Unleashing the Power Surge: Navigating the Component Choice Challenges of Higher Voltage in EVs

E&A 2023

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ELECTRONICS & APPLICATIONS '23

26 T/M 28 SEPTEMBER '23
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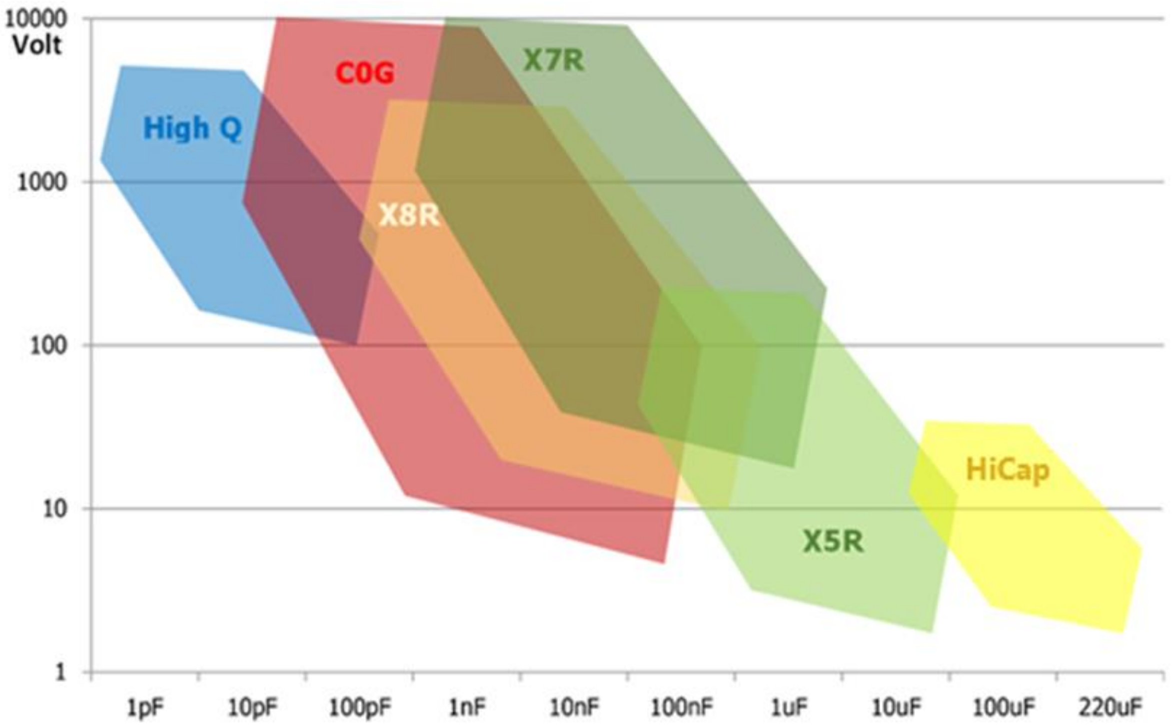


Higher Voltage Levels

- Why is the voltage level in EV-systems increasing?
- What challenges come with this increase?
- How to solve these design challenges?

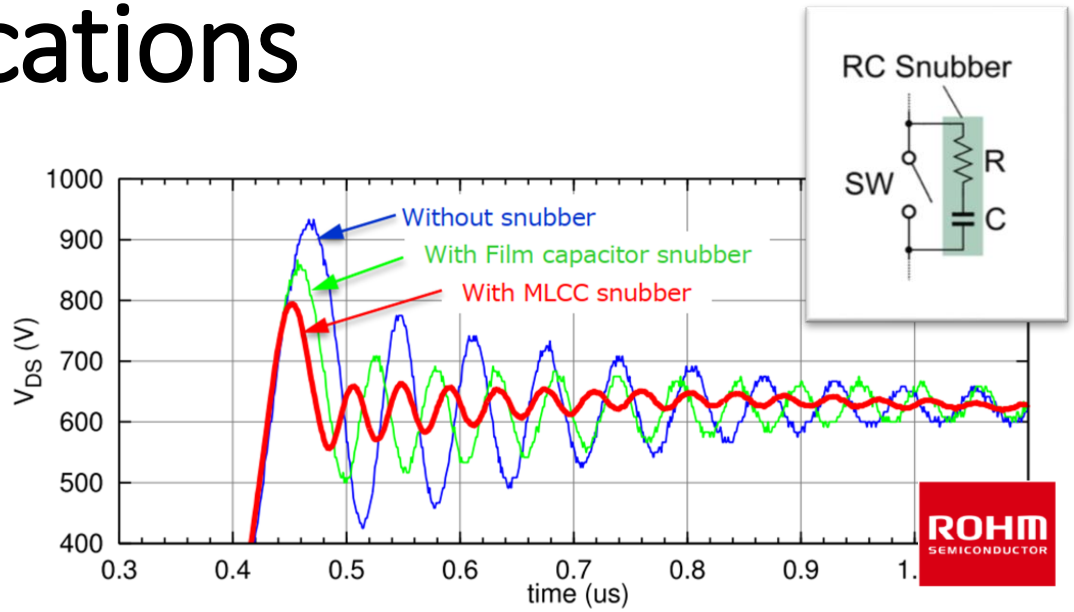
EV Voltage Levels

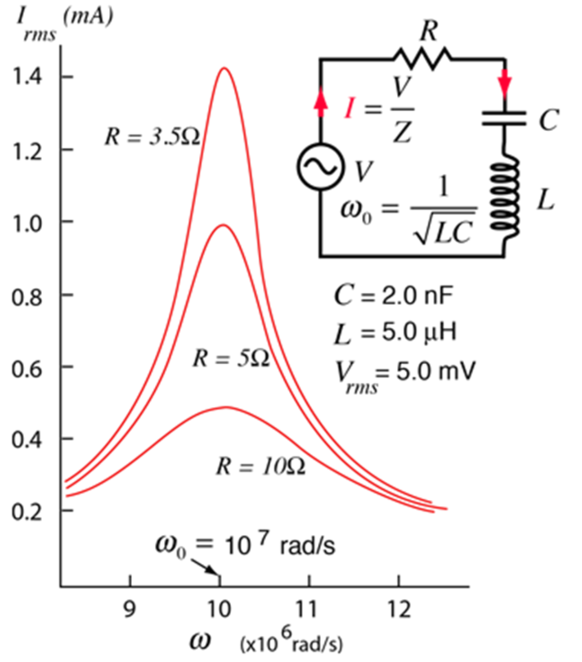
Low Voltage | **Medium Voltage**

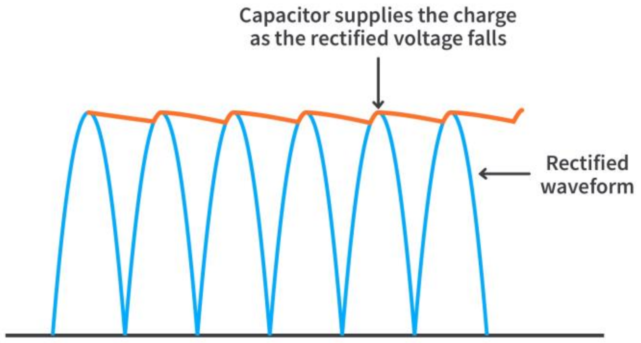
12V/24V	48V	200-300V	400V	800V
ICE Internal Combustion Engine	**MHEV** Mild Hybrid	**HEV** Hybrid	**BEV** Battery Electric Vehicle	

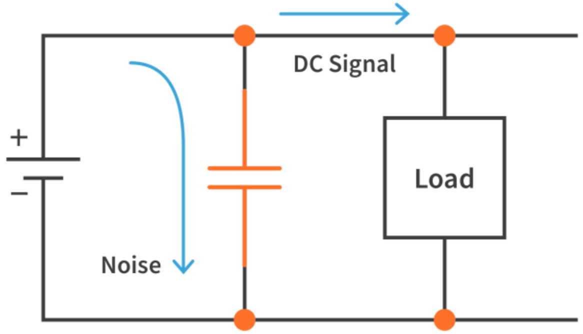
MLCC Applications

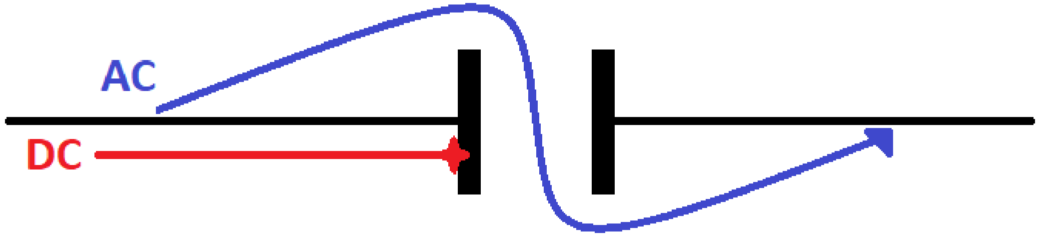
- DC Link
- DC Blocking
- Filter
- Snubber
- Resonant Circuit











Design Challenges

1. Creepage and Surface Arcing
2. Voltage handling
3. Thermal Resistance
4. Dielectric Stability
5. Chip self-heating
6. Physical Durability
7. Surge Protection

Higher Voltage Levels
Maintaining Proper Creepage Distance for High-Voltage Capacitors

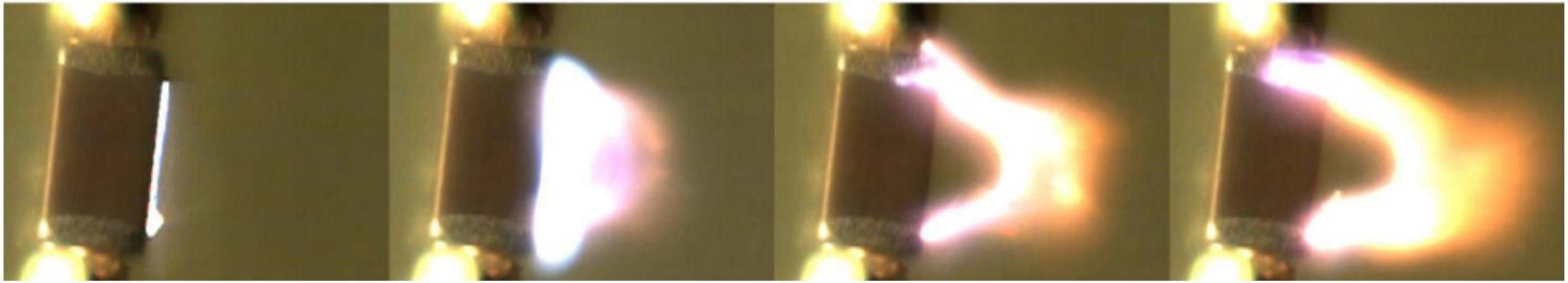


Figure 2. An example of an improper creepage distance that resulted in arcing.

