IPSES S.r.l.

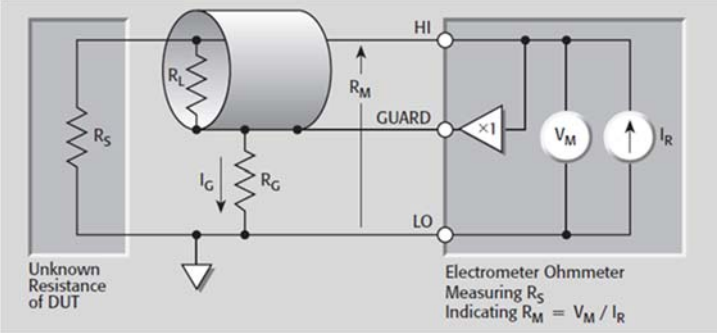
Scientific
Electronics

BOUNDARY SCAN TEST COMBINED WITH FUNCTIONAL TEST

The test of medium complexity boards at the end of production has always been made by an ICT test followed by functional test, sometimes preceded by optical and X-ray inspection.

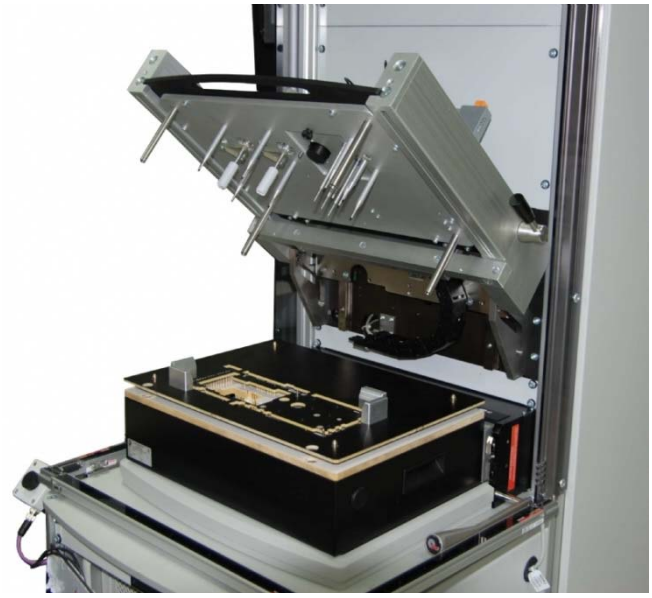
ICT test and functional test in comparison

The ICT test provides access to all nodes of the circuit through a bed of nails or via flying probes to verify the correctness of the installed components related to the different nodes. The components are isolated one by one using various techniques such as the *Guarding* technique for the more simple analog components.



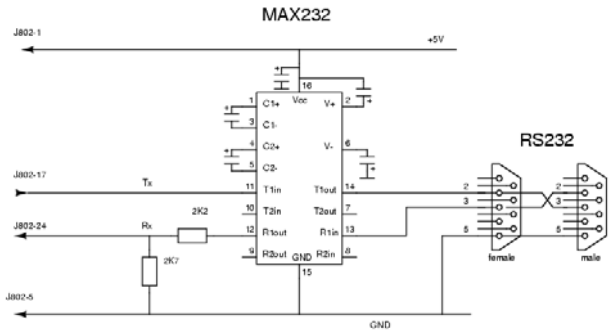
Resistance measurement using Guarding technique

This type of test verifies the correctness of the mounted components, but it is obviously not able to verify that the board, once powered, works properly: to verify the latter point it is necessary to perform a functional test.



