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Use of Syfer Multilayer Ceramic Capacitors at Higher Temperatures

Syfer Multilayer Ceramic Capacitors are approved for use over the temperature range -55°C to $+125^{\circ}\text{C}$ (150°C for X8R). This application note provides information on how Syfer product could be suitable for use at elevated temperatures of up to 200°C .

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Introduction

Syfer products are rated over the temperature range of -55°C to +150°C as shown below:

| Dielectric Classification | Lower Temperature | Upper Temperature | Maximum Cap Change |
|---------------------------|-------------------|-------------------|--------------------|
| C0G | -55°C | +125°C | +/-30ppm/°C |
| X5R | -55°C | +85°C | +/-15% |
| X7R | -55°C | +125°C | +/-15% |
| X8R | -55°C | +150°C | +/-15% |

For certain automotive and industrial applications a wider temperature range is often requested, particularly for temperatures up to 200°C. Standard product may not be suitable for use above the upper rated temperature of 125°C, but after extensive testing performed at our manufacturing facility it is possible for Syfer to make recommendations on part suitability for use at higher temperatures. It should be noted however, that although parts will function at temperatures up to 200°C the electrical properties will not meet the normal C0G, X5R, X7R or X8R specifications.

Background

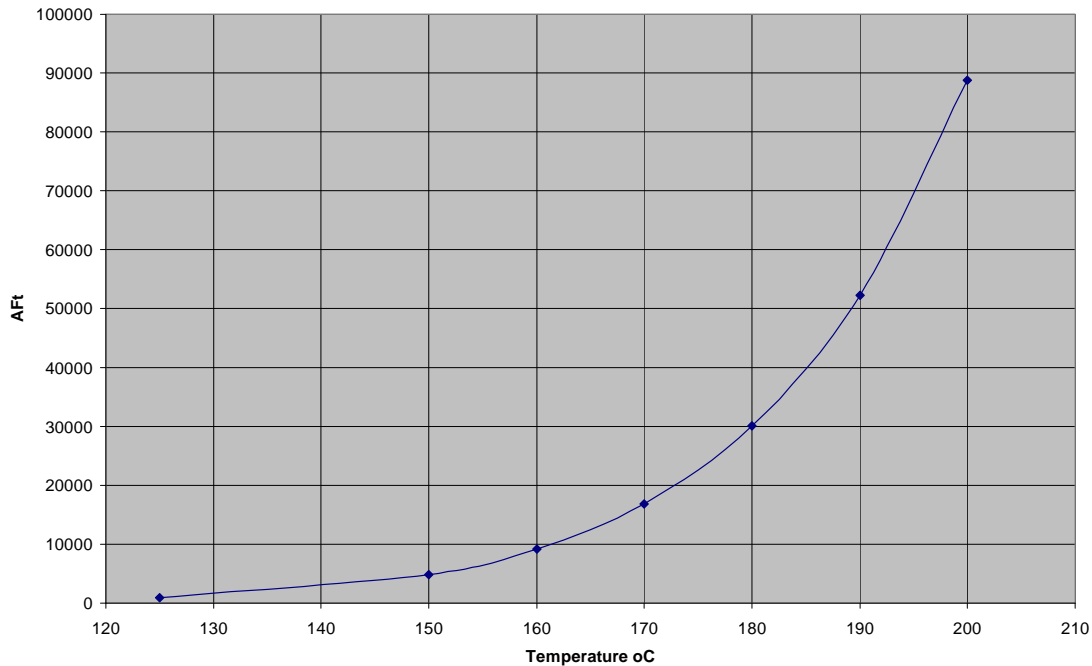
The reliability of multilayer ceramic capacitors is directly related to the voltage applied and the operating temperature as detailed in Syfer's AN0004 'Quality and Reliability Data' (available at www.syfer.com, under *Technical Information, Application notes and in our Catalogue - Product Test and Reliability Guide*).

