BY DOUG MARSH • CONSULTANT

Watch those power leads!

DANIEL VASCONCELLOS

In the Western Electric IC-manufacturing line of the early '70s, bipolar chips used "beam-lead" technology, which entailed a few back-end-wafer steps to add metallic beams onto each chip. Placing the die and then pressing the beams onto the lead frame would mechanically and electrically connect the die to the package leads. A three-amplifier biquad second-order-filter structure had become popular. To obtain higher order structures, a cascade of biquads would typically suffice.

The filter designers asked for a three-amplifier DIP so that each biquad would need only one DIP; the design would use thin-film resistors and capacitors rather than discrete components. Designers would customize resistors and capacitors for each biquad variant in the total filter. We used our yields and manufacturing costs to determine that, for the next few years, costs would be lower if we used three chips in one DIP. We designed a lead frame that would accept three dice and went to manufacturing.

Filters began rolling off the line. About a year later, someone in our filter-manufacturing plant reported that he was getting field failures for a product that employed several biquads per filter. These products were not simply out of spec; the filter was nonfunctional.

The filter team found that the op amp was the culprit. I asked for a quantity of the biquads along with the filter schematic, and, a few days later, 50 dead biquad modules arrived on my desk. After a detailed investigation of each filter, I observed that most had a defective DIP.

I removed and retested several triple-op-amp DIPs from the board. In every case, the center op amp was defective, and the failure signature suggested that it was disconnected from its positive-power supply. I opened a couple of the packages and tested the leads. The positive power to the lead was intact up to the beam lead, and the bonding appeared sound. Because the beam leads were on the active side of the die, after bonding, the die was face down. Using a knife, I cut the beam leads on three sides of the center die and flipped it over. I saw that the wide V_{DD} metal runner that connected to the output-driver transistor on the chip had blown open close to the beam lead.

I noticed that the V_{DD} and V_{SS} for the center op amp came to opposite sides of the module. So, if you powered up the module backward, V_{DD} would get the negative voltage, and V_{SS} would get the positive voltage, forward-biasing the substrate diode and allowing massive current flow. I took a "good" DIP, reversed the power supplies to the middle op amp, and slowly increased the compliance limit on the power supply. After destructive testing of several parts, I determined that, at 300 mA for 10 seconds, the V_{DD} blew.

But the packages took nine months to fail in the field. When the team leader for the filter design observed testing, he saw that the operator would sometimes accidentally insert a filter backward, and the power-supply current would spike. Upon rotating the module and retesting, the device passed. They sent me some, and I found that the center op amp was good, but the V_{DD} was badly damaged. In-field electromigration slowly ate away what little V_{DD} remained. Because changing the DIP would also require changing its motherboard, we found another option. I tested a few dice and found that I could run the supplies reversed for 24 hours at 250 mA with no visible damage. The filter test center reduced the current compliance limit to 200 mA, and field failures of this type never recurred. EDN

Since 2001, Doug Marsh has done part-time analog-design contract work. Like him, you can share your Tales from the Cube and receive $200. Contact edn.editor@reedbusiness.com.