MLCC Application Notes

Open Mode and the “1210 Rule”

Frequently asked questions regarding TDK’s inner electrode design which reduce the risk of electrical short in the event of a board flex crack.

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Abstract

TDK offers the Open Mode inner electrode design on a limited cap range of commercially available MLCCs. Due to their physical size, MLCCs greater than 0805 (C2012) case size are less than 1.0mm thickness are of higher risk for board flex cracks. Decreasing the active area of the traditional overlap design prevents the potential crack path from penetrating a counterelectrode.

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Open Mode

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Q1. What is an "Open Mode" capacitor?

In response to the market demand for a reduced risk MLCC with respect to board flexure cracks, TDK introduced a unique inner electrode design that compensates for the typical crack path induced by PCB bending. This "Y" crack has been well documented as a signature crack for board flexure [1] and has been a leading cause of MLCC failures in the market for years.

Excessive board bending during PCB manufacturing or final assembly is common, and the brittle nature of ceramic components is especially prone to damage after soldered to the PCB. TDK has responded to this problem with the Open Mode MLCC for applications where flex cracking is a high concern (see illustration in Figure 1).

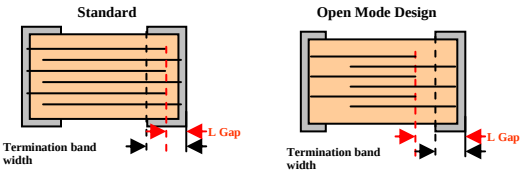

Figure 1

Q2. How can board flexure cause a shorted capacitor?

Bending a PCB board after solder will transfer stress to the populated components. If the stress exceeds the breaking strength of the ceramic capacitor a crack will occur. Furthermore, if the stress is large enough a displacement in the component may occur which could result in a shorted part as an electrode contacts a counter electrode (see Figure 2).

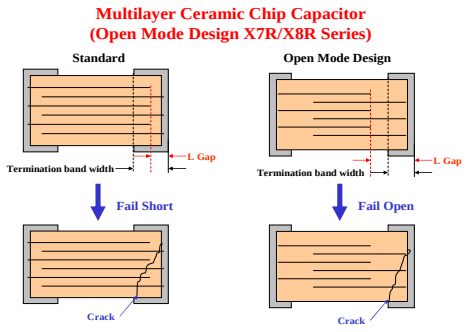

Figure 2

Q3. How does the Open Mode design reduce fail to short risk?

The active area utilized in MLCC is reduced due to the shortened electrode layers which prevent the counter electrode from being in proximity of the potential crack. In the event of a crack the propagation will not cross a counter electrode, thus minimizing the likelihood of a short. Of course this reduction in active area compromises the capacitance available.

Q4. Is the TDK Open Mode capacitor the same as the flexible termination capacitors offered by other cap suppliers?

No. The Open Mode capacitor utilizes a simple change in the length of the inner electrodes only. Flexible termination components utilize a more complex change in which a completely different termination metallurgy is introduced.

Q5. Does Open Mode offer an advantage over other fail safe MLCCs?

Yes, simple design and proven reliability. The industry at large learned a valuable lesson in the 1980s regarding thermal shock robustness. In addition to better preheat temperature controls during soldering, MLCC manufacturers learned how to balance the thermal mismatches between ceramic and metal in the sintering (co-firing) processes as well as soldering. Complete understanding of the material systems involved during this co-firing is key. Introducing a new terminal electrode system is a market risk TDK chose not to do.

Q6. How can I tell Open Mode design from the TDK part numbers?

TDK uses a letter in the part number to indicate Open Mode. Contact your TDK sales representative for the designators used in your application.

Q7. Why is Open Mode not offered in case sizes smaller than 0805 (C2012)?

Physics begin to work in the user's favor as the size of the ceramic component is reduced. Just as it is more difficult to break a small brick as opposed to a large brick, smaller MLCCs offer strength robustness that no longer warrants the Open Mode design. As an example, typical board flexure strength as a function of case size is shown below (Figure 3 & Figure 4). Smaller geometries increase the strength of the MLCC well beyond the 2mm EIA-198 industry specification. Open Mode design in these geometries are considered overkill.