The acceleration factor due to temperature increases very significantly as temperature is increased:

| Stress Temperature | 125°C | 150°C | 160°C | 170°C | 180°C | 190°C | 200°C |
|---------------------|-------|-------|-------|-------|-------|-------|-------|
| Acceleration Factor | 871 | 4884 | 9203 | 16854 | 30051 | 52258 | 88776 |



Acceleration Factor Vs Stress Temperature



Thermal stress alone is sufficient to cause electrical failure. Thermal breakdown takes place when heat is generated in the dielectric at a higher rate than it can be conducted away. This leads to increased conductivity, more heat generation and eventually to instability in the form of an uncontrolled, often very rapid temperature rise. The temperatures attained when a capacitor discharges through a region of localised thermal runaway can be high enough to melt the dielectric material.

When determining whether a particular component is suitable for use at high temperatures, customers must consider the thermal stress, and the effect of the elevated temperature on basic electrical properties such as capacitance, dissipation factor and insulation resistance.

Component Testing

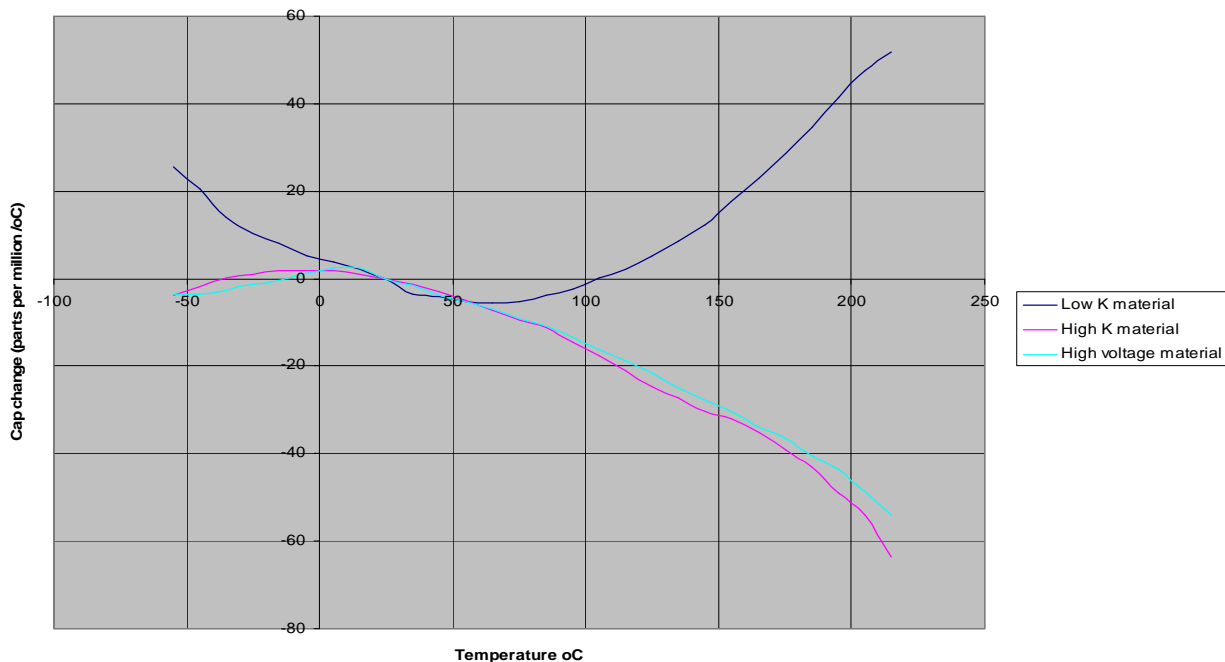
Syfer has undertaken extensive testing of standard components made from each dielectric material type used in the manufacture of multilayer chip capacitors. The basic electrical properties of Syfer components at high temperatures are exhibited graphically in the next section of this document.

Reliability testing of components at temperatures of up to 200°C has also been carried out. Recommendations for high temperature applications based on these results can be found in the final section of this document.

