

VENDING MACHINE USING VERILOG & FPGA

Project Report

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Abstract

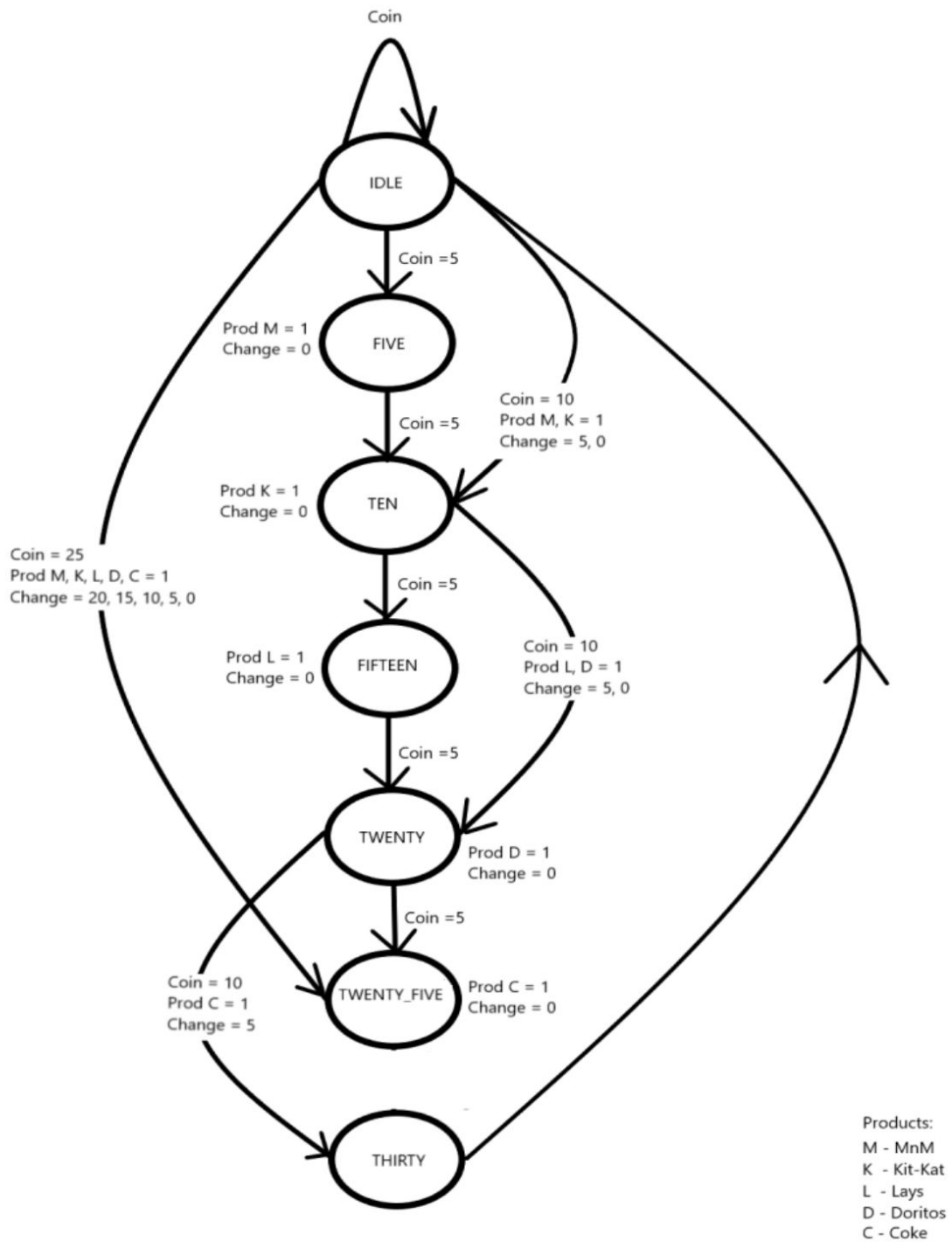
The designed vending machine accepts three currencies and dispenses five products. Nickel, Dime, and Quarter are the three currencies accepted as inputs for rendering five products with the prices ranging from 5 cents to 25 cents. Upon selection of a product, the machine displays the price and waits for the input/currency. Once the sufficient amount is received the change is calculated if any and displayed. The project is designed in Verilog and tested using Synopsys VCS. It is synthesized, simulated, and implemented on Terasic DE-10 lite FPGA using Quartus Prime Lite Edition.

