Introduction to Wirewound Resistors

The resistor is the most common and well-known of the passive electrical components, and there are many resistor technologies currently being used in various commercial, industrial, automotive, and military markets. This white paper will introduce new engineers to wirewound resistor technology and a few of their classifications. Wirewounds have been on the market for a long time and are used extensively in commercial and industrial applications — whether it's to drop voltage, restrict inrush current, or act as heaters and fuses. In electric vehicles (EV) and hybrid electric vehicles (HEV), they are also utilized as precharge and discharge resistors. This paper, however, does not provide a comprehensive overview of the devices; additional references are provided on the last page.

Construction of Wirewound Resistors

The manufacturing process starts with a cylindrical, high alumina ceramic core, onto which stainless steel end caps with pre-welded terminal wires are press fitted. Next, a resistive wire is wound onto the core. This wire is welded at both ends of the end caps, completing the circuit. Finally, a proprietary silicone coating (capable of withstanding high temperatures > 350°C) is applied to the parts in multiple layers. The inner layers protect the wire and enhance the resistor's thermal cycling capabilities, while the outer layers mechanically strengthen the component. A general schematic for a wirewound resistor's construction is shown below in Figure 1.

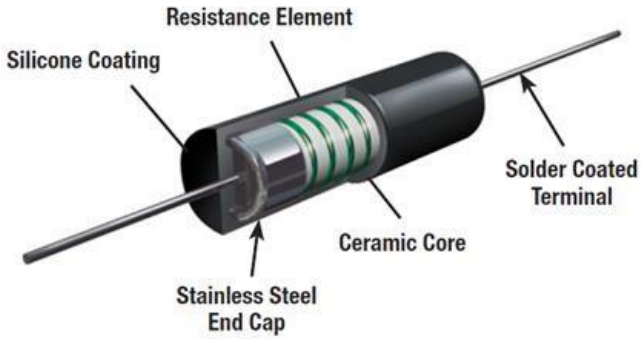

Figure 1. General Schematic of a Vishay Dale Wirewound Resistor

The size of the core varies with the power level. The higher the power, the larger the size of the core and the resistor. The diameter of the resistance also varies with the resistance values. Vishay Dale uses cupron or nichrome resistive wire, depending on the values needed. Vishay Dale can also customize the resistance wire to suit the customer's pulse energy needs.

Classification 1: Commercial, Industrial and Military Wirewound Leaded Resistors

Vishay Dale offers various commercial, industrial, and military wirewound leaded resistors.

Commercial wirewound resistors are typically offered in higher tolerances (5 % and 10 %) and offer high performance for a low cost. These families typically cannot be customized to user requirements (such as better tolerances and additional testing). They are offered with both lead (Pb)-free and tin-lead (Sn-Pb) options.

The **CW**, **ALSR**, and **CA** series are a few examples of Vishay's commercial axial wirewound resistors.

Military wirewound resistors are built according to published military specifications and include multiple periodic inspections, testing, etc. These devices offer the highest reliability, and therefore have the highest cost. As they are built to military standards, these products contain lead (Pb). The products can be customized to the customer's drawing requirements. However, any modification to the standard military component will result in a part that is no longer marked for military requirements.

An example of Vishay's established reliability axial leaded wire wound resistors is the **RWR** series. The RW series is an example of the company's non-established reliability axial leaded wire wound resistor.

Industrial wirewound resistors are built utilizing the same materials as corresponding military products and on the same production equipment. This results in a good compromise between high performance and cost. Additionally, these products can be fully customized to the customer's requirements. They are offered with both lead (Pb)-free and tin-lead (Sn-Pb) options, and available in a non-inductive version.

Examples of Vishay's industrial wirewound resistors include the **G/GN** and **RS/NS** series.

Classification 2: On-Board and Off-Board Wirewound Resistors

One primary classification of wirewound resistors depends on how they are mounted in the customer's application: on-board or off-board.

On-board components are soldered directly onto the PCB and do not need any additional heat sinking. Vishay Dale offers various on-board axial leaded wirewound resistor families in power levels starting from 0.4 W to 15 W.