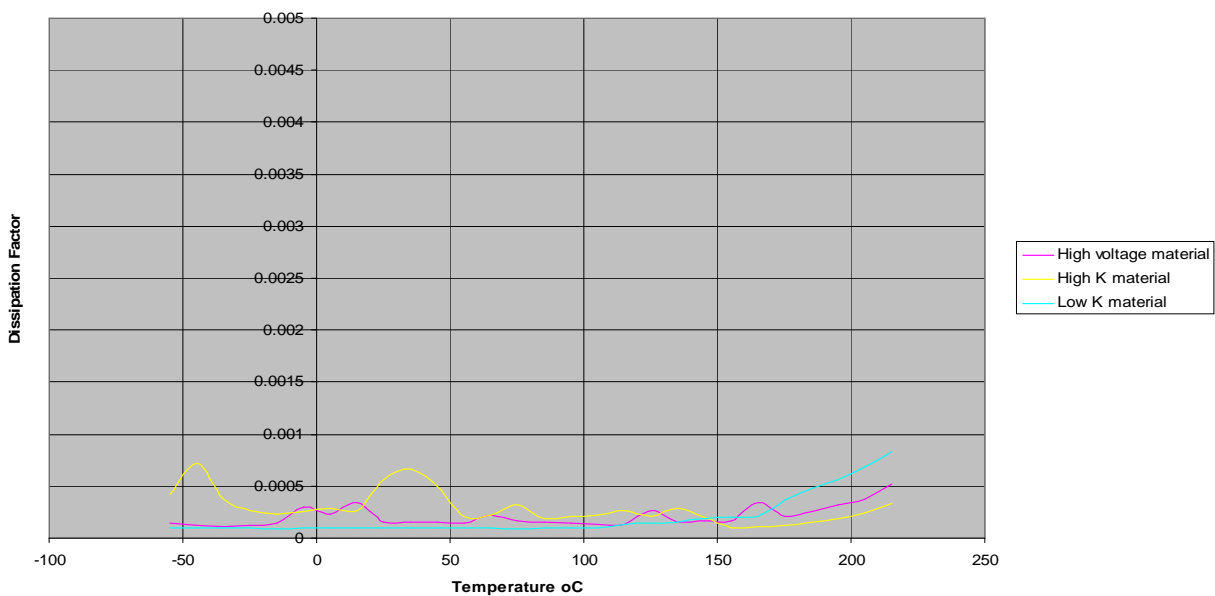


Basic Electrical Properties at High Temperatures

COG Temperature Characteristic - Capacitance

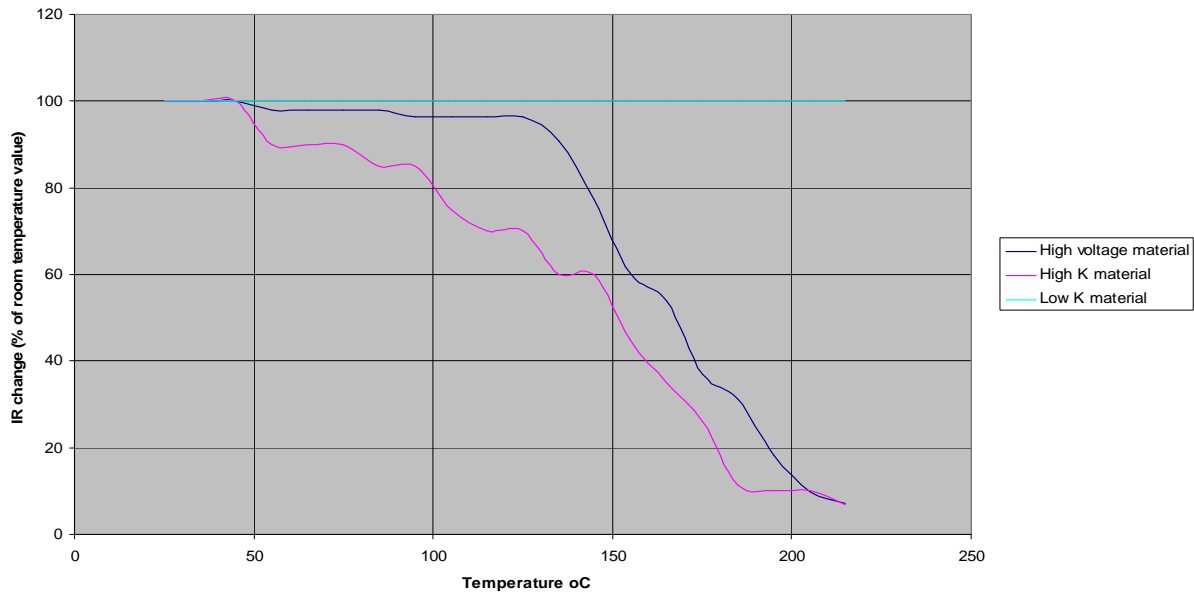


COG Temperature Characteristic - Dissipation Factor

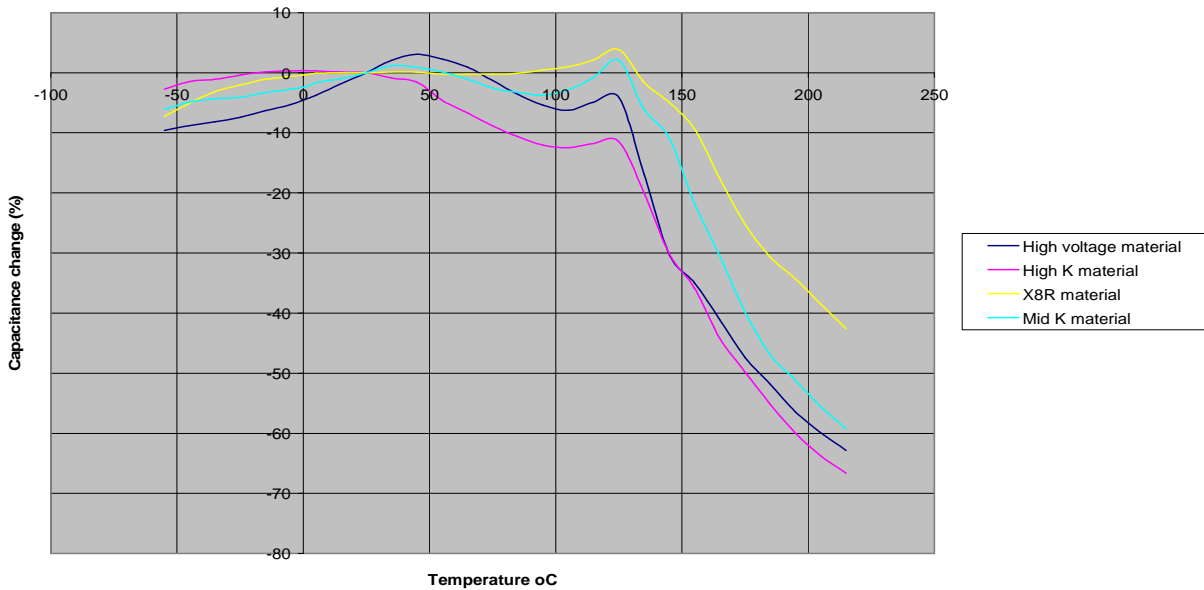




C0G Temperature Characteristic - Insulation Resistance

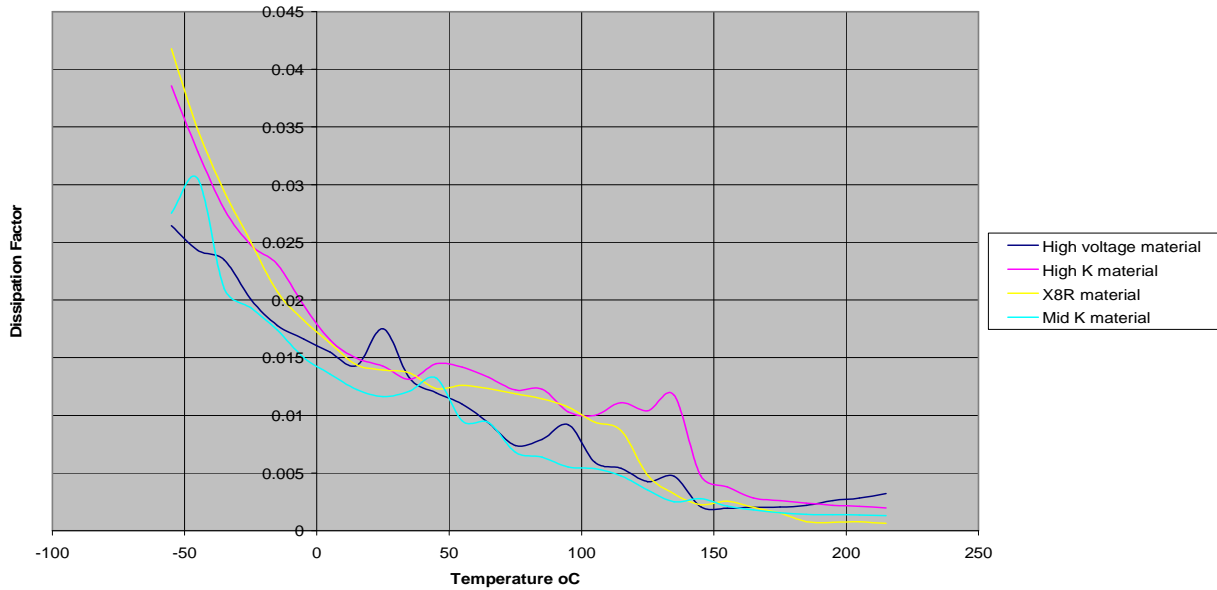


X5R / X7R / X8R Temperature Characteristic - Capacitance

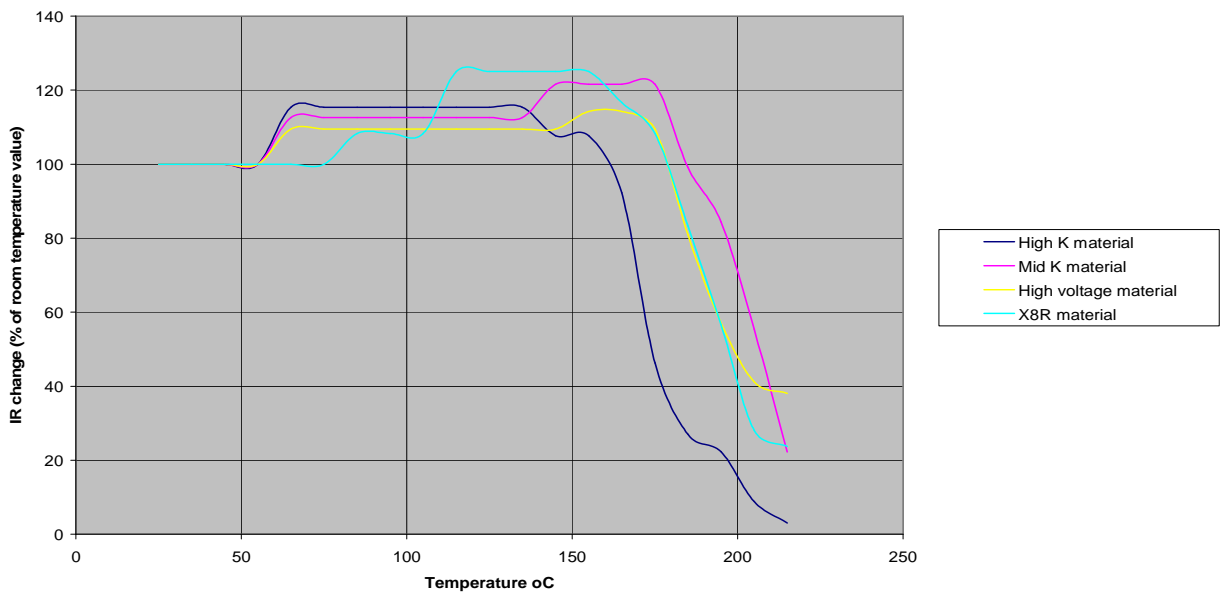




X5R / X7R / X8R Temperature Characteristic - Dissipation Factor

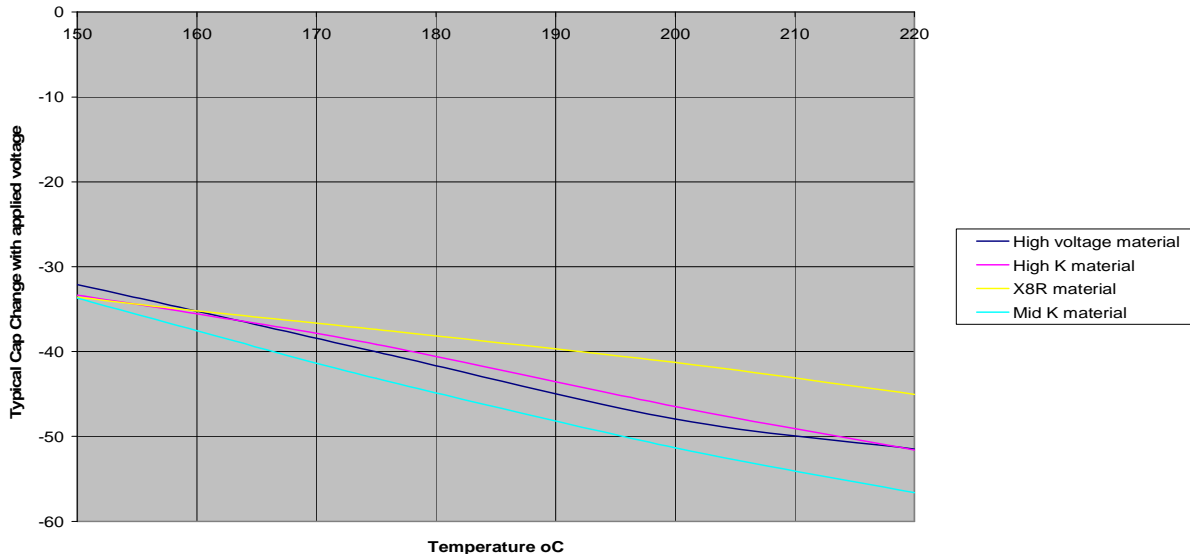


