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How To Submit A Device For Failure Analysis

By Paul L. Schimel PE, International Rectifier, El Segundo, Calif.

As an FAE, I get this call at least once a week: "We submitted some charred remains for a failure analysis and the results don't tell us anything." Having spent my time in the equipment design ranks, I can understand this statement firsthand. The failure analysis (FA) report usually comes in at the eleventh hour, when morale is at an apogee, management entropy is at a perigee and the need for answers is absolute and well beyond urgent. By this point, the R and D effort is reduced to simply trying different ideas hoping serendipity will kick in and there will be a breakthrough. At about the same time, management is asking "Is it done yet? How about now?" in half-hour long meetings that occur every 15 minutes. I've been there and I have the gray hair to prove it!

It turns out that there is a method to the madness. It is possible to submit a defective device for FA such that the results have the highest probability of having meaning and use. I'd like to take you through the process and hopefully provide you with a useful means of submitting information and interpreting the results.

When Should I Send In FAs?

First, it is imperative to understand where you are in the design process. If you are seeing failures on a waffle-board prototype for a 5-kW power stage that was only intended to last a few hundred hours to try out the topology or evaluate noise signatures, component position, etc, these devices are best left out of the FA lab. You may not have a handle on all of the parasitic attributes, let alone the compensation, magnetics, noise sources, gate drive, etc. You may want to take advantage of the experience of your local FAE and discuss these issues with them in detail. This will be far more helpful than pausing and interrupting the nest of kapton tape, copper foil, and 10-AWG jumper wires to send some parts off to the FA lab.

On the other hand, if you are simply making a minor modification to an existing, mature product that is known good and you are seeing unexplained failures, this is worth sending into the FA lab. Since most semiconductor firms have huge software-based accounting tools that track business, the best way to begin an FA inquiry is with your local FAE. It will come back to that person anyway, and if the local FAE is involved from the start, the odds of you sending in the right information and correctly interpreting the results are that much better.

How Does The FA Lab Work?

In general, the FA lab is a team of engineers that have some wonderful tools for decaping and examining failed devices. They have wet labs to dissolve or etch away the encapsulation to expose the die, compound microscopes and electron microscopes to carefully look for failures, and device test capability to validate which pins may have failed in which state, leakage currents, etc. These are seasoned engineers that understand silicon failure mechanisms. They may not fully understand the commutation of a phase-shifted full bridge, but they will tell you what is happening at the device level.

What Do I Send In?

If you are at the point where you have a significant number of unexplained failures, and you have conferred with your local FAE and agreed that an FA is in order, by all means, send it in. As another option, you may wish to get the sales team involved and send the device in through your point of contact in the sales world. This ensures that the documentation will be in order when it gets there.

You will want to send in as much applicable information as possible. Submit circuit schematics, gerber files, several bad devices, critical waveforms with proper scaling and perhaps an actual PCB. Why so much stuff? Well, if we simply sent in the device in the figure with no other accompanying information, the FA report would come back very quickly. It would read something to the effect of "Electrical Overstress (EOS)—the device was subjected to too much current, too much voltage, or both."

On paper that looks terrible. It looks like the FA lab is on summer vacation and pressed the "easy" button, yielding a vague, machine-generated, codified response. But that's not the case at all. The device was basically reduced to charcoal by some catastrophic event. Whether with unassisted eye or at 1000x magnification on a scanning electron microscope, charcoal looks like charcoal. There aren't any device attributes or features left to discern. They were all vaporized by energies WELL beyond what the device was intended to see. The good folks in the FA lab can't tell from the device alone why it went bad when the damage is this severe.