Introduction

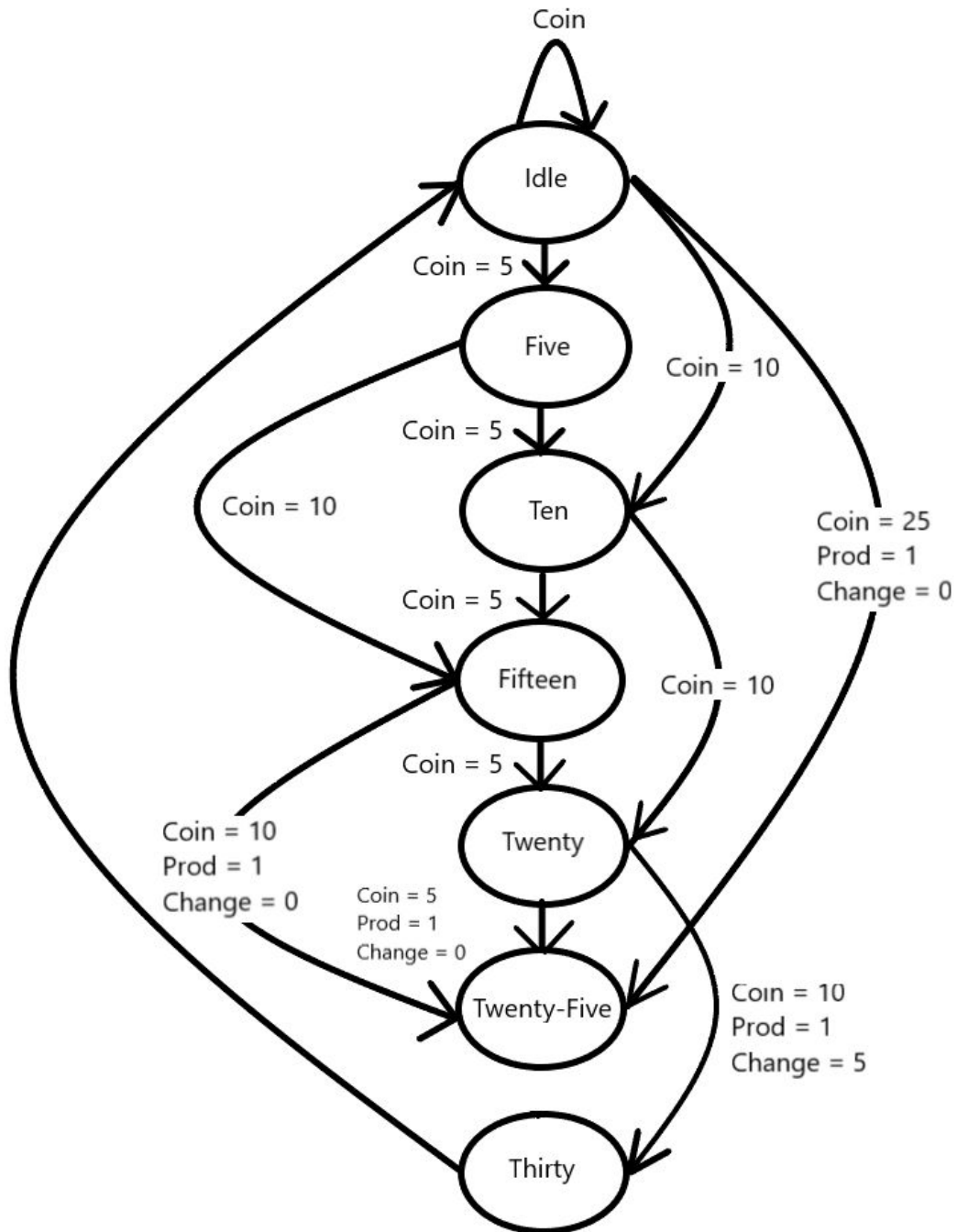
The machine is developed to dispense five products that are MnM, KitKat, Lays, Doritos, and Coke with the price being 5, 10, 15, 20, and 25 cents respectively; these products are assigned to switches SW9 to SW5 respectively on the FPGA board. Selection of a product first displays its price in the two of the six LED segments, HEX5 and HEX4 (7 segment LEDs), and then waits for the amount to be inserted. The three currencies Nickel, Dime and Quarter are assigned to three switches SW0 to SW2 respectively on the FPGA. The next set of LED segments, HEX3 and HEX2 displays the amount inserted. The third set of LED segments, i.e. HEX1 and HEX0 displays “In” when any particular product is selected and the required amount is not inserted yet. It also displays change after the transaction is complete. Once the required amount is inserted LEDR4 glows indicating that the product has been dispensed. A reset switch assigned to SW4 is used to reset the machine before the next transaction.

