Boundary-Scan Bursts

into the

Modern Production Facility

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ABSTRACT

The IEEE 1149.1 boundary-scan standard was adopted ten years ago to solve anticipated problems in printed circuit board testing as board densities and complexities continued to escalate. We can see today that the foresight of the original JTAG committee was excellent.

For several years after adoption of the standard, relatively few users had implemented boundary-scan solutions in their production lines. Now, however, for a number of reasons, interest in boundary-scan has rapidly intensified:

- IC manufacturers have accepted boundary-scan as a feature that must be included in new ICs;
- Advances in board and IC Packaging technologies have accelerated, making new test strategies imperative; and
- Standard tools for engineering and production are now available to support boundary-scan, dramatically reducing test development effort, capital investments, along with a corresponding reduction in time to market.

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As a result, virtually every manufacturer of modern electronic boards has either adopted boundary-scan or faces difficult problems in manufacturing that could be resolved through boundary-scan.

This presentation examines recent developments in boundary-scan technology as it relates to the development and production environments. Advanced tools, packaged to meet the needs of these environments, have brought boundary-scan into its prime. A detailed description of life-cycle implementation of boundary-scan is provided covering R&D, the factory, and service.

FACTORS DRIVING RAPID MIGRATION TO BOUNDARY-SCAN

Three major factors have coincided to place boundary-scan at the forefront of today's electronic test methods:

- First, printed circuit boards using surface-mount technology (SMT) have evolved to the point where new test methods are essential. With widespread use of ball-grid array and other chip-size packages, discrete test points are no longer available in sufficient quantity and reliability to support thorough testing using conventional means. Designers have adopted SMT to save space on their boards, so there's no incentive to consume real estate by adding test points. A means of access that doesn't require a significant amount of area is essential.

