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

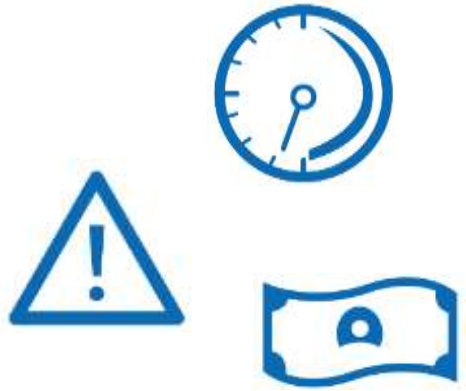
Consumer Electronics:

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

Type of Failure	Description
Component	Quality of delivered components
Process	What process, depending on machine park
Production	Shorts, wrong mounting or solder problems
Function	Dynamic, functional and environment
Design	Not in series production

→ **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-usable

Test Coverage

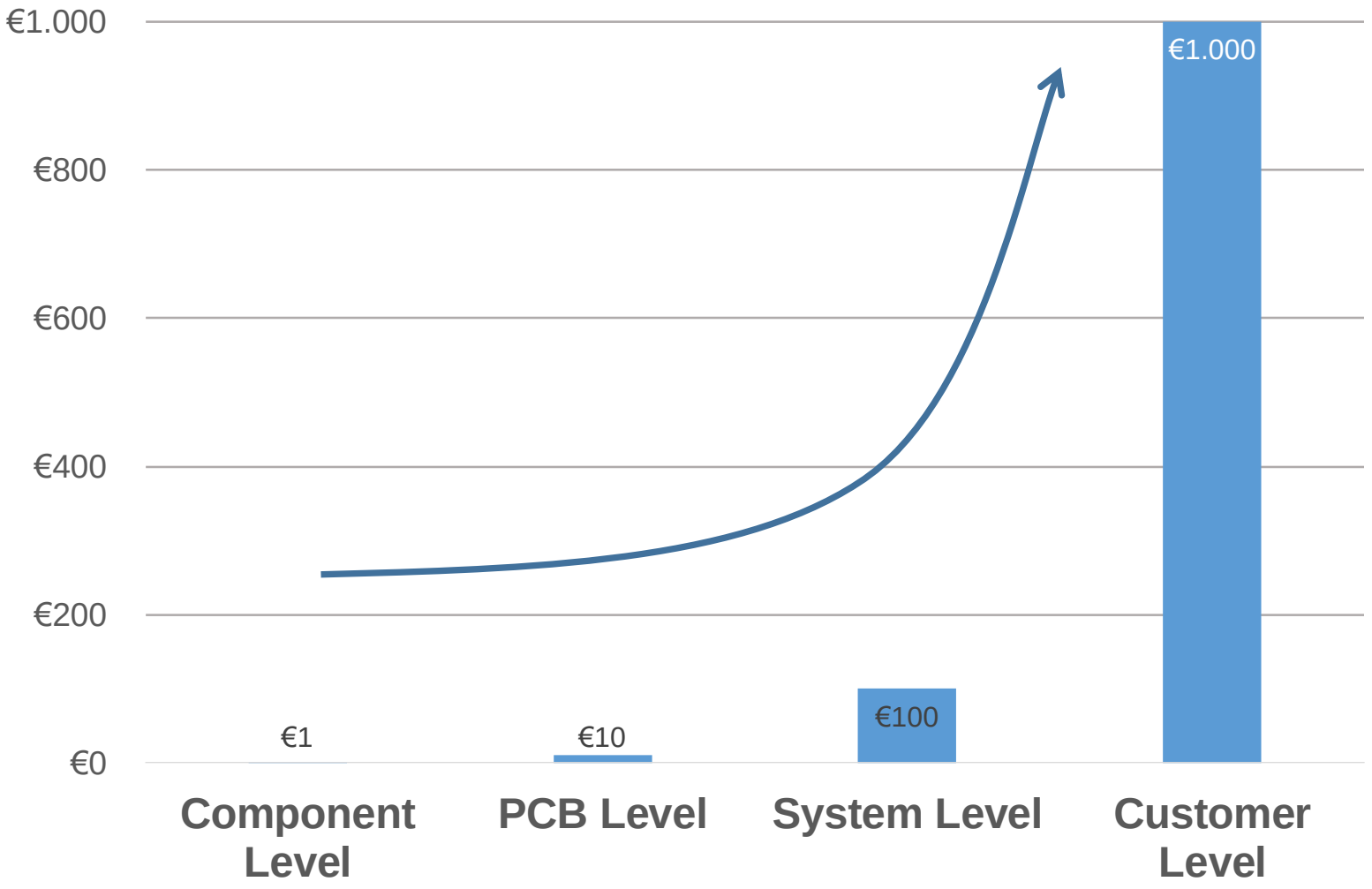
What is my test coverage?

Coverage: of the de facto possible / occurring Failures

ICT: easy to declare

FKT: declaration → impossible, not easy to investigate

Costs



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 functionallity 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**

