Kingston Testing
Going Beyond Standards

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1.0 Introduction

New memory technologies are being launched faster than ever in the computer industry, as memory bandwidth becomes increasingly critical to enable the newest and fastest processors and platforms. Poorly designed or poorly manufactured memory products can cause system instability, unreliability, or failure.

The computer industry’s major platform technology providers, including Intel® Corporation, AMD® Corporation, VIA® Technologies, Silicon Integrated Systems® (SiS) Corporation, ALi® Corporation, nVIDIA® Corporation, along with technology companies like Rambus® Inc., have made progress in addressing industry-wide memory module design issues through the use of Memory Design Validation programs.

However, the challenge of Memory Production Verification, key to manufacturing compliant memory modules in high volume, has been left to the memory module industry to voluntarily address. With the increasing complexity of memory technologies, large investments in advanced engineering, testing capabilities, and state-of-the-art manufacturing equipment are required by module manufacturers. These technology investments are required in order to consistently ship specification-compliant and compatible products in high volume.

Kingston® Technology Company, Inc. foresaw this evolutionary requirement in 1996, and invested over $25 million in engineering, manufacturing, quality, and testing facilities. Kingston continues to invest millions in our testing infrastructure to ensure delivery of only quality products. Kingston was also the first memory module manufacturer to get the ISO 9001 quality standard certification in our Fountain Valley, CA facility in 1994. Kingston's manufacturing centers in Taiwan, Malaysia, and China are ISO 9002 certified.

Today, Kingston is an industry leader focused on one key goal – to manufacture and deliver premium quality memory products in volume to our customers, which include: OEM, Distribution, Corporate Reseller, System Builder, Retail, SOHO (Small Office/Home Office) and other customers.

Testing expertise has become a major differentiator for Kingston – a key capability that allowed Kingston to become the world’s leading contract manufacturer of memory products to the global semiconductor manufacturers for many years.
2.0 Best Practices: Memory Chip Design Validation

Memory Design Validation programs include two parts:

- Memory Chip Design Validation
- Memory Module Design Validation

Memory chips are the most critical components of memory modules, as they store all the data for use by the computer's processor. Without reliable memory, the risk of data corruption or computer crashes greatly increases.

When a new memory chip technology is introduced, such as RDRAM or DDR, or when a new speed grade of existing memory technology is introduced, such as 1066MHz RDRAMs or 400MHz DDR, the platform technology companies will set up specific industry labs to provide Memory Chip Design Validation testing services. The Memory Chip Design Validation testing will verify that memory chips (and later, modules) meet the applicable specifications provided by the platform technology company or by JEDEC, the computer industry's standards organization.

The Memory Chip Design Validation testing, from a “Best Practices” perspective on current RDRAM and DDR programs, includes the following steps:

2.1 ATE SPECIFICATION TESTING OF MEMORY CHIPS

As new memory chip technologies are introduced, it is important to ensure that new DRAMs meet the specifications or standards defined by the memory technology enablers. The majority of memory technology standards are created, approved, and published by JEDEC. In some cases, such as RDRAM technology, Intel Corporation and Rambus Inc. defined the standards. Additionally, Intel Corporation has issued memory specification addenda to specific JEDEC specifications for Intel's platforms; other Tier I and Tier II system OEMs and semiconductor companies have also developed and utilize proprietary memory modules for use in high performance systems of various types.

Based upon the memory specifications, the global semiconductor companies produce engineering samples of the new memory chips and make them available to the platform technology companies, as well as to their top customers like Kingston for memory chip design validation testing.
The new memory chips are first tested on high-end memory testers known as Automated Test Equipment (ATE) testers, such as the Agilent®, Advantest®, or similar ATE platforms. These ATE testers, costing in excess of $1 million each for the hardware alone, have an accuracy rate that is measured in picoseconds (one-trillionth of a second). The testing performed on these ATE testers verifies that new memory chips meet reference electrical specifications as defined in the relevant technology standard.

