Door Lock - DE1 Project

School project - A door lock with an Arty board

Team members

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Link to our GitHub project folder

Project objectives

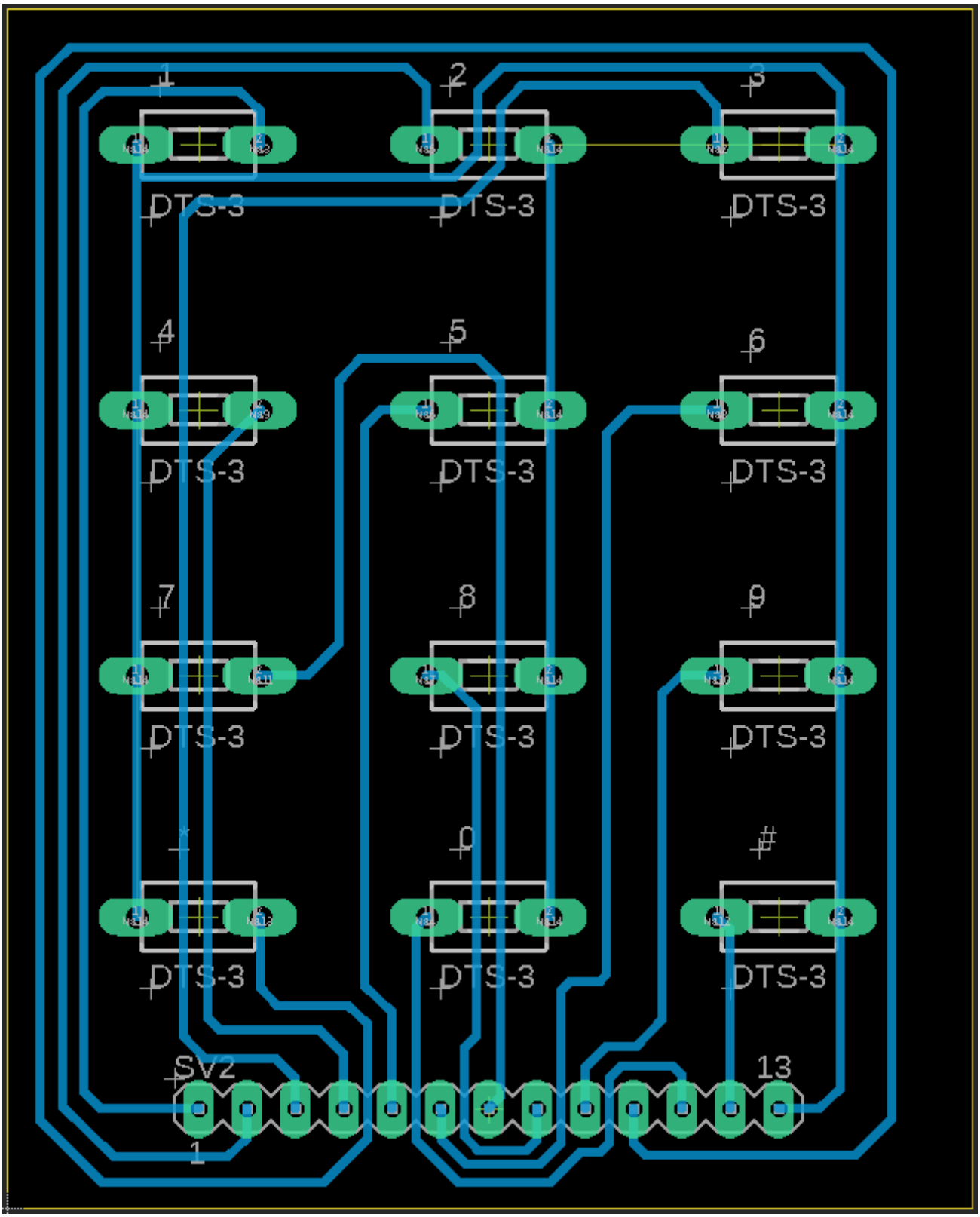
Making a Door Lock system with:

- 4-digit PIN terminal
- 4-digit 7-segment display
- 4x3 push buttons keyboard
- relay for door lock control