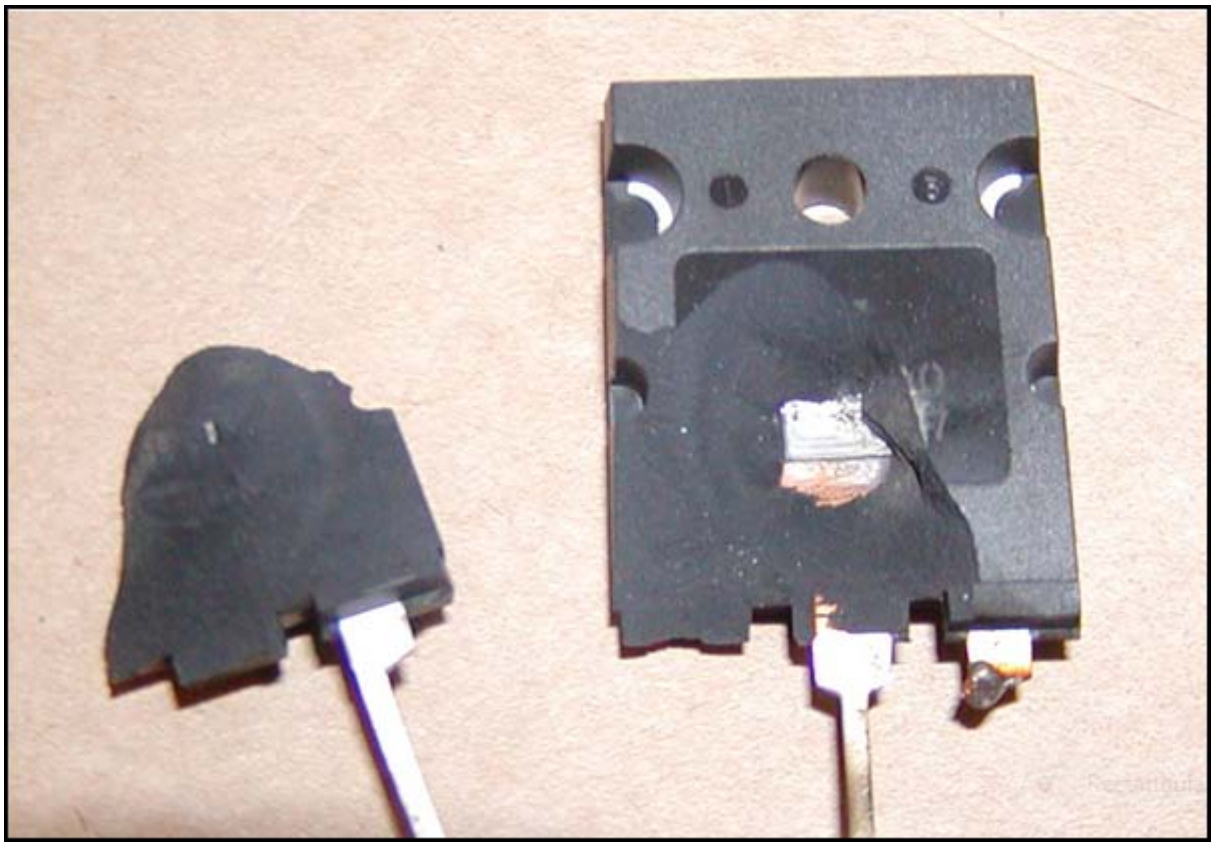

Figure. Sending in a charred device such as this one for failure analysis is not likely to yield useful information, unless you also submit supporting information about the application in which the device failed.

What if we did this a little differently? What if we first called the local FAE and reviewed the failures, schematic, waveforms, layout, temperatures, etc and did a little collective brainstorming on why this device may have failed and how to fix it? If needed, we could then send this same information to the FA lab. The results of this inquiry would read much differently than the scenario above. There would be more conclusive results and suggestions. We might not get the 'root cause' but we would get much more information than simply sending in a charred, ruptured lump of coal with nothing else.

Should you find it necessary to submit an IR device for FA, you can find complete directions at http://www.irf.com/product-info/reliability/rdainst.htm. We refer to these as RDA's, which is our own acronym that means "Request for Device Analysis." Other companies have other acronyms, but the procedures are very similar. The proper forms and procedures are included on the web page along with where to send them.

The Results Of The FA

After a fairly short time, you will receive an RDA number for tracking purposes and shortly thereafter an RDA report, usually via email as a PDF file. This report will have high-resolution pictures, a statement of the failures observed, and any conclusions, suggestions or root causes that could be discerned.

