

All-in-one development boards help create affordable home laboratories for students

Mircea Dăbâcan¹, Clint Cole², Albert Fazakas³, Mihaela Radu⁴

¹. Applied Electronics Department, Technical University of Cluj-Napoca, 26-28 Gh. Barițiu street, Cluj-Napoca, Romania, Mircea.Dabacan@digilent.ro

². Digilent Inc., 215 East Main, Suite D, Pullman, WA, U.S.A., ccole@digilentinc.com

³. Bases of Electronics Department, Technical University of Cluj-Napoca, 26-28 Gh. Barițiu street, Cluj-Napoca, Romania, Albert.Fazakas@bel.utcluj.ro

⁴ Electrical and Computer Engineering Department, Rose-Hulman Institute of Technology, 5500 Wabash Avenue, CM4105, Terre Haute, IN, U.S.A., radu@rose-hulman.edu

ABSTRACT

Digital design practice done during the laboratory classes is usually restricted due to the busy schedules. Digilent produces affordable development boards so students can make their own laboratory experiments at home.

This paper presents the Digilent development boards and their applicability both in classrooms and for student home made designs. The paper also presents several design contests that encourage students to develop their own designs on Digilent boards..

1. INTRODUCTION

Learning digital design at any level cannot be imagined without practice. Usually, digital design practice is done during the laboratory activities. However, the time allocated for laboratory work is restricted due to both the busy schedules of students and the limited number of laboratory rooms.

Digilent produces and distributes FPGA- and microcontroller-based development boards at affordable prices. Consequently, it offers the solution for students first of all to extend their practice time and also develop a hobby that makes use of digital design.

This paper presents the adequacy of Digilent boards for teaching digital systems laboratories. In the second chapter an example of the resources provided by a Digilent development board is illustrated. These development boards are successfully used in many universities worldwide. The following chapter briefly presents specific courses involving the usage of Digilent boards at laboratories at the Technical University of Cluj-Napoca, Romania (TUCN).

The fourth chapter deals with extra curriculum activities such as design contests held at the Technical University of Cluj-Napoca and at the Rose-Hulman Institute of Technology. These contests involve Digilent FPGA and microcontroller based development boards.

The end of the paper outlines the conclusions and further enhancement possibilities of the development boards, as well as novel possibilities for encouraging the students to delve furthermore into the intricacies of digital design.

2. RESOURCES OFFERED BY THE DIGILENT FPGA-BASED DEVELOPMENT BOARDS

The Digilent development boards are made in such way as to support for and also to be able to be extended to a large amount of peripherals, making the boards useful in several curricula at different levels. For example, the FPGA-based development boards contain 8 DIP switches, pushbuttons, 8 LED-s and a four-digit seven segment display, which allow students to experiment simple digital designs such as testing combinational logic, counters, registers.

Figure 1 presents the Nexys2 development board [1], available on the market since September 2007. Nexys2 is an improvement of the Nexys board that was made available on the market in June 2006.

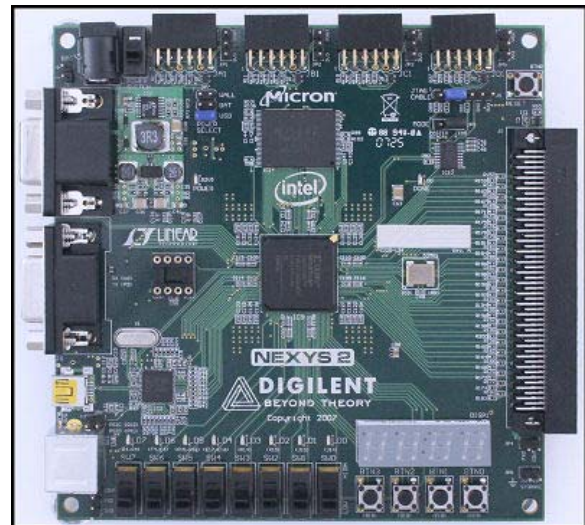


Figure 1. The Digilent Nexys2 board

The development board also contains standard communication interfaces such as PS2, UART and an USB port that emulates a standard EPP interface. These interfaces enable students to experiment standard communication protocols.

The expansion connectors allow the attachment of various advanced peripherals, such as A/D and D/A converters, Ethernet interface and video decoders. Digilent also offers a wide range of peripheral modules called PMODs [2] that extend the functionality of the development boards.

All the boards can be used with the free Xilinx ISE WebPack software. The Nexys and Basys boards can be powered from the computer's USB board, the USB cable is shipped in the development kit. Therefore a student buying a Digilent FPGA-based development board does not have to pay extra for power supplies and cables. Also these boards come in a DVD case that makes them easily portable. A student can simply start to experiment digital designs without any required special board preparation and configuration steps.

