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Know your ceramic capacitor, part one

Although advancements in dielectric materials and fabrication processes have improved integrated capacitors, chip designers still depend on board-level devices to support virtually all ICs. Primary tasks for board-level capacitors are power-supply bypassing and signal coupling, but many ICs still depend on external parts for timebase generation, filtering, and waveform shaping.

Driven largely by matters of size, cost, and availability, multilayer ceramic is among the most common capacitor constructions in the industry. This trend has accelerated over the last several years, during which tantalum prices more than quadrupled, making volumetrically efficient tantalum capacitors more expensive and less available than they historically have been.

The EIA (Electronic Industries Alliance) associates ceramic capacitors with four classes, of which the first three are in widespread use today (**Reference 1**). Three-character alphanumeric designations within a class characterize the capacitor's thermal behavior. The significance of the designators, however, is class-specific.

Class I ceramic capacitors are temperature-compensated and, therefore, provide the most stable performance of all the classes. The EIA designators for Class I capacitors describe the device's temperature coefficient of capacitance. The designator's three characters provide a mantissa, a multiplier, and a tolerance (**Table 1**, available in the Web version of this column at www.edn.com/080918ji).

Class I capacitors exhibit a low-voltage coefficient of capacitance, an important attribute in signal-processing circuits in which low distortion is a requirement.

The most common Class I capacitor carries the designation C0G, and nominally provides a zero temperature coefficient of capacitance with a ±30 ppm/°C tolerance over a 25 to 85°C range. Note that the temperature range over which the temperature coefficient of capacitance and its tolerance apply is not the capacitor's full operating-temperature range. To the extent that C0Gs deviate from their ideal zero temperature coefficient of capacitance, their drift tends to be linear with temperature. Some manufacturers, therefore, specify their C0G capacitors' drift within the ±30 ppm/°C band from −55 to +125°C.

Class I capacitors also exhibit a low-voltage coefficient of capacitance, which is an important attribute in signal-processing circuits in which low distortion is a requirement. This observation isn't to suggest that a Class I capacitor—or any ceramic capacitor, for that matter—is your best choice for critical signal-processing circuits. However, if your application doesn't require the precision of, say, instrumentation-quality measurement circuits or professional-quality audio equipment, you'll be hard-pressed to find a more compact, inexpensive, and readily available capacitor than a multilayer ceramic.

For high-frequency applications, Class I ceramic capacitors exhibit lower parasitic series inductances and thus higher resonant frequencies than do devices of Class II and higher. RF-rated C0G capacitors with values as large as 50 pF typically exhibit resonant frequencies in excess of 1 GHz.

Class I multilayer ceramic capacitors are readily available in surface-mount form factors in capacitances as large as 10 nF. Some suppliers provide surface-mount devices with capacitances as large as 100 nF and leaded devices in excess of 1 μF. Owing to their limited dielectric constants, typically in the range of 10 to 100, Class I devices at the upper end of the technology's capacitance range tend to be quite large. The higher dielectric constant of Class II ceramics produces more compact devices with a wider range of capacitances than do Class I ceramics—the next subject in *Analog Domain*. EDN

REFERENCE

1 "Ceramic dielectric capacitors classes I, II, III, and IV," Electronic Industries Alliance, Standard EIA 198-1F.

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