Electronic Systems Design: The Need for Integrated Software Simulation

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Abstract

The continuous increase in complexity of electronic systems is making the design of such systems more challenging than ever before. As a result, designers are finding it impossible to design efficient systems without employing an integrated software simulation environment and using sophisticated Electronic Design Automation (EDA) tools. This paper describes the benefits of an integrated software simulation approach and presents the industry design trends. These trends include concurrent design, system level design, virtual prototyping, design verification, design for test, fault simulation, and design for manufacturing. The paper also discusses the importance of teaching integrated simulation methodologies in engineering and engineering technology programs.

Introduction

Over the last 10 years, electronic systems have grown more complex and designers have been moving from the traditional sequential design approach to a concurrent methodology. The concurrent design methodology employs an integrated software simulation environment where the electronic designer takes into consideration the physical layout, manufacturing, and assembly issues of a product. This environment is facilitated through the use of EDA tools. These tools are capable of simultaneous simulation of the electrical and manufacturing features of a product and provide advanced design capabilities such as virtual prototyping, rapid prototyping, and hardware-software co-design. The proper uses of EDA tools have been proven to produce complex designs, reduce development time, and improve product quality.

The need for integrated simulation is obvious when considering hardware design and software development. In this case, testing hardware and software independently does not normally lead to complete verification, and delaying system integration until the hardware design is finished may impact the cost and time schedule. In a similar way, separating the electronic design phase from the manufacturing and assembly issues may create costly problems that can be prevented. Therefore, it is crucial to make sure that the design is completely correct before the manufacturing and testing stages.

To be able to produce graduates who are prepared for industry, engineering and engineering technology programs should be aware of the latest industry design trends and ready to incorporate into their curricula the relevant materials and techniques. While this paper mainly addresses electronic design, the concepts apply to other engineering and engineering technology fields. As
more companies become aware of the benefits of an integrated software simulation environment, the demand for engineers and technologists with the proper training and design skills should increase.

**EDA Tools and Their Capabilities**

EDA tools have been very useful in implementing an integrated software simulation environment. They have evolved over the years and now support the whole design process from the initial interpretation of system requirements to the final stages of manufacturing. While specific features and capabilities of EDA systems vary greatly, their major elements may be grouped as follows:

- **Entry tools**: they deal with schematic capture, block diagrams, Hardware Description Languages (HDLs), and system level design methods.
- **Simulation tools**: they handle analog and digital simulation, HDL simulation, signal integrity analysis, timing analysis, electromagnetic interference analysis, thermal analysis, vibration and fatigue analysis, and faults analysis.
- **Synthesis tools**: they cover HDL, behavioral languages, and Register Transfer Level (RTL).
- **Printed Circuit Board (PCB) tools**: they include layout editors, routing tools, and design rule checkers.
- **Field Programmable Gate Array (FPGA) tools**: they include design entry, simulation, and placement.
- **Miscellaneous tools**: these tools can handle other design issues such as wire harness design, virtual prototyping, and design for manufacturing.

While some EDA companies such as Mentor Graphics, Viewlogic, VeriBest, and Cadence offer a wide range of software tools that support most of the design functions, other vendors offer point solutions specialized in handling a few of the design tasks. Therefore, the designer must carefully determine his or her design needs and identify the tools that satisfy them. These tools must be compatible to easily correct errors found during simulation and avoid problems that result from moving files between them. Another issue that the designer must be aware of when dealing with multiple tools is the possibility of wasting time learning and maintaining them.

A successful integrated software simulation environment can be achieved only if the available tools provide all the capabilities required for a specific design. Assuming complex projects, then the EDA system should be able to:

- Perform electrical, mechanical, and manufacturing simulation in a concurrent design environment.
- Perform system level design and simulation including virtual prototyping, hardware/software co-design, and high-level synthesis.
- Support rapid prototyping.
- Perform mixed-signal (analog and digital) design and simulation.
- Analyze various design levels, from gates to whole systems.
- Provide a centralized database of files.
Industry Design Trends

Many companies, including automotive, communications, aerospace, and computers, have been successfully using EDA tools. The major goal has been to produce complex designs while reducing the cost and development time. Coupled with advances in EDA, this goal has led over the last few years to a shift from the old “find and fix” approach to a new “predict and prevent” paradigm. Figure 1 illustrates the relationships between the various design functions that support this new approach. Here, the design starts with a virtual prototype and ends with complete design verification. This total system approach has driven the industry design trends that are described in the following paragraphs.