### 2.2 MEMORY CHIP RLC TESTING

RLC is an engineering acronym which stands for the following electrical characteristics:

- R: Resistance
- L: Inductance
- C: Capacitance

Special analyzers, called Vector Network Analyzers (VNAs) are used to characterize the parasitic resistance, inductance, and capacitance for the signal pins of a memory chip. These electrical characteristics are measured for all input pins, Input/Output (I/O) pins, and clock pins.

The RLC electrical parameters are normally used in memory module design simulations to determine the electrical demands (loading) that memory modules will place on the computer's memory controller as well as the signal distortions or electrical noise caused by the memory modules. Excessive loading or noise impacts a system's performance and can additionally cause instability or memory failure.

RLC parameter measurement has become more critical for higher-speed memory technologies such as RDRAM, 333MHz DDR or faster, and DDR2 in the future.

Once new memory chips complete validation testing, the next step is to build memory module prototypes and validate them.

### 3.0 Best Practices: Memory Module Design Validation

With every new chip memory technology that is introduced, there are new memory module designs that need to be validated. The platform or technology companies seeking to enable new memory module technologies will set up validation labs to provide the following Memory Module Design Validation services to the industry:
3.1 ATE SPECIFICATION TESTING OF MEMORY MODULES

Memory modules being validated are checked on ATE testers to ensure that they meet the applicable module specifications from JEDEC or chipset manufacturers. These memory modules must be built with validated memory chips (DRAMs) if required by the specific validation program.

The ATE specification testing looks for potential problems caused by the interaction of the memory module components, which may cause potential signal degradation, marginal electrical parameters, and timing problems. The PCB (Printed Circuit Board) design, layout, and fabrication quality, as well as the resistors, capacitors, the EEPROM (Electronically Erasable Programmable Read-Only Memory) chip containing the SPD data, PLL (Phase-Locked Loop chips), and register chips are all critical contributors to a module’s quality and performance.

3.2 REFERENCE SYSTEM VALIDATION OF MEMORY MODULES

All certifying companies require System Validation on reference platforms (called Customer Reference Boards or CRBs), using custom software and proprietary test methods that they provide to selected testing labs. Reference platforms are special motherboards, typically built before production motherboards are shipped, that contain the new chipsets, sockets and/or processors. The memory module’s SPD data verification and, in specific cases, Power Cycling and Power Management tests are also included in Reference System Validation.

As modules pass the reference system validation process, the part numbers are listed on the platform company’s validated memory websites. These websites allow customers to view which modules have passed the Reference System Validation testing.

The four different tests used in system validations will be described in the following sections:

3.2.1 GUARDBAND TESTING (also called Margin Testing)

Guardband Testing is used to stress memory modules to ensure that the modules have a sufficient operating margin at the edges of the specified operating ranges. Guardband testing in special temperature chambers is key to ensure that memory modules meet high quality and high reliability standards.
The 4-corner Guardband testing (named after the matrix shown below) stresses memory modules under the following four conditions:

<table>
<thead>
<tr>
<th>Lower Operating Voltage Limit</th>
<th>Higher Operating Voltage Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Guardband tests are very effective in detecting quality problems with any of the components used to build memory modules. All four corners represent extreme test conditions.

### 3.2.2 SPD DATA VERIFICATION

The Serial Presence Detect (SPD) data is programmed into a special chip (EEPROM) on memory modules. The SPD chip contains critical data, including memory timing parameters, which are read by the computer motherboard during the boot up sequence. SPD Data Verification involves checking its contents for invalid entries as well as to verify that the data matches the module information provided by the memory module manufacturer. Incorrect SPD data can cause computer performance and stability issues.

### 3.2.3 POWER CYCLING TESTING (PCT)

Power Cycling testing subjects the memory modules being tested to repeated system reboot cycles. Power Cycling usually tests both Warm Boots (rebooting the system by resetting it) and Cold Boots (rebooting the system by completely turning off the electrical power, and then powering it back on).

