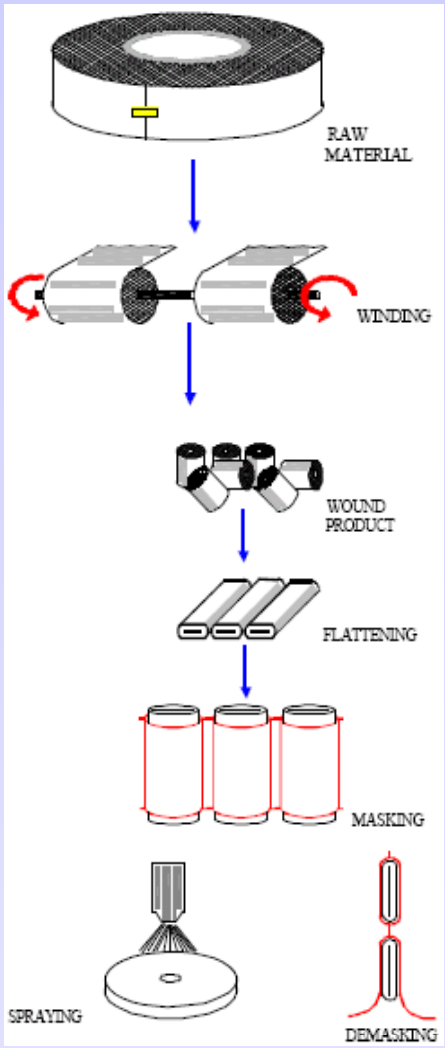
IR ⇨ Infinite
LS ⇨ zero
ESR ⇨ zero

ELECTRICAL CHARACTERISTICS AND PERFORMANCES FOR DIFFERENT FILM CAPACITORS

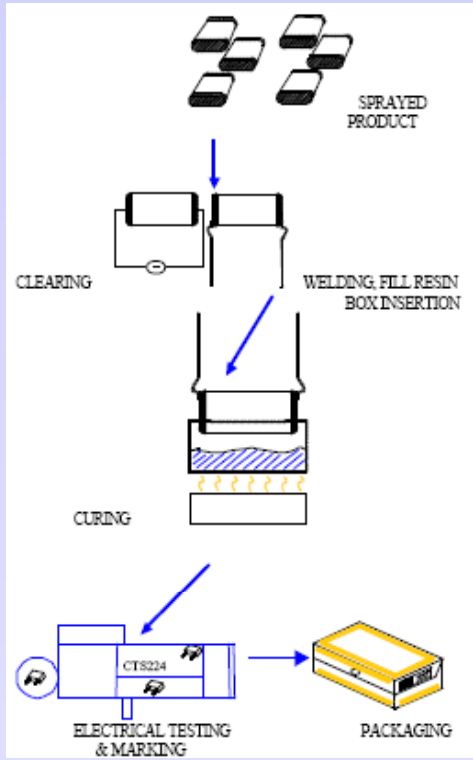
	PolyEthylene Terephthalate PET (MKT)	PolyPropylene PP (MKP)	PolyEthylene Naphthalate PEN (MKN)	PolyPhenylene Sulfide PPS
Metallized	YES	YES	YES	YES
Dielectric constant	100	80	95	80
Minimum thickness	1µm	2,8µm	1.4µm	1.2µm
Working temperature	125°C	105°C (125°C for particular PP)	125°C	140°C
Tand (1kHz) (typical)	50×10^{-4}	2×10^{-4}	40×10^{-4}	2×10^{-4}
Behaviour vs frequency	MEDIUM	GOOD	MEDIUM	GOOD
Tolerance (standard)	± 5% to 10%	± 2.5% to ± 20%	±10%	± 2% to ± 10%
Stability	± 3%	± 0.5%	± 3%	± 0.5%
Self-healing properties	MEDIUM	GOOD	MEDIUM	LOW

PROCESS FLOW CHART

- *Raw Material Procurement*
- *Winding*
- *Flattening*
- *Masking*
- *Metallization Spraying*
- *Demasking*



