FPGA e-Lab, a Technique to Remote Access a Laboratory to Design and Test

Reza Hashemian, Life Member IEEE
Northern Illinois University,
reza@ceet.niu.edu

Jason Riddley
Northern Illinois University,
jrriddley@gmail.com

Abstract

We are proposing a new remote access system that allows for laboratory experiments to be performed remotely in the classroom or anywhere an internet terminal is available. The system specifically employed is aimed at courses of digital design using FPGA platforms. It is a powerful tool that allows for instruction with experiments and design examples in the classroom and gives students full access to laboratory equipment and an FPGA platform remotely from an internet terminal. This system is called FPGA e-Lab. It is constructed of a Xilinx Spartan-3E Starter Kit whose hardware is interfaced through a laboratory PC via an interactive LabView Graphical User Interface (GUI) and acquisition hardware as well as RS-232 serial and USB ports. Microsoft XP Remote Desktop is the vehicle used to access the Lab PC from a remote location.

1. The Proposed Methodology

The objective of this presentation is to introduce the FPGA e-Lab system in both its construction and its importance to engineering education. The system will open up traditional laboratory courses to students who have a need for internet based instruction. For students who have physical access to the laboratory equipment, the experimentation experience can be enriched by allowing more time for the students to work beyond “lab hours” either for assignments or curiosity. The e-Lab can also be used to enhance the learning experience in the classroom with experiments complimentary to instruction making for more interesting and fun lectures without the need or confusion of bringing the lab into the classroom. The e-Lab can also be used to bring education institutions together for collaboration. This could be to put together funds to purchase more advanced equipment that any institution by itself could afford and then to be shared via the e-Lab. Or, the collaboration could be to outreach to disadvantaged institutions whose students would not normally have access to quality lab equipment.

1. Project description and specification.
2. Design entry through schematic capture and/or Hardware Description Languages such as VHDL or Verilog.
3. Functional simulation and design verification.
4. Design synthesis.
5. Design implementation, and post place and route simulation.
6. FPGA hardware reconfiguration.
7. Design verification: testing and debugging.

As for the second step, we grouped these stages based upon what software or hardware tools needed for each stage of the design and came up with laboratory rules and regulations in order to minimize problems such as lab congestion. Stages 1 through 5 do not require hardware access but only software tools that are freely available for download online from Xilinx and other vendors. Therefore, the students will be required to complete these stages outside and before entering the FPGA e-Lab environment although the tools are available for making modifications. For stages 6 and 7, students will access the FPGA e-Lab environment to program the FPGA development board, experimentally verify their designs, and make modifications, resynthesize, and retest if needed. Finally, step three is currently undergoing development and will involve other departments and expertise and involves implementing the rules and regulations for students to use the system. These regulations would include student eligibility, access periods, and student schedules. The goal is to make access convenient for those who are only able to get to a computer terminal at certain times even when lab equipment is limited and congestion is heavy, such as during finals or before projects are due.
The FPGA e-Lab system is composed of a lab PC that can be remotely accessed using Windows XP Remote Desktop; a LabView GUI and National Instruments (NI) data acquisition hardware; optional lab equipment such as an oscilloscope and arbitrary waveform generator; a FPGA development board; webcam; and custom control hardware. Figure 1 shows a graphical diagram of the system [1]. The student will access the lab PC “virtually” using Windows XP Remote Desktop as if he were sitting in front of the PC and is able to perform file transfers. The lab PC contains a number of components. One being the development software, e.g. Xilinx ISE, that can be used to perform development stages 1 through 5 in case of needed modification. The PC also includes NI data acquisition hardware that is used to interface with the FPGA development board via control hardware. The FPGA development board used in our first prototype is Xilinx’s Spartan-3E Starter Kit. The Starter Kit is controlled using custom control hardware that is interfaced to the NI PCI-6025E/CB-100 data acquisition hardware and LabView GUI. Via the LabView GUI, the on/off power, general purpose slide, and general purpose pushbutton switches on the Starter Kit can be controlled. Also via the GUI, feedback is given showing the state of the power, prog, and indicator LEDs on the Starter Kit. Figure 2 shows the control the feedback indicators in the GUI and a view of the Starter Kit. Also connected to the system in the experiment are a Hewlett-Packard 5452 Oscilloscope and an Agilent 33250A. Although these were connected directly to the Starter Kit, the idea was to demonstrate the flexibility of the system. Completing the systems feedback stage is a webcam. The webcam gives the student a “feeling” as if he is in the lab and gives the student confidence that the GUI responses to his experiment are true. The webcam also gives visual access to the LCD display available on the Starter Kit. Figure 3 shows the lab PC, GUI, webcam view, Spartan-3E Starter Kit, and control hardware surrounding the kit.

Fig. 1. Schematic diagram of a remote interface system connecting that is interfaced to the NI PCI-6025E/CB-100 data acquisition hardware and LabView GUI. Via the LabView GUI, the on/off power, general purpose slide, and general purpose pushbutton switches on the Starter Kit can be controlled. Also via the GUI, feedback is given showing the state of the power, prog, and indicator LEDs on the Starter Kit. Figure 2 shows the control the feedback indicators in the GUI and a view of the Starter Kit. Also connected to the system in the experiment are a Hewlett-Packard 5452 Oscilloscope and an Agilent 33250A. Although these were connected directly to the Starter Kit, the idea was to demonstrate the flexibility of the system. Completing the systems feedback stage is a webcam. The webcam gives the student a “feeling” as if he is in the lab and gives the student confidence that the GUI responses to his experiment are true. The webcam also gives visual access to the LCD display available on the Starter Kit. Figure 3 shows the lab PC, GUI, webcam view, Spartan-3E Starter Kit, and control hardware surrounding the kit.

Fig. 2. the GUI showing the FPGA development board and the I/O Control and Feedback Panel.

Fig. 3. An e-Lab with video Capture of the FPGA board.

References