Flex Mitigation Technology

Board flex problems?
We have the solution.

The Capacitance Company

April 2009
Topics to cover Today

- **Mechanical Cracking of MLCC’s**
  - Background
  - Causes
  - Prevention

- **Current Flex Mitigation Technologies**
  - Features, benefits, and capabilities
  - Markets & Applications
  - Potential customers
  - Competitors
  - Questions you need to ask.

- **Upcoming Technologies**

- **Q&A**
What is a Mechanical crack?

#1 MLCC Failure Mode
What is a Mechanical crack?

- Mechanical damage that occurs when handling and/or mounting Multilayer Ceramic Capacitors.

- Two Main Causes
  - Impact Cracking
    - Occurs during placement onto a PCB.
    - Improper setup of pick and place machine.
  - Flex Cracking
    - Occurs during board flexure or bending.
    - Excessive bending of PCB post soldering.
What is a "Flex Crack?"
When/where do flex cracks occur?

ANY post-mount handling that creates excessive bending of the board

- Depanelization
- Hardware application
- Mounting in assembly
- Unsupported IO edge connectors
- Stacked in process
- Pushed "to fit"
- Unsupported Pick & Place
- Mismatch in TCE (IR soldered then Wave)

Manufacturing defects of MLCC’s have been systematically eliminated
These failures are now at a PPM level
Prevention

- Board Flex cannot be eliminated at KEMET or any other capacitor manufacturer.

- 2 Convergent Paths:
  - **Education**: Change board assembly and handling techniques.
  - **Engineering**: Mitigate effects of board flex cracks

**KEMET offers one of the most comprehensive Flex-Mitigation Portfolios available in the Industry.**
Flex Mitigation Portfolio

www.kemet.com/flex
Current Flex Portfolio Technologies

- Floating Electrode \texttt{FE\ CAP}

- Open Mode

- Flexible Termination \texttt{FT\ CAP}

- Floating Electrode + Flexible Termination \texttt{FF\ CAP}

AEC Q200 Qualified
Flex Mitigation Technology: Select the right level of protection for your application

Level 0: **NO Crack Protection**
- Standard MLCC
- Target Applications: Non-Critical
- Fail-Short Condition
  - Up to 2mm flex bend capability

Level I: **Basic Level of Crack Protection**
- Floating Electrode or Open-Mode
- Target Applications: Semi - Critical
- Fail-Open Condition
  - Up to 2mm flex bend capability
- Fail-short Condition
  - Up to 5mm flex bend capability

Level II: **Intermediate Level of Crack Protection**
- Flexible Termination
- Target Applications: Critical
- Flexible termination provides for a high level of protection from thermal stress cracks, pick-and-place damage, and board flex stress
- Fail-short Condition
  - Up to 5mm flex bend capability

Level III: **High Level of Crack Protection**
- Floating Electrode plus Flexible Termination
- Target Applications: Safety Critical
- Combines cascading electrode design with tear-away, termination technology. Provides for a high level of protection from thermal stress cracks, pick-and-place damage, and board flex stress
- Fail-Open Condition
  - Up to 5mm flex bend capability
Flex Mitigation Technology: Level 0 – Standard MLCC Design

**Level 0**: No Crack Protection

**Standard MLCC**

Target Applications:
- Non-Critical

Fail-Short Condition
- Up to 2mm flex bend capability

**Level I**: Basic Level of Crack Protection

**Floating Electrode or Open-Mode**

Target Applications:
- Semi-Critical

Fail-Open Condition
- Up to 2mm flex bend capability

**Level II**: Intermediate Level of Crack Protection

**Flexible Termination**

Target Applications:
- Critical

Flexible termination provides for a high level of protection from thermal stress cracks, pick-and-place damage, and board flex stress

