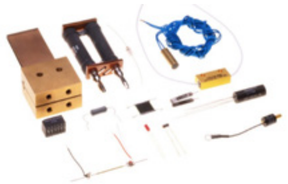
Riedon™ Custom Wirewound Resistors by Bourns for High Pulse Applications

WHITE PAPER



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INTRODUCTION

Circuits are prone to high energy waveforms from both unintended and predetermined events. It is the designer's assignment to make sure that unintended pulse energy from external factors, such as lightning coupled to AC mains, are attenuated while the desired high energy pulses inherent to the system are transferred to the output without damaging necessary components. Switched power supplies, pulse testers, and solar inverters are just a few of the applications that are susceptible to these types of energy surges.

With these requirements, circuits need a capable, high-energy resistor that can also be easily customized by a knowledgeable supplier. To help designers better understand the different capabilities of wirewound resistors, this paper provides how traditional circuit designs typically handle various high energy pulse energy events. It also outlines the main features of wirewound resistor technology that make it ideal to meet the energy requirements of both unintended surge-like waveforms and high energy pulse waveforms found in many circuits. In addition, the paper highlights the multiple characteristics of wirewound resistors that can be customized to meet specific design requirements, illustrating this device's adaptability.

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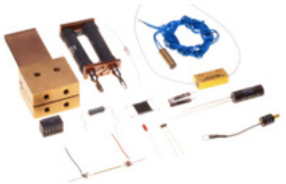

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HIGH PULSE APPLICATIONS

Circuits designed to protect against external high pulse events are effective for surges caused by lightning strikes or harmonic oscillations. Typically, these circuits use some combination of inductive, capacitive, and resistive components to absorb, or snub, the unwanted signal. The intent is to reduce the transient amplitude using inductor characteristics that limit the current rate of change, and also with capacitors, which limit the voltage rate of change.

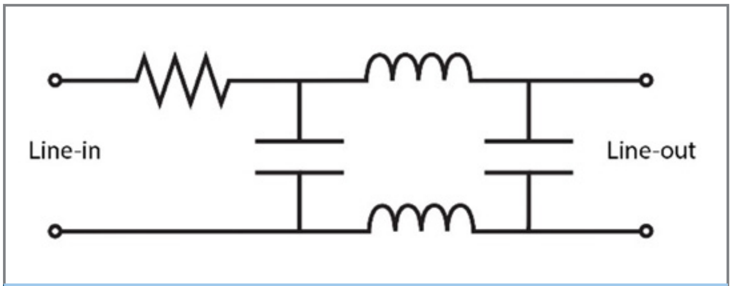

Figure 1. | *Typical EMI filter used in power supplies and lighting circuits*

Figure 1 shows a typical EMI filter design where, in a steady-state condition, there is no voltage drop across the inductors and no current through the capacitors.

When a voltage spike condition occurs at the input (Line-in), the spike will attempt to charge the first capacitor. Initially, the resistor will be subjected to the full voltage of the spike and will induce a current through the resistor following Ohm's law of I=V/R. The input resistor and first capacitor have a time constant of t=R x C. If the duration of the spike is significantly less than the time constant of the input resistor-capacitor time constant, then the impact on the filter's output will be minimal and the protection circuit will have done its job. In this instance, the resistor absorbs and dissipates the energy contained in the spike.

What's important to realize in this solution is that the resistor must be capable of withstanding the transient voltage along with the current it produces. This added voltage and current must be taken into consideration along with normal operating conditions. The resistor must be able to manage the pulse energy, which is voltage x current x time (E = V x I x t). For a non-rectangular pulse waveform, the energy can be determined by integrating the area under the waveform curve. However, to determine the maximum component ratings, a simple calculation of peak voltage (peak current x duration) will provide a useful margin of error.

