Facts at a Glance

From: Vishay Foil Resistors
October, 2013
FACTS #122

Author: Yuval Hernik
Tel: +972-54-3000191
E-mail: Yuval.Hernik@vishaypg.com

When Small Isn't Better in Precision Resistor Applications

The drive towards smaller and smaller devices demands smaller and smaller precision resistors handling greater and greater power densities. Usually this means that surface-mount chip resistors should be used whenever possible. Or does it? SMT technology is not without its trade-offs.

Excess heat and configuration considerations

Smaller sometimes means hotter. Surface-mount chip resistors run hotter than through-hole parts due to their power density. SMT devices dissipate mostly through the PCB, while through-hole devices mostly dissipate to the surrounding air. Surface-mount components thus contribute to a heat buildup in the system that affects all other devices on the board. With this excess heat, it can be expected that the long-term stability of the resistors will be degraded when operating at higher temperatures.

SMT components also raise configuration considerations. Board flex stresses may cause the chip to crack or delaminate from the board when the length vs. width (or "aspect ratio") of the chip gets beyond a reliability-prescribed limit, generally ~2:1. Expanding the width of the chip to stay within the 2:1 aspect ratio is no solution; this does nothing to eliminate the stress and simply widening the chip makes it harder to remove solvents and resins from under the chip after assembly.

Often the best choice, particularly in high-precision applications, is a through-hole resistor that is specifically designed to provide higher resistance values, higher power, tighter tolerances, and better long-term stability while using less board space and allowing easier clean-up of solvents and resins.

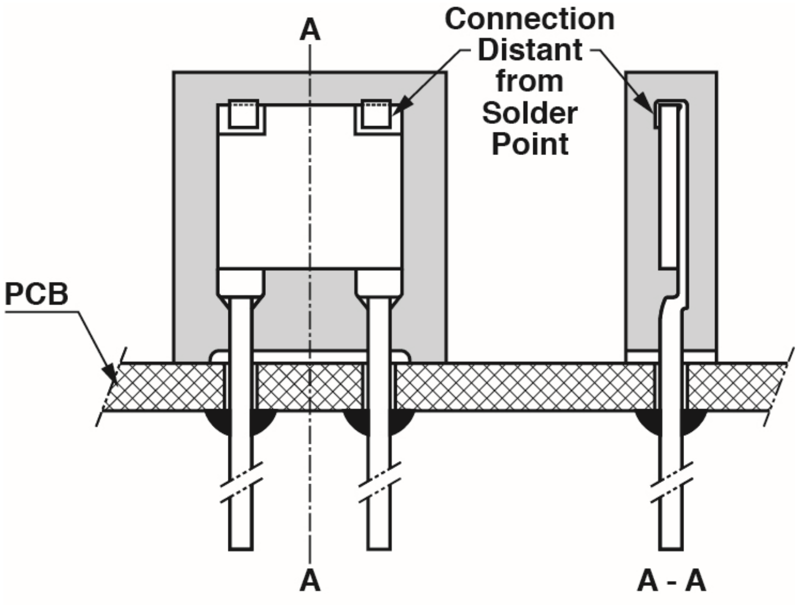


Figure 1: Through-hole components achieve better stability because they are not subjected to thermo-mechanical stresses from the PCB

Vishay Foil Resistors (VFR) brand models, including the S, Z, VHA (hermetic), and VHP100 (hermetic) series, are exactly what such applications require. These precision resistors are configured in molded rectangular blocks or metal hermetic cans, all with through-hole leads extending from the bottom surface. This approach minimizes the required board space and includes stand-offs to allow reliable cleaning underneath

Built-in stress relief

Unlike some through-hole resistors, these VFR devices require no added height for stress-relieving bends in the leads because they feature a built-in stress relief system. Before encapsulation, the precision foil resistor element is encased in a room-temperature vulcanizing rubber that isolates the foil element from stresses on the finished resistor body. The rubber sheath encases the element but does not adhere to it, leaving the element free to slide inside the sheath within the epoxy encapsulation. While the resistor body is mounted with its standoffs tight against the board, any board flexation stresses might impart a stress on the body of the resistor, but this does not reach the element itself because the element is cushioned by its rubber blanket. And, of course, the outer molded shell has much greater resistance to moisture and contaminates than chip resistors.

