

Technical Article

Safety Capacitors First: Class-X and Class-Y Capacitors

May 06, 2019 by [Nick Davis](#)

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A Special Class of Capacitors

Class-X and Class-Y [capacitors are safety-certified](#) and generally designed and used in AC line filtering in many electronic device applications. These safety capacitors are also known by other names, including *EMI/RFI suppression capacitors* and *AC line filter safety capacitors*. (EMI stands for electromagnetic interference and RFI stands for radio-frequency interference; RFI is simply higher-frequency EMI.)

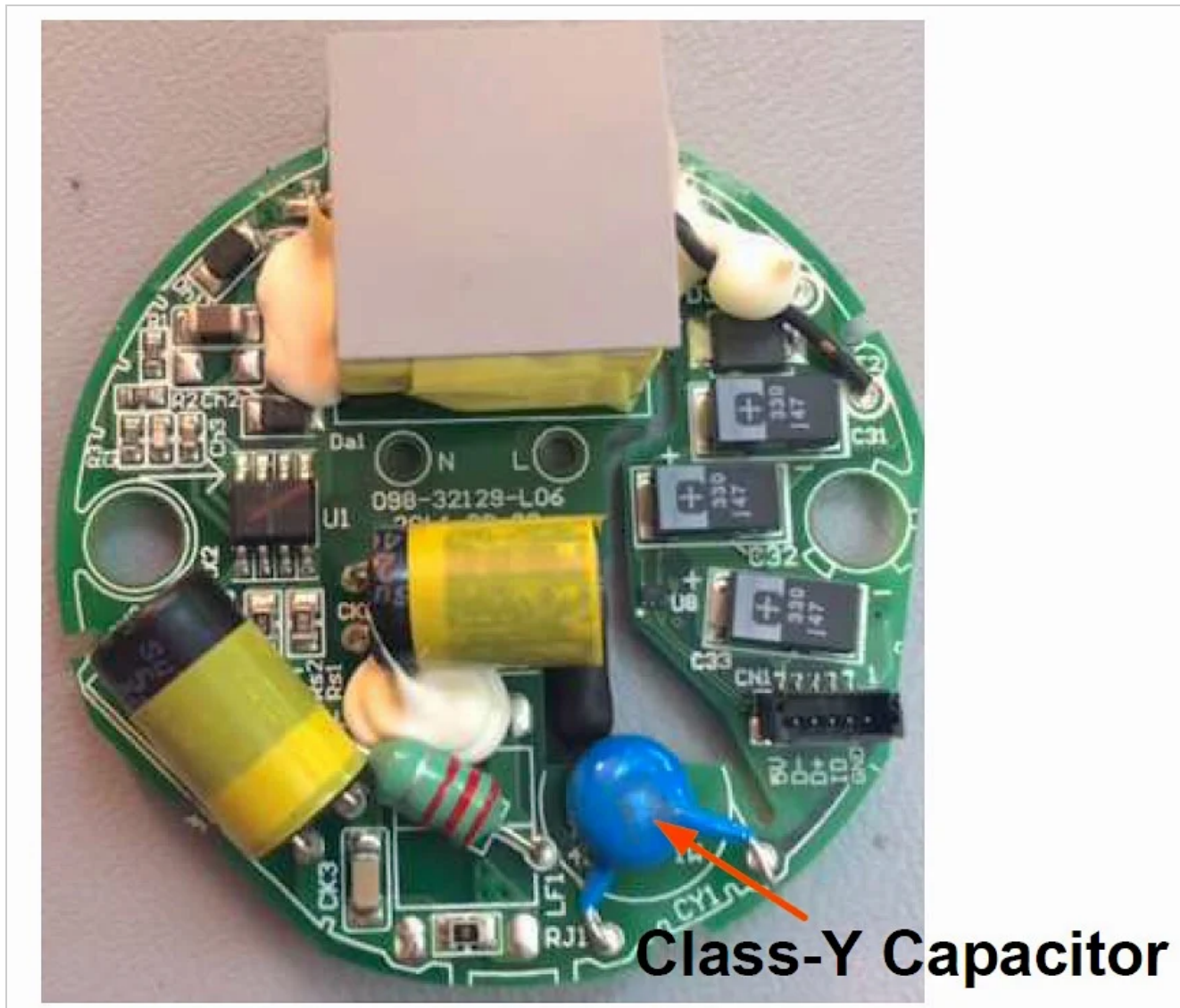


Figure 1. An example of a Class-Y capacitor. Image from this [teardown](#).

Class-X and Class-Y capacitors help to minimize the generation of EMI/RFI and the negative effects associated with received EMI/RFI.

