

Design and Implementation of Vending Machine using Verilog HDL on FPGA

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ABSTRACT: This paper describes the modeling of a Finite State based vending machine using the mealy machine model. The proposed machine has been implemented on Spartan3 FPGA development board. The advantages of using this machine have been indicated in the paper. The whole design has been functionally verified using Xilinx 9.2i and Modelsim 6.2a simulator. A vending machine is a machine which dispenses items such as snacks, beverages, lottery tickets, consumer products to customers automatically after the customer inserts currency or credit into the machine. This paper compares different aspects as timing and device utilization of the proposed machine with the previously proposed machine³. Also the paper indicates a future possibility of a betterment over existing vending machines.

KEYWORDS: Vending Machine, FPGA, Verilog, Xilinx ISE simulator, Modelsim, FSM

I. INTRODUCTION

The vending machine market is a big business with a huge annual revenue for leading nations like The USA, North America, Japan, China and some other Asian countries including India. The commercial coin based machine was first introduced in London for selling post cards. Most of the vending machines which are currently in use are based on CMOS, Microcontroller technology[1]. The latest FPGA based machine is programmable and reconfigurable. In FPGA based machine the user can easily increase the number of products with other flexibilities.

FSM stands for Finite state machine, is a model of computation used to design sequential logic circuits. It is an abstract model of machine that can be in one of the finite number of states at a time. The state at any given time is called the current state. A particular FSM is given by a set of states and the triggering condition for each transition[2]. In these, the hardware gets reduced as the whole algorithm can be explained in one process. There are mainly two types of machines—Mealy and Moore. We are using the mealy machine model in which the output depends on the present state as well as the input. The mealy machine model is shown in figure 1.

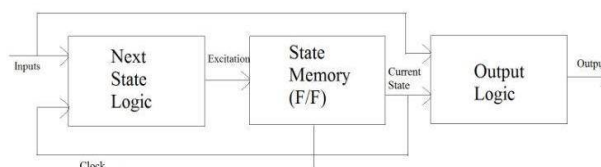


Figure 1: Mealy Machine Model

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II. RELATED WORK

Various methodologies have been developed to design the Vending Machines. A few of them are discussed here as: Fauz [2] proposes a vending machine for steaming frozen food using conceptual modelling. In this, the process of three main states (user selection state, freezer state and steaming state) have been modelled using process approach, which emphasized on the process flow or control logic to construct the model for steamed buns vending machine application. Conceptual modelling is described in [1]. In [8] the concept of automatic mobile payment is discussed. This concept is based on the short message payment with the main control module M68HC11 and GPRS module MC35. Three various methods of designing VHDL based machines are discussed in [2], [3]. In[7] a coffee vending machine is designed using Single Electron Encoded Logic (SEEL).

III. IMPLEMENTATION OF VENDING MACHINE

The proposed machine is implemented on the Spartan 3 FPGA board and has 8 goods with different costs as shown in the table below:-

TOTAL NUMBER OF PRODUCTS:- 08

QUANTITY OF EACH PRODUCT:- 07

SERIAL NUMBER	PRODUCT	COST (IN RS)	SERIAL NUMBER	PRODUCT	COST (IN RS)
1	KURKURE	10/-	5	CHOCKLATE	50/-
2	MAGGI	10/-	6	BISCUITS	50/-
3	SOUP	20/-	7	TRUFFLE	100/-
4	CHIPS	20/-	8	WAFERS	100/-

INPUT SIGNALS:-

Clock- For clock input to the board
Reset –To activate the selection of products
Rs10- To indicate a Rs.10 input
Rs20- To indicate a Rs.20 input
Rs50- To indicate a Rs.50 input
Rs100- To indicate a Rs.100 input
Cancel- For cancellation of the transaction and money back
Product- 3 bit signal to select one out of 8 products
Refill_input-To put back a product when out of stock.

