Film Capacitors

EMI suppression capacitors

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EPCOS AG is a TDK Group Company.

1 General / Standards

EMI suppression capacitors, **as the name implies**, are used to reduce electromagnetic interference. They are connected directly to line and are therefore exposed to overvoltages and transients, which could damage the capacitors. For this reason, EMI suppression capacitors must comply with the requirements of the following safety standards:

Region	Standard	Approval marks
Europe	EN 60384-14:2014 IEC 60384-14:2013	
USA	UL 1414:2000 UL 1283:2005	
Canada	CSA C22.2, No.1:2004 CSA C22.2, No.8:2013	1) or
China	CQC (GB/T 14472-1998):1998	

1) Approved by UL according to CSA

EN 60384-14:2014 / IEC 60384-14:2013, 2nd edition

With the aim of harmonizing all the European national standards and having only one standard of reference, EN 132400:1995 was issued in 1995 to replace all European national standards. The reference European standard EN 132400:1995 is identical to IEC 60384-14:2013, 2nd edition.

The ENEC (European Norms Electrical Certification) mark has replaced the following national marks:

UL 1414 (across the line and line bypass application)

UL 1414 approval is limited to capacitors with the following specifications:

Maximum capacitance: 1 µF
Maximum operating temperature: +85 °C
Maximum operating voltage: 250 V AC

There is no specific UL standard for EMI capacitors above these ratings. The UL 1283:2005 standard must be applied for UL compliance of EMI capacitors, even though it is a general standard for EMI filters.

UL 1283 (electromagnetic interference filters)

UL 1283 approval can also be requested for

capacitance > 1 µF,
temperature > +85 °C,
operating voltage > 250 V AC.

By agreement between UL and CSA, UL can test capacitors and certify compliance to CSA standards and vice-versa. For example, if UL is requested to evaluate an EMI suppression capacitor for UL 1414:2000 and CSA 22.2, No.1:2004, No 1, UL will conduct the tests common to both standards and those that are different, if any. Such a capacitor will bear the UL mark and a new "cUL" (c FL us) mark that is fully accepted by CSA.

CSA C22.2, No.1:2004 and CSA C22.2, No.8:2013

CSA requirements are almost similar to UL, with CSA C22.2, No.1:2004 being equivalent to UL 1414:2000 and CSA C22.2, No.8:2013 to UL 1283:2005.

CQC (GB/T 14472-1998)

A CQC (China Qualification Certificate) must be obtained for products marketed and imported into China. This came into effect on 1st May 2003.

2 Classification of EMI suppression capacitors

EN 60384-14:2014 and IEC 60384-14:2013 divide EMI suppression capacitors into two groups:
- X capacitors (for line-to-line or line-to-neutral connection) and
- Y capacitors (for line-to-ground or neutral-to-ground connection).

2.1 X capacitors

These are capacitors where failure of the capacitor would not lead to danger of electrical shock but could result in a risk of fire (short-circuit). EN 60384-14 divides X capacitors into 3 sub-classes according to the peak pulse voltage to which they are exposed in operation, in addition to the rated voltage. This kind of impulse can be caused by lightning in overhead cables, switching surges in neighbouring equipment or in the device in which the capacitor is used to suppress interferences.

Sub-class	Peak pulse voltage V_p in operation	Application	Peak values of surge voltage V_p (before endurance test)
X1	2.5 kV < V_p ≤ 4.0 kV	High pulse application	C_R ≤ 1.0 µF: V_p = 4.0 kV
			C_R > 1.0 µF: (enter C_R in µF) $V_p = \frac{4}{\sqrt{C_R}}$ kV
X2	V_p ≤ 2.5 kV	General purpose	C_R ≤ 1.0 µF: V_p = 2.5 kV
			C_R > 1.0 µF: (enter C_R in µF) $V_p = \frac{2.5}{\sqrt{C_R}}$ kV
X3	V_p ≤ 1.2 kV	General purpose	No test

Note: Sub-class X3 corresponds to sub-class X2 as described in IEC 60384-14:2013 (1st edition).

