ANNALS of Faculty Engineering Hunedoara
– International Journal of Engineering
Tome XV [2017] – Fascicule 3 [August]

ISSN: 1584-2665 [print; online]
ISSN: 1584-2673 [CD-Rom; online]
a free-access multidisciplinary publication
of the Faculty of Engineering Hunedoara

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IMPLEMENTATION OF A BINARY SELECTION SYSTEM CREATED IN XILINX USING FPGA

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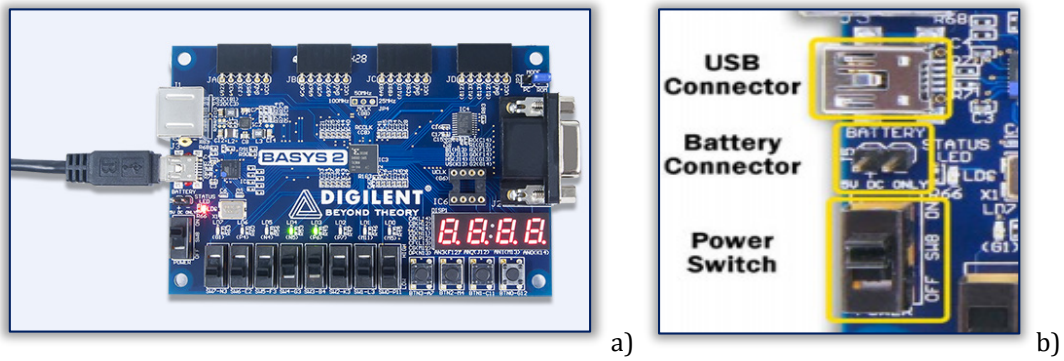
Abstract: The system requires the implementation of complex logic circuits using the hierarchical design concept. In such approach, a system block diagram has been developed, followed by the Xilinx design of each block separately. When using hardware description programs, the hierarchical design involves using a project that includes multiple files: a high-level file, specifying how to interconnect the blocks of the system structure, several low-level components, and at least one constraints file specifying data concerning the implementation. The following functional blocks have been created in Xilinx: encoder, 4-bit memory register, BCD to 7 segment decoder, and 8-bit multiplexed comparator. After implementing all circuits, their operation was tested using a Basys2 board.
Keywords: Complex logic circuits, Field programmable gate arrays, Basys2

1. INTRODUCTION

The program used to implement the application was Xilinx. This CAD (Computer Aided Design) design software containing programmable logic circuits (FPGA) enables, in the first stage, the selection of project description method: schematic, VHDL description, or state diagrams. For this application, we selected the schematic design method. [1][2][3]

After the schematic implementation of logic circuits, verification of accuracy and identification of constraints files, we used Digilent Adept System software to upload the file with the extension ".bit" on the Basys2 board (Figure 1a)[10]



a) b)

Figure 1. Basys2 board

The board can be either powered or programmed via a USB port (Figure 1b). The Digilent Adept System software detects automatically the board, but also provides a programming interface to FPGA. The Adept program enables data transfer from the computer to the Basys2 board.[8]

Usually, the Basys2 board is powered via a USB cable, but it is also fitted with a connector for an external power source, for example a battery of 3.5 V – 5.5 V. After starting, the FPGA fixed on the Basys2 board must be configured to work properly. During the configuration process, a bit is transferred into a memory cell inside the FPGA, to define the logical functions of the interconnection between circuits.[9]

The Basys2 board contains four buttons and eight slide switches for the input circuits. The entries operated by buttons have a low frequency when the button is not pressed and a high frequency when the button is pressed. The slide switches generate a constant high or low frequency, depending on the switch position. All buttons and switches contain resistors connected in series, to protect against short circuits.

For the output circuits, the board is provided with eight LEDs and a 7-segment BCD display. The anode of each LED exits the FPGA by current limiting resistors, lighting up when the logic 1 is applied to the corresponding pin. A ninth LED lights up when the board is powered on, and a tenth LED lights up when FPGA has been programmed successfully. (Figure 2)

Each of the four digits of the 7-segment BCD display consists of seven LED segments arranged as a figure eight. The LED segments can light up individually, so the 128 patterns can be displayed on one digit illuminating certain LED segments and letting the others off. Of these 128 patterns, the ten ones corresponding to the tens figure are the most useful.[10]

Since the Basys2 board provides the user with a common anode display, it was necessary to create a multiplexing circuit for displaying the figures typed on the keyboard.