In order for these capacitors to perform their EMI/RFI filtering tasks, they are directly connected to the AC power input, that is, the AC “line” and the AC “neutral” (see Figure 2 below). And because of this direct connection to the AC voltage, the capacitors may be subjected to overvoltages and/or voltage transients—lightning strikes, power surges. Thus, capacitor failure is a very real possibility.

When a Class-X capacitor, also referred to as an “across the line capacitor”—the capacitor placed between line and neutral—fails because of an overvoltage event, it is likely to fail short. This failure, in turn, would cause an overcurrent protective device, like a fuse or circuit breaker, to open. Therefore, a capacitor failing in this fashion would not cause any electrical shock hazards.

If a Class-Y capacitor, also known as the “line to ground capacitor” or “the line bypass capacitor”—the capacitor placed between line and ground—fails short, this could lead to a fatal electric shock due to the loss of the ground connection. Class-Y safety capacitors are designed to fail open. A failure will cause your electronic device to be subjected to the noise and interference that the capacitor would normally filter out, but at least there

will be no fatal electric shock hazard.

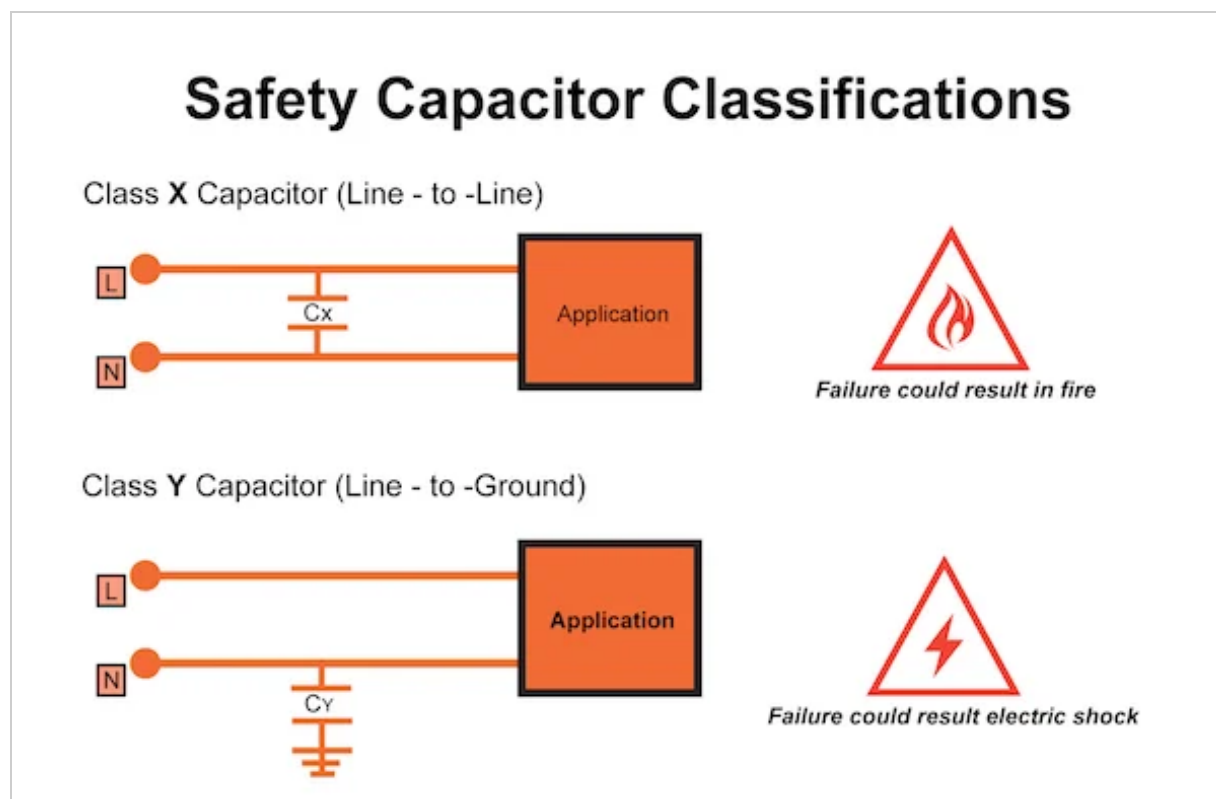


Figure 2. Placement of Class-X (C_X) and Class-Y (C_Y) safety capacitors. Image adapted from [Kemet](#) (PDF).

Rating of Class-X and Class-Y Capacitors

Class-X and Class-Y capacitors are classified according to:

- their peak voltage/rated voltage and
- the peak impulse voltage that they can safely withstand.

Tables 1 and 2 below summarize the subclasses of Class-X and Class-Y capacitors.

