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Experience of Xilinx FPGAs and Vivado Usage for Education Purposes in Ukraine

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***Abstract*— this article is to share experience of lecturers from Department of Radioelectronic Technologies of Information Systems (RETS) at Lviv Polytechnic National University in the usage of AMD Xilinx FPGAs and Vivado design suit for educational purposes. This article shows overview of several educational FPGA boards and finally Cmod-S7 (Spartan-7 based) board was chosen for initial trial. Vivado design suit and its Standard and Enterprise editions are described. The peculiarities and computer resources requirements for Vivado installation are described. The features of AMD University Donation Program overviewed and our successful experience of free Vivado licenses acquiring for student's lab. Finally, all pros and cons of AMD Xilinx usage are summarized. This article could be helpful for all university departments where Xilinx FPGAs considered to be introduced for educational purposes.**

Keywords— Xilinx, Cmod-S7, Vivado, AMD university donation program.

I. INTRODUCTION (*HEADING 1*)

FPGAs (Field-Programmable Gate Arrays) are crucial in today's technology landscape due to their performance and ability to implement custom hardware solutions for a wide range of applications, from telecommunications to data processing and embedded systems. By studying FPGA design, students gain essential skills in digital logic, hardware description languages (HDLs), and system architecture, preparing them for careers in cutting-edge fields such as artificial intelligence, IoT, and robotics, where the demand for customizable and efficient hardware solutions is rapidly growing. Learning FPGA design not only enhances their technical knowledge but also fosters problem-solving skills and innovation, which are invaluable in the ever-evolving tech industry.

At Department of Radioelectronic Technologies of Information Systems (RETS) at Lviv Polytechnic National University there are courses where FPGA basis and Verilog HDL language are studied. For practical side we used so far only the simulators. To improve students, experience there was decision to introduce several laboratory works involving real FPGA educational boards and execute Verilog programs on the real hardware.

When choosing an educational FPGA board, it is essential to pay attention to several important aspects to ensure the effectiveness of laboratory work. First, consider the compatibility of the board with the software you plan to use and the availability of any necessary licenses. Availability of the programmer, preferably to have onboard programmer. Many companies, such as Xilinx and Altera, offer free versions of their software for educational purposes, which can help reduce costs.

Second, the price of the board is a critical factor. It should fit within your budget while still providing sufficient performance and functionality for completing educational tasks. The third aspect to consider is the availability of documentation and learning materials. Quality documentation assists students in quickly grasping concepts and implementing projects.

Equally important is the reputation of the manufacturer. Choosing a board from recognized industry standards like Xilinx or Altera can enhance the learning experience, given their popularity in the professional environment. Finally, pay attention to the available interfaces on the board, as a variety of I/O options increases opportunities for designing and implementing more complex systems.

II. XILINX EDUCATIONAL FPGA BOARDS

A. Xilinx Educational Boards Overview

Our aim was to create labs at our university department to choose affordable FPGA board which fulfills the requirements mentioned in the introductions chapter. The FPGA manufacturer selection also was oriented to the needs of companies where FPGA engineers are needed. So, the most popular as of today are AMD Xilinx and Altera (Intel). Our decision was to proceed with AMD Xilinx since it was required in more companies where our graduates work. Below there is comparison of several FPGA boards we

analyzed. The complete Xilinx FPGAs portfolio could be found in [1].

The Elbert V2 is an entry-level FPGA development board featuring the Spartan-3A FPGA. Designed specifically for beginners, it includes a variety of user-friendly interfaces such as 16 switches, 8 LEDs, and 7-segment displays, making it ideal for learning digital design concepts. Its compact and affordable setting allows new users to explore basic FPGA programming. The key drawback of such board that it uses the outdated FPGA family Spartan-3A, which in addition is not supported by Vivado.

The Cmod A7-35T is a powerful and compact FPGA board that incorporates the Artix-7 FPGA, offering 35,000 logic cells for versatile digital design projects. This board provides a good range of interfaces, including USB for programming and multiple GPIO connections, making it suitable for intermediate users and hobbyists.

The Cmod S7 (Fig.1) is a cost-effective FPGA development platform featuring the Spartan-7 FPGA, well-known for its low power consumption. With options like USB connectivity, UART, I2C, and GPIO interfaces, this board is perfect for both educational use and practical projects requiring low-power solutions. Cmod A7-35T and Cmod S7 are the balance of performance and price allowing users to create more complex FPGA applications and designs effectively.

The TE0725-04-21C module boasts the Artix-7 A15T FPGA, offering enhanced capabilities for embedded applications. With dual 50-pin headers and diverse connectivity options like HDMI and USB, this board is ideal for developers seeking to integrate FPGA functionalities into their designs.

Fig. 1. Xilinx Educational FPGA Board: Cmod S7 FPGA

Integrating the Zynq-7010 FPGA with an ARM Cortex-A9 processor, the TE0722-04-41I offers a powerful platform for hybrid applications requiring both hardware and software processing. With interfaces such as USB, GPIO, and Ethernet, it is designed for advanced projects that combine embedded computing with FPGA-level customization.