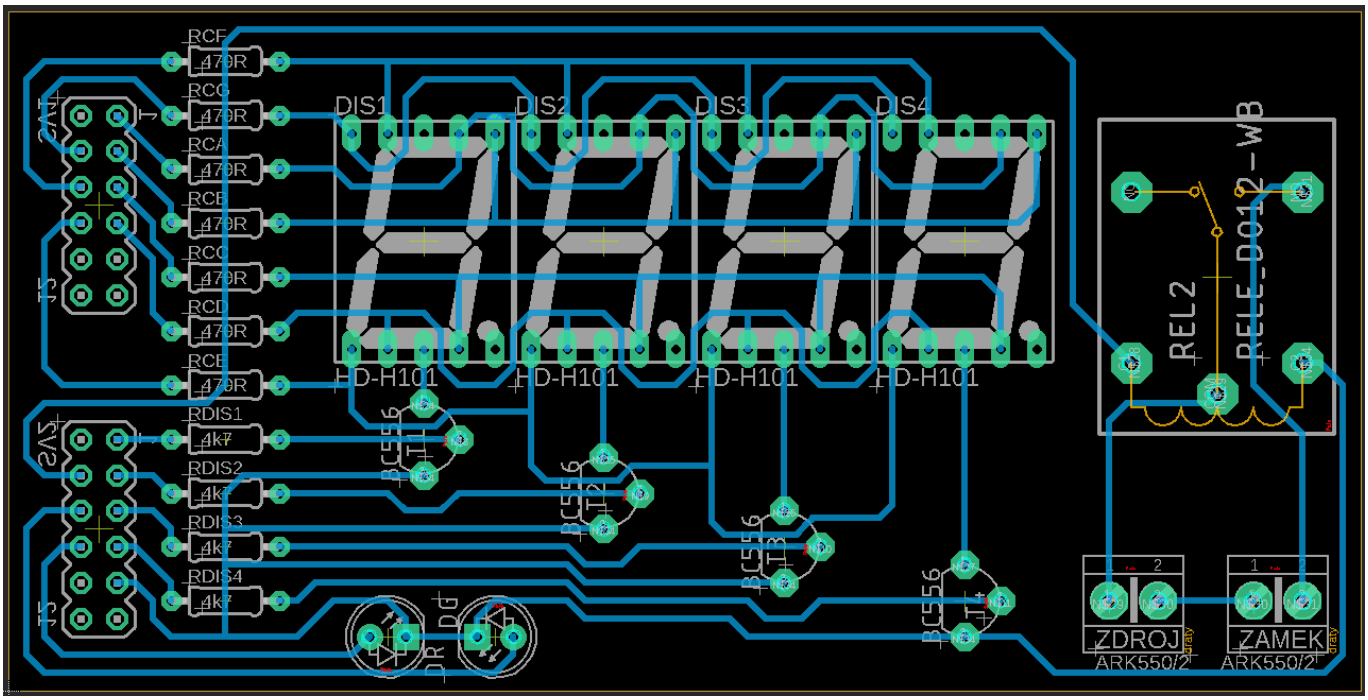
Hardware description

Whole system will be mainly run on an Arty A7-35T board with a custom number keypad keyboard, a 4-digit display and a relay to lock the door. The keyboard and display with relay are solved at two other external boards. On the board with display and relay are two LED diodes to signal if the lock is open or not and two terminal blocks, one for the lock and the second one for the external source which is there in case we would need more current to open a bigger lock (safe or something like that). This board can be connected directly into pmod ports on Arty A7. The keyboard will be connected into the Arduino/chipKIT shield connectors IO0-IO11.

