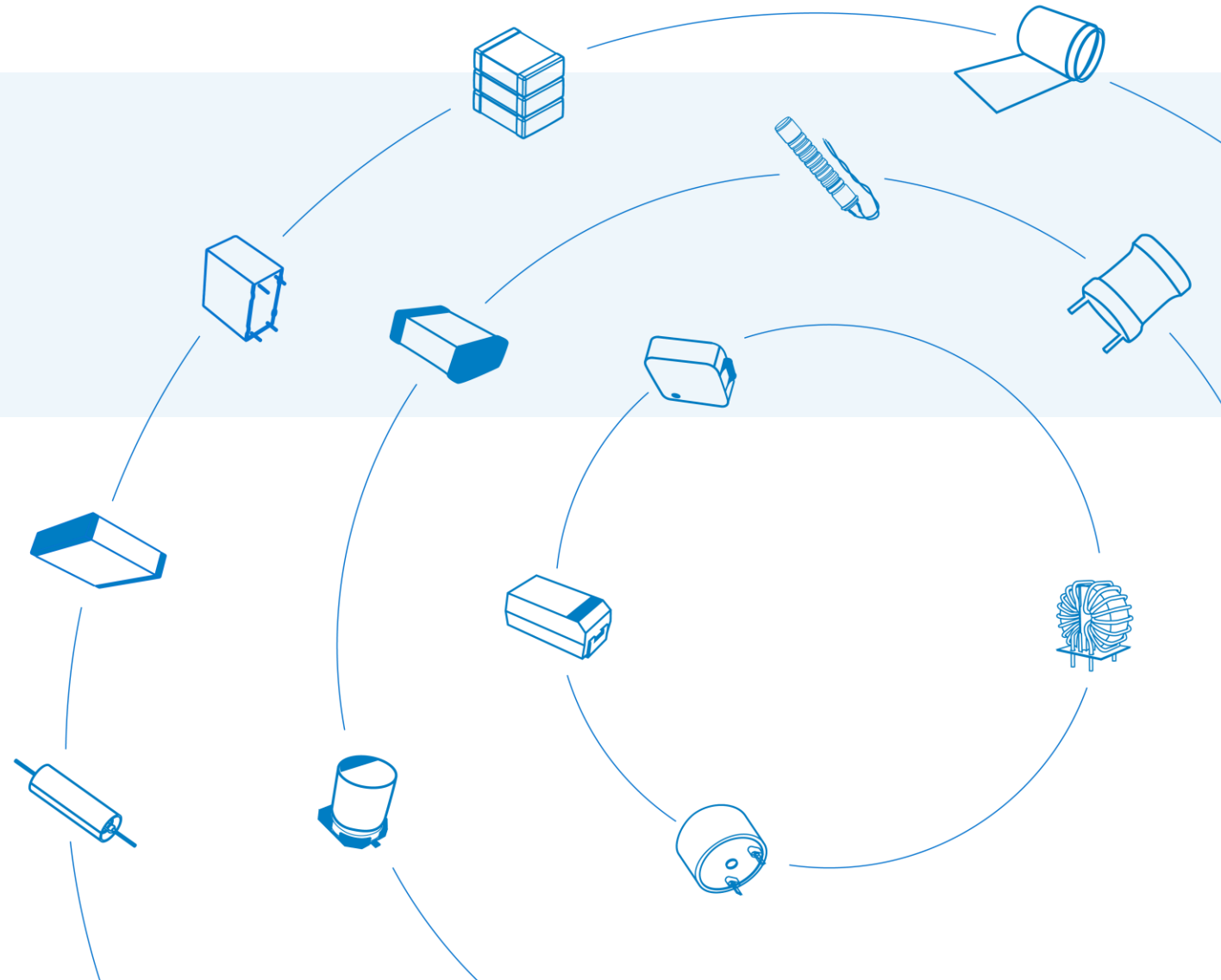


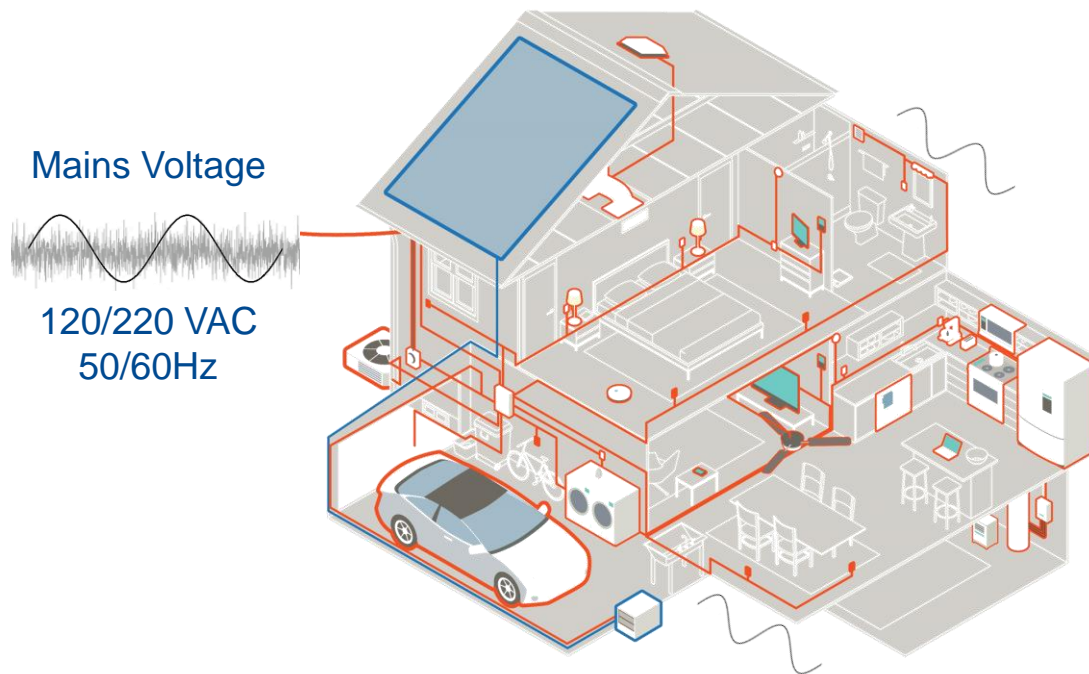
Safety Capacitors Overview

Film and Ceramic safety rated



