Guideline for Derating Capacitors

Capacitor Derating:

This is a general set of guidelines and recommendations for reducing capacitor power dissipation with increasing ambient temperature.
Recall that depending on the dielectric used the value of a capacitor also changes over temperature.
Refer to this chart for Capacitor Value Change by Temperature per dielectric.
In general, limit, when ever possible, the operating temperature a capacitor might encounter.
However always operate the capacitor at a voltage less than the rated working voltage of the capacitor.

General Recommendations:
Capacitors should be derated between 30 and 60% depending on the material's maximum ambient temperature.

Ceramic capacitors should have a voltage derating factor of 0.60 [110C max]. [Ceramic capacitor manufacturers]

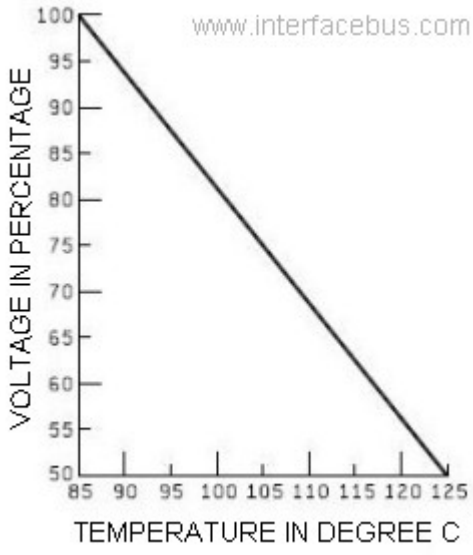
Glass Dielectric, a voltage derating factor of 0.50 [110C max].

Plastic Film Dielectric, a voltage derating factor of 0.60 [85C max].

Tantalum Foil, use a voltage derating factor of 0.50 [70C max]. [Tantalum capacitor manufacturers]
Tantalum Solid, use a voltage derating factor of 0.30 to 0.50 [70C max / 110C max].
Derate via Device [Voltage rating] / derate factor = maximum applied voltage ~ Voltage applies to sum of AC ripple and DC voltages.
Tantalum capacitors should be de-rated as much as possible, more so when used in low-impedance circuits [by-pass].
When Tantalum capacitors are used in charging/discharging or switching current circuits, the derate factor should be 30% [or more], and a series resistor should be used to limit the current.
The reliability [Failure Rate] of Tantalum capacitors is given by the following equation: $F = F_U \times F_T \times F_R \times F_B$
$\mathbf{F_U}$ = Applied Voltage / Rated Voltage. $\mathbf{F_T}$ = Operating Temperature
$\mathbf{F_R}$ = Series Resistance. $\mathbf{F_B}$ = Basic Failure rate
The capacitor manufacture would need to be consulted to obtain the correction factors. How ever, the correction factors increase with increasing Temperature, Applied Voltage, and failure rate, but decrease as the series resistance is increased. The correction factor [$\mathbf{F_U}$] is equal to one for an applied voltage equal to the rated voltage, but reduces to 0.06 if the capacitor is derated by 50%, and drops to 0.001 if the capacitor voltage is de-rated by 30% of applied voltage [the applied voltage is 30% of the rated voltage]. The correction factor [$\mathbf{F_T}$] is equal to one for an operating temperature of 85^{o}C, and drops to 0.2 for a temperature of 55^{o}C. An example of the Basic Failure rate [$\mathbf{F_B}$] might be 1%/1000 hours. The correction factor [$\mathbf{F_R}$] is equal to one for a resistance of 0.1 ohms, and drops to 0.2 for a series resistance of 1 ohm.

Rule-of-Thumb
Capacitor Stress Ratio = Operating Voltage / Rated Voltage = 75% of operational limits
The Stress Ratio is the same as a Derating Factor

It may not be possible to control the operational temperature, but rated



Capacitor Derating

voltage can be controlled in the design process. Always use a capacitor that exceeds the rated voltage seen in the circuit. When in doubt use the next highest rated voltage capacitor, if size and cost do not come into consideration. The size of the capacitor may increase as its rated voltage is increased.
The voltage de-rating is shown [as an example] for MIL-PRF-19978 capacitors [US military specifications].

Packaging Considerations:
Package size has a direct relation to power dissipation.
The larger the components package the more power the device can dissipate.
Axial Leaded Devices
metal Can Devices
Surface Mount Devices [SMD]
Common Surface Mount sizes; 0201, 0402, 0603, 0805, 1206, 1210, and 1812.
There are other Standard chip sizes: SMD Capacitor Case Sizes.

A **manufacturers list** of Capacitors.

Due to the low capacitive reactance, at high frequencies and with high capacitances, the continuous duty current will usually be reached at a voltage below the maximum rated voltage. Similarly, due to the high capacitive reactance at low frequencies and with low capacitances, the maximum voltage will often be reached before the rated current. Necessary care should be taken to ensure that neither current nor voltage exceed the derated value established by the derating requirements specified for each capacitor type.

When AC operation is required, the peak ac voltage plus any DC bias shall not exceed the derated values established by the derating requirements.

Back to the main Component Derating page for guidelines and temperature curves.

Home


Distributors

Components

Equipment

Software

Standards

Buses

Design

Reference