

Rarely Asked Questions

Strange but true stories from the call logs of Analog Devices

Too Hot or Too Cold May Be Just Right*

Q. Are absolute maximum and minimum temperatures as absolute as voltage or current ratings?

A. No! While integrated circuit manufacturers cannot guarantee devices used outside their temperature ratings, ICs do not suddenly cease to work beyond these limits. But engineers who choose to use ICs at other temperatures must determine for themselves how well they will work, and how consistent their behavior will be.

There are useful general rules. At temperatures around 185 to 200°C (the exact value depends on the process), increased leakage and reduced gain make silicon IC operation unpredictable, and accelerated dopant diffusion limits lifetimes to hundreds, or at best thousands, of hours. Nevertheless, ICs are regularly used at these temperatures in applications, such as drill head instrumentation, where degraded performance and reduced lifetime are acceptable. At slightly higher temperatures, though, operational lifetimes may become too short to be useful.

At very low temperatures, reduced carrier mobility eventually causes devices to stop working, but some circuits will function, albeit out of specification, at temperatures below 50 K.

Basic physics is not the only limiting factor. Design compromises may improve performance in one temperature range at the cost of malfunction outside it — the AD590 temperature sensor, for example, works in liquid nitrogen if it is powered and then cooled, but will not start at 77 K.

More subtle effects result from performance optimization — the commercial grade of a device (0 to 70°C) may have very good accuracy within this temperature range, but dreadful accuracy outside it, while the military grade (–55 to +155°C) of the same device may maintain slightly lower accuracy over the wider



temperature range because of a different trimming algorithm, or even from a slightly different circuit design. The difference between the grades may not only be due to different testing.

Two other issues are the behavior of the package material, which may fail before the silicon, and the effects of thermal shock — the fact that an AD590 will work at 77 K if cooled slowly does not mean that it will survive the high transient thermo-mechanical stresses of suddenly being plunged into liquid nitrogen.

The only way to use a device outside its specified temperature range is to test, test, test, and test again, thus ensuring that you understand how the non-standard temperature affects the behavior of devices from several different batches. Check all your assumptions.¹ The IC manufacturer may or may not be helpful and will probably not give any guarantees for out-of-temperature operation.

* "The Goldilocks Enigma" by Paul Davies ISBN 0547053584

¹ "Check your assumptions. In fact, check your assumptions at the door." "Barrayar" by Lois McMaster Bujold ISBN 2290313157

To learn more about temperature ranges

Go to: <http://rbi.ims.ca/5705-100>



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