Electromagnetic Compliance

KEMET



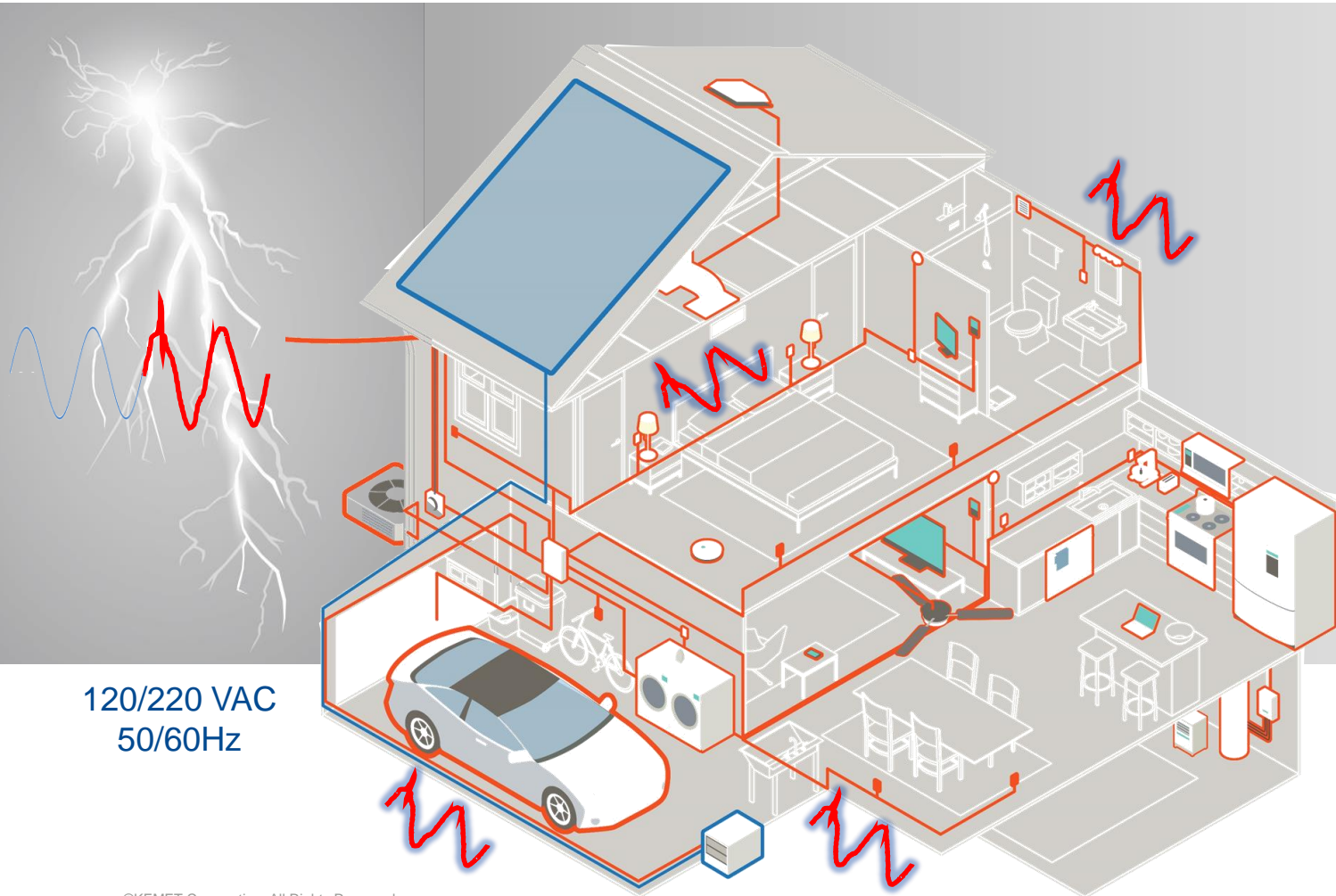
Products are subject to meet EMC standards

