Test Match–Partnering Specialist Boundary-Scan with ICT

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Introduction: Boosting ICT to Improve Testability

Popular ICT platforms from well-known vendors can perform a wide variety of analogue, digital, powered, and unpowered tests to verify the integrity of electronic assemblies. In addition to basic opens and shorts testing, analogue test capabilities include resistor, capacitor, potentiometer, diode and transistor tests. They can also verify power rails, and can generate digital test vectors as well as analogue waveforms to check for circuit functionality.

The test coverage that can be achieved using a bed of nails fixture alone is becoming increasingly limited. The biggest problem here is that any component pins not extending through to the probed side of the assembly are not accessible to the fixture nails unless the individual nets connected to it are exposed via unmasked vias, attached thru-hole connectors, or test points. The process of adding test access for ICT increases the cost of design, layout, and manufacturing: extra vias, extra test points, and extra routing necessities all increase the overall complexity of the assembly. Physical test access is not free.

Boundary-scan, used in conjunction with fixture-based tests, can extend test coverage on boards where test access is limited, and is critical to providing powered-shorts, opens and core-logic testing. IEEE 1149.1 compliant boundary-scan devices have the capability of driving and measuring pin states without physical access to the pin using a tester probe. ICT vendors integrate boundary-scan capabilities developed in-house to provide basic scan functionality that is native to the test platform, but this is not without its drawbacks.