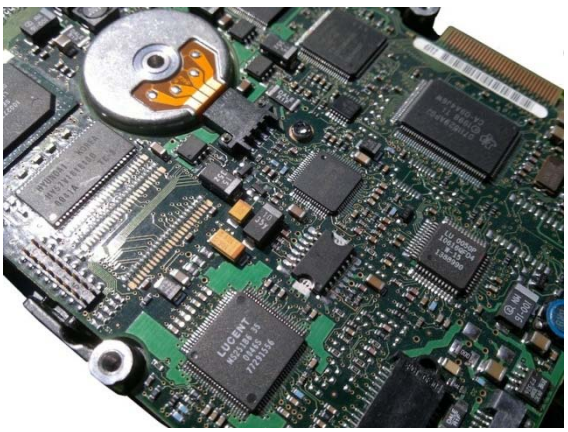
Despite the proliferation of new testing techniques, functional test is certainly the mainstay for ensuring the proper operation of electronic systems and boards. Conceptually, this type of test is simple because it aims to test all the functionality of the DUT (*Device under test*) having as a reference what the DUT was designed for, then testing all the various parts of the circuit and verifying they perform the required functionality. Also in this case the test bench involves a bed of nails equipped with all the necessary instruments to stimulate and verify the operation of the DUT.
In the case of a processing and wireless communication board, for example, to perform a functional test you will need to use, in addition to stimulation and acquisition classical instrumentation such as power supplies, digital and analog I/O, also instrument for RF analysis (spectrum and vector analyzers, transceiver, etc..) and fast acquisition devices (oscilloscopes and digitizers).

Comparing the two types of tests and considering the simple case of a MAX202 driver for serial interface, through ICT test you can check the values of the capacitors in the charge pump, while the functional test will perform the sending and reading of data packets.

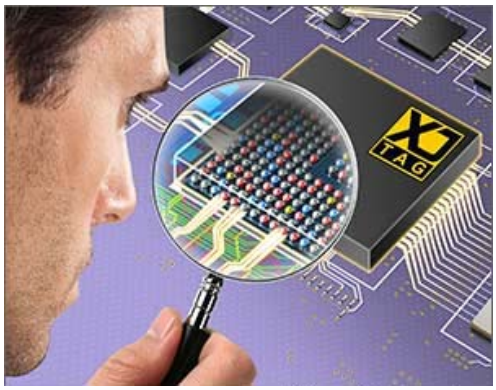


Typical Connection diagram of MAX232 driver

Until recently, therefore, the ICT test has allowed to easily verify the proper installation of all components before the execution of the functional test. However, the density of components often achieved in the boards does not permit the placement of a sufficient number of test points and the use of BGA components, hardly accessible once welded - although there are techniques based on the variation of the capacity developed to avoid the physical contact of pads - is increasingly frequent: so **the use of ICT test is becoming more and more uneconomical or even impossible.**



