

The Benefits of Advanced SSD Testing with Epic Chambers

WHITE PAPER

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Summary

Customers have long been familiar with Teledyne LeCroy's industry leading SVF Pro with Enduro test and validation software that is integrated with our SSD test platforms. With our Epic Chamber test solutions, customers can utilize same proven architecture, software and performance – including PCIe Gen 4 support – already in wide use by SSD manufacturers.

Additionally, we provide advanced manufacturing test software called Greenlight that brings the power of the Teledyne LeCroy test platform to the world of manufacturing. Greenlight runs on top of our core software, SVF Pro, allowing the DUTs to be fully evaluated and verified.

Our Epic chamber solutions help our customers discover “hard to find” performance and functionality bugs that they can proactively act on.

Teledyne LeCroy's Epic Test Chambers

Teledyne LeCroy and Daichu Technologies have collaborated to develop industry leading Epic Series of testers for SSD and flash storage-see Figure 1. The Epic Series is based on Daichu's proven tester technology that has been used by some of the world's most renowned storage suppliers. The chambers are powered by Teledyne LeCroy's advanced test software SVF Pro that has played a key role in ensuring the robustness of many popular SSD on the market today.



Figure 1: Teledyne LeCroy Epic 360C0 – Gen 4 360 DUT Chamber

The Epic line of chambers provide the industry's widest temperature range and lowest temperature variance (-40 to 90 degrees celsius) per DUT in the industry. The chambers come with support for a broad range of DUTs from 10 to 360 and support for all popular storage protocols, form factors and interfaces including PCIe Gen 4.

The result is the industry's only “unified” tester with a common software architecture. SVF Pro is integrated across all of our test platforms allowing customers to implement a cohesive test framework from design and development through production.

Importance of SSD Testing with Epic Chambers

The benefits of SSD are well-known: System boot times that are typically 25%-33% faster than hard disk drives (HDD), half of the power draw for longer battery life, reduced noise during use, and greater mean time between failure (MTBF). Additionally, SSDs have no moving parts and generally produce less heat than an HDD.

However, as with any electronic device, thermal issues remain for SSD. Consequently, temperature is an important aspect for all SSD environmental test plans. Engineers are designing SSD to handle more chips, more channels, more cores, and more controllers to handle a greater level of processing capability. Additionally, increasing volumes of SSDs are being used in rugged thermal environments. These devices must be proven to withstand harsh conditions.

The purpose for testing solid-state drives in an Epic Chamber are twofold. First, storage engineers need to make sure that drives will perform reliably at a given temperature range, as they may deploy them in environments ranging from data centers to deserts. Second, elevating temperature serves to add stress to the device and thus accelerate expected failure times. SSD manufacturers cannot wait five years to add up drive failures at room temperature, but they can extrapolate at this number based on many years of heightened temperature testing and subsequent analysis.

Solid State Drive (SSD) endurance is defined as the amount of data that can be written to a flash-based drive before it becomes unreliable. The temperature the drive is stored at can have extreme effects on the reliability of the drive. Recent studies on the reliability of flash based SSD identified temperature as one of the external factors increase failure rates for SSDs. Failure rates vary greatly as temperatures increased beyond that operating range.

A recent study out of Carnegie Mellon University in collaboration with Facebook analyzed the reliability of flash based SSD. One of the external factors that the researchers considered was temperature. In examining three distinct groups of SSD in a Facebook data center, the study described similar failure rates at a range of 30-40°C, but the failure rates varied greatly as temperatures increased beyond that operating range. Failure rates are explained in the following tables-Table 1 and Table 2.

