Radio Interference Suppression Capacitors

INTERFERENCE

There are two main sources of radio interference:

- Devices, which due to their construction produce RF energy. These include generators for use in industry, medicine and science, as well as oscillators, radio and TV receivers etc.
- Devices, which produce a wide spectrum of frequencies, due to rapid variations in electrical current intensity. These include devices with switching components, thyristors, triacs, commutators and similar.

Interference from source to receiver is spread in three ways:

- along wiring
- by coupling
- by radiation

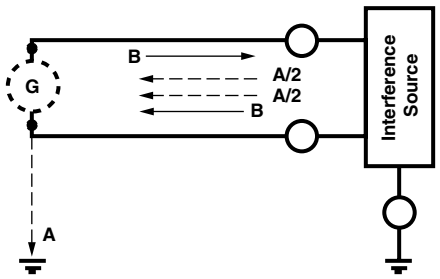
To frequencies of 30 MHz approximately, interference is spread mainly along the installed electrical wiring. In this range inductive and capacitive coupling also occurs between the wiring and other metal parts of the devices acting as supports of interference transfer.

Frequencies higher than 30 MHz are spread by radiation since interference source dimensions and terminal wiring are in order of size to the wave length of the radiated interference. The metal parts therefore act as antennas.

The device connected to the mains supply produces two kinds of interference currents, running along wiring as seen in figure A. Symmetrical interference current B runs in different directions in the phase and neutral wires.

Asymmetrical interference current A runs in the same direction in both leads and ends in the same device via the earthing connection. An earthing connection can either be an earthing wire or capacitance between the device and the surrounding.

Interference on long or medium radio waves is generally greater if the device is earthed. In this case impedance to the surrounding is short circuited and the asymmetrical interference current increases.



A) Asymmetric Terminal Voltage/Current

B) Symmetric Terminal Voltage/Current

RADIO INTERFERENCE SUPPRESSION CAPACITORS

Classification

The suppression capacitor is the most effective interference component. Its impedance decreases with the frequency, so that we have a short circuit between the mains terminals and/or between the terminals and ground at high frequency. Capacitors for applications between the mains terminals are called:

X-Capacitors

X-capacitors, also called across the line capacitors, are capacitors with unlimited capacitance for use where their failure due to a short circuit would not lead to the danger of an electric shock.
Capacitors for applications between terminals and ground are called:

Y-Capacitors

Y-capacitors, also called line bypass capacitors, are capacitors, which serves to reduce the asymmetrical interference voltage, and are located between a live conductor and the metal case which may be touched.

In fulfilling their technical function in electrical equipment, machines and installations, Y-capacitors bridge industrial insulating systems whose reliability, in conjunction with an additional protection measure prevents danger to human beings and animals.

They are intended for use in circumstances where failure of the protection measures of the equipment could lead to a danger of electric shocks.

Normally X- and Y-capacitors can also be combined in the same case and are called:

XY-Capacitors

SAFETY STANDARDS

Before radio interference suppression capacitors can be used in a mains application, they must fulfil safety standards defined by national authorities.

The basic world standard for these components is the IEC 60384-14 (ed.3).

According to these rules capacitors are subdivided into two classes, class X and class Y.

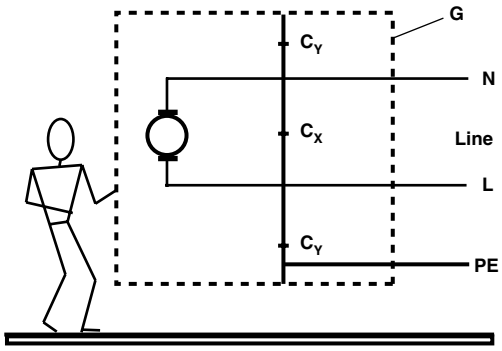


Figure a)
An example of radio interference suppression with X- and Y- capacitors used in equipment belonging to protection class I.

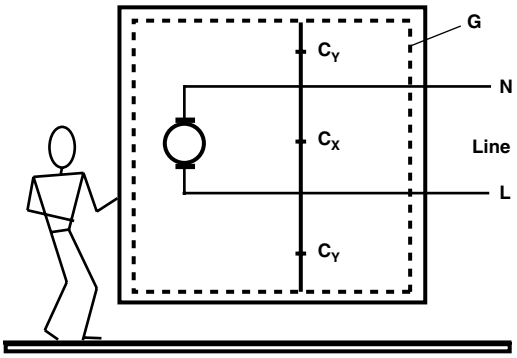


Figure b)
An example of radio interference suppression with X- and Y- capacitors used in equipment belonging to protection class II.

