

Ceramic Capacitors Improvements

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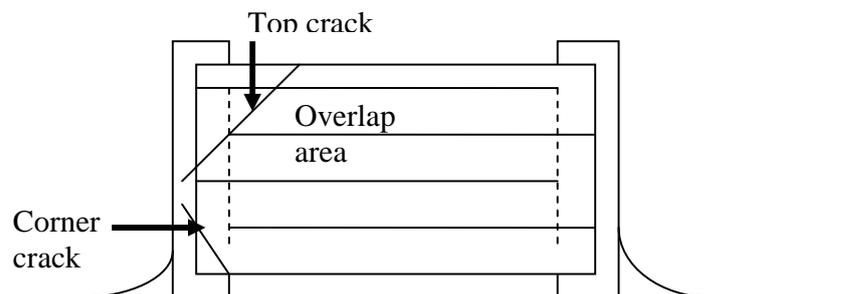
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Selection of ceramic capacitors is often a topic of concern among designers. There are three families of different characteristics. These are the NPO/COG; the X5 & X7 and the Y5 & Z5 families. They are made from different insulation materials and therefore have very different temperature and voltage responses.

Trade-offs occur for selecting these families. The Y5 & Z5 give large capacitance values up to 100 uF in a small package, but the capacitance varies greatly (+22% to -82%) with temperature and applied voltage. The X5 & X7 family varies less with temperature ($\pm 15\%$) and applied voltage, but are limited to about 22 uF in value. The NPO/COG group has the least variation as a function of temperature and voltage as well as over time but is limited to values less than 0.1 uF. This last group can be trimmed to values as tight as 0.1 pF and so tends to be preferred for precision applications.

Ceramic capacitors are often selected in applications for decoupling, precise timing, band pass filters, application requiring high stability and many high Q circuits. One problem with ceramic capacitors is that they are fragile. Low mechanical stress environments are best. Recently, the fragility of ceramics has been reduced by the introduction of a "Flexible End" capacitor. This is a soft polymer material that is coated on the ends of the capacitors and typically doubles the resistance to applied stress. Otherwise, the component has the same electrical characteristics of a regular X5R capacitor. There are three manufacturers who produce this improved version, but none have a complete line yet.

The flexible material works by carrying the stress that typically emanates from the corner of the capacitor. It prevents the many corner cracks from forming and damaging the capacitor. Corner cracks can arise from a variety of common activities. These include damage during machine placement, damage from board-to-board separation, damage from board flexing, damage from thermal shock, damage from board mounting hardware in close proximity to the capacitor or damage from mechanical shock.



It is a corner crack that propagates from a high stress point, often where the solder terminates on a mounting pad. The crack will change the value of the capacitor slightly in the short term. However, in the long term as the crack propagates they often cross plates and lead to internal shorts. Thus, a cracked capacitor on a power line can begin to heat and eventually leave a burn mark on a printed circuit board or even start a fire when sufficient power is present.

The application of the flexible polymer material helps to prevent the generation and propagation of these cracks. One other thing some manufacturers add is to change the plate overlap area. By reducing this overlap and so removing the over lap from the likely zone of crack propagation, even if cracks occur, these may not lead to electrical shorts. This change may cause the capacitor to grow taller in order to maintain the same overall capacitance.

Question1 - How can one tell if there is a problem? Normally one would see an overall ceramic capacitor failure rate that has increased by a factor of 2 or 3. In addition, the dominant failure mode often changes from open to electrical short. The third clue is having an occasional burned board from a capacitor failure. In all cases failure analysis is required to determine that the capacitor was cracked.

Question 2 - How can the cracked capacitor problem be eliminated or minimized? Measure the stress on the board in the proximity of large capacitors. This usually means sizes 1206 or larger. It should be kept below about 750 micro strain units. This is often measured in terms of a deflection. For a 1206 package this flexible end termination should withstand up to a 5 mm deflection for a 90 mm span. The older versions would break at some point beyond a 2mm deflection. These are standard test conditions per AEC-Q200.

Alignment is important for any stress measurement on capacitors. To reduce any unavoidable stress, the capacitor should be aligned so that this stress is across the narrow width of the capacitor rather than along the length.

Question 3 - Are these flexible end termination capacitors the same as prior ceramic capacitors? The three current manufacturers say they are. The only difference is that a thin intermediate layer in added to the construction. If questions arise about long term stability, life tests are recommended