Discrete Components Optimize Medical Equipment Performance and Reliability

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Medical electronics applications require components that are smaller, more robust, and highly versatile, particularly as medical equipment becomes increasingly portable. Because medical systems often use discrete electronic components in their circuit designs, passive components are critical to optimizing performance and reliability. Passive components are often employed in medical equipment for high voltage and high power management, as well as precision current sensing and current limiting, and there are a number of package types and specifications to consider for optimal performance in medical equipment.

High voltage and high power medical applications
Medical imaging applications, including X-ray machines, ultrasound equipment, and MRI equipment, as well as defibrillators, often require high voltage power supplies, which incorporate a number of discrete components. As such, voltage specifications for some equipment can reach several thousand volts, while still requiring components that occupy limited real estate.

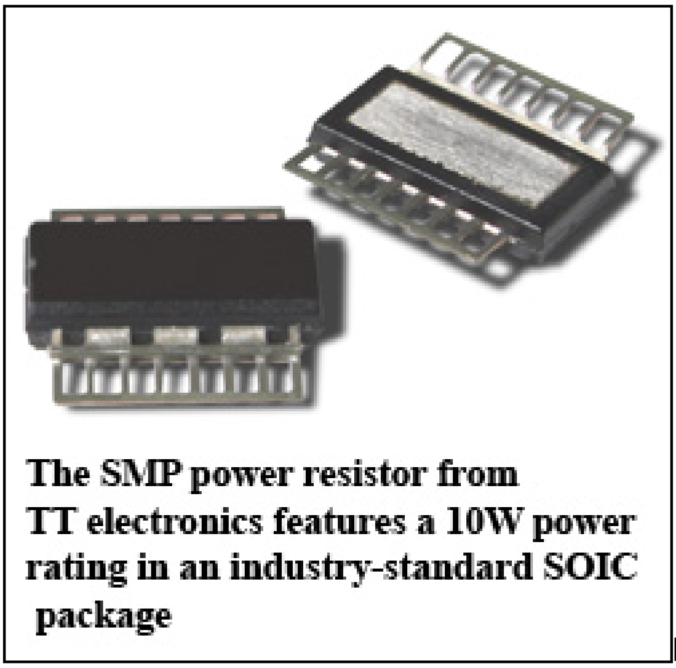
Component designers develop small, high voltage products by employing a long conductive path to reduce voltage and stress within the component. Chip resistors that reach 3000 volts in a standard 2512 package are being used in medical equipment today. This voltage rating can go even higher if the resistor is potted or otherwise encapsulated to be kept from arcing. As a comparison, a typical voltage rating for a 1206 component is around 400V, but for chip resistors of that size designed for medical equipment, that rating is often in the range of 1000V.

TT electronics' HVC Series resistor is rated to 3KV in a 2512 package

Although 3000V may seem to exceed inherent limitations of voltage separation due to the permittivity of air, passive component designers often reach these limits through the use of PC board encapsulants to limit flash-over between the component terminals.

Along with the standard voltage rating, the voltage coefficient of resistance (VCR) is a key parameter in medical circuit designs, representing the change of resistance as voltage fluctuates. Employing a resistor that features an extremely low VCR rating, such as O to -5ppm/V, will significantly increase stability in high voltage applications.

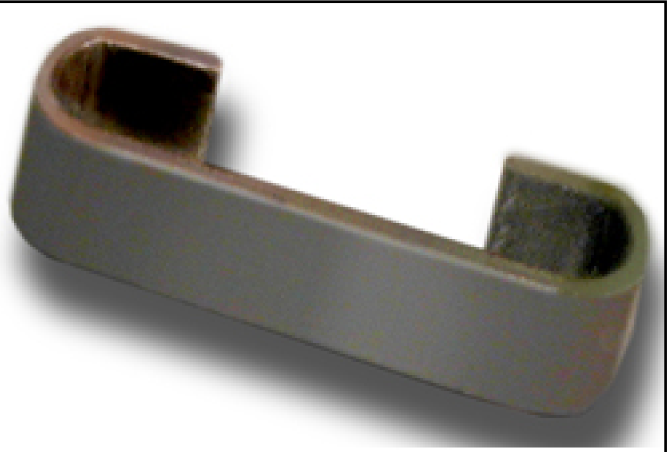
In terms of power, applications such as those mentioned above as well as medical instrumentation equipment, often require extremely high power discrete components. Whereas wirewound and chip resistors may be ideally suited for high voltage applications, employing a high power film resistor also has its benefits, as it eliminates inductance that is normally found in wirewound resistors. Some film resistors are capable of power ratings to 600W. Other small, compact resistors that offer a high power rating in an industry-established (SOIC) footprint are also advantageous, as they do not require the unique landing pad arrangement that some high power resistors require.