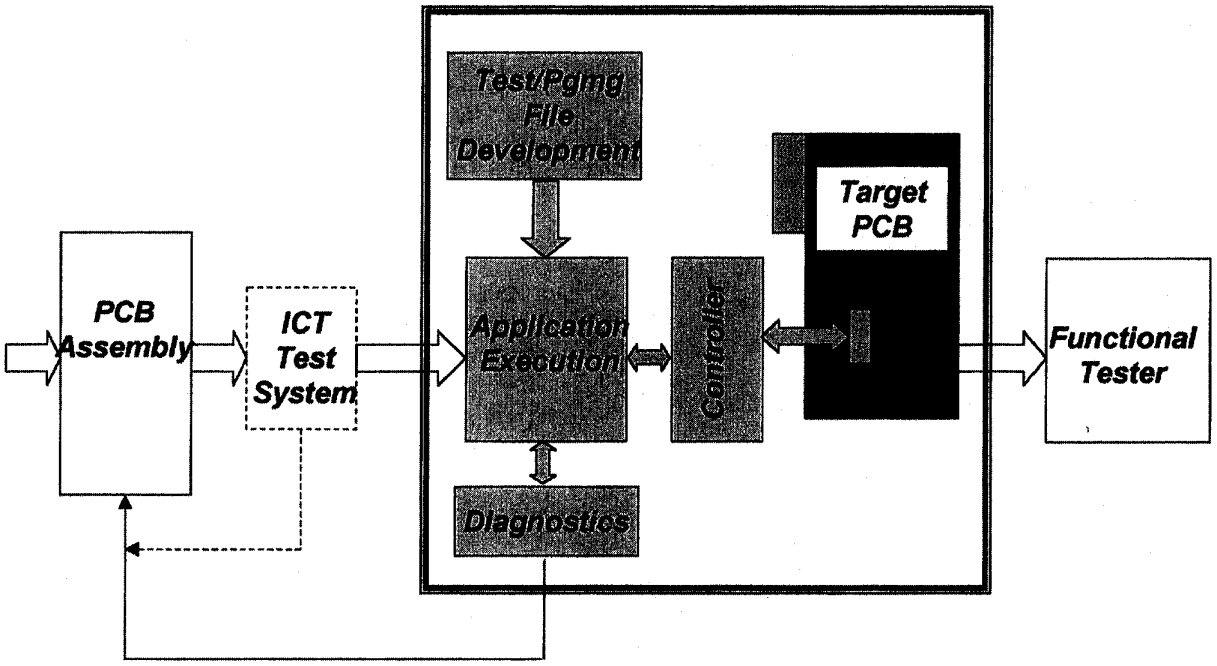

Fig. 1. Stand-alone boundary-scan system

- Second, the number of ICs supporting boundary-scan has continued to increase so that today virtually every modern digital board contains the capability for scan testing. Almost all ASICs, PLDs, microprocessors, and DSPs support boundary-scan, and a number of system-level scan devices are available to support hierarchical testing.
- Finally, powerful tools are now available to generate tests and other applications quickly without burdening the designer with the tedious details of preparing boundary-scan solutions. In many cases, applications can be developed automatically, early in the design cycle, and then executed at high speed in the production environment.

LIFE-CYCLE SUPPORT FROM BOUNDARY-SCAN

Design Support and Prototype Debugging

Shorter time to market is imperative for today's developer. If it allows a product to hit a "market window," reducing the interval between project inception and revenue production means more than simply increasing the marke; it can make the difference between product success and failure. Concurrent engineering is a process that strives to minimize time to market by aligning the efforts of the development organization and the production team from the beginning of the project. By design, the product is to be manufacturable and testable, avoiding costly rework and assuring that budget and schedule targets are met.

Boundary-scan, as a design tool and a debugging aid, plays a crucial role in the pre-production phase of the product life cycle. Adherence to a relatively simple set of design rules will assure testability of the product using boundary-scan. The percent of test coverage can be monitored and managed as the design progresses, based strictly on the schematic documents, without need for pre-prototyping.

Moreover, by means of the boundary-scan standard interface, actual test vectors are developed quickly, in parallel with the design. When the design is ready, so is the test. There is no extra interval to design and produce a costly dedicated fixture for the board.

A related time-saver is the simplification brought to the designer in debugging first prototypes. Traditionally, receipt of the initial hardware was the beginning of a difficult troubleshooting effort, which could be performed only by the designer. It involved the simultaneous discovery of design bugs and manufacturing faults, all done without the benefit of test routines. Boundary-scan changes the scenario: automated test routines are available to help uncover the manufacturing faults in the prototype, so the engineer can concentrate on the design issues. As a result, prototypes are up and running

