



Kozio

***Improve Product
Quality and Reliability
with In-System
Diagnostics***

Introduction

Product quality and reliability (Q&R) are first-order design requirements for any product development. Measuring and monitoring quality over time permit product development and manufacturing teams to know, objectively, if the product is meeting Q&R goals at any time during its lifecycle, from initial design stages to volume product shipments. Meeting stringent Q&R goals is becoming more difficult, as teams develop increasingly sophisticated products, containing more complex and higher-integration components, under tight schedules and with fewer resources than ever before. Now, more than ever, product teams must do more, must do it better, and must do it with less.

In embedded systems, hardware diagnostics is a key determinant of product Q&R. Hardware diagnostics comprises two categories: *design verification* and *hardware validation*. Design verification refers to analysis conducted on prototype boards to identify design errors, to ensure that the design correctly implements the specifications. Hardware validation

Design verification

Facilitates board bring-up, isolates design errors on prototype boards, and exercises the system during compliance-to-specification testing.

solutions are applied during product development and during volume manufacturing cycle to isolate malfunctioning units, to ensure that each and every assembled unit also

Hardware validation

Certifies manufactured boards, including those distributed to application development and test teams; shipped to customers; and evaluated in support and return scenarios.

meets specifications. An effective diagnostic solution ensures problem identification at the earliest possible time, and provides the most efficient means of resolving design problems. When implemented correctly, a comprehensive verification and validation solution minimizes costly board spins; prevents undetected errors from reaching customers; speeds

code development and system integration; and reduces manufacturing and support costs. This paper explores the challenges of implementing effective verification and validation solutions, highlighting the benefits of employing a single software platform that can address complex diagnostic requirements throughout the product lifecycle, from genesis, through design, manufacturing and in-field use, to end-of-life.

Common Design Verification Issues

Diagnostics Written By Hardware Engineering

For a new design, a hardware engineer may be tasked with writing diagnostics code. From the hardware engineering perspective, however, the fundamental goal is to deliver a working board – one that performs to specification – to the firmware and software groups. If the hardware engineer does not fully understand all of the application code operations, or if time constraints preclude anything but minimal coverage, then the diagnostics cases may be written too narrowly, only covering specific test points.

Reducing the emphasis on design verification increases the risk of passing on undetected errors to later stages of the development cycle. In the worst-case scenario, a design error reaching a customer can be highly detrimental to a company's reputation and financial performance. Even if discovered during product development, hardware design errors cause:

- Additional board spins that delay release;
- Resource conflicts that require software engineers to resolve complex issues, while having to learn unfamiliar processors, new peripherals, and additional features and requirements;
- Significant cost overruns, to identify and resolve hardware failures;
- Missed revenue opportunities.

Board spin

The process of producing another board revision, incorporating rework and other changes into the hardware design.

In addition to functional design errors, minimized verification testing overlooks other critical elements, such as performance. By not fully testing system performance until later in the development cycle, or by relying on simulation models to accomplish this analysis, designers assume the risk of not discovering performance bottlenecks until it may be too late to respond, resulting in a less competitive product.

Software Engineering Performs Dual Roles

In some companies, the firmware team may be held accountable for developing diagnostics. Similar to hardware designers, these individuals often lose focus on the

Board bring-up

The process of running software on a new hardware design, exercising the hardware components for the first time.

need for comprehensive design verification capabilities, based on the need to meet a stringent development schedule. Pressure to make do with only minimal diagnostics work typically results in an application that supports only board bring-up, and even then, barely. In this scenario, an overly simplistic diagnostic tool may not

provide the flexibility and extensibility to write new cases or modify existing tests, which may be required for issue resolution in the future.

Using Application Code for Verification

In certain instances, engineering teams may simply run the application to verify a design. This option relies on the fundamental assumption that application testing will exercise fully the hardware platform, as it will be used in the field. This assumption is far from valid, given the complexity and variety of operating modes in today's complex embedded systems.

This alternative also adds significant complexity to defect root cause analysis. With additional variables to be considered, including software code that may not have fully undergone QA testing, problem isolation can be a daunting task.

Finally, using application code for diagnostics necessitates that the software coding and hardware design be completed at the same time. This methodology presents an

inordinate degree of risk to teams working to avoid undetected design flaws. System integration is slowed as defects are followed from hardware to software and back to hardware again (and vice versa).

Staffing Dedicated Diagnostics Engineers

To avoid the resource constraints and risks associated with developing diagnostic solutions internally, many engineering managers opt to hire one or more diagnostics specialists, frequently on a contract basis. This option can be an effective strategy depending upon the degree of skill exhibited by the engineer as well as the duration of the engagement.

While porting an existing solution to a new platform may only require a few months of effort, writing a comprehensive diagnostic application from scratch can take up to 18 months, depending upon functional and platform-specific requirements. Therefore, the implementation of exhaustive yet cost-effective solutions is difficult. Factoring in the time required to recruit candidates who possess the requisite hardware and firmware knowledge, hiring a diagnostics specialist can be a costly and time-consuming endeavor, one that adversely affects an embedded project's schedule and budget.