Keyboard


1
2
3
DTS-3
DTS-3
DTS-3
4
5
6
DTS-3
DTS-3
DTS-3
7
8
9
DTS-3
DTS-3
DTS-3
*
0
#
DTS-3
DTS-3
DTS-3
SV2
13
1

Display

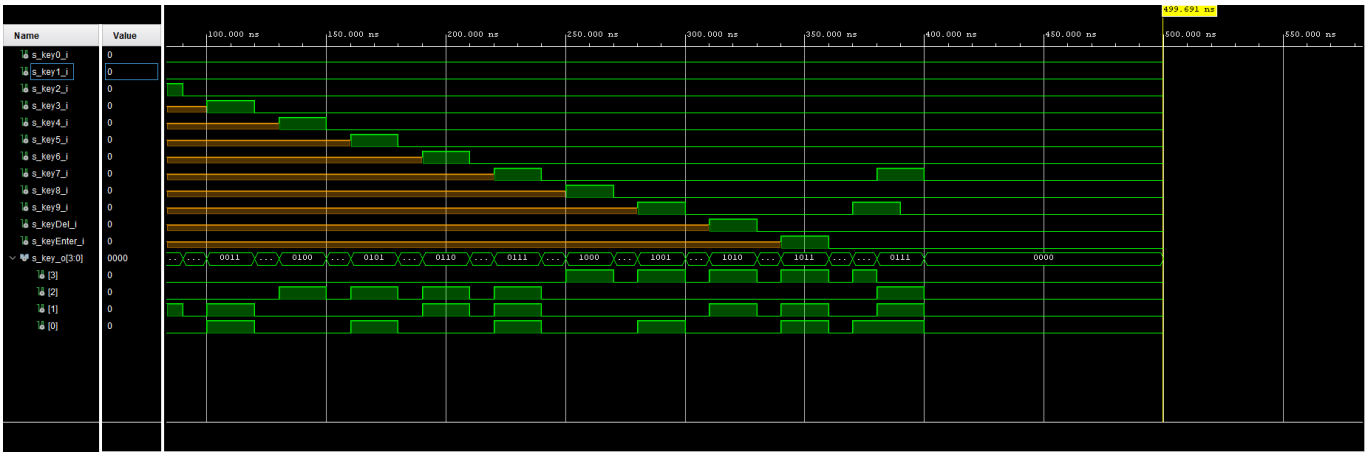


VHDL modules description and simulations

Keyboard

Module: The keyboard is solved in the simplest way. Buttons are connected to 3,3V power supply and every single button is connected to Arduino/chipKIT shield connectors IO0-IO11. The module recognizes, in which port is the voltage. Then it sends the value assigned to the port where the just the supply is.

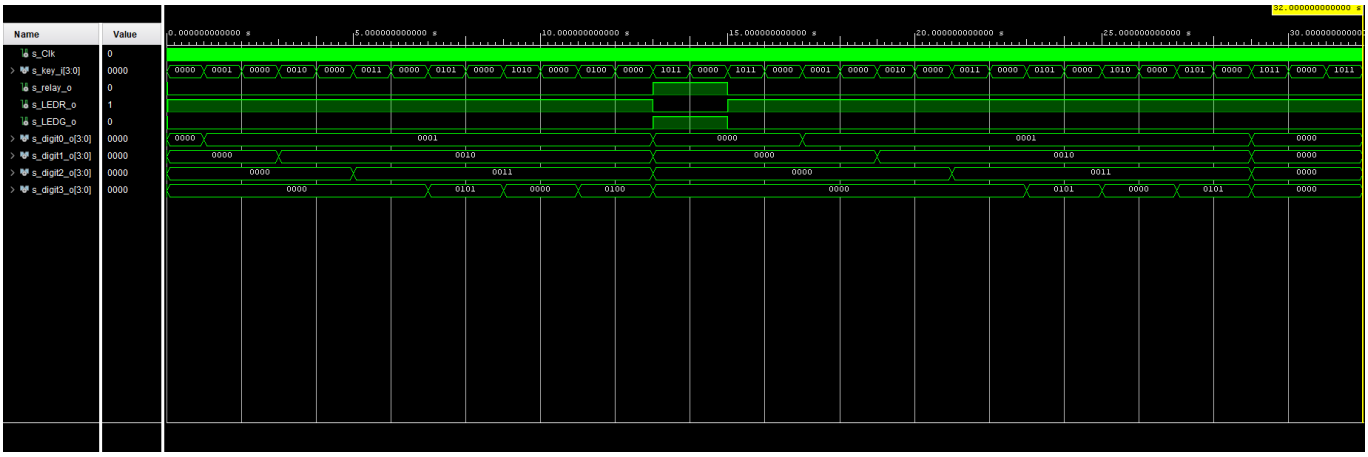
Simulation: In this simulation we can see that after pressing some key then in output is the value of the pressed key at this moment.



