



12 THINGS TO KNOW ABOUT PREVENTING OVERLOADS WITH SAFETY CAPACITORS

1 THE CLASS OF CAPACITOR YOU NEED DEPENDS ON WHETHER YOU'RE DOING DIFFERENTIAL MODE OR COMMON MODE FILTERING

DIFFERENTIAL MODE INTERFERENCE
 Differential mode interference is where pulses run along the wires (L-N) in opposite directions. For differential-mode filtering, you need Class X capacitors connected between the lines, effectively returning high frequency interference back to its source

COMMON MODE INTERFERENCE
 Common mode interference is where pulses run in the same direction in both wires (L-N) in the same device. For common-mode filtering you need Class Y capacitors connected between the wires and ground, bypassing the interference pulses from the wires to the ground

2 SAFETY REQUIREMENTS DIFFER DEPENDING ON THE TYPE OF CAPACITOR



The noise level in all electronic/ electric devices has to be kept below a certain level, which is defined in the particular device standards

Filtering is done by components such as capacitors or chokes or a combination of these components
 Since safety capacitors operate directly connected to the mains, they have to meet the requirements of the IEC 60384-14 safety standard



The safety requirements are much higher for Y capacitors, because a short/failure of such a component could lead to an immediate danger of an electric shock (see below)

3 WHILE CAPACITOR SHORTS IN CLASS X1/X2/X3/X4 APPLICATIONS AREN'T A BIG DEAL, THEY CAN LEAD TO ELECTROCUTION IN CLASS Y1/Y2/Y3 APPLICATIONS DUE TO HIGHER SURGE LEVELS

Failure of an **X** or a **Y** capacitor will lead to the malfunction or destruction of the device



A crack in a surface-mount part, built by putting two capacitors in series, can result in diminished capacitance rather than a short, since a short can occur in one section without affecting the other

Since **X** capacitors connect line and neutral, failure would not lead to the danger of an electric shock, but it could open safety fuses or circuit breakers and in an extreme case catch on fire

Y capacitors are located between a live conductor and the metal shielding, which someone could touch, so failure can cause electric shocks



4 THERE ARE PROS AND CONS TO USING FILM CAPACITORS

PROS Film capacitors offer higher capacitance values compared to other technologies. For example, Vishay offers film capacitors with these ratings:

TYPE	UP TO
X2	40 μ F at 310 V _{AC}
X1	8.2 μ F at 480 V _{AC}
Y2	1.0 μ F at 305 V _{AC}

Film capacitors have the ability to **recover from a dielectric breakdown** with just a **tiny decrease in capacitance**. This is called a "self-healing" effect. It happens because the arc created during a dielectric breakdown evaporates the metallization layer and thus clears the fault condition

The capacitance and dissipation factor of film capacitors are highly stable across a wide temperature range from **-40 °C to +110 °C**.

The internal series construction of X2 film safety capacitors helps the device to **last longer** and **maintain capacitance** in series impedance or across-the-line applications



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CONS



Film safety capacitors are through-hole devices, and if the application uses SMD components, they may need a different soldering process than the other components on the board

Film capacitors are usually more expensive than ceramic capacitors

5 THERE ARE PROS AND CONS TO USING CERAMIC CAPACITORS

PROS

Leaded ceramic capacitors have **highest dielectric** and pulse strength of all technologies

Leaded ceramic capacitors are the only ones available in the **X1/Y1 safety classification**

Leaded ceramic capacitors can handle pulses up to **10 kV**



Surface-mount ceramic capacitors are available with a capacitance value of **1 nF** and an **NPO temperature coefficient of capacitance**



Leaded ceramic capacitors are usually **less expensive** than film capacitors

CONS

Ceramic capacitors have relatively low capacitance values compared to other technologies, so there are some applications where they can't be used

6 HOW YOU ARRANGE COMPONENTS ON THE BOARD HAS AN EFFECT ON WHETHER YOU'RE MEETING SAFETY REQUIREMENTS

The market is always driving toward smaller components, but compliance with IEC 60384-14 means safety capacitors need to follow guidelines for creepage and clearance distances



For X1/Y1 capacitors, the **minimum allowed creepage and clearance distance is 8 mm**

Surface-mount capacitors also need to meet certain standards for termination-to-termination creepage

Vishay's surface-mount capacitors meet the strict 4 mm test that competing devices don't



7 SURFACE-MOUNT CAPACITORS HAVE A LOWER TOTAL IMPLEMENTATION COST THAN THROUGH-HOLE CAPACITORS

Through-hole devices may be less per piece, but they cost more to assemble

As a rough estimate, it costs less than \$ 0.01 to assemble an SMT part versus \$ 0.05 to assemble a through-hole part



8 NOT ALL SINGLE-LAYER CAPACITORS ARE EQUAL REGARDLESS OF WHAT THEIR DATASHEETS MAY SAY 3 EXAMPLES

1

Although it is sufficient for a X1/Y1 capacitor to withstand 8 kV pulses according to IEC 60384-14, Vishay guarantees a pulse strength of 10 kV for our VY1...C series

2

In terms of reliability, Vishay's AY2 and VY1...C series are qualified with a biased 85/85 1000 h test, although this is not required by the IEC standard (which requires only 40/95 500 h)

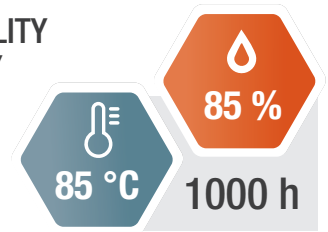
3

The switch from silver to copper electrodes in our new VY1...C series also results in an improved component lifespan, since it eliminates the negative effects of silver migration



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9 BOTH FILM AND LEADED CERAMIC CAPACITORS ARE AVAILABLE WITH THE ABILITY TO WITHSTAND HARSH TESTING CONDITIONS (85 °C/85 % RELATIVE HUMIDITY FOR 1000 h AT THE RATED VOLTAGE)



10 IT'S IMPORTANT TO PAY ATTENTION TO HUMIDITY



The latest edition of the IEC 60384-14 standard includes a “humidity grade” which reflects the components’ ability to operate in high humidity environments

The highest grade (Grade III) can be fulfilled by Vishay’s AY2 and VY1...C series, which are qualified using a 85/85 1000 h test procedure

Vishay’s F340 family features X1, X2 and Y2 devices which comply with Grade III B, meaning the capacitor must withstand 85 °C/85 %/1000 h at rated voltage with limited degradation of capacitance and dissipation factor

11 YOU CAN USE MULTIPLE CAPACITORS IN A SINGLE LOCATION TO ADD TO TOTAL CAPACITANCE

Restrictions of the leakage current limit the capacitance value of Y1 capacitors to 4.7 nF, but there are applications that require higher capacitance values. In these applications, two or more capacitors can be used in parallel



When using capacitors in parallel, voltage derating may be required depending on the number of capacitors involved



Vishay offers X1/Y1 capacitors up to a uniquely high capacitance value of 20 nF with our 440LS20-R, saving board space and assembly costs, while lowering the risk of failure



12 THERE IS A LOWER COST SINGLE-LAYER CAPACITOR OPTION WHERE Y5V DIELECTRIC IS GOOD ENOUGH

Y5V temperature coefficients are available for both X1/Y1 and X1/Y2 capacitors

Y5V devices save space because of their higher dielectric constant (making the components smaller)

Y5V devices cost less since less ceramic material is used

In many applications, operation temperatures are pretty predictable and low – and even at higher temperatures, a certain minimum capacitance value can be sufficient for filtering