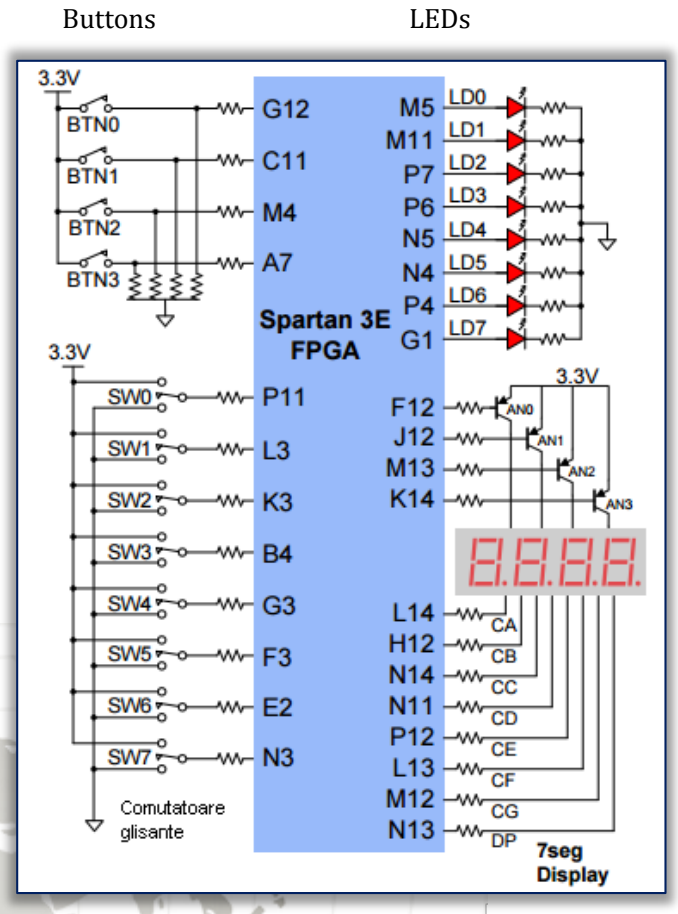


Figure 2. I/O circuits of Basys2 board

2. DESCRIPTION OF APPLICATION

The operating principle of the proposed system is based on the block diagram (Figure 3), containing the main modules created in Xilinx. [4]

