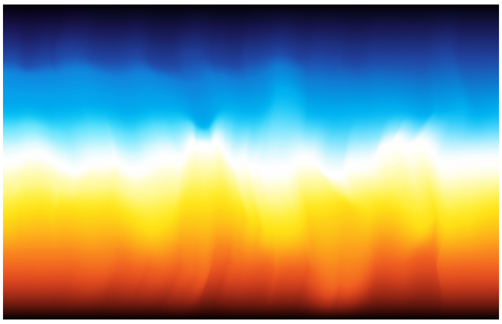
White Paper

A Modern Approach to Thermal Throttling in PCIe SSDs



Introduction

Thermal throttling is a mechanism to protect a component from being damaged due to high temperatures. When the temperature of a component reaches the maximum temperature that it is designed to operate at, speeds will be throttled to reduce the temperature. With SSDs, thermal throttling is essential, because drive damage can lead to data loss. Because speeds are throttled, read/write tasks are slowed down.

Most PCIe SSDs use a very rudimentary thermal throttling algorithm, which controls temperatures by lowering and increasing system frequencies based on specified temperatures. For example, if the temperature reaches 85°C, the flash clock frequency would be lowered to a pre-defined speed to allow the system to cool down. Once the temperature drops to a specified level, the speed would then be raised in response. This method is fine for consumer applications, but not industrial.

Challenges

The Trade Off Between Speed and Temperature

Industrial system integrators require a stable transfer speed, and the traditional methods of thermal throttling can sometimes result in speeds jumping up and down in quick succession. Stable speeds and sophisticated thermal throttling algorithms are important for industrial use cases where devices have a specified task that is repeated over and over again, and sudden major slowdowns are unacceptable.

Applications include, but are not limited to smart security, where large video and image files may need to be written and read constantly, and at high speeds in order to facilitate facial recognition and high-quality security footage processing.

In industrial applications, it's not always important to have the fastest speeds, and instead, industrial integrators often prefer to have consistent speeds that they can rely on. It's better for a process to always take 10 seconds to complete, rather than sometimes taking 5 seconds, and other times taking 20 seconds. This is because, in industrial settings, single read/write processes may be part of a queue of actions, and there may be other processes that need to have an accurate expectation on when read/write processes will be completed so they can be ready for the next step.

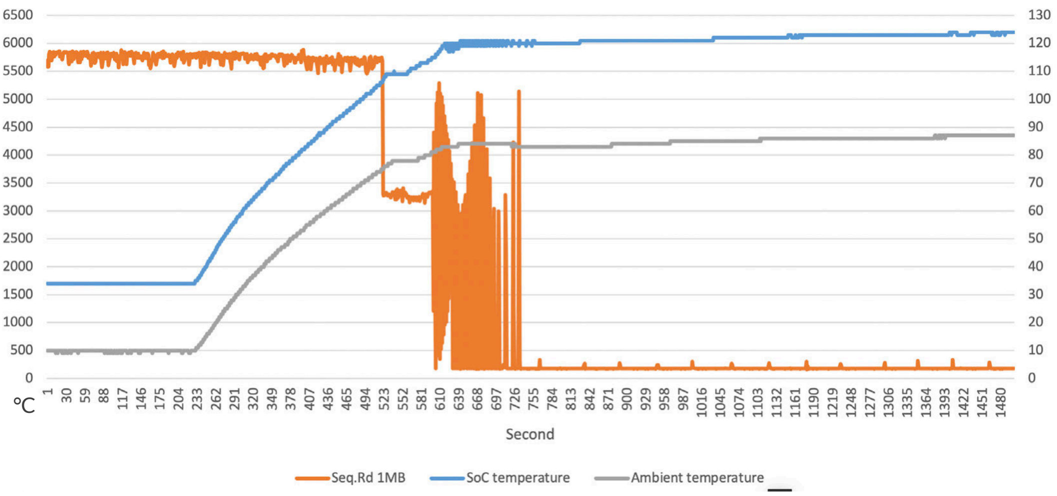


Image 1: With the old thermal throttling algorithm, as temperatures rise, SSD speeds decrease erratically.

Solutions

A Balanced Algorithm for the Industrial Market

Innodisk's advanced thermal throttling technology uses an innovative algorithm to achieve more precise temperature control. The algorithm does this by calculating the difference between the current and target temperatures, and increasing or reducing the number of commands sent to the NAND flash in response. This allows a more stable temperature. Additionally, unlike the old thermal throttling technology, Innodisk's advanced algorithm does not immediately reduce the speed when the temperature threshold is exceeded; instead, it smoothly reduces the speed over time, resulting in less erratic speed fluctuations.

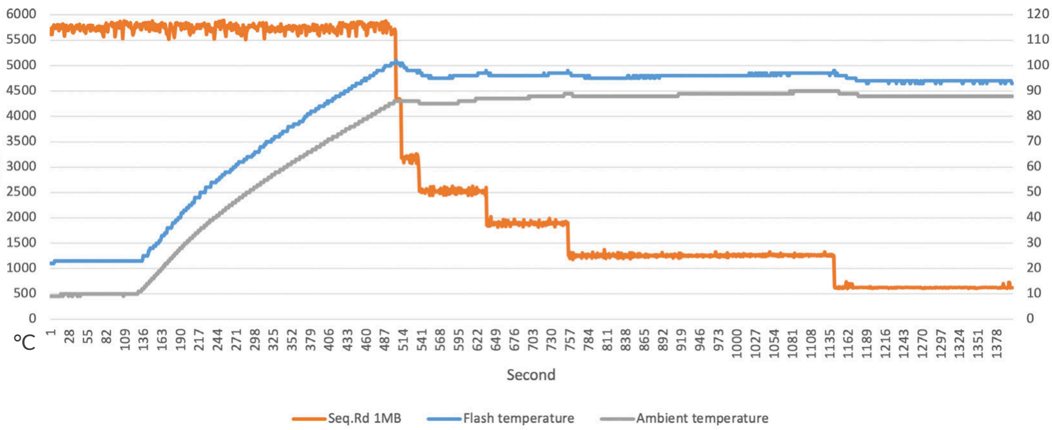


Image 2: With Innodisk's new thermal throttling algorithm, as temperatures rise, SSD speeds decrease steadily.

