International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
NATIONAL CONFERENCE on Developments, Advances & Trends in Engineering Sciences
(NCDATES- 09th & 10th January 2015)

RESEARCH ARTICLE OPEN ACCESS

Implementation of FPGA Based Smart Vending Machine

B Jyothi [1], I. Sarah [2], A. Srinivas [3]
[1] CMR College of Engineering & Technology , Assoc. Prof, E.C.E Dept., Hyderabad, India
Email: jyothiboorla404@gmail.com
[2] CMR College of Engineering & Technology, Asst. Prof, E.C.E Dept., Narsapur,Medak, India
Email: isarahpaul@gmail.com
[3] CMR College of Engineering & Technology, Asst. Prof, E.C.E Dept., Narsapur,Medak, India
Email: asrinivas011@gmail.com

Abstract:
A vending machine is a machine which dispenses items such as snacks, beverages, lottery tickets, consumer products and even gold and gems to customers automatically, after the customer inserts currency or card into the machine. Vending machines are very common in the countries like Japan, Germany, and U.S. etc. The requirements of the vending machines are increasing day by day due to the modern and fast life style. The FPGA based vending machines are more flexible and faster than the CMOS based machines. The FPGA based vending machine is also programmable and can be reprogrammed whereas in the Embedded based machines we have to change the whole architecture of the machine if we want to change or enhance the design of the machine.

In this paper implemention of vending machine using Finite State Machine (FSM) Model is proposed using VHDL.FSM modelling is the most important part in developing proposed vending machine model as this reduces the required hardware. In this project MEALY Machine Model is used to model the process for state i.e. user selection, waiting for money insertion, product delivery and servicing.

Keywords- *FSM, VHDL, Vending Machine, FPGA.*

I. INTRODUCTION

Vending Machines are used to dispense various products like Coffee, Snacks, and Cold Drink etc. when money is inserted into it**.** Vending Machines have been in existence since 1880s. The first commercial coin operated machine was introduced in London and England used for selling post cards. The vending machines are more accessible and practical than the convention purchasing method.
Nowadays, these can be found everywhere like at railway stations selling train tickets, in schools and offices vending drinks and snacks , in banks as ATM machine and provides even diamonds and platinum jewelers to customers. Previous CMOS and SED based machines are more time consuming than the FPGA based machines. The FPGA based machine is also more flexible, programmable and can be re-programmed. But in microcontroller based machine, if one wants to enhance the design, he has to change the whole architecture again but in FPGA user can easily increase the number of products.

In this paper a novel approach is proposed to design a Vending Machine with auto-billing features. The machine also supports a cancel feature means that the person can withdraw the request and the money will be returned back to the user. This machine can be used at various places like Hotels, Restaurants and food streets. This reduces the time and cost.

The machines usually work, when some money (usually coins or paper money) is put in a slot. Then a button needs to be pushed, or a lever pulled. If there is enough money in the machine, the selected item will be dropped to a tray, where it can be taken out by the person making the purchase. Older vending machines were mechanical, but most new ones are electronic. Many modern vending machines can accept debit or credit cards in addition to cash.

Some products need to be prepared to become available. For example, tickets are printed or magnetized on the spot, and coffee is freshly concocted. One of the most common form of vending machine, the snack machine, often uses a metal coil which when ordered rotates to release the product.

In the Western world, some vending machines dispense personal products, typically in public toilet facilities. The machines in ladies' restrooms typically sell pads or tampons. The machines in men's rooms, when they are present, are most commonly for the sale of condoms, though in some locations they may

be found dispensing cologne, medicine, small candies, or even pornography. These are often found at toilets used by transient persons in high traffic locations, such as bus stations, shopping centers, airports and service stations.

1.1 Operation of Vending Machine

I. When the user puts in money, money counter tells the control unit, the amount of money inserted in the Vending Machine.

II. When the user presses the button to purchase the item that he wants, the control unit turns on the motor and dispenses the product if correct amount is inserted.

III. If there is any change, machine will return it to the user.

IV. The machine will demand for servicing when the products are not available inside the machine.

1.2 FSM (Finite State Machine) [2] [3]

In a Finite State Machine the circuit's output is defined in a different set of states i.e. each output is a state. A State Register to hold the state of the machine and a next state logic to decode the next state. An output register defines the output of the machine. In FSM based machines the hardware gets reduced as in this the whole algorithm can be explained in one process.

Two types of State machines are:

MEALY Machine: In this machine model, the output depends on the present state as well as on the input. The MEALY machine model is shown in figure 1.

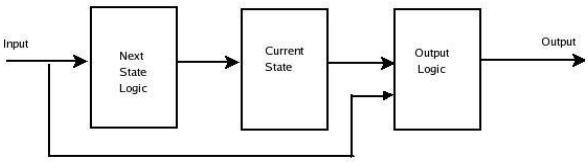

Figure 1: MEALY Machine Model

MOORE Machine: In Moore machine model the output only depends on the present state. The MOORE machine model is shown in figure 2.

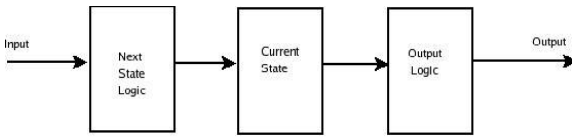

Figure 2: MOORE Machine Model

The paper is organized as: section 2 describes the related work. Section 3 relates the implementation of Vending Machine and section 4 gives the design methodology with description of states. Section 5 and section 6 shows simulation results and conclusion respectively.

