New Alternatives to Costly Tantalum Nitride Resistors

Corrosion is generally a bad thing. Moisture and metal are simply not a good combination. Whether it is on the terminals of your car battery or on a precision thin film resistor in a critical portion of your circuit, it spells trouble. For your car battery the answer can be a simple as regular maintenance and a wire brush, but for thin film Nichrome resistors until recently there have been few choices. The only proven solution was to replace the Nichrome resistors with thin film resistors with Tantalum Nitride elements. The self passivating property of Tantalum Nitride elements when exposed to moisture made them necessary for applications where prolonged exposure to moisture is likely such as automotive or industrial electronics. However, the cost of these resistors limited their use to only those critical circuits where they were absolutely necessary. Recently new materials and processing techniques have changed the thin film resistor landscape, and allowed certain Nichrome resistor types back in as a more cost effective alternative. But before discussing this new Nichrome solution let's define the problem in detail.

It is possible that any Nichrome resistor element to experience corrosion in a humid atmosphere. However, there are certain conditions that act as catalysts and greatly increase the chance for excessive resistance shift or even open failure. The presence of electrical potential is definitely a catalyst, however it is not the full story. High resistance values are appear to be more susceptible, which is logical since they are more likely to be operated at or near their maximum voltage and not at maximum power. A resistor running at rated power usually generates enough heat itself that any moisture finding its way onto the surface of the part would quickly evaporate. But we can certainly apply this same logic to any resistance value and say that if the part is running at around 10% to 20% rated power it is will have a higher risk factor. But even with these factors present, the only failures due to Nichrome resistor corrosion at the customer or the manufacturer level also involved a flaw, misalignment, or pinhole in the outer protective coating. The manufacture of these precision resistor types, while not at the extreme speeds that commercial thick film chips, are still done in such a way that a rare imperfection as mentioned above is possible. If the above conditions were present for a resistor with this type of passivation flaw we would then have the recipe for a potential (electrical) disaster.

One might suggest then that a solution would be to slow down the passivation processes to the point where no misalignments or pinholes are possible. To a degree some manufacturers do this. But in the real world of today's manufacturing, to guarantee no passivation miscues would be impractical and the manufacturing costs for this Nichrome part would increase to essentially the same in cost as the Tantalum Nitride equivalents that the design engineer is trying to replace. A better solution is to introduce materials that are more glasslike in nature, both as an addition to the Nichrome resistive element itself, and as a secondary line of defense against moisture under the final passivation coating. The addition of small amounts of this silicon-based material to the Nichrome element itself reduces its susceptibility to corrosion. As long as the amounts are kept to a minimum, the excellent electrical and stability properties that a Nichrome resistive element provides are unchanged. Additionally, the use of a silicon based material as an initial protective layer against moisture under the final passivation layer, makes the chance of a pinhole through both layers so remote that it is essentially irrelevant. Both of these additions increase cost only in small increments. Another property that can help minimize the effects of moisture on this type of part is substrate smoothness. A smoother surface will have fewer valleys where the condensation can collect or pool up. Again, if one of these valleys were to line up with a passivation flaw or hole, we increase our chance for a problem. All of these techniques are currently easily incorporated into current manufacturing and lead to a product shows resistance shifts over humidity testing that are equal to or even less than those for a Tantalum Nitride element. The typical humidity test parameters used in the industry are done at 85 degrees C, 85% or greater relative humidity, 10% rated power, and at least 1000 hours in length.

Clearly all market segments have price pressure. Power supplies depending on the end application are no different. Power supplies would use precision resistors at or near rated power more often than many market segments. But there are certainly still many occurrences of precision resistors used in voltage division, or to set gain or other type of feedback where the need for a reliable cost effective precision resistor is a must.

One example would be automotive power circuits. Automotive power design engineers must take into account all reasonable weather conditions and environmental effects. Of all the challenges that this engineer faces, resistor cost and moisture sensitivity would likely not be the first issues considered. Now with this new type of technology, they don't have to be.

Power circuitry for the medical industry would be assumed to be less concerned about potential moisture problems. However, by their nature, they are more intolerant of any potential electrical, mechanical, or environmental problem. Medical devices typically have no margin for error and we are all thankful for that at the patient level. However, there is a growing market trend to make these medical instruments and apparatus smaller and portable so that it can be included onboard ambulances. Now the reliability of these precision resistors with respect to all environmental conditions becomes paramount. One would certainly hope, for example, that the heart monitor on an ambulance wouldn't fail simply because it was the rainy time of year in that location.

Instrumentation is another obvious application where there is very little if any room for environmental variance, especially if this instrumentation happens to be aboard an airplane or helicopter for example. Instrumentation aboard boats and other marine vehicles would also follow in this category. This would include both the circuitry used for the control systems but also gauges that measure and report vehicle dynamics to the operator. For aerospace those dynamics could include speed, altitude, pitch, banking, fuel, landing gear position, and radar. For nautical vessels the instrumentation applications may includes such things as speed, weather conditions, depth finder, fuel, trim to name a few. Both of these segments may also use instrumentation for direction and or GPS positioning.

These same mobile vehicles are examples of one (large scale) type of portable electronic entity. Anything with electronics that is not operated by plugging it into a permanent power outlet qualifies for this. For any device fitting these criteria whether it is as large as a fishing boat or as small as a PDA, some of the power supply concerns are largely similar. While the space constraints for the automotive design engineer for example, aren't remotely the same as that for the PDA, both will be required to provide predictable, reliable power for extended periods of time, regardless of geographic location. In that sense they may both be forced into a requirement for a precision resistor that ignores Mother Nature.

The communications industry of today is being pushed to faster and more efficient levels than previously though possible. If the equipment for this voice and data communication is in the bowels of an office building, then there will obviously be fewer concerns about environmental conditions. However, if this equipment is at the base of a remote communications in the middle of a cornfield in Iowa, the potential for weather related issues certainly exists. This communications hub could be a microwave or fiber optic link, but in either case this high-speed communications equipment would definitely need peace of mind that a precision moisture tolerant resistor would provide. And given the increased speeds and downsizing, cost is also becoming increasingly important to this market segment.

Industrial power and controls are also another application where operating conditions can be very unpredictable. Elevator and escalator controls are typically inside a controlled atmosphere such as shopping malls, hotels, or office buildings. But they also may be exposed to the elements at places such as parking lots; amusement parks would certainly have a use for an inexpensive precision resistor such as this. Other types of industrial power or controls such as boiler controls, machinery such as ovens, fans and ventilation, and motors of many different types must consider both the allowable price point as well as the long-term reliability of their design.

Finally, in this age of downsized and minimized engineering departments, the list of companies with what they would consider adequate engineering resources is dwindling. For those companies who don't have the technical horsepower to determine the long term reliability of their design, this new precision product is the perfect solution. It provides assurance that no matter what the design will be subjected to environmentally, moisture corrosion will not be an issue, period. And it accomplishes this for only a minimal cost increase as opposed to a Tantalum Nitride solution, that typically being 40% to 70% higher in cost would require the design engineer to make absolutely certain that the application needed such a part before designing it in.