Platform	SSDs	PCIe	Per SSD				
			Capacity	Age (years)	Data written	Data read	UBER
A	1	v1, ×4	720 GB	2.4 ± 1.0	27.2 TB	23.8 TB	5.2×10^{-10}
B	2				48.5 TB	45.1 TB	2.6×10^{-9}
C	1	v2, ×4	1.2 TB	1.6 ± 0.9	37.8 TB	43.4 TB	1.5×10^{-10}
D	2				18.9 TB	30.6 TB	5.7×10^{-11}
E	1		3.2 TB	0.5 ± 0.5	23.9 TB	51.1 TB	5.1×10^{-11}
F	2				14.8 TB	18.2 TB	1.8×10^{-10}

Table 1: The platforms examined in our study. PCIe technology is denoted by vX, ×Y where X = version and Y = number of lanes. Data was collected over the entire age of the SSDs. Data written and data read are to/from the physical storage over an SSD's lifetime. UBER = uncorrectable bit error rate (Section 3.2).

Table 1 – Reported Failure Rates vs SSD Physical Storage

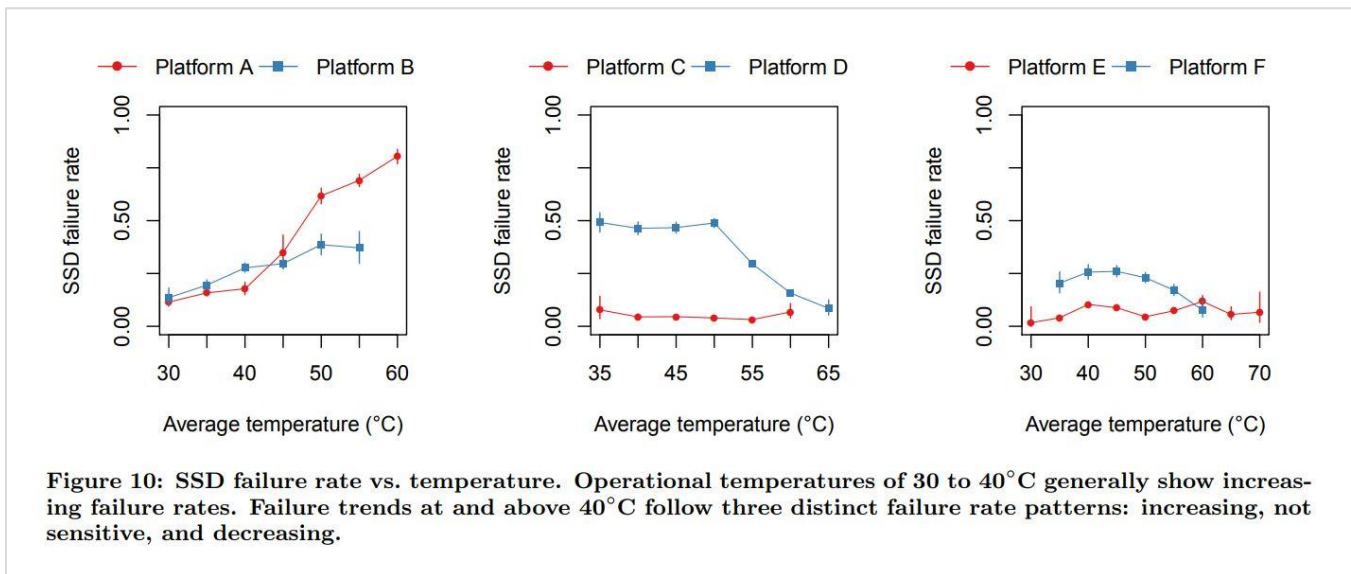


Table 2 – Reported SSD Failure Rates vs Temperature

Consequently, measuring the thermal characteristics of SSD has become critical for the successful design and implementation. It is important that thermal management is considered not only in the design phase, but that the products are tested to determine the impact of temperature on the SSD to avoid errors, lost information and device failure.