- *Clearing*
- *Wire Weldings*
- *Resin Filling*
- *Box Insertion*
- *Electrical Testing*
- *Marking*
- *Packaging*



SELF - HEALING

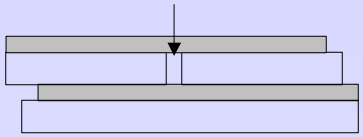
Capacitors with metallized Polypropylene film have excellent “self-healing” properties, compared to other film capacitors or other capacitor technologies (impregnated paper,…). This property allows the use of thin dielectric materials; capacitors made with Polyester base film, metal-foil electrodes, impregnated paper caps, must always be designed with a safety margin to avoid a possible permanent short circuit in case of dielectric breakdown.

3 – Metal layer < 0.02µm
4 – Dielectric: 1µm

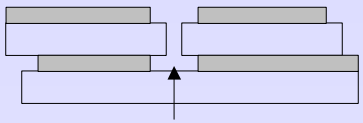
Metallized film capacitors: the metal layer is very thin and, in case of dielectric breakdown, the energy released by the arc discharge in the breakdown channel is sufficient to totally evaporate the thin metal coating close to the channel. This results in insulation restoring and a small capacitance drop.

Metallized film capacitors

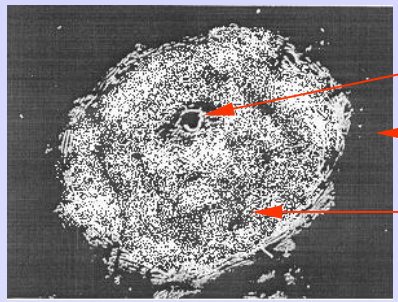
Breakdown



Result of breakdown:

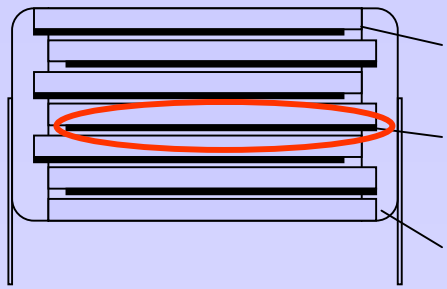


Metallization is evaporated (insulation restored)



The advantages of single metallized film are the following:
- smaller size (thinner electrode and dielectric)
- higher capacitance value (thinner electrode and dielectric)
- higher reliability (self-healing in case of dielectric breakdown)
- lower cost (smaller size)
- lower weight (smaller size)

CORONA EFFECT (Air molecules ionization)

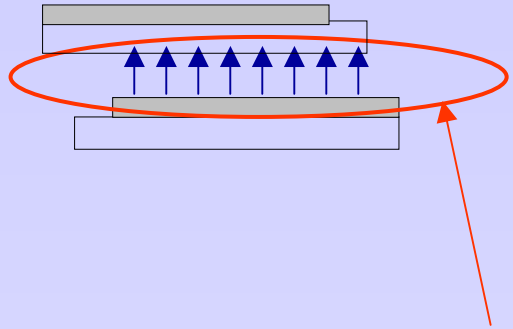


plastic film dielectric

Single metallized film

metal-sprayed contact layer

MKP



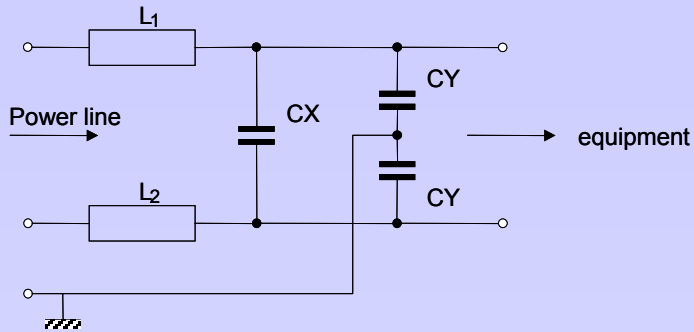
Due to the contemporaneous presence of air inside the capacitor and Vac, internal surface discharges happen and cause the partial evaporation of internal metallization. This is the reason of the capacitance value decrease.

