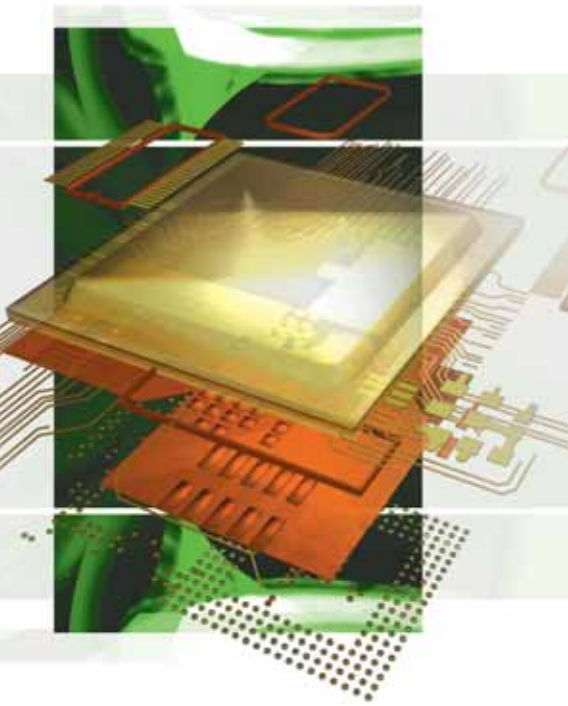
FPGA-Based Simulation for Rapid Prototyping

You can run an HDL simulator along with an FPGA through USB using iNCITE.



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Designing a hardware block does not simply mean RTL coding and simulation; the process usually includes FPGA-based prototyping. To do this requires a huge effort – including the preparation of a PCB board that implements your design and its surrounding functions in hardware – even though you probably only want to see the functionality of your design and not its surrounding components.

One possible solution around this has actually existed for some time: conventional emulation. This hardware-assisted acceleration technique connects an HDL simulator to programmable devices, allowing a design to run on real hardware while its surrounding functions are simulated on top of software.

In this article, I'll describe Dynalith Systems's iNCITE USB-connected FPGA board, supporting Xilinx® Spartan™-3 FPGAs. The iNCITE board provides a USB-based communication channel between software and an FPGA. Using industry-standard HDL simulator software, you can run your design in the FPGA under software control.

iNCITE

iNCITE is an FPGA-mounted PCB board featuring various on-board memories, a host computer interface using USB 2.0, and a board-to-board connector (see Figure 1). For application-specific peripherals, the iNCITE-AVREM application board incorporates audio, video, RS-232C, Ethernet, MMC, and PS/2. With both boards, you can easily implement a complete system-on-chip (SOC) or embedded system.

Design Flow for FPGA-Based Simulation

As shown in Figure 2, there are four design steps. In the first step, the design under test (DUT) and its test bench are developed using a pure software simulator, such as the free ModelSim-XE HDL simulator. When a synthesizable RTL version of the DUT is ready, the DUT is synthesized using an industry-standard FPGA synthesizer such as XST (Xilinx Synthesis Technology), a proprietary synthesis engine in Xilinx ISE™ software.

The synthesis result EDIF is processed by iNSPIRE-Lite, which is the GUI-based integrated design environment for iNCITE (Xilinx place and route is used internally). During this step, two files are generated: an emulation information file (EIF) and a proxy module. The EIF contains the necessary data and bitstream to configure the FPGA. The proxy module handles communication between the simulator and the FPGA through USB.

The test bench runs on top of the HDL simulator while the DUT runs in the FPGA. During simulation with iNCITE, the EIF is automatically downloaded to the FPGA through the USB channel at the start of simulation.

The channel between iNCITE and software is a generic one; thus, you can use any programming language including C, C++, SystemC, and MATLAB/Simulink. Essentially, you can build a virtual system

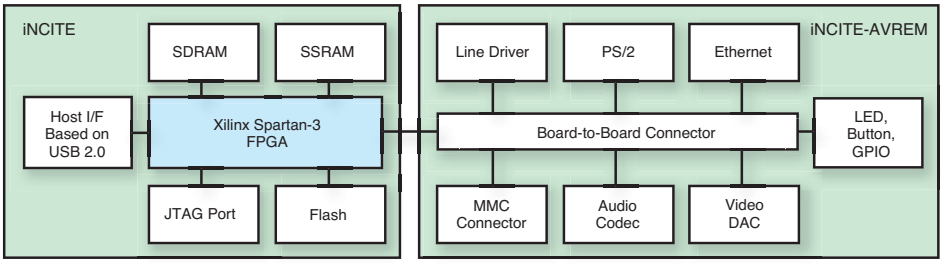

Figure 1 – Functional block diagram of iNCITE and iNCITE-AVREM

around the actual FPGA without preparing a PCB board, since the DUT is implemented in the FPGA and its surrounding blocks are modeled using your preferred language, including HDL and high-level languages.

Rapid Prototyping

Functional verification utilizing hardware has three major categories: logic simulation acceleration, emulation, and prototyping. Acceleration is based on the same idea described previously: some parts of the design run in the hardware while other parts are simulated on top of the software.

Emulation uses special hardware in the context of a real environment, where our design runs in programmable devices connected to a target hardware board.

Prototyping is a customized emulation system encompassing all parts of a system, including user design. It is usually implemented using an FPGA and PCB board. In other words, prototyping requires that you design the system before final production. Although the first two categories normally use off-the-shelf products, prototyping is time-consuming and costly, as it requires PCB design and debugging.