Comparator

Module: The comparator accountable for showing information that is presented, meaning displaying the currently assigned PIN code, lighting a corresponding LED if the door is locked or unlocked and sending a signal to the door relay to unlock it. It's important role is also to reset the code if the combination was incorrectly entered or when it was correct and will need to be put in the next time. Another thing is the '*' key, which deletes the last number that was put in.

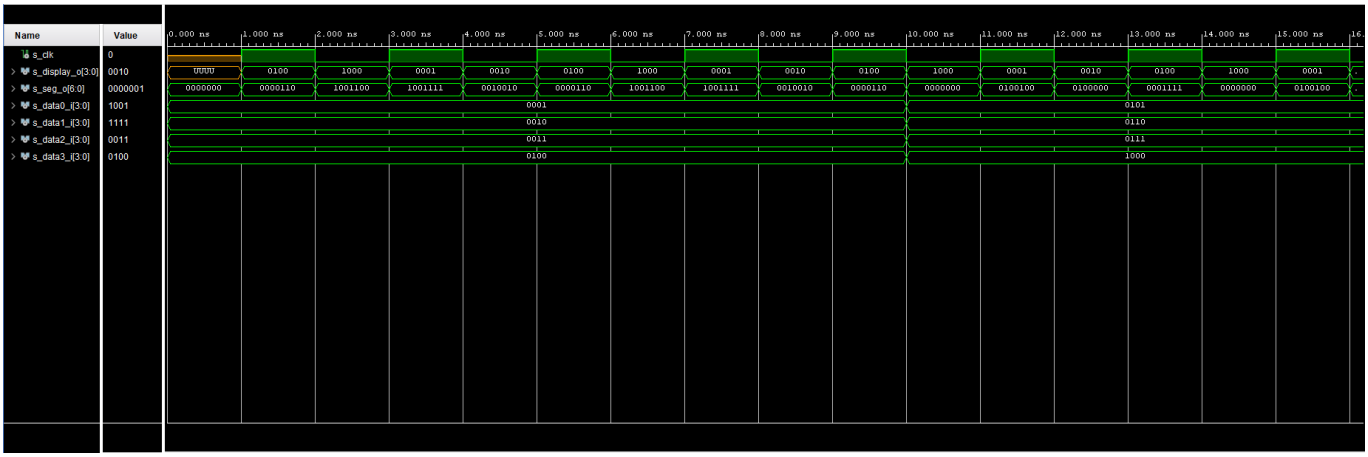
Simulation: Signals s_digit includes outcoming values into comparator. There are numbers one two three and at fourth position is as first number five then is pressed star, number five is deleted and then is written number four (the right number). After the password is entered we press a cross, each number of the display is deleted, red LED light off, green LED light on and lock is open. With the next press a cross is the lock closed. In the end of the simulation we can see the situation when we enter the wrong password and the lock does not open.

