

## SELF-LEARNING TOOL FOR DIGITAL TEST

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In this paper a conception is presented how to improve the skills of students to be educated for hardware and SOC design in test related topics. We present a learning method based on using so-called *living pictures* [1]. The method deals with the goal, to put interactive teaching modules to the Internet that can be used in a lecture as well as for individual self-studies.

The core of the teaching concept presented are JAVA-applets (interactive modules) running on any browser connected to the Internet. We call this type of applet "Living Pictures". The program for representing "living pictures" for teaching Digital Test is written in Java 1.3 [2]. It can be run over network, using standard browsers like Netscape and Internet Explorer with Java 1.3 runtime plug-in, or with Java 1.3 applet viewer. The program can be used for teaching the basics of testing digital systems, test generation, fault simulation and fault diagnosis.

The work window of the applet consists of three main parts: vector insertion panel, view panel for design schematics, view panel for displaying information.

The vector insertion panel has two subpanels for inserting single input test vectors and for setting up the feedback configuration of a Linear Feedback Shift Register (LFSR) to be used for automatically generating test vectors. In the LFSR mode, the first subpanel is used for initializing the LFSR. The LFSR based Automated Test Pattern Generator (ATPG) is used for emulating different BIST ideas like Built-In-Logic-Block-Observer (BILBO) or Circular-Self-Test-Path (CSTP) [3]. The first subpanel is also used when creating test vectors for specific fault detection. In this case, the fault activating and propagating values are inserted one by one into the signal boxes at connections of the design schematics, and the input test vector will be deduced from these internal signal values.

The schematics panel displays currently selected schematics. The small boxes at the lines display internal signal values on connections. The boxes are clickable during manual test vector generation and fault diagnosis. In the test generation mode, the needed signal values for fault activation or fault propagation can be inserted directly at the connections. In the fault diagnosis mode, by clicking the boxes, a guided probing procedure can be simulated. A click on the box shows the result of measuring the "real" signal on the corresponding connection of the simulated faulty circuit.

Detected faults, signal conflicts etc. are displayed as colored bold wires. Color coding is as following: red - stuck-at-1 fault is detectable, green - stuck-at-0 fault is detectable, gray - undefined (don't care) signal, and blue - conflicting signals.

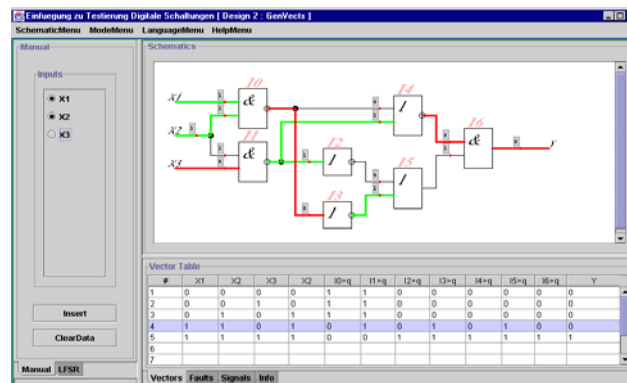


Figure 1. “Living picture” as Java applet

The data panel displays information about simulated test vectors and detected faults. In fault simulation mode you can click on the row of a given vector and have a visualization which faults are detected. In signal (waveform) mode you can select all the signals in interest and leave out those which are not.

There are four main menus used with the applet: schematics, mode, language, and help. The schematics menu contains a list of predefined circuits. The mode menu tells the applet what is to be done - test vector insertion, manual test generation, fault simulation or fault diagnosis.

We start by selecting a circuit from a set of predefined circuits. Then we can carry out different experiments with this circuit by selecting a proper working mode. In vector insertion mode we choose test vectors either automatically by LFSR, or by inserting vectors manually. In the manual mode, we generate step by step input patterns which are simultaneously simulated. The boxes at the lines on the schematics subpanel display the result of simulation – the values of internal signals on the connections. The waveforms can be viewed on the data subpanel .

When using LFSR, we have to specify the initial state, to set up the feedback structure, and to specify the length of the test. By LFSR we can simulate the BIST either in the mode of Built-In Logic Block Observer (BILBO) or in the mode of Circular Self-Test Path (CSTP) [3]. By changing the settings on the vector insertion panel we can emulate different feedback structures of the chosen BIST architecture.

In test generation mode we choose a target fault in the schematic and create step by step proper activated paths in the circuit to activate the fault at his site and to propagate the error signals caused by the fault towards output by clicking the needed values into boxes on the lines. From these values finally, an input vector will be deduced. The colours on lines help us to understand the current status of the task: activated faults and activated paths are marked by red and green lines, the

inconsistencies of the signal values are highlighted by blue colour. As the result of the procedure, a test pattern will be generated. The detected by the test faults are displayed also on the data panel in form of a row in the fault table.

In fault simulation mode, a fault table is generated and shown on the data panel. By selecting a test vector on the panel, all the detected faults will be highlighted by colours on the schematic panel.

In fault diagnosis mode we need at first, to create a fault table by running the fault simulator for a set of generated test vectors. Entering into the diagnosis mode will insert a random fault into the circuit. The following diagnosis strategies can be investigated: combinational and sequential diagnosis. In combinational diagnosis, a single vector or a subset of vectors can be selected and applied to the erroneous circuit (by imitating test experiments). The applet shows the results of testing, and displays also the subset of suspected faults. To improve the diagnostic resolution, additional test vector(s) may be generated and used in the repeated test experiment. Sequential diagnosis is based on the guided probing strategy. A test pattern is applied and the expected behavior of the circuit is displayed. By clicking on the connection boxes the real values of signals of the faulty circuit can be measured.

The main didactive point in learning the diagnostic strategies is to try to localize the fault by as few test vectors (combinational approach) or by as few measurements (sequential approach) as possible. A competition between students can be carried out which makes the “play” with the applet even more exciting.

By the use of web-based media we achieve: presentation of course material independent of place and time, individual learning according to the students' own needs, quick cross-referencing by hyper-linked texts, new forms of communication between teachers and students (chat, joint editing), up-to-date course material.

The conception presented allows to improve the skills of students to be educated for digital hardware and SOC design in test related topics. The principal mission of the conception is to inspire students to learn, to inspire them on a journey to knowledge, and to prepare them to develop problem-solving strategies.

### References

1. Ubar R., Wuttke H.-D. Action Based Learning System For Teaching Digital Electronics And Test. *3rd European Workshop on Microelectronics Education*", Aix-en-Provence, Kluwer Acad. Publ., May 18-19 2000, pp. 107-110.
2. <http://www.pld.ttu.ee/java/IntroI/>
3. M.Abramovici et al. Digital Systems Testing and Testable Design. IEEE Press, 1999, 652 p.