Concurrent Design
Designers have realized that to achieve high productivity the processes used are as important as the tools employed. Concurrent design may be defined as the simultaneous consideration of the electrical, mechanical, manufacturing, and assembly issues using sophisticated tools. A major advantage of a concurrent methodology is that it allows for the interaction between designers from different disciplines. This interaction and addressing the various design issues simultaneously result in early detection of design flaws and lead to fewer design changes.

System Level Design
Electronic System Level (ESL) tools describe the system at a high abstraction level. In this case, the functionality of the product is captured independently of its implementation, allowing for a quick analysis of various architectural implementations. It is predicted that a System Level Design Language (SLDL) will be available by the end of year 2000. The language will have the capabilities to describe system requirements prior to partitioning into hardware (HW) and software (SW) and will facilitate HW/SW co-design.
Virtual Prototyping
While hardware prototyping may still be necessary at some point in the development cycle, taking full advantage of software simulation can significantly improve the overall design process. A virtual prototype is used to guarantee that the system’s operation and performance meet the initial system requirements. This is done by graphically simulating the operation using a model that best matches reality. In addition to the fact that virtual prototype iterations are easier and cheaper than hardware prototype iterations, this approach reduces the time required for software and hardware integration.

Design Verification
While testing is performed after the manufacturing of a product to detect defects introduced during manufacturing, verification is performed during the design phase to verify that the design meets the specifications. In the case of embedded systems, the trend is to perform co-verification (concurrent verification of hardware and software). The major reason for this approach is the need for early identification of problems. Hardware designers, for example, can take the code that the software engineers have developed and use it to test the hardware with real software. Despite the advantages of co-verification, sophisticated tools are still unavailable.

Design for Test
Design for Test (DFT) represents a set of rules and methods that can be added to the design in order to make it easier to test a product. These additional rules and methods do not add any functionality to the product but reduce the testing time after manufacturing. Some DFT tools are available, however, they don’t offer a comprehensive solution. It is expected that these tools will be readily available within the next five years.

Fault Simulation
Fault simulation is used after the circuit has been designed to determine if there are any flaws in the product. The purpose is to run tests with specific flaws inserted as inputs. The output is compared to the output of fault-free outputs to determine if the faults are detected. The goal is normally a detection rate above 95%. Fault simulation tools are available only with few EDA tools.

Design For Manufacturing
Design for Manufacturing (DFM) tools allow addressing manufacturing aspects such as layout, fabrication, assembly, and testing of a product early in the design process. A parts list, for example, may be examined to discover any problems affecting manufacturing.

Synthesis
Synthesis is still a major topic of interest. It consists of translating functional descriptions into actual circuit implementations, using various vendor technologies. This may include several designs with price, performance, and options. The major synthesis tool is a HDL (VHDL or Verilog). Compared to schematic capture, HDL delivers designs that are easier to produce, faster to verify, readily reused in other projects, and portable across Programmable Logic Devices (PLD) vendors.
Windows NT
The improvement of computing power of Personal Computers has enhanced the performance of these systems. As a result, EDA vendors have been looking at Windows NT as a feasible alternative to the UNIX-based platform and many of them have introduced Windows-based tools in the last two years. In addition, major users such as Intel and Chrysler have already moved their entire design environment to NT-based EDA. While UNIX remains the leader in the industry, Dataquest (a consulting firm) predicts that platforms running Windows NT will become the primary platforms by the year 2001.

The Web
The latest design trend is Web-based EDA tools. One of the major advantages of web-based tools is that the Internet supports multi-site access to a single design project. This provides better communication, faster access to design data, and easier design team management.

Engineering and Engineering Technology Curricula
Engineering and engineering technology curricula include courses that utilize EDA tools\textsuperscript{12-13}. However, many of the courses use entry and simulation tools to design circuits then verify their operations. In many cases, non-electronic tasks such as PCB layout, routing, timing, and noise are not normally covered. As designers continue to move toward concurrent approaches, the demand for engineers with the proper training and design skills should increase. To produce graduates who are prepared for industry, engineering and engineering technology programs should incorporate into their curricula the relevant EDA tools and promote an integrated software simulation environment.

Conclusion
The continuous increase in complexity of electronic systems is making the design and manufacturing of such systems more challenging than ever before. As a result, designers are finding it impossible to design efficient systems without employing an integrated software simulation environment and using sophisticated EDA tools. As designers continue to move toward concurrent approaches, the demand for engineers and technologists with the proper training and design skills should increase. To be able to produce graduates who are prepared for industry, engineering and engineering technology programs should incorporate into their curricula the relevant EDA tools and emphasize the important role of integrated software simulation.

Disclaimer
Although specific EDA tools were mentioned in this paper, the authors did not attempt to include all possible vendors. Furthermore, any reference to these tools does not imply endorsement.
Bibliography


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