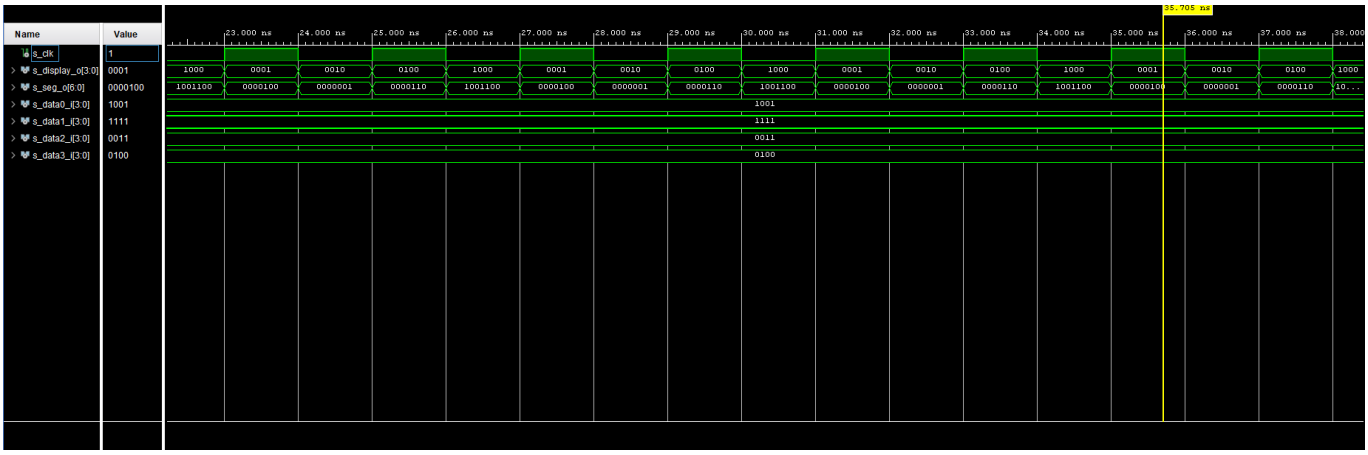


D_7seg

Module: This modul just takes the input values and transforms them into 7-bit values which can be shown on the display. Switching between displays is ensured by clk modul which with 1 kHz frequency switching between every single display every 1 ns.

Simulation: In inputs s_data are values which were entered on the keyboard. In outputs, values for certain numbers to show on display are switching every 1 ns.

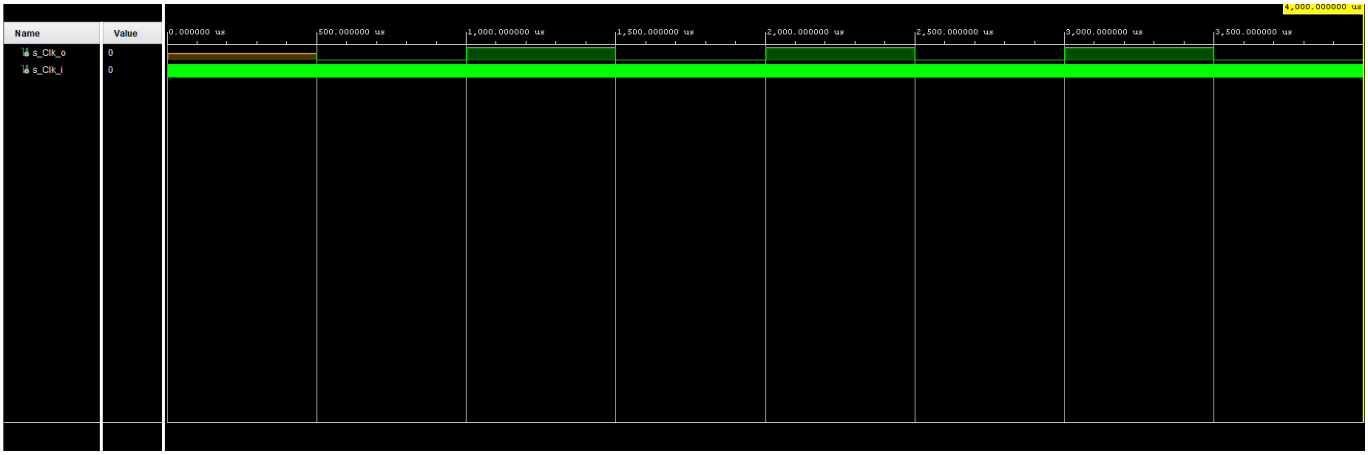




clk

Module: The boards initial 100 MHz signal would be a bit overkill for the CPU. That's why we reduce it to just 1 kHz or 1 ms intervals with this module.

Simulation: Here we can see that the output clock has a lower frequency.



