THE BEST OF BOB PEASE

What's All This Box Stuff, Anyhow?

There are many things I do with cardboard boxes. I stow papers in some of the nice boxes we get our Xerox paper in, and we stow circuits and parts in other boxes. And when people complain that our printers are running too loud, we glue some foam rubber inside a big box and clap it over the printer. That usually makes 13 to 18dB of improvement. The complaints are hushed, along with the printer noise.

But that's not the box I want to talk about today. I want to talk about the big (5 cubic-feet of volume) cardboard box with the Calibration Stickers on it. Most days, this box sits up on top of a tall cabinet, but about once a month we pull it down and put it to work.

About 5 years ago, we introduced a new temperature sensor IC, the LM34. It comes in a small TO-46 hermetic transistor package, and also in TO-92 plastic. And we had the production parts meeting an accuracy spec of +/-1°F, on a decent fraction of production. But how do you test a temperature sensor? And, how do you calibrate the tester? You calibrate a voltage detector by putting the same voltage into two units and making sure that you get the same answer from them. So, with a temp sensor, you have to put two (or more) parts in the same temperature environment and make sure they all give the right answer. In our case, we had several kinds of temp sensors, with a precision platinum RTD (Resistance Temperature Detector) as our primary calibration standard. It cost about $800 15 years ago, and I shudder at today's replacement cost.

So we put a little centrifugal blower to blow air through a piece of corrugated plastic hose and over some of the ICs and also over one or more of our precision calibrated platinum thermometers. We set up two sockets side-by-side so we could put in two units and cross-compare them with quicker response, because devices in the same package will have about the same time-constant.

After a few days, one of the technicians was trying to take some precise data in order to give them to other engineers as "Golden Units." The technician griped that he was getting inconsistent results - and they seemed to be related to when the parts were not shoved all the way down in the socket. Well, the I x R drop could change a little - but this part only drew 55 *microamperes*, and the IR drop could only be 100 nanovolts, whereas we were seeing 300 microvolts - equivalent to 0.03 degrees, for less than an eighth of an inch of movement.

We finally set up some parts with long leads, eschewing the socket, and moved the Device Under Test around in the airstream. We found that there were temperature *gradients* in the air flow coming out of the tube. We tried a longer hose, but that did not make the gradients much better. We thought about using a different kind of hose. But before we could do that, I decided to try a big box for the air to stir around in, to circulate and mix and swirl. Then, after a while, the air poured out onto the DUT's sockets. When we looked for gradients, they were gone, at the level of 0.003°F. So we taped the whole thing together securely. But one day we saw somebody trying to take some cardboard boxes away to make the lab look neater. We realized we had to make sure *our* box would be recognized as valuable. So we made up a big Calibration Sticker and slapped one on all four sides.

Now, we could have had a stirred oil bath, but that's messy and bulky, and the settling time isn't really much faster than moving air. And when you can use a big left-over cardboard box, the price is right, and it's more fun, too.

Could we have perhaps used a somewhat smaller cardboard box? Maybe, but we would have to do a calibration on it, and that wouldn't be worth the effort.

Now, around room temperature, this cardboard box is fine, but at hot and cold temperatures, we normally use a little oven. But everybody knows there are terrible gradients when you run it at 125°C, or -55°, or even at room temp! So we put in a box to surround the DUTs. Small help. Then we added a metal plate (about 1/8-in.-thick aluminum) so we could strap the platinum thermometer (we had a compact one, about 8 in. long) to the same plate that the DUTs were set into. Still, there were errors. The hot air coming from the oven's duct would blow on one comer of the box and heat it worse than another side of the box. And the whole process was quite slow if you kept the box cover closed. If you want to guess how many hours of tests we ran to discover which parts really had what error at what temperature, it was *plenty*.

We finally boiled the testing problem down to two problems - we had to get a quick response when we changed the temperature, as if the box were open, and we had to get minimum gradients when we were near the final temperature. We solved the problems with a box in a box. The outside box had some small slits and baffles, so the oven's air could not blow directly on the inner box. Then we put a lever on the cover so we could open the cover to get fast response for 98% of the temperature change. After that, we turned the lever and closed the cover to get a nice slow settling.

And all it took was a box inside a box, inside the oven. Could we have used cardboard for that? Well, in concept we could have, but it would get pretty flaky after just a few hours at 125°C, so of course we used copper-clad material, which was reasonably stable and easy to work with (the covers did keep warping a little bit, and we had to keep flattening them out). When the boxes were closed, the gradients between the metal plate, the 25 parts mounted in it, and the platinum sensor were really quite acceptable, <0.05°F.

Comments invited! / RAP
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RAP Update: *In 1996, we had to test some more temperature sensors. We had a big oven that was not too bad for gradients - less than 1°C of error. But we wanted errors a little smaller than that. So we inserted copperclad walls to partition off a "box" inside the oven. We put in a small fan to circulate the air inside the box. Then we put in another blower to blow oven air into the box. After the air temperature inside the box was nearly settled out, we turned off the power to the blower and left the fan running. After we replaced the blower (whose plastic blades melted at +150°C) we got excellent results. And, no fancy levers to open a box's cover!*

By the way, I DID do a complete write-up on the analog computer for the Platinum Sensor in the Analog Supplement of Electronic Design, June 27, 1994. If you missed that and you are interested in a copy, send me a SASE ...
