Design of Vending Machine using FPGA

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Abstract: *The vending machine is an automated device that dispenses a variety of products to customers when cash or a credit card is placed, including food, beverages, newspapers, tickets, and more. Contrary to traditional purchase methods, vending machines are more convenient and available. Today, the market for vending machines generates enormous annual revenues for developed countries like the United States, Japan, China, and some other Asian nations, including India. The goal of the paper is to create a vending machine that can dispense three different items at varying costs with the added functionality of "return change" when a coin of a higher denomination is input and "return money" when a request is cancelled. Coins of the values of five and ten are accepted by the machine. The design of vending machines uses the finite state machine (FSM) methodology. The design is accomplished by using behavioural modelling to create the Verilog code for the FSM-based machine and the Xilinx ISE tool to simulate the test-bench for three items.*

Keywords: Finite State Machine (FSM), Field Programmable Gate Array (FPGA), Moore, Mealy

I. INTRODUCTION

The vending machine is an automatic device that sells items like newspapers and tickets in addition to food like canned soups and packaged sandwiches, snacks like potato chips, chocolate bars, and candy, and hot drinks like coffee, tea, and hot chocolate. It also sells cold drinks like juice, bottled water, and soft drinks, as well as hot drinks like coffee, tea, and hot chocolate. When a product is chosen and money (often coins or paper money) is inserted into a slot, the machines typically function. Then, a lever or button needs to be pulled. If there is sufficient cash, the desired item will be dropped onto a tray, where the buyer can remove it. Vending machine specialisation increased between 2000 and 2010.Vending expanded more and more into unconventional fields like electronics, literature, or even visual arts. Automated retail kiosks is the broad name given to machines in this new category. When utilising an automated retail machine, customers choose products, occasionally using a touch screen interface, pay with a credit card or debit card, and then the product is delivered, occasionally using a robotic arm inside the machine. In Japan, where there is 1 vending machine for every 23 people, the trend of specialisation and expansion of vending machines is likely most obvious. Vending machines have gradually, albeit at a much slower rate, evolved into smart vending machines, which is reportedly comparable to how old mobile phones changed into smartphones. This development has been facilitated by newer technologies with lower adoption costs, such as the large digital touch display, internet connectivity, cameras, and various types of sensors, as well as more cost-effective embedded computing power, digital signage, and a variety of advanced payment systems (NFC, RFID, etc.). A source of information on client demographics, purchasing patterns, and other region-specific data is integrated sensors and cameras. Through interactive multimedia and social media networking, it also promotes increased customer interaction for the brands. JWT Intelligence ranked smart vending machines #79 on its list of the top 100 trends for 2014.Global shipments of smart vending machines are anticipated to reach roughly 2 million units by 2018 and further to 3.6 million units by 2020 with a penetration rate of 20.3%, according to Frost & Sullivan market research.

II. FINITE STATE MACHINES

It is vital for us to have prior understanding about finite state machines in order to understand how our machine functions. A behaviour model is a state machine. Due to its limited number of states, it is often referred to as a "finite-state machine" (FSM). The machine makes state transitions and generates outputs based on the current state and an input. Mealy and Moore machines are simple types, while Harel state charts and UML machines are more sophisticated

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ones.The fundamental components of a state machine are states and transitions, and our project is based on Mealy and Moore machines. A system is in a state when it depends on inputs from the past and responds to inputs from the future.The machine's execution begins in the one state designated as the initial state. The input that causes a state to change from one to another is defined by a state transition. Depending on the type of state machine, outputs are produced by states and/or transitions. A simple state machine is shown above. There are two states: Off and On. The initial state in this case is on, and it becomes active when the state machine is run. The arrows between the states represent potential state changes. They specify the inputs for which a state change takes place. Here, pressing the input button causes the active state to transition from On to Off and then back to On.

2.1 Moore

The Moore machine was created by Edward Moore, who first proposed the idea in 1956. States and transitions make up Moore machines. States have the capacity to produce outputs, and the output is solely decided by the state at any given time and not by any inputs.

2.2 Mealy

George H. Mealy created the Mealy machine in 1955. Mealy machines don't provide outputs in states like Moore machines do; they only produce outputs on transitions. As a result, state diagrams frequently have fewer states since transitions can be given greater thought.