General Guide - 1mm spacing per 1,000V

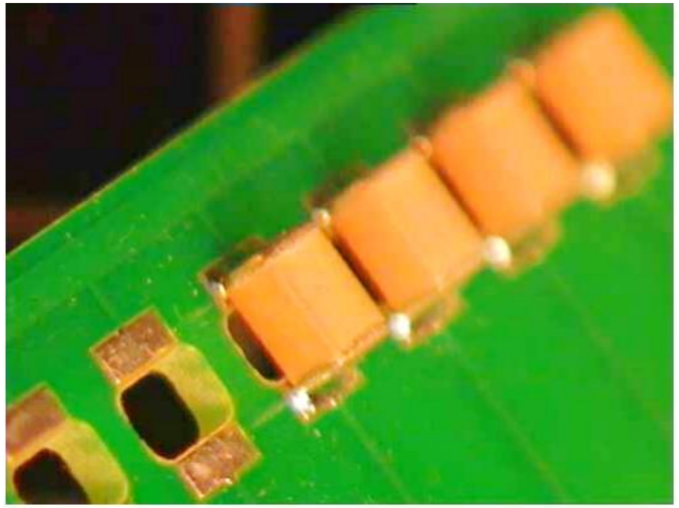
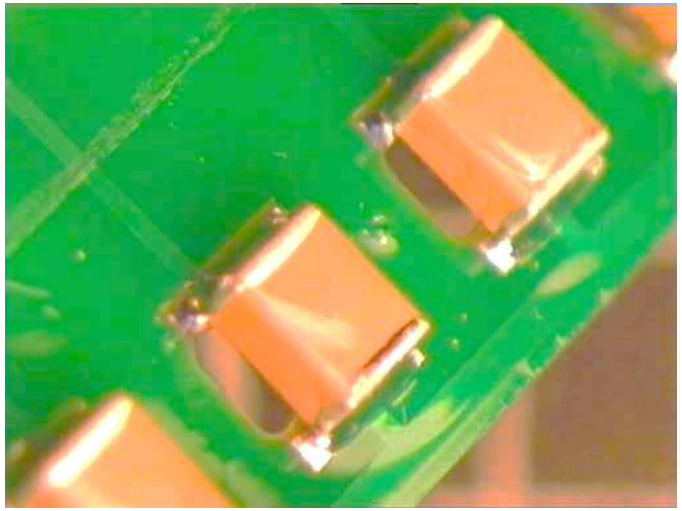
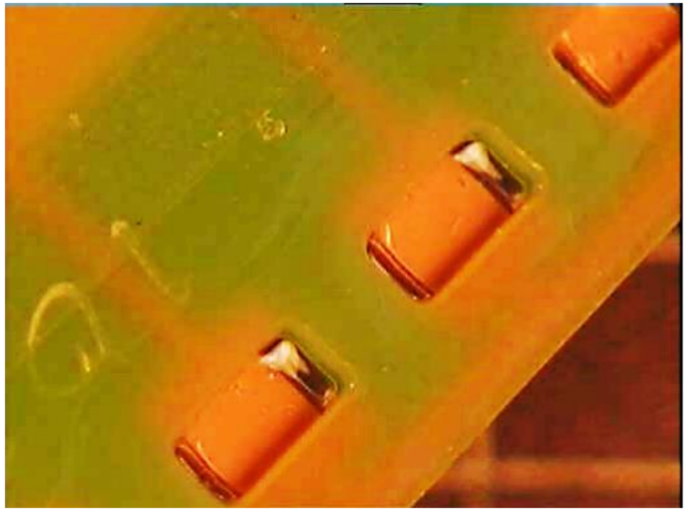
Surface Arcing

Surface arcing occurs when the dielectric strength of the surface environment is exceeded. Factors affecting this are:

1. Humidity
2. Surface Contamination
3. Dielectric Type
4. PCB design

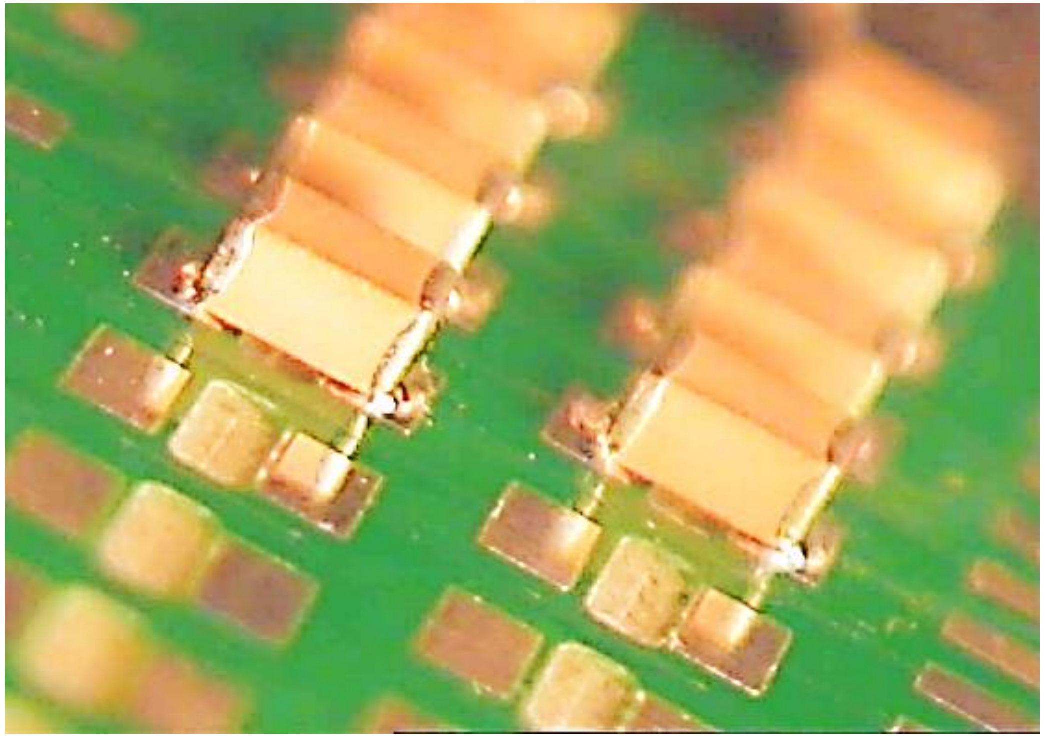
Surface Arcing and Creepage - Design

1. Slot the board under the MLCC

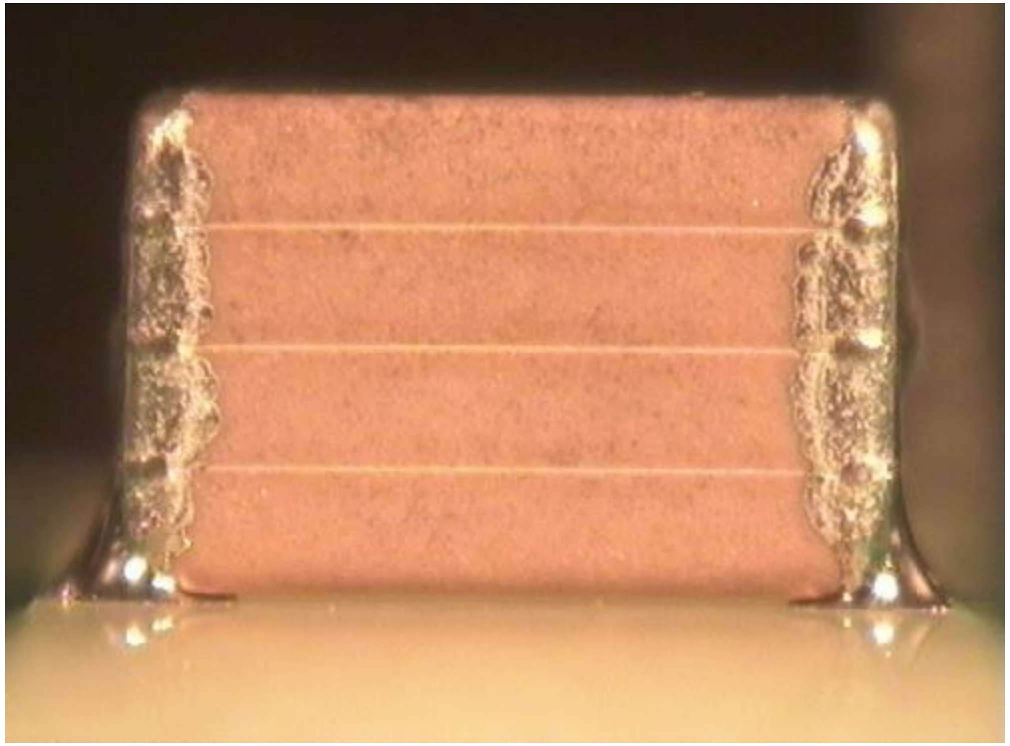
Surface Arcing and Creepage - Design

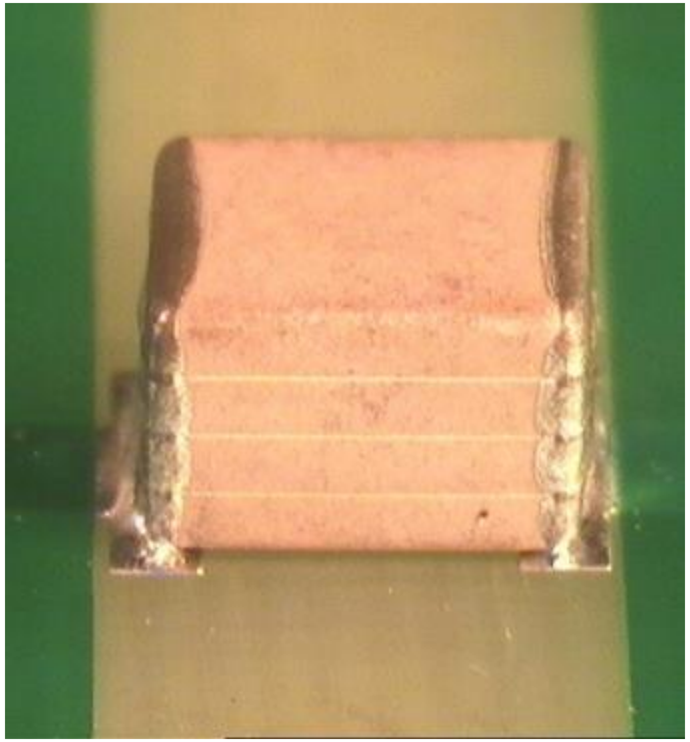
2. Route a recess in the board under the MLCC A full slot is not always viable.