### 3.2.4 POWER MANAGEMENT TESTING (PMT)

Power Management testing involves the testing of power saving modes (called S1, S3, etc.) to ensure that the tested platform can enter and exit the power saving mode without memory errors or problems.

### 4.0 Kingston’s Memory Module Design Validation Capabilities

Kingston supplements the Memory Design Validation testing that is conducted by the platform technology companies with its own internal validation testing capabilities.
Kingston has set up a proprietary validation program with Advanced Validation Labs® (AVL), Inc., which specializes in conducting validation, compatibility, and reliability testing for memory products. Kingston and AVL have extensive memory chip and module design validation capabilities and work directly with many of the key platform technology companies on new memory technology development projects.

4.1 KINGSTON-SPECIFIC SUPPLEMENTAL MEMORY DESIGN VALIDATION TESTING

Whenever a specific Memory Design Validation program does not fully address the best practices validation processes described earlier, Kingston is able to leverage its strategic industry partnerships and use its internal resources along with AVL to conduct supplemental validation testing.

For example, when PC2700 memory modules were first launched, an industry-wide Memory Chip Design Validation program was not available for several months after the release of platforms. Yet, Kingston used its own ATE tester resources to validate the new 333MHz DDR memory chips and ensure that they were compliant to the specifications prior to shipping the PC2700 modules to end-customers. These engineering initiatives resulted in Kingston being able to launch the new technology and fulfill customer orders quickly and in volume, with AVL-validated memory chips and modules.

4.2 ENGINEERING VERIFICATION OF PCB DESIGN AND MANUFACTURING QUALITY

The Printed Circuit Board (PCB) on which the memory module’s memory chips and other components are assembled onto plays a critical part in the overall quality, reliability, and performance of Kingston’s products. That’s because the PCB routes all the critical data, address and control signals as well as the supply voltages from a system board to the memory chips.

A typical PCB consists of many “sandwiched” layers onto which signal lines (called “traces”) are etched to make the connections from the module’s gold fingers (that plug into a memory module socket) to all the components on the module. Each trace is typically 0.1mm or 0.0039 inches wide, which is narrower than a single human hair.

PCBs are complex networks of traces that must be properly designed and precisely manufactured for optimal performance. The higher a memory module’s rated speed, the more critical the design and manufacturing expertise that went into designing and building the board. Kingston’s design engineers have designed memory modules since 1987 and, by working closely with technology partners including chipset manufacturers such as Intel, VIA, SiS and others, are always working on the newest and latest memory module designs to be introduced to the computer market. Kingston engineers then provide custom designs, specifications, and quality requirements to leading PCB manufacturers who build the PCBs to Kingston’s exacting standards.
4.2.1 PCB DESIGN VALIDATION TESTING

PCB validation testing includes the measurement of impedance, attenuation, delay, crosstalk, and other key parameters on PCBs. When Kingston engineers design PCBs or panels of PCBs for high-volume manufacturing, they include special test points or test "coupons" that can be probed using state-of-the-art probe stations that utilize very specialized testing equipment such as Vector Network Analyzers (VNA) or Time-Domain Reflectometers (TDR). In addition, memory modules built using the PCB being validated are probed with an oscilloscope to measure critical signal waveforms, thereby ensuring that the PCB design meets the specifications for the module. Often, computer simulations are used during the PCB design phase to predict electrical behavior prior to fabrication, thereby speeding up the PCB prototyping process.

After modules pass these initial engineering tests, then they are regularly subjected to PCB manufacturing and quality testing.

4.2.2 PCB MANUFACTURING AND QUALITY TESTING

As an ISO 9001-certified manufacturer, Kingston closely monitors the quality of PCBs manufactured by its suppliers. Every PCB supplier is closely monitored by Kingston quality engineers. Every supplier has to provide quality assurance data with every lot shipped to Kingston, in addition to successfully passing regular on-site audits of the PCB manufacturing facility by Kingston engineers. This close attention to detail ensures that PCBs meet Kingston's high quality standards.