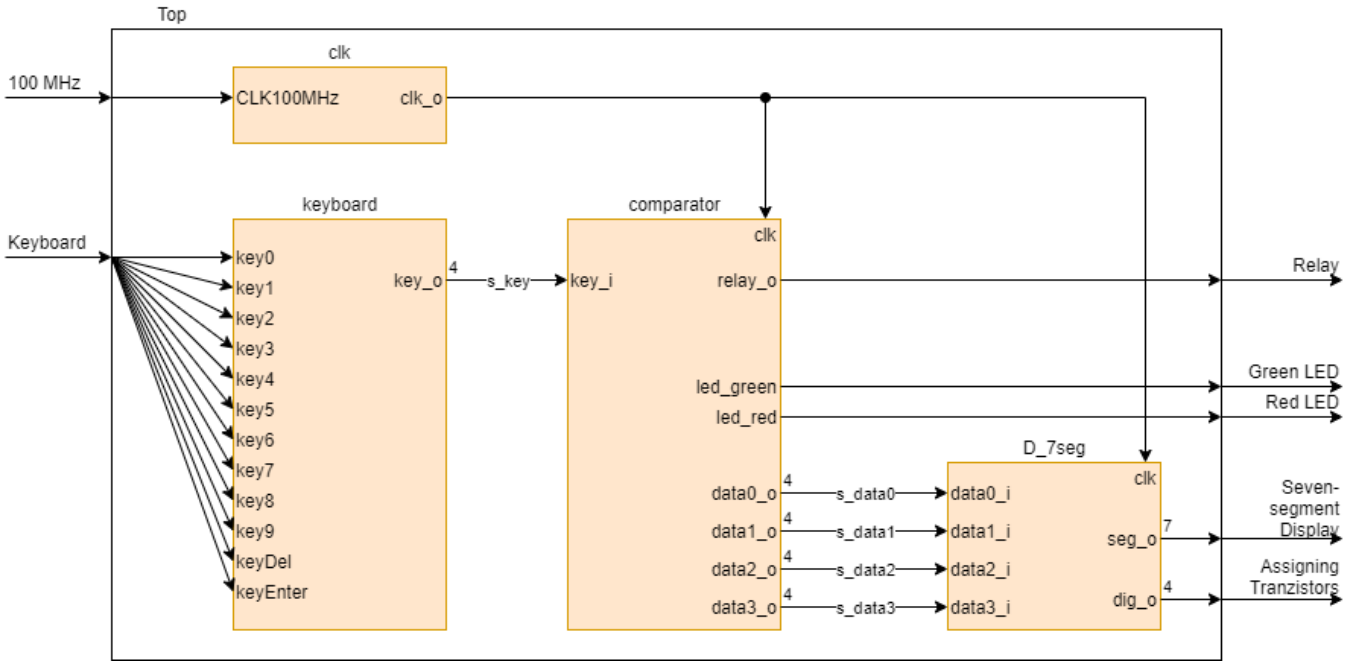
TOP module description and simulations

Pmod connectors:

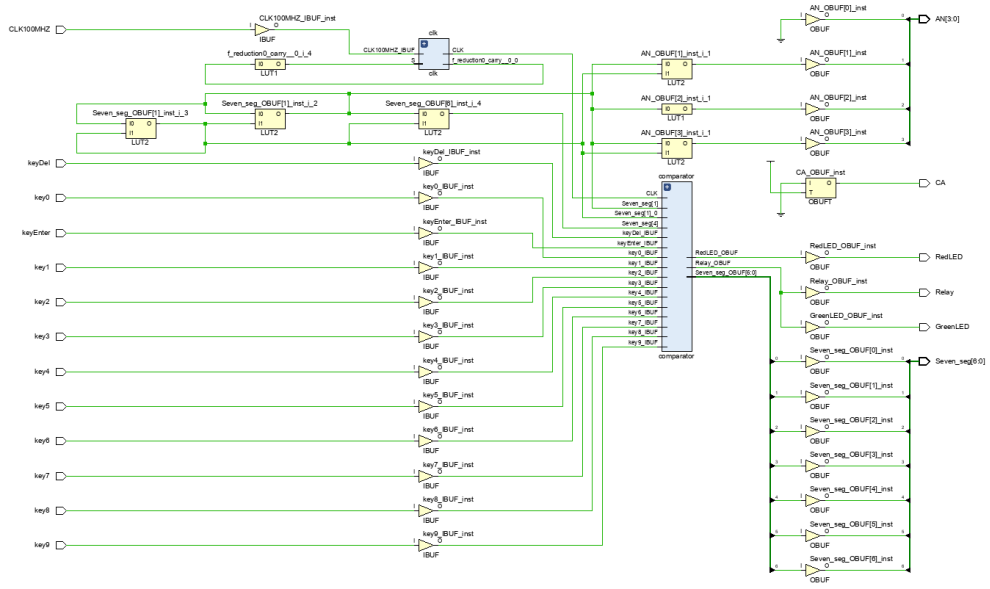
Output pins	FPGA pin	FPGA pin name
AN[3]	IO_L13N_T2_MRCC_35	F3
AN[2]	IO_L13P_T2_MRCC_35	F4
AN[1]	IO_L12N_T1_MRCC_35	D3
AN[0]	IO_L11N_T1_SRCC_35	D4
RedLED	IO_L15N_T2_DQS_35	G2
GreenLED	IO_L15P_T2_DQS_35	H2
Relay	IO_L14N_T2_SRCC_35	D2
Seven_seg[0]	IO_L20P_T3_A08_D24_14	U12

