White Paper

Ensuring Stable SSD Performance in Sensitive AIoT Applications

Executive Summary

Unstable power sources are a common challenge for AIoT devices in remote and extreme environments. Such operating environments can severely affect the AIoT device's solid-state drive (SSD) operation. Instability during startup and shutdown can cause system crashes and restarting issues, presenting a significant challenge to system operators.

Hardware-based preventive features protect the AIoT device's SSD from unstable voltage levels. Extending the ramp-up time during startup ensures that the voltage has stabilized before allowing the SSD to switch on. After a system shutdown or during a quick restart, there is often residual voltage that can cause issues. Tweaking the hardware to only allow startup after lowering the voltage mitigates this issue.

Incorporating these two hardware functions protects the AIoT device's SSD during both startup and shutdown.

Introduction

Power source instability and sudden power loss have always been challenges for storage devices, but they can be even more significant challenges in AIoT applications. The sudden drop in a device's power supply can cause data corruption, and in the worst case, lead to total device failure. For this reason, most SSDs for critical applications come with emergency functions that save data and assure that no issues occur when restarting after a sudden power loss.

These emergency functions are mainly put in place to ensure data integrity after an incident has happened. There are, however, other power supply factors that can impact SSD data integrity. For instance, some AIoT applications operate in conditions where power supply is unstable. During startup and use, the voltage might fluctuate, which in turn can interfere with SSD operation and also damage the device. Another significant risk is residual voltage after shutting down, which risks causing further issues when restarting the system.

There are, however, preventive measures that can help mitigate these issues. It is possible to implement effective safeguards by optimizing the hardware structure—allowing the SSD to prevent data corruption, damage, and sudden restart issues. This paper further explains the risks of power loss and power instability, and more importantly, what AIoT system operators can do to avoid these risks.

Background

Power instability issues are the most common in devices that experience poor and unstable power supply. This type of operating environment is common in many typical AIoT applications, such as in-vehicle computers, remote installations, as well as with AIoT devices used in areas where the power grid is less reliable.

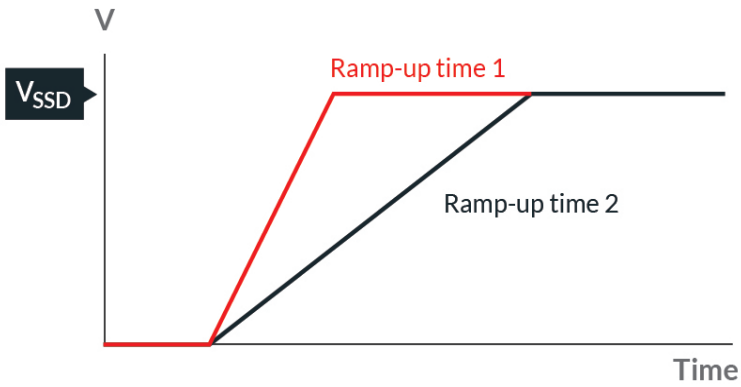
However, even in operating environments where the power supply is stable, loss of power can still occur due to unforeseen circumstances. Nearby construction work or a lightning strike is all it takes for the grid to go down momentarily. So, even in applications where the risk of power supply interruptions is low, mission-critical AIoT applications still require data integrity measures to mitigate the effects of temporary power interruptions.

Challenges

Startup Instability

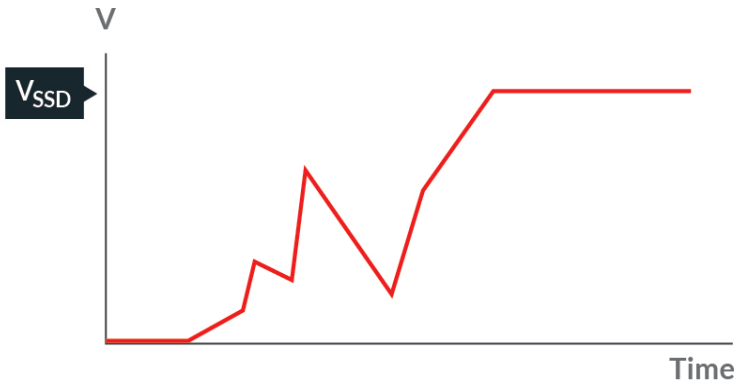
There are two risks associated with system startup: unpredictable ramp-up time and power supply instability.

