

# Internet-Based Software for Teaching Test of Digital Circuits

Raimund Ubar<sup>1</sup>, Artur Jutman<sup>1</sup>, Elmet Orasson<sup>1</sup>, Jaan Raik<sup>1</sup>, T. Evartson<sup>1</sup>,  
Heinz - Dietrich Wuttke<sup>2</sup>

<sup>1</sup>Tallinn Technical University, Raja 15, 12617, Tallinn, ESTONIA,  
Email: {[raiub.artur.elmet.jaan.teet@pld.ttu.ee](mailto:raiub.artur.elmet.jaan.teet@pld.ttu.ee)}

<sup>2</sup>Ilmenau Technical University, Helmholtzplatz1, 98684 Ilmenau, GERMANY,  
Email: [Dieter.Wuttke@tu-ilmenau.de](mailto:Dieter.Wuttke@tu-ilmenau.de)

**Abstract:** The Internet and multimedia open new possibilities for learning methods. We want to present a learning method uses two levels of teaching: so-called *living pictures* and *laboratory research*. On one hand teachers can show in basic training more complex examples and immediate demonstrate the influence of changing parameters by using computer simulated living pictures in their lessons. On the other hand students can deepen their knowledge in laboratory research. The students can use the same simulations on their home computer, because the living pictures are available on the Internet.

## 1 Introduction

Internet-based education is currently a hot research and development area. Benefits of internet-based education are clear: classroom independence and platform independence. An application installed and supported in one place can be used in other places all over the world. Most of internet-based courses made available in recent years are not more than a network of static hypertext pages. The challenge is to develop web-based educational applications, which can offer some amount of interactivity and adaptivity.

The presented work is a result of a cooperation carried out in 1999-2001 between Technical University of Ilmenau and Technical University of Tallinn (Estonia) with the goal to develop a web-based teaching and learning software in the field of digital test.

Rapid advances in the areas of deep-submicron electron technology and design automation tools are enabling engineers to design larger and more complex circuits and to integrate them into one single IC. System on a Chip (SOC) design methodology is seen as a major new technology and the future direction for semiconductor industry. On the other hand, the cost of test and verification because of the increasing complexity of systems has become a significant part of the total cost of electronic products. This is the reason why design for dependability, verification and test are becoming more and more important in all the life periods of a system - in development, production and exploitation - and therefore, these issues should be considered also in teaching tomorrow's electronics engineers. This is why the curricula in system and electronics engineering should incorporate a greater emphasis on design for testability (DFT) and on the concepts of test. Teaching in this domain should be facilitated by using integrated CAD tools that support verification, design for testability, test generation, built-in self-test, fault diagnosis and fault tolerance.

## 2 Two Levels of Learning Test

In the paper a conception is presented for training students to be educated for hardware and SOC design to improve their understanding and skills in test related topics. The training consists of two parts: interactive learning of basic problems by using web-based interactive learning modules, and laboratory research based learning of advanced problems by using low-cost test related tools.

The first part of training is based on using so-called *living pictures* [1]. The method presented deals with the goal to put interactive training modules to the Internet that can be used in a lecture as well as for individual self-studies [2]. They can be accessed independent of time and place. On one hand, teachers can show more complex examples during the lecture and immediately demonstrate the influence of changing parameters by using computer simulated “living pictures” in their lessons. On the other hand, students can use the same simulations on their home computer, because the “living pictures” are available on the Internet.

The second part of training has a target to give students already equipped with basic knowledge of test problems the possibility to go more deeper into the essence of the test problems, to get acquainted with different methods and models, and to get hands-on experience in solving some practical problems. The second part is carried out in the laboratory.

## 3 Living pictures based on Java applets

The teaching software developed supports the action-based training via Internet. The software offers a set of tools to inspect the objective to be learned, access to multiple learning modules, a big reservoir of examples and the possibility to generate new ones. It provides easy action and reaction (click and watch) by using “living pictures”, the possibility of distance learning, and learning by doing.