Compliance Testing for New Designs

Once a board is functioning properly, the next task performed by hardware engineering staff is compliance testing. This stage may involve environmental, emissions, voltage/frequency margining, protocol compliance, product safety, or other forms of testing.

In order to successfully complete compliance testing, software must be available to fully exercise the platform. This can become an issue when the software to be used for testing is not mature enough to reliably complete this process. The ultimate goal is to perform these tests before the first board spin so that any required design changes can be incorporated, and promptly tested again.

Common Hardware Validation Issues

Validating Boards During Development and Testing

Development teams are generally required to provide a mechanism for validating boards used in software development to ensure that they are functioning properly. Boards that are exhibiting incorrect behaviors must be identified and isolated to avoid unnecessary debugging activities.

Best practices for a device manufacturer call for the ability to reliably and easily validate that any given board is functioning properly at all stages of the product lifecycle.

To accomplish this step, development engineers will typically run the same program on two boards, noting any differences, to confirm the faulty unit. Obviously, the challenge with this method is that a highly stable program, itself correct and complete, must be available for use when problems are encountered.

Validating Boards During the Manufacturing Process

It is very common for companies to supply an application to manufacturing as a means of validating new boards. This process enables quick examination of a newly built board to ensure that all components are functioning properly. After completing this step, the final application is programmed on to the platform, readying it for shipment to the customer.

This solution can be built by modifying the software application to support specific manufacturing requirements, including validation of all peripherals, I/O channels, and board memories. Similar to the needs for design verification, this methodology immediately

The optimal validation method tests all components automatically, rapidly producing clear pass/fail results.

introduces resource availability and timing issues. A senior software engineer who fully grasps the application operations, hardware platform, and manufacturing test requirements is required to deliver very stable code before product manufacturing begins.

The optimal method is to provide an automatic test suite that is executed on the targeted platform, testing out all components, and providing a clear pass/fail indication. In addition, it is useful to log and archive all tests performed, board information, date, time, and other pertinent information. For some processes, it is necessary to update boards with specific data, such as a MAC address for an Ethernet chip, and this task must be addressed with the delivered technology. The challenge for most companies is finding the time and resources to support these efforts.

Validating Shipped or Returned Boards

Device manufacturers also typically have a need to certify a board that is in use at a customer's facility. Generally, if field engineers or sales support individuals suspect a faulty device, it is replaced and sent back for analysis. Whether completed onsite or not, it is important for vendors to provide a reliable mechanism for easily identifying malfunctioning units.

The lack of an effective board validation capability can result in missed opportunities for savings in manufacturing and support. By providing a simple process for certifying manufactured boards, even a novice technician can be relied upon to quickly isolate malfunctioning boards, resulting in an effective means for identifying manufacturing problems, limiting the number of bad shipments, reducing the number of returns, and accelerating support calls.

Finding the Resources to Support Board Validation

To avoid the resource conflicts described above, many device manufacturers will hire a dedicated individual or team to support the manufacturing process full time. This team is solely responsible for providing an application that can be used by the manufacturer to test all boards. The downside to this approach is the financial burden that adversely affects the overall project budget.

Kozio Software - A Single Source Solution

Kozio software provides a comprehensive and high-integrity diagnostics solution, consolidating design verification and hardware validation capabilities into a single platform. As readily available software, Kozio delivers an alternative to internally developed solutions, overcoming many of the budgetary, scheduling, and resource constraints discussed in previous sections.

Kozio's innovative diagnostics platform provides comprehensive functional and performance tests for all board components, including the processor, memory, busses, and peripherals for storage, connectivity, display and audio. Using Kozio software, engineers can:

Kozio software
The fastest path to fully-validated hardware

- Facilitate board bring-up;
- Isolate critical errors on prototype boards early on;
- Exercise board components for compliance testing;
- Rapidly certify manufactured boards during and after the product development cycle;
- Identify the performance characteristics of the design, independent of the application code, without relying on simulation models.

Facilitating Board Bring-Up

Within a few days, the Kozio development team will deliver personalized software to support a unique embedded design. Unlike typical embedded software products, the Kozio test software, boot manager, and application loader are pre-compiled into a single image, requiring no additional drivers or coding prior to use. To begin testing, designers simply download the image into Flash or RAM memory on the target platform. By timing the delivery of diagnostics software to coincide with the arrival of prototype boards, designers can immediately initiate board bring-up. A thorough report detailing the result of our comprehensive test and diagnostics runs can be available within minutes of board power-up.

Error Isolation

The Kozio software provides an interpreter that allows the execution of a full test suite for verifying a design or an individual test for fault isolation. Test status is provided interactively through an ANSI compatible terminal emulation program, such as TeraTerm, or through Kozio's own ValidationAssistant™. Status is displayed for each test case and test suite. All errors are documented via a unique error code, providing an easy mechanism for tracking and processing test results.