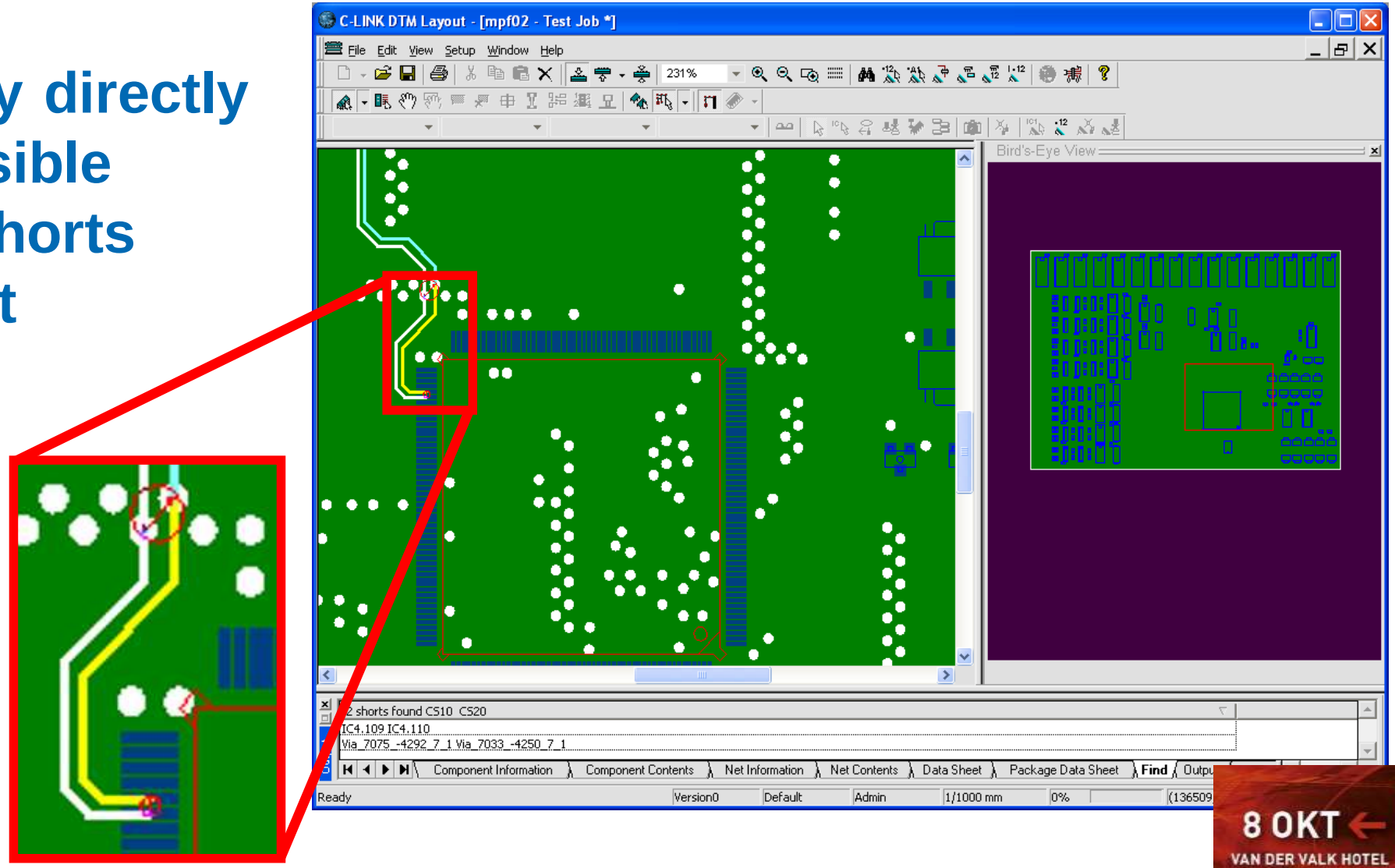
- Real dynamic tests are almost impossible
- Design problems will be not detected
- Each time the layout changes a new fixture may be necessary

