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The Use of an Embedded Microprocessor for Color Light Effects at Homes of the Future

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Key Words: *FPGA; embedded microprocessor.*

Abstract. *The paper discusses the aspects of building a system for color light effects in homes of the future using a FPGA-based embedded microprocessor. It is also discussed some opportunities for further development in order to improve the conditions of life of the inhabitants of the homes of the future.*

Introduction

One of the mandatory features characterizing the quality of the future homes is the system for lighting effects. Due to the opinion that color therapy is one of the most perspective methods for health improvement, its presence as an element in next century homes has become quite attractive.

The color therapy has originated in ancient Greece. As a treatment it has been used in Egypt, China, India and Persia. Special rooms, designed to refract the sun rays in a variety of colors, have been found by modern archaeologists in many Egyptian temples.

It could be said that our existence without colors is not conceivable. Basically, we accept the color through our eyes, skin, and muscles. Upon penetration of the color in our body, it causes various biochemical reactions in the tissues and stimulates the corresponding glands. Due to this, its presence as a system at homes of the next century becomes a necessary tool for body relaxing and restoring [1,7]. It is extremely convenient to build the realization of these systems in one FPGA chip. This approach eliminates all restrictions on the speed performance and paves the way for embedded processors use. The embedded processors are becoming the most efficient tools for the hardware realization of the resources performing several tasks in time division. This approach was realized in practice for the purposes of a Feasibility Study on Cyber Threats Identification and their Relationship with Users' Behavioral Dynamics in Future Smart Homes, under Research Grant "Funding of Fundamental & Applied Scientific Research in Priority Fields", Bulgarian Science Fund, Ministry of Education Youth and Science, 2012-2014, DFNI-T01/4.

Among the great variety of FPGA and embedded processors, one of the best selections is the use of a microprocessor called PicoBlaze [2]. It is developed by Ken Chapman and can be implemented in contemporary and future generations of Xilinx's FPGA [3].

Architecture

The block diagram of the system for lighting effects at homes of the future, developed by the use of PicoBlaze microprocessor is shown in *figure 1*.

This is an improved version of the classic scheme. The role of the PC in the system being developed is restricted to serve as an intelligent terminal in the process of initialization, diagnosis and to maintain the dialogue with the consumer. It can also be used to exchange information with the embedded processor. Usually the information sent by PC contains commands. As a response the PC receives information about the current status of the process running on the embedded processor.

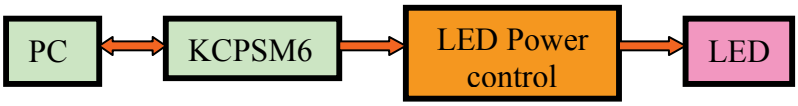


Figure 1. Block diagram of the system for lighting effects

In order to fulfill the communication with the PC, a hardware USB-UART bridge in the system of the embedded processor is included. This bridge provides full duplex 115K communication between the PC and the embedded processor. This speed turns out to be perfectly adequate to manage the developed system and allows its synchronization with sound effects.

The Implementation

The hardware that accepts the commands from the PC to generate one or another light effect is realized on the basis of the embedded processor. In this case, the role of the embedded processor is played by PicoBlaze. The choice of PicoBlaze is leveraged by the fact that it can be embedded without problems in Spartan-6, Virtex-6 and 7-Series Xilinx's FPGA series. The scheme of the controller is shown