Encapsulated molded foil resistors have a greater surface area (see Figure 2). This in turn enables

- higher resistor values on the vertical surface
- resistance patterns to be created to enable very tight tolerances down to 0.001%
- pattern designs that reduce inductance, capacitance, and reactance (to a 1 ns rise time)

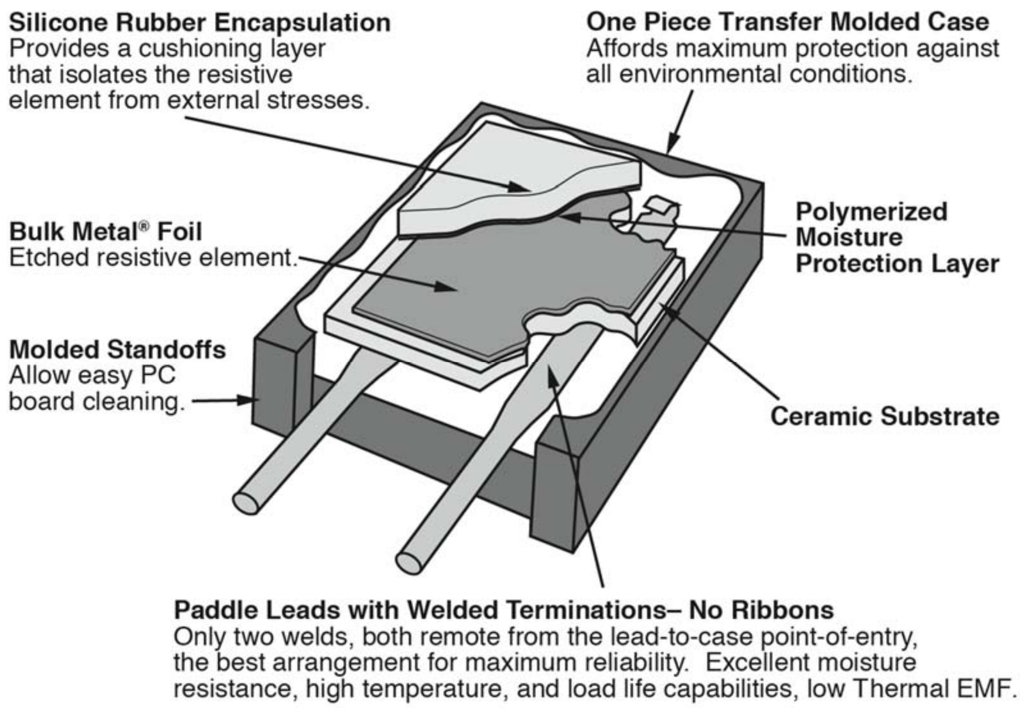


Figure 2: Through-hole precision resistor construction

On some occasions SMT will be the only option for a design. In such cases, we highly recommend the use of a surface-mount device with flexible terminations, such as the VFR SMRXD Series. (See Figure 3)