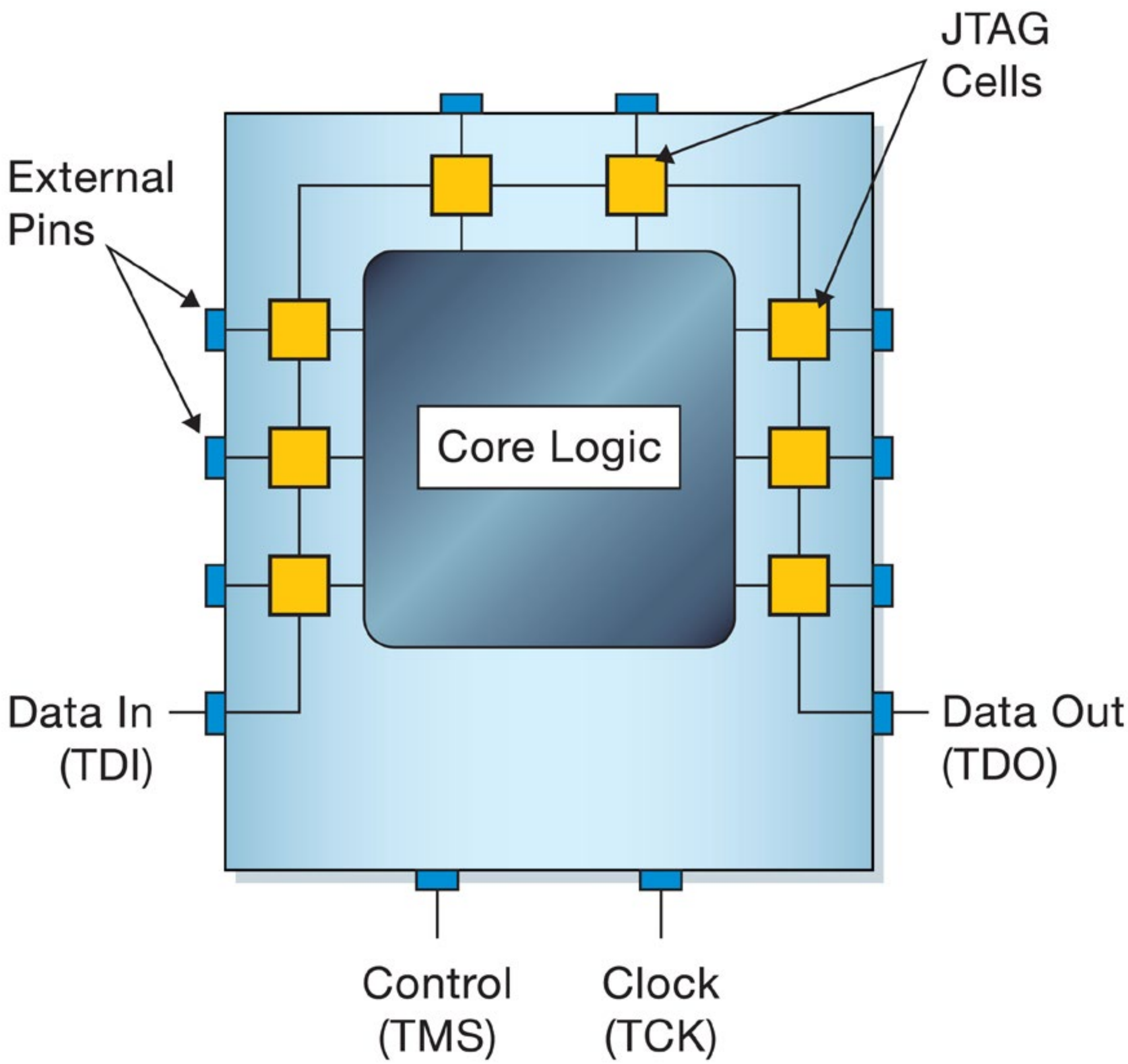

Figure 1: Simplified diagram of a boundary-scan component.

Flying probe testers can offer an alternative to ICT that eliminates some disadvantages such as the cost and lead times associated with bed-of-nails test fixtures and the PCBA modifications they require. On the other hand, devices like BGAs with inaccessible pins restrict the coverage possible using ordinary flying probe testing. Augmenting flying probe with boundary-scan can help overcome this problem and delivers additional valuable benefits.

Test Without Touching

The native boundary-scan test capability of a system such as the Keysight 3070 ICT station is able to generate tests for boundary-scan devices connected to the boundary-scan chain.

Testing non boundary-scan devices on nets connected to the boundary-scan chain is possible, using Keysight's optional Silicon Nails tool.

As the name suggests, Silicon Nails uses the scan capable IC in a boundary-scan chain to probe the pins of the connected non boundary-scan device. However, some amount of manual interaction may be required, particularly if any pin on the non boundary-scan device is not connected to a boundary-scan cell. The VCL (vector construction language) libraries assume that all pins on the target device are accessible. If this is

