

## Kingston Testing Overview

## Every Cell. Every Chip. Every Module. The Kingston Testing Story

At Kingston Technology, we put our memory modules through the most extensive testing in the industry. From design to prototype to production, a Kingston module stops at multiple testing stations and undergoes many tests across various categories before it is allowed to enter our packing and shipping areas. These tests occur at each of our worldwide manufacturing facilities. We perform verification tests of our designs, as well as qualification tests of our materials, such as printed circuit boards (PCBs), DRAM chips, and passive components. We also verify the quality and consistency of our suppliers through rigorous incoming quality inspections and tests. And we continually monitor our testing, verifying and validating that our results are consistent, our processes efficient, and our equipment calibrated and up to date for each type of module we test. All of our testing has a very specific goal: to produce the highest quality product for our customers.

### OUR PARTNERS PASS OUR TESTS

Kingston's ongoing, proactive Supplier Quality Program certifies and monitors DRAM chips, PCBs and passive components. Kingston has established strict control requirements that subject received component lots to stringent compliance testing. And we review and qualify our suppliers' manufacturing and testing processes on an ongoing basis, including regular factory audits.

In the following pages we will take you through our extensive design engineering testing—where design and specifications come together. We will take you through our production testing to verify manufacturing quality, performance and reliability. And we will continually remind you that the processes you read about apply to each and every one of the 25 million modules we produce each month.

## Kingston is Known for Testing

Kingston is a recognized world leader in memory testing technology and innovation. Kingston holds 29 patents for testers and test-related technologies, and employs a dedicated staff of experienced test engineers. Industry leaders like Intel team with Kingston to develop and deploy a range of testing programs and processes, and often turn to Kingston to support future memory technology. Today, memory semiconductor companies worldwide use Advanced Validation Labs (AVL), an independent third-party testing company founded by Kingston's test engineering team, to conduct component, module, and platform validation.

Kingston invests in the latest test equipment and continually improves our custom-designed test hardware and software. This combination of tools and talent allows us to test more thoroughly and more efficiently.

## Design Engineering Testing

Kingston's engineers design our memory and circuit boards, as well as the advanced automatic test equipment (ATEs) we use throughout our testing process. They work closely with leading semiconductor, processor, chipset, motherboard manufacturers, and PC OEMs to design memory that supports current and future computing systems. Kingston holds a seat on the Board of Directors of JEDEC (Joint Electron Device Engineering Council), the computer industry's standards body which develops the specifications for computer memory. Kingston's engineers actively participate in the memory technology subcommittees working on current- and next- generation memory products.

Kingston puts each new module prototype through a rigorous testing process to ensure the reliability, integrity, and compatibility of its design. Each new design is subjected to a series of reviews and tests, and each module is manufactured to be 100% compatible with the system or class of systems for which it is designed, or meet OEM and industry standard specifications—before it ever reaches the production phase.

## Design Verification

There are three reasons a prototype might not perform to specification: design, components, or manufacturing. Kingston engineers test for all three. The designs are verified using high-end Advantest ATE specification testers that test for any signs of signal degradation, marginal electrical parameters, or timing problems. If the prototype fails to perform to 'spec' in any area, it is rejected, and the cause—design, component or manufacturing—is analyzed and corrected. For each subsequent prototype, the entire process is repeated. When the prototype passes all tests—when it meets all design specifications—a small number are built for further testing.

## Signal Integrity Tests

Signal Integrity (SI) testing measures critical memory module timings and checks the condition of signals at critical transition stages. Traditionally, engineers used oscilloscope probing techniques to check signal waveforms in real time for electrical noise, jitter, voltage overshoot/undershoot as well as measuring critical timing parameters. Today, Kingston engineers use "rank margining tools" in special motherboards to generate an engineering "Eye Diagram" style chart of data outputs from the module. This Eye Diagram verifies memory module performance measured on the target platform type. This part of the design verification testing process ensures the Kingston memory module design is sound and ready for production shipment.

## Compatibility Testing

New memory modules are designed to handle the increased performance capabilities of emerging systems and the applications that will run on them. To ensure compatibility, we test our modules on the target system motherboard and on major operating systems (OS), from legacy to next generation.

## Software Benchtop Tests

From legacy computers to the most popular on the market today, Kingston ensures its memory modules work well with systems, application software and well beyond. We know the wide variety of applications in use today and test our prototypes on system boards with real-world applications, from CAD/CAM to firewalls to media players. Our engineers also run a broad range of other tests on the prototype, including independent benchmarks.

## Reliability Tests

Each Kingston memory module goes through multiple reliability tests. First, the module is put through up to 1,000 calibrated hot and cold cycles. Next, the module is subjected to temperature and humidity stress tests for up to 1,000 hours. Additionally, we put our modules through Guardband “four corner” tests that cycle them through another series of high-and-low voltage and temperature cycles.