2.2 Y capacitors

These capacitors are intended for use where failure of the capacitor could result in a dangerous electrical shock. Y capacitors are capacitors of enhanced electrical and mechanical reliability and limited capacitance. Limitation of the capacitance is intended to reduce the current passing through the capacitor when AC voltage is applied and to reduce the energy content of the capacitor to a limit that is not dangerous when DC voltage is applied.

Y capacitors are used in electrical equipment and machines to bridge operational insulation that provides safety, in connection with additional protective measures, in order to avert danger to humans and animals.

EN 60384-14 divides Y capacitors into the following sub-classes:

Sub-class	Type of bridged insulation	Rated AC voltage	Peak values of surge voltage V_p (before endurance test)
Y1	Double or reinforced insulation	$V_R \leq 250$ V	8.0 kV
Y2	Basic or supplementary insulation	150 V $\leq V_R \leq$ 250 V	5.0 kV
Y3	Basic or supplementary insulation	150 V $\leq V_R \leq$ 250 V	No test
Y4	Basic or supplementary insulation	$V_R <$ 150 V	2.5 kV

Note: Sub-class Y3 corresponds to class Y as described in IEC 60384-14:2013 (1st edition).

3 Some important tests to IEC 60384-14:2013 / EN 60384-14:2014

Impulse voltage test

Each capacitor except those of sub-classes X3 and Y3 is tested with the surge voltage (V_p) as shown in the above table.

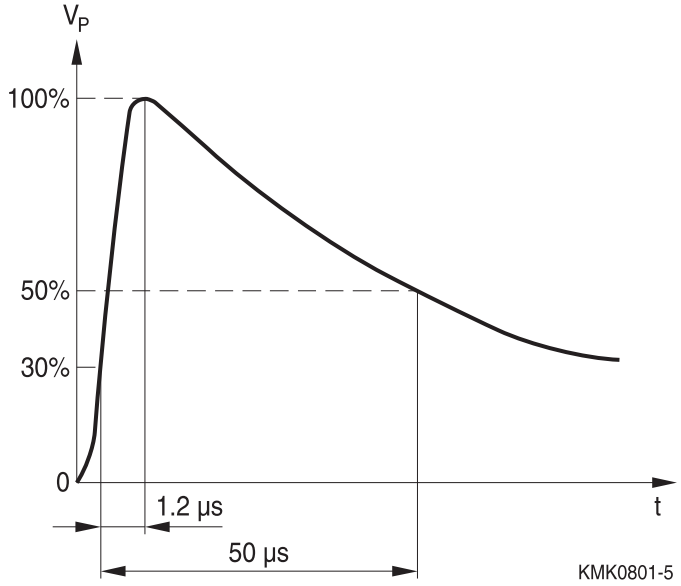

Figure 1
Impulse voltage test for X and Y capacitors

Endurance test

Capacitors are tested with a voltage of 1.25 times the rated voltage for class X2 and 1.7 times for class Y2 at the upper category temperature for 1000 h.

Each hour the test voltage is increased to 1000 V_{RMS}, 50 Hz for a period of 0.1 s.

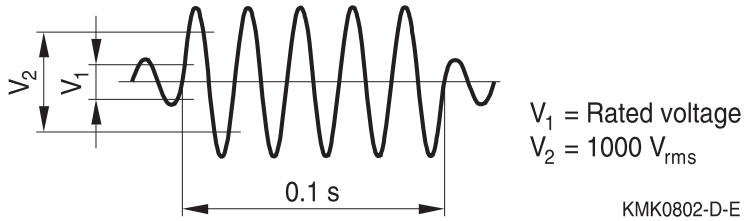

Figure 2
Endurance test for X and Y capacitors

Active flammability test

This test is to ensure that capacitors do not ignite at a defined electrical overload. Capacitors are applied the rated voltage at 50 Hz with 20 superimposed pulses of 2.5 kV for class X2 and 5 kV for class Y2.