In addition to auditing key quality data provided by PCB manufacturers, Kingston quality engineers order regular examination of PCB cross-sections under high-power microscopes. These cross-sections can reveal materials or manufacturing process defects that can impact a memory module's functionality or reliability. In addition, every PCB lot received by Kingston is subject to incoming inspection where PCBs are randomly picked from every lot to undergo visual inspections, electrical measurements, and other PCB testing (described in 3.1.1). After modules are built, quality engineers can send module samples to external labs for reliability testing such as Temperature Cycling Testing (TCT) and Thermal Humidity Bias (THB) testing (see Section 8 for details).
In the module industry, PCB quality is often sacrificed in order to save some manufacturing costs. Kingston proudly pays more for its PCBs than many module vendors in the industry to continue to deliver premium quality products.

4.3 SIGNAL INTEGRITY TESTING ON MEMORY MODULES

This testing is also known as Signal Quality and Integrity testing. The industry's Memory Design Validation programs do not generally include Signal Integrity testing. Kingston works closely with AVL to conduct these important tests on all new technology memory modules.

Oscilloscopes are used to probe key signals going into and out of a memory module. Trained AVL technicians check the clock, address, control, and data signals, verify that the electrical waveforms appear as they are supposed to, and that the module is not degrading any critical signals or causing noise that may make a computer unreliable.

Noise can be thought of as extraneous signals that, beyond specified levels, can cause memory failures or raise long-term reliability concerns.

Problems detected in these tests can point to quality and potential reliability issues with the memory module's design and major components, and will require further investigation by engineers.

4.4 COMPATIBILITY TESTING ON OEM SYSTEMS AND SPECIFIC MOTHERBOARDS

Because of the differences in the design of computer motherboards, Kingston believes that it is important to test memory modules in specific OEM systems or major motherboards to verify compatibility (the industry's Memory Module Design Validation programs only test on reference platforms).

This section will cover Kingston's proprietary testing of memory modules on specific OEM systems, and ValueRAM's testing process for leading motherboards.

4.4.1 KINGSTON'S SYSTEM-SPECIFIC COMPATIBILITY TESTING

Compatibility testing is a real-world testing process that recreates the demands of heavy use on a specific OEM system or motherboard. It verifies the functional quality of a memory module's design, components, manufacturing, and factory testing in a designated system.

Compatibility testing of memory modules on specific systems is a core competency at Kingston - Kingston engineers have produced and shipped tens of millions of system-specific memory modules since 1987.

When new computer platforms are released, Kingston engineers verify that memory modules pass system diagnostics as well as compatibility testing in the systems they are designed to support.
A number of special memory tests as well as system-recommended operating systems and software applications are run for extended periods of time to check that the memory module design and build are compatible on a specific platform.

For example, Kingston engineers will conduct a variety of tests, including testing minimum and maximum memory loads (filling memory module sockets to the maximum number of memory banks supported by the chipset or system board), mixing different Kingston modules built with memory chips from different semiconductor manufacturers, and mixing Kingston and OEM modules. They will test different operating systems and applications as required, and try different computer configuration settings to check for possible errors.

Kingston's compatibility testing process is one of the most comprehensive in the memory module industry. Kingston engineers have developed a wide-ranging memory testing expertise that can only be gained from building and testing tens of millions of reliable, high quality memory modules. This special expertise enabled Kingston to become the #1 provider of memory manufacturing and testing services for the global semiconductor manufacturers.

4.4.2 VALUERAM™ MOTHERBOARD-COMPATIBILITY ASSURED PROGRAM

Kingston is working closely with the leading motherboard manufacturers, including Asustek®, Micro-Star International® (MSI), Tyan®, Gigabyte®, SuperMicro®, and others to conduct pre-release compatibility testing of Kingston ValueRAM™ memory modules on new motherboards.