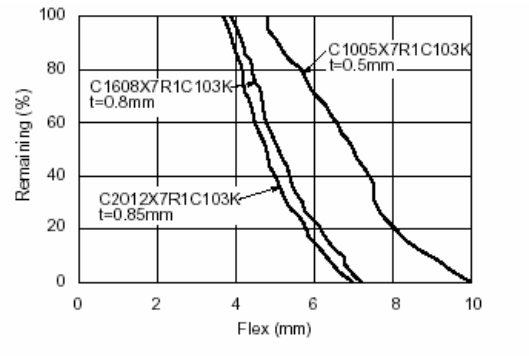

Figure 3, Flex Strength vs Case Size

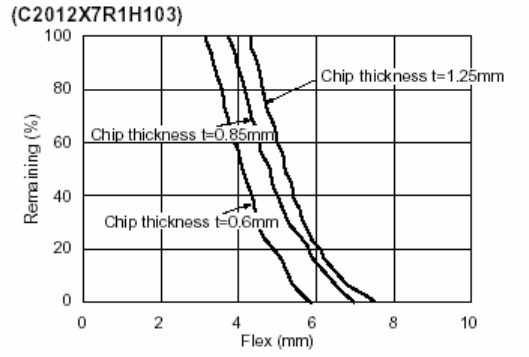

Figure 4, Flex Strength vs Thickness

Q8. What is the "1210 Rule"?

Many design engineers utilize a basic rule of thumb that prohibits the use of any 1210 or larger case sized MLCC for fear of increased risk of failed components due to board flexure. The 1210 Rule addresses the significance of larger components but it fails to address the significance of thicker components.

Q9. How can I justify using a large MLCC despite the "1210 Rule"?

The strength of brittle materials is often measured by Modulus of Rupture. The MOR of a ceramic body is function of its geometry - proportional to its width and thickness, but inversely proportional to its length. Thus longer MLCCs with the same thickness will result in lower bending strength, however this loss of strength can be offset by utilizing a thicker component.

1210 and larger components are offered in a variety of thicknesses, many greater than 2mm. Components of this size are often more robust to board flexure stresses than 1206 or 0805 sized components, and well exceed the 2mm bending requirement.

Not using these higher value components severely limits the designer's engineer's capacitor options - especially in the case of higher capacitance values for Tantalum replacement application.

Q10. Does TDK offer an alternative rule?

Its TDK's position that complete avoidance of 1210 and higher case size is going too far. If significant board flex concerns exist then we recommend a">= 0805 <1.0mm Avoidance Rule" which simply means avoiding components with small thicknesses aspect ratios.

Components of case size 0805 and higher with thickness less than 1.0mm are mechanically weaker than the same component >1.0mm. Employing this guideline will improve the mechanical robustness of the design while still allowing for high capacitance value MLCCs.

Q11. What should I do if I want to reduce the bending risk of components not available in Open Mode?

The following guidelines can used to reduce the bending risk of MLCCs:
1. Minimize all post soldering board flexure potential.
2. Downsize all MLCCs to the smallest case size available.
3. Locate all MLCCs away from high stress planes.
4. Mount MLCCs parallel(not perpendicular) to stress planes.
5. Use redundant series placements, 90 degrees from each other when maximum safety is critical.

Q12. Since Open Mode comes with a price premium, under what conditions should I design in this special MLCC?

Examples of high risk circuit applications would include:
1. All direct battery line applications.
2. Any circuit >20A
3. Regions of historic board flexure or high risk/problem areas.

Q13. How can I find the latest cap ranges available in Open Mode?

See your TDK representative for the currently available cap ranges in all MLCC product series.

References;

1. Common Cracking Modes in Surface Mount Multilayer Ceramic Capacitors; TDK Components USA, Inc.

End of Report

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