Boundary Scan test

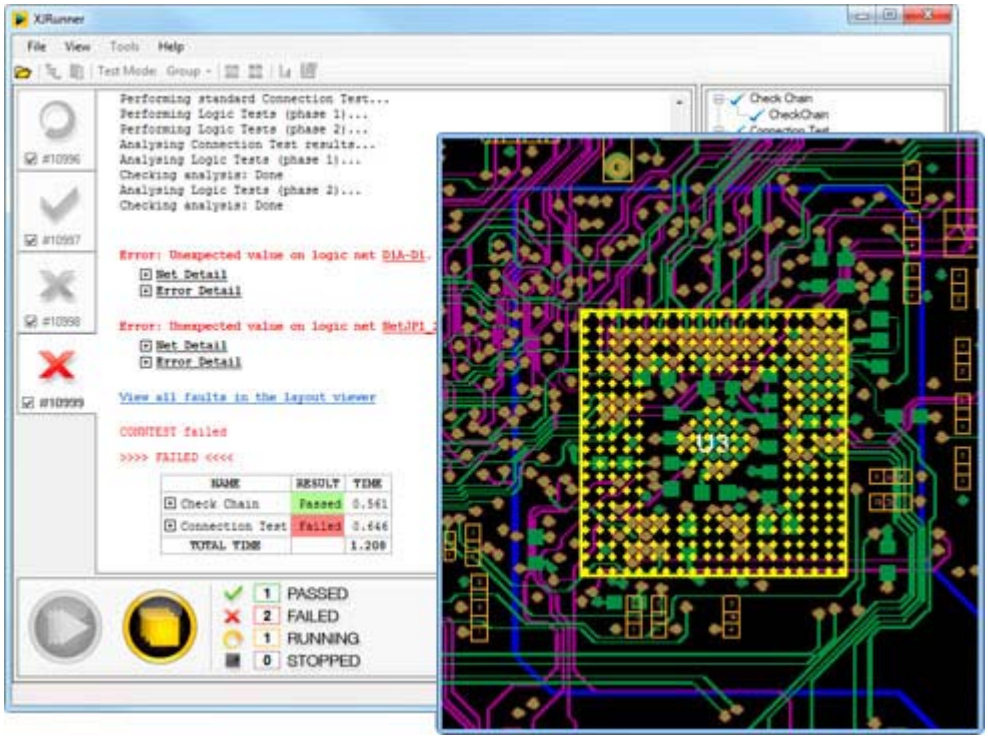


The increasing complexity of digital electronics has instead made more and more present the Boundary Scan interface that is available on all the latest digital components such as FPGAs, microcontrollers, RAM, converters.

The Boundary Scan, following the standard JTAG IEEE 1149.x, provides circuitry within the chip that makes available a comprehensive testing protocol at the board level.

This circuitry, properly implemented by chip vendors, involves the replacement of the physical probe with boundary scan cell, referred to as BSC. BSCs simulate virtual probes for each input and output on the chip. Each cell makes possible to observe the normal flow of data through the pins of I/O and allows to check the status of the pin through the serial communication of the Boundary chain.

The Boundary Scan test, although conceptually very different from ICT, allows to verify the proper interconnection of all the components (the absence of short circuits among the tracks and continuity verification), as well as the presence of many components. Even if it is not able to verify with accuracy their value, some functional implementations are possible for all those components accessible from JTAG chain. In addition, the Boundary Scan tool is, in many cases, also used for programming these components.



Example of JTAG software for Boundary scan test that shows the connection pads of a chip

The ICT test can then be replaced in many parts of the circuit with an infinitely less invasive Boundary Scan test: the latter, in fact, requires access to the card using the single JTAG connector (or pads), already available on the board for

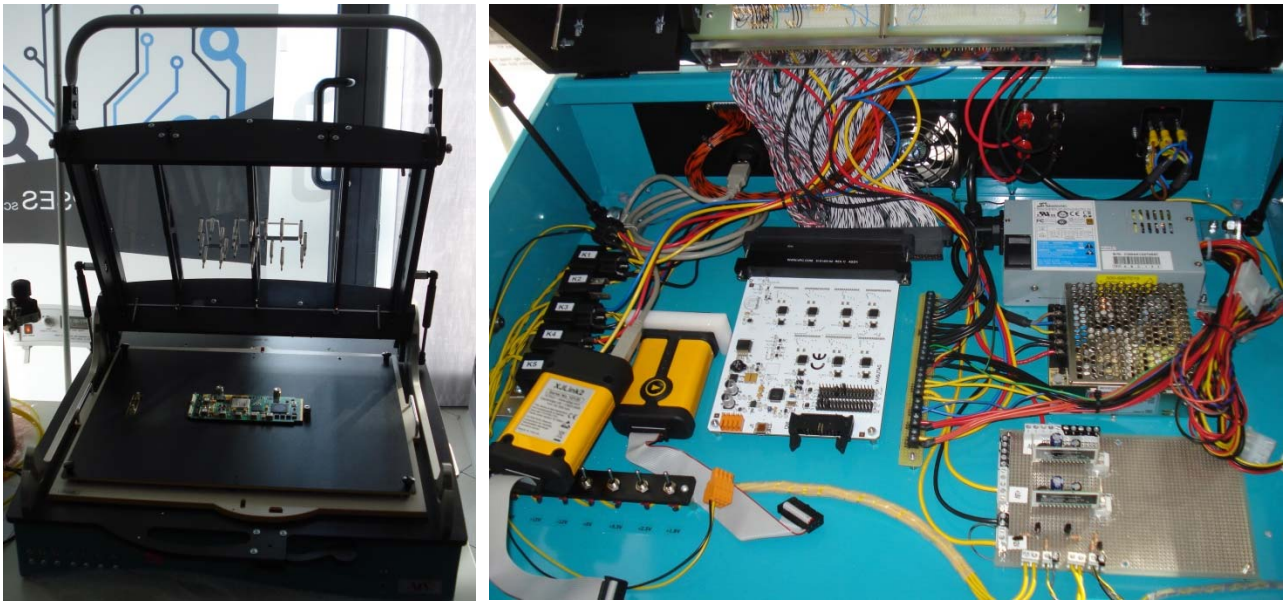
debugging and programming needs. However, the test based on the Boundary Scan cannot, by its nature, completely test all the circuits present in an electronic board: by itself it will never be able to test analog parts, as well as, more generally, autonomously it cannot test all the components without Boundary interface.