**Fail-short Condition**
- Up to 5mm flex bend capability

**Level III**: High Level of Crack Protection

**Floating Electrode plus Flexible Termination**

Target Applications:
- Safety Critical

Combines cascading electrode design with tear-away, termination technology. Provides for a high level of protection from thermal stress cracks, pick-and-place damage, and board flex stress

**Fail-Open Condition**
- Up to 5mm flex bend capability
Flex Mitigation Technology: Level 0 – Standard MLCC Design

- Standard MLCC design.
- No crack protection.
- Allows for up to 2mm Flex bend capability (Industry Standard)
- Recommended for non-critical applications
- Flex crack could result in a fail-short condition (Catastrophic Failure)

www.kemet.com/flex
<table>
<thead>
<tr>
<th>Level 0: <strong>NO</strong> Crack Protection</th>
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<td>Standard MLCC</td>
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Flex Mitigation Technology:
Level I – Basic Level of Crack Protection

Floating Electrode FE CAP

Open Mode

www.kemet.com/flex
Flex Mitigation Technology:
Level I – Open Mode

• The margin area between the end termination and the effective (active) area is increased in order to prevent cracks from propagating through opposing electrodes.

• May experience a drop in capacitance but a short is unlikely.

• Design reduces likelihood of a low-IR or short circuit condition in a board flex situation.

• Reduces chance for a catastrophic and potentially costly failure event.

• Available in mid to high capacitance values up to 1µF

www.kemet.com/flex
Flex Mitigation Technology:  
Level I – Floating Electrode  FE CAP

- Serial design commonly seen in High Voltage MLCC’s.
- May experience a drop in capacitance but a short is unlikely.
- Design reduces likelihood of a low-IR or short circuit condition in a board flex situation.
- Reduces chance for a catastrophic and potentially costly failure event.
- Available in low to mid capacitance values less than 1µF.

www.kemet.com/flex
Level I: Basic Level of Crack Protection

Floating Electrode or Open-Mode

Target Applications: Semi - Critical

Fail-Open Condition
Up to 2mm flex bend capability

Level II: Intermediate Level of Crack Protection

Flexible Termination

Target Applications: Critical

Flexible termination provides for a high level of protection from thermal stress cracks, pick-and-place damage, and board flex stress

Fail-short Condition
Up to 5mm flex bend capability

Level III: High Level of Crack Protection

Floating Electrode plus Flexible Termination

Target Applications: Safety Critical

Combines cascading electrode design with tear-away, termination technology. Provides for a high level of protection from thermal stress cracks, pick-and-place damage, and board flex stress

Fail-Open Condition
Up to 5mm flex bend capability
Flex Mitigation Technology: Level II – Flexible Termination

- Standard Termination
- Flexible Terminations

Conductive Epoxy

Ceramic Body
Reduce stresses transmitted to the brittle ceramic body.

Stresses are transferred to the end terminations.

Maintains circuit integrity in extreme flex environments.

Reduces chance for a catastrophic and potentially costly failure event.

Up to 5mm of bend flex capability.
  - Fail short failure mode if overstressed.

Improved temperature cycling performance over standard termination system.

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### Flex Mitigation Technology:

**Level III** – **Flexible Termination** *plus* Floating Electrode.

#### Level III: High Level of Crack Protection

**Floating Electrode** *plus* **Flexible Termination**

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#### Level II: Intermediate Level of Crack Protection

**Flexible Termination**

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<th>Critical</th>
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<th>Fail-short Condition</th>
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#### Level I: Basic Level of Crack Protection

**Floating Electrode or Open-Mode**

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#### Level 0: NO Crack Protection

**Standard MLCC**

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KEMET FF-CAP is built to give designers the best possible choice for safety critical applications:

- Flexible Termination – Tear away technology.
  - High mechanical performance able to withstand, 5mm bend flex.
- Floating Electrode Design
  - Open failure mode when products are overstressed.
- Available in low to mid capacitance values.
## Current Flex Crack Mitigation Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Target Values</th>
<th>Failure Mode</th>
<th>Flex Capability</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floating Electrode “FE CAP”</td>
<td>Low to Mid Capacitance</td>
<td>Open</td>
<td>2mm</td>
<td></td>
</tr>
<tr>
<td>Open Mode</td>
<td>Mid to High Capacitance</td>
<td>Open</td>
<td>2mm</td>
<td></td>
</tr>
<tr>
<td>Flexible Termination “FT CAP”</td>
<td>High Capacitance</td>
<td>Short</td>
<td>Up to 5 mm</td>
<td></td>
</tr>
<tr>
<td>Floating Electrode + Flexible Termination “FF CAP”</td>
<td>Low to Mid Capacitance</td>
<td>Open</td>
<td>Up to 5mm</td>
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Flex Solutions

AEC Q200 Qualified

<table>
<thead>
<tr>
<th>Flexible Termination</th>
<th>6.3 - 16V</th>
<th>25V</th>
<th>50V</th>
<th>100V</th>
<th>200V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1206</td>
<td>102-106</td>
<td>102-475</td>
<td>102-225</td>
<td>102-474</td>
<td>102-154</td>
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<tr>
<td>1210</td>
<td>222-106</td>
<td>222-106</td>
<td>222-475</td>
<td>222-105</td>
<td>222-104</td>
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<tr>
<td>1808</td>
<td>-</td>
<td>-</td>
<td>472-184</td>
<td>472-563</td>
<td>472-183</td>
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<tr>
<td>1812</td>
<td>-</td>
<td>682-106</td>
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<td>682-105</td>
<td>682-474</td>
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<tr>
<td>1825</td>
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<td>223-225</td>
<td>223-684</td>
<td>223-474</td>
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<td>274-226</td>
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<td>274-105</td>
<td>823-105</td>
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<tr>
<td>2225</td>
<td>-</td>
<td>-</td>
<td>473-225</td>
<td>473-105</td>
<td>473-125</td>
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<tr>
<th>Floating Electrode (also available with Flexible Termination*)</th>
<th>6.3 - 16V</th>
<th>25V</th>
<th>50V</th>
<th>100V</th>
<th>200V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0402*</td>
<td>151-102</td>
<td>151-102</td>
<td>151-102</td>
<td>181-822</td>
<td>181-472</td>
</tr>
<tr>
<td>0805</td>
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<td>181-104</td>
<td>181-104</td>
<td>181-223</td>
<td>181-103</td>
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*0402’s are not currently offered with Flexible Termination
Applications & Markets
Applications:
• Circuits with a direct battery or power source connection.
• Critical and safety relevant circuits without (integrated) current limitation.
• Any application that is subject to high levels of board flexure or temperature cycling.

Examples
• Raw Power Input side filtering (power plane/bus)
• High current applications (automobile battery line)
• Circuits that cannot be fused to open.

Markets:
Consumer
Medical
Industrial (Power supply)
Automotive
Aerospace
Telecom
Questions You Need To Ask
Flex Mitigation Technology:
Questions you need to ask…..

• Does your application have a direct battery or power source connection?
• Is your application a critical and safety relevant circuit?
• Is there any integrated current limitation in your circuit?
• Is your circuit board subject to high levels of board flexure during assembly, mounting or depanelization?
• In case of component failure (flex crack) do you prefer an open or short circuit condition?
• Are you placing MLCC’s close to the edges or corners of your board?
• Are MLCCs being placed near or around connectors or heavy components?
Ordering Information

www.kemet.com/flex
Flex Portfolio Part Numbers

- **Floating Electrode FE CAP**
  - Example: C0805S563K4RAC

- **Open Mode**
  - Example: C0805F474K3RAC

- **Flexible Termination FT CAP**  – Now available up to 2225 case size!
  - Example: C0805X105K3RAC

- **Floating Electrode + Flexible Termination FF CAP**
  - Example: C0805Y223K1RAC

- **Coming Soon!**
  - High Voltage SMD with Flexible Termination – CY09