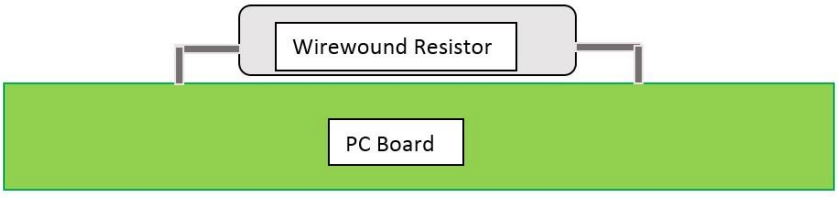

Figure 2. General Schematic of an On-Board Wirewound Resistor

Off -board resistors, by virtue of their construction, can dissipate higher power in a small package but need to be mounted on a heatsink. The necessary heatsink area to extract 100 % power from these units is recommended on their datasheets. These resistors can also be used without heatsinks, and with reduced heatsinks, but the power needs to be derated accordingly. This information is also included on their datasheets.

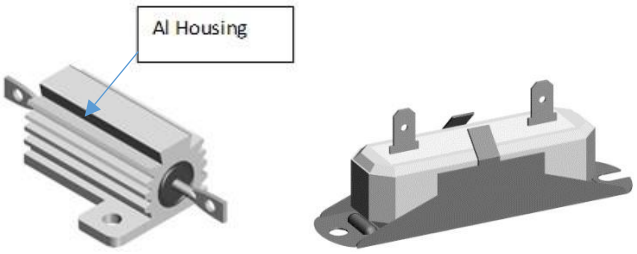

Figure 3. Shows Aluminum-Housed and SPR Off-Board Resistors

Examples of Vishay's off-board resistors include:

- **RH/NH** (up to 250 W) and **SPR2213/2214** (up to 100 W) industrial aluminum-housed resistors
- **RER** (up to 30 W) established reliability aluminum-housed resistors
- **RE** (up to 120 W) non-established reliability aluminum-housed resistors

In addition to the above off-board resistors, Vishay Huntington and Vishay Milwaukee offer tubular wirewound resistors for very high power applications. These tubular resistors need specialized hardware (called mounting brackets) for mounting purposes. The following links will lead the reader to the respective brand pages with more information:

- http://www.vishay.com/company/brands/huntington/
- http://www.vishay.com/milwaukee/

Classification 3: Inductive and Non-Inductive Wirewound Resistors

Wirewound resistors, by virtue of their construction, have self-inductance and are hence inductive. In a noninductive resistor, a second layer of resistance wire is wound in the opposite direction of the first wind. These two windings are separated by a layer of coating material. The second winding cancels the inductance from the first winding, resulting in a very low (typically a few nH or less) net inductance value.
Vishay Dale offers non-inductive versions (in the Aryton-Perry winding pattern) of all its industrial and military resistors. These wirewound products are listed in the datasheets of their inductive counterparts. The resistance value range for the non-inductive versions (when not specified on the datasheet) is half or less than that of the

inductive versions. The schematic below shows inductive and non-inductive wirewound resistors. In most cases, the non-inductive resistors have more wire mass than the inductive resistors, and as a result, have a higher pulse performance capability.

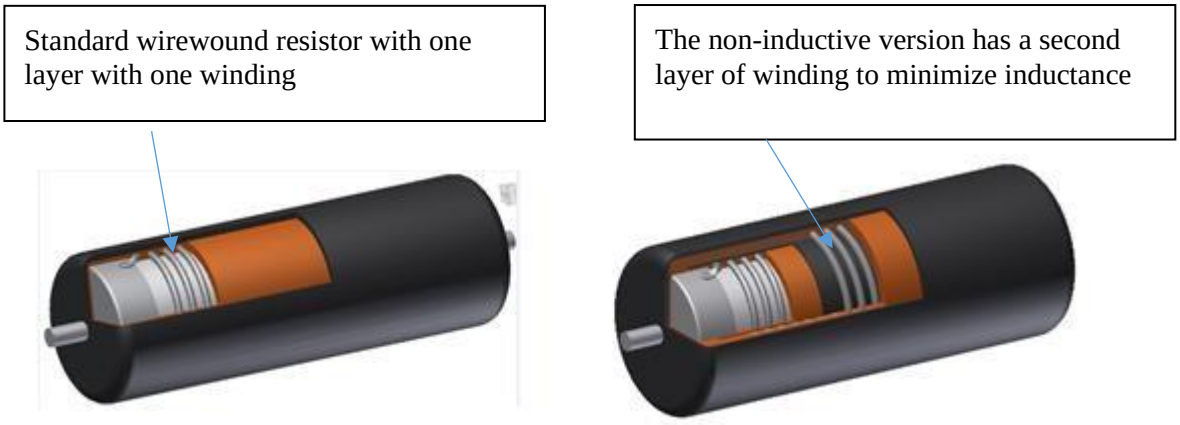

Figure 4. General Schematic of an Inductive and Non-Inductive Axial Leaded Wirewound Resistor

