BY JOSHUA ISRAELSOHN, CONTRIBUTING TECHNICAL EDITOR

Know your ceramic capacitor, part two

The last installment of *Analog Domain* introduced the four classifications of ceramic capacitors that the EIA (Electronics Industries Alliance) defines in its standard EIA 198-1F (**references 1** and **2**). The standard defines the attributes associated with the familiar, if cryptic, designations that identify various ceramic capacitors, including C0G, X7R, and Z5U—members of EIA classes I, II, and III, respectively. The designations correspond to the electrical and thermal behaviors that characterize ceramic capacitors' various dielectric formulations.

As I noted in that article, Class I ceramics excel with the lowest temperature coefficients of capacitance, the lowest voltage coefficients of capacitance, and the highest Q of the four EIA ceramic-dielectric types. The disadvantages of Class I ceramics include their low dielectric constants, constraining the upper extent of the capacitance range that manufacturers can provide within a given case size. For a given capacitance requirement, this constraint in turn limits an application's density and increases its component costs.

Applications not demanding Class I ceramics' parametric performance can take advantage of the greater densities and lower costs attainable with ceramic classes II and III, which feature significantly larger dielectric constants. The more space- and cost-efficient Class II ceramics, however, exhibit parametric shifts for which you must account when specifying these devices.

The most obvious shift results from the temperature coefficient of capacitance. Capacitors conforming to EIA classes II and III do not specify a temperature coefficient in such terms but rather a temperature range and a maximum capacitance shift over that range (**tables 1** and **2**, available in the Web version of this column at www.edn.com/081127ji). X7R capacitors, for example, feature an operating-temperature range of −55 to −125°C, over which the capacitance can vary ±15%.

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Class III capacitors, the least expensive of the common types, raise concerns if the component-selection process does not properly take into account their characteristics. The operating-temperature range of Z5U, for example, extends to only 10°C, which is insufficient for most portable electronics in which Class III devices' density is particularly attractive. Also, over the narrow 75°C operating range, a Z5U device's capacitance can drop by more than half. Another popular Class III device, Y5V, provides guaranteed performance to −30°C, but, over its 115°C operating range, its capacitance can fall to one-fifth its nominal value.

Ceramic capacitors in classes II and III also present a significant and nonlinear voltage coefficient of capacitance. The capacitance of Class II devices typically falls 10% with applied voltages of 50 to 70% of the device's maximum working voltage. Class III devices lose capacitance starting at 10% of the maximum working voltage and exhibit as little as 30% of their nameplate value at 90% of their voltage range.

Designers involved with typical low-voltage CMOS applications see typical working-voltage maximums of 50 and 100V, so they needn't concern themselves with the voltage effect. However, those designing higher-voltage circuits for applications such as analog-signal processing and motion control should make note of the voltage effect on the capacitors they specify and adjust the design values to the components' behavior. **EDN**

REFERENCES

1. Israelsohn, Joshua, "Know your ceramic capacitor, part one," *EDN*, Sept 18, 2008, pg 24, www.edn.com/article/CA6594098.
2. "Ceramic dielectric capacitors classes I, II, III, and IV," Electronic Industries Alliance, Standard EIA 198-1F, www.eia.org.

Joshua Israelsohn is a co-founder of JAS Technical Media, where he manages technical-communication services. You can find his contact information at www.jas-technicalmedia.com/Contact.

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