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

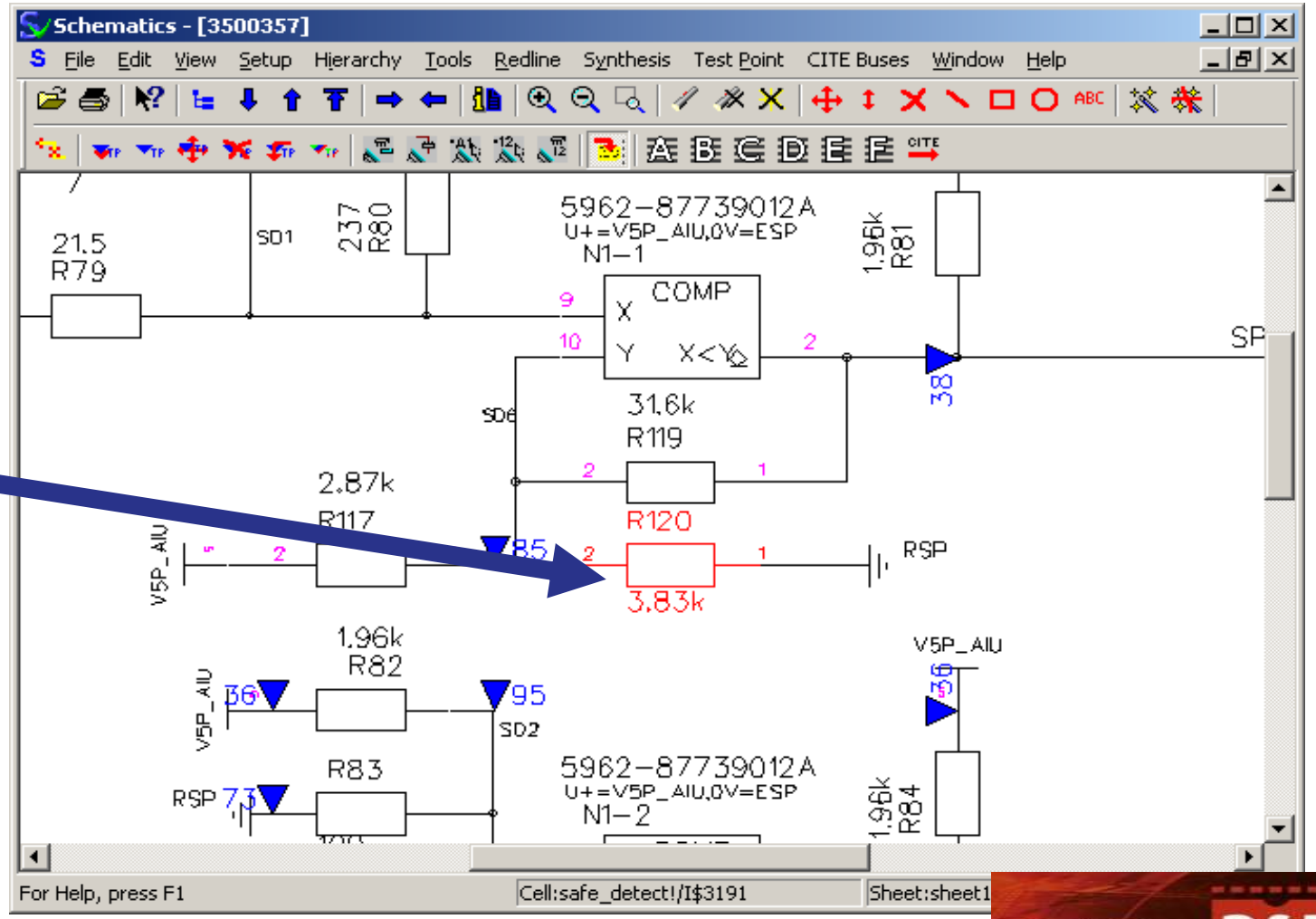
Example In-Circuit Test

Layout-display directly points to possible locations of shorts and offers fast diagnosis



