In-Circuit- or Functional Test?

or

why test at all?

Hans Baka - CEO
Digitaltest GmbH
Our Experience

Avionics & Aerospace

Automotive & Transportation

Consumer Electronics

Automation

Test Houses

Computer & Peripherals

Military

Electronic Manufacturing Services (EMS)

Industrial Electronics

Medical Technology

Information Technology

Complete Solution – One Provider
Some of our users

- BOSCH
- Lenze
- BECKHOFF
- Itron
- Continental
- TRUMPF
- Sagemcom
- GE Medical Systems
- ABB
- Siemens
- Hubbell
- Emerson
- Sew Eurodrive
- Pepperl+Fuchs Products
- Gigaset
- Schneider Electric
- Matsushita Automation Controls
- Honeywell
Some more...
Do I have to test?

This question is related to my product and my customers

- **Safety Products:**
  Automotive, Medical, Military, Avionics,...

- **Machinery:**
  100.000 € machine stands still because one little electronic part (10€) has a defect: maybe high Service cost, damaged reputation (credibility).

- **Consumer-Electronics:**
  high end products are more critical than low cost products. Failure in a 20€ coffee machine is not as critical as failure in a 900€!
What can or must be tested:

This question is related to the quality of my components and my production process.

- **Component Failure:** delivery quality of the Components?
- **Process Failure:** what process, depending on machine park?
- **Production Failure:** Shorts, wrong mounting, solder problems!
- **Functional Failure:** Dynamic, functional and environment
- **Design Failure:** not at series production!

→ **actual** failure classes need to be detected and reviewed,
What kind of machines are used, is there AOI before?
What can or must be tested:

If the first two questions are answered, the next question is about the Test Coverage

• **Protection parts:**
  EMV, PullUp, serial termination, protection parts:
  → only with ICT rationally testable

• **Partly-ICT / Cluster-ICT + Cluster-FCT:**
  e.g. at restricted contactability, Simplification / Standardization of Tests, Cost-reduction (Adapter, Testprogram development, ...)

• **Product innovation:**
  Design based on existing Cluster (Schema/Layout...)
  If constant Layout- Cluster why not constant Test-Cluster (Circuit structure, Testpads, ...)
  → Fixture re usable?
What is my test coverage?

How can I investigate the depth of test and the coverage

Coverage:

of the de facto possible / occurring Failures

• ICT: easy to declare

• FKT: declaration → impossible, not easy to investigate!
The cost for the identification and repair of a failure increases by factor 10 after each production step!
The Methods

In-Circuit Test

Detecting and Localizing of:
- wrong or missing Components (static)
- Shorts, Opens
- Pullup/Pulldowns, Protection parts
- Polarity

Optical Inspection AOI

Detecting and Localizing of:
- Open solder joints at IC's
- Solder problems
- Wrong IC's
(if the IC's are BS compliant)

Functional Test

Detecting and Localizing of:
- Functional Failure (Powerup)
- Interactive Problems
- Under real Power

Boundary Scan

Detecting and Localizing of:
- Insertion Failures
- Solder Failures
- Mechanical Problems

System (real time) Test

Detecting and Localizing of:
- Dynamic Failure
- System Test
- Real environmental parameters
# The Methods

<table>
<thead>
<tr>
<th>In-Circuit Test (ICT)</th>
<th>Functional Test (FCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Test of Components in a circuitry)</td>
<td>(Test of the Functionality of the PCB or parts of the PCB)</td>
</tr>
<tr>
<td>Analogue and digital Components will be tested for their Values &amp; Functions. The tests include Component Values, Polarity, Contact, and shortage between the electrical nets.</td>
<td>By stimulating digital and/or analogue parameters at the inputs of the circuit, the output parameters are measured and verified.</td>
</tr>
<tr>
<td>The test of components in between complex circuitry will be performed by isolating the components with a “Guarding” technique.</td>
<td>The interaction of the components in the real circuitry will be tested and a correct function can be investigated.</td>
</tr>
</tbody>
</table>
## Advantage of each Method

<table>
<thead>
<tr>
<th>In-Circuit Test (ICT)</th>
<th>Functional- Test (FCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component values are tested. Production failures can be detected. When a failure is detected the problem will be pinpointed and the failure will be localized. With this level of Diagnostics the repair of the PCB is easy and can be performed by an operator and does not require an engineer.</td>
<td>The Functionality of the PCB or parts of the circuitry will be tested. By changing the parameters the feedback of the components, in a small tolerance band, can be forced. Functional test can also detect development failures (wrong dimension of components).</td>
</tr>
<tr>
<td>Easy automatic development of the test program by reading the CAD-Data and the BOM lets the APG (automatic program generator) generate the test program with all needed parameters for each component. The test time is fast and a high throughput can be reached.</td>
<td>A Functional test can be performed static, dynamic or up to real time.</td>
</tr>
<tr>
<td></td>
<td>The FCT doesn’t need complex fixturing and in most cases it can be performed by using only the edge connectors.</td>
</tr>
</tbody>
</table>
## Disadvantage of each Method

### In-Circuit Test (ICT)

For a complete test a fixture with spring probes on each electrical net will be needed. This fixture can be expensive. (maybe Flying Probe?)

Real dynamic tests are almost impossible.

Design problems will be not detected.

Each time the layout changes a new fixture may be necessary.

