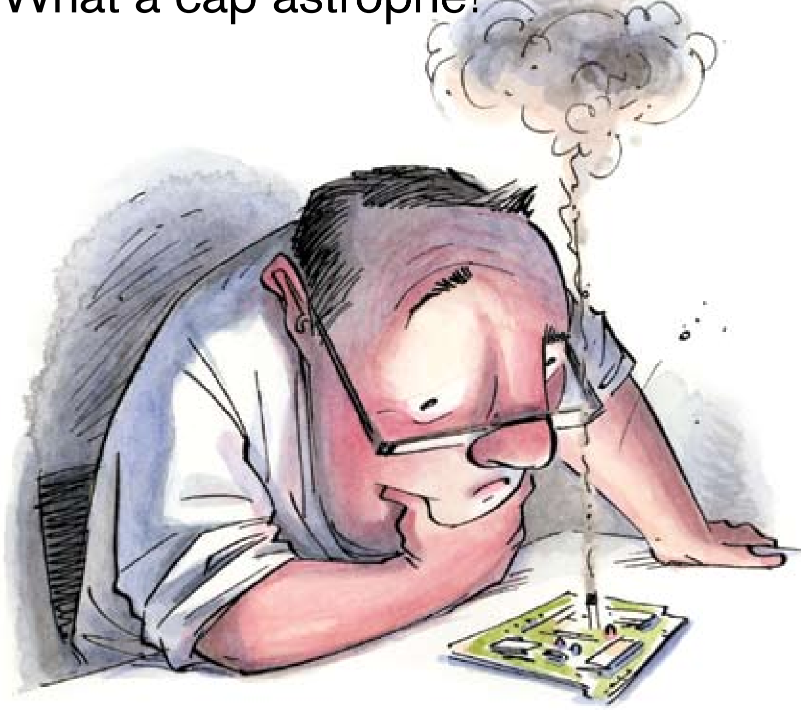
What a cap-astrophe!



I was working at a manufacturer that was experiencing unexplained tantalum-capacitor failure. It wasn't that the capacitors were just failing, but the failure was catastrophic and was rendering PCBs (printed-circuit boards) unfixable. There seemed to be no explanation. We found no misapplication issues for this small, dedicated microcomputer PCB. Worse yet, the supplier blamed us.

The capacitor application was a dc input-power-bypass function. Some analysis indicated that the units had significant ripple current, but it was well within its current rating. The temperature increase was only 13°C over the rated 40°C ambient—far below the 85°C capacitor specification. The operating voltage was 27V—far below the rated voltage of 50V, so there was no issue there.

The first break came when we observed two failures that were not catastrophic; part of the chip capacitors remained intact. I sent one capacitor that had blown off the PCB and one complete PCB to the capacitor vendor for analysis, which in turn sent them offshore to the manufacturing division. The division came back with a plausible diagnosis: A serpentine burn pattern on the pellet clearly indicated excessive voltage.

I did some Internet research on tantalum-capacitor failures and found that the tantalum capacitors' pellets contain minor defects that must be cleared during manufacturing. In this process, the voltage is increased gradually through a resistor to the rated voltage plus a guardband. The series resistor prevents uncontrolled thermal runaway from destroying the pellet. I also learned that soldering PCBs at high temperatures during manufacturing causes stresses that may cause microfractures inside the pellet. These microfractures may in turn lead to failure in low-impedance applications. The microfractures also reduce the device's voltage rating so that failure analysis will indicate classic overvoltage failure.

Lead frames reduce this stress on the pellet to improve reliability. Pellets without lead frames must be soldered directly to the PCB, thus causing mechanical stress; this stress increases substantially with pellet size. Modern construction techniques for large tantalum capacitors use multiple smaller pellets that connect to a common lead frame. We had all these conditions simultaneously—large pellets, no lead frames, a low-impedance voltage source, and overvoltage failure.

A second break came unexpectedly when a service tech noted that the first-generation artwork was reliable. Further checking revealed the first-generation PCB paralleled four 6.8-μF tantalum capacitors, whereas the later ones paralleled two 6.8-μF capacitors and one 15-μF capacitor to save board space. The 15-μF capacitor was the one that was failing.

Now we had the probable cause, but no solution. The supplier remained unresponsive, and we were stuck with the product because it was application-specific. Having no control over the product, how could we possibly solve the problem or take care of all units in the field?

I had the idea to build a capacitor-postprocessing fixture. Its function was to slowly ramp up the voltage applied to the PCB with enough current capacity to power everything on the PCB but with sufficient internal resistance to limit transient capacitor-clearing fault current. Surprisingly, the postprocessing fixture worked! No failures occurred during postprocessing of the units in stock or those in the field. This finding demonstrated that the series element successfully limited clearing-fault current, assuming that 10 to 20% of the units perhaps would fail.

The proof was in the pudding: We went from about one or two failures per month to more than 18 months without a single failure. Works for me! EDN

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