X and Y Capacitors
EMI Capacitors on the AC Line

X capacitors are across the line. If they short-circuit, the risk is fire.

Y capacitors are from line to chassis. If they short-circuit, the risk is a shock to the user.

Because of the risks, X and Y capacitors are safety agency tested.
Self-healing

- Metallized film capacitors can repair themselves after a voltage spike.

  Breakdown occurs after surge.

  Thin metallization heats up and melts.

  Area around breakdown is isolated. No short circuit!
Self-healing

• Metallized film capacitors can repair themselves after a voltage spike.
• Ceramic caps cannot. Their failure mode can be a short circuit, with risk of shock in the case of a Y capacitor.

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Thin metallization heats up and melts.
Area around breakdown is isolated. No short circuit!
X Capacitors
X2 Capacitor PHE840M
Benefits for the designer
X2 Capacitor PHE840M

Benefits for the designer

- Lower prices, smaller sizes.
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• Many values in “standard” leadspacings plus new smaller alternates.
  – 1µF in 27.5mm and new 22.5.
  – 2.2 µF in 37.5mm and new 27.5.
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• UL approval at 280VAC.
  – Eases design-ins for 277VAC applications.
• Low loss polypropylene design for high frequency applications. (Polyester caps can heat up too much.)
  – High frequency motor drives, aircraft power (400Hz).
A Product for Every Voltage
X caps for industrial applications

AC voltage | Film        | Paper        |
-----------|-------------|--------------|
275/280    | PHE840M     | PME271M      |
300        | PHE840E     | PME271E      |
330        | PHE841      |              |
440/480    | PHE844      | PME278       |
600 & up   | PHE845      | PME264       |

Use one capacitor of the correct voltage instead of two low-voltage parts in series.
Y Capacitor Comparison

Ceramic

Metallized paper & film
Y Capacitor Comparison

Ceramic
Less expensive.

Metallized paper & film
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Ceramic

Less expensive.

Unstable over time and ______ Stable.

Metallized paper & film

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Stable.
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Less expensive.

Unstable over time and temperature.

Pushes over (may require additional insulation).

Metallized paper & film

Stable.

Boxed types do not push over. (Lower total cost.)
## Y Capacitor Comparison

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**Y Capacitor Comparison**

**Ceramic**

- Less expensive.
- Unstable over time and temperature.
- Pushes over (may require additional insulation).
- Maximum capacitance available is ~0.022µF.
- Failure mode tends toward short circuit.

**Metallized paper & film**

- Stable.
- Boxed types do not push over. (Lower total cost.)
- Available up to 1.0µF. (Ideal for industrial apps.)
- Self healing. Failure mode is open circuit.
New film Y cap PHE850
Alternative to ceramics
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Alternative to ceramics

- Metallized, self-healing construction.
  - Safer failure mode at near-ceramic prices.
New film Y cap PHE850
Alternative to ceramics

- Metallized, self-healing construction.
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- Very wide C-value range: 0.001 – 1 µF.
  - Higher values excellent for industrial applications.
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  – Safer failure mode at near-ceramic prices.
• Very wide C-value range: 0.001 – 1µF.
  – Higher values excellent for industrial applications.
• Small physical size.
• Does not push over.
  – Can lower total cost to use.
SMD Film Capacitors

Focusing the sales effort for maximum results
SMD Application Chart

<table>
<thead>
<tr>
<th>Capacitance Value</th>
<th>Ta</th>
<th>Al</th>
<th>Nb</th>
<th>Film</th>
<th>PET</th>
<th>PEN</th>
<th>PPS</th>
<th>X5R</th>
<th>X7R</th>
<th>NPO</th>
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<td>100μF</td>
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</table>

- Cap. change over temp. range:
  - >20% unpredictable
  - 10% predictable
  - 5% predictable
  - 2%
  - 1%
  - flat

- Aging per decade of time:
  - 3%
  - 1%
  - none

- DC voltage dependence:
  - -70%
  - -15%
  - none

- Piezoelectric?
  - Yes
  - No

- DF @ 100KHz:
  - >3%
  - 2%
  - 0.5%
  - 0.1%
Solder Withstand is a Critical Factor

- Economical Pb-free solders require higher soldering temperatures. Also small parts heat more than large ones.
- More care is needed in choosing an SMD film cap. Cost vs. higher allowed temperature.
- The catalog is a good general guideline of the worst case, but some sizes handle more heat than others. If unsure get the customer’s solder profile.
Comparing Naked and Encapsulated
"In case of high humidity storage and short cycle reflow soldering profiles, it is recommended that the capacitors be pre-conditioned in an 85°C oven for a minimum of 12 hours prior to reflow soldering to minimize any effects caused by the rapid vaporization of the moisture."

Source: ITW Paktron Film Capacitor Catalog
Wound & Encapsulated Capacitors Do Not Delaminate

Naked stacked construction

Potential delamination of stack with heat and moisture. More a potential problem in large sizes.

Wound construction

Winding holds itself together. No delamination.
SMD Film Technologies

Naked stacked (Arco LDE, LDB)

Encapsulated (MMC, GMC, SMC)
SMD Film Technologies

Naked stacked (Arco LDE, LDB)

• Good solder withstand.
• Acceptable environmental performance in many applications.
• Smaller physical size, especially in low voltages.
• Potentially lower cost in small sizes.
• Potential delamination in larger sizes.

Encapsulated (MMC, GMC, SMC)
SMD Film Technologies

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- Good solder withstand.
- Acceptable environmental performance in many applications.
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- Potential delamination in larger sizes.

Encapsulated (MMC, GMC, SMC)
- Better solder withstand.
- Better environmental performance, resistance to moisture / chemicals.
- Larger physical size. (Vertical mounting can help!)
- Potentially higher cost in small sizes.
- Will not delaminate.
A Focused Sales Effort Will Yield Results!
Film SMD will be used when...

- Stable properties are needed and the C-value is too large for NPO ceramic.
- The films are the last leaded parts on the board. (Otherwise a leaded film will do.)
- Thermal expansion stress is damaging large ceramics.
There is a place for naked and encapsulated:

Encapsulated:

• For higher soldering temperatures.
• For better environmental stability.
• Higher C-values / voltages.
There is a place for naked and encapsulated:

Encapsulated:
- For higher soldering temperatures.
- For better environmental stability.
- Higher C-values / voltages.

Naked:
- Low voltage / small C-values.
- Moderate soldering conditions.
- Few environmental concerns.
- Where small size is paramount.
Vertical mounting of encapsulated parts.

Series GMC
1.0μF / 100V
Size 6560, footprint 16.5 x 15
247mm²

Vertical mounting
Size 6528, footprint 16.5 x 7
116mm²
New products enhance our SMD offering.

- Series GPC for pulse applications. dV/dt values up to 2200 V/μS.
- Series SPC – like GPC but better at high frequencies.
- Series SMP253, safety agency approved Y2 capacitor.
Key Selling Points
(Why Kemet SMD Film?)

- Broad product range:
  - Choose from multiple dielectrics.
  - Naked or encapsulated.
  - SMD pulse/AC capacitors GPC and SPC.
  - SMD Y capacitor SMP253.
- Superior solder withstand.
- Superior environmental protection.
- No thermal expansion stress problem.
- Vertical mounting option saves footprint.