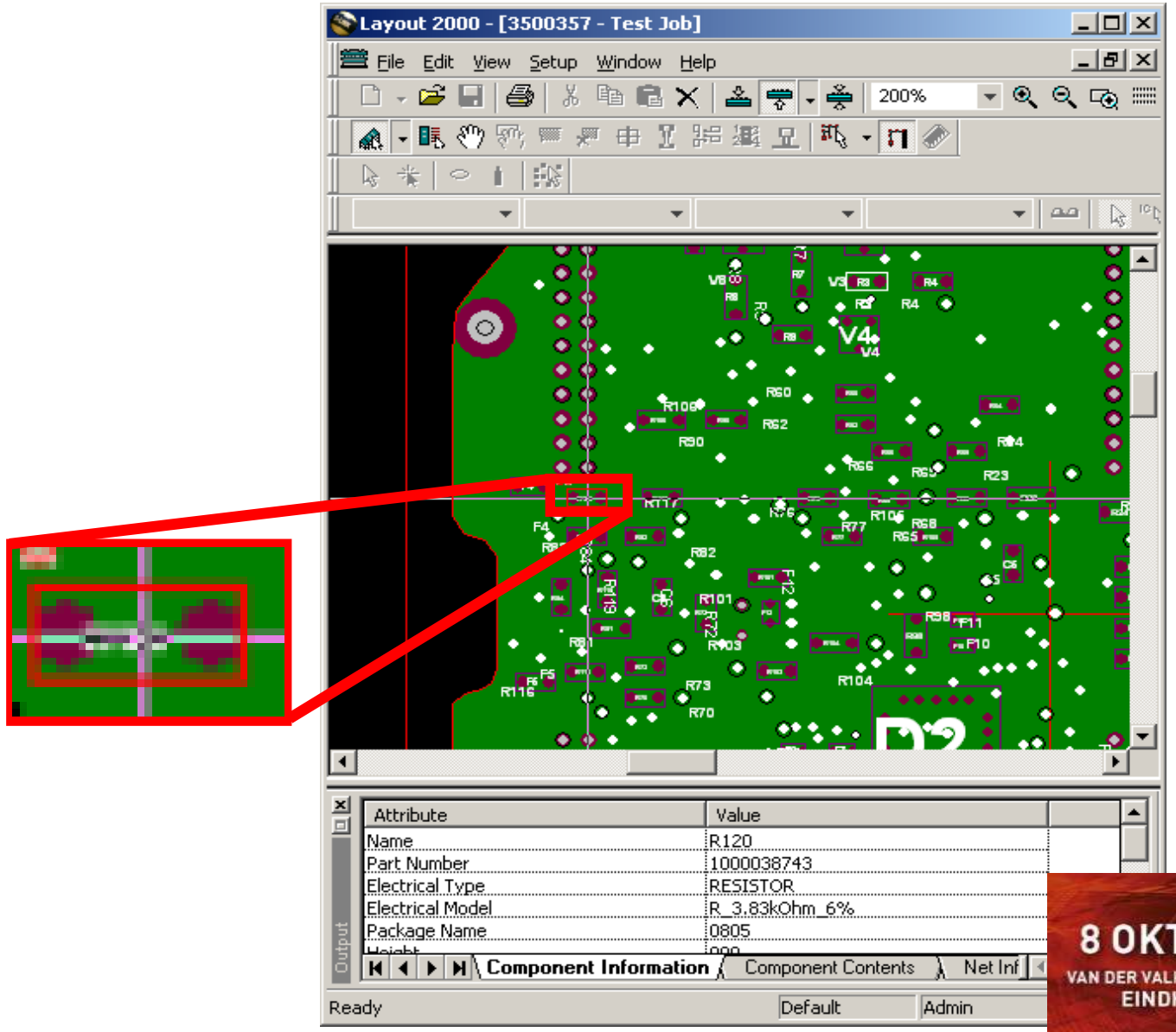
Example In-Circuit Test

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



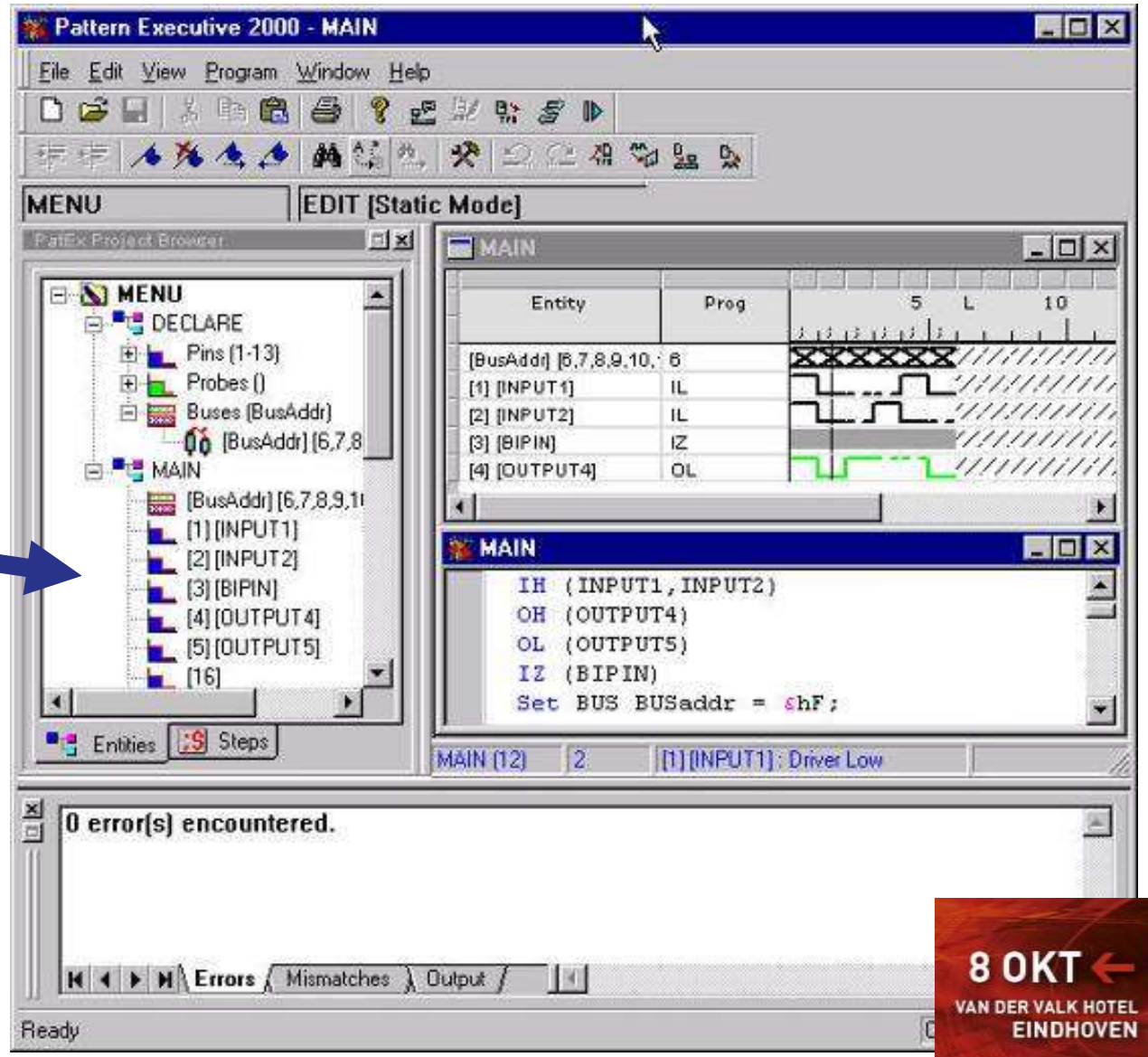
Example In-Circuit Test

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

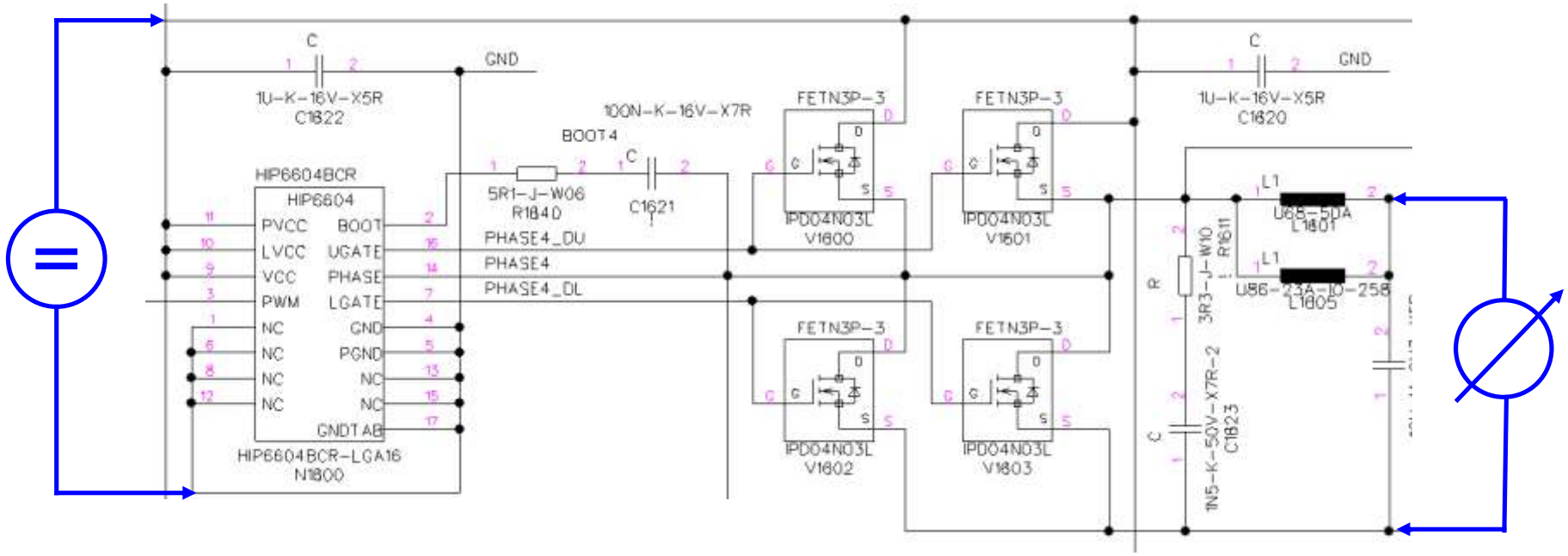
- Test results point directly to defective structures, so that all graphical help functions can be used