### Functional-Test (FCT)

No automatic development of the test program is possible. Knowledge and know-how of the functionality of the PCB is necessary.

A failure will not automatically pinpoint the defective component. The diagnosis and repair of the board is complex, time consuming and requires highly qualified personnel.

Even if the functional test passes, incorrect components can be mounted (Pullup…) and can cause problems at the customer’s side.

The test time can be very long.
Example ICT (1)

Easy diagnosis and therefore fast and cost efficient repair. Collected data can be used for fast optimization of the process. Test results point directly to defective structures, so that all graphical help functions can be used.

Layout-display directly points to possible locations of shorts and offers fast diagnosis.
Example ICT (2)

Easy diagnosis and therefore fast and cost efficient repair. Collected data can be used for fast optimization of the process. Test results point directly to failing components, so that all graphical help functions can be used.

Directly linked Schematics-display showing the faulty component and its environment. (incl. Interactive debugging)
Example ICT (3)

Easy diagnosis and therefore fast and cost efficient repair. Collected data can be used for fast optimization of the process. Test results point directly to failing components, so that all graphical help functions can be used.

Layout-display directly points to faulty components and offers fast localization.
Example ICT (4)

Easy diagnosis and therefore fast and cost efficient repair. Collected data can be used for fast optimization of the process. Test results point directly to failing components, so that all graphical help functions can be used.

Digital-Display shows the state of involved driver/sensors and supports diagnosis of digital failures. (incl. Interactive debugging)
Example FCT (1)

Verification of UUT function (or parts) with real voltage- and load conditions:

Safe function of switching regulator also with:

- min/typ/max load
- Under-/Over- voltage

- 1U-K-16V-X5R
  - C1922

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- Verification of UUT function (or parts) with real voltage- and load conditions:

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- 1U-K-16V-X5R
  - C1922

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- Verification of UUT function (or parts) with real voltage- and load conditions:

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- 1U-K-16V-X5R
  - C1922

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- Verification of UUT function (or parts) with real voltage- and load conditions:

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- 1U-K-16V-X5R
  - C1922

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- Verification of UUT function (or parts) with real voltage- and load conditions:

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- 1U-K-16V-X5R
  - C1922

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- Verification of UUT function (or parts) with real voltage- and load conditions:

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- 1U-K-16V-X5R
  - C1922

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- Verification of UUT function (or parts) with real voltage- and load conditions:

- Safe function of switching regulator also with:
  - min/typ/max load
  - Under-/Over- voltage

- 1U-K-16V-X5R
  - C1922
Example FCT (2)

All segments enlightened with same intensity and color?:

✓ Automatic optical evaluation of color and brightness, actuation of controls (switches, trimmers,..)
Example FCT (3)

Calculation and programming of configuration data:

- adjust UUT adjustment & determine configuration data
- program to UUT memory and verify

I2C ADDRESS: A6

- 4.7R-J-W06 R7303
- 100N-K-18V-X7R C7302

Digitaltest GmbH. All rights reserved.

©2017 Digitaltest GmbH. All rights reserved.
Example FCT (4)

Verify UUT (or parts of UUT) under real time conditions:

Missing / wrong signal-termination:

✓ / ? Failure-detection: "Pcb does not start up (always?)"

? Diagnosis / Failure localization
Example FCT (5)

PCB powered up and Start_Up-Test says "Pass", but in normal operation random failures (or not...)

¿ - what is really tested/used during Start_Up & FCT
- all Opens / Shorts detected during these tests
Combination (1)

- aICT
- + Power & aFCT
- + dICT
- + Programming
- + BIST & Communication

- 100% adaptation
- Overlapping tests / redundancies

⇒ HIGH COSTS
Combination (2)

- partial aICT (active)
  - Bscan & Programming
  - BIST & Communication

- Adaptation
- Redundancies
- TP-Development
- Test time
  → LESS COST
Test-Strategy

Mix of Methods

- Minimize costs
- Adjust the strategy to every single product
- Avoid redundancies
  → accurate analysis, what is tested where
  complimentary tests, not overlapping tests

- Reduce costs for adaptation
  → f.e. ICT only where really necessary
  (only to ensure correct start_up of pcb under power)
  Integrate BoundaryScan

- Minimize handling
  → Integration of various methods on a single test station
  (f.e. with HV-Matrix also 230V-Test on a combinational tester)
Cost influencing factors

- Kind of product (safety -> consumer)
- Test-depth
- Test-Method(s)
- Equipment pool
- Adaptation
- TP-development
- Production quantity
  - Handling (manual -> InLine)
  - Handling-time
  - Test-time
  - Failure-rate
  - Re-Test

$\sum$
Test-Strategy

How to test which product?

• Analysis of the single product:
  Structure, industrial segment of usage, fault spectrum, adaptability, production quantity, costs, ...

• Flexible decision for a product specific strategy

• needs:
  → flexible test system (Combinational Test System, maybe Flying Prober)
  → flexible tester-pool with:
    common HW-platform (maintenance, spare parts,...)
    consistent SW-platform (Know-How, programming, operation,...)

→ optimal cost-benefit ratio for all cases
Thank you for your interest!

For further information:

info@digitaltest.de

or Tel. +49(0)7244-9640-0 (Europe)
+01 (0) 9256038650 (USA)

This Webinar was recorded and will provided to you after this meeting