OUTPUT SIGNALS:-

Deliver- To indicate the delivery of a product after money is inserted
Finish- To indicate that the selected product is out of stock
Change- To indicate the change (if any) to the buyer
Return_back- To indicate the return of entire money inserted on cancellation

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The entire implemented machine can be summarized as:-

- 1- The machine has 8 items with each item being 7 in number and it will work only when the reset signal is high.
- 2- The machine will accept notes of denominations of INR 10, 20, 50 and 100 only.
- 3- The current transaction can be cancelled until the entire money has been inserted.
- 4- On pressing the cancel button, the entire money is returned back through the return output signal.
- 5- In case the required product is not available, the machine goes to the refill state.

IV. DESIGN METHODOLOGY

Initially the reset signal is high and the machine is ready for the user to select the product. This state is the initial state of the machine and after this the user will select the product to be dispensed. After selecting a particular input, machine goes to state 2 or 3 depending upon the product availability. Let us suppose that the user selects 1st input. The machine will firstly check, whether the product corresponding to input 1 is available in the machine or not. If yes, it goes to state 2 and when the desired amount is inserted in the machine, it will go to the product state 4 and the product will be delivered. If the product is not available in the machine, then the control unit will demand for servicing and move towards state 3 and after service the machine will automatically get reset.

There is also an additional feature of withdrawing the request if the user doesn't want to take the product. If cancel button is pressed before the entire money has been inserted, the money inserted will be returned to the user through the return output. A money count signal is used for calculating the total money inserted in the machine and if it is more than the amount of the product then the extra change will be returned to the user. The total amount of the money taken at a time is shown by the money signal. Similarly the user can select and get the other products following the above procedure. This methodology is explained using a flow diagram shown in Fig2.