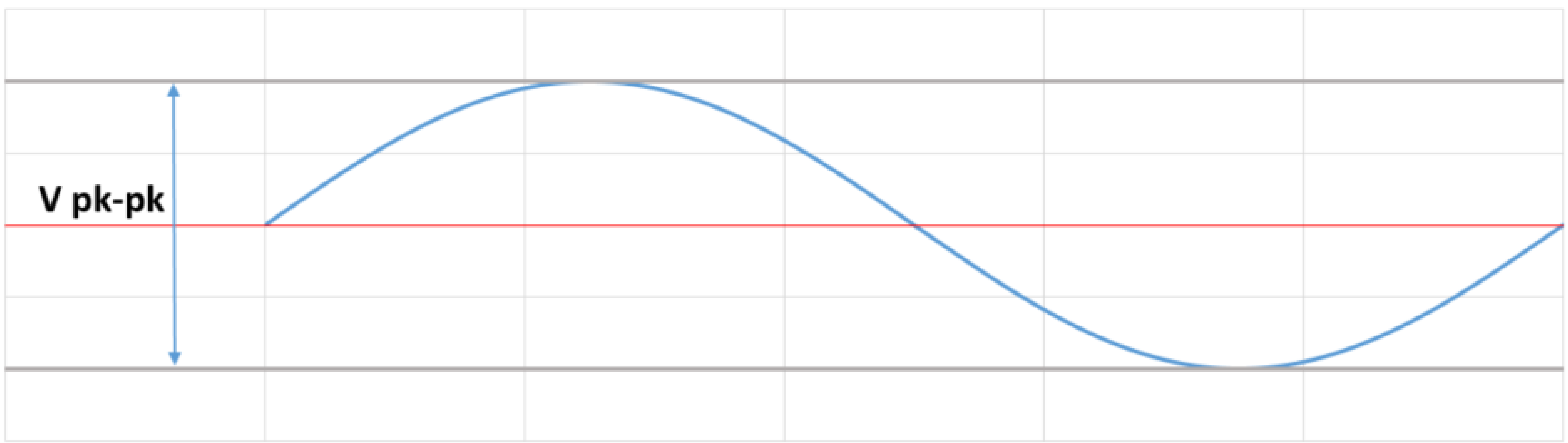
Surface Arcing and Creepage - Design

3. Remove the mask layer of the board under the chip





Use of DC rated capacitor in AC voltage application

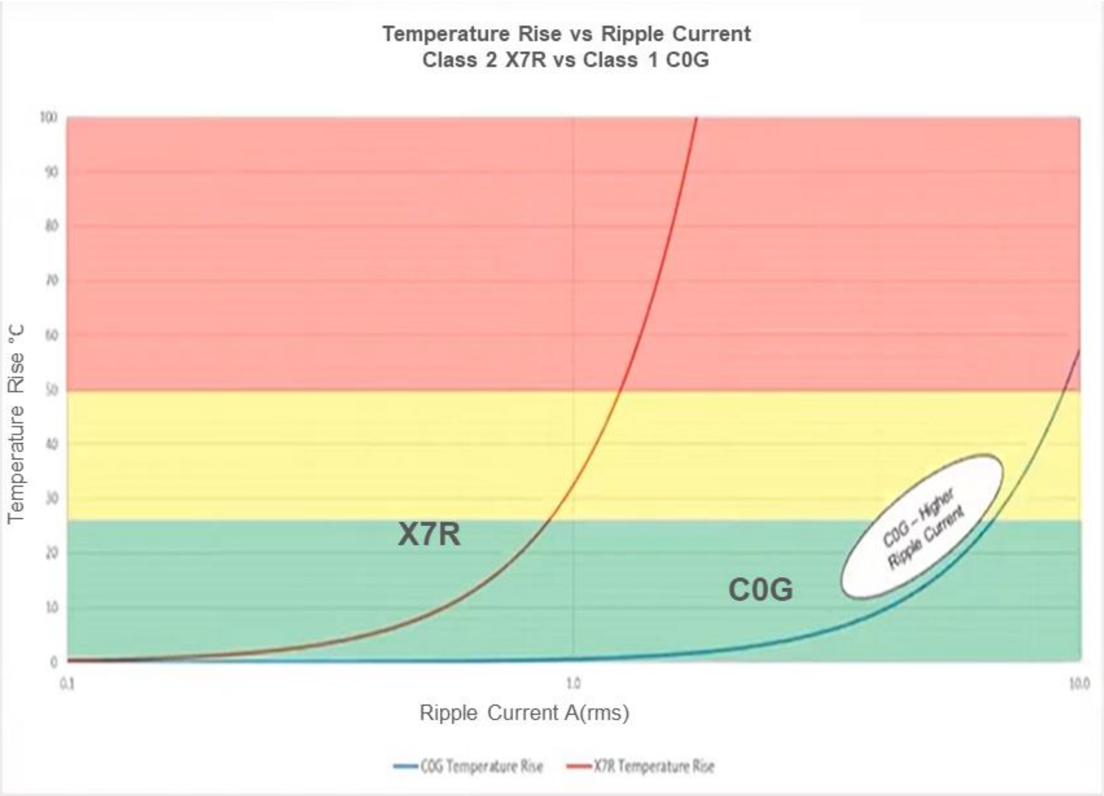


The maximum peak to peak of an AC voltage should not exceed the DC rating of the capacitor. Component dc rating > Vpk-pk. NOT RMS