The rated voltage is maintained for 2 min. after the last discharge. This is a destructive test, and the failure condition is that cheesecloth around the capacitor shall not burn with a flame. No electrical measurements are required.

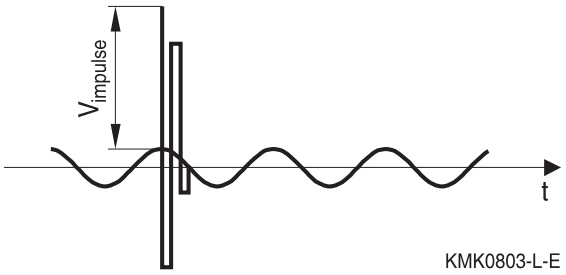

Figure 3
Active flammability test for X and Y capacitors

Voltage proof test

- The voltage of the following table shall be applied between the respective measuring points for a period not less than 1 s fot lot-by-lot quality conformance testing.
- Test between terminals and case shall be carries out only for qualification approval test.
- For testing period of 1 s the voltage of the following table shall be multiplied by 1.25.

Class	Range of rated voltages	Test between terminals	Test between terminals and case
X1 X2	≤ 760 V	4.3 V_R (DC)	2 · V_R + 1500 V AC
Y1	≤ 500 V	4000 V AC	4000 V AC
Y2	≤ 300 V	1500 V AC or 2250 V DC	2 · V_R + 1500 V AC

- Attention is drawn to the fact that repetition of the voltage proof test by the user may damage the capacitor.
- EPCOS recommends that if repetition of the voltage proof test is made by the customer, the applied voltage should not be greater than 66% of the test voltage specified in this table.

4 Typical application

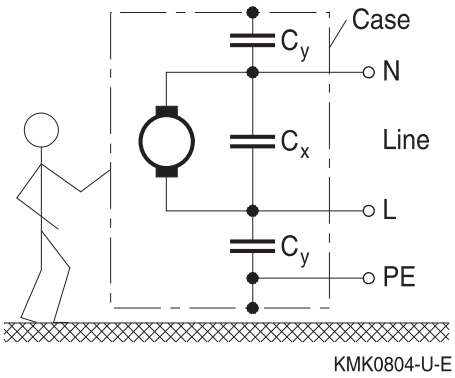

Figure 4
Example of EMI suppression with X and Y capacitors

Depending on how they are connected, X and Y capacitors are effective against different kinds of electromagnetic interference. X capacitors connected between the line phases are effective against symmetrical interference (differential mode). Y capacitors connected between a phase and neutral (zero potential) are effective against asymmetrical interference (common mode).

5 Humidity resistant X2 EMI suppression capacitors

The series B3293* and B3292* H/J are enhanced X2 series for severe ambient conditions. This series can withstand the following damp heat tests:

B3293* (recommended series)

- 40 °C/93% r.h./305 V AC (50 Hz)/2000 h
  Capacitance change (ΔC/C): ≤10%
  Dissipation factor change (Δ tan δ): ≤5 · 10^{-3} (at 1 kHz)
  Δtan d/tan d ≤100% (10 kHz)
  Insulation resistance R_{ins}: >10 MΩ
- 85 °C/85% r.h./240 V AC (50 Hz)/1000 h
  Capacitance change (ΔC/C): ≤10%
  Dissipation factor change (Δ tan δ): ≤5 · 10^{-3} (at 1 kHz)
  Δ tan δ/tan δ ≤100% (10 kHz)
  Insulation resistance R_{ins}: >10 MΩ

B32932* H/J

- 85 °C/85% r.h./240 V AC (50 Hz)/1000 h
  Capacitance change (ΔC/C): ≤10%
  Dissipation factor change (Δ tan δ): ≤5 · 10^{-3} (at 1 kHz) for LS 15 and LS 22.5 mm
  Dissipation factor change (Δ tan δ): ≤20 · 10^{-3} (at 1 kHz) for LS 27.5 and LS 37.5 mm
  Insulation resistance R_{ins}: >200 MΩ
  Δ tan δ/tan δ ≤2000% (10 kHz)