As mentioned above, wirewound resistors, by virtue of their construction, have self-inductance. Vishay Dale offers noise suppressor products that have high self-inductance. These resistors are used in automotive applications to minimize radio frequency interference (RFI) caused by electrical discharges. The products can be fully customized (inductance value, caps, terminals, etc.) to meet a customer's requirements.

NSR 

NSR-HP 

Classification 4: Silicone Coating or Vitreous Coating

Vishay Dale offers a high temperature silicone coating on all its axial leaded wirewound resistors. This black coating, when fully cured, is very hard and offers good mechanical protection. Parts with the silicone coating also meet Mil-Std-202 Method 106 for moisture resistance performance. However, the coating is not moisture impervious. To eliminate any trapped moisture within the unit, it is extremely important to completely dry the parts after any kind of rinsing / cleaning operations (during the board assembly process) and before any conformal coating is applied.

In addition to the high temperature silicone coating, Vishay Huntington and Vishay Milwaukee offer a vitreous enamel coating. The coating is more mechanically robust, offers excellent moisture resistance, and withstands

extremely high temperatures. Both of these options are printed with the appropriate information, as listed on their respective datasheets.

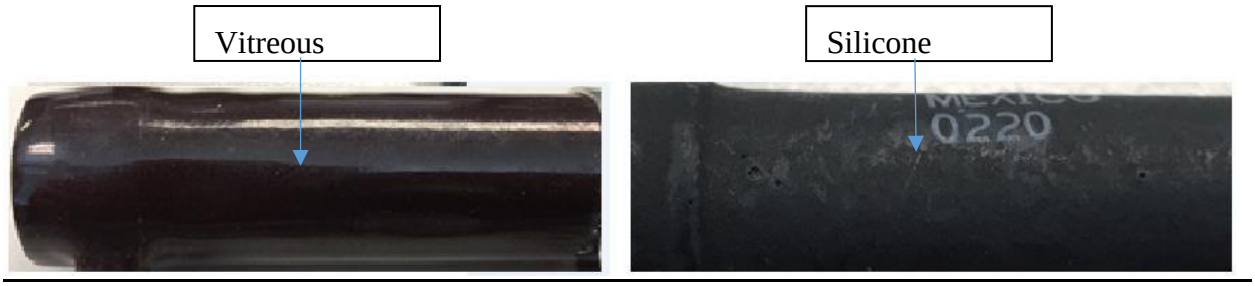

Figure 5. Vitreous and Silicone Coating

Conclusion:

It is commonly assumed that wirewound resistors are “simple,” but many factors need to be considered to select the proper component for reliable performance in a particular design / application. Customers are strongly encouraged to contact Vishay sales / marketing personnel with questions related to Vishay Dale wirewound resistors, or if any assistance is needed for product selection.

References:

1. Resistors 101, Vishay publication: VMN-SG2113-1205
   https://www.vishay.com/docs/49873/49873_sg2113.pdf

2. Military 101, Vishay publication: VMN-SG 2116-1311
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3. Pulse capabilities of Vishay-Dale wirewound resistors, Vishay publication: VMN-PL0396-1604
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4. NSR-Noise Suppressors – Wirewound Products, Vishay Application Note:
   https://www.vishay.com/docs/30255/an0004.pdf

5. Silicone Coated Wirewound Resistors Selection Guide, Vishay publication:
   https://www.vishay.com/docs/49348/industrial-wirewound-resistors-silicone-coated_vmn-sg2013.pdf

6. The heat is on- High Power Surface Mount Resistors, Vishay Application Note:
   https://www.vishay.com/docs/60132/highpowersurfacemountresistors.pdf