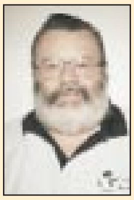

RON MANCINI

Time-tested tricks find hidden failure modes

Many years ago, I designed and tested an interface circuit. I was satisfied that the circuit met spec at specified conditions. Much to my chagrin, field failures occurred shortly after deployment, thus "meeting spec" was inadequate. Before applying power, customer signals on the input interface caused lockup, which required powering down to recover. No spec defined power-down operation, but management killed my raise anyway!

Customers use hardware in every weird configuration imaginable, and the challenge to engineers is to find and solve potential problems before field deployment.

Young design engineers test hardware to verify design specifications. Experienced engineers test failure modes that they have encountered. The best engineers anticipate field usage to try to prevent field failures. Ensuring this prevention requires an engineer/customer interchange. Customers use hardware in every weird configuration imaginable, and the challenge to engineers is to find and solve potential problems before field deployment. Over the years, I have developed some tests that approximate field use.

My favorite such test is the "rusty-file" test. Break the hot 115V-ac wire, connect one end to a rusty file, and drag the other end back and forth across the file. (Beware: This circuit is hot!) Further testing should subject the equipment to every possible 115V-ac connection; the equipment will break if the ac-input design is weak. Next, find the biggest air conditioner in your company, and connect the 115V-ac input from 220V ac to neutral. If your design survives, it is ready for real-world power.

Next, operate a big solenoid from the dc mains to check for dc transient rejection. Run a radar magnet over the equipment to check for susceptibility to external magnetic fields. Increase input voltages to the maximum (not spec) that the equipment can expect in the field (about 36V). Look for input breakdown; you can solve this problem with a series resistor.

A more subtle problem is op-amp inversion. Yes, certain op amps (the OP42 used to be an offender) invert the output when the input voltage exceeds the supply voltage. The amplifier inversion locks up a feedback loop; thus, sometimes, when the offending amplifier is in a motor-control loop, you see some stupendous crashes.

Standards require static testing, but you should subject the hardware to twice the voltage of the static spec. You can live with operational problems at twice the static voltage, but you can't live with component failure. What happens when somebody inadvertently shorts the output to a hard voltage source? Failures resulting from output shorts to 115V ac may be acceptable, but 15V-dc failures are not. Outputs must withstand a short to ground; some gorilla always grounds the output.

Some semiconductors are susceptible to light. Engineers accused the first plastic transistors of leaking until some bright guy discovered that the encapsulating plastic was transparent to UV. Shining a 300W spotlight around the hardware exposes light sensitivity. Experiment with bad media to see if they introduce problems, such as media getting stuck, controller lockup, or head crashes. Finally, try every combination of front-panel switches and knobs. Don't let what a knowledgeable customer would do influence you; rather, assume that some dummy will flip switches without reading the instruction book.

This testing identifies possible field failures. If you know of a test that I missed, send a description to me so I can include it in a future column.

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