All the switches used on the board are debounced and generates a pulse at the selection of that particular switch. A variable “prod_flag” is used to keep the state unchanged until the required amount is received and prod goes high. Once the amount is received the flag resets itself and repeats the process for the next selected product. These were the few prime challenges faced while implementing the project which were eventually overcome.

State diagram for Vending Machine



State diagram for product Coke



Working

The vending machine dispenses five products namely MnM(5 cents), Kitkat(10cents), Lays(15cents), Doritos (20cents), and Coke(25cents). The product can be obtained by inserting the currencies in Nickel, Dime and Quarter. The vending machine works on seven states namely IDLE, FIVE, TEN, FIFTEEN, TWENTY, TWENTY-FIVE, and THIRTY. The machine is initially on the IDLE state. Once the user selects a product the machine waits for the amount to be inserted. For example, the selected product is Coke (25 cents) and the user wants to insert three dimes. When a dime is inserted in the IDLE state, it goes to state TEN. It waits in the state TEN for more inputs, which is indicated by an “In”. If the user now inserts second dime, the state goes to TWENTY. Now, after the user inserts the third dime, the state is traversed to THIRTY. The machine now has received the sufficient amount. Here, in the final state, THIRTY, the product Coke is dispensed and the change Nickel is returned.

The Seven segment display is used to display the cost of the product, amount inserted and the change to be returned. The HEX5 and HEX4 displays the product cost. The HEX3 and HEX2 displays the amount inserted. If multiple coins are inserted then the total amount gets displayed. The HEX1 and HEX0 display the change if to be returned. The HEX1 and HEX0 also displays “In” indicating more amount to be inserted if the inserted amount is insufficient. The LEDR4 glows indicating the product dispensed.

The below screenshots demonstrate the working of the above mentioned case for product Coke.

1: In Idle State all the LED segments display a hyphen.



2: User selects the product Coke. The amount for product coke is displayed on the seven segment HEX5 and HEX4.



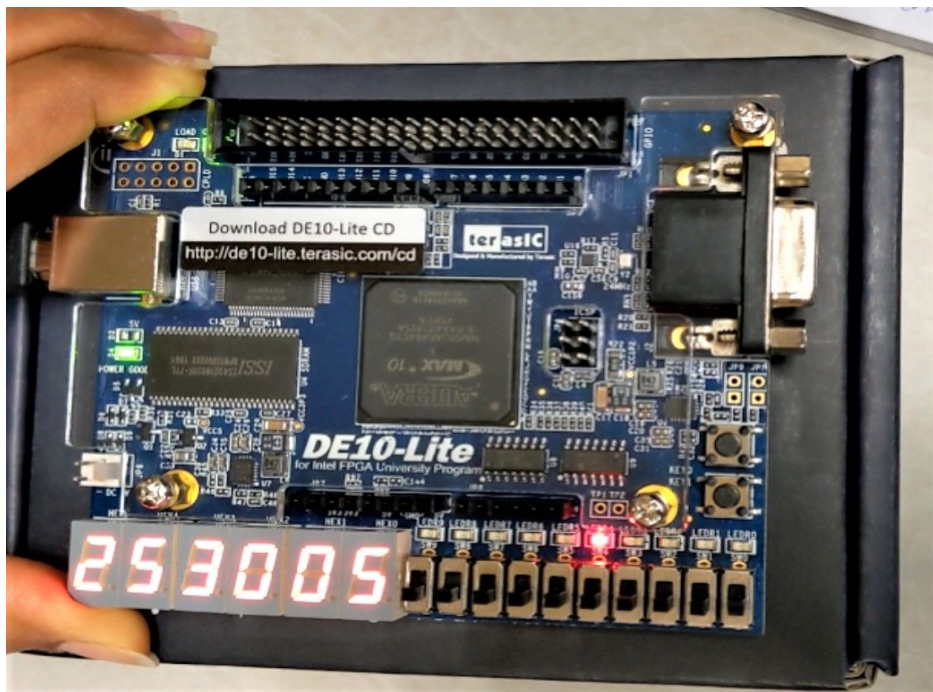
3: A dime is inserted. The HEX3 and HEX2 displays 10 indicating dime inserted. The “In” on the HEX1 and HEX0 display indicates additional amount to be inserted.