During the manufacturing process, there are many phases oriented to the pulling out of the air between the film layers of the caps: winding – flattening – thermal treatment. Anyway a certain quantity of air remains inside the film capacitor layers.

The environment humidity decrease the air dielectric strength and favourites the corona effect discharges.

SUPPRESSOR CAPACITOR

Electronic Filter lay-out



- Every electronic / electrical equipment produce **R**adio **F**requency **I**nterferences (**RFI**).
- RFI emission coming from inside or outside the system can be the cause of equipment malfunctioning. (**E**lectro **M**agnetic **S**usceptibility - **EMS**).
- National and International standards regulates the maximum permissible noise level.
- All suppressor capacitors have to be according with EN 132400 (IEC 60384-14)

CLASS X CAPACITORS

Class X capacitors will be divided into three sub-classes according to the peak voltage (Vp) of the impulses superimposed on the main voltage to which they may be subjected in service.
Such impulses may arise from lightening strikes on outside lines, from switching in the equipment in which the capacitor is used.

SUB-CLASS	Vp	APPLICATION	Vp IMPULSE BEFORE ENDURANCE TEST
X1	> 1.2kV ≤ 4.0kV	High pulse application	$4kV \quad for \quad C \le 1\mu F \quad ; \quad \frac{4}{\sqrt{C}} kV \quad for \quad C > 1\mu F$
X2	≤ 2.5kV	General purposes	$2.5kV \quad for \quad C \le 1\mu F \quad ; \quad \frac{2.5}{\sqrt{C}} kV \quad for \quad C > 1\mu F$
X3	≤ 1.2kV	General purposes	NONE

SUPPRESSOR CAPACITOR (Cont'd.)

CLASS Y CAPACITORS

Class Y capacitors will be divided into four sub-classes according to the type of insulation which could be bridged in case of short circuit of the capacitor.

SUB CLASS	TYPE OF INSULATION BRIDGED	RATED VOLTAGE	Vp IMPULSE BEFORE ENDURANCE TEST
Y1	Double or reinforced insulation	≤ 500Vac	8kV
Y2	Basic or supplementary insulation	≥ 150Vac ≤ 300Vac	5kV
Y3	Basic or supplementary insulation	≥ 150Vac ≤ 250Vac	NONE
Y4	Basic or supplementary insulation	< 150Vac	2.5kV

MAIN STANDARDS FOR RFI SUPPRESSION CAPACITORS

EUROPE Reference Standard: **EN 132400 (IEC 60384-14)**

U.S.A. Reference Standards: UL 1414 and UL 1283

UL 1414: Across-the-line

- Max capacitance value: 1µF
- Max operating temperature:+ 85°C
- Max voltage: 250Vac
- UL 1414 approval covers also UL 1283 approval (not viceversa)

UL 1283: Electromagnetic Interference filters

- The UL 1283 approval can be requested also for capacitance values higher than 1µF, rated voltages higher than 250Vac and temperatures higher than + 85°C

CANADA Reference Standard: CAN/CSA 384-14

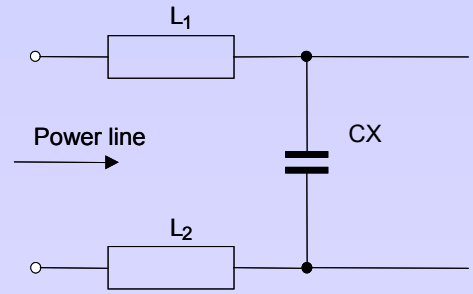
CAN/CSA 384-14: Across-the-line applications

- The CAN/CSA 384-14 approval is identical to IEC 60384-14. It harmonizes and can be requested also for capacitance values higher than 1µF, temperatures higher than 85°C and voltages higher than 250Vac.