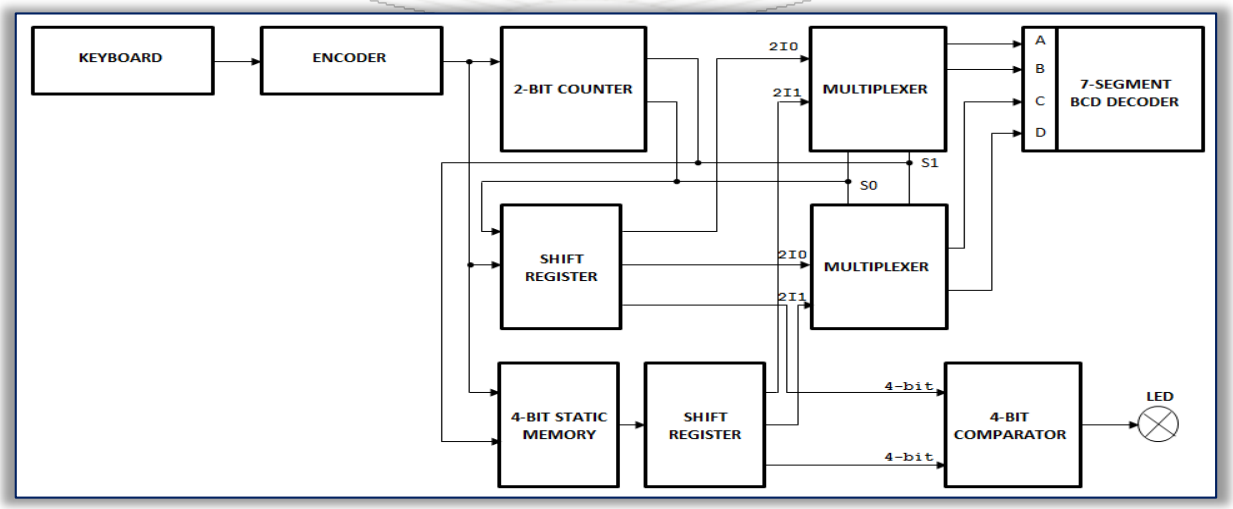
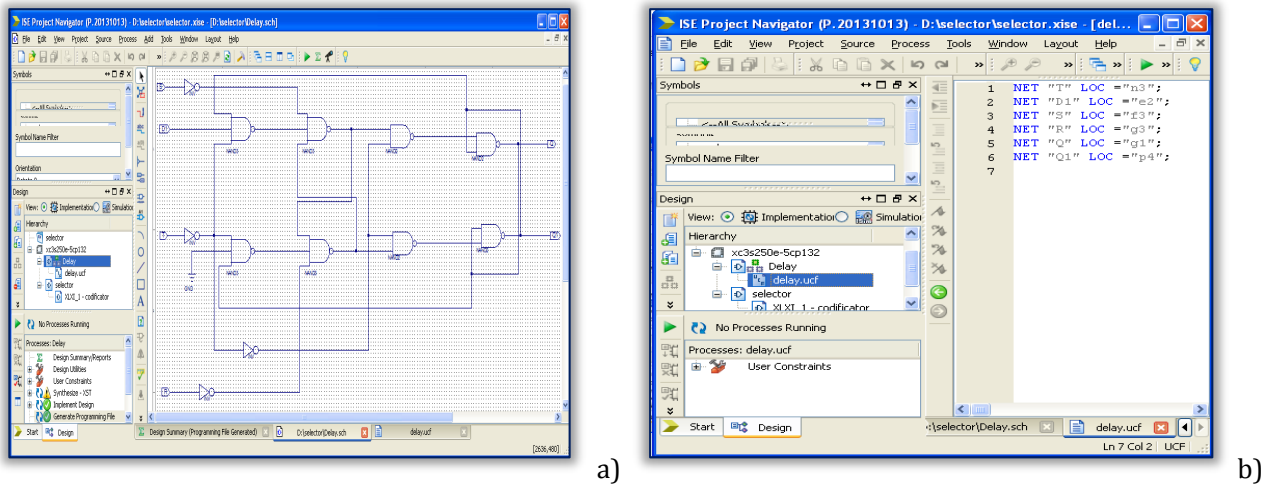


Figure 3. The block diagram of the system

We present below the internal structure of each functional block individually, as follows:

The delay flip-flop was created in Xilinx (Figure 4a), starting from the logical diagram of a MMC 4013 circuit, after which the constraints file was created (Figure 4b), and its operation has been verified using the Basys2 board. [11] The delay flip-flop was required to be inserted into the structure of the 2-bit counter. Also, to create the 4-bit memory, it was necessary to build a D-Latch flip-flop.[5][6][7]

After verifying the correct operation of the flip-flop, we created the schematic symbol of the flip-flop used in the diagram of the component in whose structure it was integrated.