In applications where transients occur as a result of switching power sources or loads, the circuits most likely already contain inductive or capacitive elements, making it possible to design pulse suppression around those elements using suitable pulse-handling resistors to absorb the surge energy. Some applications, like switched-mode power supplies, can generate repetitive pulses, making it important to choose a resistor technology designed for repetitive energy dissipation. Another form of pulsed energy is battery testers. Battery testers deliberately generate large amounts of energy for a singular pulse of energy. This energy needs to be dissipated in a very short time, which can significantly stress the tester's electrical components. It is recommended that designers incorporate a high pulse-handling resistor that can absorb this energy during the critical millisecond duration discharge period.

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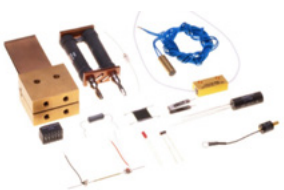

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WIREWOUND RESISTOR BASICS

With the various circuit needs for both external and internal high energy pulse protection capabilities, a resistor that offers high energy dissipation and is customizable is frequently needed. These requirements can be achieved with wirewound resistor technology, which is considered the best customizable solution for applications requiring high energy capabilities.

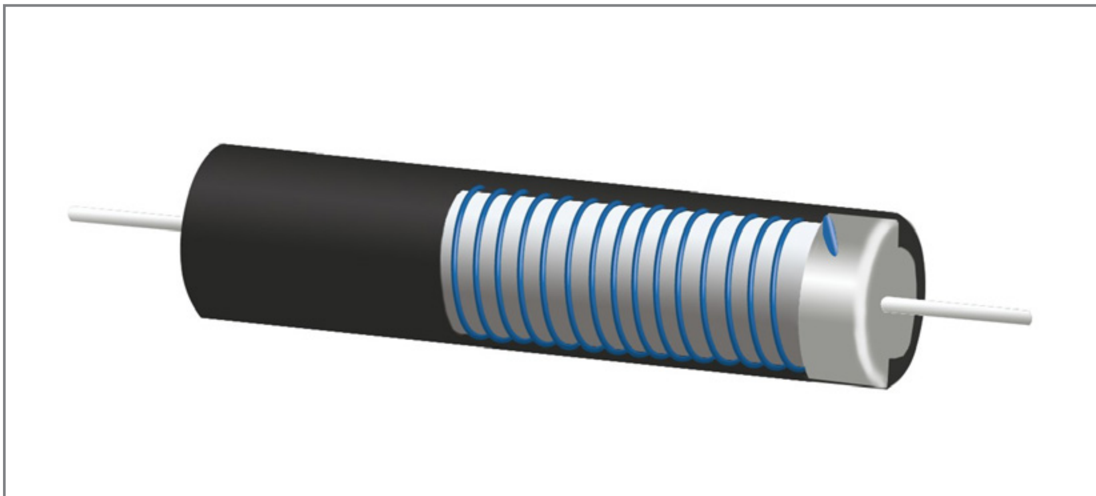

Figure 2. | *The basic structure of a wirewound resistor*

As shown in Figure 2, the fundamental construction of a wirewound resistor uses a resistance wire that is wound around a ceramic core. The resistance wire is terminated by welding it to axial-leaded metal end-caps that are pressed onto the core. This assembly is then encapsulated to protect the device from moisture and physical damage. Wirewound resistors of this design are capable of 2.5 kW dissipation with tolerances of ±0.005 %, making them superior solutions for high energy pulse applications. Suppliers that construct their wirewound resistors with stable materials can deliver ±15 to ±50 ppm precision while also providing -38 dB current noise.

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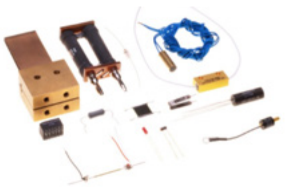

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CUSTOMIZATION OF WIREWOUND RESISTORS

The construction of a wirewound resistor allows for precise control of resistance values, excellent Temperature Coefficient of Resistance (TCR), and the ability to operate at extreme temperatures. All these attributes can be changed based on the size, shape, and type of metal alloys deployed in the resistor design.

