

SELECTING A NON-INDUCTIVE BULK CERAMIC RESISTOR

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These rugged resistors offer design advantages in demanding applications



Materials used in non-inductive bulk ceramic resistors construction allow simpler and more efficient designs than standard wire-wounds

From soft-start/current-limit and snubber circuits to dynamic braking and RF dummy loads, the list of applications for non-inductive bulk ceramic resistors continues to grow as more design engineers discover the devices' inherent advantages. Bulk ceramic resistors are ideal for a wide range of requirements in equipment such as radar, motor drives, broadcast transmitters, RF amplifiers, semiconductor process, power conditioning, x-ray, lasers, medical defibrillators, and energy research.

Sophisticated electronic equipment and systems often require rugged resistors that perform reliably under conditions involving a combination of high voltage, current, or energy.

Typically, these are advanced-technology power-intense higher-cost systems, where it is critical that the resistors meet stringent requirements. Bulk ceramic resistors represent the best choice for these applications because of their many design advantages.

Construction characteristics

Chemically inert and thermally stable, the resistors are inherently non-inductive because of their bulk ceramic construction, which allows energy and power to be uniformly distributed through the entire ceramic resistor body with no film or wire to fail. The bulk ceramic material also allows simple, efficient resistor designs that enable the designer to minimize the resistor package size while providing the required performance and reliability.

Bulk ceramic resistors can be manufactured in many geometries and sizes, from fractional watts to kilowatts. Design requirements for custom sizes, surface mount, or special footprints can be met easily. In cases where several carbon-composition resistors have been used together in an array to achieve a particular rating, they have been replaced with a single bulk ceramic resistor, frequently at a lower installed cost.

Snubber circuits

Familiar wire-wound and low-inductance carbon-composition and film resistors most often don't hold up well under a combination of high-voltage, current, or energy conditions. Using snubber-circuit applications as an example, a comparison of these resistors shows that they do not match the performance and reliability of the bulk ceramic resistor.

As power is dissipated in a short spike, the instantaneous peak power may measure many megawatts. Because of the small mass of the resistive element, film and wire-wound resistors suffer degradation and failure through thermal shock, jeopardizing the devices they are intended to protect.

Even so-called non-inductive wire-wound resistors display some inductance, which may not be appreciable at tens or even hundreds of hertz used in older designs. However, the high operating speeds used in applications such as modern power-conversion systems can render these resistors useless because low nanohenry (nH) inductance is needed.

Carbon-composition resistors are non-inductive and provide an adequate solution at low average power, but they can be unstable because of moisture or high voltage. Carbon-composition resistors rated at 2 W and higher are almost impossible to source.

RF/digital loads and high-frequency filters

Bulk ceramic resistors are used extensively for high-frequency RF loads in broadcast and communication equipment because of their non-inductive characteristics. They provide excellent non-inductive power-handling capacity at frequencies into the gigahertz range, with no sacrifice in power dissipation.

Film resistors may provide the needed non-inductive characteristics required by such RF applications, but they have size limitations and present reliability problems due to potential film burnout. This is especially true in advanced digital applications such as digital radio and TV transmitters involving pulses at high frequencies.

Bulk ceramic resistors give the designer a compact size advantage versus wire-wound resistors in such applications. For example, a wire-wound resistor rated at 20 W with a 150-J pulse rating may measure 2 to 3 in. long with a 0.4-in. diameter. Those same requirements could be met by an axial-leaded bulk ceramic resistor measuring just 0.75 (L) x 0.3 (dia.) in. By the same token, a bulk ceramic resistor of the same size as a wire-wound resistor can provide a far greater energy rating.

High voltage

Resistors produced from bulk ceramic materials have displayed several key advantages in demanding high voltage situations, including both continuous-wave and pulse applications. These include radar and broadcast transmitters, x-ray systems, defibrillators, lasers, and high voltage semiconductor process equipment applications, where resistors must handle peak voltage anywhere from 20 to 80 kV. Typical applications include current limit in capacitor charge/discharge, crowbar, and tube-arc circuits. In these uses, bulk ceramic resistors provide low inductance, high average power per unit size, stability at high voltage, and durability at extreme peak-power levels.

Wire-wound Resistors vs. Bulk Ceramic Resistors				
Parameter	Resistor Type			
	Wire-wound	Film	Composition	Ceramic
Non-inductive	Poor	Excellent	Good	Good
Peak power	Poor	Poor	Good	Excellent
Overload				Excellent
Geometry size	Complex package	Flexible	Limited	Flexible
	5 W to 1 kW	0.1 W to 1 kW	0.5 W to 2 kW	1 W to 1 kW
Cost	Low to medium	Low	Low	Medium

Soft-start, surge, pre-charge

Soft-start, surge, and pre-charge applications in motor-drive controls and medium-to-high-power power supplies provide another example of the advantages of bulk ceramic resistors, as they deliver excellent performance where high peak power or high-energy pulses must be handled in a small size. As alternatives to carbon-composition resistors, one bulk-ceramic resistor can often be used as drop-in replacements for 1- and 2-W sizes.

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