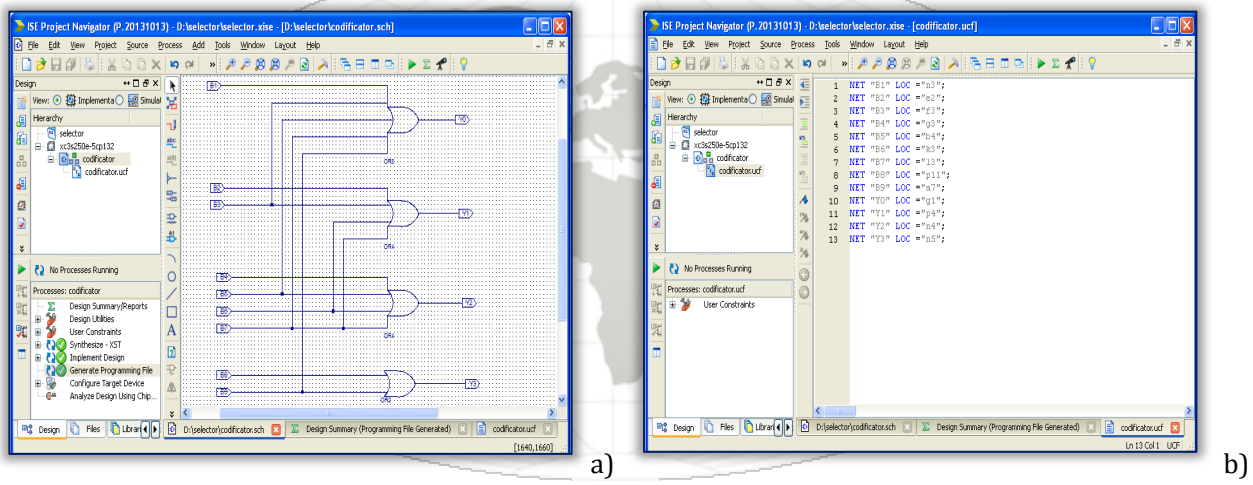


a) b)

Figure 4. Delay flip-flop created in Xilinx

We have also built the encoder structure (Figure 5a) and the related constraints file (Figure 5b), followed by the verification of operation using the Basys2 board. .[5][6][7]

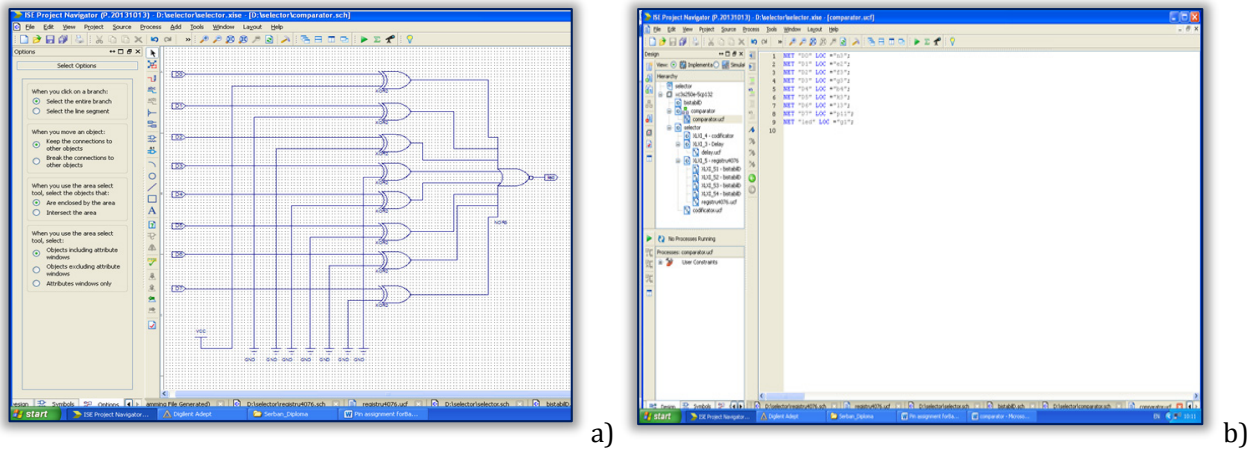
Based on the results, we obtained the encoder schematic symbol, used subsequently in the final circuit.



a) b)

Figure 5. Encoder created in Xilinx

The 4-bit comparator (Figure 6a), realised on the basis of the diagram with logic gates EXCLUSIVE-OR (XOR), whose constraints file is shown in Figure 6b, shows the result of coincidence between the typed number and the stored one, following the verification of operation on the Basys2 board. [5][6][7]