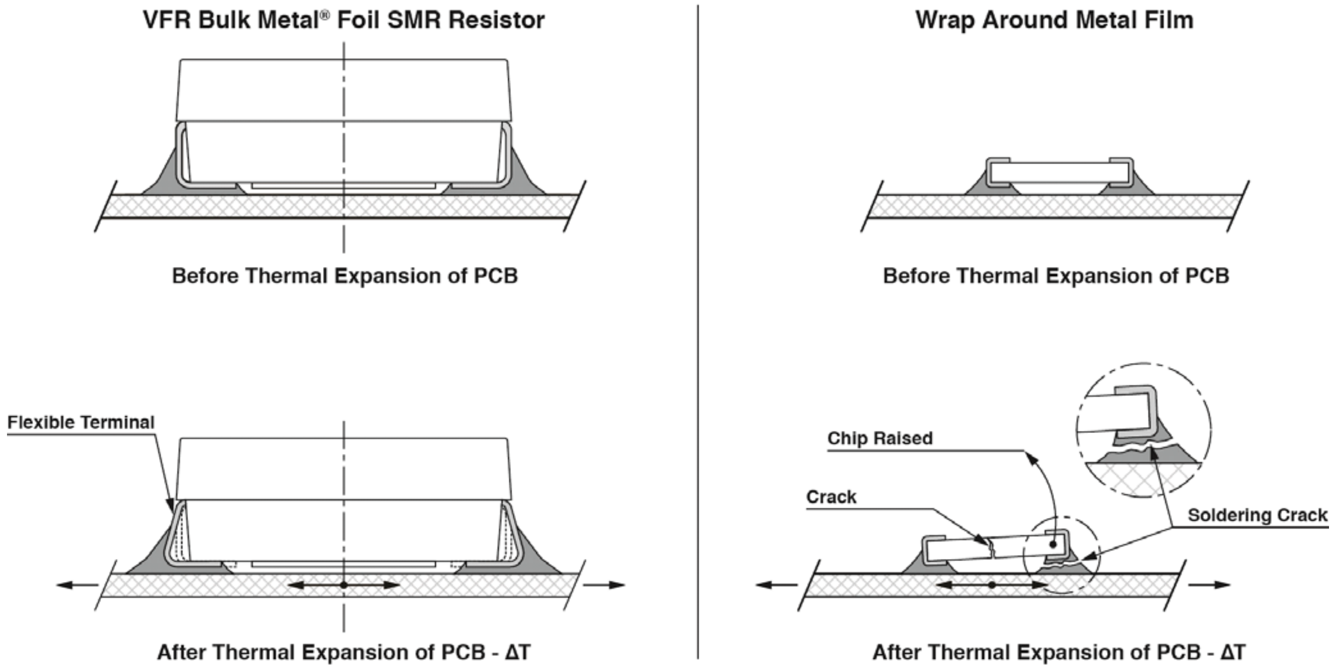
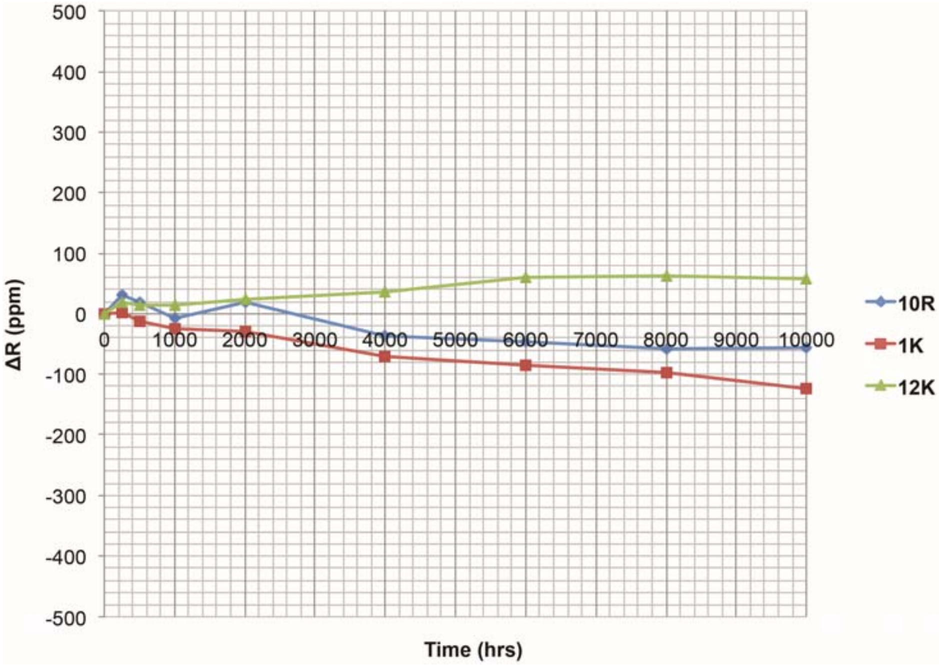


Figure 3: Surface-mount precision resistor with flexible terminations after thermal expansion or bending of the PCB.