The complexity of the FPGA devices on many development boards facilitates the building of embedded processor systems such as the 32-bit soft-core Microblaze processor. The Basys-250, Nexys, Nexys2, S3E-Starter and the XUP-V2Pro boards belong to this category.

3. TEACHING WITH DIGILENT BOARDS AT THE TUCN

The Faculty of Electronics, Telecommunications and Information Technology (ETIT) of the TUCN offers two courses that involve [3]. The first one is Digital Systems which counts for 4 ECTS and it is taught in the fourth semester to build skills in beginner to intermediate level digital systems design. Use of Digilent boards is made at the laboratory and project classes where students develop simple projects such as UART or SPI interfaces.

The second course is called FPGA Systems and also counts for 4 ECTS. It is taught in the eight semester and targets intermediate to advanced digital systems design. Examples of designs include static and dynamic memory controllers and signal processing units. The Master of Science degree also offers courses for high-speed complex digital systems design and embedded processing design on FPGA devices.

The Faculty of Automation and Computer Science (ACS) of the TUCN also offers two courses where Digilent development boards are used [4]: Computer Architecture, of 5ECTs in the fourth semester and Structure of Computer Systems, of 5ECTs, in the sixth semester.

Obviously, making more complex designs can be achieved by students preparing for extracurricular activities such as student conferences and design contests.

4. DESIGN CONTESTS

Among reference designs and board demo projects, Digilent, Inc. also offers support for the development boards by means of ingenious reference designs developed in student design contests. The contests mentioned are hosted by TUCN and also by the Rose-Hulman Institute of Technology; the former launched the fourth edition this year, while the latter held the first edition last year [5].

The contest is based on interesting designs made by students on Digilent development boards, the winner being awarded with a notebook computer; the second and third place teams received digital cameras and MP3 players. What is more, students who were able to finalize and present a functional design could keep the hardware they have worked on. Table 1 shows the number of enrolled teams together with the number of teams that were able to make a functional design and to present it at the contest.

Table 1. Number of enrolled teams and finalized projects in the first three editions of the Digilent Design Contest held at the TUCN

Design contest Edition	Number of enrolled teams	Number of finalized projects
First Edition, January 2006	26	11
Second Edition, October 2006	21	7
Third Edition, May 2007	42	15

To be noted that teams can also participate at the contest with designs made on embedded processing boards such as the Digilent Cerebot and Cerebot II. These development boards feature an AtMega64L microcontroller.

Each contest edition targets the newest development boards from Digilent; therefore the contest is useful for a feedback on the newly developed boards.

For instance the first edition targeted the D2SB board featuring an XC2S200E FPGA. An awarded design to be mentioned from this edition is a pong video game on the

D2SB board that uses a monitor and a keyboard for control. The FPGA device usage was about 90%

Another of design worthy to be mentioned is the hexapod robot awarded at the third edition. The robot is completely controlled by the FPGA device on a Nexys board and, using a digital camera and a Digilent VDEC video decoder board, takes pictures and uploads them to a computer using the USB port. Figure 2 shows the hexapod spy robot design.

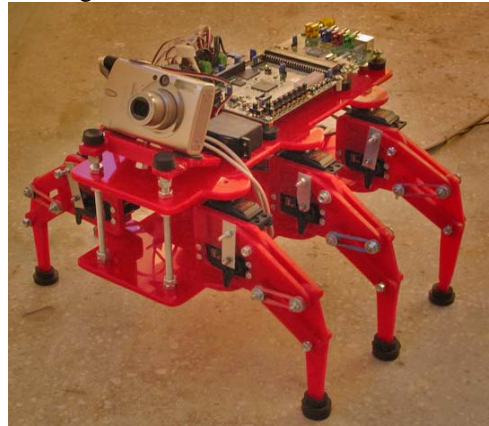


Figure 2. The Hexapod Spy Robot

One more interesting design contest example is a project developed in cooperation between two students from the TUCN and six students from the HAMK University of Applied Sciences, Finland, Forssa [6]. The design was awarded runner-up at the first edition of the Artemis Orchestra contest. The project consists in an embedded system that plays a real flute. The unit that interprets the MIDI messages for the flute and controls the actuators playing the flute buttons and the valves controlling the air flow in the flute was made on a Digilent Nexys board.

5. CONCLUSIONS

This paper illustrates the adequacy of Digilent development boards both for teaching digital systems design and experimenting designs by the students at home. The resources of the Digilent boards were also briefly presented. What is more, course examples and design contest examples that stimulate the student's interest in experimenting designs were outlined.

More advanced board developments include more complex boards that allow higher level designs and more specified peripheral modules such as SD card interfaces or graphic LCD displays. Further developments for the design contests are targeted on international participation.

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