The mentioned above FPGA boards and approximate prices are summarized in the Table 1.

There are many other FPGA evaluation boards described in [2], but they usually are not affordable for university budget. Our decision was start with Cmod S7 FPGA [3]. The key advantages of Cmod S7 (Fig.1) usage are: relatively low price, big popularity with many examples, user documentation, onboard programmer and availability of enough features for basic FPGA course.

TABLE I. FPGA BOARDS SUMMARY

FPGA Board	Available peripheral interfaces	Price, USD
Elbert V2 (Spartan-3A)	8 LEDs, 6 Push Buttons and 8 way DIP switch, Micro SD Card Adapter.	50
Cmod A7-35T (XC7A35T)	GPIO, 2 Buttons, 4 LEDs, 1 RGB LED, 2 Analog Inputs	100
Cmod S7 (XC7S25)	GPIO, 2 Buttons, 4 LEDs, 1 RGB LED, 2 Analog Inputs.	100
TE0725 (Artix-7 (A15T))	2x 50-pin headers, HDMI, USB, GPIO	150-200
TE0722 (Zynq-7010)	GPIO, RGB LED, MicroSD Card socket	160-250

The next chapter explains the order and delivery to Ukraine procedure.

B. FPGA Boards Ordering and Delivery to Ukraine

Our department has ordered the Cmod S7 FPGA development board from two different suppliers, allowing us to analyze the cost and logistics of each option. The first supplier is Digilent [3], where the price of the Cmod S7 is $99 and shipping $28, resulting in a total cost of $127. Digilent is a well-known and reputable supplier in the educational electronics field, offering excellent customer support and reliable delivery times. However, the shipping cost is relatively high, adding an extra amount to the total cost.

On the other hand, our second supplier is Mouser [4], which also lists the Cmod S7 at $99 and free shipping to some European cities. Then we spend $7 for delivery to Ukraine via the NP Shopping service, bringing the total cost to $106. This option reduces the overall expense, making it more economical. Moreover, Mouser is also a reputable distributor, providing confidence in the quality of the purchase.

But shipping of FPGA boards is not so straight forward as for other electrical parts. When shipping goods to Ukraine, particularly items like FPGA development boards that may have potential technological or military purposes implications, export control measures are often put in place to ensure compliance with international laws and regulations. These controls are crucial for preventing the unintended dissemination of sensitive technologies that could be used for military or illicit purposes.

To comply with export control regulations, shippers may be required to fill out specific forms that gather detailed information about the shipment. Common questions typically included in such forms encompass the intended end-use of the item, the identity of the recipient, the nature of the technology involved, and whether the item has any dual-use potential. Additionally, shippers might need to provide justifications for why the item should be allowed to enter Ukraine, outlining its educational or research applications and confirming that the recipient has no intent to misuse the technology.

Once the export control form is printed out, it needs to be filled in accurately and signed up to confirm the information provided is truthful and complete. After this, the signed document must be scanned and submitted for review. The review process may take several days, during which authorities assess the justification for the shipment. If the justifications are deemed reasonable and compliant with legal standards, the FPGA shipment will be unblocked and

allowed to proceed to its destination. Such export control forms needed to be filled when we ordered in Digilent and Mauser seller.

III. Peculiarities of Vivado Design Suite usage

A. Vivado Editions

To start designing with the FPGA Xilinx has several tools. For the educational purposes to get basic understanding of how to design FPGA based the best is Vivado Design Suit. AMD Vivado is the design software for AMD adaptive SoCs and FPGAs. It includes Design Entry, Synthesis, Place and Route, Verification/Simulation tools [5].

AMD Vivado Design Suite has two major editions:

- Standard (also called as WebPack);
- Enterprise Edition.

By default, user located at Ukraine are limited with downloading installer because of export control restrictions. To be able to download installers for any of these Vivado editions user must print and fill export control form. Some details provided in such export control form are detailed at the end of this paper.

Below the key differences between these two editions are described and it is important to consider with which edition to proceed during educations course preparation.

B. Vivado Standard Edition

The Vivado Standard Edition is free and available for download, providing instant access to core features and functionality. Below are the lists of FPGA architectures supported by Vivado Standard Editions in Spartan and Artix series:

- Spartan 7: XC7S6, XC7S15, XC7S25, XC7S50, XC7S75, XC7S100.
- Artix 7 FPGA: XC7A12T, XC7A15T, XC7A25T, XC7A35T, XC7A50T, XC7A75T, XC7A100T, XC7A200.

Supported architectures for other series are detailed in “Architecture Support” tab in [6].

C. Vivado Enterprise Edition

Purchase licensing options for the Enterprise Edition start at $4,395. It is the full-featured version of the design suite and supports all AMD devices.