Consider a component with an AC rating

Further MLCC Considerations

Temperature Rise



$$P = I^2 ESR$$

$$T_{rise} = P \cdot R_\theta$$

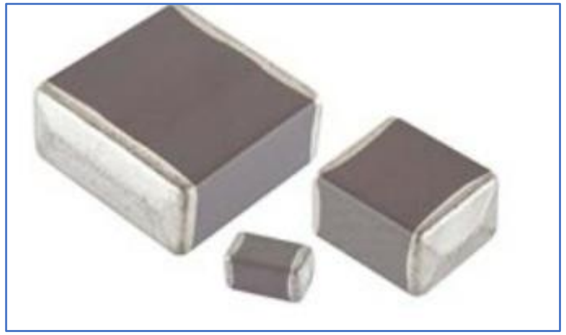
where

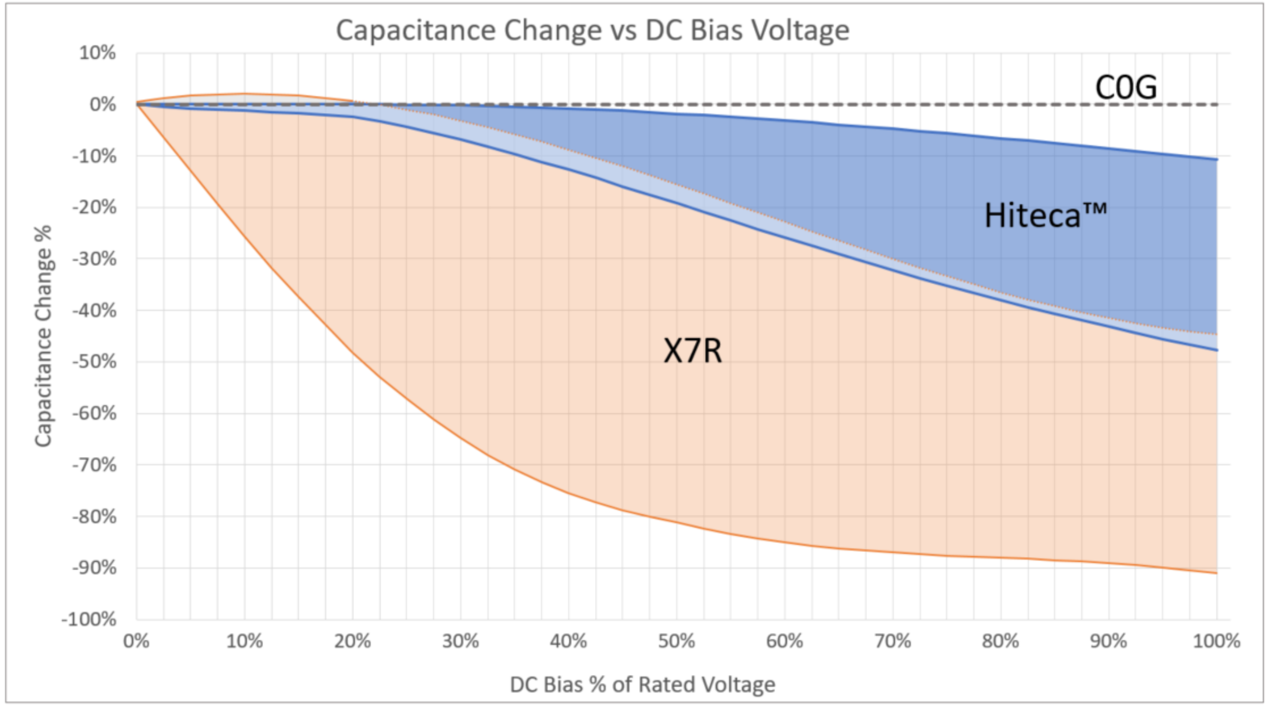
R_θ = Thermal Resistance of MLCC

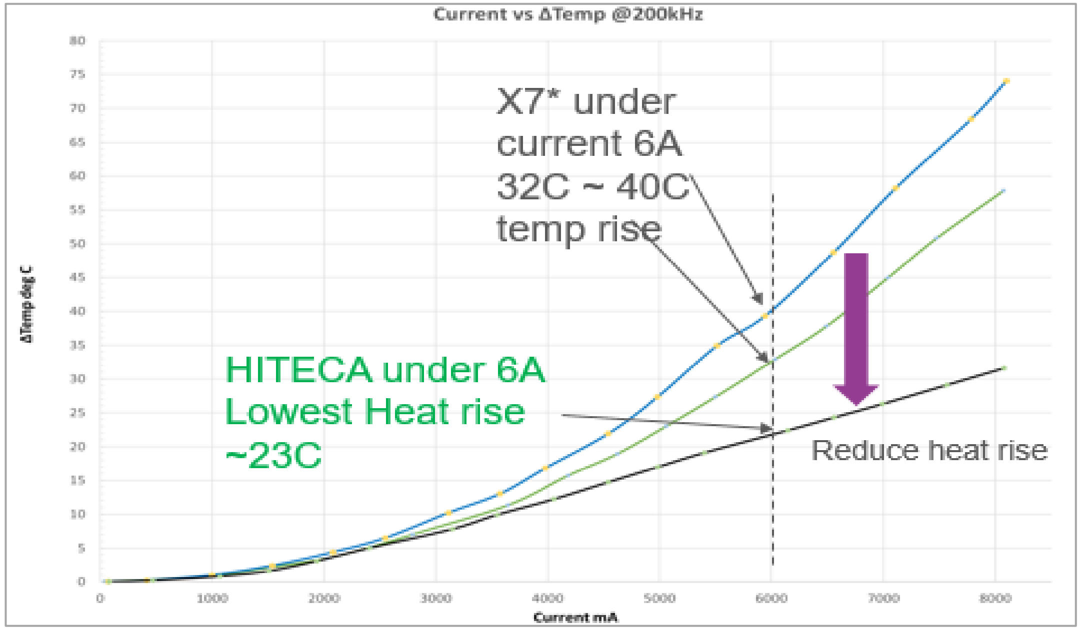
P = Dissipated Power (Heat)

More Stable Class II Dielectrics

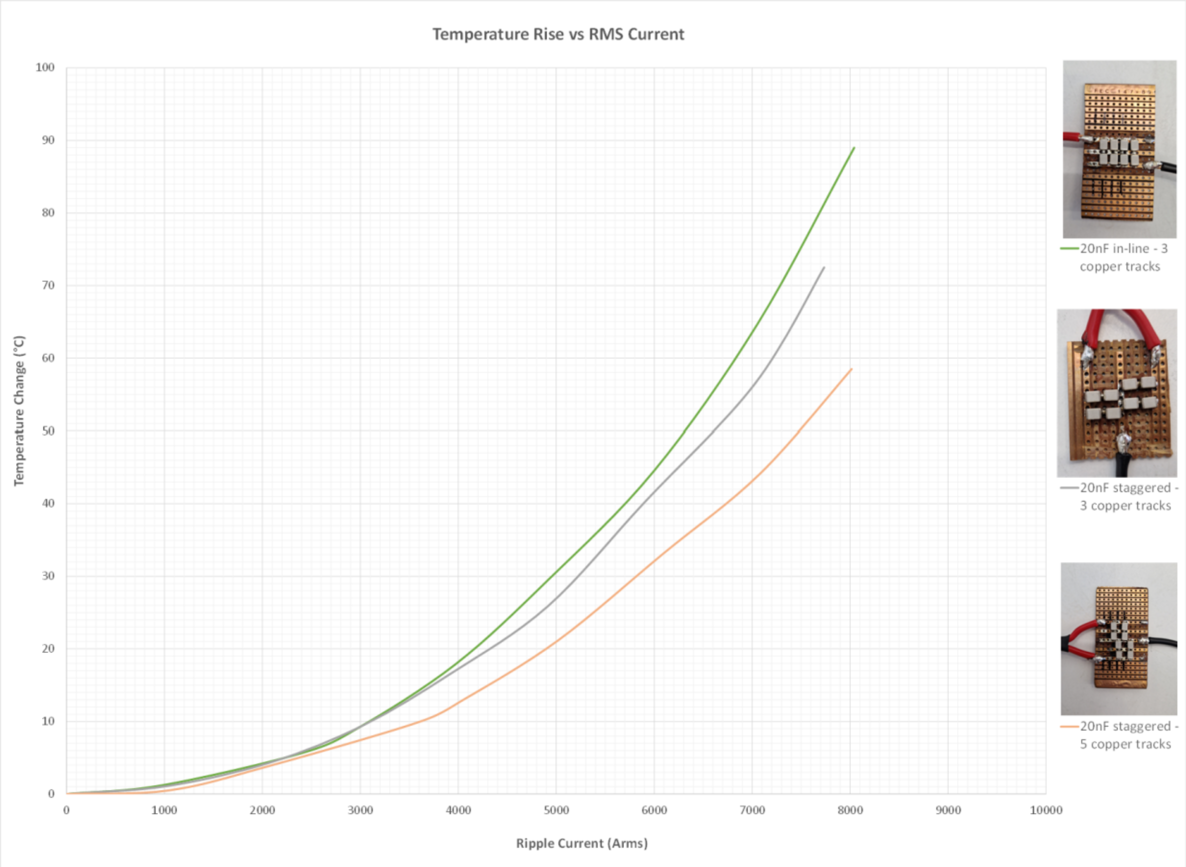
- Better voltage stability and lower losses than commercial X7R
- Improved temp rise under ripple current at high frequency