The resistance of a wirewound device is determined by the length and cross-sectional area of the wire together with the resistivity of the material the wire is made from. For example, a thin copper wire that is 30 m long may have a resistance of just a few ohms, whereas using a higher resistivity, nickel-chrome alloy wire of similar diameter and length may produce a resistance of several thousand ohms. The material choices together with wire size and length enable the wide range of resistance values that are possible with wirewound resistors. Since the use of longer resistance wire allows them to be trimmed more accurately, tolerances of ±0.01 % can be attained.

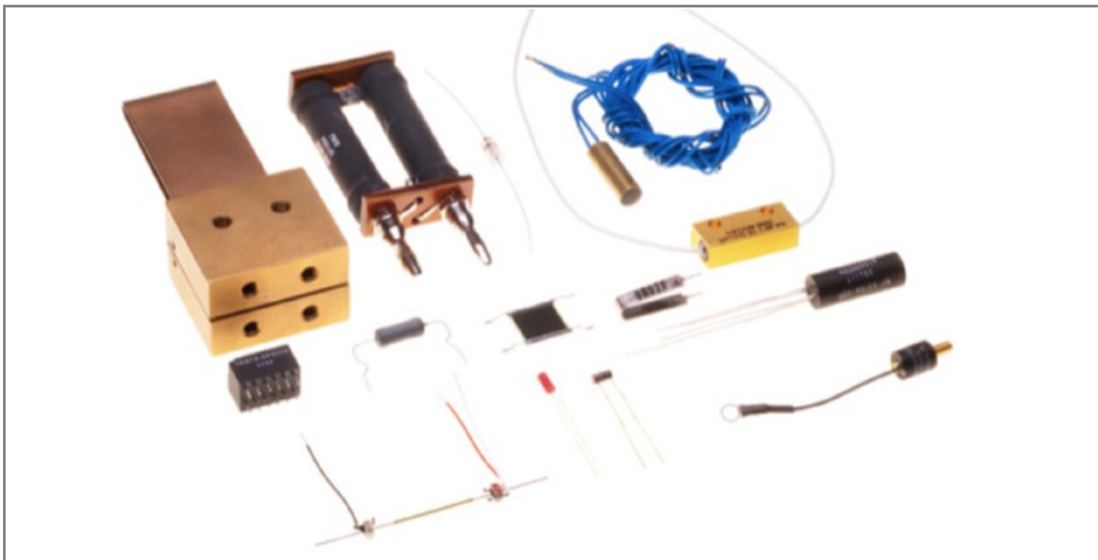

Figure 3. | *Pictured are the various forms of Riedon™ wirewound resistors by Bourns, illustrating the wide variety of customization this technology offers*

Material choice is also a factor that determines other key performance characteristics of wirewound resistors. To achieve a low TCR, the alloy “RO-800”, which is formulated to have a TCR of ±5 to ±10 ppm/°C is a viable solution. The opposite may be true in certain applications, such as temperature sensing and compensation, where higher TCRs are more appropriate. Materials such as copper and nickel have TCRs of ±3900 ppm/°C and ±6700 ppm/°C, respectively.

Operation at extreme temperatures is another reason for choosing wirewound resistors. The Riedon™ UT Series axial resistors by Bourns, for example, will operate from -55 °C to +275 °C with proper derating, and can provide operating temperatures up to +275 °C. As a result, this technology is ideal for use in the aerospace industry and applications such as fire suppression systems.

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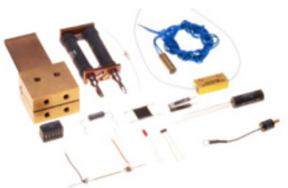

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OPTIMIZING PULSE PERFORMANCE

The construction of wirewound resistors allows for optimization of pulse handling requirements. The need to withstand high voltages can be met using wires that are coated to prevent arcing between adjacent turns. Another method is to use higher resistivity wire so that fewer turns are required. This increases the gap between windings. Even the self-inductance of wirewound resistors can be overcome by using the bifilar winding technique show in Figure 4. By arranging the turns in different directions, the opposing magnetic fields created cancel out each winding's inductance.