X5R / X7R / X8R Temperature Characteristic - Insulation Resistance





X5R / X7R / X8R Temperature Characteristic - Voltage Coefficient



Recommendations

As component reliability is detrimentally affected due to thermal stresses it is not recommended that standard components are used at temperatures $>125^{\circ}\text{C}$ however:-

A - For temperatures up to 160°C , most standard components will give reliable performance, but the Syfer recommendation is for the component user to select components with a voltage rating $\geq 30\%$ higher than the component that would normally be selected. (See www.syfer.com, Quick reference guides for max cap per size/ voltage for standard product)

For example, if a 0805 50V 10nF component would normally be used, the recommendation would be to use an 0805 100V 10nF part – NB the 0805 63V 10nF would not meet the recommendation as the voltage increase is only 26%.

B - For temperatures $>160^{\circ}\text{C}$, Syfer test data shows that the reliability is affected exponentially in a similar way to that shown on the thermal stress graph above. This makes it very difficult to provide a simple set of rules for component users to apply for use between $>160^{\circ}\text{C}$ and 200°C .

Consequently, for component use $>160^{\circ}\text{C}$, Syfer recommends the user contacts our technical team with details of the exact application and Syfer will recommend the most suitable component. This will ensure that the customer will always get the most reliable and cost effective solution to their needs.

As an example, the recommended component size for a particular application may be a 1206 size chip for use at 170°C , but for the same capacitance value and working voltage an 1812 chip may be needed for use at 200°C .

For more information contact the Syfer Technology Material and Process Engineering Manager (aellmore@syfer.co.uk).