To assist beginners or those designing small- to medium-scale projects, the iNCITE application board can serve as a ready-to-prototype system (Figure 3). With this system, you can easily implement a complete SOC or embedded system. For the example shown in Figure 3, we built and mapped a complete OpenRISC-based SOC on the FPGA using iNCITE, while other peripherals and memories were incorporated using iNCITE-AVREM.

Conclusion

iNCITE, iNCITE-AVREM, and iNSPIRE-Lite provide an ideal design and verification environment, allowing you to run your design through an FPGA board. You can work in the same test bench from RTL design to FPGA-based gate-level verification without having to prototype a PCB.

These tools are also ideal for teaching, seminars, and small- and medium-sized designs, as the environment runs the gamut from pure simulation to FPGA prototyping through logic synthesis and FPGA place and route.

For more information about iNCITE, visit *www.dynalith.com/incite.php*. For more information about Dynalith Systems, visit *www.dynalith.com*.

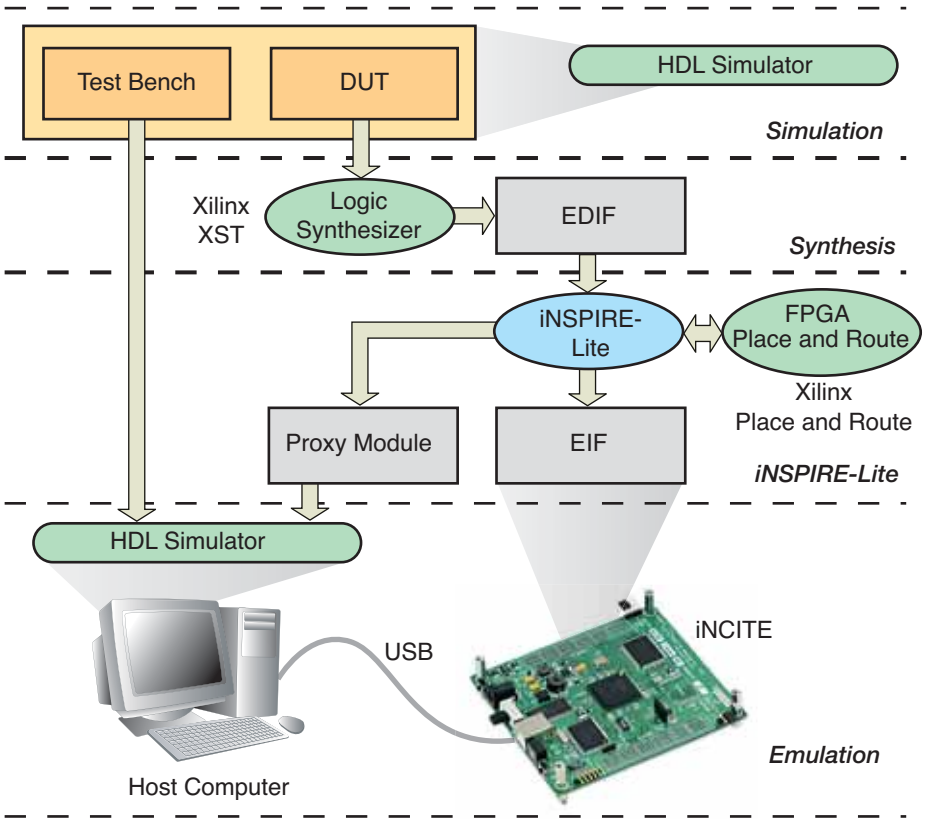

Figure 2 – iNCITE design flow

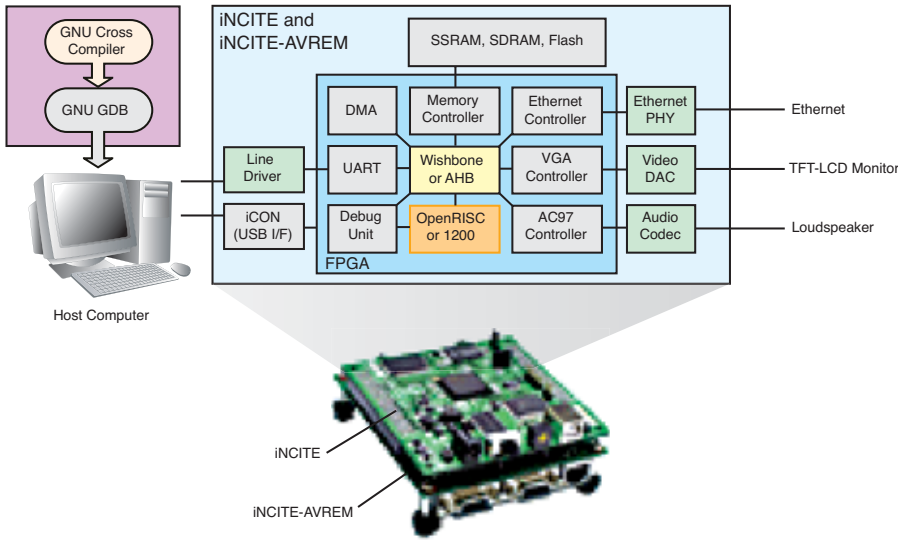

Figure 3 – Prototyping example of OpenRISC-based SOC