A comprehensive library of test suites for validating components is included with each license. New test cases can be written in an easy to learn script language or in C, enabling the inclusion of customized tests in the test database. These tests can access

custom IC designs (ASICs or FPGAs) or other components, and can be incorporated into larger test suites to increase both the depth and the breadth of total test coverage.

Compliance Testing

The delivered diagnostics software provides the ability to exercise the entire platform with continuous looping, supporting most compliance testing requirements including those involving emissions, power, and performance testing.

Reliable Manufacturing Testing

The Koizio tool suite provides an extensible test process that can be configured by the user or by a Koizio developer to support unique manufacturing test requirements. This includes the ability to fully test a board, clearly report pass/fail results, execute in-system programming and log the information to a database for future reference.

Performance Characteristics

With Koizio software a designer can determine best-case values for various characteristics of a new board design, independent of the software application.

Cleaning Up the “Bone Pile”

A complete diagnostics solution addresses board bring-up, design verification, board validation, manufacturing test, picking through the bone pile, and provides fault isolation on returned boards.

The term “bone pile” is sometimes used to describe boards that failed the automated manufacturing test. Such boards are set aside for fault isolation analysis at a later date. Software that can immediately assist in fault isolation, by pinpointing problem areas, is of value for reducing the

“Bone Pile”
Boards that failed to pass automatic manufacturing test

frequency of failed boards.

How It Works

To complete delivery of diagnostic software personalized to a unique target board, Koizio developers require only a hardware specification, needing limited or no direct interaction with the hardware designers. Additional development time and customer input may be necessary to support complex logic such as a proprietary ASIC or FPGA. Each Koizio software license is tied to a specific hardware platform, allowing unlimited internal copies for each platform.

In as little as two days, Koizio can produce an application and test database that covers all board components, providing full diagnostics capability including design verification and hardware validation. The software executable needs only to be downloaded to the target circuit board, where it runs directly, at full operating speed, in order to provide the most accurate test points.

Koizio Flash-N-Run™
Provides the ability to deliver software ready for immediate use on a custom platform.

The standalone application Koizio delivers represents a complete system, including a boot manager, diagnostics application, test executive, test database, and scripting language.

The interactive interpreter is accessed via a serial or Ethernet cable connecting the target platform and host computer, with the host running Koizio's ValidationAssistant™ or an ANSI compatible terminal emulation program. When the target is powered on, Koizio software automatically runs, accepting commands via the host program.

Using the interactive interpreter built into the application, the user can run any individual test method or test suite contained in the comprehensive test database. This step is as simple as entering "test.sdram" or "test.platform" at the command prompt. A new test case can be created at the command prompt and saved for independent use or for running multiple times in a loop.

Custom functions, written in C, can be developed and added to a special directory that automatically builds the module and adds it to the test database.

Test scripts written on a running target can be uploaded to a host as a text file. This, coupled with support for downloading scripts to the target, provides an easy mechanism for sharing test scripts across multiple platforms. Users writing scripts also have full access to an extensive set of high level programming constructs as well as to any test primitive in the test database.

Benefits of Koizio's In-System Diagnostics

Koizio's software delivers, out-of-the-box, a high-integrity validation suite for comprehensive at-speed functional testing, personalized to a specific 32-bit embedded circuit board. Proven on over 130 unique board designs, the Koizio solution brings user benefits by accelerating board bring-up, by automating production test, and by offering powerful in-field and power-on self-test capabilities.

Deploying Koizio software increases the predictability of the hardware design process, and accelerates the time to fully-validated hardware. With the hardware platform stabilizing to a robust and reliable status early, software developers are able to more rapidly bring up the application software, since it is built on a solid foundation.

Fewer validation escapes pass through this comprehensive process, reducing the number of latent defects that could otherwise escape to downstream users or customers, and improving the integrity of the final delivered system. Using the same test methods and suites during manufacturing ensures that each and every board achieves the same high quality standard. Additionally, the Koizio solution supports efficient manufacturing test, offering the lowest per-board touch-time available, with a simple operator interface: *"scan it; test it; program it, track it."*

Finally, these same powerful and thorough diagnostics can be shipped with each target board, allowing full hardware test and diagnostics to be run every time the board

powers-on in the field. Problem identification, field support, and return materials analysis all benefit from running the same diagnostics used throughout the product lifecycle.

Summary

An effective design verification solution enables device manufacturers to eradicate design errors early in the development process, saving time and money throughout the development cycle. Hardware validation technology provides a reliable means for certifying commissioned boards, reducing manufacturing and support costs. When attempting to build these solutions internally, however, device manufacturers can encounter considerable staffing, budgetary, coverage and scheduling issues, potentially affecting the overall success of an embedded project.

Device manufacturers can avoid the pitfalls of internally built diagnostics solutions, using a single software platform supporting complex diagnostic requirements. Kozio software provides readily available, comprehensive, system-level verification and validation software, customized to support unique embedded designs.

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