Precision current sensing and current limiting

In highly reliable medical equipment, precision is of the utmost importance due to the nature of the application. Whether the component is designed for use in portable imaging or diagnostic equipment, or instrumentation within the hospital, specifications are critical for precision current sensing. As such, discrete component manufacturers must utilize resistors that minimize power loss and heat generation while maximizing voltage drop across the resistor to ensure a highly reliable and accurate device. Selecting a resistor with a low resistance value to minimize power loss and temperature rise, while resulting in a voltage drop that is within the circuit’s measurement capability, is the first place to start. In terms of operating in an elevated thermal environment, metal strip surface mount discrete components typically exhibit good thermal stability (temperature coefficient of resistance, or TCR) at single-digit milliohm levels. However, the design of flat thick film and metal strip current sense resistors is such that they transfer almost all of the power dissipated as heat onto the PC board. Alternative discrete component designs are available that elevate the hot spot of the resistor off the board, minimizing the temperature rise of the PC board and taking advantage of any forced or induced air flow to minimize the component temperature rise.

Discrete resistive components are often used as current limiters for defibrillation and patient monitor connection applications. Defibrillators charge large capacitive loads to prepare for energy transfer to the patient. When charging those capacitors (or if no defibrillation is required, safely discharging the capacitors), a simple and reliable method for controlling the current flow is to place a rugged resistor in series with the capacitor. Additionally, on-board programming typically performs a periodic self-test that changes and discharges the system, requiring load resistors to perform current limiting and dummy load duties. Cable assemblies dedicated to pediatric patients use series resistors to reduce the energy delivered to the patient.



TT electronics' OARS Series resistors feature an open-air surface mount form factor for maximum PC board heat dissipation

In-hospital patient monitoring connectors often integrate the cables for several devices into a single connector assembly. These devices must be protected from downstream voltage spikes resulting from a variety of events ranging from static discharge to patient defibrillation. Placing a resistor or collection of resistors in series with the cable will limit the load to be absorbed by sensitive equipment.

Both wirewound and thick film resistors are utilized for current limiting applications. In a short duration surge event, a large amount of energy must be absorbed by the component in a relatively short period of time (usually 50 milliseconds or less). For these events, little benefit is gained from heat transfer to the component substrate or packaging – the entire load must be handled by the conductive portion of the resistor. Wirewound resistors are available with a variety of alloys, diameters, and winding patterns to optimize the pulse handling characteristics of the component. The mass of wire that can be distributed to a component is substantial, thus the largest pulse applications tend to employ wirewound components.

Although in most cases the film mass of a thick film component is less than that of a wirewound component, leading to lower joule ratings than wirewound products, thick film discretes are also suitable for current limiting applications. For high resistance products (above approximately 1K?), thick film resistors will often outperform fine-diameter wirewound products. Plus, surface mount thick film components are generally smaller, lower cost, and more readily available than wirewound resistors. In terms of specific thick film components, both cyclindrical and flat components are suitable, and because the pulse handling capacity of cylindrical surface mount components is often higher than expected, they are being increasingly employed in challenging pulse applications.

Conclusion
Discrete electronic components are paramount to the inherent precision and reliability of medical devices. Whether employed for high voltage, high power, current sensing or current limiting use, thick and thin film passive components are critical to optimizing the performance of equipment both in hospitals and out in the

field.

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