Envoy Data Memory
SSD CONTROLLER
Technical Brief

Thermal Throttling

Introduction

SSD performance requirement is getting higher nowadays, especially in PCIe market demand, the interface bandwidth is higher than SATA for several times. There are higher performance requirements no matter in commercial, enterprise or data center application. On the other hand, owning to market demand, it's also required to reduce the size of SSD form-factor for a thinner and lighter SSD.

Higher performance and smaller form-factor bring the SSD thermal issue. The temperature of the SSD would raise and even cause an overheating phenomenon.

When there is overheating for the SSD, the components could be damaged owning to high temperature and data correctness could also be impacted. EDM offers thermal throttling mechanism by firmware control. We use three temperature thresholds which are defined as ceiling line, thermal line and bottom line to differentiate different thermal throttling stage. We have different read, write speed controlled in these states. Under EDM mechanism, temperature would be controlled in an appropriate range which could prevent the controller temperature from overheating and also increase the SSD thermal efficiency effectively.

EDM Technology:

Thermal Throttling

To reduce the overheating issue, EDM thermal throttling mechanism reduces overheating by intelligent speed acceleration and deceleration firmware control.

Assuming there are n level for the flash clock frequency. Which are level 1, level 2…level n. When the thermal throttling is triggered, the flash clock frequency would be reduced to level 1 and the command delay would also be added to cool down the drive.

After flash clock frequency is reduced to level 1, The controller temperature would be
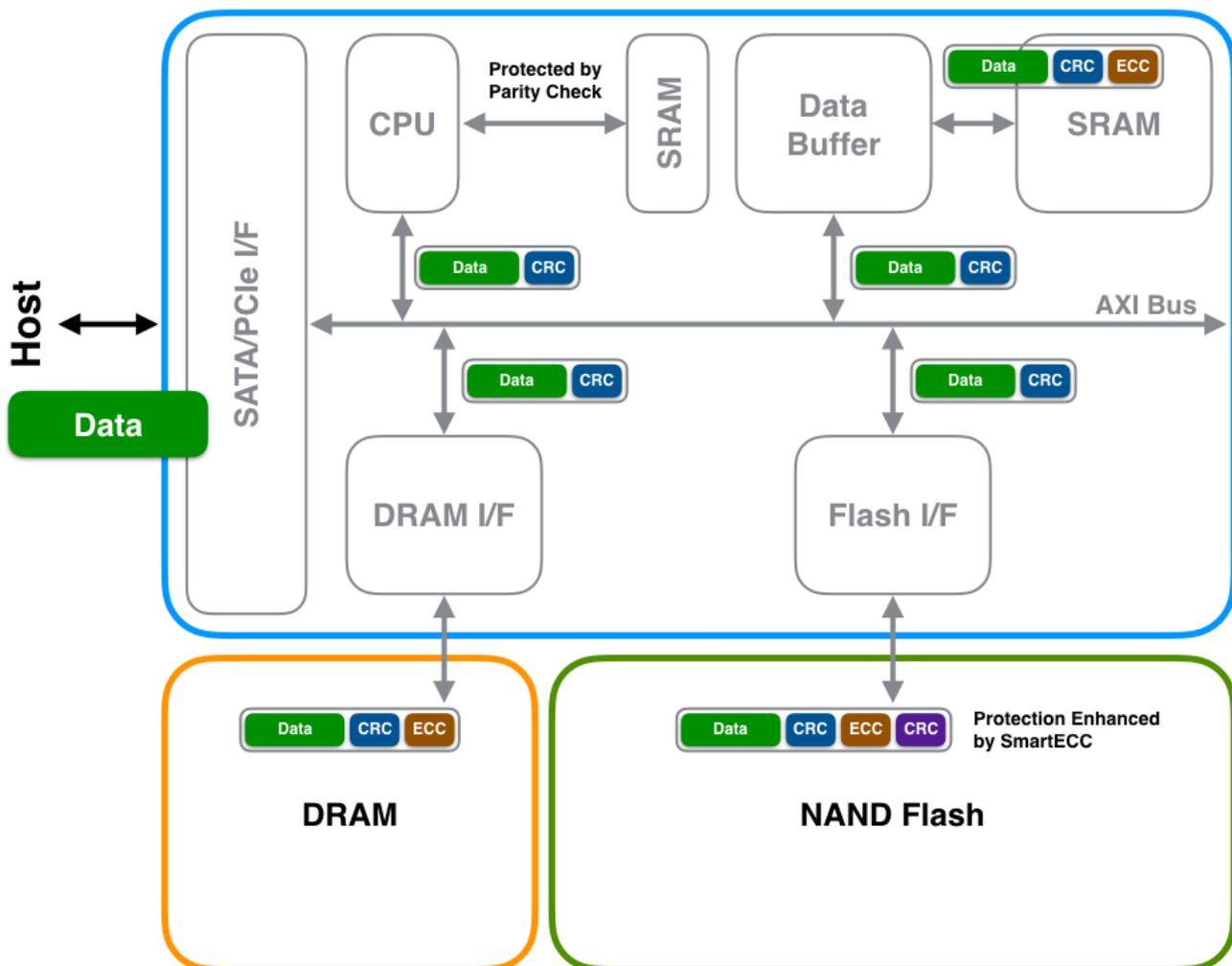
We use 3 temperature threshold which are called as ceiling line, thermal line and bottom line to do the thermal throttling.

