Testing BGA connections without test points – How using a combination of electrical test methods can even find the faults that are actually untraceable

It's a familiar scenario: assemblies are becoming smaller and more complex. Particularly in the context of the increasing networking of the IoT (Internet of Things), in the future more and more everyday objects will be equipped with electronic assemblies, ultimately becoming part of a large network. While the assemblies continue to shrink in size, at the same time the performance requirements and complexity increase—for example due to mixed-signal components—while physical access is reduced. Across various markets, users report a decline of up to 20% in test points within the last five years. The access options for electrical test methods for the purpose of quality assurance are becoming fewer. Manufacturers producing mid-range volumes are in particular asking themselves how, despite all this, they can free themselves from this tricky situation and guarantee full functionality. A solution can be found by combining two test methods.

Various errors occur in the manufacture of printed circuit boards that can be found using different test methods. However, none of the individual methods can alone provide the maximum testing depth. Defective or missing parts, incorrect assembly, insufficient solder joints, missing contacts or violation of tolerances can be detected using electrical or optical test methods. Optical processes, such as automatic optical inspection (AOI) or automatic X-ray inspection (AXI) (more or less) cover any visible defects. Electrical tests provide information about whether components are behaving correctly and functioning properly in the network. The Flying Probe Test (FPT), In-Circuit Test (ICT), Functional Test and JTAG/Boundary Scan Test are amongst the best-known today.
Below, we set out a combination of the Flying Probe Test and Boundary Scan Test that promises a world of new possibilities for testing electrical assemblies.

Flying Probe Test

The Flying Probe Test method predominantly checks discrete, analogue components. It is similar to the In-Circuit Test, although the contact on the circuit board is achieved by means of needles which can be positioned freely.
In-circuit Tests require special adapters for this with a fixed needle bed, allowing fast parallel testing. The FPT moves to the test points with a high degree of accuracy and sequentially checks the components within the placement.
With its movable needles, the advantage of the FPT compared with the ICT is that there is no need for expensive adaptors with long lead times. Users can quickly adapt test programs to match changing designs, which makes the FPT a flexible solution. However, the Flying Probe is only very restricted in its ability to implement digital tests, on account of limited concurrent access.

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Image: Various Flying Probe Testers from TAKAYA at the site in Düsseldorf. Front: the flagship APT-1400F

The last decade has seen a remarkable development in terms of contact accuracy and speed, however, which can be attributed to faster and more accurate mechanics. For one thing, mechanical access is no longer confined solely to test points or connectors. Similarly, there has been a steady improvement in testing throughput.
Used in combination with automatic loading and unloading systems, the FPT has now also become extremely interesting for medium and high production volumes. The Flying Probe compensates for its higher initial costs with lower project costs.

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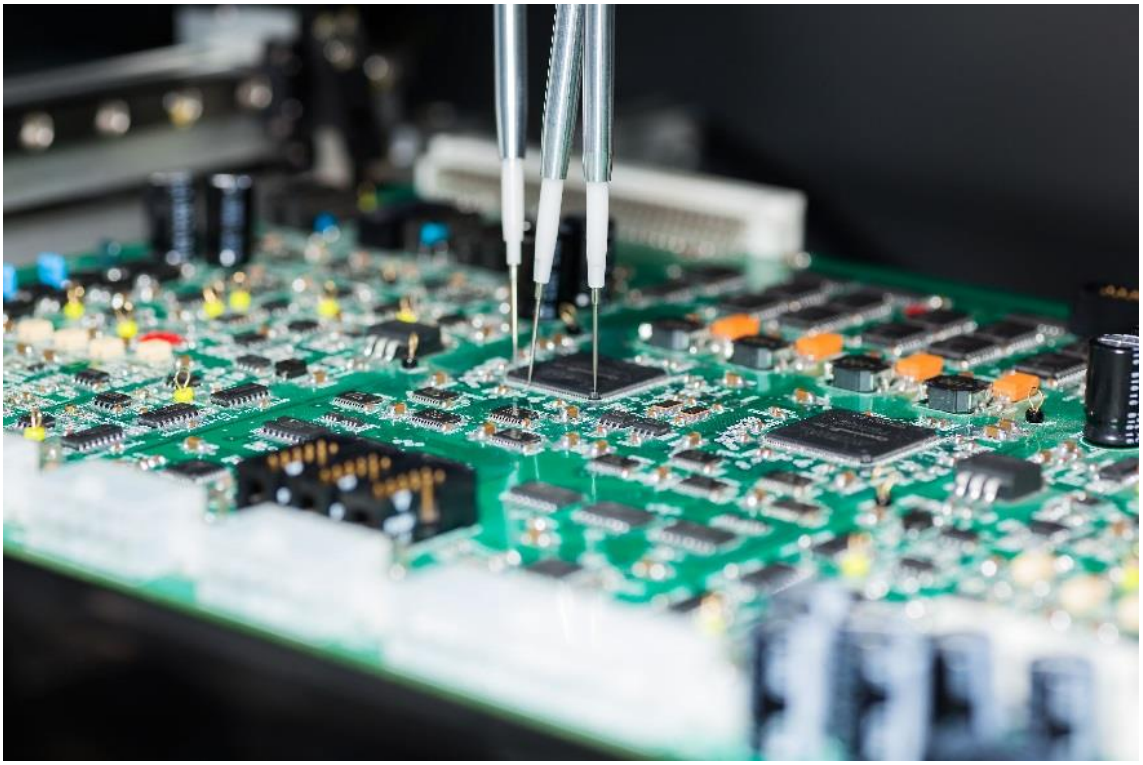

