**NanoCycler HS24 answers the challenge
of the high-speed NAND characterization**

Speed, speed, speed. As storage systems become more and more pervasive for a wide range of applications, high speed and high bandwidth data access with consistent latency are paramount to meet data center performances and customer experience.

The recent release of ONFi 5 increases the NAND I/O speed to a stunning 2.4 GT/s, enabling it to saturate PCIe Gen5 x4 delivering nearly 16 GB/s, and with Gen5 x8 even beyond 16 GB/s.

NAND characterization at full speed – as the device will work in the target application – is essential to obtain good quality data and tune the SSD firmware for the highest reliability and performance and for the longest lifetime.

At 2.4 GT/sec, the I/O bus becomes a communication channel with potential bit errors. In order to analyze the bit error rate of the NAND array correctly, the I/O errors have to be at least two orders of magnitude below the array BER, typically specified at 1.5e-2.

NplusT's NanoCycler, a leading NAND characterization system, has proven its ability to match those requirements and evaluate ONFi5 NAND devices at their full speed. NanoCycler's timing accuracy, timing control with few psec resolutions and sophisticated training/calibration procedures allow the minimalization of the I/O bit errors, providing thus reliable information about the array BER. Moreover, the same features support the die-by-die timing analysis inside the NAND package, helping SSD developers to optimize further their products.

In our analysis, we measure the I/O BER with different timing settings to understand the correlation between the timing margins (width of the DQ/DQS alignment for a specific target BER) and the related BER. We execute this analysis for every die and LUN in a package, to reveal potential differences due to the package-internal layout and bonding. For those analyses, the I/O buffers of the NAND LUNs are used to exclude the NAND array BERs.

The chart below shows the DQS timing margins at 2.4 GT/s at different BER levels for different LUN in the NAND package.
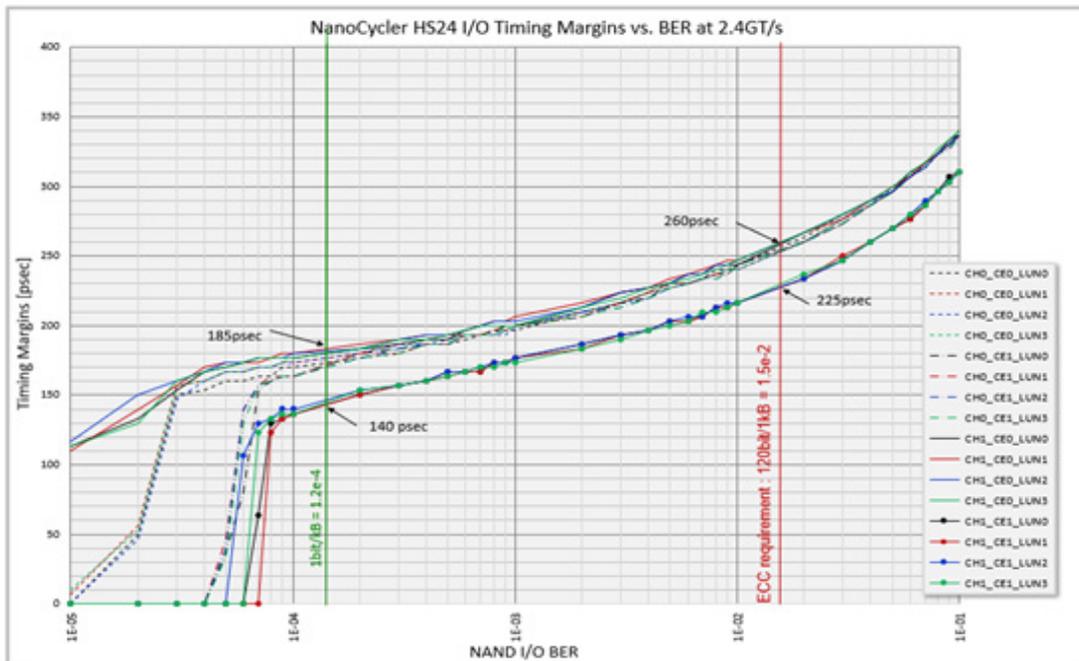

The chart demonstrates that NanoCycler HS24 provides good timing margins and low data noise at 2.4GT/s. The I/O BER, at 2 orders of magnitude below the ECC error correction threshold required by the NAND vendors, provides at least 140 psec timing margin, sufficient for reliable characterization.