Output pins	FPGA pin	FPGA pin name
Seven_seg[1]	IO_L20N_T3_A07_D23_14	V12
Seven_seg[2]	IO_L21P_T3_DQS_14	V10
Seven_seg[3]	IO_L21N_T3_DQS_A06_D22_14	V11
Seven_seg[4]	IO_L22P_T3_A05_D21_14	U14
Seven_seg[5]	IO_L22N_T3_A04_D20_14	V14
Seven_seg[6]	IO_L23P_T3_A03_D19_14	T13
key0	IO_L16P_T2_CSI_B_14	V15
key1	IO_L18P_T2_A12_D28_14	U16
key2	IO_L8N_T1_D12_14	P14
key3	IO_L19P_T3_A10_D26_14	T11
key4	IO_L5P_T0_D06_14	R12
key5	IO_L14P_T2_SRCC_14	T14
key6	IO_L14N_T2_SRCC_14	T15
key7	IO_L15N_T2_DQS_DOUT_CSO_B_14	T16
key8	IO_L11P_T1_SRCC_14	N15
key9	IO_L10P_T1_D14_14	M16
keyDel	IO_L18N_T2_A11_D27_14	V17
keyEnter	IO_L17N_T2_A13_D29_14	U18

Diagram of the Top module

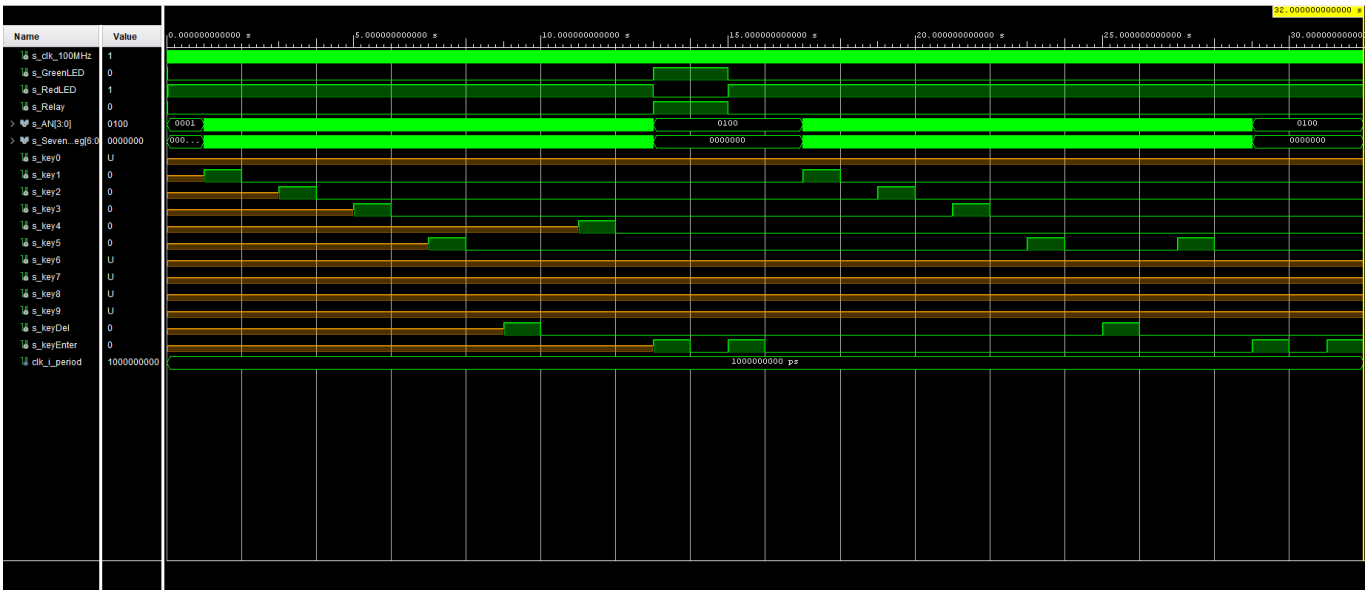


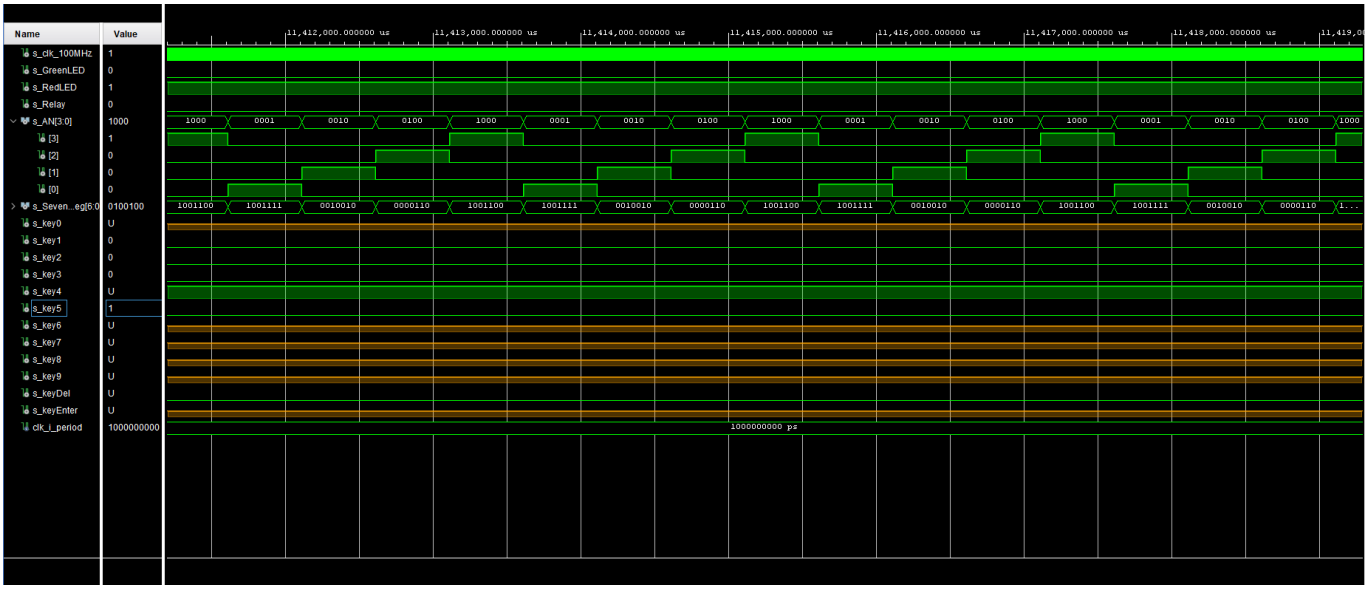
Schematic exported from the Vivado synthesis



Module: This program consists of 4 modules. The first one being the initial *keyboard* input to which signals from its keys are conducted. After a button is pressed a signal containing a corresponding number in a binary form and is sent to the key_o output. The number '0' is represented as "1111", the '*' key as "1010" and '#' is "1011". Next comes the *comparator* that is partly controlled by a *clk* signal which is transposed from being 100 MHz to just 1 kHz. Input values that are entered are stored in the comparator and after the '#' key is pressed it evaluates if the code entered agrees with the set code. The module has a realy_o output that has a value of 1 when the code is correct and therefore unlocks the door. The two LEDs, one red that shines if the door is locked and a green one working the other way around. The outputs from the comparator are also data of entered values which are then sent to the driver for 7-segment displays and are presented after the matter.

Simulation: We simulate enter of the numbers 1, 2 and 3, after which we add a 5 that is then deleted with '*' key (s_keyDel in code) and number 4 is pressed instead. The '#' key confirms our input, switches on the relay to unlock the door and changes the LED color. After that we click the '#' key once more to switch the relay off and return the original LED color back. The other instances are to demonstrate a wrongly inserted code when the relay and LEDs don't react.





Video

YouTube video for Door Lock - DE1 Project

References

- Arty A7 Reference Manual [online]. Available from: https://reference.digilentinc.com/reference/programmable-logic/arty-a7/reference-manual
- https://www.gme.cz/led-display-14-2mm-hdsp-h101
- https://www.ics.uci.edu/~jmoorkan/vhdlref/