III. WORKING

First, we have fixed 3 input formats, if the input is 2’b01=Rs5 or 2’b10=Rs10 or 2’b11=Rs20. Also 2’b11 equals Rs20 only if it is given as input otherwise 2’b11 represents Rs15 State. Now a module has been created and the ports have been mentioned within the brackets. Within the module block we first mention the parameters s0,s1,s2,s3 these will signify our different states of the FSM model we developed In the previous sections. Rs0 state/Reset state, Rs5 state, Rs10 state, Rs15 state are represented by s0,s1,s2,s3 respectively. We also have created a parameter n which will act as our product selector i.e whether it is a Rs10,Rs15,Rs20 product. Now inside the always block, according to the value of n there will be a different section of the code that will run and give us the output. For example if n=10:- This program runs based on case statements. The first case is for s0: within these cases there are multiple if loops that will determine the next state of the vending machine and also the output. If the input is of 2’b00 which is essentially Rs0 the state of the machine will not change and also won’t give any output, now when the input is 2’b01 the next becomes s1 as the input given was Rs5 but it is not sufficient to give the desired product which is of worth Rs10 and so the machine waits for more currency to be added until it has enough to dispense the product with the change if any. Similarly the program will run the same way our FSM model works.

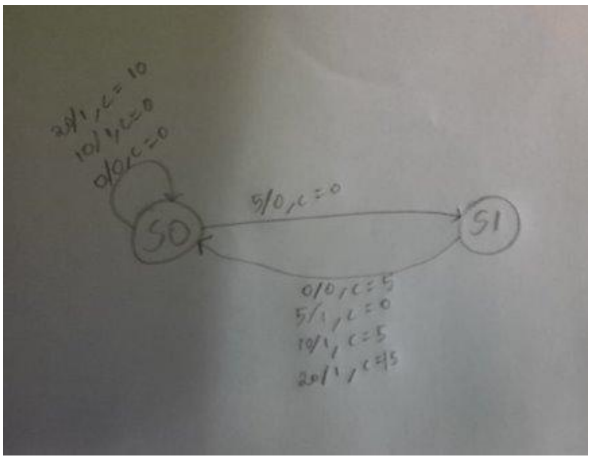

Figure 1: State Diagram for product of Rs10

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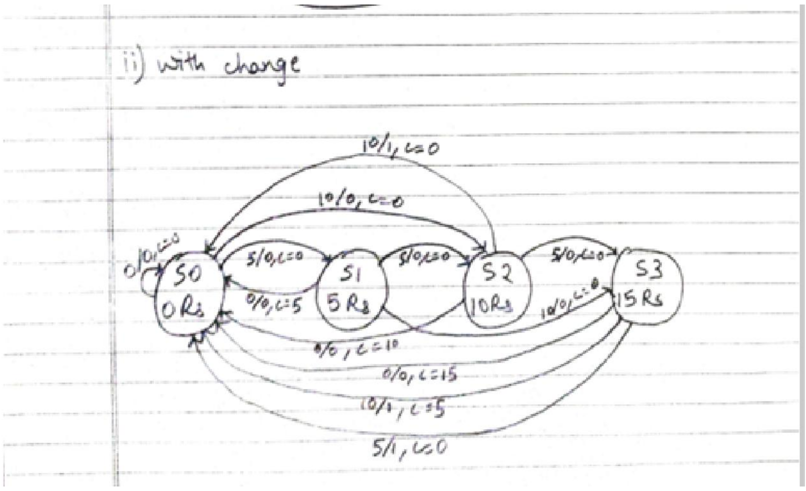