Kingston's Design Engineering department coordinates the program, which involves either the motherboard manufacturer or Kingston conducting the compatibility testing of ValueRAM modules on many of the new motherboards. The qualified modules are then listed on ValueRAM's website and each motherboard manufacturer's website.

This engineering-level relationship often extends into new motherboard development processes, as seen when Kingston built the first prototypes of 32-bit RIMM modules for Asustek and developed new 1GB and 2GB server modules for SuperMicro and Tyan platforms. Kingston also builds many of the newest technology memory module prototypes for chipset manufacturers or technology companies.

The extension of Kingston's memory validation program to include specific compatibility testing on many of the newest motherboards will help system builders increase their customers' satisfaction and deliver high quality, reliable memory modules.

5.0 Kingston’s Memory Module Production Verification

Kingston also set up its own Memory Module Production Verification process to pick up where the industry's Memory Design Validation programs left off – ensuring Kingston's capability to manufacture, test, and ship premium quality memory modules in high volume.
Kingston’s Memory Module Production Verification process includes the following steps:

5.1 PRODUCTION TESTER VALIDATION

Production tester platforms and testing processes can only be effective if they are set up by knowledgeable engineers who understand how to build memory test platforms and how to customize testing software to screen out faulty memory modules and chips.

Production testing effectiveness cannot be measured by testing yields, as the poorest testing processes can be made to deliver 100 percent “good” yields. “True” testing effectiveness is the ability to catch an extremely high percentage of the modules that could potentially fail during end-customer use.

As memory prices fall, testing effectiveness is often compromised by certain memory module companies who cut their testing investments and processes to reduce costs, sometimes even skipping testing completely to deliver lowest price modules. Often, customers are unaware that the modules they are purchasing have had minimal or no testing. Kingston does not operate in this manner as 100 percent production testing is done regardless of market conditions.

Kingston has built its reputation on delivering premium quality memory modules, and has always emphasized high-effectiveness 100 percent production testing for all its shipped modules. Kingston’s test engineers actually start working on production test platforms during the early memory technology development process. A good look of the many testing issues confronted and addressed by the test engineers is provided in the Kingston KT2100 Test System White Paper, available at www.kingston.com. The KT2100 Test System utilizes special system boards that have been modified by Kingston engineers to enhance testing effectiveness. These modified system boards subject memory modules to extreme-condition testing to maximize compatibility and reliability screening.

Once a test platform is developed using modified system board testers or high-volume ATE platforms such as the multi-million dollar Advantest platforms Kingston also uses, it must be validated to ensure that its testing yields are optimal. For example, a tester may pass 100 percent of modules if it checks only a few parameters. Kingston engineers optimize the production testers to meet high testing coverage before modules are shipped out. This production testing validation process is key to ensuring effective, high volume testing.

The validation process for a new test platform is similar to the process used to validate the production process for new memory technologies (to be covered in the next section).
When a new test platform is set up (including all the hardware and software components), Kingston test and quality engineers will test lots of 10,000 or more modules on ATE testers (such as Advantest testing platforms) as well as on the new production test platforms. Instances where a specific module passes on one platform but fails on another will be extensively analyzed to determine if test coverage issues need to be addressed. For example, during Kingston's launch of PC2700 DDR memory modules, ATE and two modified system board platforms were used to test over 15,000 modules; the results were compared, and any testing discrepancy was analyzed and addressed. Kingston engineers specify whether production testing will be done on ATE testers or customized testers to ensure the best test effectiveness for specific modules.

This process, also called “Correlation” because multiple tester platforms are being compared against each other, is a complex process that consumes time and resources, but is key to Kingston's quality program. The results allow Kingston engineers to finalize a customized production-testing platform that meets stringent quality requirements.