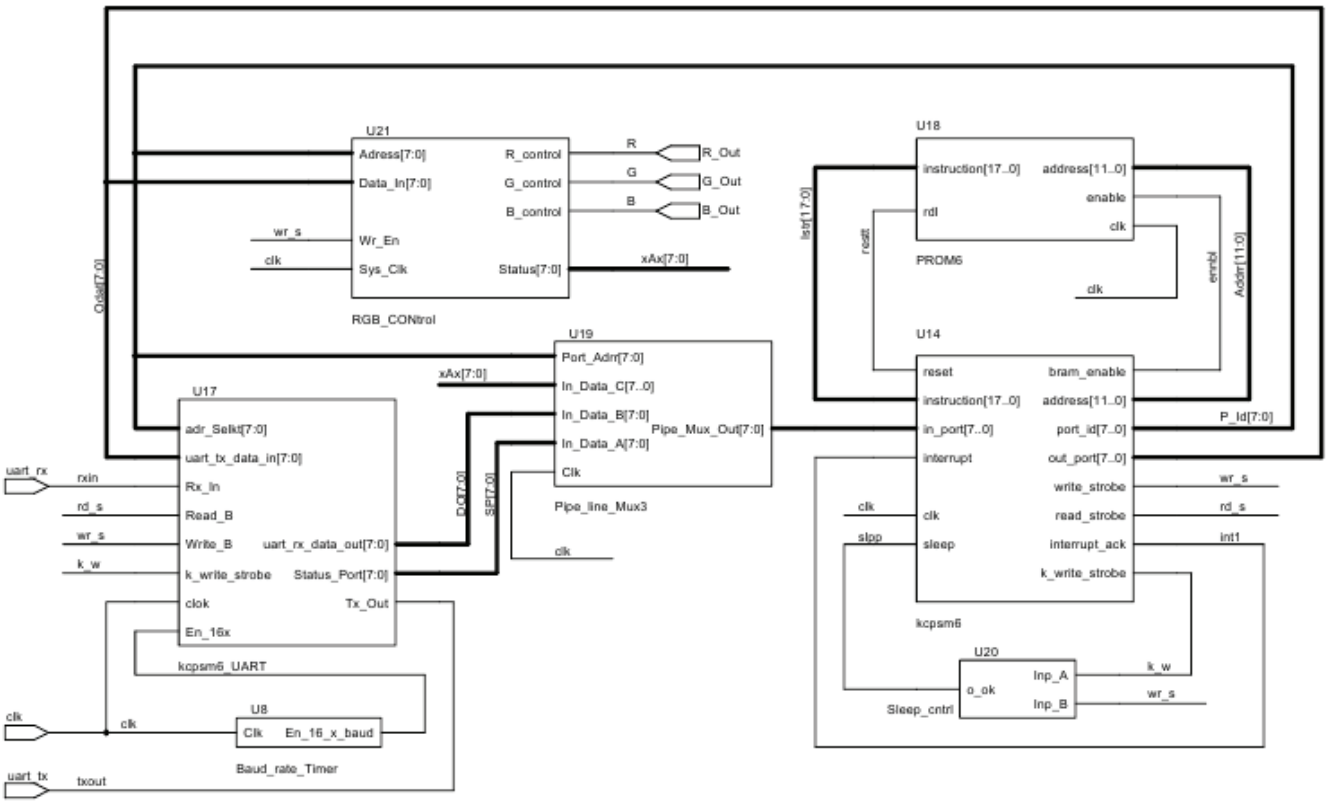


Figure 2. Scheme of the controller for light effects generating

in *figure 2*. It is created by means of OrCad EDA tools.

The project is not very big. Downloaded in the smallest Spartan-6 (XC6SLX4) FPGA chip, the project occupies less than 16% of its resources. The project implementation in this FPGA chip is shown in *figure 3*. The embedded processors and the accompanying modules are written in VHDL, according to the methodology described in [4]. This methodology allows the automatic generation of the configuration file of the created hardware ensemble of the system and a template for the assembler program of PicoBlaze directly from its own scheme. The PicoBlaze control program written in assembler is small. Its length does not exceed 300 command lines. Since PicoBlaze can handle up to 4k command lines, the remaining place can be used to store information about different lighting effects. Besides its own memory, such information can be loaded in the resources of FPGA BRAM blocks.

The Software

The software of the system for lighting effects consists of two program modules. The first one controls the behavior of the embedded processor. The second module controls the terminal program that performs the dialogue with the user through a PC. The program that determines the operation of the embedded processor provides the following functions:

• Initializes the device in a standby mode, defined by the user.

• Initializes the registers responsible for the generation of colors according to the commands received from the PC.

• Supports the exchange of command sequences and scripts with a terminal program.

As a terminal program the system uses Pico Term and Matlab modules [5].

To realize the data exchange with a PC, the program for light effects generation is written in Matlab environment. The program code is available under the e-mail request to the author.

Experimental Results

As a base for the practical realization of the system for color light effects generating, universal FPGA and CPLD hardware environment [6] is used. This environment is shown in *figure 4*. As a media for all experiments and tests, the hardware environment was equipped with a Spartan Series 6 XC6SLX4 FPGA chip. In order to achieve the best convenience of the process of system development, JTAG Loader program was used. It provides the possibility to load every change in the program directly into the RAM memory of the FPGA device without the need for a new configuration of the project. Due to this, great reduction of