## Production Testing

When the prototypes pass all these tests, the production process begins. Here, every module undergoes a battery of quality tests in three areas:

1. Manufacturing Quality.

As an integrated part of the automated manufacturing process, tests verify the quality of the manufacturing process—we test both electrical characteristics and quality of construction.

2. Performance Quality.

We put every module through a series of repetitive performance and stress tests, ensuring that it operates flawlessly at the extremes of every specification.

3. Reliability Quality.

Finally, our memory has to prove it can hold up over the most critical period of memory usage: the first three months which is the critical period where most modules that are not up to par will fail.

## Testing for Manufacturing Quality

Kingston’s manufacturing process is entirely automated on industry-leading surface mount technology (SMT) lines. From the moment the board and components come together to the time the boards are trimmed, no manual processes occur. SMT lines include automated optical inspection that verifies every traceline and solder point to ensure that the module is manufactured to specification. As part of our quality standards, a series of electrical tests are conducted at this point to ensure that every circuit meets the established specifications, prior to moving to full production.

## Testing for Performance

When we know the module was manufactured correctly, it then moves to production testing. Here we test to make sure it performs correctly under heavy stress. We need to be sure that every Kingston module meets its specifications for speed, storage, capacity, voltage and more, under extreme conditions.

### Chip and Cell-level Stress Testing

Every manufacturer establishes an acceptable threshold of bad cells for its shipped product. Kingston's threshold is zero. If even one cell tests bad (and keep in mind that a 16GB module contains 136 billion cells), the module is rejected. We perform two tests to ensure that every cell on every chip on every module is good:

1. Memory Interface Testing verifies that a memory module complies with protocol, timing, and other operational specifications to properly interface to the memory controller.
2. Memory Core Testing verifies that the memory storage area, or "core," can reliably store and output data.

Kingston tests 100% of the memory cells in each module several times, using a range of pattern tests that expose bad or marginal memory core cells. Specially designed patterns of bits (for instance, alternating 1s and 0s) are written to the memory module and read back. This checks for bit errors, as well as any impact the operation had on surrounding cells which would indicate a current leakage or signal coupling disturbance from one cell to another.

Kingston performs additional pattern tests for:

- Each cell's ability to retain data written to and read from it.
- Interference between adjacent cells.
- Each cell's ability to write and provide data within the specified timing specifications, including burst writes.
- Stable memory module performance under varying motherboard electrical conditions.

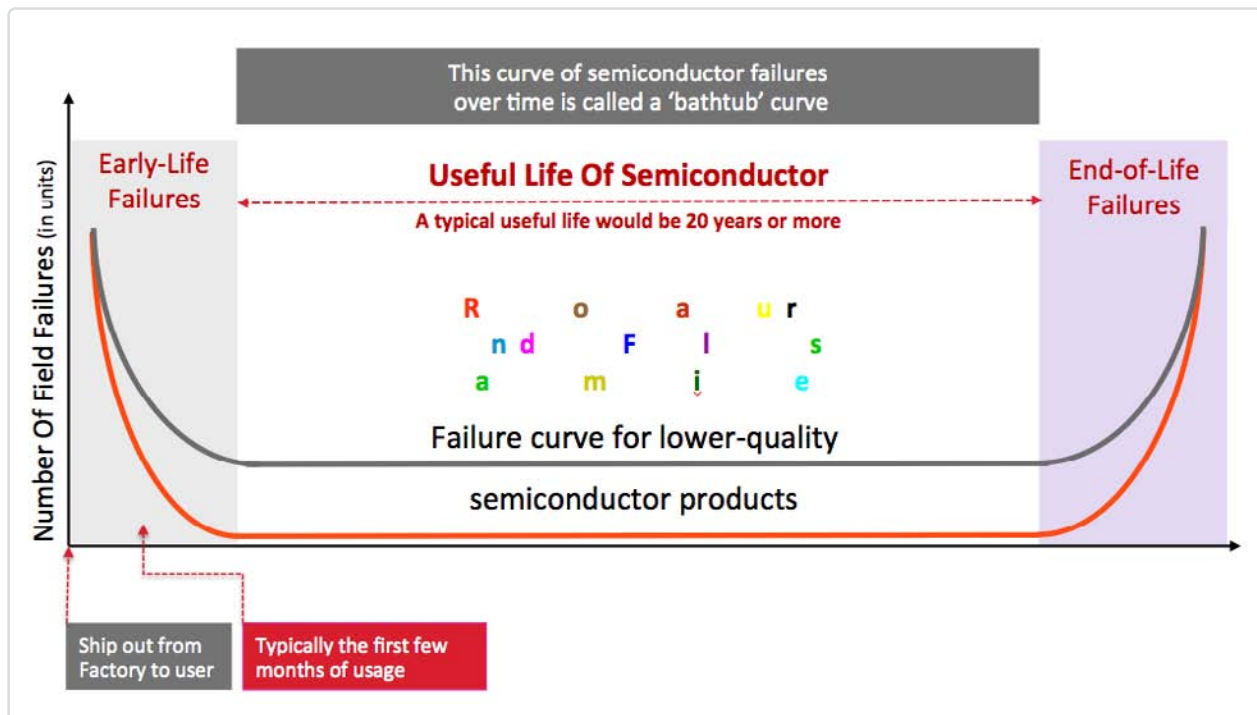
If any single cell—just one out of 136 billion—fails any test, the entire module is rejected. Kingston verifies that every memory module works flawlessly at its rated speed and voltage.