For example, Kingston's RC2000 Rambus tester (designed and built by Kingston's engineers) was verified by Intel to have a testing effectiveness, measured at a very low 500 Defective Parts per Million (DPM) – an industry-leading achievement for low-cost, high-volume system board testers.

5.2 HIGH VOLUME PRODUCTION VERIFICATION

Kingston engineers have instituted a high volume production verification process, which verifies that Kingston's standard manufacturing process can consistently deliver compliant memory modules. Kingston is in a select group of memory module manufacturers, mainly the global DRAM manufacturers, which conducts extensive production verification studies.

For example, before Kingston shipped any production-grade PC800, PC1600/2100 or PC2700 and faster memory modules, Kingston engineers conducted verification testing on many lots of memory modules in its manufacturing centers worldwide.

Production lots of at least 10,000 memory modules were tested on ATE platforms using the programs used for module technology specification testing; then, these modules were tested on multiple production motherboards to check for compatibility. Module samples from different production lots were also sent to AVL for Guardband and Signal Integrity testing.

Results of this extensive testing are analyzed by Kingston's test and quality engineers. Any discrepancy in test results (such as modules failing on one platform and passing on another) need to be thoroughly investigated by engineers and resolved.

These high-volume production verification studies are a systematic method for ensuring the true effectiveness of the entire manufacturing and testing processes.
6.0 **Kingston’s 100% Production Testing**

Kingston’s extensive Memory Production Verification process, described in the previous section, ensures Kingston’s ability to start volume production of specification-compliant memory modules.

Kingston tests 100 percent of its memory modules during the production process for several minutes to ensure their compatibility and functionality.

Kingston design and quality engineers regularly monitor production processes, field returns, and other customer data to ensure the high effectiveness of this 100 percent production testing process. Dedicated test engineers continually enhance the test platforms, test software, or testing processes to maintain Kingston’s high quality standard.

For more than 15 years, Kingston has developed a portfolio of specialized test software that test memory module in two different ways:

6.1 **At-speed Memory Module Testing**

At-speed testing is important for verifying that memory modules work properly when tested at their specified speeds. When high-speed memory technologies are launched, new testers may often need to be designed or purchased to support the manufacturing of memory modules. To reduce test costs, some memory module manufacturers cut corners and test modules at a lower speed on older test platforms. Kingston believes that this practice ultimately leads to poor customer satisfaction, as customers essentially become the final production testers for the high-speed modules.

Whether memory modules are rated at 333MHz or 1066MHz, Kingston tests every module at its rated speed. This ensures that memory modules and chips can properly operate at their highest rated speed. Kingston’s reputation for quality starts from having its modules work the first time, straight out of the box.

6.2 **Memory Chip and Cell-Level Stress Testing**

Testing memory modules involves two levels of testing:

- **Memory Interface Testing**: this testing verifies that a memory module complies with the protocol, timing, and other operational specifications to properly interface to the memory controller
- **Memory Core Testing**: this testing verifies that the memory storage area, or "core", of memory chips can reliably store and output data.
Kingston tests 100 percent of all the memory cells, also called the memory core, at least several times. Through a proprietary test process that is constantly evolving, memory modules are subjected to a series of tests that include various pattern tests. Pattern tests seek out bad or marginal memory core cells or bring out module design or manufacturing issues that cause data corruption.

In a pattern test, a specially designed pattern of bits is written to the memory module and read back, checking for bit errors. In one pattern, for instance, 1’s and 0’s may be written in alternating fashion and read back. In another, 1’s and 0’s are quickly written to cells to check if surrounding cells are impacted – if there is “current leakage” or “signal coupling disturbance” from one cell to another, a memory cell may see its value change from a ‘0’ to a ‘1’, thereby corrupting data.

Customized patterns test the memory core to check 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

Many of Kingston’s pattern tests have proven themselves over the years for both commercial and OEM customers, demonstrating their ability to root out bad DRAM cells and catch timing problems.