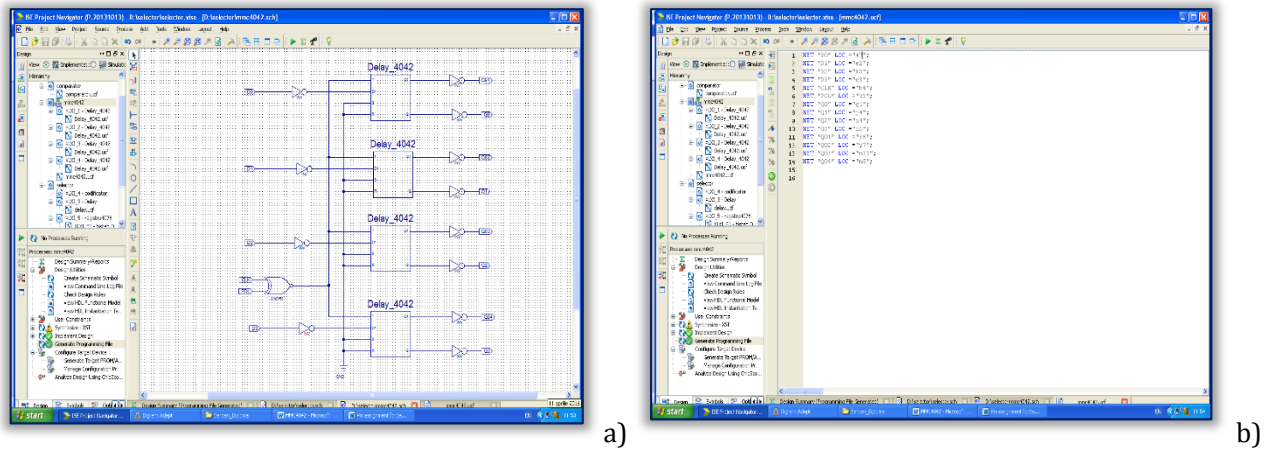


a) b)

Figure 6. Comparator created in Xilinx

The memory circuit (Figure 7a), used to store the addresses of input quantities, has been realised using the structure of a MMC 4042, which is a 4-bit static memory required to keep the addresses of memory registers stable for the displayed numbers. [11]

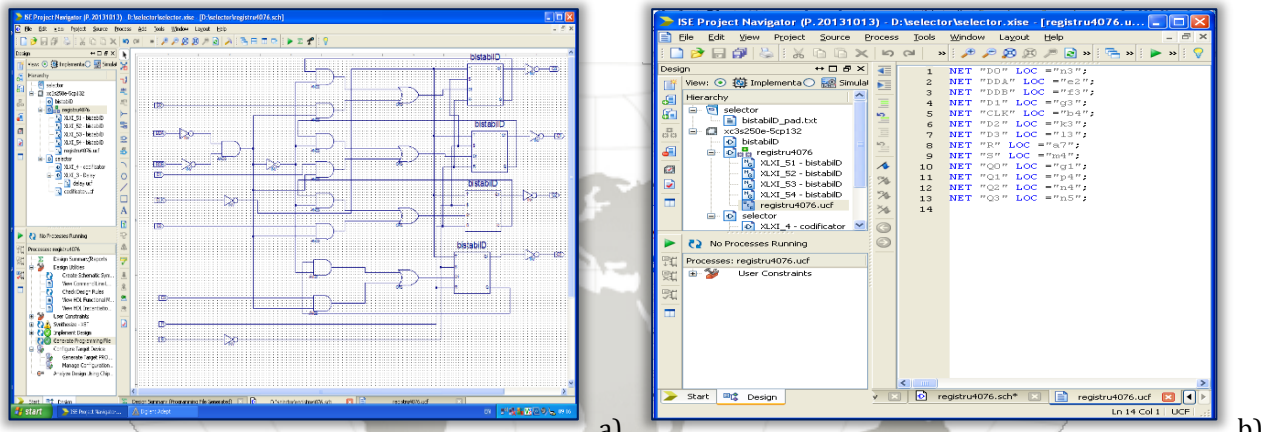
The constraints file (Figure 7b) assigns the input and output signals related to the memory circuit used to verify the operation on the Basys2 board.



a) b)

Figure 7. Memory circuit created in Xilinx

The shift registers were realised using the structure of the MMC 4076 circuit (Figure 8a), followed by the constraints file (Figure 8b), to verify the circuit operation.[11]



a) b)

Figure 8. Shift register created in Xilinx

To control the display on the Basys2 board, it was necessary to implement a multiplexer realised using the 74LS153 circuit diagram (Figure 9).[11]

