 BY RON MANCINI

# Where does the energy go?

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In the early 1970s, I worked for Datapoint when it was the leader in distributed data processing. The company manufactured the first desktop computers, and the only reasonable method of program or data entry was a cassette-tape deck. Digital data is much more finicky than music; thus, the tape decks had constant-speed capstan drives, which were more rugged than an audio tape deck.

The capstan drive consisted of a brushless dc motor, four TO5 drive transistors, and commutation circuits. Datapoint put large numbers of computers with tape decks in the field, and the tape-deck-capstan motor drive had always been a source of field problems; the drive transistors failed sporadically. Because the drive problems came and went, the company lived with the problems.

Shortly after I was hired as an analog expert, the manufacturing team experienced many drive-transistor failures during endurance testing. I was directed to fix the tape-deck problems. The first step was to review the capstan-motor-drive history. The drive manufacturer had changed from TO5 transistors to TO92 transistors. After checking the maximum power-dissipation ratings, 500 mW for the TO5 and 350 mW for the TO92, I thought the solution was going to be easy. Replacing failed TO92 transistors with TO5 transistors reduced the failure rate from 60 to 1.5%. This reduction in failure rate is wonderful, but failing 1.5% of the time is garbage in my book.

So, I analyzed the problem. The transistor-power dissipation at the set power-supply voltage was 302 mW. I couldn't understand how a TO5 transistor could fail under those circumstances, so it was back to the lab and the factory floor to determine the real failure cause. The director of manufacturing was screaming because he couldn't ship computers with TO92 transistors. And I refused to change to TO5 transistors because their failure rate was unacceptable. The first day of lab testing revealed no conditions that could be responsible for a 1.5%-transistor-failure rate.

After more testing, I still couldn't find the failure mode. The engineering vice president entered the lab during elevated-temperature testing and questioned my sanity when he saw that the tape deck's ambient temperature was 100°C, the plastic was getting soft, and the tape deck was still running. But at least I knew that heat was not the problem.

The problem's cause had to be in the factory, so back I went. The endurance test was forcing failures, so I reviewed the test specifications: Nothing seemed wrong. I asked the manufacturing guys to help me set up the endurance test. During setup, I monitored tape-deck supply voltage because it was not supposed to change during the test. To my surprise, the tape deck's supply voltage increased 20%. A constant-speed motor is a constant-energy device; thus, the transistors dissipated the extra energy, causing their power dissipation to rise 453 mW in a 40°C environment. The endurance-test specification required the 5V power supply to be set to maximum, and, because the 12V supply was slaving off the 5V supply, the drive-supply voltage increased 20%. Now, it was easy to solve the problem by changing to TIP transistors with a 2W rating, and the transistors were in stock. The decreased failure rate more than offset the increased transistor cost. EDN

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