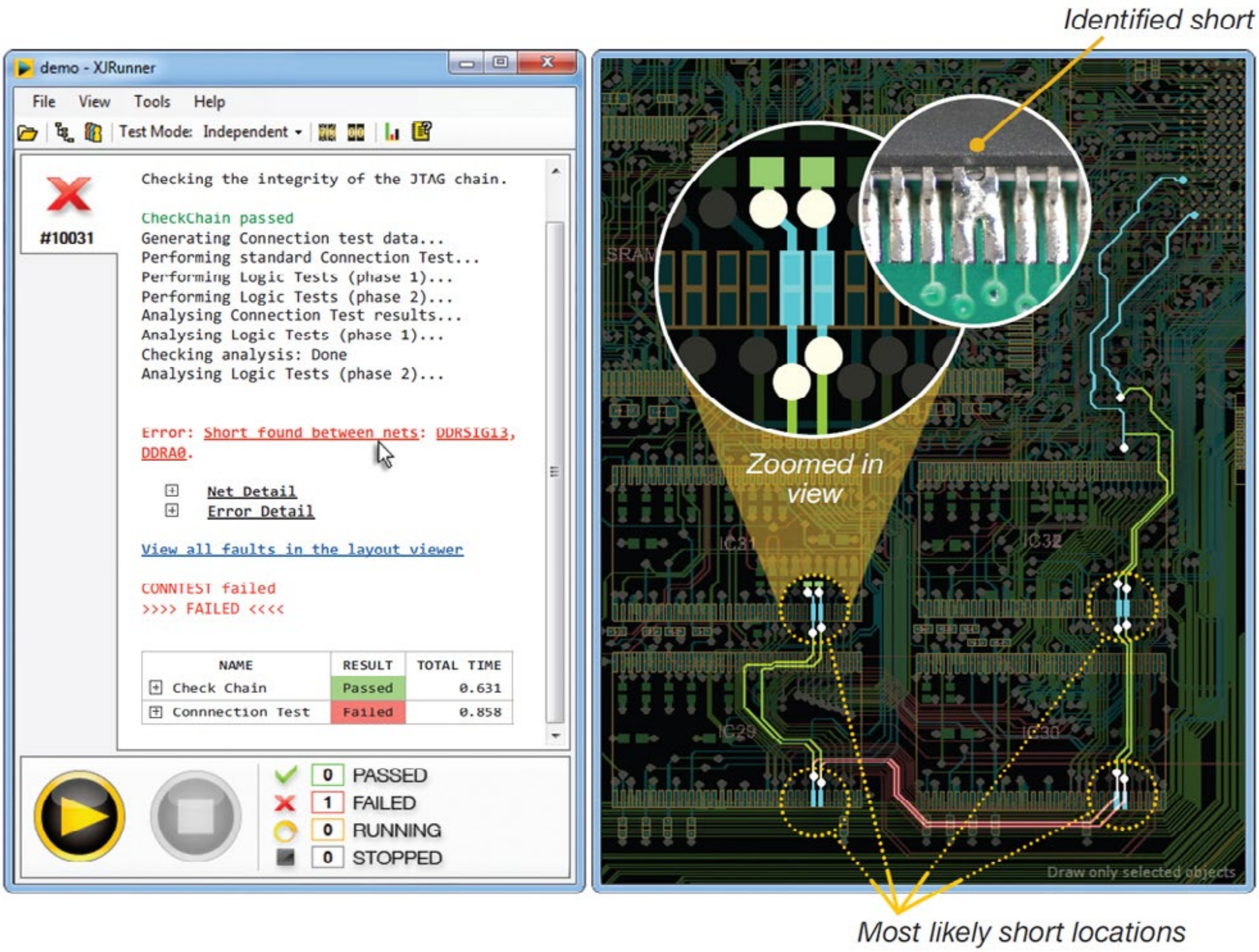

Figure 2: Advanced connection tests can identify and pinpoint the possible physical locations of faults.

not the case, Silicon Nails will not generate the test properly. The user must then modify the library to change the properties of non-accessible pins so that the Silicon Nails test can be generated. Similar modifications have to be made for every test that the system is unable to generate automatically.

In contrast, writing test scripts can be straightforward with specialist external boundary-scan tools, especially when using a high-level device-centric language. The system automatically generates test vectors at runtime that meet the stated requirements. Moreover, users can benefit from the increased capabilities of specialist equipment, such as advanced connection tests that are able to identify faults that more basic tests cannot detect, and can pinpoint the causes of any faults extremely accurately. Tests such as shorts, opens, pull-ups, pull-downs and interconnection testing can be performed automatically.

By combining specialist boundary-scan capabilities with ICT, users can take advantage of state-of-the-art boundary-scan functionality, such as automatic generation of tests for non boundary-scan devices. Test scripts are easy to write, particularly when using a high-level device-centric language that allows the test description to be abstracted from the detail of generating test vectors.

Making changes to the executing boundary-scan tests is as simple as changing the underlying scripting language rather than wading through millions of lines of test vectors: Pinout and board netlist changes can be easily integrated into the test platform without making changes to the board file and regenerating (and hence needing to re-debug) test vectors.

Libraries developed in a higher level device centric language are also more reusable and can be migrated project to project without modification. DDR3, PHY, SPI, I²C, and much more become easily testable and the libraries are not specific to the devices.

In addition, specialist boundary-scan tools tend to have better signal integrity and can push bits into the scan chain at a much faster rate than most ICT hardware, allowing more devices to be tested more quickly.

Integrating Specialist Boundary-Scan

Integrating a specialist boundary-scan system such as XJTAG with the ICT equipment provides a convenient means of performing boundary-scan test without changing to a different test-execution environment or removing the unit under test from the ICT fixture. Combining ICT and external boundary-scan in one efficient process step can help improve efficiency, minimise demand for additional items of test equipment on the production line, and protect sensitive hardware from physical damage, loss or misplacement.

The Keysight 3070 utility card and similar Teradyne multi-function application board simplifies integrating the user's choice of external electronics. Users can plug-in custom modules to perform specific test functions.

Specialty boundary-scan controllers take advantage of this extensibility. They are approved by the respective ICT vendors, and plug directly into the expansion board to provide access to specialist boundary-scan test and programming tools. Multiple instances of the controller can be installed into each board, which can boost throughput significantly without custom fixturing.

Specialty controllers can connect to a maximum of four boundary-scan chains on the unit under test, and multiple controllers can be fitted to each utility card or multi-function application board. This gives users the flexibility to test boards with more than one boundary-scan chain, or to test multiple panellised boards simultaneously. The controller also allows in-system programming of devices at close to their theoretical maximum programming speeds. Multiple controllers can program multiple boards simultaneously, so all boards in a panelised assembly can be programmed in the same time needed to program a single board. Paired with the throughput multiplier effect that comes from combining ICT, boundary-scan and programming in a single step, this can become a tremendous time saver.