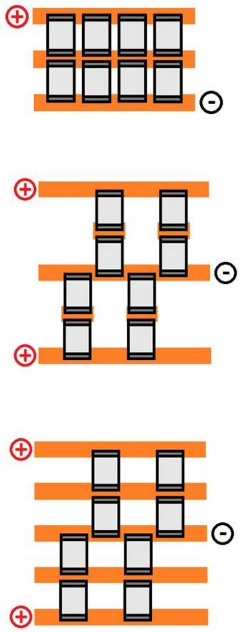


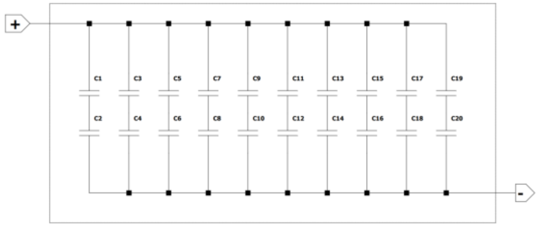


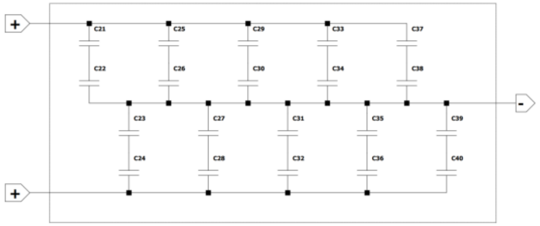


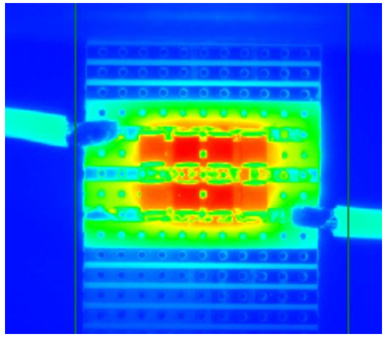
Chip Spacing and Arrangement

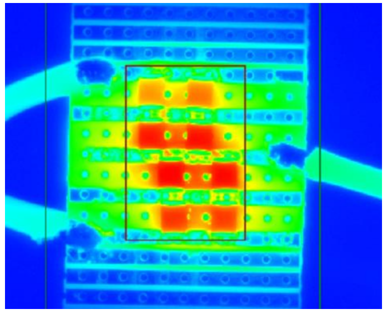




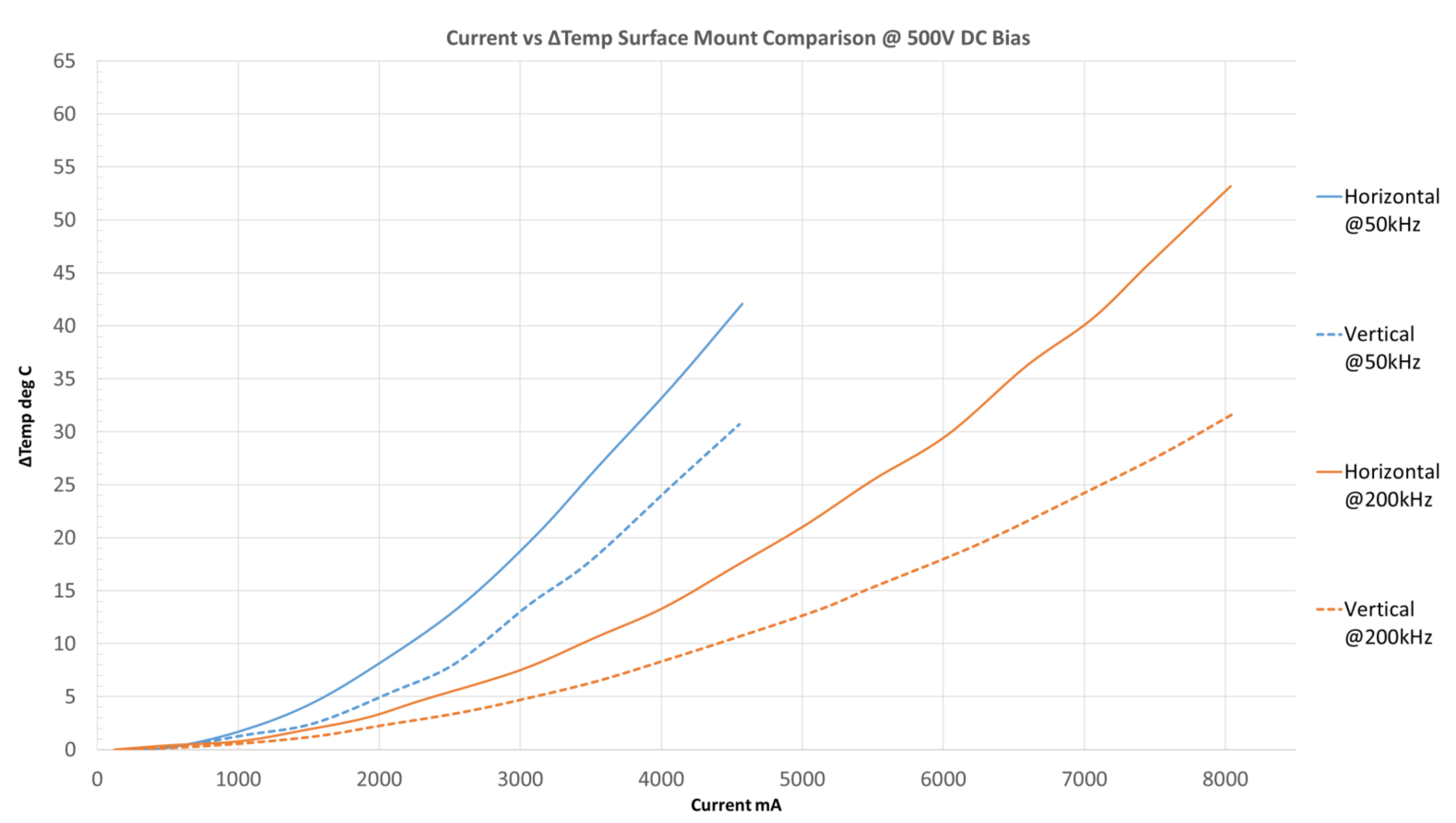


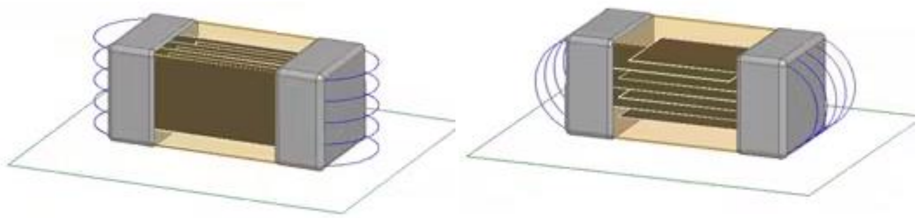


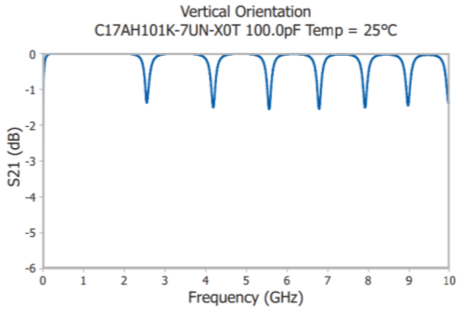


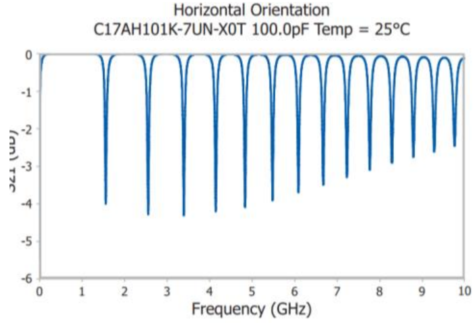


Chip Orientation - Horizontal vs. Vertical









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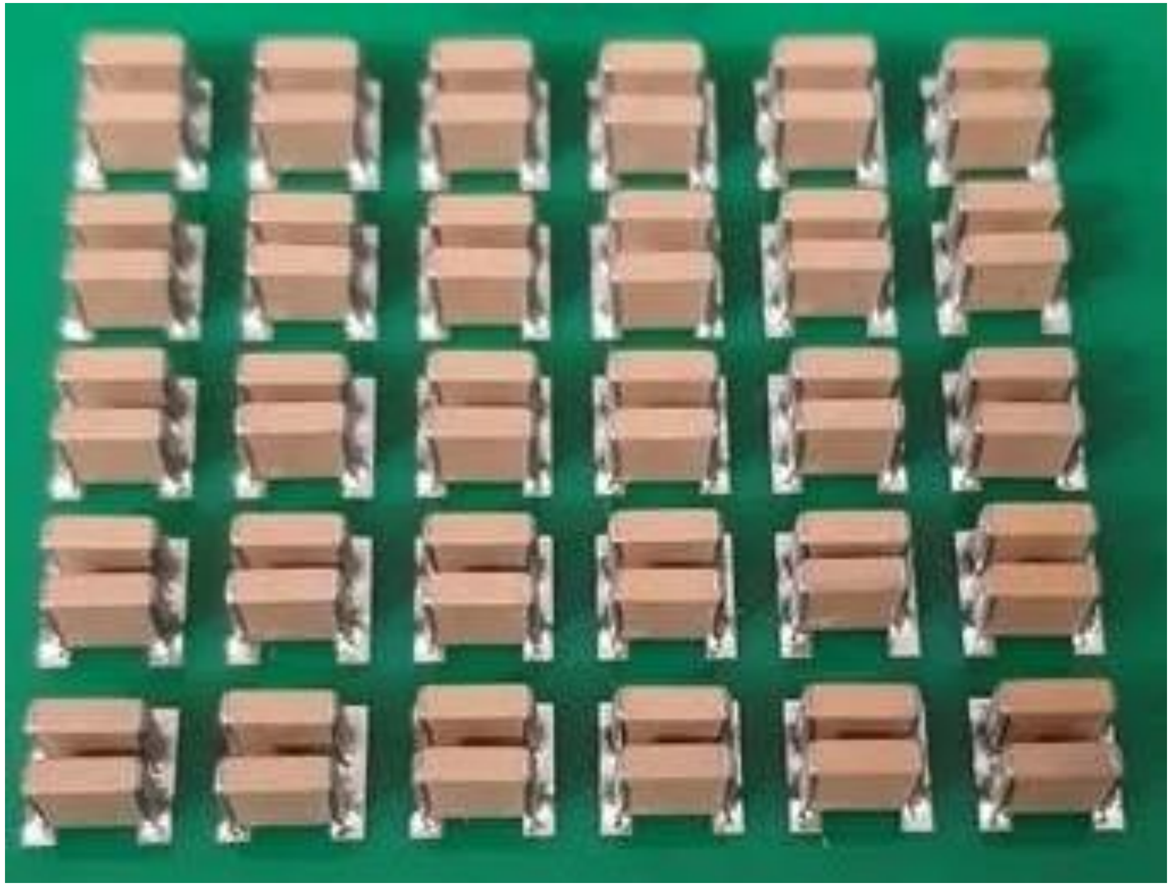
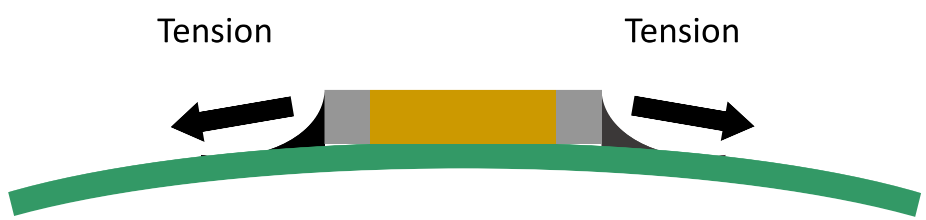
Chip Orientation - Horizontal vs. Vertical



Further MLCC Considerations

Shock and Vibration / Bend and Flex



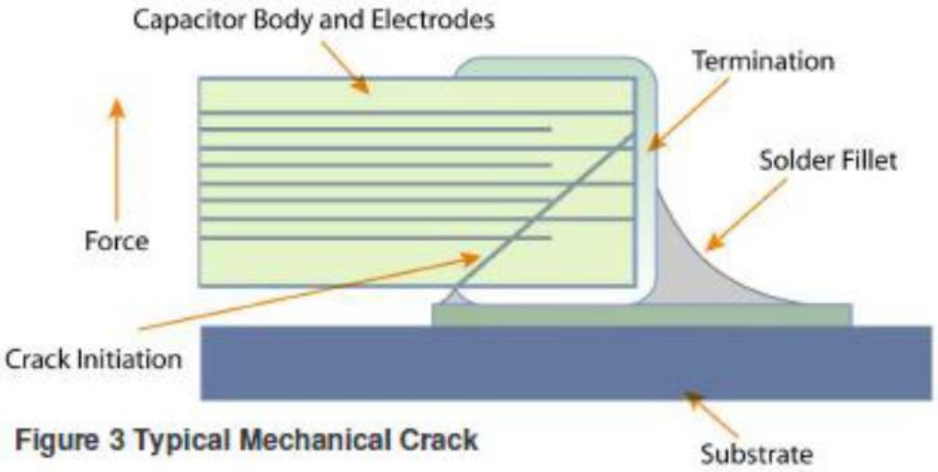
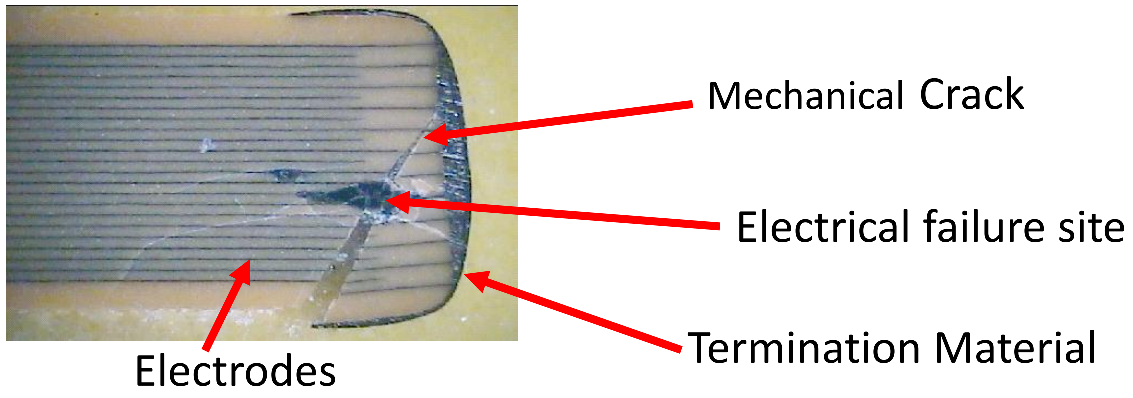
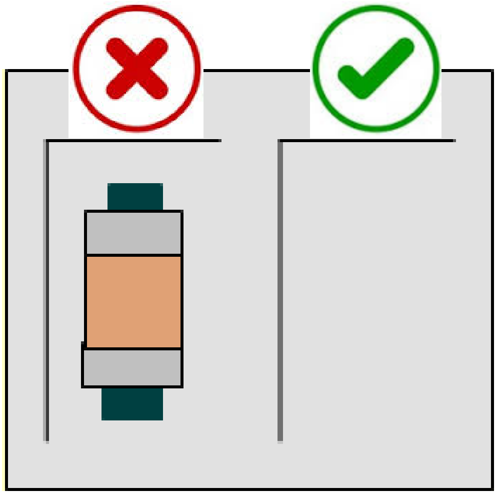