Subclass (IEC 60384-14)	Peak Voltage Pulse (while in service)	Peak impulse before endurance test
X1	$>2.5\text{kV}$ $\leq 4.0\text{kV}$	$4\text{kV per } C \leq 1\mu\text{F}$ $4/\sqrt{C} \text{ kV per } C > 1\mu\text{F}$
X2	$\leq 2.5\text{kV}$	$2.5\text{kV per } C \leq 1\mu\text{F}$ $2.5/\sqrt{C} \text{ kV per } C > 1\mu\text{F}$
X3	$\leq 1.2\text{kV}$	None

Table 1. Class-X subclass ratings*

Subclass (IEC 60384-14)	Rated Voltage	Peak impulse before endurance test
Y1	$\leq 500\text{VAC}$	8kV
Y2	$150\text{VAC} \leq V < 300\text{VAC}$	5kV
Y3	$150\text{VAC} \leq V < 250\text{VAC}$	None
Y4	$< 150\text{VAC}$	2.5kV

Table 2. Class-Y subclass ratings*

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* Per the following international standards, according to [Kemet](#) (PDF):

- UL 1414: American standard for across-the-line applications.
- UL 1283: American standard for electromagnetic interference filters.
- CAN/CSA C22.2 No.1: across-the-line applications
- CAN/CSA 384-14: across-the-line applications

Applications for Class-X and Class-Y Capacitors

Subclass X2 and Y2 are the most commonly used safety-certified capacitors. Depending upon your own application and requirements, they are *probably* the ones you'll want to use. This is assumed because X2 and Y2 safety capacitors are used in common appliances that operate from ordinary household wall outlets. **To be clear, you should select your Class-X and Class-Y capacitors according to your design's purpose and requirements.**

Whereas X2 and Y2 caps are appropriate for household applications, X1 and Y1 safety capacitors are used in industrial settings. As an example, a subclass X1 safety capacitor would be used for an industrial lighting ballast that is connected to a 3-phase line.

Of course, you could always use subclass X1 and Y1 in non-industrial applications, but you'll be spending more money and the larger sizes may prove inconvenient.

You might be asking, are X2 and Y2 safety capacitors interchangeable?

A Y2 capacitor can safely be used in place of an X2 capacitor, but an X2 capacitor should not be used in place of a Y2 capacitor. This is because, although an X2-type capacitor would work and filter noise sufficiently, it would not meet the line-to-ground safety standards. Y2 safety capacitors are more robust, are able to withstand higher peak impulse voltages, and are designed to fail open as opposed to failing short.

There are also safety caps that combine aspects of X and Y types, such that they have met both X and Y safety requirements and standards. So for an X1/Y1 combination, this simply means that the capacitor can be used either as an X1 capacitor in a line-to-line application or as a Y1 capacitor in a line-to-ground application. Examples include the following:

- [Vishay](#) (PDF) offers their VY2 Class X1 (440 VAC) / Class Y2 (300 VAC) capacitor. See Figure 3 below.
- [Kemet](#) (PDF) offers both X1/Y1 and X1/Y2 class combinations.



Figure 3. Class X1/Y2 safety capacitor offered by [Vishay](#) (PDF).

Safety Approval Logo Markings

All safety-certified capacitors should have the proper logo markings/symbols on their casing. See Figure 4 below for an example and see Figure 5 for a definition/description of these logos:



Figure 4. Safety capacitor with proper logo markings. Courtesy of [DXM Technology](#).

	Standard No.	Logo
UL	UL 1414	
CSA	C2221-01/C22.2NO1-98	
VDE	EN12400/IEC60384-14 2ND	
SEMKO	EN12400/IEC60384-14 2ND	
FIMKO	EN12400/IEC60384-14 2ND	
NEMKO	EN12400/IEC60384-14 2ND	
DEMKO	EN12400/IEC60384-14 2ND	
SEV	EN12400/IEC60384-14 2ND	
CQC	GB/T14472-1998	
CE	EN132400	

Figure 5. Safety markings and definitions. Make sure you have these memorized because there will be a test later. Courtesy of [DXM Technology](#).

In Summary

Because Class-X and Class-Y capacitors must be connected directly to AC lines (line-to-neutral or line-to-ground) in order for them to perform their EMI and RFI filtering functions, they must be rated and certified as "safety capacitors."

Both Class-X and Class-Y capacitors have subclasses: subclass X1, X2, and X3, and subclass Y1, Y2, Y3, and Y4. Subclass X2 and Y2 are the most common type of subclass for applications that use 120VAC (USA) or

220/240VAC (Europe). X/Y combination capacitors are also available, so you might consider using one of these, as well.

Whichever safety capacitor you choose, make sure that it has all the proper safety-approval logo markings.

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