Additionally, with SVF Pro (and Greenlight), thermal testing can be coupled with long-run, full-performance testing under stressful simulated I/O environments. SVF Pro can:

- Generate traffic and inject errors
- Ensure performance (IOPS, Bandwidth, Latency)
- Control power and temperature
- Execute customized test sequences, record logs
- Exercise built-in protocol conformance test suite and analyzer
- Also, SSDs can be tested to make sure that the data is accurate and reliable

For SSD manufacturers it has become imperative to utilize environmental chambers for testing and debugging solid-state drives (SSD) during an SSD’s pre-production and production phases.

Value of Epic’s Common, Unified Software Architecture

Teledyne LeCroy’s common, unified software architecture allows us to deliver the same comprehensive feature set throughout the SSD product and test lifecycle-see Figure 2. SVF Pro is the software test “engine” that provides an unprecedented level of functionality, performance, and ease of use for testing storage devices. SVF Pro significantly enhance the modularity, scalability and reliability of the industry’s most widely used and hardened test platform.

SVF Pro’s comprehensive feature set and capabilities are based on Teledyne LeCroy’s unique experience in working closely with a broad range of customers, enabling a deep understanding of their requirements. In

In addition, the core SVF engine has been battle-tested over 10+ years in intense test environments at major SSD and flash storage customer sites worldwide.

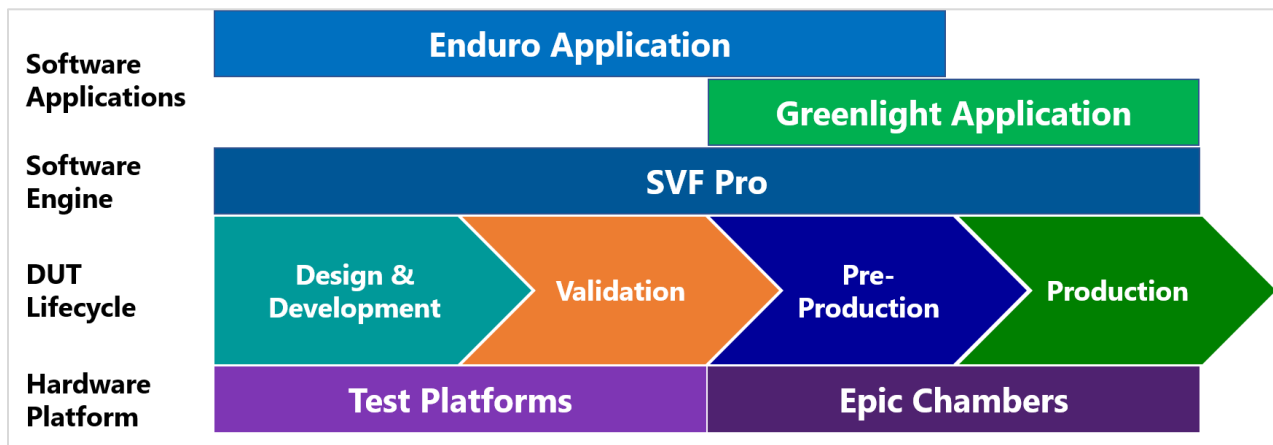


Figure 2: Teledyne LeCroy's Unified Storage Validation (SVF) Framework

SVF Pro: Industry's Premier Test Software Engine

Teledyne LeCroy's SVF Pro provides an unprecedented level of functionality, performance, and ease of use for testing storage devices. These same set of features are delivered with our Epic Chamber customers-see Figure 3.