Innodisk's firmware development team found that in addition to frequency reduction, controlling the number of commands send to NAND flash can also achieve cool down. It is for this reason that the newly developed firmware is controlled by the difference between actual and target temperature. For example, if the target temperature is set to 110°C, and the SSD's current temperature is 80°C, the drive can increase the commands sent to the NAND flash, resulting in an increase in temperature, and speed. Unlike the old thermal throttling mechanism, Innodisk's advanced firmware has countless deceleration and acceleration points, so when the temperature rises, a smooth deceleration in speed can be achieved.

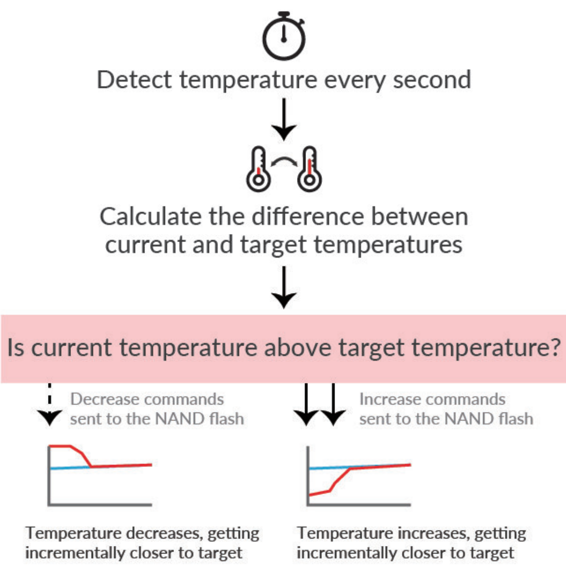


Image 3: New thermal throttling algorithm flow

This advanced thermal throttling algorithm is only possible on newer controllers, since they have an independent engine to control the number of commands send to the NAND flash.

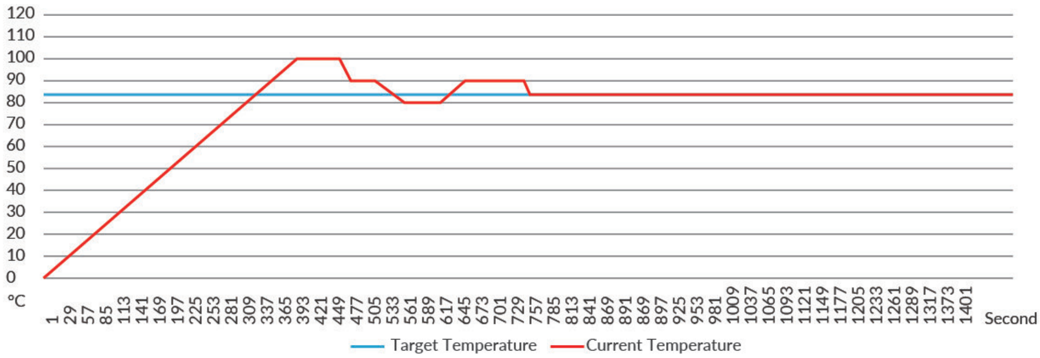


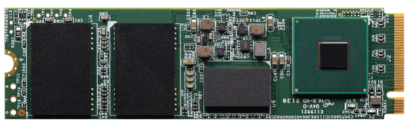
Image 4: The difference in target and current temperature is calculated every second. If the current temperature is higher than the target temperature, fewer commands will be sent to the NAND flash, resulting in a reduction in SSD temperature. If the current temperature is below the target temperature, more commands are sent to the NAND flash, resulting in an increase in SSD speed and temperature.

There is no setup to use the new thermal throttling algorithm. All Innodisk PCIe SSDs that support the new firmware are already pre-configured with this new technology.

Product Line

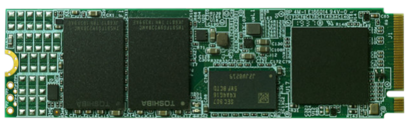
M.2 (P80) 4TG2-P

- PCIe Gen. IVx4, NVMe 1.4
- Excellent data transfer speeds
- Stable sustained performance
- Heat-spreading design
- LDPC ECC engine supported



M.2 (P80) 3TG6-P

- PCIe Gen. III x4, NVMe 1.3
- Excellent data transfer speeds
- Stable sustained performance
- Heat-spreading design
- LDPC ECC engine supported



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Conclusion

It is obvious that for system integrators with high speed and high temperature requirements, such as those with 5G, AIoT, networking and other industrial applications, Innodisk's advanced thermal throttling algorithm, and others like it, offer previously unheard of thermal control. It is certain that this advanced firmware will lead the way for integrators to roll out innovative applications in harsh environments, without having to suffer through erratic speed fluctuations and inconsistencies.

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