CLASS X-CAPACITORS

Class X-capacitors, X-capacitors for short, are subdivided into three subclasses, class X1, class X2 and class X3 corresponding to the peak voltages of the impulses superimposed on the mains voltage to which they may be subjected to in services. Such impulses may arise from lighting strikes on outside lines, from switching in neighbouring equipment, or switching in the equipment in which the capacitor is used.

SUBCLASS	PEAK IMPULSE VOLTAGE IN SERVICE	IEC. 664 INST. CATEGORY	APPLICATION	PEAK IMPULSE VOLTAGE U_P APPLIED BEFORE ENDURANCE TEST
X1	> 2.5 kV ≤ 4.0 kV	III	High pulse application	When $C_R \leq 1$ µF $U_P = 4$ kV When $C_R \geq 1$ µF $U_P = 4/\sqrt{C_{R\,in}}$ kV
X2	≤ 2.5 kV	II	General purpose	When $C_R > 1$ µF $U_P = 2.5$ kV When $C_R \leq 1$ µF $U_P = 2.5/\sqrt{C_{R\,in}}$ kV
X3	≤ 1.2 kV	-	General purpose	None

Note

• C_R is in µF

CLASS Y-CAPACITORS

Class Y-capacitors are further subdivided into four subclasses Y1, Y2, Y3 and Y4

SUBCLASS	TYPE OF INSULATING BRIDGES	RANGE OF RATED VOLTAGES	PEAK IMPULSE VOLTAGE U_P APPLIED BEFORE ENDURANCE TEST
Y1	Double Insulation or Reinforced Insulation	≤ 250 V	8.0 kV
Y2	Basic Insulating or Supplemantary Insulation	≥ 150 V ≤ 250 V	5.0 kV
Y3	Basic Insulating or Supplemantary Insulation	≤ 150 V ≥ 250 V	None
Y4	Basic Insulating or Supplemantary Insulation	≤ 150 V	2.5 kV

In Europe the safety standard EN 60384-14: 2005 is applicable, which is fully in line with IEC 60384-14 (ed.3). The safety mark for this is the ENEC mark.

For China the standard GB/T14472, controlled by the CQC mark, and in Canada the standard E-384-14, controlled by the CSA mark are applicable and are also in line with IEC 60384-14 ed 3.

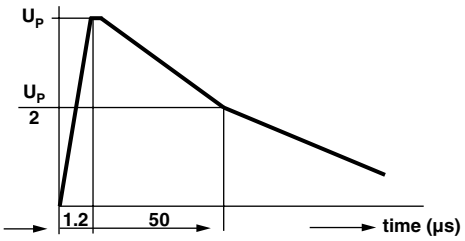
The USA has still different classifications and standards, UL1414 and UL1283, with the applicable UL mark.

In the product datasheets it can be found for which standard the capacitors are approved and are allowed to bear their safety approval marks.

ADDITIONAL DEFINITIONS FOR RFI CAPACITORS

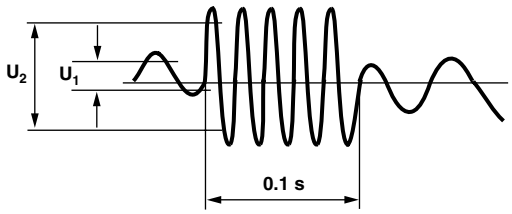
Impulse Voltage

RFI capacitors must withstand an impulse voltage with peak value U_P, rise time 1.2 µs and half pulse time of 50 µs according the graph below. U_P is defined per capacitor class.



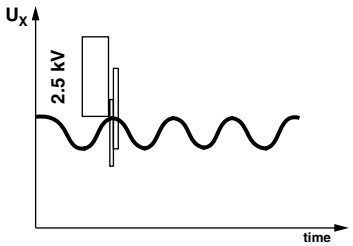
Endurance Test

All capacitors have to be tested for 1000 h at the upper category temperature with a voltage of 1.25 times rated voltage (U_R) for X-class capacitors and 1.7 times rated voltage (U_R) for Y-class capacitors. Every hour the test voltage has to be increase up to 1000 V_{RMS} for a time period of 0.1 s.



Active Flammability Test

All capacitors have to be tested with the rated voltage (U_R). at the frequency 50 Hz with superimposed 20 pulses at U_P with an interval between the successive discharges of 5 s. The capacitor shall be individually wrapped in at least one but not more than two complete layers of specified cheese-cloth. After finishing the test, the cheese-cloth shall not burn with a flame.



Insertion Loss

The ratio of the voltage before and after insertion of the suppressor as measured at the terminations.