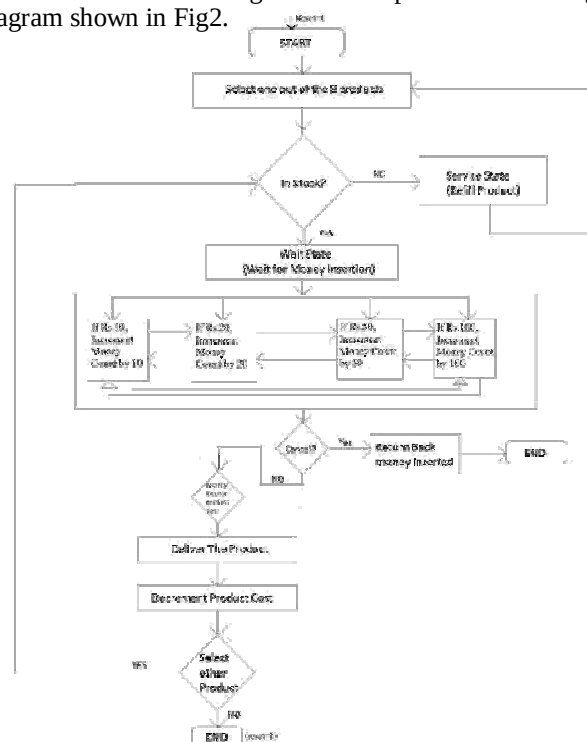


Figure 2: Flow Chart for proposed Vending Machine

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V. SIMULATION RESULTS

1. The first simulation shows selection of product seven and subsequent insertion of INR 100 in figure 3.

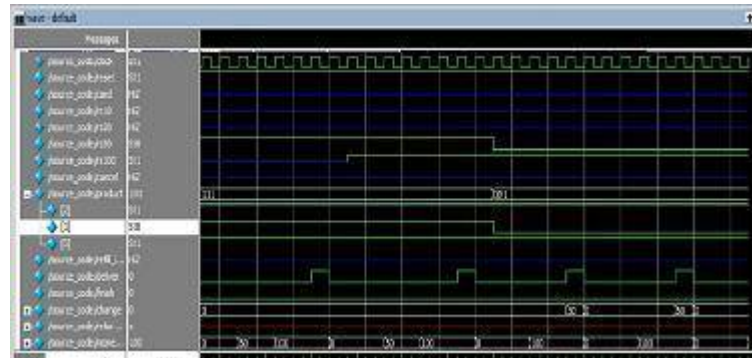


Figure 3: Simulation waveform with INR 100 input = High

2. The second simulation shows selection of product five and insertion of INR 150 with a change of INR 50 in figure 4.

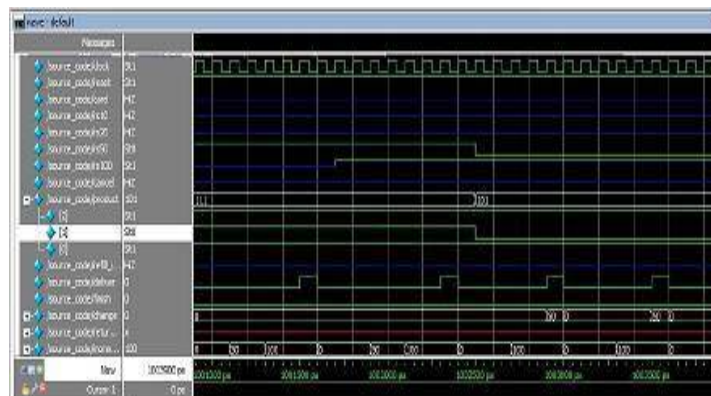


Figure 4: Simulation Waveform with change INR 50= high

3. The third simulation shows the register transfer level (RTL) view of the vending machine which displays gates and elements used in the digital circuitry.

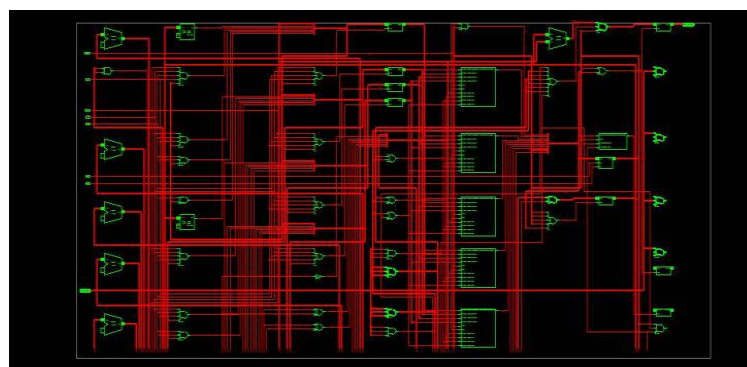


Figure 5: RTL schematic of vending machine

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Logic Utilization	Used	Available	Current Utilization Efficiency	Previous Utilization Efficiency
Number of Slices	91	3584	2%	6 %
Number of Slice Flip Flops	61	7168	0%	1%
Number of 4 input LUTs	163	7168	2%	6%
Number of bounded IOBs	28	173	16%	17%
Number of GCLKs	1	8	12%	12%

Table 1:Efficiency of algorithm shown by reduction in Device Utilization Summary

VI. CONCLUSION AND FUTURE WORK

It has been observed in different scenarios, that FPGA based vending machine gives faster response and shows low power consumption as compared to the microcontroller based machines. The results clearly indicate that the computational efficiency is increased by 10% as the algorithm uses less logic utilizations as compared to the existing FPGA based design algorithms [3].The comparison is shown in table 1.

The system has much more enhanced capabilities like withdrawal of money in between the transaction and automatic refill indication. Also we can monitor the FPGA based vending machine with the main frame computer. Its algorithm is very flexible and reliable as the vendor can easily enhance the algorithm for large number of products and money of different denominations at low cost as compared to microprocessor based vending machine. The next step would be to incorporate some of the following features-reverse vending capability, card payment facility and capability to queue & process a set of orders on FIFO basis.

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