A new approach: functional testing combined with Boundary scan test

In order to wholly test a system, the Boundary Scan test must be associated to functional test: in this way not only it will possible to complete the test of the system in all the parts uncovered by Boundary Scan, but you can then perform the functional test itself.

Contrary to what happens implementing ICT and functional test, where it is almost mandatory to have two different test stations, in this case it is possible to integrate everything into only one bench: in fact, since the connections required for access a board by Boundary Scan are only four signals for each Boundary chain, just the addition of 4 needles is needed to integrate Boundary Scan into a functional fixture.

Having the necessary experience in the development of devices and interfaces for the functional and Boundary Scan test, it is possible to develop fixtures and test benches that integrate both technologies, providing complete devices with costs and development times extremely competitive.



Fixture that integrates into a single device functional and Boundary Scan test. On the left there is the fixture with the DUT inserted; on the right there is a detail of the interior of the fixture in which both devices for functional test and interface for testing in Boundary Scan are integrated.

Functional test + Boundary Scan test = maximum reliability and effectiveness

The combination of functional and Boundary Scan test on a single system leads to numerous and considerable benefits: not only the two are complementary and thus their combination allows to cover each other in areas where they would be deficient, but their integrated use increases the reliability and effectiveness of the test that will not simply be the sum of what can be achieved individually by the two. Making interacting the two techniques it possible to create favorable test conditions that would otherwise be impossible to have: for example, by the excitation of the probe planned for the functional test, it is possible to generate patterns that can be verified by the Boundary Scan chain and, through the Boundary Scan, you can activate parts of the circuit which will then be verified by the functional test. The effectiveness of an integrated approach is therefore not only to have a double type of test in a single device, but to improve the test itself, which becomes most reliable and trustworthy.

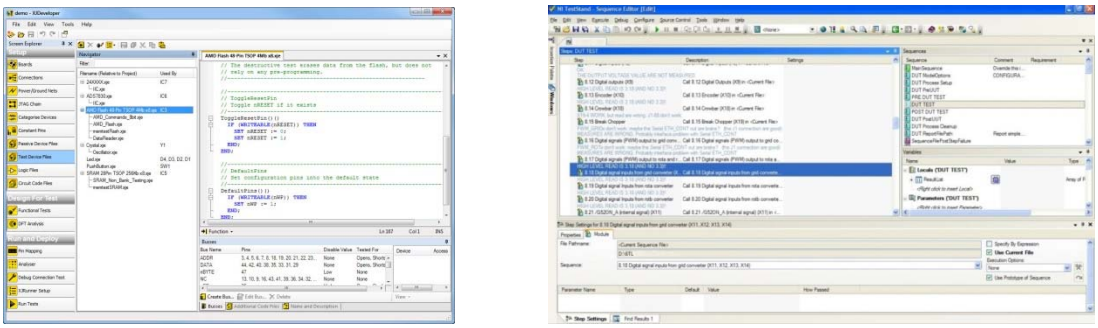
The integrated approach allows to reach:

- Full Coverage of all the circuits of the DUT (analog and digital) and of all nets.
- Shorter test time: besides the fact that Boundary Scan and functional test sequences will be executed in parallel, it is also necessary to consider the time of loading and unloading of the DUT in the test bench, which obviously doubles in case of use of two stations.
- High performance in-system programming.
- Better and more accurate fault diagnosis, with a unique reporting.