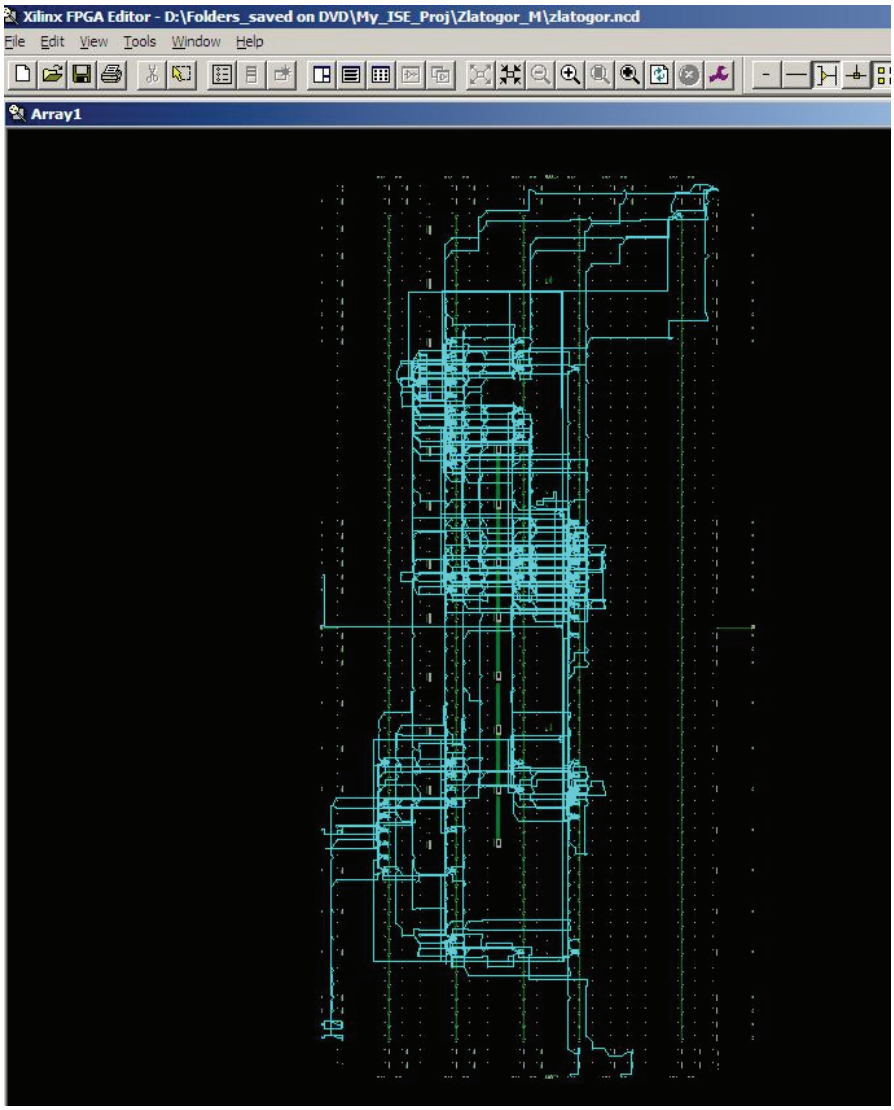


Figure 3. The project in a FPGA chip

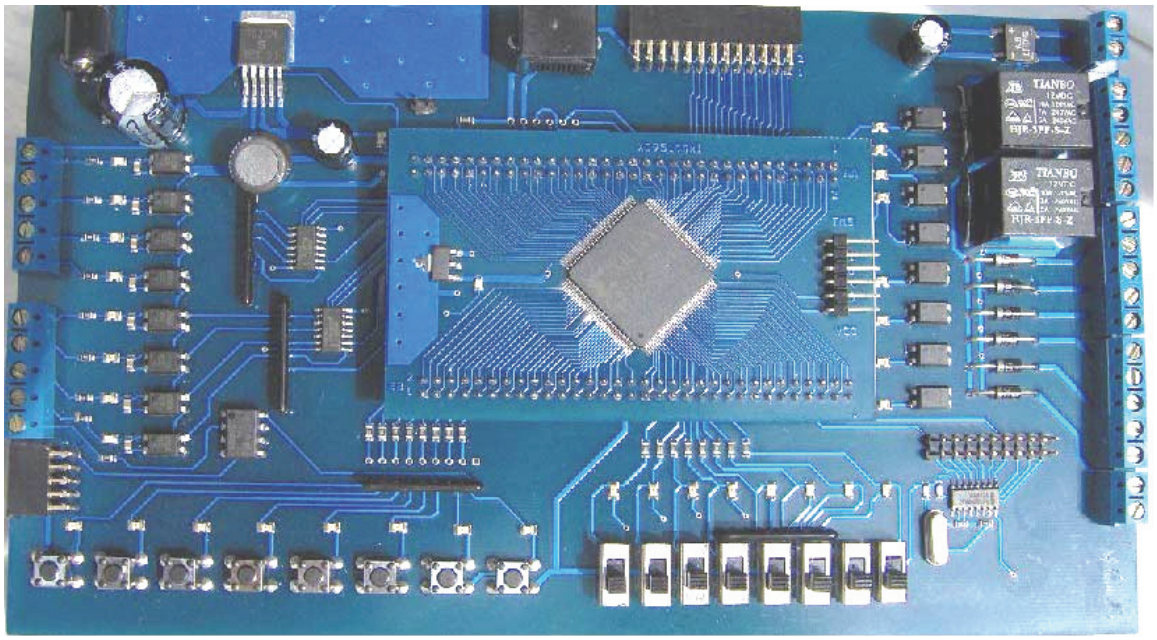


Figure 4. Universal FPGA and CPLD hardware environmen

the development time is realized.

Conclusion

The practical tests of the device for color light effects generating, based on an embedded PicoBlaze processor have shown sufficient indications of reliability. Due to the advanced hardware and software capabilities of the developed system, it is able to generate wide palette of colors and nuances. They can be selected according to the aim of the particular situation to be investigated. The features of the controller can be extended by using additional hardware from the FPGA resources. This made possible its successful use in different areas such like led advertising boards, applying different effects.

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