In-Circuit- or Functional Test? Or why test at all?

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Do you have to test?

→ This question is related to product and customers

**Safety Products:**
e.g. Automotive, Military, Avionics

**Machinery:**
Production line stands still because electronic part has a defect

**Consumer Electronics:**
High end products are more critical than low cost products
Do you have to test?

Not testing can result in:

- Additional costs (e.g. repair or service costs)
- Time loss
- Damaged reputation
- Safety risks
What can or must be tested:

This question is related to quality of components and production

<table>
<thead>
<tr>
<th>Type of Failure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Quality of delivered components</td>
</tr>
<tr>
<td>Process</td>
<td>What process, depending on machine park</td>
</tr>
<tr>
<td>Production</td>
<td>Shorts, wrong mounting or solder problems</td>
</tr>
<tr>
<td>Function</td>
<td>Dynamic, functional and environment</td>
</tr>
<tr>
<td>Design</td>
<td>Not in series production</td>
</tr>
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</table>

Actual failure classes need to be detected and reviewed
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-usuable
Test Coverage

What is my test coverage?

Coverage: of the de facto possible / occurring Failures

ICT: easy to declare

FKT: declaration → impossible, not easy to investigate
Factor 10 Rule:
The costs 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

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

**System Test**
Detecting and Localizing of:
- Dynamic Failure
- System Test
- Real environmental parameters

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

**Optical Inspection (AOI)**
Detecting and Localizing of:
- Insertion Failures
- Solder Failures
- Mechanical Problems
The methods

In-Circuit Test (ICT)

→ Test of components in a circuitry

• Analogue & digital components tested for Values & Functions

• Tests include: component values, polarity, contact & shortage between the nets

• Test of components in between complex circuitry will be performed by isolating the components with a “Guarding” technique

Functional Test (FCT)

→ Test of the functionality of the PCB or parts of the PCB

• By stimulating digital and/or analogue parameters at the inputs of the circuit, the output parameters are measured & verified

• The interaction of the components in the real circuitry will be tested & a correct function can be investigated
Advantages of each method

**In-Circuit Test (ICT)**

- Component values are tested
- Production failures can be detected
- Detected problem will be pinpointed & the failure be localized
- The level of diagnostics makes the repair of the PCB easy & can be performed by an operator, no engineer required
- Easy automatic development of the test program by reading the CAD- & BOM-Data
- APG (automatic program generator) generates the test program with all needed parameters for each component
- The test time is fast and a high throughput can be reached

**Functional Test (FCT)**

- The functionality of the PCB or parts of the circuitry will be tested
- By changing the parameters the feedback of the components can be forced
- Detects development failures (wrong dimension of components)
- Can be performed static, dynamic or up to real time
- Doesn’t need complex fixturing & in most cases it can be performed by using only the edge connectors
Disadvantages of each method

In-Circuit Test (ICT)

- Complete test requires an (expensive) fixture with spring probes on each electrical net

  → **Flying Probe Test could be the better solution**

- 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
- Knowledge of the functionality of the PCB is necessary
- A failure will not automatically pinpoint the defective component
- Diagnosis & repair 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 customers side
- Test time can be very long
Example In-Circuit Test

Layout-display directly points to possible locations of shorts and offers fast diagnosis.
Example In-Circuit Test

Directly linked Schematics-display showing the faulty component and its environment (incl. Interactive debugging)
Example In-Circuit Test

Layout-display directly points to faulty components and offers fast localization.
Example In-Circuit Test

Digital-Display shows the state of involved driver/sensors and supports diagnosis of digital failures (incl. Interactive debugging)
Example In-Circuit Test - Summary

• 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
Example Functional Test

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
Example Functional Test

All segments enlightened with same intensity and color?

Automatic optical evaluation of color and brightness, actuation of controls (switches, trimmers,..)
Example Functional Test

Calculation and programming of configuration data:

• Modify UUT adjustment & determine configuration data
  ✓
• Program to UUT memory and verify
  ✓
Example Functional Test

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 Functional Test

PCB powered up and Start_Up-Test says "Pass", but in normal operation random failures

- What is really tested/used during Start_Up & FCT
- All Opens / Shorts detected during these tests
Combination 1

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

- 100% adaption
- Overlapping tests / redundancies

→ HIGH COSTS
Combination 2

- partial aICT (active)
- + Power & aFCT
- + BIST & Communication

↓ Adaptation
↓ Redundancies
↓ TP-Development
↓ Test time

→ LOWER COSTS
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
  → e.g. ICT only where really necessary (only to ensure correct start_up of pcb under power)
  → Integrate Boundary Scan

• Minimize handling
  → Integration of various methods on a single test station
Test strategy

Cost factors

Product type
(safety -> consumer)

Test depth

Test method(s)

Equipment

Adaptation

TP-development

Production quantity

Handling
(manual -> InLine)

Handling time

Test time

Failure rate

Re-Test

Test depth

Test method(s)

Equipment

Adaptation

TP-development

Handling
(manual -> InLine)

Handling time

Test time

Failure rate

Re-Test
Test strategy

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
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