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Test Re-Use Boosts Productivity

Integrating specialist boundary-scan in this way can not only simplify test generation, but also helps when it comes to diagnosing and repairing boards. The increased test coverage of previously inaccessible nets and devices saves the need to interpret failure messages that can be ambiguous, thereby reducing the time to identify the cause of a defect.

The same boundary-scan tests can be used in bench-top repair as are used in production ICT since they are not dependent on access granted to the circuits by a fixture which increases throughput of the ICT station and test fixture by minimising the time devoted to rework. Production equipment can be used for production more often.

Test engineers can utilise the same boundary-scan tests used by the board designers when creating tests to be run on the production test platform, which minimises duplicated effort.

Moreover, boundary-scan tests can be debugged on the bench rather than on the tester, minimising the time test engineers must spend using the production test equipment to troubleshoot tests. The boundary-scan application can be completely validated before being integrat-

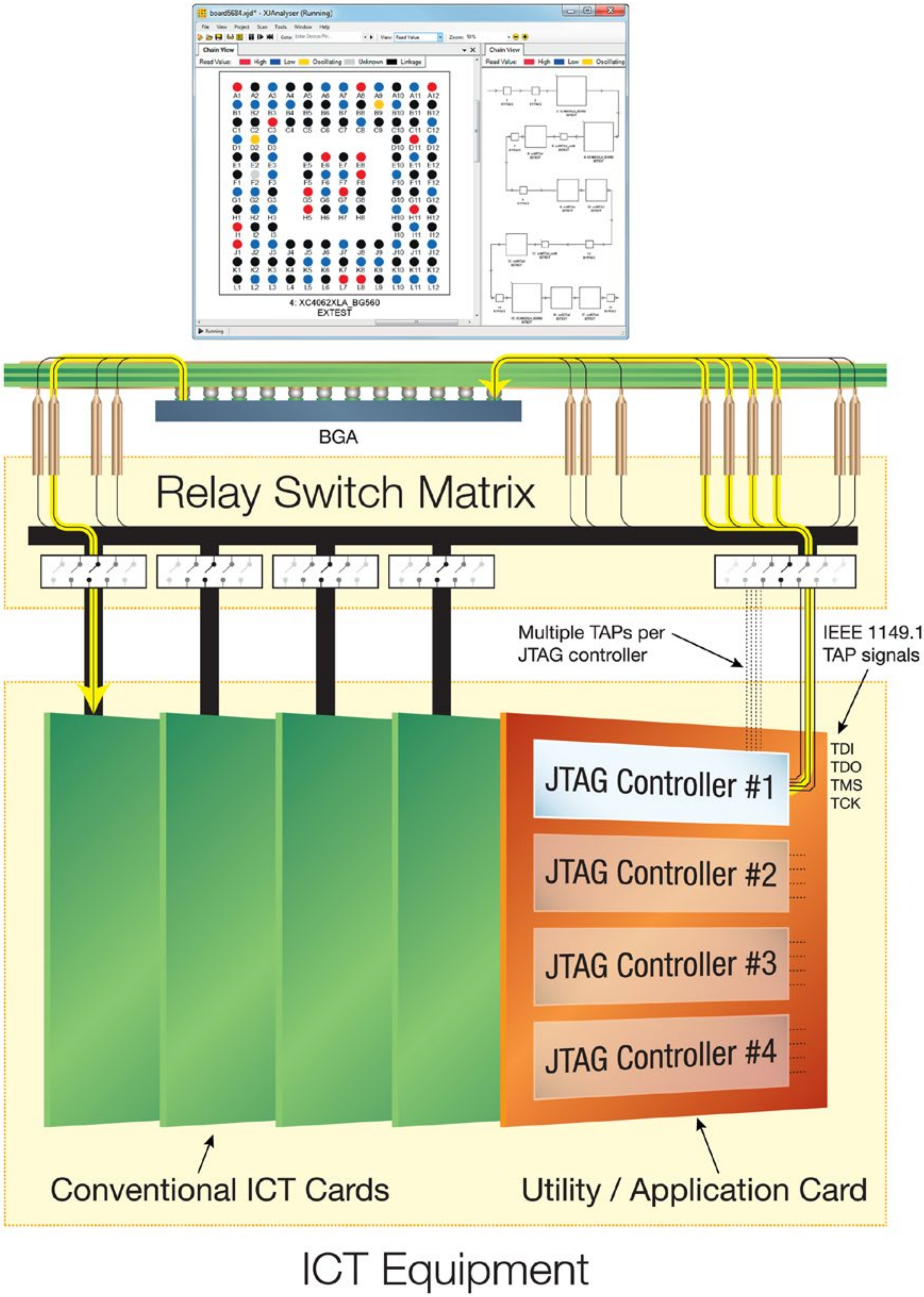

Figure 3: Specialist boundary-scan can work alongside ICT to increase fault coverage and simplify test creation and fault analysis.

