THE DLA-APPROVED SERIES OF PRECISION POWER RESISTORS

By // Aalyia Shaukat

Low-ohmic precision resistors are a cornerstone component to current and power sensing, often used in battery-powered systems and motor drives. The resistors themselves must be optimized for precision to best measure current. However, they must also be optimized in accordance with the specific requirements of their end application.

Aerospace and defense-related standards and regulations for these components present unique challenges to their design and development. With these challenges of implementing current-sense resistors in aerospace applications, though, come opportunities for manufacturers of thermal alloys as well as power and precision resistors to innovate and solve.

Current-sense resistor considerations

Resistors can technically be used to measure current and, therefore, power by means of Ohm's law. However, these current-sensing components will inevitably heat up as current passes through them. Supporting low resistance values will help with this self-heating issue, but there are far more considerations for these specialized components over standard, run-of-the-mill resistors.

For one, precision is paramount. This means that the resistance value should not deviate significantly from the specified value over temperature and aging. The materials used in the low-ohmic precision resistors and the integrity of their overall construction should be optimized. Employing alloys with a low temperature coefficient of resistance (TCR) ensures that the natural expansion of their internal materials in the presence of heat is minimal, thereby maintaining a consistent resistance value and a high level of long-term stability.

Isabellenhütte is no stranger to developing high-reliability current-sense resistors for mission-critical applications, including those in the industrial, medical, automotive, and aerospace sectors.

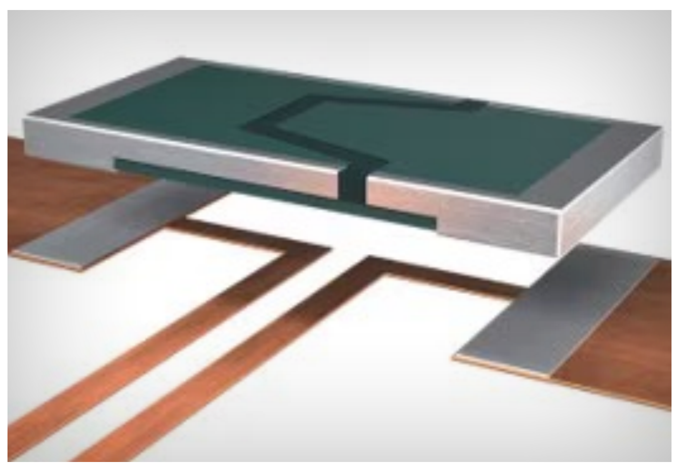

Figure 1 Low-ohmic chip shunt resistors offer a platform for current sensing when integrated in a circuit. Source: Isabellenhütte

Aerospace and defense considerations

The demands of the aerospace environment diverge significantly from those of terrestrial equipment. The radiation environment is entirely different because climbing to higher altitudes out of the Earth's atmosphere leaves equipment susceptible to a spectrum of radiation, ranging from ultraviolet (UV) to electromagnetic (EM) radiation. The various orbits in which spacecraft are deployed also present their own unique radiation environments. The level of exposure will also vary based on mission life, time of deployment (for example, during a solar maximum or minimum), and the subsystems that must remain functional at different points during the mission.

For these reasons, and many others, designing space electronics or any non-terrestrial aircraft was often viewed as a niche field, relegated to state agencies and large corporations. NewSpace has redefined this trend, with smaller companies and research organizations launching small satellites with a limited mission life or developing drone technologies, which have more relaxed requirements for aerospace equipment in the quest for shorter lead times and cost-effectiveness. It is more common for radiation-tolerant components to be leveraged instead of their fully radiation-hardened counterparts.

Figure 2 The 0.005 Ω to 1 Ω VMS precision and power resistor with a tin-lead contact plating for applicability in aerospace and defense. Source: Isabellenhütte

The DLA and ESCC

The Defense and Logistics Agency (DLA) has long been the de facto organization in the United States for procuring space-grade components. Electronics components of specific manufacturers that have been audited by the DLA can then appear on their Qualified Products List (QPL), ensuring that the products have been pre-tested and meet all the qualification parameters required.

On the European side, the European Space Agency (ESA) has a subcommittee dedicated to qualifying space components known as European Space Components Coordination (ESCC). The agencies within ESCC will coordinate between space component vendors, procurement professionals, and international space agencies to formalize the standards for electrical, electronic and electro-mechanical (EEE) space components.