Example Functional Test

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

Safe function of switching regulator also with:

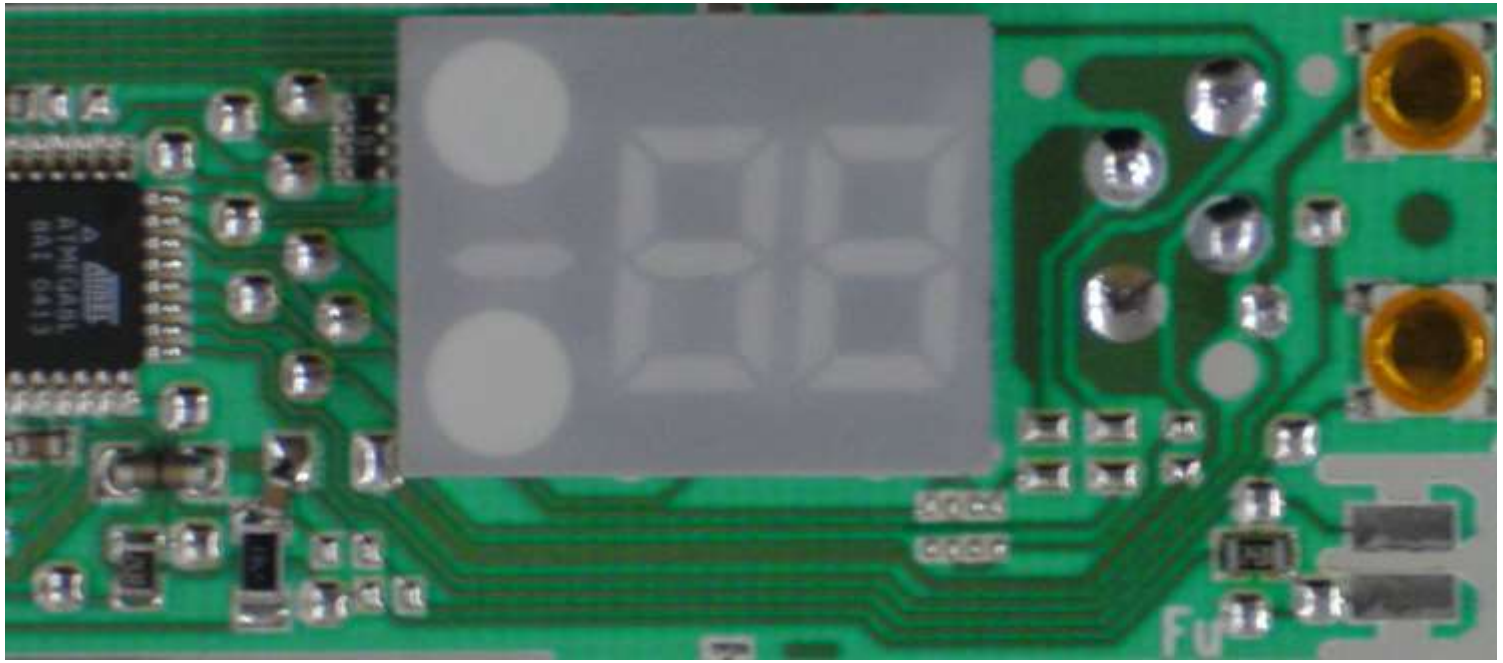
- Min/typ/max load
- Under-/over- voltage



Example Functional Test

All segments enlightened with same intensity and color?

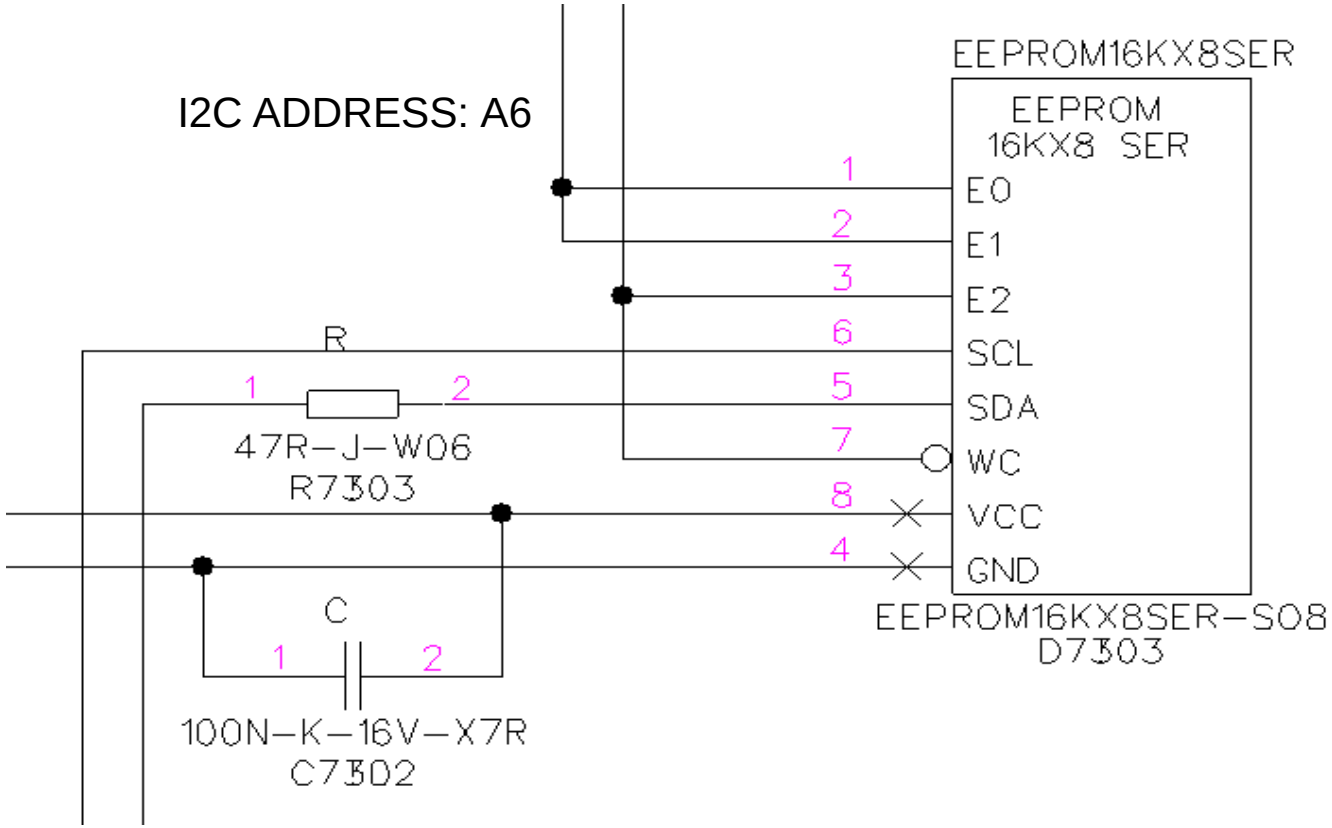
Automatic optical evaluation of color and brightness, actuation of controls ✓ (switches, trimmers,..)