When the controller temperature hit the

kept monitoring. If the temperature keeps raising and hits the ceiling line threshold, the flash clock frequency would be triggered for further reduction down to level 2.

The temperature would be kept monitored and once the temperature is detected to hit the ceiling line again, the flash clock frequency would be reduced one further level. In summary, once the thermal throttling triggered, firmware would keep monitoring the temperature and once the temperature increases and hits the ceiling line criteria, the flash clock frequency would be reduced to cool down the drive.

Although thermal throttling mechanism could reduce the drive temperature, the drive 's data throughput is also needed to be careful handled since it's also important to have a balance between the drive's temperature and performance.

Once the drive is cool down and the temperature is lower and down to bottom line threshold. The flash clock frequency would be increased 1 level. For example, after the drive is triggered with thermal throttling, assuming the flash clock frequency is at level 5. Once the temperature is detected to be dropped to bottom line, the flash clock frequency would be increased one level to level 4.

The temperature would be kept monitored and once the temperature is detected to be reduced to the bottom line again, the flash clock frequency would be increased one further level. In summary, once the thermal throttling triggered, firmware would keep monitoring the temperature and once the temperature drops to the bottom line criteria, the flash clock frequency would be increased thus drive read and write performance wouldn't be impacted too much owning to thermal throttling.

In other words, through EDM thermal throttling mechanism, the operating temperature could be controlled well in the appropriate range between bottom to ceiling line temperature, as shown in below figure 1.
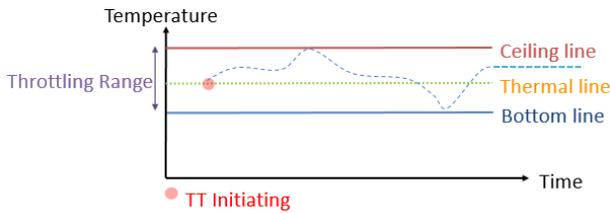
Fig.1 EDM thermal throttling mechanism

Summary

For PCIe or SATA SSD market, owning to higher speed requirements, thermal throttling is an important feature to prevent the SSD from overheating.

EDM thermal throttling mechanism use three threshold- Ceiling line, Thermal line and Bottom line temperature to do the thermal control.

1) The thermal throttling would be triggered once the SSD temperature is up to thermal line temperature.

2) When thermal throttling is triggered, flash clock frequency would be reduced to level 1 and the command delay would also be added

3) During thermal throttling control period, once the SSD temperature is up to ceiling line temperature, the flash clock rate would be further reduced one level, range from level 1,2,…n

4) During thermal throttling control period, once the SSD temperature is decline to bottom line temperature, the flash clock rate would be further increased one level until up to the flash clock rate original full speed.

EDM thermal throttling mechanism has a well balance between thermal control and drive performance dynamic adjustment, which could effectively prevent the SSD overheating issue.