The VMx series of low-ohmic precision and power resistors has recently been DLA-approved and has already been deployed in an array of aerospace applications from spacecraft to commercial and military aircraft. Similarly, the SMx series is certified by the ESCC program. Both of these precision resistors feature tin-leaded terminals and undergo extensive additional testing, accompanied by qualifications that are reciprocal between space agencies, which enable customers to streamline their design and certification processes. As shown in Table 1, the VMx and SMx series are available in four footprints, with a continuous power rating of up to 3 W and a resistance as low as 3.3 mΩ.

Series	Wattage	Package size	Resistance range (mΩ)	TCR (ppm/K)	Specification
SMP-PW	1	2010	5 to 1K	50 to 100	ESCC 4001/027
SMS-PW	2	2512	5 to 1K	50 to 100	ESCC 4001/027
SMT-PW	3	2817	4 to 4.7K	50 to 100	ESCC 4001/027
SMV-PW	3	4723	3.3 to 1K	30 to 50	ESCC 4001/028
VMI-M	0.5	0805	10 to 50	30 to 50	DLA 25003
VMK-M	0.75	1206	10 to 470	20	DLA 25004
VMP-M	1.5	2010	5 to 1K	20	DLA 25005
VMS-M	2	2512	5 to 1K	20	DLA 25006

Table 1 Specification of low-ohmic precision and power resistors approved for aerospace and military use. Source: Isabellenhütte

Space-specific failure mode for current sense resistors

Tin whiskering poses a serious problem in space applications, where pure tin parts and components made from tin alloys, such as those containing cadmium and zinc, will grow whisker-like tin tendrils. According to the DLA, tin whiskers tend to grow from alloys with a tin content of greater than 97% and can occur anytime from one day to years after manufacture, where conformal coatings will not prevent their formation.

While this phenomenon is not exclusive to space, it tends to form more rapidly at higher altitudes. The vacuum of space presents a potentially catastrophic failure: the current required to open a short circuit caused by a tin whisker fuse is on the order of a few amps, but the vaporized tin can initiate a plasma that can conduct hundreds of amps, causing metal vapor arcs. In current-sense applications, a tin whisker is another potentially lossy electrical path that could lead to inaccurate measurements or no measurement at all.

According to NASA, "there are reports of at least three tin-whisker-induced short circuits that resulted in complete failure of on-orbit commercial satellites." Unfortunately, the role this conductor plays in modern electronics cannot be understated. Tin is a vital material for manufacturing solder, connectors, and plating all types of electronics equipment, so feasible solutions to this problem are necessary.

The DLA states, "alloys of 3% lead, by mass, have shown to inhibit the growth of tin whiskers." For low-ohmic precision resistors, using a tin-lead (SnPb) plating on the contacts can effectively mitigate the formation of tin whiskers and maintain the reliability of the component in space applications.

Figure 3 Tin whiskers tend to grow more rapidly in aircraft and spacecraft that operate at higher altitudes.
Source: Isabellenhütte

Applications

The applications for precision current-sense resistors are numerous in the aerospace industry. A battery management system (BMS) utilizes low-ohmic precision resistors to monitor battery current accurately. In motor drives, drive inverters will convert the main DC rail to multi-phase AC to drive the motor. Precision resistors are necessary to measure the current directly in each phase.

Aerospace and defense equipment utilizes both batteries and motors extensively, calling for high reliability current-sense solutions. Satellites can typically come equipped with tens to hundreds of actuators and will invariably have battery packs to harness the abundant solar energy available in space. Manned drones, including eVTOLs, is a prolific technology that demands compact and lightweight solutions to maximize size, weight and power (SWaP).

The Isabellenhütte advantage

Space-grade components used in electronic equipment come with their own specific environmental and regulatory considerations. Manufacturers that undergo the relevant audits and approvals can be relied upon to function in aerospace applications. The VMx and SMx series of precision and power resistors offers a good long-term stability in aerospace use cases due to its low TCR and SnPb-plated contacts for higher reliability in aerospace and defense applications. To learn more about the VMx series of low-ohmic precision and power resistors, contact the experts at Isabellenhütte.