Image: Probes contact pins on an assembly

Boundary Scan Test

The Boundary Scan Test method is based on register cells that are implemented between a pin and an IC logic (see figure). This allows digital signals to be measured and stimulated at the IC pins, regardless of the IC functions. The only requirement is boundary scan-enabled components in the design ("Design-for-Testability"). Information is transferred between the test system and component via the so-called JTAG port (test bus), which is the only test element that needs to be included in the design. Complexity is considerably reduced compared with an ICT adaptor and test sequences can be created easily. Since no mechanical processes are necessary, boundary scanning is a very fast test method, with test times in the region of milliseconds. However, to date it has proved impossible to test analogue components. For mixed-signal applications this is actually an unsolvable problem then – the advantages of these two methods would not be combined.

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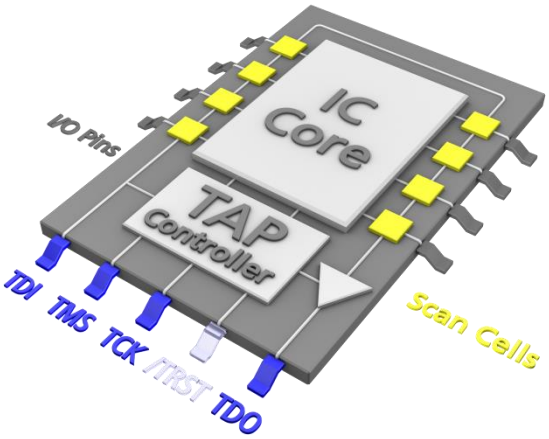

Image: Schematic structure of a boundary scan-enabled IC

Combining test methods—maximising testing depth

The Flying Probes from TAKAYA are modular in their design and can be and set up according to customer requirements. A GÖPEL electronic Boundary Scan Option provides the basis for higher test coverage and faster test execution. Here the Flying Probe tests the discrete, analogue components, whilst the Boundary Scan covers the digital area with parallel access via the cells. Test times are reduced as a result of networks tested by the Boundary Scan being eliminated from the Flying Probes' short circuit test, for example. The high accuracy of the TAKAYA system means that it is possible for pads as small as 60 µm to be contacted. This allows it to contact components and areas which are not accessible in the ICT. Users therefore benefit from high speeds and very high fault coverage, even with highly compact printed circuit boards. This allows users to be flexible at all times, and expensive adaptors and the high costs associated with generating test programs are a thing of the past. This combination ultimately also allows comprehensive testing, even when there is virtually no test access incorporated in the design, as the example below shows.

