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Application Note

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Swissbit SSDs as a diagnostic device for host issues

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1 Abstract

Issues with a host computer PCIe bus interface or its power supplies can cause the host/SSD interface to unexpectedly no longer recognize an operating SSD. If this occurs, that SSD is described as having fallen off the bus. There are three possible reasons for this:

1. Unrecovered Bus Link Loss
2. Brownout
3. SSD Firmware Error/Hang

If a Swissbit SSD falls off the bus, the drive can be used as a diagnostic device to determine the cause. Better yet, Swissbit NVMe SSDs diagnose and report on every isolated occurrence, without the need to replicate the issue. This information can then be shared with the host designer. Swissbit SSDs can be used for this purpose at any time in the field.

2 Falling Off the Bus

The three underlying possible reasons causing an SSD to fall of the bus are very different, yet they all lead to the same characteristic: the SSD no longer responds to host commands, leading the host to believe the SSD is non-operational. The following sections describe the each of the three possible reasons for a non-operational drive.

2.1 Unrecovered Bus Link Loss

After the bus link between host and SSD is initially established during the SSD power-on routine, the link normally remains intact until the SSD is powered down. If a bus link loss occurs during SSD operation, the SSD and host will renegotiate to reestablish the link. In such a case, if the link cannot be reestablished due to some electrical or mechanical issue with the bus interface, the host will no longer detect the SSD because the SSD cannot receive any host commands nor respond to the host. In this case, the drive is still fully functional, as it is still powered on, but the host determines the drive has fallen off the bus because the drive is not responding.

2.2 Brownout

Power supplies that supply the voltage to SSDs and other components in a host system ideally exhibit no decrease in output voltage in response to changes in current demand from such components. However, not all power supplies are ideal. In the real world, there is some small amount of voltage droop in response to current draw characteristics. Most of the time, the voltage droop is small enough that it has no negative effect on the operation of components in host system. Sometimes, however, the voltage droop is large enough to affect drive operation.

All SSDs have a required minimum supply voltage. As long as a power supply voltage drop results in voltage that is greater than the minimum specification, the SSD will continue to operate normally. However, if the SSD encounters a brownout, the drive may no longer operate and shut down. Brownouts occur when the power supply voltage drop results in voltage that falls below the minimum requirement, but then returns to above the this minimum requirement.

If an SSD with power loss protection (PLP) encounters a brownout where the supply voltage falls enough to trigger PLP, then no matter how short the brownout, the SSD is going to execute its PLP operation. At this point, the

drive controller will shut down, requiring a subsequent power cycle to restart the SSD.

In this case, the SSD is no longer operating because the controller has shut down. This underlying behavior is different than the unrecovered bus link loss case, where the drive is still functional. However, from the host viewpoint, the characteristic is the same – the SSD has fallen off the bus.

2.3 Firmware Error/Hang

Though very less probable than the previous two reasons, the third possible reason for a drive to fall off the bus is if the SSD firmware experiences an error condition that results in a firmware hang. In this case, the SSD firmware no longer communicates with the host. The underlying behavior of a firmware error/hang is different than both of the two previous cases, because the SSD did not experience a bus loss or a power disruption. Because the SSD firmware is hung, the device will not communicate with the host, although the hardware interface may still acknowledge receipt of commands. However, from the host perspective, the end result is the same – the SSD has fallen off the bus.

3 Swissbit Diagnostic Tool

Swissbit SSDs with PLP (PowerSafe feature) provide a feature that makes the SSD a diagnostic device for identifying root causes of drive detection issues. This feature allows the customer to easily determine which of the three possible reasons led the SSD to fall off the bus. This feature has the following very useful characteristics:

1. It is built into every PLP drive.
2. It is autonomous; so, there is no need to enable it.
3. Nothing needs to be recorded prior to an event that leads to an SSD falling off the bus. In other words, there is no need to read any values (to establish a baseline for comparison) before a drive falls off the bus.
4. There is no need replicate the event after the initial occurrence with additional diagnostics, which is a typical first step in investigating an issue. Instead, the customer can simply power cycle the SSD after the event and determine the cause based on flags stored during the event.

This capability is included in the Swissbit SSDs N3002/N3602 and N3202.

4 How to Use the SSD as a Diagnostic Device

If a Swissbit SSD falls off the bus while operating, the drive firmware stores the state of two flags. The customer can then cycle power on the drive and read the state of these flags in the Telemetry Log. The following sections describe these flags and provide information on how to decode them.

Flags:

1. PFail_PrevPowerCycle (PF)
2. BusLinkLoss_PrevPowerCycle (BLL)

Flag	Telemetry Log	
	Offset	Bit
PFail_PrevPowerCycle (PF)	30	2
BusLinkLoss_PrevPowerCycle (BLL)	30	0

Decoder:

Decoder		
Flags Read in *Next* Power On Period		Reason SSD Fell Off the Bus in *Previous* Power On Period
PF	BLL	
1	1	Unrecovered Bus Link Loss
1	0	Brownout
0	1	N/A
0	0	Firmware Error / Hang

To supplement these flags, there is a counter (BusLinkLossCount) that counts occurrences of all abnormal bus link loss events over the life of the drive. An abnormal bus link loss is a link loss, recovered or not recovered, that occurs during drive operation. Bus link losses that occur during shutdowns, safe and unsafe, however, are normal and are not counted in BusLinkLossCount. In addition to the two flags that identify why a drive fell off the bus in the previous power on period, customers can view this counter to see if there have been ongoing recoverable bus link loss issues in general. This counter is also provided in the Telemetry Log.

Counter	Telemetry Log
	Offset
BusLinkLossCount	140 – 143

5 Conclusion

The three most common reasons for an SSD to seemingly fall off the bus are bus link loss, power issues (brownout), and firmware errors. In the unlikely event the host no longer detects the device, Swissbit SSDs store critical information about the cause in the Telemetry Log. Using the values of two flags and a counter, customers can determine why the host lost the connection and identify any potential issues with the bus.

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