Can’t Touch This: When Electronics Become Too Hot to Hold

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The inner geek in all of us is always craving the newest hot gadget at the store. After all, it’s twice as thin and has four times the performance over last month’s model, right? But the one question no one ever asks is, “How hot is this product – really?” We all take for granted that the product has enough safety margins to never burn the user. If that were always true, there wouldn’t be terms like “toasted skin syndrome” popping up on the evening news with images of permanently disfigured legs or warnings to all us men about infertility from laptop use.

According to WebMd, prolonged exposure to temperatures as little as 109.4oF (43oC) is sufficient to cause physical burns. As anyone who has taken a couple of hours of conference calls from their smartphone can attest, our portable electronics are getting hot! While it may not be hot enough to throw the phone across the room, I’m sure it has left many of us with red sweaty ears, the first signs of a burn.

Unlike a PC with plenty of surface area and active ventilation, cooling a tablet or a smartphone is much more challenging. With the arms race in full force, every company is pushing for faster and thinner tablets and handsets. With a multi-core, gigahertz plus processor squeezed into a fanless case no thicker than a couple layers of cardboard, protecting the processor from overheating is not the bottleneck in the system. Instead, case temperature and user safety is becoming the biggest thermal challenge faced by today’s ultra-thin tablets and smart phones.

Despite the best thermal management algorithms, there’s one flaw in all of the equations. “What is the case temperature?” While this may sound like a simple question with a simple solution of gluing a temperature sensor to the case, the problem is much more challenging. Thin is what sells, and adding a sensor onto the case would only increase its thickness. That is, if the manufacturer is willing to face the assembly challenges and additional costs of wiring the sensor back to the printed circuit board (PCB) with less than a couple millimeters of clearance (Figure 1).

Until today, phones had little choice but to rely on a local temperature sensor on the PCB or the processor’s internal sensor and use it as an approximation of the case. While acceptable under most conditions, this fudge factor method fails to consider external environmental conditions such as ambient temperature, humidity, airflow, and sunlight – all of which can dramatically change the case temperature. If the fudge factor approximation used is insufficient, then user safety again can be a concern. Overshoot with an overly cautious fudge factor that is too conservative, and performance can be greatly degraded as the processor prematurely throttles

down in an effort to cool the system (Figure 2).

What’s needed is a contactless measurement system capable of measuring the case temperature while bypassing the thickness and assembly constraints. While contactless infrared thermopile (IR) thermal sensors are not new, their use has been largely relegated to appliances and industrial equipment due to their large metal can packages and high costs. That is until now (Figure 3).

A new generation of single-chip thermal IR sensors, like the TMP006 for example, are specifically designed for ultra-thin consumer handheld electronics. At only 1.6 mm x 1.6 mm x 0.625 mm, the TMP006 is over 20 times smaller than any other thermal IR solution, allowing it to easily fit into the thinnest products in the market. Design engineers benefit from an on-chip thermopile for the IR measurement, as well as the signal conditioning, 16-bit analog-to-digital converter (ADC), and a local temperature reference.

Handset and tablet manufacturers can now directly measure their product’s case temperature and be able to account for the environmental effects of real world usage. With today’s mobile processors already exceeding 3 Watts, the TMP006 is the perfect complement to enable the next generation of phones.

With better measurements comes better performance, perhaps even a burst turbo mode where the processor can be safely overclocked without risk to the user. Or let’s just go a little crazy and point the IR sensor outside the phone. After 10 years of living in Texas, I’d like to know the temperature of my steak as well. Who knows, maybe one day there will even be an app to tell me I’m running a fever.

Figure 1: Ideal case measurement.

In Figure 1, the temperature sensor is placed directly on the case at the hottest location. While this configuration solves the case temperature challenge, it is rarely used due to increased thickness, difficult and expensive assembly, and reduced reliability.

Figure 2: Typical measurement.

In Figure 2, a temperature sensor is placed adjacent to the CPU or relies on the CPU’s internal temperature sensor. This is the most typical configuration used today. The case temperature is unknown and safety is based upon the internal temperature of the phone.
It does not factor in environmental conditions outside the system (for example ambient temperature, humidity, air flow, sunlight, etc.). This configuration artificially limits the CPU to an arbitrary temperature limit, preventing the system from maximizing performance to environmental conditions.

Figure 3: Contactless case temperature measurement.

In Figure 3, a new generation of ultra-small passive IR sensors is placed on the PCB adjacent to the hottest object in the system. This sensor measures the radiative heat from the case and determines its temperature. This approach not only solves the assembly challenge of measuring the case temperature, but allows for greater safety and the ability to maximize performance to the environmental conditions.

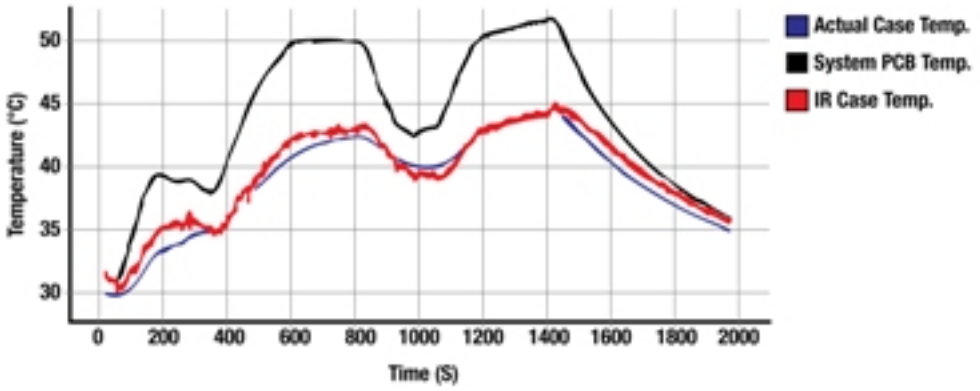

Figure 4: Real life measurements of case temperature.

In Figure 4, the graph shows the large disparity between the system PCB temperature and the actual case temperature while running various applications. The results also show how contactless IR sensing can closely track the actual case temperature.

Conclusion

Can’t touch this? For designers and consumers alike, the question of whether the newest geekiest gadget is too hot to touch may be a sensory concern of the past. Thanks to IR temperature measurements, our next generation gadgets can achieve the trifecta: safer, faster, and thinner.

For more information or to download a datasheet for the TMP006, visit: www.ti.com/tmp006-ca [1].

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[1] http://www.ti.com/tmp006-ca