An Aside

In terms of communications, this reminds me of a story from Elbert Hubbard that was transcribed around the turn of the nineteenth century when the Spanish-American war broke out (see the note.) President McKinley wished to secure the help of a "Mr Garcia." He called several messengers into his office and stated his intent as "wanting to get a message to Garcia post haste" and no other information other than a notion that Garcia might be in Cuba somewhere. A soldier by the name of Rowan grabbed up the letter and ran off with the utmost urgency. The president marveled at Rowan and said "that's a great messenger and a great soldier." The others were waiting for pertinent information like Garcia's address or specific whereabouts. A month later Rowan returned having given the letter to somebody in Cuba with the name Garcia. The proper Garcia was never heard from.

Conclusions

Whether submitting a device for FA or enlisting the help of a clandestine defector, the fastest answer isn't always the right one. If we sacrifice a little speed for detail, the results are much more meaningful. Please contact and utilize your local FAE on issues like this as your first point of contact. The FAEs have lots of experience with the devices, the circuits, and the applications.

From there, if it is necessary, fill out the forms at the link mentioned above (or the equivalent forms from another vendor, if the device is not from IR). Include as much relevant information as possible and either send it in to the specified location or hand it off to your local sales support team and they'll send it out. Once you receive the report, you may wish to confer with your local FAE again for design suggestions or tips on how to mitigate and avoid the failure. The engineers that performed the work in the FA lab are also available for discussion in most cases.

Note: The story paraphrased here was Elbert Hubbard's "A message to Garcia" which is dated 1899 as cited in the secondary text that I found it cited in.

About The Author

Paul Schimel was raised on the banks of the mighty Des Plaines River in Stickney, Illinois. By his mother's account, he was apparently abducted by hungry wolves and raised in a doorless barn at an early age. In spite of this claim, he started his engineering career at the age of 5 when he managed to muster enough purchase on a screwdriver to unscrew the cover to the service panel and prod around with a stainless steel kitchen fork. He was revived in an ambulance shortly thereafter.

Two weeks later, he did it again, thus determining that there were two hot sides and one neutral with respect to the steel freezer that he was standing on for the test. (He couldn't discriminate phase with his instrumentation.) From there he went on to investigate just about everything that's been put together.

He was in the positive (making stuff work) by age 11, spending most of his free time working on things in the back alleys of Cicero, Ill. with mentors and childhood buddies. He was working conventional machine tools and welding by 14. Through high school, he fixed most anything that was breakable including yard equipment, two-way radio gear, power tools, TVs, and stereos. He attended the School of Electrical Engineering at the University of Illinois at Urbana Champaign, specializing in power electronics where he earned a BSEE degree and had his hands in every power electronics project that the department was doing including the Hybrid Electric Vehicle and the Sunrayce Solar Powered Car.

After this, he went on to spend eight years in successful design engineering roles in consumer equipment including power supply design for projection and direct view televisions and telecommunications equipment including ring generators, battery rectifiers/eliminators, dc-dc converters, and UPSs—both switch-mode and ferroresonant. His design work encompassed prototypes, PCB layout, magnetics design, electronic design, debug, thermal management, EMC testing, safety agency approvals, mechanical design, and design for mass production.

He then moved on to field applications engineering where he has spent the last six years on power management support and design work for Unitrode/TI, Fairchild and International Rectifier. He has assisted successful designs from mW to MVA and from prototype stages to finished end equipment. He moonlights in broadcasting, antique test equipment restoration, metal working, wood working, TIG welding, loudspeaker

building, and amateur radio (K5NJP). He holds a commercial radio telephone license, a refrigeration license, and he is a licensed PE.

The vast majority of folks that purport themselves as having technical knowledge need two hours to explain what they do. When Mr. Schimel is asked the same question, he says "I make stuff go. Circuits, cars, trains, air conditioners, motors, relationships, plumbing, whatever it is…I make it go!"

Mr Schimel holds several patents on magnetic structures for power electronics and novel circuitry. He has published several hands-on type articles in Power Electronics Technology, EDN, RSES, QST and various other trade publications. He has been a senior field applications engineer at IR for the last three years and he enjoys it immensely.