Figure 3 Typical Mechanical Crack

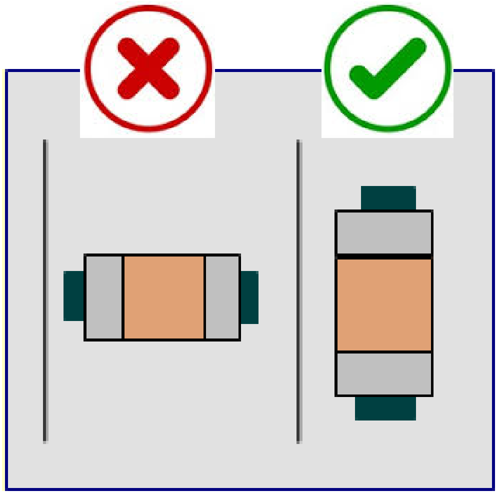


Position/Orientation in relation to PCB edge and other components

- Capacitor placement not recommended in the corner of the PCB.



- Recommended capacitor orientation with respect to PCB edge (denoted by black lines).
- Note: Stress zone is typically within 5mm of PCB edge or fixing point.



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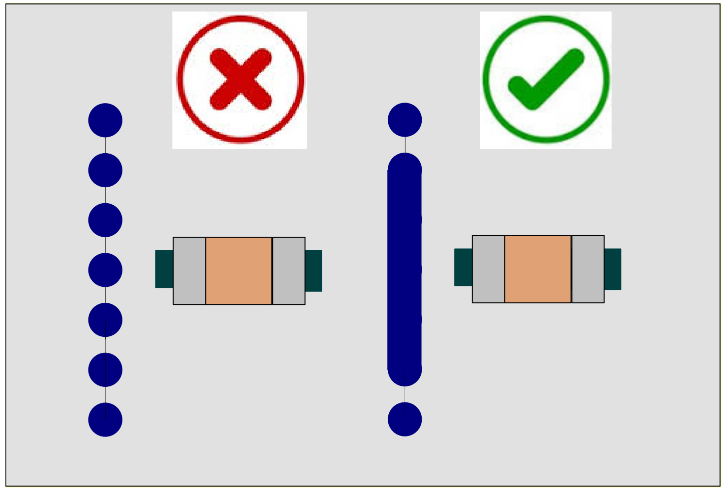
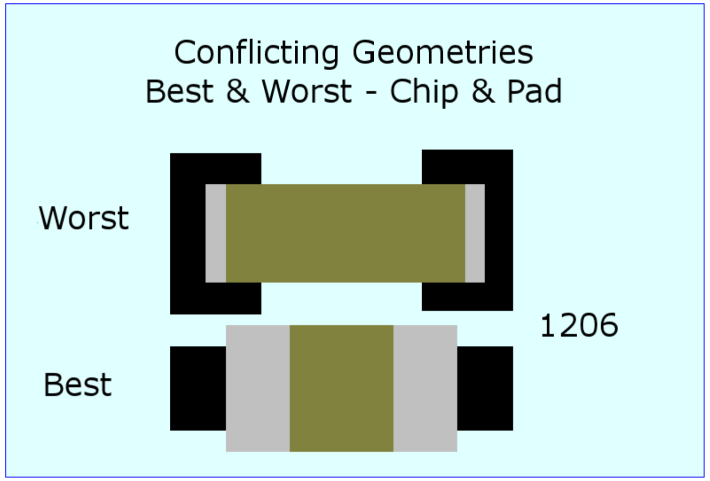
PCB Slots and Solder pad/land sizes

- Using a slot along the depanelisation edge reduces the level of stress exerted onto the capacitor by approximately 50%

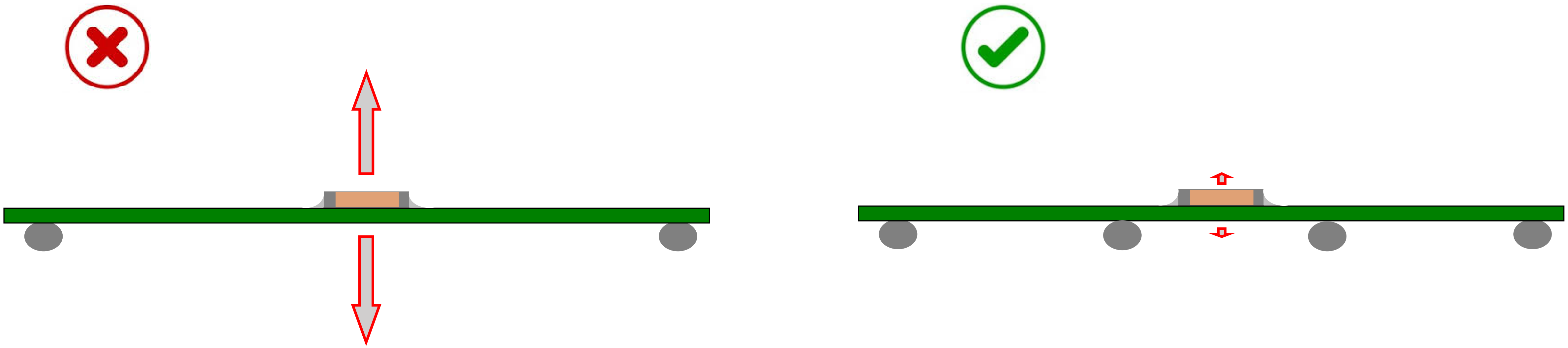


- Reducing the pad/ land size can reduce the level of stress exerted onto the capacitor by approximately 50%



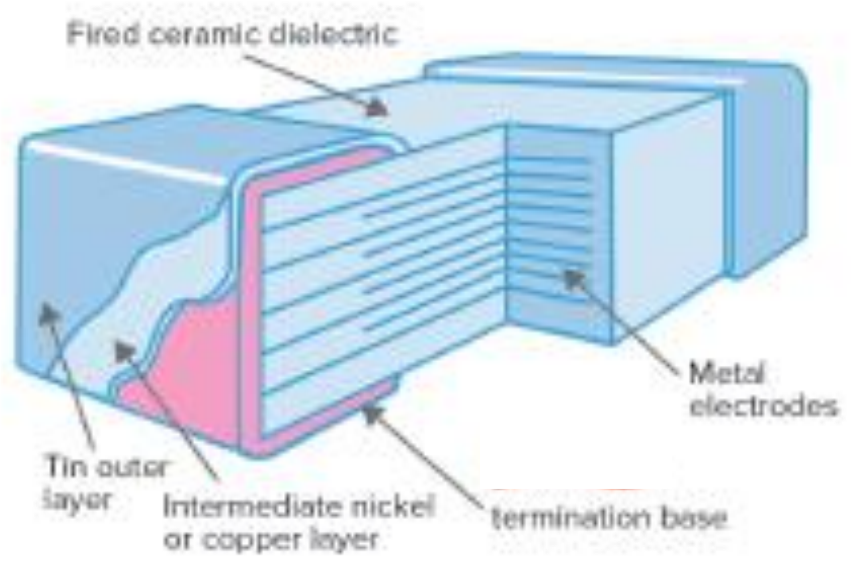
Board Design

- X7R Automotive must be Flexicap to pass AEC-Q200
- No excuse for mishandling boards or bad design