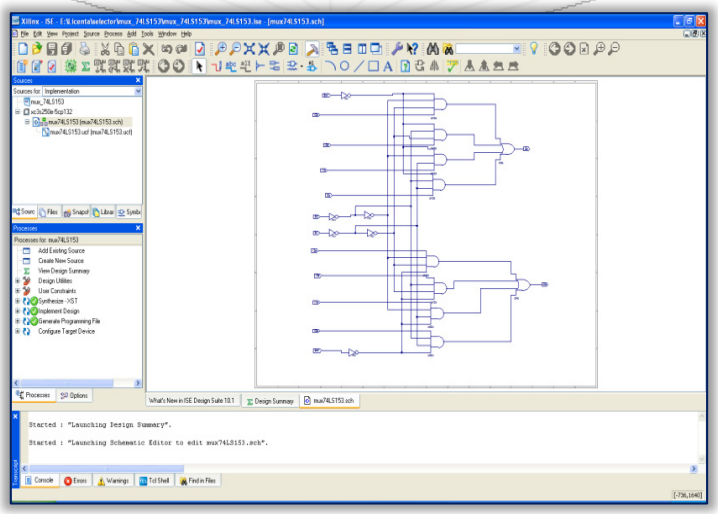


Figure 9. The implemented diagram of multiplexer

After the implementation of all components, the system diagram was integrated (Figure 10), followed by the verification of its operation.

The verify the operation of the system, the number 10 was set in the comparator structure. By entering this number via the keyboard, the green LED will light on the Basys2 board, indicating the equality between the displayed number and the set number (Figure 11a). If the number entered via the keyboard differs from the set number, then the LED remains off (Figure 11b). The LED is used to indicate whether the output voltage exists or not.

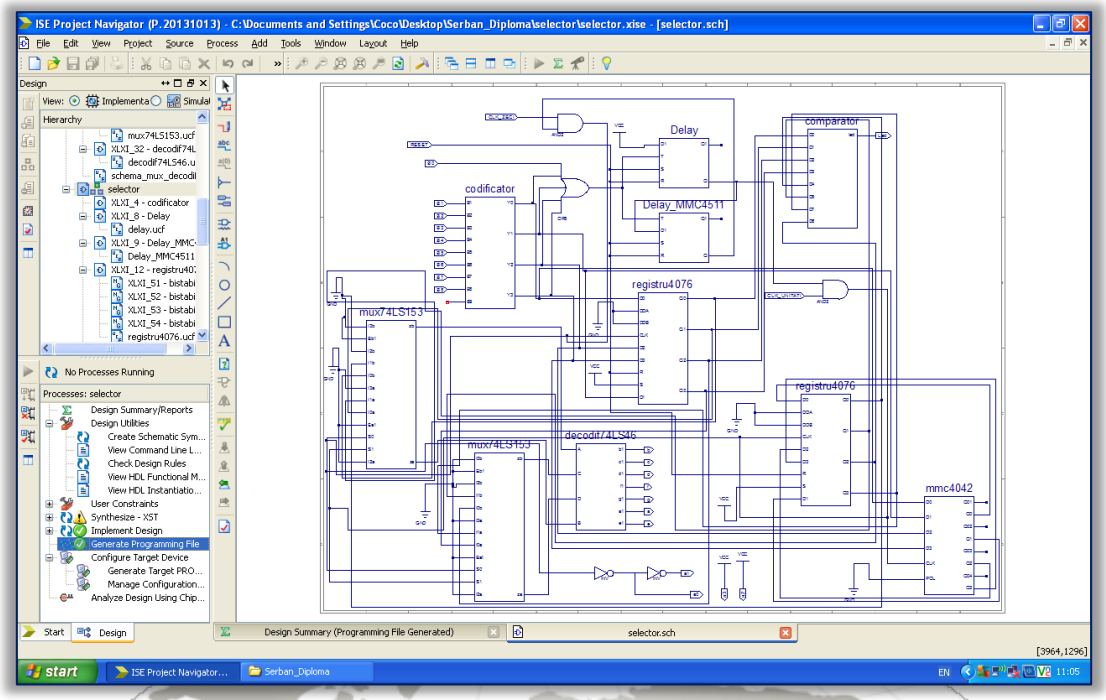
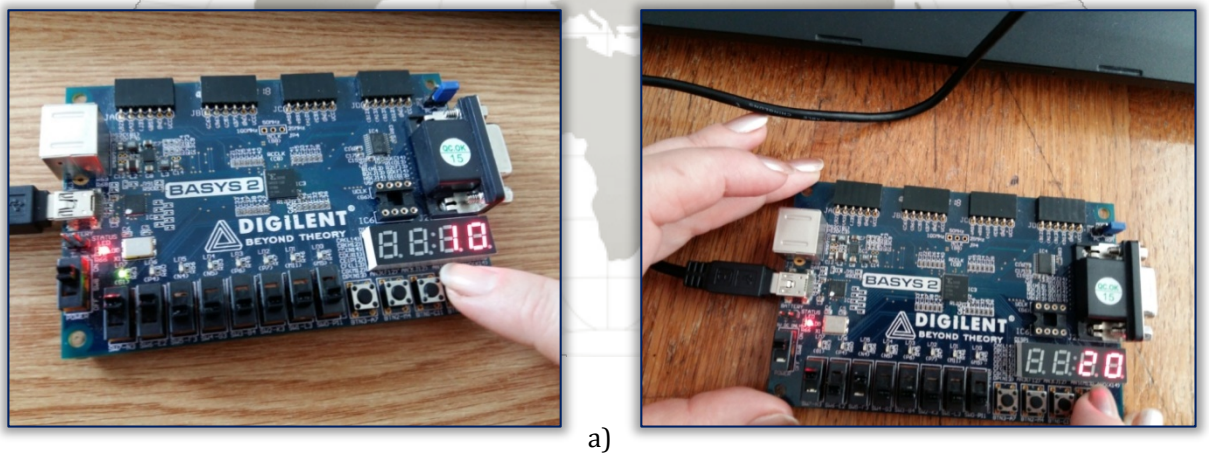