Figure 2: State Diagram for product of Rs 20

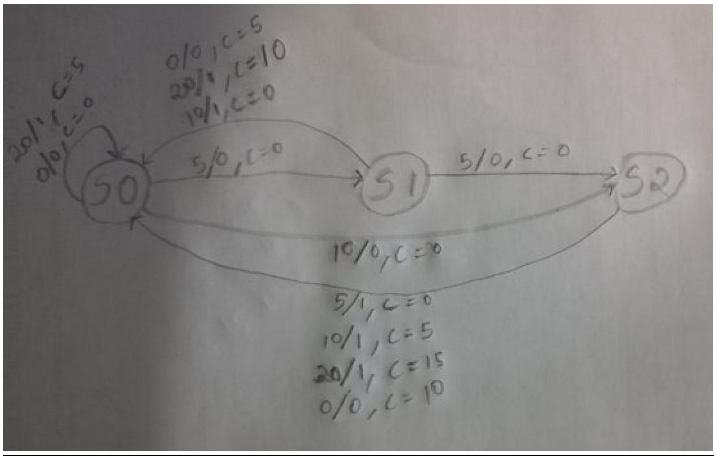

Figure 3: State Diagram for product of Rs15

3.1 Working of Test Bench Code

Test bench coding is necessary as it will verify the design of our program and it also ensures the timing and overall functionality of the machine designed. Code starts with module creation, inside the module we define the input and output ports as reg and wire respectively. Then we instantiate the design module that we had created in the section prior to this. Now we initialize rst=1 and clk=0, when rst=0 the machine will start working with every positive edge of the clk waveform. After a #6 delay we set rst to zero and give our first denomination input which is 2'b01 (Rs5), after another #19 delay we give our second input of 2'b10 (Rs10) this delay is given so that we can study and understand the working accurately. Further input of 2'b11 (Rs20) is given after another #20 for the same reason and the block is ended. We set the clock waveform to have high and low values every 5ns.