Power is a network and devices must protect from noise but most important not to generate interference

Devices can affect one another

Isolation between devices is needed

Voltage Surges due to Lightning Strikes



Lightning around an area can induce high voltage spikes into the line

Safety Capacitors must be able to safely withstand pulses.

What are Safety Capacitors?

Primary Functions

Interference suppression capacitor, is designed to aid in the filtering of AC line voltages

Safety rated to be used on line-to-line and line-to-ground applications

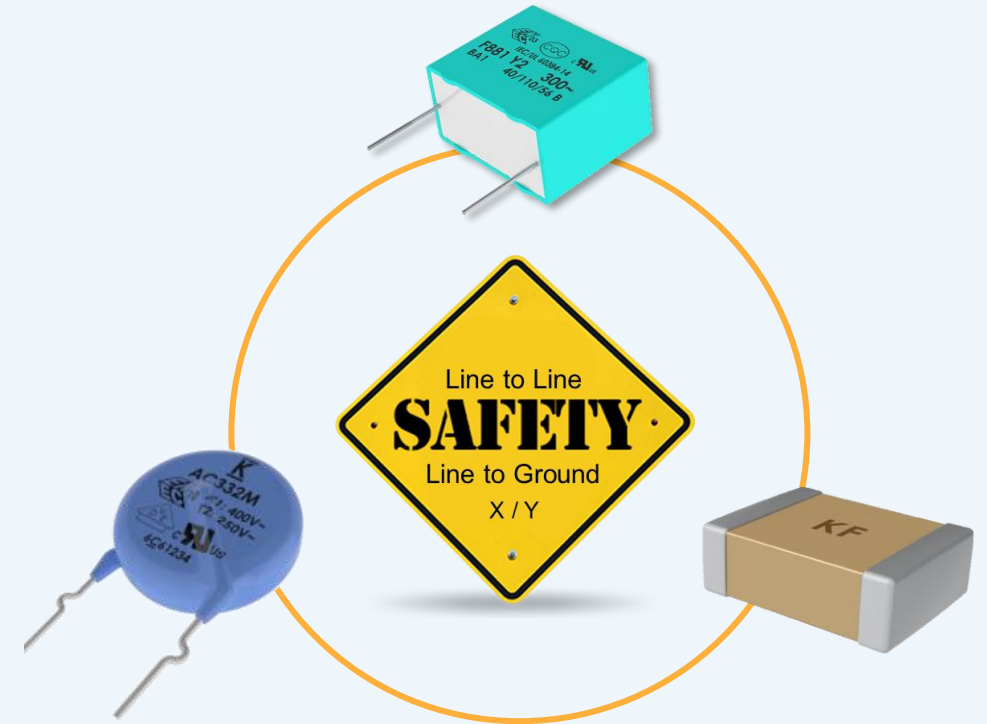
Return path to differential mode or common mode currents