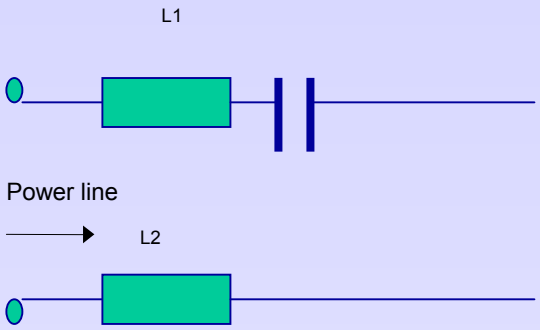
CHINA Reference Standard: GB/IT14472-1998

WHERE TO USE SUPPRESSOR CAPACITORS ?

The X2 metallized film capacitor is designed to withstand all International Standards.



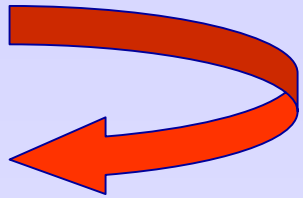
The X2 metallized film capacitor is designed to filter spikes in parallel with the main.



The use of X2 metallized film capacitor <u>is not recommended</u> for any other application different than suppression in parallel with the main, like position in serial with the main and general decoupling.

WHERE TO USE SUPPRESSOR CAPACITORS ?

- The suppressor cap is designed to work in parallel with the main at low frequency (50/60 Hz).
- The suppressor capacitor is supposed to withstand high peak voltage values through all its life and then it must have high performances of self-healing.
- In International Standards don't care about suppressor capacitance change in severe ambient conditions.



For all the above reasons , X2 is recommended for circuit position in parallel with the main.

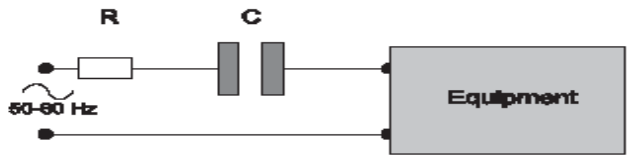
CAPACITORS IN SERIES / PARALLEL WITH THE MAIN

SERIES with the MAIN

Applications:

- Energy meters.
- Control boards for WHITE goods and home appliances.
- Relays and switching gears for industrial application.
- All the applications where the capacitors is used to store energy or to divide the main voltage.

Electric scheme



Main performances requested to the capacitor.

- Capacitance stability.
- Good self-healing properties (under severe Surge test).

The most suitable series to be used in serial with the main are:

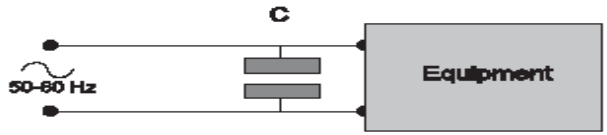
- R.752 (230Vac) and R75L (250Vac): polypropylene cap with parallel construction and small dimensions; goods self-healing properties and good properties in damp environment.
- R.603 (300Vac): polyester cap with impregnation and series construction; good self-healing properties and goods properties in damp environment.
- R.47 (440Vac): polypropylene cap with series construction and approved as Class X2 or X1 noise suppressor; high self-healing properties.

PARALLEL with the MAIN

Applications:

The capacitor in parallel with the main is requested by international standard with the main goal of noise suppression and safety.

Electric scheme



Main performances requested to the capacitor.

- Safety (under severe Impulse Voltage test)
- Endurance tests required by the International Standards.

The most suitable series to be used in parallel with the main are:

- R.46 (275-300Vac): polypropylene cap officially approved as Class X2 noise suppressor.
- R.46S (275Vac): polypropylene cap officially approved as Class X2 noise suppressor with internal protection against damp environment.
- R.46 125°C (275Vac): polypropylene cap officially approved as Class X2 noise suppressor for application up 125°C.