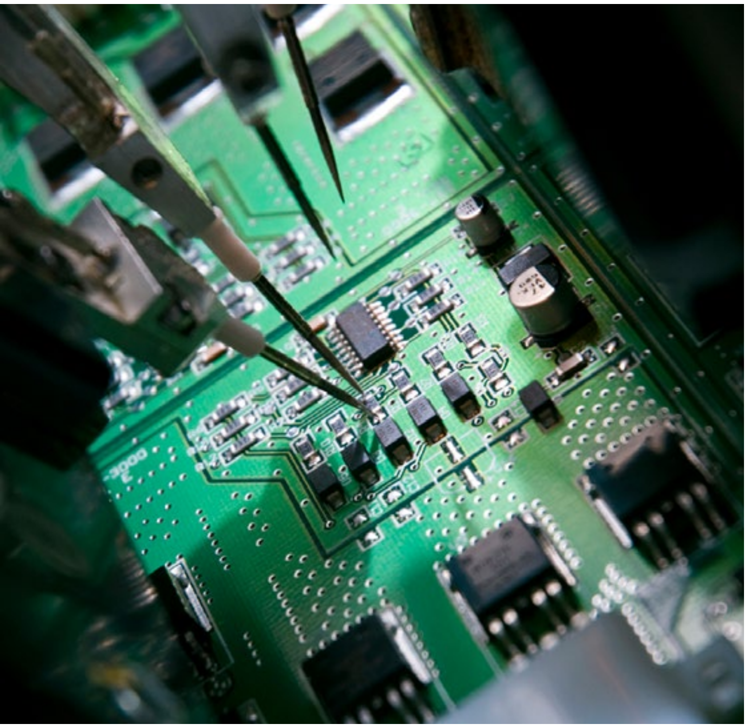

Figure 4: Typical flying probe tester.

ed into the ICT, which can save fighting code that needs to be debugged and potential fixture problems all at the same time.

Flying Probe + Boundary-Scan

Flying probe machines work around the constraints of physical access needed for ICT test fixtures. With the help of automated programming and debugging, which helps to minimise development time, a new application can be turned round in an afternoon instead of weeks needed to deliver an ICT fixture.

However, components with inaccessible pins can still compromise test coverage. By integrating boundary-scan capability in the flying probe tester, it becomes possible to apply powered-test vectors directly to pins of a boundary-scan device. Testing can also be extended to non boundary-scan capable devices on the board. Monitoring the response then allows the status of the device and its connections to be assessed. Moreover, the benefits associated with library re-use are as applicable to flying probe as they are to ICT, and help flying probe to retain its quick-turn advantage.

Boundary-scan also allows processes not normally possible using conventional flying probe methods—such as oscillator testing, programmable part verification and complex logic disabling—without adding excessive complexity and so defeating the purpose of a flying probe tester.

With boundary-scan added to the mix, testing is no longer limited to four, six, or eight probes. Tests can drive and receive as many signals as the board design allows, which opens up test coverage and diagnostic usability previously impossible to attain.

Increased test coverage means better defect detection at test and fewer defects and product returns after the customer hits the "on" switch for the first time.

Depending on the type of board, this combination of flying probe and boundary-scan test may exceed the test coverage achievable using ICT with a bed-of-nails fixture!

Engineers can add the benefits of boundary-scan to flying probe without also adding the difficulty of a fixture-based test program. Diagnostics are improved, and operators do not need to be taught how to interpret ambiguous test failures since boundary-scan is a digital test technology and points directly to the problem.

It is even possible to run the same boundary-scan test on the flying probe and on an ICT platform like the 3070. A project can start with flying probe boundary-scan and then transition smoothly to ICT when higher volume testing is required, since the boundary-scan tests are reusable.

Conclusion

Specialist boundary-scan is an ideal companion to ICT and flying probe testing. Users can benefit from better fault coverage, better test re-use, faster test development and fuller diagnostics. Popular ICT platforms have the necessary expansion capability built in, and specialty boundary-scan can be integrated successfully with flying probe equipment. **SMT**

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