Survive high voltage transients

Reliable under constant AC line voltages with safety failure mechanism

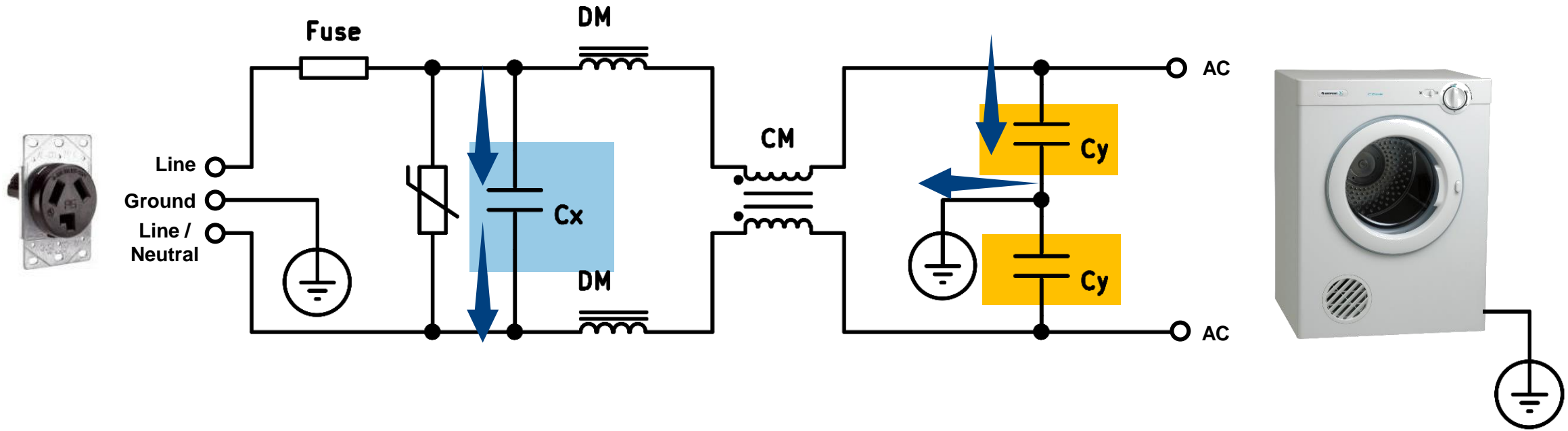
Meet IEC 60384-14 / UL 60384-14 standards

KEMET



How do we Reduce EMI on AC Line?

AC Line Filter



Chokes

- Differential Mode
- Common Mode

Class X Capacitors

- Line to Neutral
- Line to Line

Class Y Capacitors

- Line to Ground

Sub Classification

Per IEC 60384-14



Subclass	Peak Impulse Voltage in Service	Application	Peak Impulse before endurance test
X1	>2.5 kV ≤ 4.0 kV	High pulse application (Industrial)	4 kV per C ≤ 1μF 4/√C kV per C >1μF
X2	≤ 2.5 kV	General purpose (Home appliance)	2.5 kV per C ≤1μF 2.5/√C kV per C >1μF

Subclass	Rated Voltage	Type of Bridged Insulation	Peak Impulse before endurance test
Y1	≤ 500 Vac	Double insulation or reinforced Insulation (Industrial)	8 kV
Y2	≥ 150 Vac ≤ 500 Vac	Basic insulation or supplementary insulation (Home appliance)	5 kV

Example → X1 400 VAC / Y2 250 VAC

CLASS X

Specifically designed to be used across AC line to neutral.

Protect against **differential mode** interference

CLASS Y

Specifically designed to be used from the AC line to chassis.

