Alumina-Substrate Resistors Protect Medical Electronics

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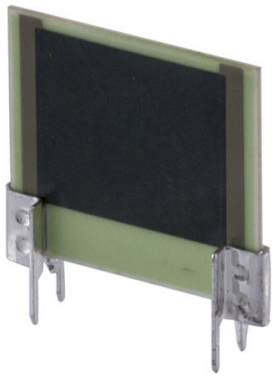
Offering high resistance values, reliable high-voltage handling, and a compact footprint, alumina-substrate resistors are suitable for a range of medical device applications, including defibrillators.

Electrical surges can disable electronic devices of any type, including those used in the medical device sphere. To protect electronics from dangerous surges, medical equipment manufacturers rely on several types of resistors, including thick-film technologies.

Capable of replacing standard carbon-composition resistors in medical device applications, thick-film resistors absorb large amounts of energy and offer noninductive performance in an axial package. Versatile and compact, they can be employed in such medical devices as x-ray systems, defibrillators, and defibrillator monitoring equipment.



TP-series high-energy resistors offer noninductive performance and high power density, in addition to the impulse energy capability normally associated with wirewound or composition resistors.

Thick-Film-on-Alumina-Substrate Technology

Thick-film resistors are composed of conductive, resistive, and insulating pastes deposited and fused onto a ceramic substrate base. One of the most effective and popular substrates is made from alumina (Al_2O_3).

A ceramic material, alumina offers a range of advantages for resistor technology. Because resistors and other passive components are printed directly on the ceramic base, they occupy less room than other technologies and also allow users to develop creative component configurations. Moreover, alumina provides high thermal conductivity and good heat-dissipation characteristics, eliminating hot-spotting and other errors.

One of the most important advantages of thick-film-on-alumina-substrate resistors is their incorporation of resistive pastes. Ranging in resistance values from 10 Ω/sq to 10 MΩ/sq, these pastes enable design engineers to develop resistors with higher or lower resistance simply by modifying the thickness of the paste. Thanks to this technology, designers do not have to change the geometry or size of the resistor to achieve different resistance values.

Among the most important considerations for engineers of medical equipment such as defibrillators and defibrillator monitoring equipment is to design the devices so that they can withstand high pulse and high voltage levels. For example, defibrillators have to endure voltages as high as 2000 V and pulses varying in intensity from 20–300 J, depending on the manufacturer.

While alumina-substrate resistors can accommodate high voltage requirements with ease, they can handle high current pulses only if the component design is modified. This modification is accomplished by increasing the width, or the surface area, of the resistive paste applied to the substrate.

Enabling Medical Device Miniaturization

With the advent of automated external defibrillators, patients for the first time could be treated for such cardiovascular conditions as cardiac dysrhythmias, ventricular fibrillation, and pulseless ventricular tachycardia in the home setting. Alumina-substrate-based resistors allow for device miniaturization, and have contributed to the development of portable defibrillators.

Printed resistors on the surface of the alumina substrate are very thin, exhibiting approximately the same height as the copper conductive traces on a printed circuit board. Capable of fitting into a planar package, the substrates can also incorporate components directly on top of the resistors while maintaining conductor traces between them, doubling the space utilization.

Alumina's ceramic properties also contribute to miniaturization. Because it is conductive on one side (the side on which the conductive and resistive pastes are deposited) and nonconductive on the other, designers can place other elements very close to the backside of the resistor without worrying about a fault or arc. Should a fault occur, the failure mode of an alumina resistor is still an open circuit.

Alumina-Substrate Versus Wirewound Resistors

Unlike thick-film resistors, wirewound resistors, which are typically composed of a rod-shaped ceramic or fiberglass core wrapped in metallic wire, generally do not need to specify a maximum voltage because they are less likely to create potential conduction from typically nonconductive traces. Moreover, wirewound resistors can handle high current pulses well because the wire wrapped around the core provides a large surface area to absorb the pulse. When the current jumps, the lengths of wrapped wire can handle the sudden pulse spike. Thick-film resistors, on the other hand, are less suitable for handling current pulse because they are smaller, providing less overall surface area.

Nevertheless, while wirewound resistors are better able to handle high current pulses than thick-film technologies, their wire diameters cannot be increased enough to endure high defibrillator voltages up to 2500 V. Thus, it is easier to design alumina resistors to handle high current pulses than it is to design wirewound resistors to handle extreme voltages.

Suitable for medical device applications such as defibrillators and defibrillator-monitoring equipment, Ohmite's TFS series of thick-film-on-alumina-substrate resistors are screen printed on glass and feature resistance values ranging from 100 Ω to 100 KΩ.

In addition, it is more difficult to achieve high resistance values with wirewound resistors than with thick-film alumina-based resistors. In the case of wirewound technologies, manufacturers must fabricate a smaller and smaller wire diameter to achieve higher and higher resistivity values.

High resistance values are also inherently less valuable in wirewound constructions because of their fine wires. Moreover, wirewound resistors can occasionally experience circuit interference caused by the inductively wound wire.

In addition, the entire resistor is wrapped in conductive wire in wirewound designs, so designers must be careful about placing other elements too close to the resistor. For example, if a conductive component is placed too close to the wirewound resistor, it may arc or cause a fault.

After weighing these pros and cons, medical device designers and engineers can derive a range of benefits from using alumina substrate technology, especially in defibrillators and defibrillator monitoring equipment. Offering high resistance values, reliable high-voltage handling, a compact footprint, and tight tolerances, alumina substrate resistors compare favorably with wirewound resistors in medical device applications.

Mike West is director of operations and engineering at Ohmite Manufacturing Co. (Arlington Heights, IL).