For educational purposes only there is possibility to obtain license for Vivado Enterprise Edition for free. This is thanks to AMD University Donation Program. This program end experience with it is described in the next chapter.

D. Computer Resources for Vivado Installation

Before proceeding with Vivado setup it is important to estimate PC resources available at university class, because often computers used at universities are outdated and this can cause troubles and performance degradations when working with Vivado.

AMD Vivado supports the Windows 10 and Linux (Red Hat 7,8, Ubuntu 16+) operating systems on x86 and x86-64 processor architectures. Regarding disk space usage there is sense to split between 3 requirements:

- Installer download size ~ 17 GB.
- Disc space required ~ 63 GB.
- Final Disk Usage ~46 GB.

RAM memory usage during FPGA design synthesis and implementation when working with Artix, Spartan series is approximately 2 GB and peak 3 GB.

IV. AMD University Donation Program

A. About AMD University Donation Program

The AMD University Program (AUP) [7] is a dedicated global initiative designed to bridge the gap between academic research and commercial engineering. At its core, the program aims to empower the next generation of innovators by providing accredited universities, professors, and researchers with advanced computing tools free of charge. Through its structured Donation Program, AMD helps academic institutions overcome budget constraints, allowing them to modernize engineering labs and expand curricula in fields like digital design, AI, computer science, and embedded systems. AMD accepts formal applications from verified faculty members to donate physical equipment, cloud resources, and software packages.

A. Experience of Vivado Enterprise License Obtaining

AMD University Program also donates full-featured, non-truncated suites of its signature design environments, enabling universities to run complex industrial workflows without reliance on restricted student-tier editions.

In our RETS department we decided to use such an opportunity to obtain UEF-VIVADO-ENTER-25 licenses. It is a highly popular academic software donation bundle provided specifically to university labs. The code itself represents a multi-seat package for Vivado ML Enterprise Edition, the industrial-grade design environment utilized for synthesizing and analyzing hardware descriptions. In this specific part number, UEF denotes a University Education Floating license format. The VIVADO-ENTER segment confirms the donation grants the full Enterprise Edition rather than the free, device-limited Standard version. The trailing number 25 specifies that the donation contains a 25-seat license, meaning 25 concurrent users can run the software simultaneously across a university network. The donation is provided as a certificate-based floating license or as generated individual activation keys for separate computers, also called as node-locked licenses. To generate licenses the special online tool [8] at AMD side is available.

When proceeding with floating license the professor installs the master license file on a single university server running a license manager daemon, and individual student workstations access the enterprise tool suite over the local area network. In case of node-locked license it tied to a specific, unique computer or workstation based on its hardware identifier. This means the software can only be used on that designated machine and cannot be accessed over a network by other devices.

By donating the Enterprise Edition rather than the standard variant, AMD unlocks full commercial design features for students. Students can target high-end, cutting-edge hardware architectures like Versal adaptive SoCs and UltraScale+ FPGAs that are normally blocked behind a corporate paywall. It includes access to Intelligent Design Runs, utilizing machine learning algorithms to dramatically improve Quality of Result metrics, timing closure, and routing efficiency. The package incorporates advanced sub-tools like the Power Design Manager for analyzing thermal and electrical constraints, multi-threading support for rapid bitstream generation, and full code coverage simulation capabilities.

To be able to get free Vivado Enterprise licenses for educational purposes at university there is necessary to perform the following steps:

- Create AMD account using corporate email and fill all necessary department details (address, email, phone number, web site etc.)
- Complete AUP Enrollment (fill special form and wait 1-3 days for confirmation by email)
- Perform donation request by accessing AUP member's site.

Unfortunately for Ukrainian universities there is one more step. It is filling export control form. Such a form should be printed on the university letterhead, signed, scanned and returned by email. In such a form user must provide the following information in details:

- Purchaser (the party abroad who has entered the transaction to purchase an item for delivery to the ultimate consignee);
- Ultimate Consignee (the party who will actually receive the material for the end use);
- End User (the party abroad that receives and ultimately uses)
- End Use(s) (must contain a complete and detailed description of the end use intended by the End User).

V. SUMMARY

The summary is providing pros and cons of Xilinx FPGA usage for educational purposes.

List of pros:

- Xilinx FPGAs are very popular and widely used. Vivado Design suit as well.
- There is noticeable demand of FPGA engineers in the IT market experienced with Xilinx tools and HW. So, experienced graduates with Xilinx FPGAs increase university department popularity and university rating at all.

List of cons:

- Every ordering of FPGA evaluation boards requires filling of export control forms.
- Since FPGA boards are relatively expensive the custom duty could be extra expenses. When the package exceeds €150, a 10% customs duty and a 20% VAT are assessed on the amount that exceeds the €150 limit.
- Vivado design suit is resource demanded and for some outdated computers used at universities could be a blocking issue or significant performance degradation. For example, disk space required is about 46 GB + modern OS is required.

REFERENCES

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