Protect against **common mode** interference

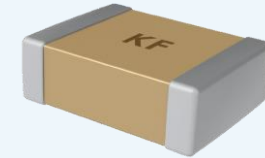
Substitution

Can you substitute one class with another?

Class	Substitution ¹
X1	Y1 or Y2
X2	X1, Y1, or Y2
Y2	Y1
Y1	None

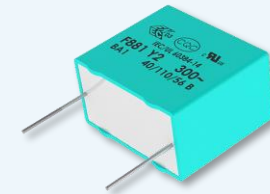
¹Substitutions are of the same or higher voltage rating

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For Ceramic Safety capacitors the DC voltage rating is up to the RMS voltage rating.

250VAC → 250VDC

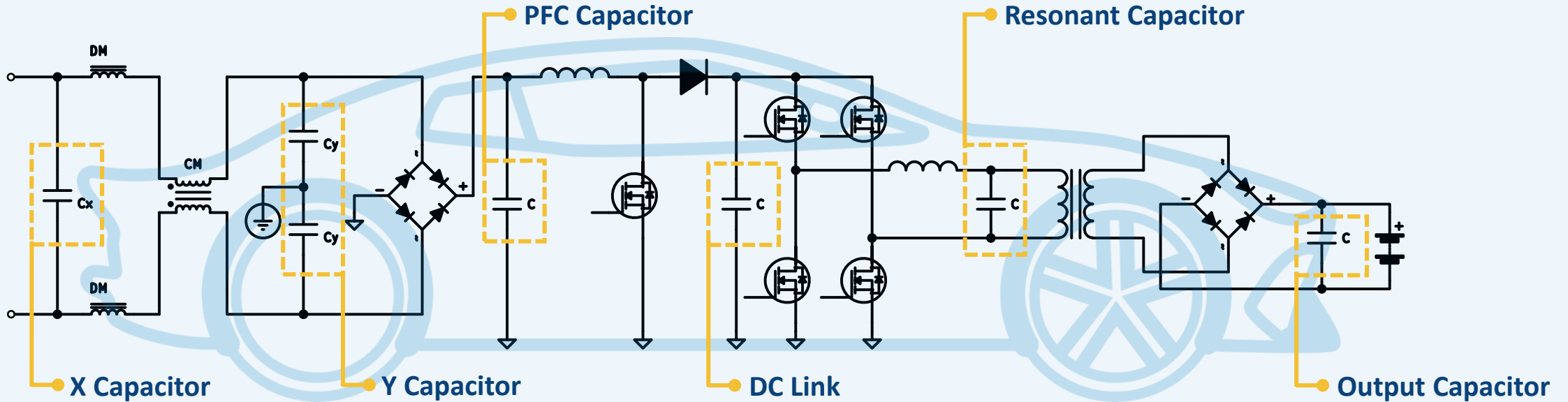


Film Safety capacitors on the other hand vary in DC rating higher than the RMS voltage

760VAC → 1500VDC



Automotive Environments Applications



On board Charger

- Connection to the grid
- Safety agency certification required

Motor Inverters

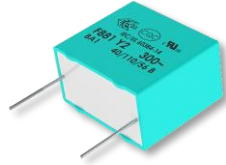
- Electric Shock
- Electric Hazard

Fast Battery Disconnect

- Impulse voltage
- High voltage disconnect

Safety Capacitors Types

Film Capacitors



Operating Voltage up to 760VAC

Temperature up to 125°C

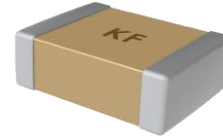
5 kV and 2.5 kV Impulse Rated

470 pF to 10 μ F
(Metalized paper and film)

X1, X2, Y1, Y2 Classes

Advantage:
Automotive and harsh environment capability

MLCC



250V AC Operating Voltage

Temperature 125 °C

5 kV and 2.5 kV Impulse Rated

3pF to 22nF
(C0G and X7R)

X1/Y2 and X2 Classes

Advantage:
Size reduction and high density

Ceramic Disc



Operating Voltage up to 760VAC

Temperature up to 125°C

5 kV and 2.5 kV Impulse Rated

10 pF up to 10 nF
(X7R and Y5R)