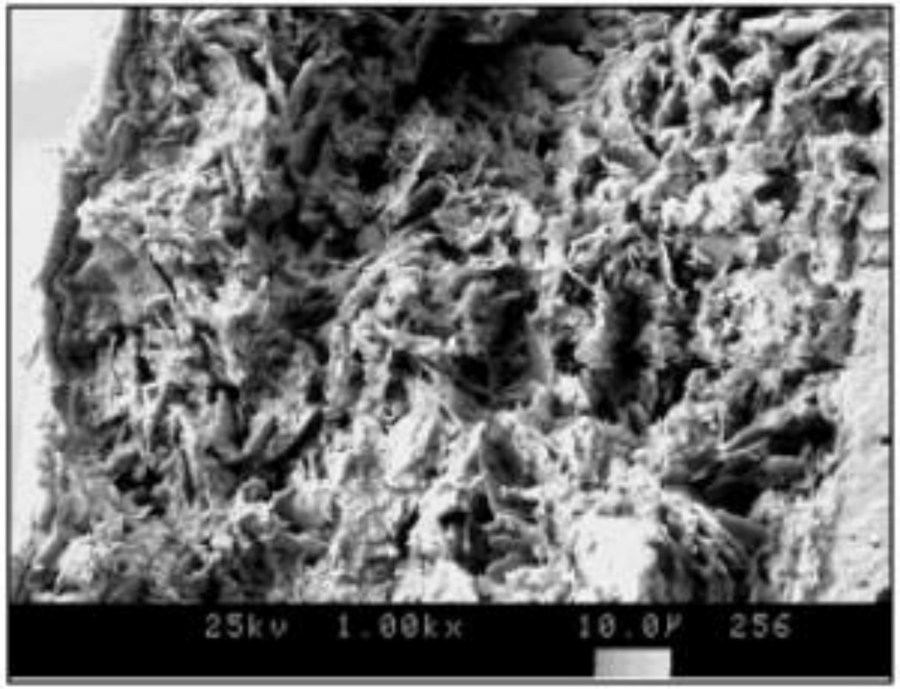


Flexible Termination

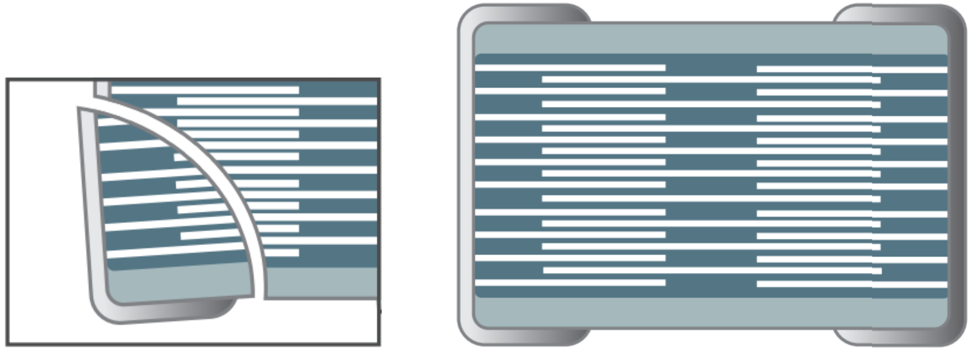
- FlexiCap™ termination material is a silver loaded epoxy polymer that is flexible and absorbs mechanical strain between the Printed Circuit Board and the ceramic component.

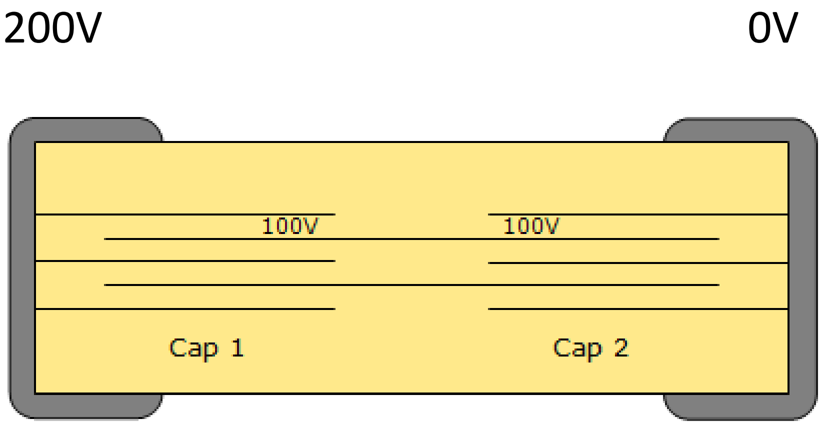


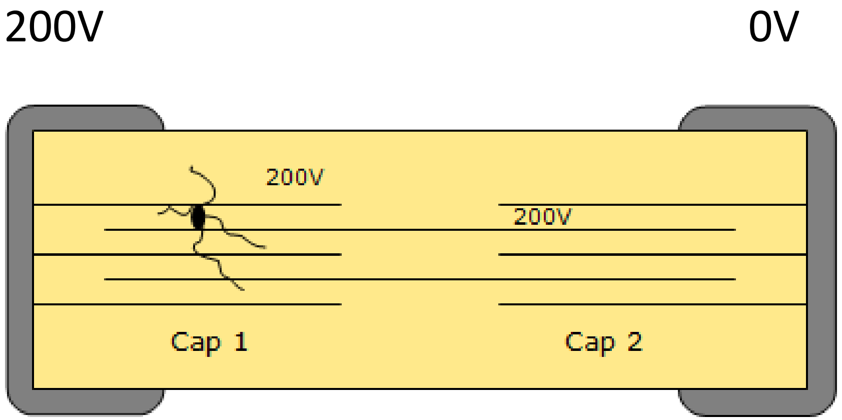
FlexiCap™ MLCC cross section



Tandem Capacitors



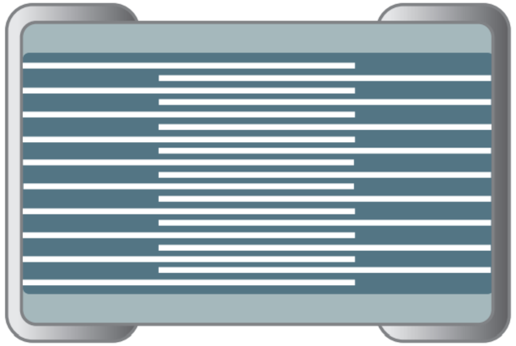


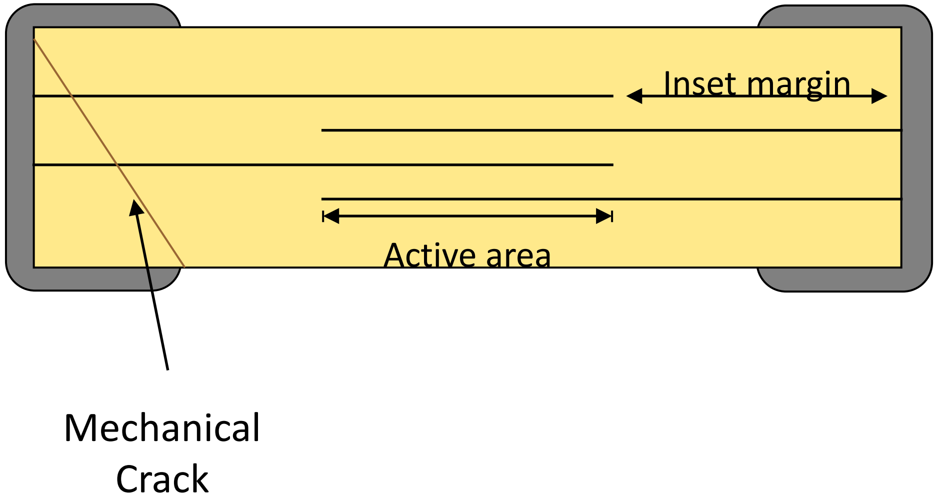


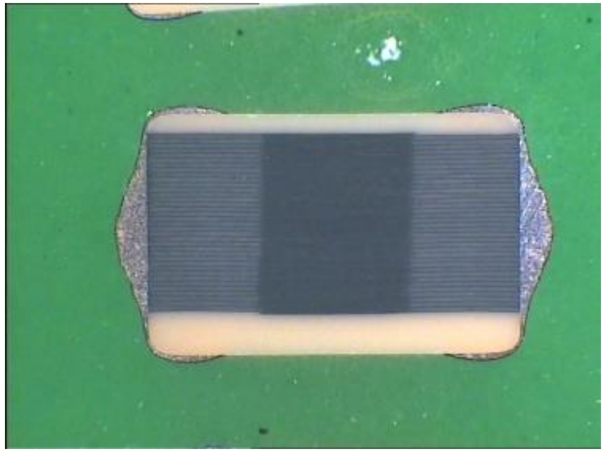
Each section is capable of withstanding full rated voltage

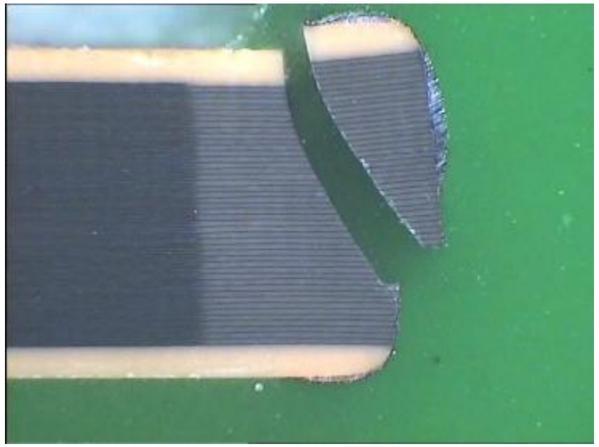
Open Mode

Designed for applications where mechanical cracking is a severe problem and short circuit failures due to cracking are need avoiding







