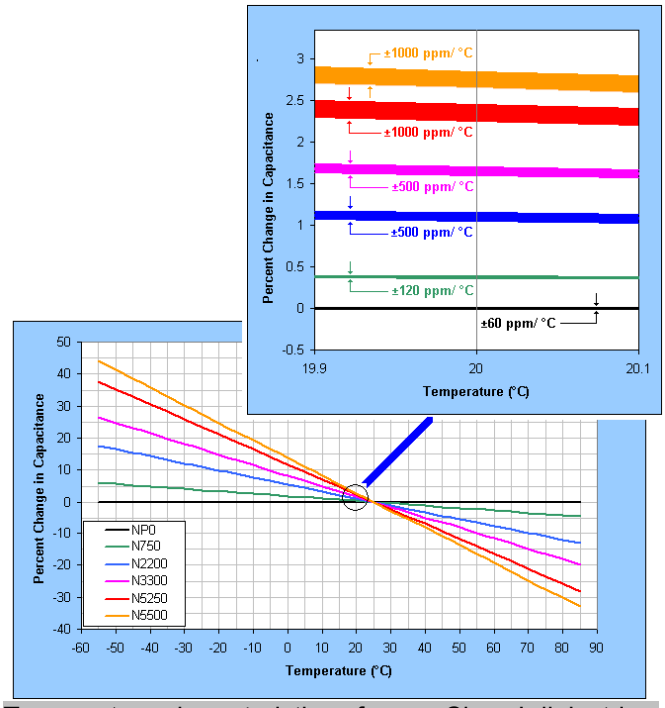
Dielectric Characteristics

High Energy Corporation designs and manufactures ceramic capacitors spanning a very broad range of applications. For this reason, it blends, mills and fires a broad range of dielectric materials, each optimized for a specific use. The properties of a few representative dielectrics are discussed herein. Broadly, all of our dielectrics fall into one of two categories, either Class I or Class II.

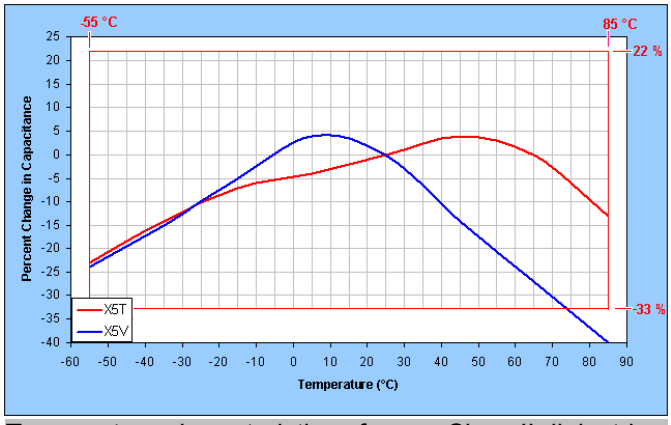
Class I capacitors are intended for use in high-Q circuits where a *low dissipation factor* and *stability of capacitance value* are of paramount importance. Dielectrics providing these characteristics are made from high-purity calcium titanate ($CaTiO_3$) blended with proprietary mixes of other titanate materials. Basic Class I dielectrics exhibit a low (below 150) relative dielectric constant, **K.** Various additives can increase this into the high-hundreds, providing *extended temperature compensating* Class I capacitors.



Temperature characteristics of some Class I dielectrics.

Class I capacitors have a (near) *linear* change in capacitance with temperature, as shown above. The identifying *Industry Type* is a simple code for the slope of this characteristic. An **N** says the slope is *negative*, while a **P** denotes a *positive* slope. The number following the letter gives the slope in parts-per-million per degree Centigrade (ppm/°C). All High Energy Class I designs use 'N' dielectrics.

Class I *Industry Type* **NP0** is a special case. This abbreviation stands for "negative-positive-zero", denoting a capacitor of (essentially) constant value with temperature. High Energy **NP0** capacitors exhibit the *same* capacitance from –55 to 85 °C within a temperature tolerance of ±60 ppm/ °C, as shown by the expanded inset at left below. Note that the *absolute* capacitance tolerance (i.e. ± 5%) is specified separately.



Temperature characteristics of some Class II dielectrics.

Class II capacitors are used in circuits where Q and component stability is less critical. This includes bypass decoupling, filters and other frequency discriminating circuits. These capacitors use a 'high-**K**' dielectric (**K** up to 10,000) to achieve a high capacitance/volume ratio. The dielectric is compounded upon a barium titanate (Ba_2TiO_3) base.

Class II parts are much smaller than Class I for similar capacitance. However, Class II parts provide much less tightly controlled capacitance variation with temperature as shown above.

The letter-number-letter dielectric identifier specifies a "performance rectangle". The first letter defines the *lowest* operating temperature. For example, **X** means –55 °C. The number defines the *maximum* operating temperature. For example, **5** means +85°C. The last letter defines the allowable plus and minus *percentage change in capacitance*. For instance, **T** stands for +22 % to –33 %, while **V** indicates a range of +22 % to –82 %.

Class II capacitors can also exhibit capacitance change *with time* and *with operating voltage*. They can also demonstrate *microphonic* behavior, owing to the piezoelectric character of Ba_2TiO_3.