At this very high data rate, we see also the different characteristics of the dies selected by the channel, CE and LUN, inside the same package. This difference is even more evident in the bathtub chart below.
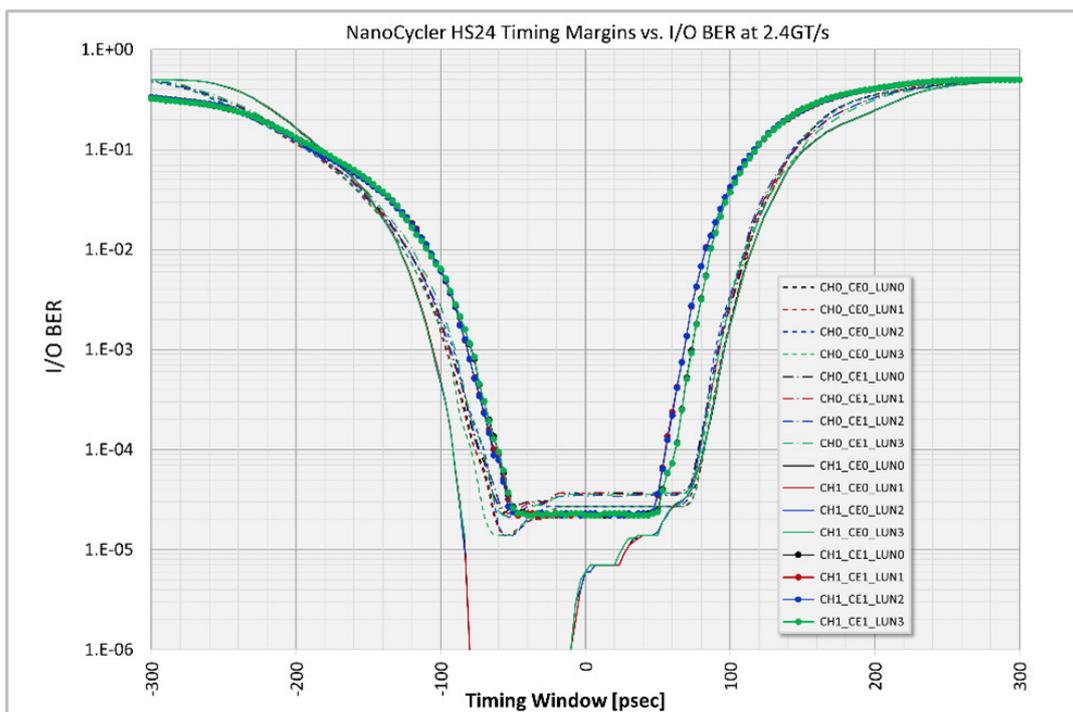
At the I/O BER of 1e-4, the timing window of the "worse" LUN is 137psec. The window width, as shown in the bar chart, correlates strongly with the CE signal; this fact indicates an I/O interconnectivity dependency effect.
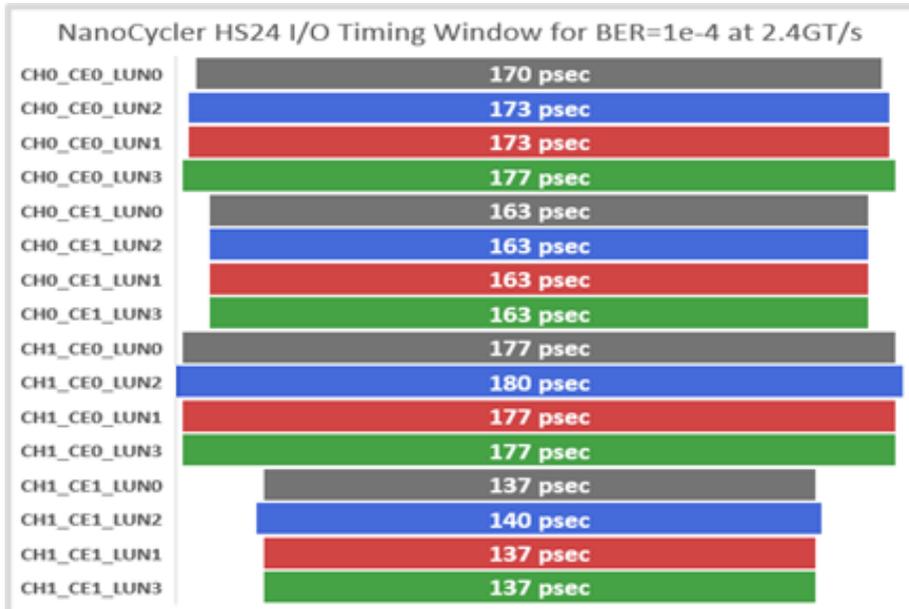
In order to obtain these high quality results, NanoCycler is equipped – beyond the very high resolution I/O timing generators and data sampling, programmable driving strength and ODT – also with high precision programmable voltage generators for the NAND. Moreover, high sampling rate current measurements help SSD developers to understand dynamic behavior, current peaks, so design the hardware for good power integrity.
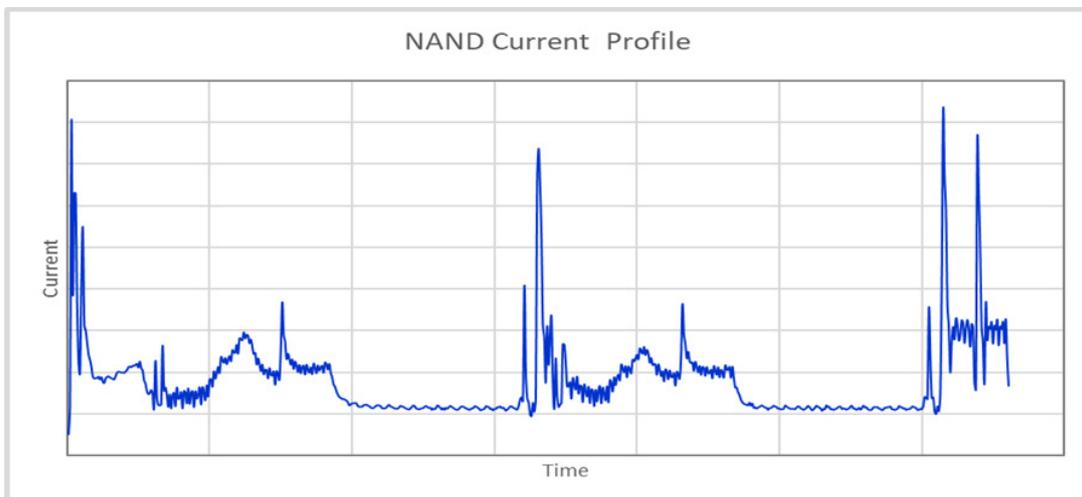
NanoCycler HS24 – the latest member of the NanoCycler family – is today's only commercial equipment proven to characterize with the required quality and resolution the ONFi5 NAND devices at their full operating speed.

Features	Specification
Timings Generator	Control Signal edge placement accuracy < 1 nsec DQ, DQS edge placement accuracy < 4 psec
Timings Acquisition	Control Signal acquisition accuracy < 20 nsec DQ sampling rate period: 417 pS, accuracy < 4 psec
Voltages Generators	Programmable Vccq : 0.95..1.9 V, accuracy 25 mV
	Programmable Vcc : 1... 3.8 V, accuracy 25 mV
	Programmable Vpp : 10..14 V, accuracy 25 mV
Current Measurement	50 nsec sampling rate
	2k samples buffer
	1-5 mA accuracy

In addition to the above extreme speed and accuracy, NanoCycler's wide set of features, including per-package temperature control, unlimited flexibility of programming custom commands and signal sequences, and a comprehensive set of built-in powerful characterization functions, allows its immediate utilization out of the box and maximizes its productivity providing excellent cost-of-ownership.