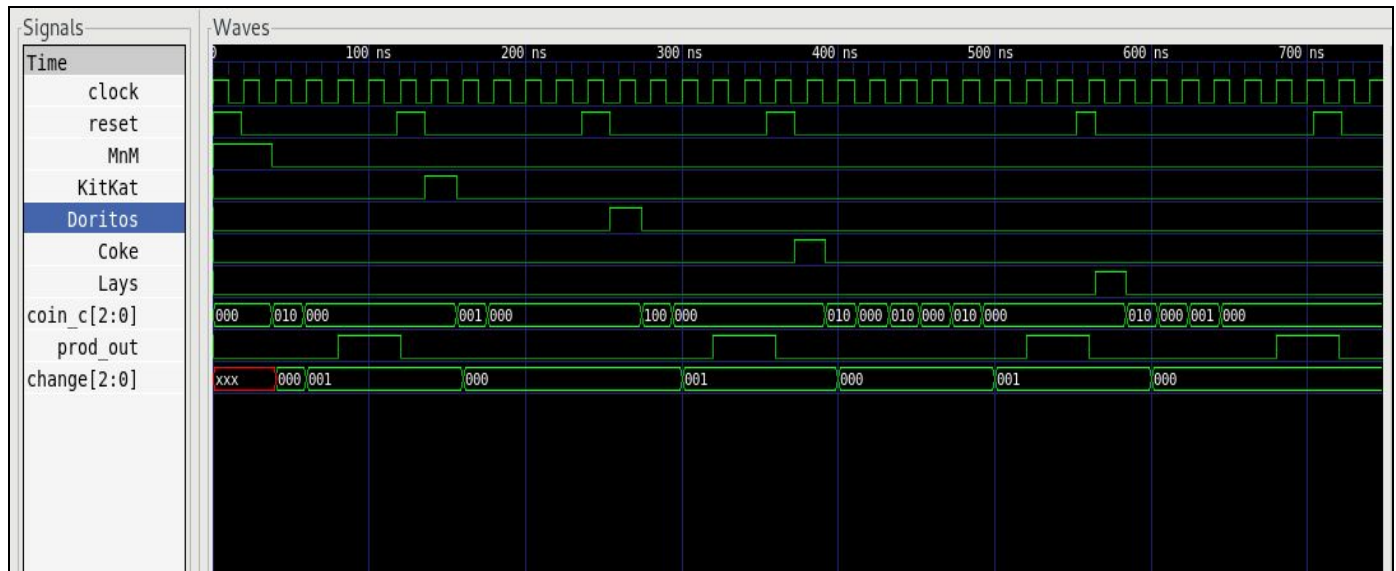
4: Second dime is inserted. The HEX3 and HEX2 displays 20, which is the total inserted amount for two dimes.



