Safety Capacitors
Overview
Film and Ceramic safety rated
Electromagnetic Compliance

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.

120/220 VAC 50/60Hz
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
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

<table>
<thead>
<tr>
<th>Subclass</th>
<th>Peak Impulse Voltage in Service</th>
<th>Application</th>
<th>Peak Impulse before endurance test</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1</td>
<td>&gt;2.5 kV ≤ 4.0 kV</td>
<td>High pulse application (Industrial)</td>
<td>4 kV per C ≤ 1µF 4/√C kV per C &gt;1µF</td>
</tr>
<tr>
<td>X2</td>
<td>≤ 2.5 kV</td>
<td>General purpose (Home appliance)</td>
<td>2.5 kV per C ≤1µF 2.5/√C kV per C &gt;1µF</td>
</tr>
</tbody>
</table>

### Subclass
#### Rated Voltage
<table>
<thead>
<tr>
<th>Subclass</th>
<th>Type of Bridged Insulation</th>
<th>Peak Impulse before endurance test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1</td>
<td>Double insulation or reinforced Insulation (Industrial)</td>
<td>8 kV</td>
</tr>
<tr>
<td>Y2</td>
<td>Basic insulation or supplementary insulation (Home appliance)</td>
<td>5 kV</td>
</tr>
</tbody>
</table>

**Example → X1 400 VAC / Y2 250 VAC**

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**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?

<table>
<thead>
<tr>
<th>Class</th>
<th>Substitution¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1</td>
<td>Y1 or Y2</td>
</tr>
<tr>
<td>X2</td>
<td>X1, Y1, or Y2</td>
</tr>
<tr>
<td>Y2</td>
<td>Y1</td>
</tr>
<tr>
<td>Y1</td>
<td>None</td>
</tr>
</tbody>
</table>

¹Substitutions are of the same or higher voltage rating

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

- **250VAC** → **250VDC**
- **760VAC** → **1500VAC**

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

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Voltage Range</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>R47</td>
<td>440Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>R49</td>
<td>330Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>PHE844</td>
<td>480Vac -105 °C</td>
<td></td>
</tr>
<tr>
<td>PHE845</td>
<td>760Vac -105 °C</td>
<td></td>
</tr>
<tr>
<td>F871</td>
<td>330Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>F872</td>
<td>480Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>F873</td>
<td>760Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>P278</td>
<td>480Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>PME271E</td>
<td>300Vac -110 °C</td>
<td></td>
</tr>
</tbody>
</table>

## Class Y1

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Voltage Range</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>P295</td>
<td>500Vac -115 °C</td>
<td></td>
</tr>
<tr>
<td>PME295</td>
<td>480Vac -115 °C</td>
<td></td>
</tr>
</tbody>
</table>

## Class Y2

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Voltage Range</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>R41-T</td>
<td>300Vac -125 °C</td>
<td></td>
</tr>
<tr>
<td>R41</td>
<td>300Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>PME271Y</td>
<td>300Vac -115 °C</td>
<td></td>
</tr>
<tr>
<td>F881</td>
<td>300Vac -110 °C</td>
<td></td>
</tr>
</tbody>
</table>

## Class X2

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Voltage Range</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>R46</td>
<td>310Vac -125 °C</td>
<td></td>
</tr>
<tr>
<td>R47</td>
<td>520Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>F861</td>
<td>310Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>F862</td>
<td>310Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>F863</td>
<td>310Vac -110 °C</td>
<td></td>
</tr>
<tr>
<td>PME264</td>
<td>660Vac - 85 °C</td>
<td></td>
</tr>
<tr>
<td>PME271M</td>
<td>275Vac -110 °C</td>
<td></td>
</tr>
</tbody>
</table>

### 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**

### 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)

<table>
<thead>
<tr>
<th>X1</th>
<th>400Vac</th>
<th>440Vac</th>
<th>760Vac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1</td>
<td>250Vac</td>
<td>400Vac</td>
<td>500Vac</td>
</tr>
<tr>
<td>Y2</td>
<td>250Vac</td>
<td>300Vac</td>
<td></td>
</tr>
</tbody>
</table>

### ER Series
(ER0, ERK, ERP)

<table>
<thead>
<tr>
<th>Y1</th>
<th>400Vac</th>
<th>440Vac</th>
<th>760Vac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y2</td>
<td>250Vac</td>
<td>300Vac</td>
<td></td>
</tr>
</tbody>
</table>

### KJ Series
(KJN, KJY)

<table>
<thead>
<tr>
<th>Y1</th>
<th>250Vac</th>
<th>500Vac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y2</td>
<td>250Vac</td>
<td>400Vac</td>
</tr>
</tbody>
</table>

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### 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 µF 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