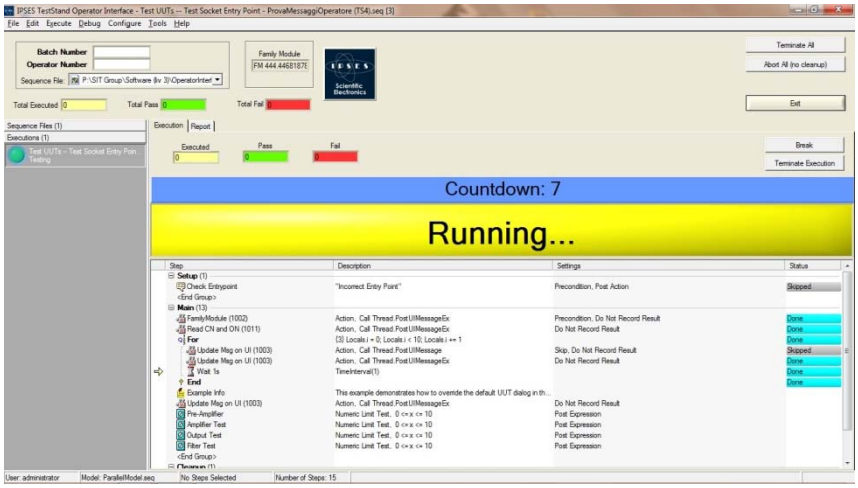
For the development of an integrated test system, leading companies providing functional and boundary scan solutions include in their catalog powerful tools that allow you to have both the necessary hardware for interfacing, and the development environments for the test sequences. The JTAG boards for PXI allows interfacing to the Boundary chain by simply entering the Module within a PXI rack that can be equipped with several hardware modules suitable for the specific application of functional test.

PXI boards for the *Boundary Scan* test and PXI rack equipped with hardware modules

Although the development of Boundary test sequence should be carried out with the specific tool (the environment for JTAG developer), the generated sequence can not only be associated with the sequence of the functional test, but you can manage jointly the parts of the sequences which provide the interaction between the two types of tests. In this way, once functional and Boundary sequences are developed and the related, the operator interface will be unique.

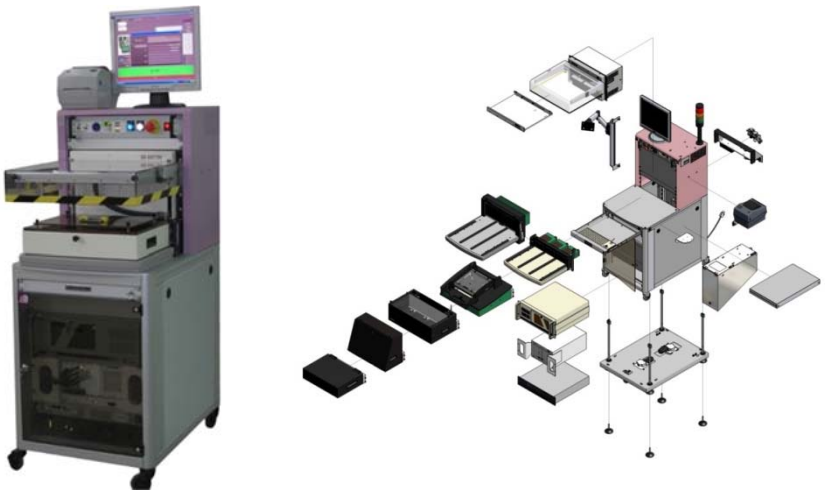


***Boundary* sequence and functional sequence**



Unique operator Interface developed combined boundary and functional sequence

By choosing a modular and customizable test system that allows an easy integration of different types of hardware, including ones developed by third parties, you can have an easily upgradeable and configurable single bench that integrates functional and Boundary test, improving not only the reliability of the test itself, but speeding it with much lower investment costs.



Modular Test Platform scheme and the modular concept with which you can assemble the different parts, integrating third-party hardware and fully customizing the bench

Contacts

IPSES S. r. l.

Headquarters:
via Lazzarotto, 10
20020 Cesate (MI) Italy

tel. +39 02 39449519 **fax** +39 02 700403170
e-mail: info@ipses.com **http:** www.ipses.com