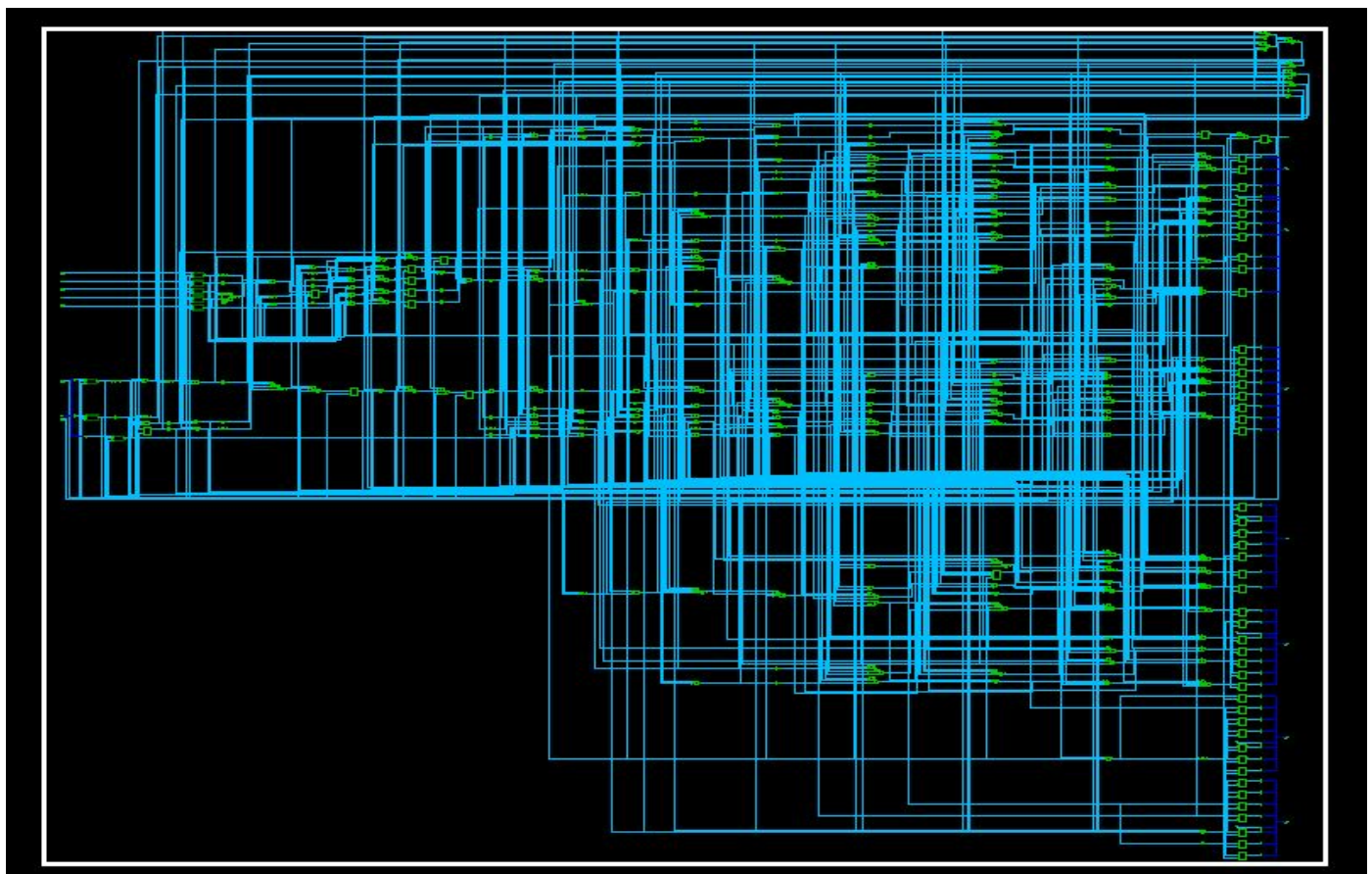
5: The third dime is inserted. The HEX3 and HEX2 displays the total amount 30 that is inserted till now. The change 5 cents to be returned is displayed on HEX1 and HEX0. The LED on switch 4 glows indicating the product dispensed.



Waveform



Schematic



Conclusion

The vending machine is successfully designed, simulated and synthesized on Terasic DE10 Lite FPGA by Quartus Prime lite software. The designed vending machine dispenses the product also if the currencies are provided in multiples. The video demonstration covers the working for all the test cases. The seven-segment display efficiently displays the results without any errors or delays.

Contributions

All the team members have equally contributed in all the stages of project submission starting from the deciding on vending machine specifications, State diagram, development of Verilog code, simulations, synthesis, and the final interfacing part on the FPGA.

References:

1. <https://www.fpga4student.com/2017/04/simple-debouncing-verilog-code-for.html>
2. <https://pdfs.semanticscholar.org/efb2/1848c1818f3ba509b220d41131e59ee2ae55.pdf>
3. <https://www.youtube.com/watch?v=lc-Q8OX3Cb0&frags=wn>