Figure 10. Binary system selection diagram



a) b)

Figure 11. The pictures show the operation in the situations described above

CONCLUSIONS

An advantage of the Xilinx program is its flexibility, but also the fact that we can relatively easily develop projects just using the library of the program. Other advantages are its high programmability and low time required for design and presentation of the product on the market.

Also, the program has an IEEE standard recognized by all manufacturers.

The FPGA devices enable the design of specialized hardware architectures, thanks to the flexibility advantage of the programmable environment in which the implementation is carried out. This provides an extra degree of freedom in the design of digital control systems compared to the use of microprocessors, because the hardware architecture of the control system must not be imposed previously.

The presented system enables serial selection of two numbers typed independently which, if matching with the set ones, they activate a control device. If the two numbers do not match with the stored ones, the system does not react. The numbers entered via the keyboard are viewed on the display of the FPGA board.

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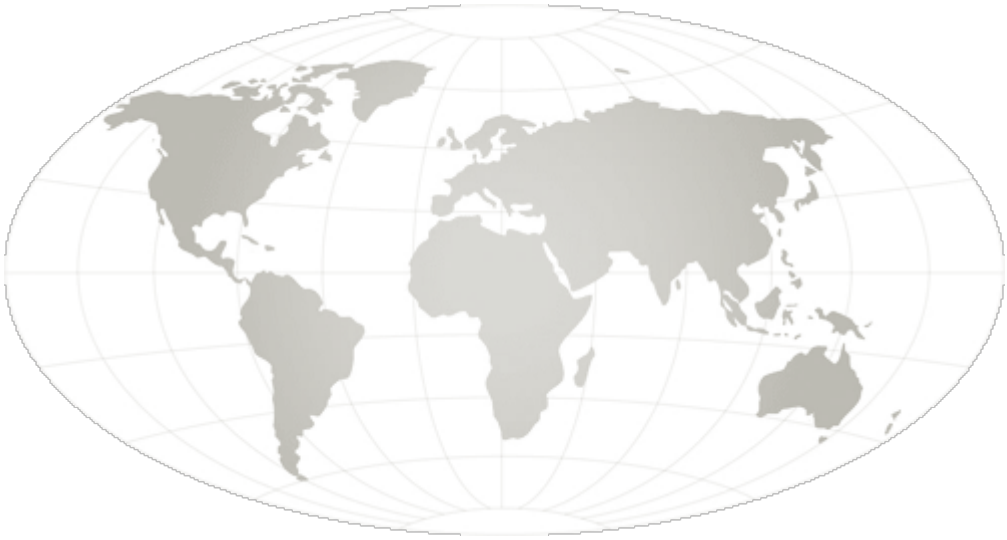

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