Typically, SSDs only start after crossing a pre-set voltage threshold. However, this can cause problems when the ramp-up time takes too long, as the voltage threshold is not sufficient for the SSD. The ramp-up time is dependent on the local power supply situation. It can, therefore, vary from place to place (see graph 1), making it difficult for the manufacturer to produce a design that takes such variations into account.



Graph 1: Two examples of differing device ramp-up times.

During ramp-up, the voltage can fluctuate (see graph 2). While the rise in voltage level can trigger the SSD's startup, the voltage level may continue fluctuating before eventually stabilizing. As with the slow ramp-up time described above, this scenario can cause issues with device startup and potentially lead to data corruption and damage to the SSD.



Graph 2: Fluctuating voltage during SSD ramp-up.

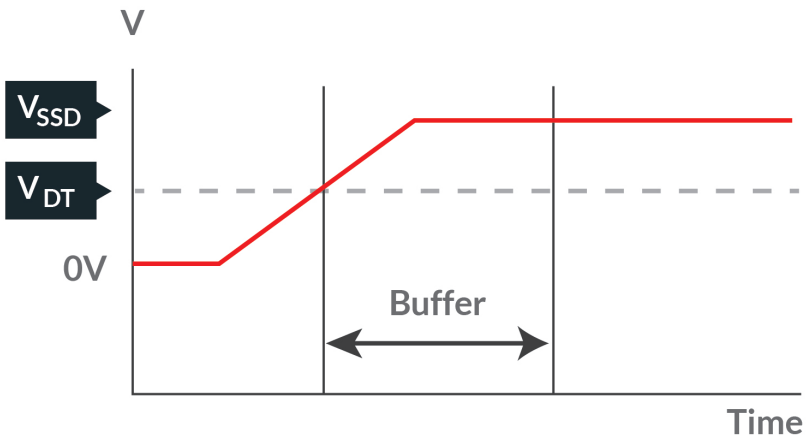
Residual Voltage

After a successful shutdown, the voltage level should be near or at zero volts. However, an inadequate power supply can leave a residual voltage after shutdown, potentially causing problems when restarting.

Solutions

Ramp-up Buffer

To avoid any issues at startup, the SSD creates a buffer zone after reaching the pre-set voltage threshold. When the threshold is met, the SSD adjusts the device startup time to ensure that a stable voltage level has been reached. Any power instability or slow ramp-up time is thus safely caught within the buffer. This function runs at every system startup, so it also accounts for differing conditions the device may face.



Graph 3: After reaching the threshold voltage (V_{DT}), the SSD adds a buffer zone to ensure that it achieves stable voltage (V_{SSD}) before initiating a startup.

Startup Without Residual Voltage Interference

Residual voltage can cause issues during SSD startup. If there is any residual voltage after shutdown, the SSD forces it down to near zero volts before allowing a system restart. This safeguard is always active, ensuring safe startups every time and thus further increasing the SSD's preventive power protection.

Conclusion

An unstable power supply is a considerable risk factor for any AIoT device using flash memory. Algorithms for safe shutdown have been available for a long time. Still, few are aware of the preventive measures available to ensure a safer power on and power off, as well as more stable performance.

Efficient power protection measures can safeguard any SSD from unstable and fluctuating voltage—allowing the AIoT device to achieve greater data integrity and an overall more efficiently run system.

The Innodisk Solution

iPower Guard™

iPower Guard™ technology is a set of preventive measures that protect the SSD in an unstable power supply environment. This comprehensive package comprises safeguards for startup and shutdown to maintain device performance and ensure data integrity.

iPower Guard is available with our 3SE4, 3TE7, and 3TG6-P SSD series.
*(Not available for some form factors)

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