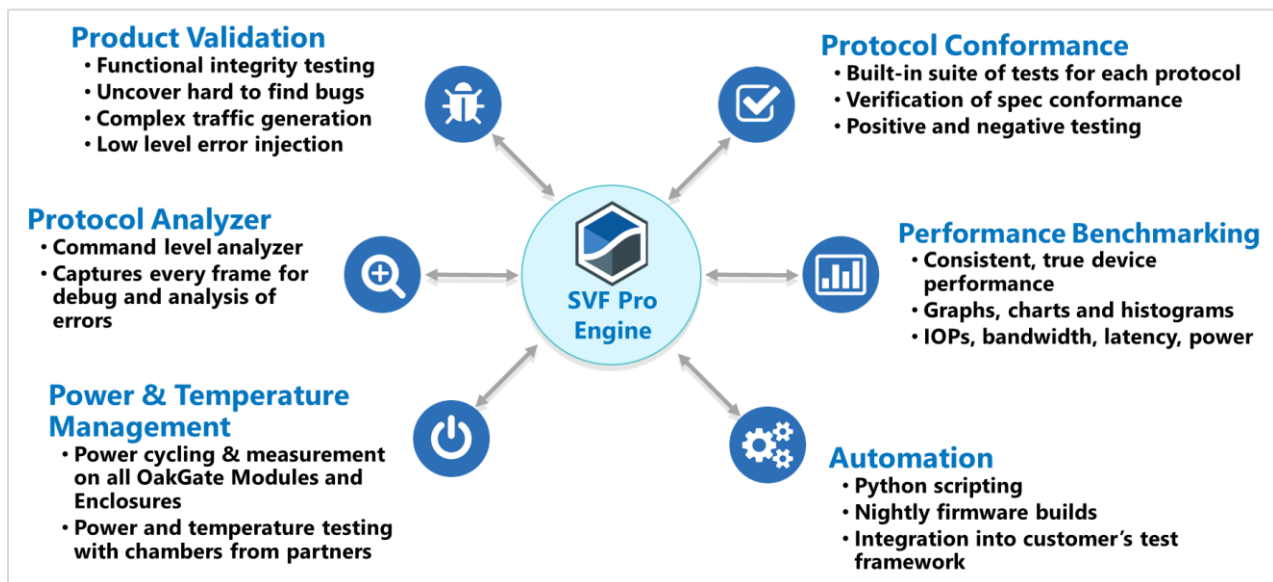


Figure 3: Teledyne LeCroy's Storage Validation Framework (SVF) Feature Set

SVF Pro provides our customers with unparalleled test coverage and is centered on these three core pillars:

1. **Product Validation** is designed to test functional integrity of the product and uncover bugs. The user can do so via complex traffic generation and error injection.
2. **Protocol Conformance** provides a large set of built-in tests that helps verify conformance with a specific protocol that the device supports. The user can of course add his own unique tests as well.
3. **Performance Benchmarking** allows the use to measure the true performance of the device under various workloads and generate all kinds of graphs and histograms.

Around these three core pillars, SVF Pro incorporates a number of advanced capabilities. We have a built-in command level analyzer that records each command and lets the user go back analyze what led to a specific error. Additionally, customers can perform power cycling and power measurements on an individual DUT basis.

Last but not the least, we have several ways our customers can write their own scripts to exercise specific functionality. Customers can write Python test scripts and run those through our REST APIs.

Greenlight: Advanced Manufacturing Test Software

Greenlight is an advanced manufacturing test software designed specifically to bring the power of the Teledyne LeCroy test platform to the world of manufacturing. The application was designed expressly for manufacturing environments, where the need for simultaneous testing across hundreds of devices is paramount and each device needs to behave atomically without affecting other devices. The user interface was designed for ease of use and includes optimized views for operators and engineers.

Greenlight runs on top of OakGate’s robust core software, SVF Pro,



Figure 4: Greenlight Software GUI

allowing the DUTs to be fully evaluated and verified. Greenlight includes an operator mode for operators on the production floor. Only the main controls and status information are displayed for test execution. The simple user interface design employs simple green-yellow-red test result metrics- see Figure 4.