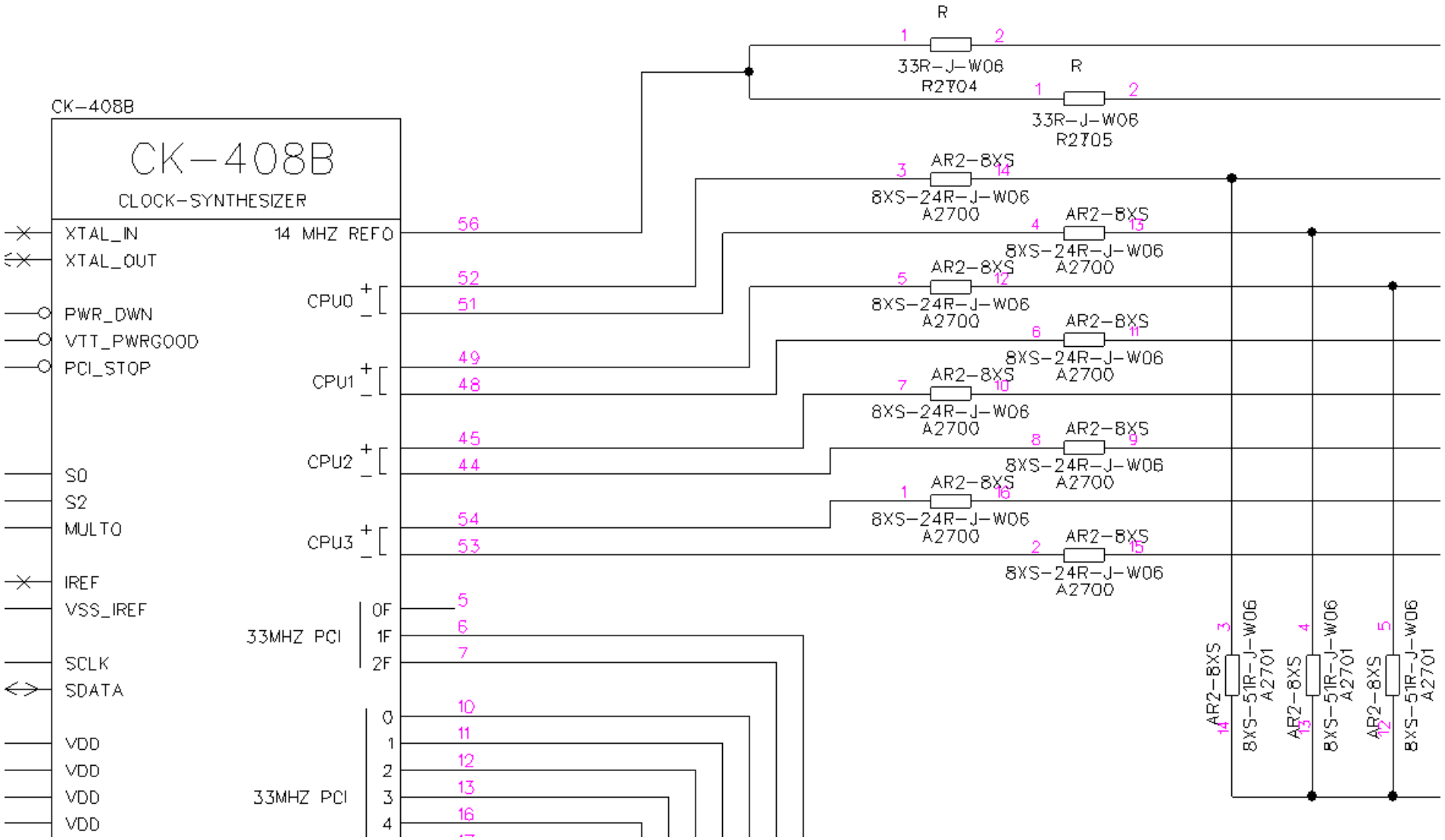
Example Functional Test

Calculation and programming of configuration data:

- Modify UUT adjustment & determine configuration data ✓
- Program to UUT memory and verify ✓



