Heat Gun and Cold Spray
Your Best Debugging Tools

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If you suspect timing problems of any kind, it's best to test your circuit under extreme operating conditions. All CMOS circuits get slower when hot, and faster when cold; the delay change is about 0.3% per degree centigrade. Testing at both temperature extremes can give you a good indication of your real timing margins.

Don't be too cautious in your temperature testing. Our devices tolerate well over +100°C (which is the boiling point of water, so if you wet your finger before touching the package, it will sizzle) and well under -40°C (where your finger will stick to the package). If you can keep your finger on the package for 10 seconds, then the surface temperature is below +65°C.

Two failure modes

Digital circuits can fail for two very different reasons:

- *The circuit is too slow* — As you know, a lack of circuit speed (excessive delays) limits the performance. It is therefore a common practice to check for proper design operation by increasing the clock frequency until the circuit fails. In large, complex systems it may be impossible or impractical to change the clock frequency.

- *The circuit is too fast* — Excessive circuit speed can also cause failure, but this cannot be tested by varying the clock rate. This type of failure can show up at any clock rate, and is more likely to affect slow designs that have not taken high speed issues, such as potential race conditions and hold times, into consideration.

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Luckily there are easy ways to manipulate the performance of any CMOS device, even after it has been soldered into the system. To verify timing margins, you can:

- Apply cold spray and cool the chip down as much as possible. At -40°C, the circuit delays are about 20% shorter than at room temperature, where they are about 20% shorter than at the worst-case test temperature of +85°C. That means a 36% decrease in delay, or a 56% increase in performance, compared to the worst-case spec. This is equivalent to several speed grade improvements.

- Raise the supply voltage to 10% above nominal. Raising the supply voltage increases performance, roughly proportional with the voltage.

By applying heat (up to +100°C) and lowering the supply voltage (to 10% below nominal) you can create the opposite effect, decreasing performance.

The beauty of the extreme temperature tests is that you can do them in a working system, on individual devices, without any expensive or destructive re-work.

A general test of design stability

Test your circuit both at high temperature and low Vcc, as well as at cold temperature and high Vcc:

- If your design fails at high temperatures and low Vcc, it is due to insufficient performance margins — the chip is too slow — and you should use a faster speed grade to improve your performance margin.

- If your design fails at cold temperatures and high Vcc, it is due to a poor asynchronous design that must be corrected, because the design has race conditions.

You should never release to production a digital design that fails at cold temperature or high Vcc!

Conclusion

If your design passes these hot/cold temperature and high/low Vcc tests, you are assured that it will work, in the field, under the worst operating conditions.