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IV. WAVEFORMS

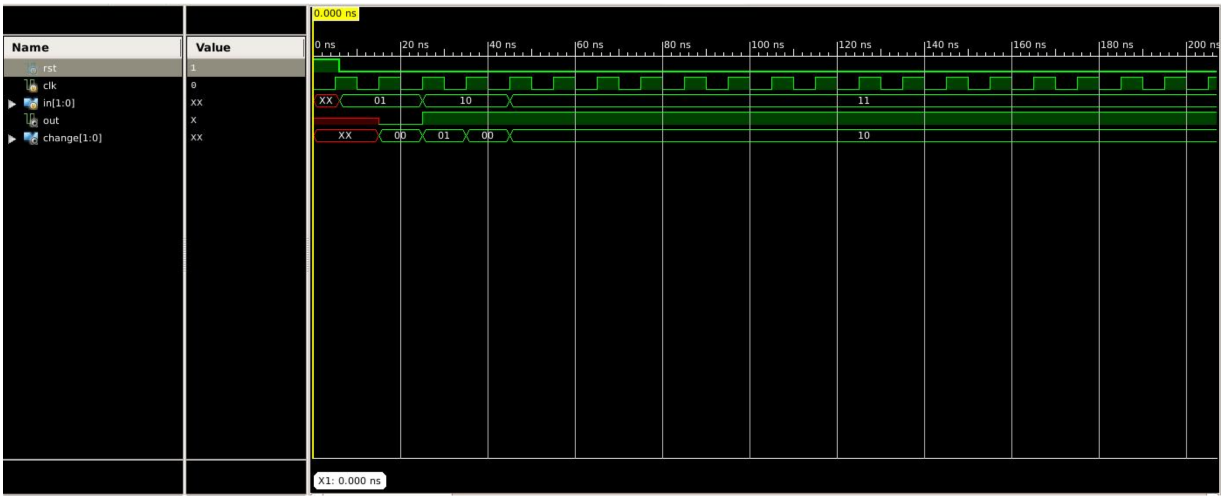

Figure 4: N=10

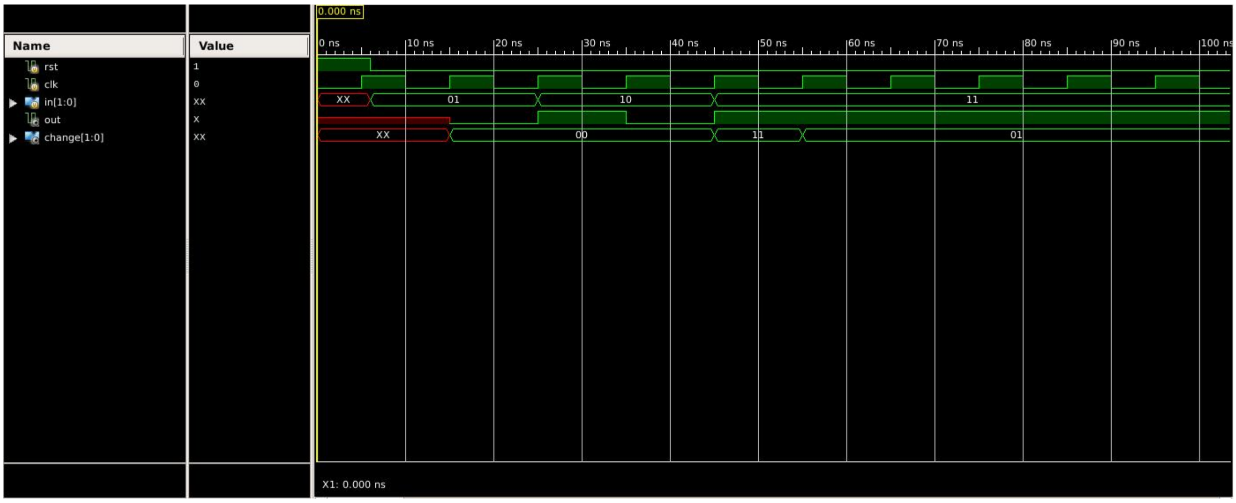

Figure 5: N=15

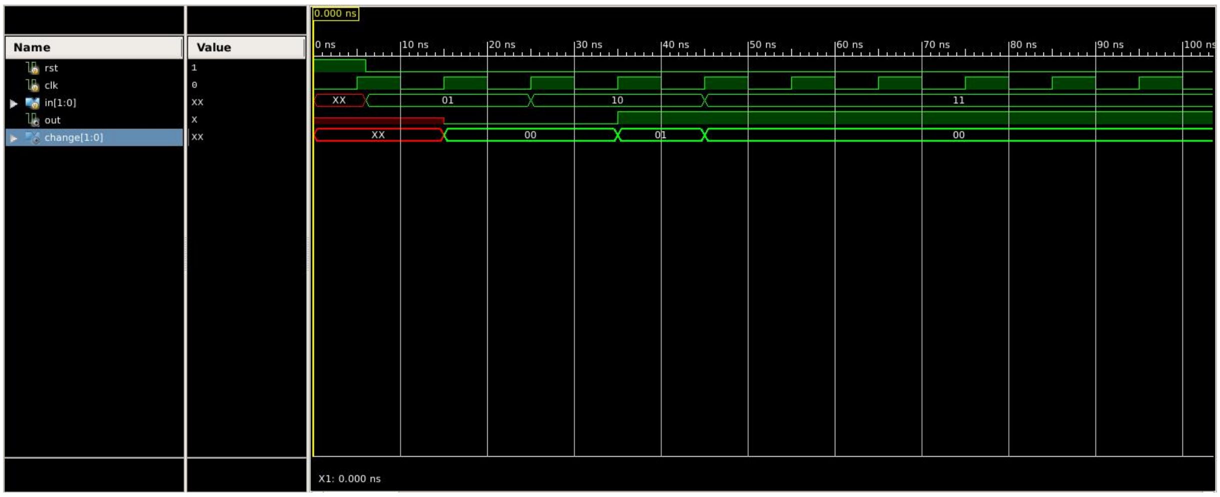

Figure 6: N=20

V. APPLICATIONS

5.1 Foods, Drinks, and Sale of Tickets

The best use of vending machines is for food, drinks, or both! The finest things we've ever gotten from these machines are snacks and cold or hot beverages. It is utilised to sell tickets in advance of any particular event, including local baseball games, music concerts, and theatre performances.

5.2 For Condom Distribution

This sounds strange! But is a fact that nobody can ignore! Walk around your street and we bet, you'll notice at least one of it. So why to go to medical or retail shop? Just locate yourself to nearby condom vending machine and get it off the machine.

5.3 Advanced uses and Future Developments

With recent massive technological changes, we have come across some other non-traditional uses of vending machines wherein we have witnessed machines that dispense gold, newspapers and many other items.Since its evolution, we have witnessed simple to smart machines, but wait, the development is still under the process and we are sure to come across even smarter, better and wider range of vending machine that are sure to make our life easier!

VI. CONCLUSION

The vending machine was successful in dispensing three products A, B and C of prices Rs.10/-, Rs.15/- and Rs-20/- respectively, with the additional features of dispensing product along with returning change when higher denomination coin is inserted and returning total money when request is canceled. The vending machine is successful in meeting the specifications laid out prior to the design.

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