

AC 2008-343: BEYOND VHDL SIMULATION TO ON-CHIP TESTING

Ronald Hayne, The Citadel

Beyond VHDL Simulation to On-Chip Testing

Abstract

Modern digital systems design relies heavily on hardware description languages and their associated software tools. Most important in an educational environment is logic simulation, which allows functional verification of designs without the need for hardware implementation. While this allows quick investigation of multiple design examples, simulation alone cannot prepare our students for the technical challenges associated with the final translation to actual hardware.

Programmable logic devices provide an integrated platform for implementation of digital circuits. Mapping designs to hardware provides students additional experience and insights associated with synthesis and device programming tools. Field programmable gate arrays (FPGAs) allow rapid prototyping of digital designs on a single chip, eliminating the need for multiple devices and error-prone external wiring. This tight integration presents additional challenges when it comes to testing the final hardware. Access to internal signals is limited, often making debugging more difficult.

As the density of FPGA devices increases, so does the impracticality of attaching test equipment probes to these devices under test. The Xilinx® design environment now provides optional real-time verification tools that provide on-chip debug at or near operating system speed. The ChipScope™ Pro tools integrate key logic analyzer and other test and measurement hardware components with the target design inside the FPGA. The ChipScope Pro tools communicate with these components and provide the designer with a robust logic analyzer solution.

A program of instruction has been developed that uses VHDL, FPGAs, and ChipScope Pro to teach advanced digital systems design. Throughout the course, digital designs are first modeled using VHDL and then functionally verified via logic simulation. Designs are then synthesized and mapped to target FPGA devices providing valuable insights into the practicalities and limitations of hardware implementation. Logic analyzer and input-output cores can be embedded into the FPGA design, providing a real-time test and verification system. The final hardware implementation is then demonstrated using ChipScope Pro to provide access to on-chip signals.

Design examples used in this course include a floating-point multiplier, a universal asynchronous receiver-transmitter (UART), and a reduced instruction set computer (RISC) processor based on the MIPS instruction set architecture. All designs are modeled and verified in VHDL, then realized and tested on an FPGA. Thus, these textbook examples are turned into functional prototypes, bridging the gap between theory and actual hardware. Ultimately, the use of these integrated design tools has provided a more robust learning experience that moves beyond VHDL simulation to hardware implementation and on-chip testing.