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dV/dt Ratings for Multi-layer Ceramic Capacitors

Historically the dV/dt rating of Multi-Layer Ceramic Capacitors (MLCC's) is not a parameter that has generally been requested by customers or provided by manufacturers. In recent years however, as the maximum capacitance values of MLCC's has increased in any given case size, many customers have looked to MLCC's as replacements for Metalised Film Capacitors (MFC's), which have suffered from supply difficulties and shortages. The dv/dt rating of MFC's is very important to this capacitor technology and is quoted by all manufacturers. Buyers of MFC's, being conscious of their dV/dt rating, also request this data when looking for a MLCC replacement. Firstly we need to understand why the dV/dt rating is so critical for MFC's

The basic construction of MFC's is described as follows.

To begin plain dielectric film is placed in a vacuum and a thin layer of metal alloy is deposited on it. The metallised film is wound into a cylinder so that a metallised edge extends on each end of the wound capacitor section. Both ends are then sprayed with small droplets of molten metal that adhere along, and make contact with, the metallisation on the film. The wire lead is welded to this end spray. The end spray process does not result in a uniform connection to the metallisation and there is some damage and connection loss at the edge of the film from the heat contained in the metal droplets. During application the capacitor current must be shared by all the minute connection points of the metal end spray to the metallisation of the film. Since the actual contacts between the metal end spray and the metallisation are relatively few and tiny, and the contact is made to a very thin layer of metallisation, the current density at each contact is enormous. If the peak current rises past a certain point the metallisation vaporizes adjacent to the connections with the highest current density. Since these connection points are now gone, the remaining connection points must carry more current. After a finite number of pulses the capacitor fails and becomes an open circuit.

Therefore when MFC's are used in pulse applications the overriding concern is the value of the peak current during a voltage transition. Because it is very difficult to measure fast current pulses directly, maximum pulse current is usually specified by dV/dt of voltage waveforms across the capacitor.
I = C * dV/dt.

It is also worth noting that metallised polyester film capacitors have higher dV/dt ratings than a comparable metallised polypropylene, because the film does not sustain as much damage by the hot metal end spray or the heat generated at lead welding.

In contrast we should also look at the construction of MLCC's. These are manufactured by interleaving parallel layers of dielectric and metal to form the multi-layer construction. Thus the effective internal electrode contact area to either the external lead (radial leaded) or nickel barrier

termination (SMD) is orders of magnitude greater than the equivalent MFC. This results in much lower current densities during voltage transitions. Therefore an MLCC can withstand much higher dV/dt values than the equivalent MFC. Failure of an MLCC due to high dV/dt values is not generally recognised as a normal failure mechanism and hence dV/dt ratings are not normally quoted by manufacturers of MLCC's. It has been demonstrated in snubber applications that MLCC's are capable of withstanding dV/dt ratings of greater than 8KV/µSec.

Although we have shown that MLCC's are not susceptible to high dV/dt ratings in the same way as MFC's we also need to consider the effects of the power rating (or temperature rise)of the capacitor. Any continuously changing voltage condition will result in a current flowing through the capacitor. **Irms = Vrms/Xc** with the power being dissipated as $\mathbf{I^2 * R}$ (where R is the ESR at the voltage frequency). If the power rating of the capacitor is exceeded it will lead to excessive self heating and ultimately failure of the capacitor. This is applicable to both MLCC's and MFC's.

When using a MLCC as a replacement for a MFC it is usually recommended that NP0/C0G dielectric is used. This dielectric material is similar to MFC's in terms of Temperature and Voltage Coefficients.

In summary, when replacing a Metalised Film Capacitor with a (NP0/C0G) Multi-Layer Capacitor the dV/dt rating should not be of concern however careful attention should be paid to the maximum power rating of each type capacitor technology.

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