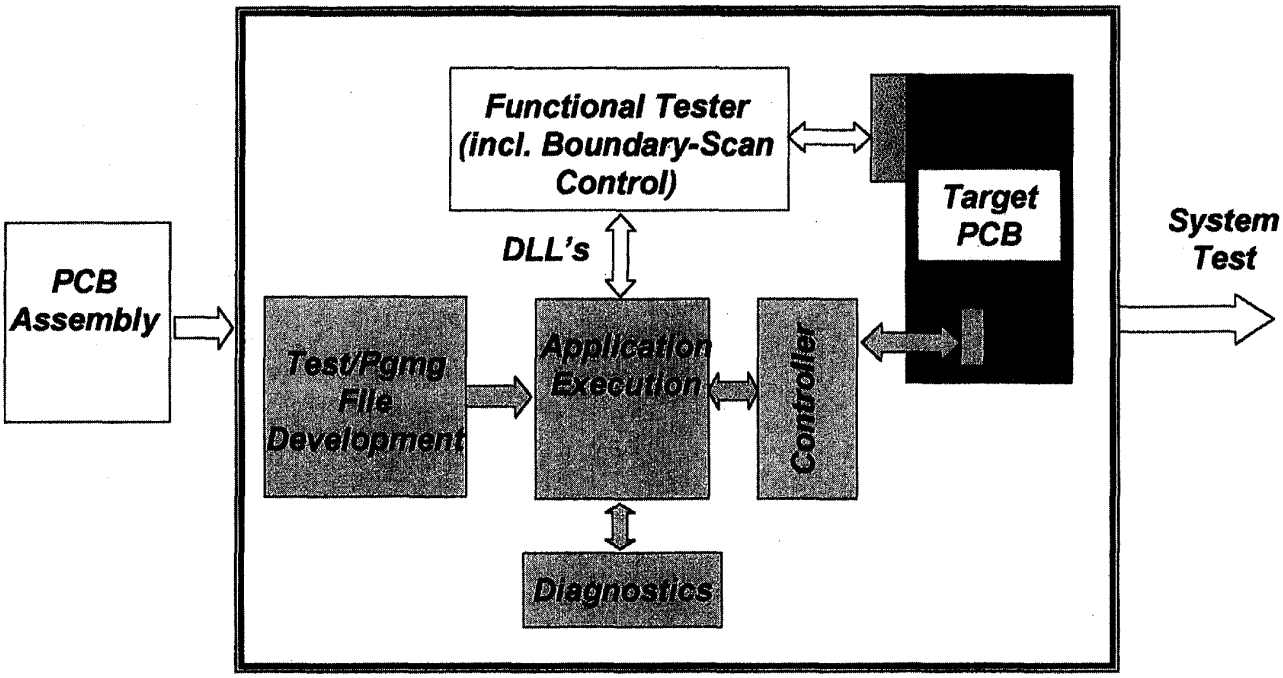

Fig. 2. Integrated boundary-scan system (with functional tester)

sooner, and the engineers can devote their skills to design rather than troubleshooting.

There is an additional payoff of boundary-scan in the development phase, the ease of programming flash memory and PLDs. Once the programming applications have been generated (automatically) it is a simple matter to reprogram in-system if the design changes.

Integrating Boundary-Scan within the Production Process

Boundary-scan technology brings substantial benefits to the production line. The test and in-system programming (ISP) applications that are developed quickly in design can be ported smoothly into production. Tests can be prepared before production begins, and costly fixturing is avoided. Fixture simplicity and ease of test preparation are advantageous later, also, as engineering changes can be accommodated easily.

Depending on the design of the board, two essential production parameters can be met:

- High beat rates (boundary-scan tests and ISP run at high speed); and
- High diagnostic resolution, often down to the pin level.

In some cases, the production line has a pre-existing process control system in place, making adoption of a new tool or user interface undesirable or unacceptable. Furthermore, there may be severe limitations on consuming more floor space or adding process steps to the line. Properly integrated, a boundary-scan solution addresses both of these concerns, as it can be made part of another test step such as in-circuit testing, flying prober, or functional test. The testing and in-system programming applications become routines which are called from and report results to the process executive.

In other cases, the production facility would benefit from establishing a stand-alone boundary-scan test station to perform the test and ISP functions. (See Figure 1, on previous page.)

Enhancing the Effectiveness of Functional Test

Most production lines include a functional test station prior to shipment to verify that the system performance meets expectations. Often functional testing is based on a thorough understanding of the system:

- First to prepare the tests; and
- Second, to interpret the results when a functional test fails.

Should manufacturing faults be intermingled with design bugs, then the repair activity becomes extremely difficult. Boundary-scan simplifies the process by addressing the preparation and interpretation of functional tests by means of systematic routines to weed out and debug manufacturing faults. This leaves the true functional errors for engineering analysis. (See Figure 2, on previous page.)

Repair Process

At the end of the life cycle, boundary-scan provides a convenient means of repairing products and reprogramming them with current flash and PLD code. There is no need to maintain a set of specialized fixtures for each board.

Boundary-scan repair testing is easily implemented on a stand-alone desk-top or laptop PC, or within another test system. Diagnostics are precise, supporting rapid analysis and correction.

CONCULSION

Three factors have combined to bring boundary-scan to maturity as a practical solution for SMT manufacturers today.

- The complexity of assemblies being produced has advanced to the point where a scan-based solution is essential to obtaining test access.
- A large number of new IC devices is now available supporting the standard and allowing almost every printed circuit assembly to use boundary-scan for testing and programming.
- Powerful advances in the software and hardware tools greatly simplify implementation of boundary-scan and integrating it into the factory.

The benefits of boundary-scan can be realized in environments that adopt design-for-test principles and place value on use of a uniform methodology to address test and programming applications throughout the production facility.■