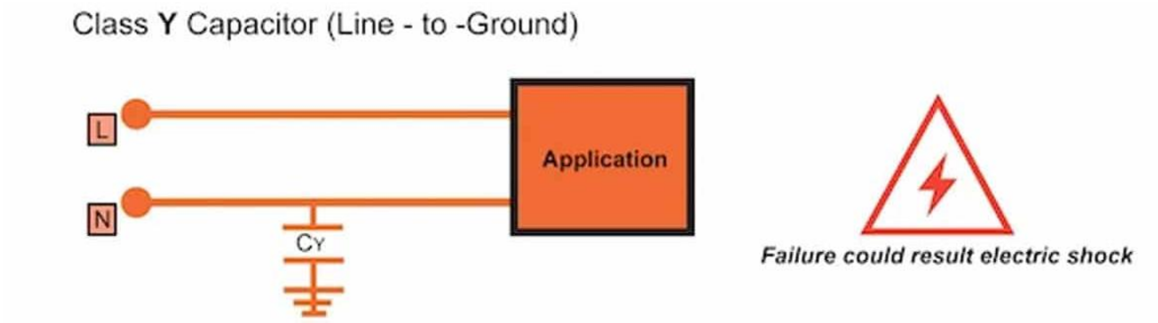


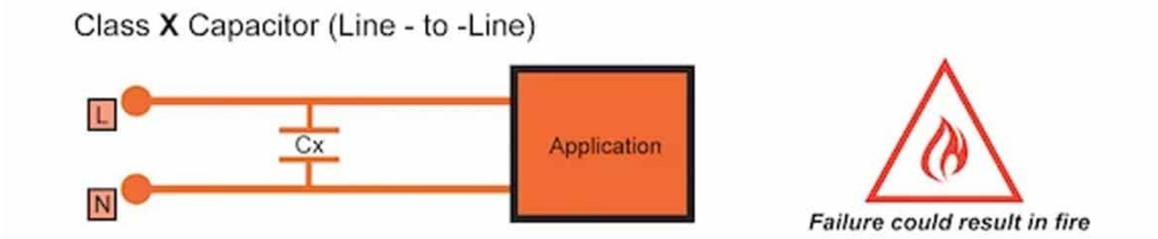
Safety Capacitors

TÜV and UL certified safety rated MLCC’s

BAUART GEPRÜFT TYPE APPROVED — TÜV Rheinland Product Safety

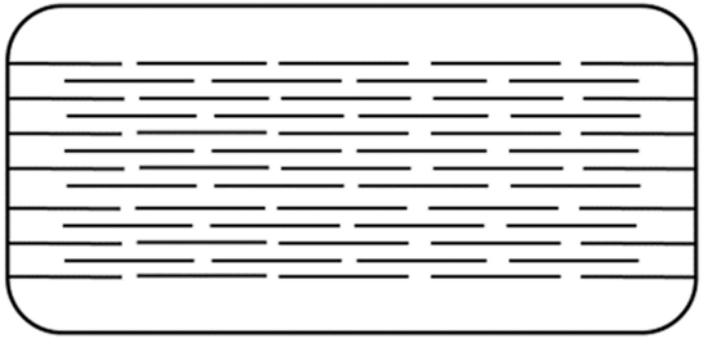
c UL US





SYX/UYX FAMILY – Y2 (250VAC)/X1 (305VAC) 5KV IMPULSE

Applications	• High voltage battery systems within electric vehicles • Three-phase systems requiring 305Vac line to line • Industrial and domestic equipment where safety is critical • Plug-in power supplies	
Benefits	• Class Y2/X1 safety capacitors, including Humidity Robustness Grade III • Guaranteed 4mm creepage is mandatory for 250Vac Class Y2 and 305Vac Class X1 full certification • Humidity Robustness Grade III as per EN 60384-14 fully certified	• 5kV impulse and 1kVDC rating • 1kVDC qualified • Components are 100% DWV tested to 4kV • AQL tested to 4kVDC and 3000Vac 60s — ideal for high voltage battery systems • Unmarked (UYX) components available with additional 2500VDC rating • Case sizes: 1808, 1812, 2211, 2215 and 2220



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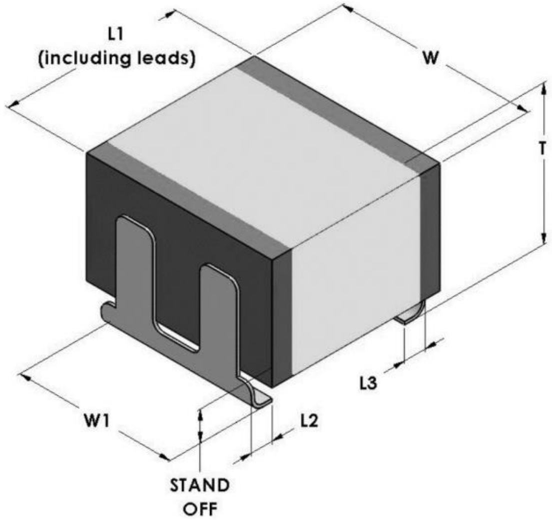
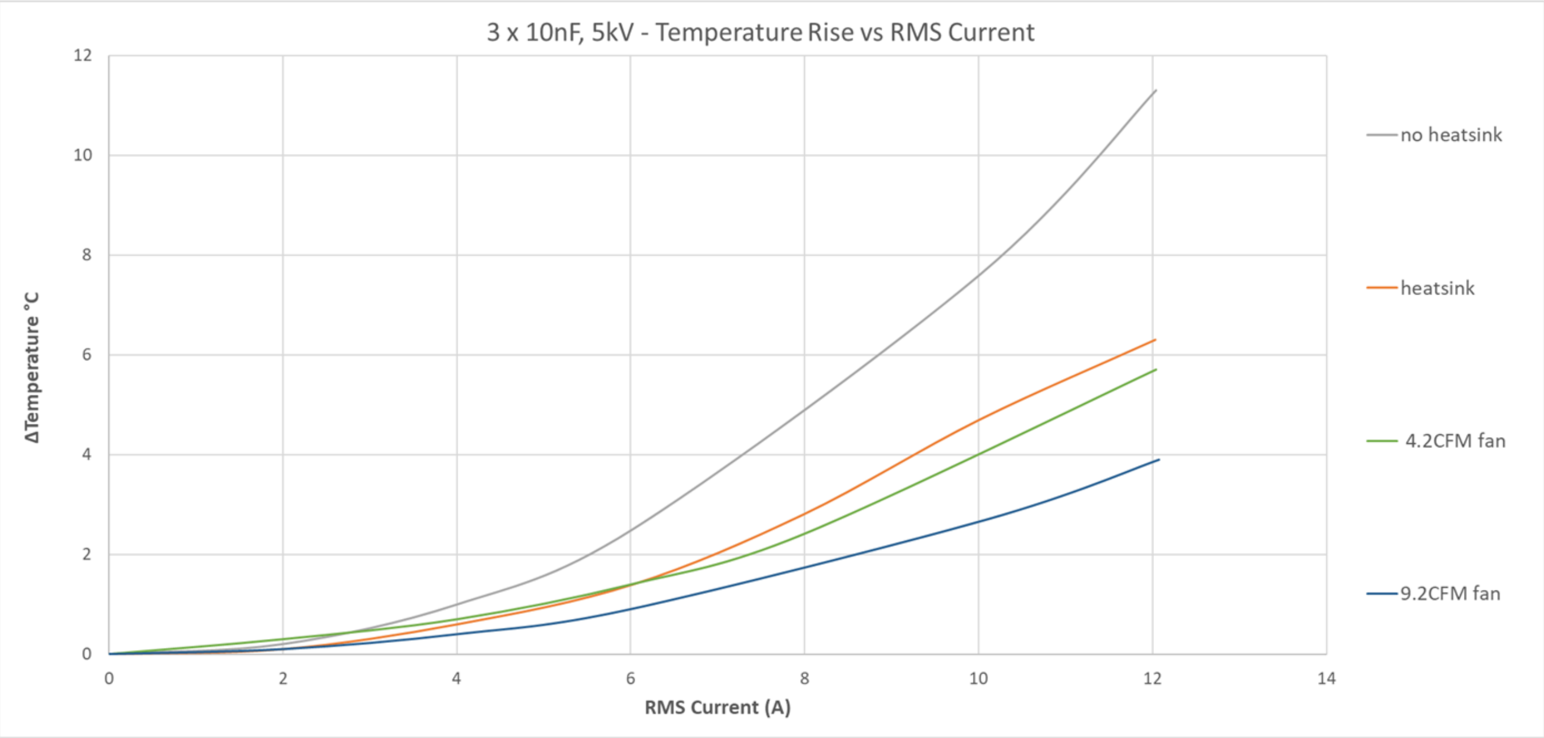
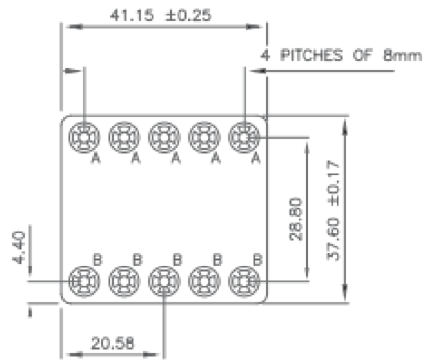
Lead Framing

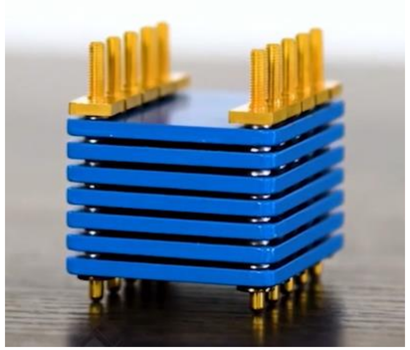


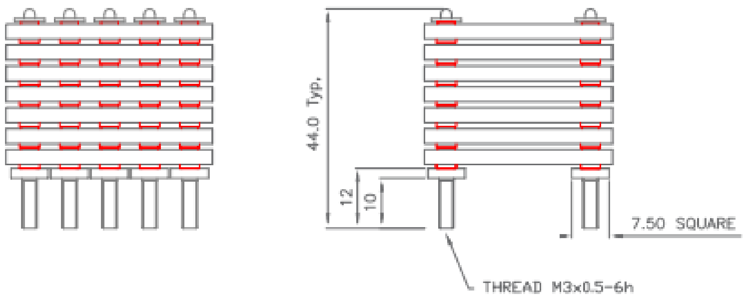
Applications	• High voltage where stability under temperature and voltage is critical • DC-DC converters • Wireless charging resonant tank • Battery management • PTC heater controller • EV and HEV
Benefits	• Enhanced performance under critical testing conditions such as thermal shock and mechanical vibration • Capable of 3000 thermal cycles with no degradation of interconnect when mounted to FR4 board • Suitable for both industrial and automotive markets • Offers 3kV and 4kV parts to satisfy the demands of 800V battery system DWV testing • High voltage ratings allow for component de-rating in application

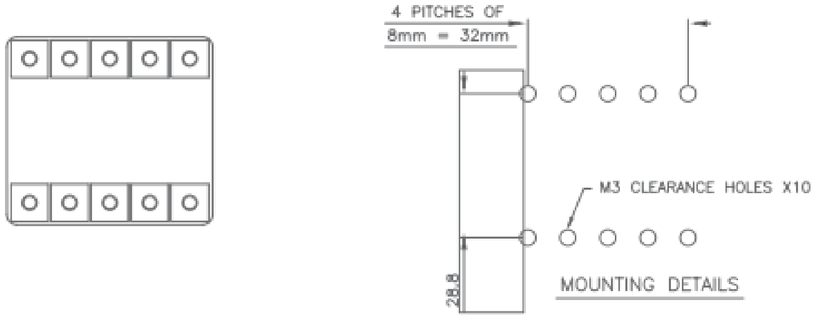
Large Cap Assembly











Conclusions

Higher Voltage increases efficiency in design, build and performance.

At the component level this requires us to consider the immediate PCB design along with all aspects of the component’s internal and external design.

Higher voltages and the resultant higher margins for safety adds new problems which require new solutions

Addressing the challenges of higher voltage and higher power systems calls for rigorous real-world testing to fully understand the effects of multiple variables

Thank you for your attention!

You can find us at Booth 71D22.