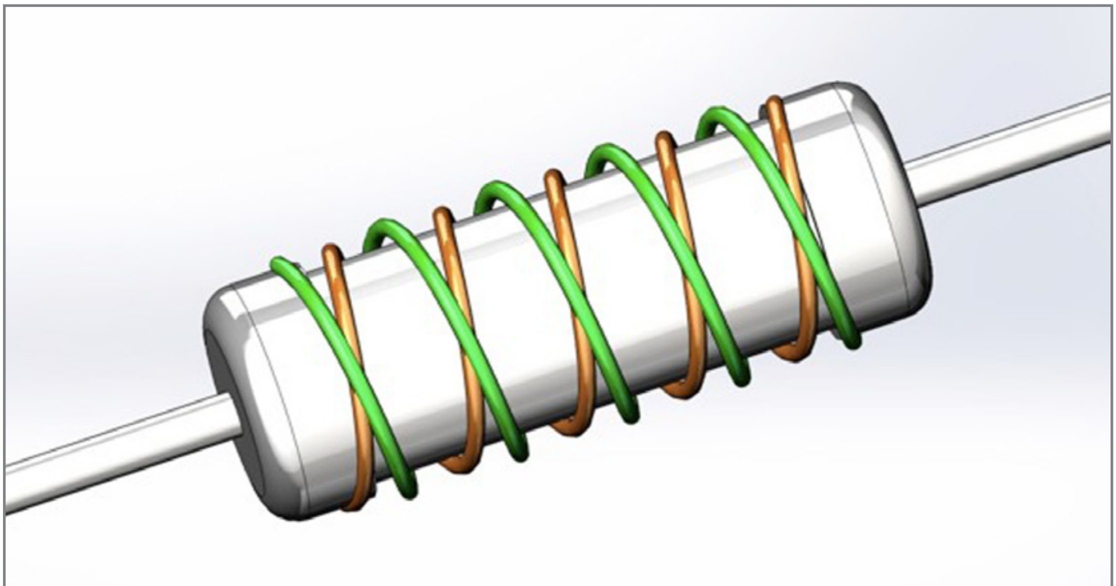
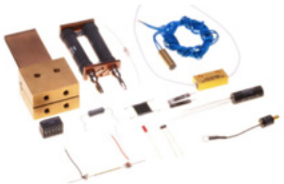


Figure 4. | *Non-inductive winding can produce wirewound resistors with minimal self-inductance*

Resistors in the Model UT Series are well-suited for high pulse applications as they can withstand over 1000 joules. Their values range from 0.02 ohms to 260K ohms, with tolerances down to ±0.01 % and a TCR as low as ±20 ppm/°C.

It is important to note that understanding the pulse handling capabilities required by different applications and relating that to the data sheet specification is not always straightforward. Consideration needs to be given to the pulse's characteristic, distinguishing between a fast high-voltage transient or an inrush current. The pulse shape, whether it is square, triangular, or irregular, and whether it is a repetitive pulse, also must be taken into account in determining the energy handling capability of a resistor.

The industry standard specification for pulses of up to five seconds is that the resistor must be capable of withstanding five times its rated power for that period. So, regardless of package size or resistance value, a 5 W resistor must be able to handle 25 W for 5 seconds, which is 125 joules. For shorter pulses, the joule rating is determined by the mass of the resistance wire, which is then dependent upon resistor value and package type, including its size and whether it's an axial or surface mount component.



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CONCLUSION

This paper has presented the many reasons why wirewound resistors provide the ideal solution for high pulse applications. Their ability to absorb both repetitive and isolated pulsed energy makes them ideal in these designs. Wirewound resistors also deliver the features necessary for applications that need a wide range of resistance values, low temperature coefficients, and long-term stability.

Furthermore, the ease with which wirewound resistors can be customized is a distinct advantage that enables designers to specify the resistive features and capabilities they require beyond standard catalog parts. For high energy pulse applications, wirewound resistors are known to supply best-in-class protection performance that help safeguard components from harmful transients while also helping to ensure the system's energy output is maintained.

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