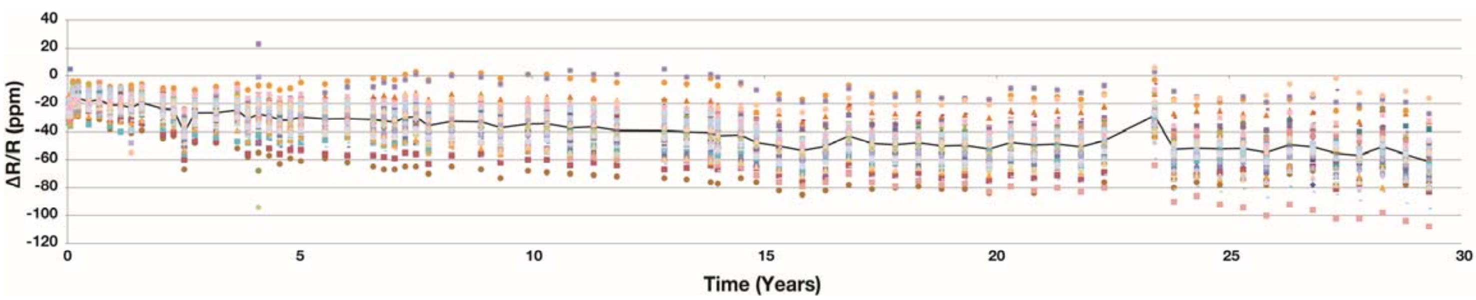
Too close for comfort

VFR foil resistor technology is the most precise resistor technology available, with its very low TCR, low thermal EMF, non-measurable noise, and unparalleled long-term stability. As much as we strive for device miniaturization, a tightly packed board isn't always a good idea in precision applications. For example, if the plane of the mounted resistive element is parallel to the PCB, microphonic noise can result. This parasitic effect is triggered by vibrational movement, which induces spurious signals in much the same way as the diaphragm in a speaker system. A horizontally oriented resistor element can produce microphonic noise as a result of physical vibration or even as the effect of strong sonic waves. Microphonic noise is also a reason to avoid using SMT for feedback components. The better choice is vertically oriented through-hole parts with the legs configured to absorb the deflection from the surface of the PCB.

Figure 4: Example of load life stability comparison data between foil surface-mount resistor size 0805 after 10 000 h to foil resistor with through-hole style after 29 years.



VSMP0805 (10 000 h) – Surface-Mount



Through-hole style (29 years)

In fact, many combinations of precision device specifications are available only in through-hole parts, as the table below shows. Beyond their uses in production designs, through-hole components are especially useful when prototyping. Free-of-charge samples of most of the resistors mentioned above can be shipped to your desk within one week. But the moral of the story is that while SMT may sometimes seem more modern, precision never goes out of style.

Type—Through-Hole Style	Resistance Value	Absolute Tolerance	Match Tolerance	Absolute TCR	TCR Tracking
S102	Voltage Divider Matched Pair: 500 Ω/ 500 Ω	0.01%	0.01%	2 ppm/°C	1 ppm/°C
Z201	Voltage Divider Matched Pair: 100 Ω/1 kΩ	0.01%	0.005%	0.8 ppm/°C	0.5 ppm/°C
VHP101 (Hermetically Sealed)	1k75	0.005%	N/A	5 ppm—TCR window (20°C to 30°C)	N/A
VHD200Z	Hermetically Sealed Voltage Divider: 2 kΩ/14 kΩ	0.005%	0.005%	0.8 ppm/°C	0.3 ppm/°C
300144Z	Voltage Divider: 500 Ω/2 kΩ	0.01%	0.005%	2 ppm/°C	0.75 ppm/°C
VFD244Z	Voltage Divider Matched Pair: 2 kΩ/17 kΩ	0.005%	0.002%	0.8 ppm/°C	0.5 ppm/°C
New Generation Current Sense—10A	0R1	1%	N/A	1.5 ppm/°C (20°C to 35°C)	N/A
New Generation Current Sense	Voltage Divider Matched pair: 0R2/0R2	0.1%	0.1%	1 ppm/°C	0.5 ppm/°C (20°C to 50°C)
VAR (Audio)	100 kΩ	0.01%	N/A	0.5 ppm/°C	N/A

Table 1: Examples of specific products and capabilities. Each type is available with a wide variety of ranges and performance specifications.

Further information about Vishay Foil Resistors products is available at:

www.vishayfoilresistors.com

Follow Vishay Foil Resistors at: **http://twitter.com/FoilResistor**

To learn more, please contact us at: **Foil@vishaypg.com**