For development engineers, additional controls are available in engineer mode. This gives them access to the full capabilities of the application for test creation, execution,

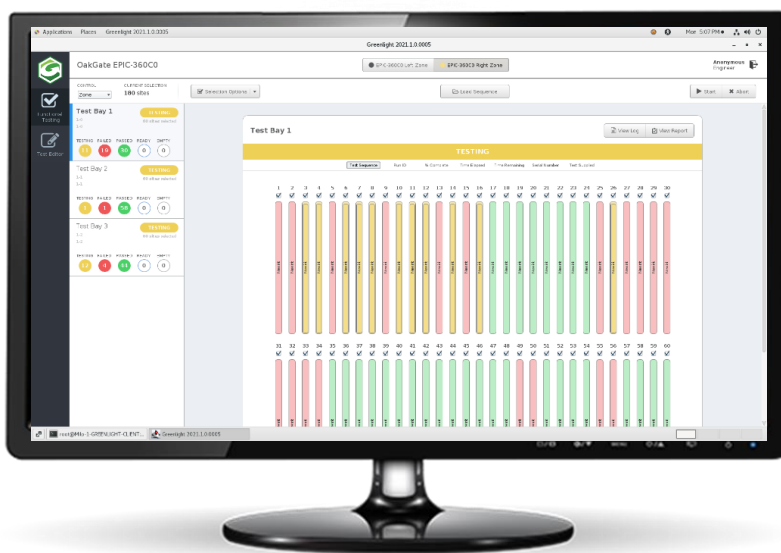


Figure 5: Greenlight Test Results - Epic 360C0 Test Chamber

and debug. Greenlight test results from an Epic 360C0 show are shown in Figure 5. The results show a mix of test results in one of the test bays inside the 360 DUT chamber. The test-board-centric views, where the interface directly reflects the physical test board layout, helps operators maintain accuracy when populating, testing and removing good/failed boards from the system.

The Advantages of Testing with an Epic Chamber

As stated previously, Epic utilizes SVF Pro's complete set of SSD test features and capabilities. Furthermore, the Epic line of chambers provide the industry's widest temperature range and support for a broad range of DUTs from 10 to 360-see Figure 6. Our chamber platforms support all popular storage protocols, form factors and interfaces including PCIe Gen 4. And, users can adjust the airflow to accommodate end-user's requirements.



Figure 6: Epic Gen 4 10 DUT, 56 DUT and 360 DUT Solutions

Additionally, the Teledyne LeCroy Epic line of Chambers provides customers with the industry's most comprehensive test functionality that includes:

- Long Run Testing
- Age Testing
- Low and High Temperature Testing
- Marginal Voltage Testing
- High performance read/write access during thermal and marginal voltage tests

For SSD manufacturers the ability to utilize environmental chambers for testing and debugging solid-state drives (SSD) during an SSD's pre-production and production phases has become increasingly important as SSDs are being used for an increasingly number of applications.

As an example, Industrial SSDs are found in high-performance applications where data integrity and reliability are of paramount importance, such as data centers, server farms, aerospace and avionics, military applications, machine automation, medical solutions, and in-vehicle computing. Furthermore, being able to leverage the same comprehensive SVF Pro features and test cases from development through production improves the manufacturers return on investment.

Summary

Teledyne LeCroy's Epic chamber portfolio now help users fully test their solid-state storage devices during pre- and post-production. Additionally, the software will help to discover "hard to find" performance and functionality challenges.

Key Benefits:

- The Epic family of chamber-based testers combines the industry's most widely used SSD validation software from Teledyne LeCroy and proven high-density tester technology from Daichu Technologies
- Epic provides the industry's widest temperature range and lowest temperature variance (-40 to 90 degrees celsius) per DUT in the industry.
- Additionally, the chamber supports all the popular storage protocols, form factors and interfaces including PCIe Gen 4
- The Epic Chambers include the industry's only "unified" tester with common software architecture that utilizes SVF Pro, the gold-standard for SSD test and validation

For more information and/or demonstration of the Epic Chamber with SVF Pro/Greenlight and other Teledyne LeCroy products, visit <https://www.teledynelecroy.com/oakgate> or contact us by email at oakgate_marketing@teledyne.com