How To Select a Capacitor For Your Application

Before the proper capacitor can be selected certain electrical and mechanical parameters required by the given application must be clearly specified, the most important of which are discussed below:

For DC applications

Working Voltage (WVDC);
This is specified based on the maximum potential that the selected capacitor will see in operation. It is customary to use a safety factor of 2 for most applications; that is, specify WVDC to be twice the maximum voltage the unit will see in its circuit. Temperature Characteristic/Coefficient of Capacitance (TC); This parameter describes the manner in which capacitance value varies with operating temperature. Capacitance can change either linearly or non-linearly with temperature. In the former case the relationship would be specified as a temperature coefficient and expressed in parts per million of capacitance change per degree C; e.g. P090 representing a capacitance change of plus 90 parts per million (equal to 0.009%) per degree C, N750 representing a capacitance change of minus 750 parts per million (equal to -0.075%) per degree C, NP0 (negative positive zero) representing an essentially unchanged capacitance over the operating temperature range. Class 1 ceramic dielectrics and polypropylene and polycarbonate plastic film capacitors are examples of capacitors whose value changes linearly with temperature. The temperature dependence of units whose capacitance values vary non-linearly with temperature is specified as a temperature characteristic, which is defined as the percent change from the 25 degrees C value at a given temperature; e.g. X7R denotes a maximum capacitance variation of plus or minus 15% from the 25 degree value over the temperature range of –55 to +125 degrees C (typical of ceramic and tantalum oxide dielectrics), Y5V denotes a maximum capacitance variation of +22/-82% over the range of –30 to + 85 degrees. For ceramic dielectrics, it is generally true that the more negative the TC is, the smaller a capacitor's physical size will be for a given capacitance value, because, in most cases the more negative the TC is, the higher will be the dielectric constant (K). Dissipation Factor (DF) and Q;

DF is a measure of loss due to heating, expressed as a decimal. It is a unitless quantity, dependant on dielectric loss (the loss caused by the motion of electrons within the dielectric) and series resistance (ESR) contributed to by electrodes, terminations, leads, etc. From an electrical standpoint, ideally, we would like a capacitor to have a 90 degree phase angle (pure reactance). However, in the real world, the aforementioned losses cause the angle to be somewhat less than the ideal 90 degrees. Mathematically, DF is the cotangent of the actual phase angle and Q is the tangent of this angle. Hence, Q = 1/DF. The range of Q's available runs from about 40 for Class II dielectrics to 10,000 or more for Class I materials. For most DC applications, a DF of .025 or lower is acceptable as there is minimal current passing through the device.

Capacitance and Tolerance;

For many DC applications, such as bypass and blocking, it is important to have a minimum capacitance (C min) throughout the operating voltage and temperature range of the application. Since this catalog specifies nominal 25 degrees (C nom) values, the minimum C nom to assure that the capacitance value will not fall below C min under operating conditions must be calculated.

In general C nom = C min . 0.8 (1-T/100) (1-TN/100) where C nom = the nominal value of the capacitor to be specified C min = the minimum acceptable capacitance under any given conditions in the device's operating environment T is the negative tolerance of the device in % e.g. T=10 for a +/-10% device, T=80 for a +10/-80% device and T=0 for a GMV device TN is the specified maximum negative change of capacitance over the operating temperature range, expressed in percent e.g. TN = 15 for X7R temperature characteristic, 56 for Z5U and 82 for Y5V 0.8 is a compensation factor to account for voltage coefficient, ageing, etc.

Example:

Circuit design requires a capacitor with C min of 1000 pf. Select a capacitor with the lowest TN and widest tolerance for which C nom will meet the physical size requirement of the circuit. Initially, select a device with Z5U temperature characteristic and +/-20% tolerance. C nom = ______1000___________ = 3551 pf 0.8 (1-20/100)(1-56/100) Check the catalog for the next highest standard value which would be 3900 pf. If this value is available in an acceptable size and voltage rating, choose it. If not, retry with the next lowest temperature characteristic and or tolerance. Repeat until a suitable unit is found. For AC applications Because in AC applications appreciable current can pass through the device there is significant heating, which must be kept to a minimum. This usually means using a Class I dielectric, which has inherently lower DF but also has much lower dielectric constant (K)(1), which usually dictates use of a larger chip. This is not all bad as the larger chip will be capable of dissipating more of the generated heat. The desired goal should be to limit the maximum temperature of the chip to 125 degrees C. In determining this, both the maximum ambient temperature the device will operate at and the temperature rise due to current (self heating) must be considered. Hence, if a temperature rise of 20 degrees is anticipated, the maximum ambient temperature should be limited to 105 degrees. However, if the maximum ambient is going to be 85 degrees, the temperature rise due to self-heating can be as high as 40 degrees. If necessary to meet the required conditions, heat sinking or even cooling must be considered.