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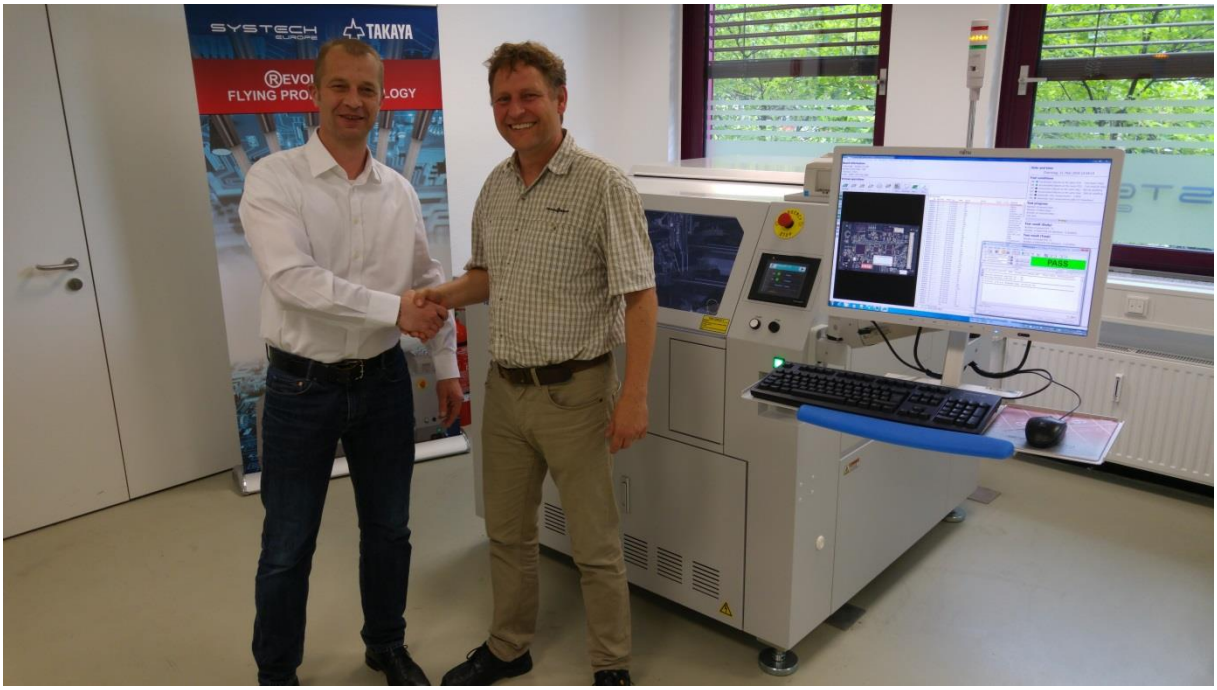

Image: Boris Opfer (left, SYSTECH Europe) and Alexander Beck (right, GÖPEL electronic) implement the integration of the Boundary Scan in the Flying Probe Test system

Test access without test points

One example of an assembly from real life has a boundary scan-enabled BGA but cannot have test points or additional boundary scan components. The precise contacting possibilities of the Flying Probe Tester provide completely new possibilities for interacting with the Boundary Scan. For example, it is possible to find an unsoldered BGA pin without an additional test point in the following scenario:
Boundary Scan sets the output values High and Low on the corresponding BGA pin. The Flying Probe contacts a component pad (it doesn't matter whether this is an IC pad, SMD pad, THT solder joint, or through-hole), if possible at the other end of the network, and performs the measurements. These so-called "interactive" tests can now easily be generated automatically and provide convenient fault analysis.
Another typical example is the testing of D/A converters. Using Boundary Scan, the digital values are fed to the converter and the analogue output value is activated. The GÖPEL electronic Boundary Scan System can now also position the probes in an appropriate and targeted manner and record and evaluate the expected analogue measured value.
None of the individual systems alone are able to cover such scenarios; it is only the combination of the two methods that provides this additional benefit.

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Summary

A high quality of testing ensures higher quality in the manufacturing process. This article has shown that single test method alone can guarantee one-hundred-percent test coverage, however. The combination of the Flying Probe Test and Boundary Scan has already been able to establish itself in the past. Advancements in the relevant fields of technology will in the future be able to provide real savings in the production and testing process. GÖPEL electronic has already enjoyed several decades of successful cooperation with TAKAYA, manufacturer of the world's first Flying Probe Test system. With more than 2,000 systems installed around the globe, in 30 years we have built up unprecedented expertise. As a pioneer of the Boundary Scan Test method, GÖPEL electronic provides a useful complement to the established Flying Probe Testers for a sustainable testing strategy with lower test costs.

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