X1, Y2 Classes

Advantage:
Low pF range and slim profile

Safety Film Capacitor

Product Highlight

Class X1

R47	440Vac -110 °C
R49	330Vac -110 °C
PHE844	480Vac -105 °C
PHE845	760Vac -105 °C
F871	330Vac -110 °C
F872	480Vac -110 °C
F873	760Vac -110 °C
P278	480Vac -110 °C
PME271E	300Vac -110 °C

Class X2

R46	310Vac -125 °C
R47	520Vac -110 °C
F861	310Vac -110 °C
F862	310Vac -110 °C
F863	310Vac -110 °C
PME264	660Vac - 85 °C
PME271M	275Vac -110 °C

Class Y1

P295	500Vac -115 °C
PME295	480Vac -115 °C

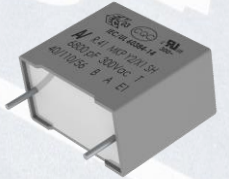
Class Y2

R41-T	300Vac -125 °C
R41	300Vac -110 °C
PME271Y	300Vac -115 °C
F881	300Vac -110 °C

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R41-T Series

- IEC-60384-14 THB Grade IIIB: 85°C, 85% RH, 1,000 hours at 300 VAC – 1500 VDC
- Y2/X1 Solution per UL, ENEC and CQC standards



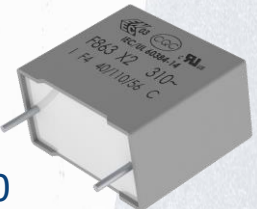
AEC
Q200

125°C
Rated

THB
85/85

F863 and F862 Series

- Harsh Environment Applications
- IEC-60384-14 THB Grade IIIB: 85°C, 85% RH, 1,000 hours at 300 Vac – 1500 Vdc

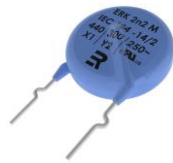


Ceramic Safety Capacitor Offering



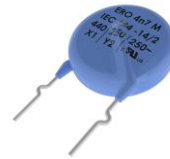
C900 Series

(AC, AS, AH)



ER Series

(ERO, ERK, ERP)



KJ Series

(KJN, KJY)

X1

400Vac
440Vac
760Vac

400Vac
440Vac
760Vac

400Vac
440Vac

Y1

250Vac
400Vac
500Vac

500Vac

250Vac
400Vac

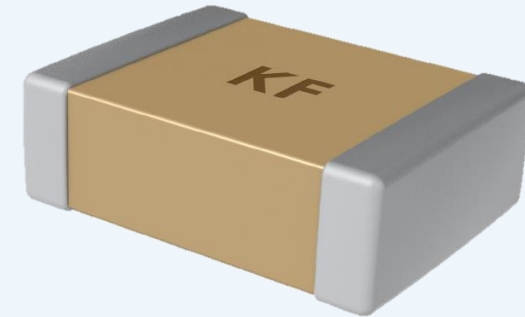
Y2

250Vac
300Vac

250Vac
300Vac



CAS Safety SMD



X1 250 VAC / Y2 250 VAC

X2 250 VAC

Up to 5 kV Pulse Capable

Industrial Grade

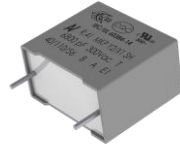
Case Sizes
1808-2225



Key Takeaways



Film Capacitors



AEC-Q200 Automotive options

R41-T Series 125°C

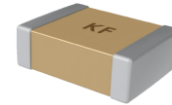
IEC-60384-14 THB Grade IIIB: 85°C, 85% RH support for harsh environments and Automotive

X1, X2, Y1, Y2 Classes

High capacity values :
470 pF to 10 μ F high voltages

Self Healing dielectrics
(Metalized paper and film)

MLCC



250V AC Operating Voltage

Temperature 125 °C

5 kV and 2.5 kV Impulse Rated

X1/Y2 and X2 Classes in
capacitance from 3pF to 22nF

High density, miniaturization
Temperature stable options
dielectric C0G as well as X7R

Ceramic Disc



Operating Voltage up to 760VAC

Temperature up to 125°C

Available in X1 and Y2 Class

Low capacity capability:
10 pF up to 10 nF at high voltage

Slim form factor using X7R and
Y5R dielectrics