CIRCUIT DESIGNER'S NOTEBOOK

Understanding Temperature Coefficient of Capacitance

Temperature Coefficient of Capacitance (TCC) describes the maximum change in capacitance over a specified temperature range. The capacitance value stated by the manufacturer is established at a reference temperature of 25°C. TCC should always be considered for applications operating above or below this temperature.

Class 1 Capacitors – These capacitors are highly stable with temperature and are referred to as temperature compensating. TCC specifications for class 1 capacitors will always specify the capacitance change in parts per million (ppm) per degrees centigrade. The maximum capacitance change is calculated by multiplying the capacitance by the TCC by the change in temperature above or below the reference temperature all divided by 1,000,000.

Example: Given a 1000 pF NPO capacitor, what is the maximum capaictance drift at 35 °C?

Solution: TCC for an NPO is 0±30 ppm per °C.
Change in temperature from the
25 °C reference = 35 – 25 = 10 °C

Answer:

$$\frac{\text{cap value} \times \text{TCC} \times \Delta T}{1{,}000{,}000} = \text{cap change}$$

or

$$\frac{1000\text{ pF} \times \pm 30\text{ (ppm)} \times 10}{1{,}000{,}000} = \pm 0.3\text{ pF}$$

Therefore, a 1000 pF capacitor subjected to a 10°C change in temperature may result in a value as high as 1000.3 pF or as low as 999.7 pF.

Class 1 capacitors are best suited for applications where stability over a wide variation of temperatures and high Q are required. Filter networks, and most circuits associated with tuning and timing as well as various types of resonant circuits generally require class 1 capacitors.

Class 2 Capacitors – Class 2 capacitors are not as temperature stable as class 1 however their main advantage is volumetric efficiency, i.e. more capacitance for a given case size. These capacitors are best suited for applications where higher capacitance values are important while Q and stability over temperature are not of major concern. TCC for class 2 capacitor dielectrics is expressed as a percentage.

The maximum capacitance change is therefore calculated by multiplying the specified capacitance by the percentage associated with the TCC for that capacitor.

Example: Given a 1000 pF X7R capacitor, what is the maximum capacitance change?

Solution: TCC for an X7R is ± 15%
1000 pF x 0.15 = 150 pF

Therefore in this example a 1000 pF capacitor at temperatures above or below 25°C reference may be as high as 1150 pF and as low as 850 pF.

EIA Class 2 TCC Designations

First Character: Defines the low temperature limit.
X = -55 °C Y = -30 °C Z = +10 °C

Second Character: Defines the high temperature limit.
5 = +85 °C 7 = +125 °C

Third Character: Defines the maximum capacitance change in percentage.

V = +22, -82%	R = ±15%
U = +22, -56%	P = ±10%
T = +22, -33%	F = ±7.5%
S = +22%	E = ±4.7%

Conclusion – TCC should always be factored in to designs operating at temperatures above or below 25°C. Further information on this topic can be obtained from the RF Applications department.

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