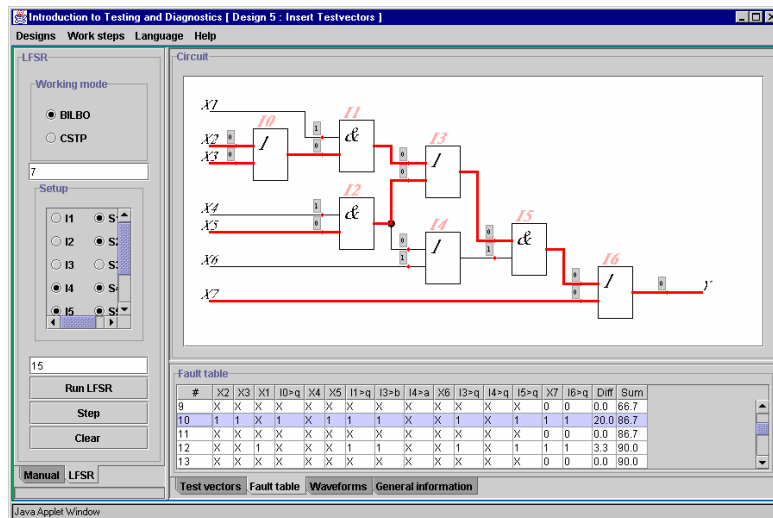


Figure 1. Java Applet for Teaching Digital Test

Java-applets (interactive modules) are the core of that concept, running on any browser connected to the Internet. By using interaction possibilities the students can generate examples that are interesting enough to encourage their own experiments. They can produce input stimuli (either manually or using built-in generators) and watch the reactions. In reaction to the inputs, a simulation component starts which executes the method that has to be taught, and presents its results using a visualization component. There is also an explanation component, describing the unknown method step by step, using the actual chosen or generated example. The software is written in Java 2, and it can be run over network, using standard browsers like Netscape and Internet Explorer with Java 1.2 runtime plug-in, or with Java 2 applet viewer.

The software can be used for teaching the basics of Digital Test and Testable Design as illustrative tool explaining the problems of fault modeling, fault simulation, test generation and fault diagnosis. The work window of this program (Fig.1) consists of three parts - vector insertion panel, view panel for design schematics, and view panel for test vectors, fault tables and waveforms. Vector insertion panel has two sub-panels - one for manually inserting vectors and another one for automated pseudorandom test generation by different methods. The boxes at the lines on schematics are click-able for inserting proper signals during test generation. The software supports following topics: fault simulation, test generation, testability analysis and built-in self-test. The key problems can be taught and learned using the software on different examples.

#### 4 Diagnostic PC-based tools for laboratory training

Traditional VLSI test generation and fault simulation software on workstations are both costly and unable to handle large numbers of students simultaneously in educational courses. During the recent years, many different low-cost tools running on PCs have been developed to fill this gap. They include usually the major basic tools needed for IC design: schematic capture, layout editors, simulators and place and route tools.

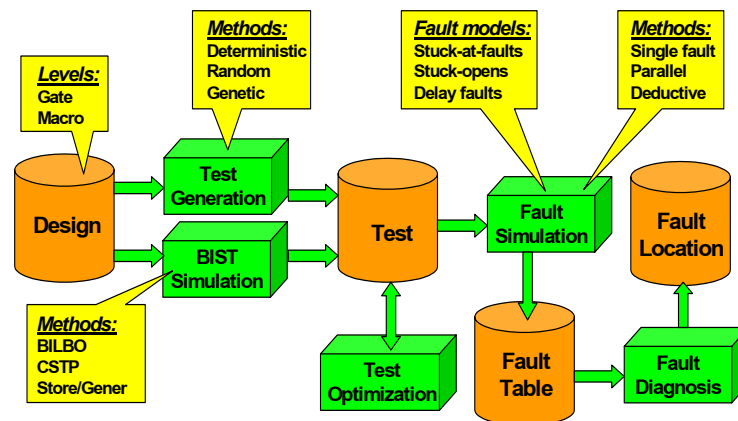


Figure 2. Turbo Tester Tool Environment

Low-cost systems for solving a large class of tasks from the dependability area - test synthesis and analysis, fault diagnosis, testability analysis, built-in self-test, especially

for teaching purposes, are missing. For this reasons, at the Tallinn Technical University the diagnostic software Turbo-Tester (TT) [3] was developed (Fig.2).

TT software consists of a set of tools for solving different test related tasks by different methods and algorithms: test pattern generation by deterministic, random and genetic algorithms, test program optimization (test compaction), fault simulation and fault grading for combinational and sequential circuits, multi-valued simulation for detecting hazards and analyzing dynamic behaviour of circuits, testability analysis and fault diagnosis. The representation of the circuit can be given at gate- and macro levels which gives a possibility to investigate the complexity issues of different test algorithms. The software system is continuously updated by introducing new tools.

After learning theoretical topics described in the previous section, a laboratory work follows with more complex and realistic designs, where the arbitrary available design software (schematic editor as minimum), and TT diagnostic software is used. A lot of different options, available in TT, give students an opportunity to compare different models and methods used in the testing practice. The students develop circuits as diagnostic objectives, investigate by TT the testability of circuits, redesign them if necessary for improving the testability, insert self-test BIST structures, analyze the efficiencies and trade-offs of different BIST solutions and learn to make proper engineering decisions in the field of testable design.

## 5 Conclusions

The combination of a two level education concept offers a bright range of enhanced training possibilities for students. At the one hand site the *living pictures* concept can be used for a first contact and individual exploration of the ideas of test and testable design. Students can get familiar with the basic ideas and choose examples at their own level of knowledge. By the use of web-based media we achieve that the presentation of course material is independent of place and time and individual learning according to the students' own needs can take place.

On the other hand the skilled students get their extended knowledge in *laboratory research*. They become able to compare different diagnostic and design methods and are better prepared for challenges of the new technologies in chip design.

## Acknowledgment

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