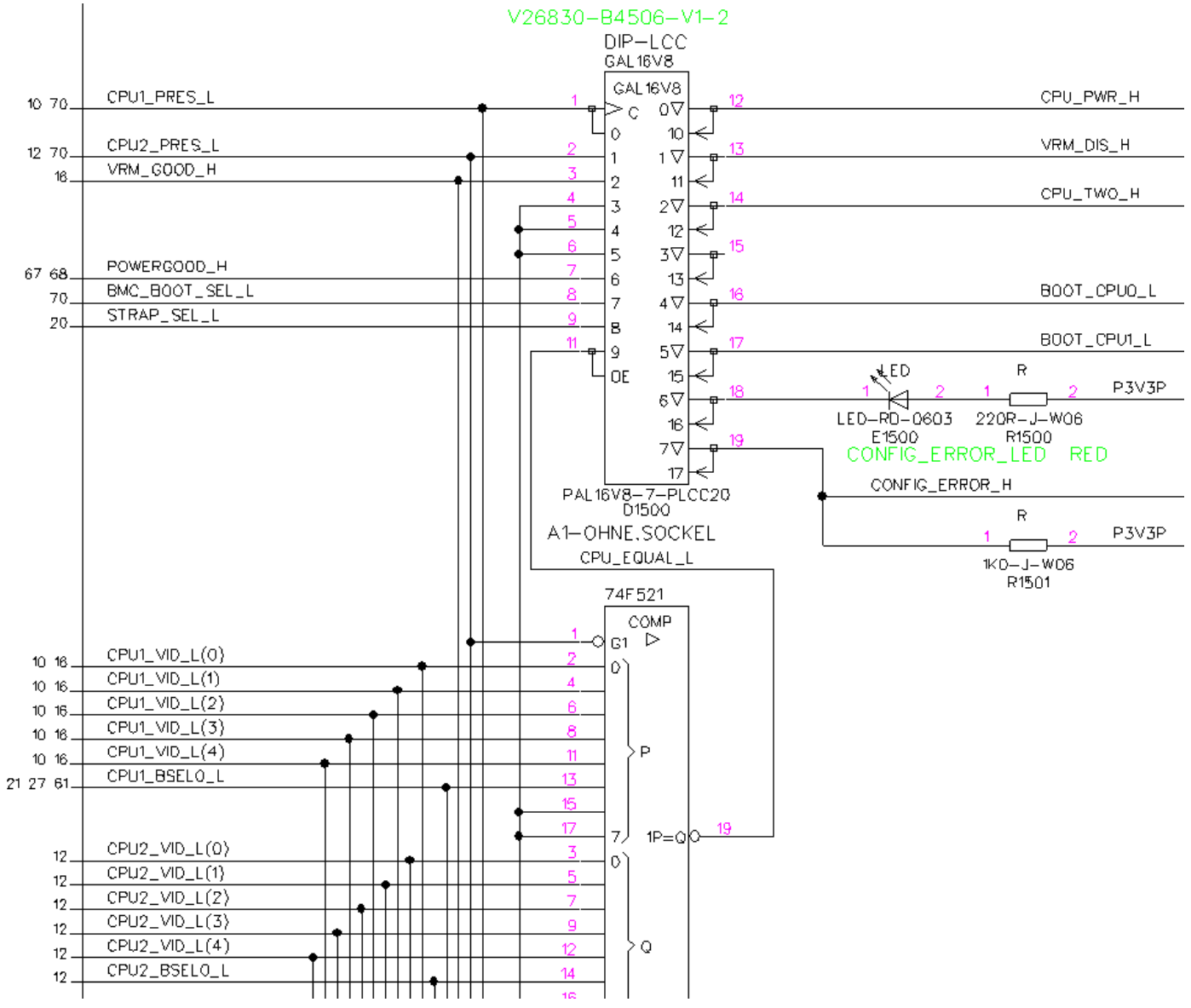
Example Functional Test



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

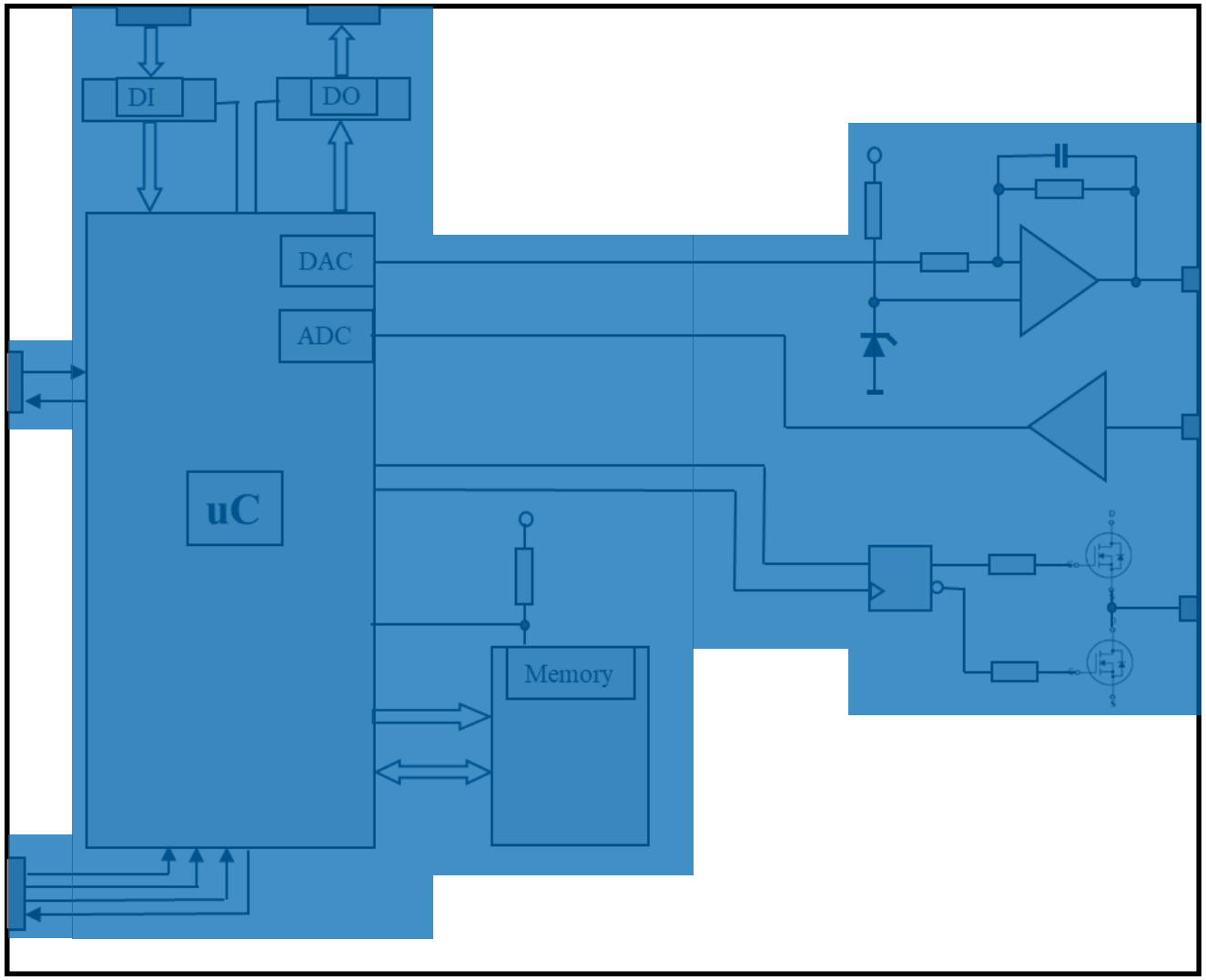
Example Functional Test



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

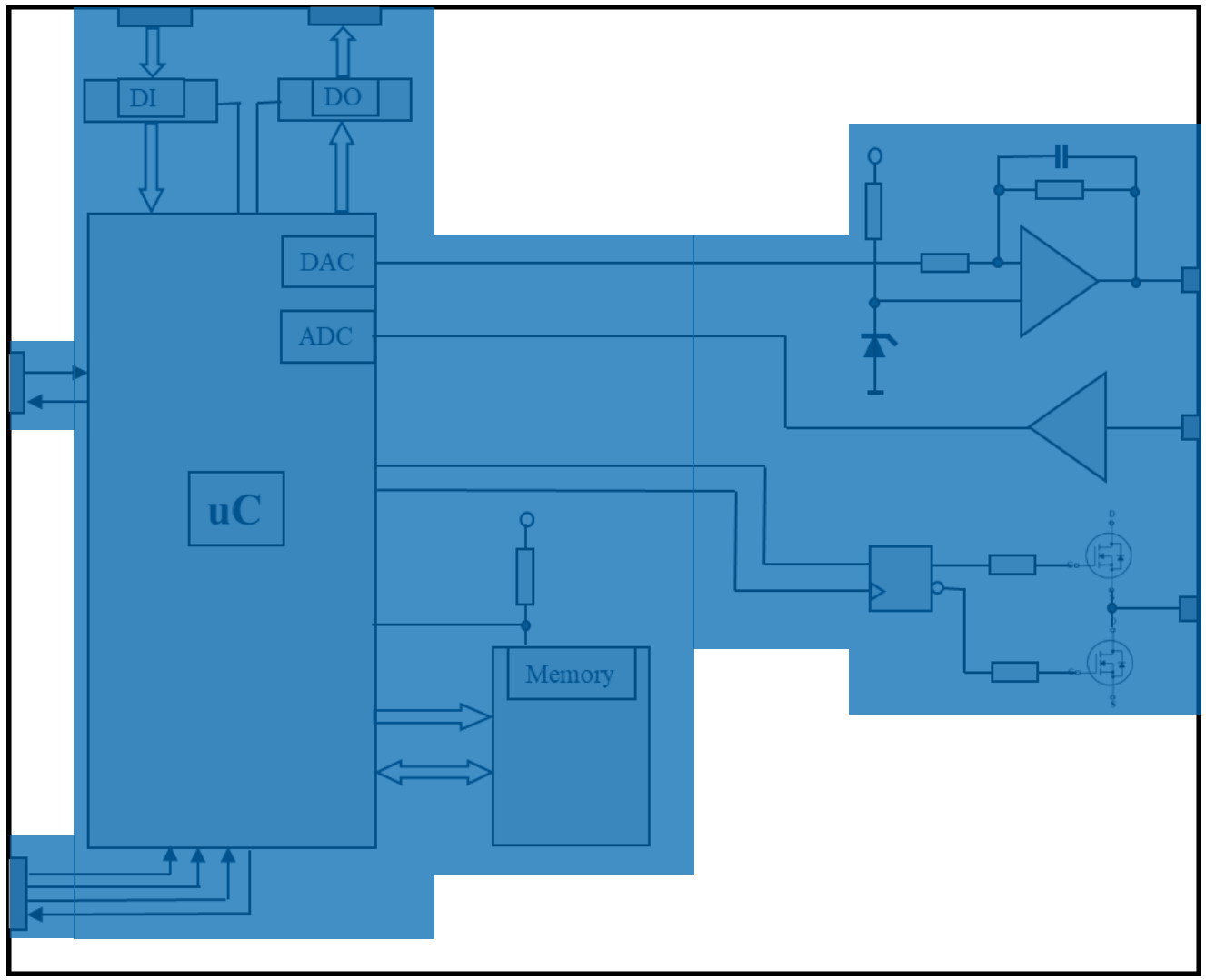


- ➢ **aICT**
- **+ Power & aFCT**
- **+ dICT**
- **+ Programming**
- **+ BIST & Communication**

- 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 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

Thank you for your interest!

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