### Testing for Reliability

Up to this point we have subjected our memory to heavy stresses. Before a Kingston server module can be packed and shipped, it has to prove that it will hold up over a long period of time. That leaves one more test that must be performed before it reaches our final Quality Assurance gate: it has to pass our patented server burn-in process to screen early-life failures.



Early-life failures for semiconductors typically manifest during the first three months of use. Electronics engineers refer to this period as the semiconductor reliability (bathtub) life curve. Memory failures beyond this period are extremely rare. Kingston subjects every server-class module to a Kingston designed and patented burn-in procedure in our internally-designed KT-2500: a specialized tester that takes a chip through three months of performance and stress testing in a 24 hour period.



Each KT-2500 tests 500 server modules at a time, using specially-designed testing platforms called Advanced Pattern Testing Controllers. Memory modules are tested for up to 24 hours at 100° C/212° F. Tests are conducted at high voltage, and every cell is continuously exercised; this high level of stress testing results in screening out the marginal modules susceptible to early-life failure.

## Verifying Our Testing

To ensure the consistency of the 100% production testing process, Kingston Quality Assurance (QA) engineers place additional checks on the testing process itself. A quality assurance gate is set up after the modules pass all their tests to double-check testing effectiveness. Our QA engineers use Acceptable Quality Level (AQL) standard sampling methodology on every production lot. If modules fail the quality sample testing, the entire lot is put on hold and design engineers initiate failure analysis to investigate and resolve the issue. In some cases, the lot is subjected to a 100% retest on the same or different test platforms to address the testing issues.

## Kingston's Memory Life Testing

Kingston's Quality Assurance department regularly sends module samples to independent testing labs for life testing of our memory. Life testing involves the use of accelerated environmental stress conditions in special chambers to age the module up to 20 years. Life testing is very expensive, time-consuming, and must be done regularly for quality and reliability monitoring. The results of the accelerated testing help measure the consistent quality of Kingston's memory products as well as its high volume processes over time.

### KINGSTON CONSTANTLY TESTS ITS TESTS

Kingston subjects its production testing to ongoing testing of its own. Kingston test engineers start working on production test platforms during the early memory technology development process. They run lots of 10,000 units on both ATE and production testers, and then compare the results to see how deep testing coverage is, and to determine which platform will deliver best testing results. This process—we call it Correlation—results in a precisely-optimized final production testing environment.

## The Kingston Warranty

Kingston is so confident in our testing processes that we stand behind our modules with the simplest warranty in the world. Lifetime\*.

From the day you buy Kingston memory to long after your system warranty expires, the Kingston memory module warranty still protects you. No matter which machines the memory runs on. No matter what server components it runs with.

In addition to our limited lifetime product warranty, Kingston also has a regionally available service program designed to keep your systems up and running in the event of a memory module failure.

We couple the best warranty with the best service. KingstonCare may include service cost reimbursement, same-day cross shipping, an on-site spares program, and more. All backed up by Kingston support professionals and service partners who are always ready to help you work through any issue. Please check with your local Kingston representative for details on this service program.

## 100% Production Testing is the Difference

There is no doubt about it—Kingston's testing is the most rigorous in the memory industry. Kingston server memory is installed in and relied upon by many of the world's largest datacenters. The reasons for our server memory success are simple. Because we design our modules, we test that design. Because we carefully select our suppliers, we test their ability to build and deliver high quality components. Because we manufacture our modules, we test the quality of our manufacturing. Because we expect our modules to perform over a long time, we test that performance and that reliability. We design and patent testing equipment. We hold a seat on the board of JEDEC, where industry standards for memory are created. That's why you never have to worry about the quality, performance or reliability of Kingston memory. We tested it.

For more information on Kingston memory designed for use in server environments, please contact your regional Kingston sales teams or visit [www.kingston.com/server\\_solutions](http://www.kingston.com/server_solutions)

\*Kingston warrants to the original end user customer that its products are free from defects in material and workmanship. Subject to the conditions and limitations set forth below, Kingston will, at its option, either repair or replace any part of its products that prove defective by reason of improper workmanship or materials. Repaired parts or replacement products will be provided by Kingston on an exchange basis, and will be either new or recertified. All recertified products have been tested to ensure that they are functionally equivalent to new products. If Kingston is unable to repair or replace the product, it will refund or credit the lesser of either the current value of the product at the time the warranty claim is made or the purchase price.