7.0 Kingston’s Quality Gates for Checking Testing Process Consistency

To ensure the consistency of the 100 percent production testing process, Kingston’s quality assurance engineers place additional checks on the testing process.

A quality assurance gate is set up after the modules are first tested to double-check testing effectiveness (the “gate” terminology is analogous to a real gate; if the gate is closed, memory modules cannot continue to the packing and shipping steps unless released by a quality assurance engineer).

Quality engineers can utilize the same (or even different) tester platforms to test samples from the lot; if samples fail the quality testing, the lot is put on hold and design engineers initiate failure analysis to investigate and resolve the hold. In some cases, the lot is subjected to a 100 percent retest on the same or different test platforms to address the testing issues.
In some cases, quality engineers will request “mini-validation” testing on ATE platforms to analyze the failures, or send the modules to AVL labs for Memory Design Validation testing (such as Guardband Testing). The results help the Quality Assurance and Design Engineering departments take appropriate corrective actions.

8.0 Kingston’s Reliability Testing to Ensure Long-Term Product and Process Consistency

Kingston’s Quality Assurance department monitors memory module reliability on an on-going basis. A sampling of memory products is regularly sent to testing labs for reliability testing.

Reliability testing includes special tests that involve accelerated environmental stress testing in special temperature chambers. Reliability testing is very expensive, time-consuming, and is done periodically 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. After the reliability testing is completed, engineers can review the test results and determine whether there are any quality problems or reliability concerns. Periodic reliability testing is key to monitor the overall process and component quality as well as checking quality statistics.

On a side note, Kingston procures its memory chips directly from the global semiconductor manufacturers or from Payton Technology Company, Inc, a sister company which provides custom chip packaging and testing services for Kingston, utilizing wafers from these same semiconductor manufacturers. These directly-sourced memory chips undergo 24–48 hours of burn-in testing prior to shipment to Kingston. Kingston’s engineers qualify every DRAM manufacturer and review their memory chip reliability testing data prior to using them on Kingston memory modules.

Kingston’s reliability testing feeds back important performance data to the design, quality, and test engineers who use this information to improve component procurement, module engineering, manufacturing, quality, and testing processes. Thus, these tests result in even higher levels of product quality while keeping costs within customers’ expectations.

Typical reliability tests conducted on Kingston’s memory modules include:

- **Thermal Humidity Bias (THB) Test**: This test is also called 85-85 because it tests memory modules at 85 degrees Celsius and 85 percent relative humidity. THB testing generally takes up to 1000 hours.
• **Temperature Cycling Test (TCT):** This thermal stress test, conducted in special ovens, subjects the memory modules to repeated hot and cold cycles for up to 1000 cycles, which may take weeks to complete. Temperature cycling simulates the environmental wear-and-tear of modules over time.

Failing modules are investigated by Kingston’s Design Engineering, Test Engineering and Quality Assurance departments for root causes.

Kingston’s Quality Assurance department provides the reliability testing results to the Kingston Quality Team, which then can initiate ISO 9000 process improvement initiatives across all departments worldwide.

### 9.0 Conclusion

Kingston is the memory brand that assures customers of strong engineering, manufacturing, and testing capabilities. In fact, Kingston has designed and built its own proprietary testers for over 15 years, and has been granted several engineering and testing patents by the U.S. Patent Office.

There is more to the Kingston testing edge: Kingston’s Memory Design and Production Validation processes continue to differentiate Kingston from other memory providers. Kingston continues to invest into research and development to be ready for the next generation of DDR technology, called DDR2.

Kingston’s success is best measured in the number of satisfied customers worldwide, in over 70 countries. Kingston continues to invest in its engineering and testing capabilities to be the most trusted supplier of premium memory modules.

**For additional information please visit:**

[www.kingston.com](http://www.kingston.com)

[www.valueram.com](http://www.valueram.com)