CAPACITORS IN SERIES / PARALLEL WITH THE MAIN

SERIES with the MAIN	parallel construction	series construction	series construction
Series	Series with the main **R.752 - R.75L**	Series with the main **R.603**	X2 - X1 class **R.47**
Pitch	15 - 37.5 mm	22.5 - 37.5 mm	10 - 37.5 mm
Dielectric	Polypropylene	Polyester	Polypropylene
Electrodes	Metallized film	Metallized film	Metallized film
Capacitance range	56nF - 10µF	0.15µF - 6.8µF	4700pF - 2.2µF
Rated voltage	230 - 250 Vac	300 Vac	440 - 520 Vac
Available tolerance	±10%; ±20%;(*);	±5%; ±10%; ±20% ;	±10%; ±20%;(*);
Pulse rise time (dv/dt)	70 to 500 V/µs	100 to 200 V/µs	150 to 750 V/µs
Climatic category (IEC 60068-1)	55/105/56	55/105/56	40/110/56
Operating temperature range	-55°C to +105°C	-55°C to +105°C	-40°C to +110°C
Packaging	Loose or taped	Loose or taped	Loose or taped

PARALLEL with the MAIN	parallel construction	parallel construction	parallel construction
	X2 class		
Series	**R.46**	**R.46S**	**R.46 125°C**
Pitch	10 - 37.5 mm	10 - 37.5 mm	10 - 22.5 mm
Dielectric	Polypropylene	Polypropylene	Polypropylene
Electrodes	Metallized film	Metallized film	Metallized film
Capacitance range	10nF - 10µF	22nF - 10µF	10nF - 1µF
Rated voltage	275 - 300 Vac	275 Vac	275 Vac
Available tolerance	±10%; ±20%;(*);	±10%; ±20%;(*) ;	±10%; ±20%; (*);
Pulse rise time (dv/dt)	100 to 500 V/µs	100 to 500 V/µs	200 to 500 V/µs
Climatic category (IEC 60068-1)	40/110/56	40/110/56	40/125/56
Operating temperature range	-40°C to +110°C	-40°C to +110°C	-40°C to +125°C
Packaging	Loose or taped	Loose or taped	Loose or taped

R752 and R75L performances

Damp heat, steady state:

Test conditions 1st

Temperature:	+40°C±2°C
Relative humidity (RH):	93% ±2%
Test duration:	56 days

Performance

Capacitance change |ΔC/C|:	≤2%
DF change (Δtgδ):	≤10x10^{-4} at 1kHz
Insulation resistance:	≥50% of initial limit.

Test conditions 2nd

Temperature:	+40°C±2°C
Relative humidity (RH):	93% ±2%
Test duration:	56 days
Voltage applied:	V_R

Performance

Capacitance change |ΔC/C|:	≤5%
DF change (Δtgδ):	≤10x10^{-4} at 1kHz
Insulation resistance:	≥50% of initial limit.

Test conditions 3rd

Temperature:	+85°C±2°C
Relative humidity (RH):	85% ±2%
Test duration:	250 h
Voltage applied:	V_R

Performance

Capacitance change |ΔC/C|:	≤5%
DF change (Δtgδ):	≤10x10^{-4} at 1kHz
Insulation resistance:	≥50% of initial limit.

Endurance:

Test conditions

Temperature:	+85°C±2°C
Test duration:	2000 h
Voltage applied:	1.25xV_R

Performance

Capacitance change |ΔC/C|:	≤5%
DF change (Δtgδ):	≤10x10^{-4} at 10kHz for C≤1μF ≤10x10^{-4} at 1kHz for C>1μF
Insulation resistance:	≥50% of initial limit.

Resistance to soldering heat:

Test conditions

Solder bath temperature:	+260°C±5°C
Dipping time (with heat screen):	10 s±1 s

Performance

Capacitance change |ΔC/C|:	≤1%
DF change (Δtgδ):	≤10x10^{-4} at 10kHz for C≤1μF ≤10x10^{-4} at 1kHz for C>1μF
Insulation resistance:	≥initial limit.

Long term stability (after two years):

Storage: standard environmental conditions (see page 12 of DC film capacitors catalogue)

Performance

Capacitance change |ΔC/C|:	≤0.5%

Surge test: applied on the leads of the capacitor 1700Vpeak 1.2us/50us 5 pulses each phase.