National Aeronautics and Space Administration

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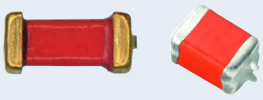
Preventing Incorrect Installation of Polarized Capacitors

Even though NASA's Lessons Learned Information System has an entry on the reverse installation of polarized capacitors, this error keeps reoccurring and is a "lesson not learned." The purpose of this bulletin is to discuss some of the reasons this keeps happening as well as offer best practices to prevent this error in the future.

Examples of polarity marking methods for tantalum capacitors.



- CWR09 & CWR11 capacitors identify polarity by a beveled edge in the case and/or a polarity bar marked on the case ("+" or a stripe adjacent to the anode termination).
- CWR06 capacitors typically identify polarity by a small projection "nub" in the center of the anode termination.
- Exceptions or variations to these conventions may exist.

Conventional schematic capture symbols for capacitors.

Non-polarized Polarized

Polarized capacitors continue to be installed incorrectly

So why does reverse installation continue to happen even though we've had hard lessons in the past? Probably the most significant reason is that NASA's parts derating policy masks the problem. NASA usually puts a part in an application that has significant margin on its forward operating voltage rating vs. the application forward voltage. When such a derated part is installed in reverse that large margin often results in no immediate indication or failure. This is in stark contrast to commercial terrestrial designs where applications with much smaller margin can result in immediate energetic failure. A second significant factor in all of this is the polarity marking standards in surface mount capacitors aren't "standardized" and are often at odds with one another. Does the black band mean positive or negative? Depending on the marking convention, it could be either.

One way a reverse installation error can be introduced as the design evolves is if a part, such as a capacitor, is changed from non-polarized to polarized without a proper update of the schematic and assembly drawings. In a recent occurrence, the failure of the power supply in a ground hardware simulator was the result of an abnormal voltage caused by leakage in two polarized capacitors installed in reverse polarity. Similar capacitors in the flight units on the ISS are also installed in reverse polarity but have not yet resulted in failure.

The capacitor components, which are polarized tantalum devices, were erroneously specified on the schematic with a generic, non-polarized capacitor symbol. These capacitors, originally 0.1 microfarad (µF), were later changed to 10 µF, which necessitated a change from a non-polarized to a polarized part. The capacitor value was changed in the schematic and in the parts list without changing the part symbol. Accordingly, the translation from schematic to assembly drawing arbitrarily designated the improper polarity.

In another recent instance (different hardware), an on-orbit failure was experienced due to a reverse polarity solid tantalum capacitor. Possible confusion due to differences in part polarity marking conventions may have contributed.

Best Practices for avoiding reverse installation

1. Ensure there is a procedure to review the parts list and verify in the various drawings that the polarized parts are installed or represented with the correct polarity.

2. Account for changes from non-polarized to polarized parts: review and change schematic drawings as required to ensure proper part polarity.

3. Never use non-polarized symbols to represent polarized components in drawings.

4. Recognize that the potential exists for certain components to be changed from non-polarized to polarized during design evolution.

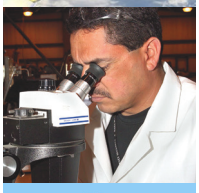
5. Ensure assembly and inspection personnel are cognizant of the allowable variations of polarity markings for polarized capacitors.

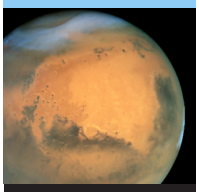
References

NESC-RP-13-00874, Reverse Polarity Capacitor Installation Anomaly on the International Space Station (ISS) Expedite the Processing of Experiments to the Space Station (ExPRESS) Logistics Carrier (ELC) Simulator, Jan. 2015.

NASA Lesson Learned 981 "Reverse Polarity Concerns With Tantalum Capacitors," June 12, 2000.

For information contact the NESC at www.nesc.nasa.gov





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