II. RELATED WORK

Various researches have been carried out in order to design the Vending Machines. A few of them are discussed here as: Fauziah Zainuddin [1] proposes a vending machine for steaming frozen food using conceptual modelling. In which the process of three main states (user selection state, freezer state and steaming state) has 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 [6]. In [4] 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. Thee various methods of designing VHDL based machines are discussed in [2], [3] and [9]. Also in [5] the passenger's requirements for ticketing system are given. In [7] a coffee vending machine is designed using single electron encoded logic (SEEL). The designed circuit is tested and its power and switching time is compared with the CMOS technology.

III. IMPLEMENTATION OF VENDING MACHINE

In this paper a state diagram is constructed for the proposed machine which can vend four products that is coffee, cold drink, candies and snacks. Four select (select1, select2, select3, select4) inputs are taken for selection of products. Select1 is used for the selection of snacks. Similarly select2, select3, select4 are used for coffee, cold drink and candies respectively. Rs_10 and rs_20 inputs represents rupees 10/- and 20/- notes respectively. A cancel input is also used when the user wants to withdraw his request and also the money will be returned through the return output. Return, product and change are the outputs. Return and change vectors are seven bits

wide. Money is an in/out signal which can be updated with the total money of all products delivered at a time. Money signal is seven bits wide. Money_count is an internal signal which can be updated at every transition. This signal is also seven bits wide. If the inserted money is more than the total money of products then the change will be returned through the change output signal. The products with their prices are shown by table 1. There are also two input signal clk and reset. The machine will work on the positive edge of clock and will return to its initial state when reset button is pressed. The proposed vending machine is designed using FSM modelling and is coded in VHDL language. The detail of the entire signal with their direction and description is shown in table 2.

Table 1: Products with their prices

S.No.	Products	Price
1.	Snacks	30/-
2.	Coffee	40/-
3.	Cold drink	40/-
4.	Candies	30/-

Table 2: Inputs/Outputs with Remarks

Name	Width	Direction	Description
clk	1	input	Clock
Reset	1	Input	Syn reset
Sel1	1	input	Snacks
Sel2	1	input	Coffee
Sel3	1	input	Cold drink
Sel4	1	input	Candies
Cancel	1	input	Cancel
Money	7	inout	Total money
Rs_10	1	input	Rupees 10/-
Rs_20	1	input	Rupees 20/-
Product	1	output	Product out
Change	7	output	Extra change
Return	7	output	Return money

IV. DESIGN METHODOLOGY

The state diagram mainly consists of four states (User Selection, Waiting for the money insertion, product deliveryand servicing (when product_not_available='1')). Initially when the reset button is pressed, the machine will be ready for the users to select the product. This state is the initial state of the design. After this the user will select the product to be dispensed. This state can be one of the select1, select2, select3 and select 4. The machine can accept only two types of notes i.e. rupees 10/- and 20/-. Let us suppose that the user selects sel1 input. The machine will firstly check that whether the products are available in the machine or not. After this the control unit will move to the waiting state, where it will wait for the money to be inserted. Then if rupees 10/- note is inserted then the machine will go to state_1 and wait until the desired money is inserted. And if rupees 20/- note is inserted the machine will move to state_2 and then wait until 30/- rupees are inserted to the machine. When the desired amount is inserted the machine will go to the snacks state and snacks will be delivered at the product output. If products are not available in the machine then the control unit will demand for servicing and after service the machine will get reset. This methodology is explained using a flow diagram shown in figure 3.

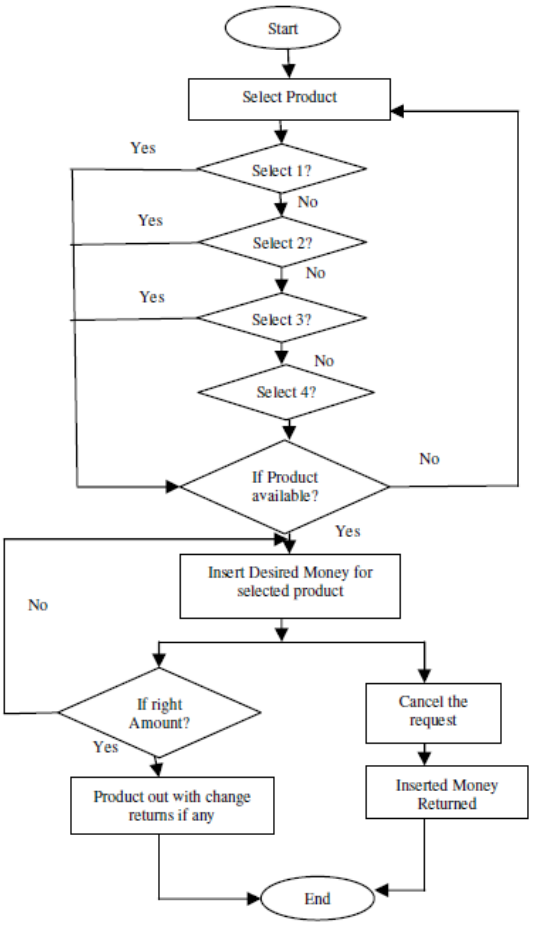

Figure 3: Flow Chart for Proposed Vending Machine

There is also an additional feature of withdrawing the request if the user doesn't want to take the product. When cancel button is pressed then 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 the money inserted is more than the money of the product then the extra change will be returned to the user. The total amount of the product taken at a time is shown by the money signal. Similarly the user can select and get the other products following the above procedure.

Description of states

The selection of products and all the states are shown below in figure 4.

- When initialize=>
  money_count=0;
  Change=0;
  Product=0;
- When select1=>
  Sel1&!sel2&!sel3&!sel4
  When
  product_available=1=>nx_st1<=waiting1;
  When
  product_available=0=>nx_st1<=service1;
- When waiting1=>
  When
  rs_10&!rs_20=>nx_st1<=state_1;
  When ! rs_10&
  rs_20=>nx_st1<=state_2;
  Change =0; Product=0;
  When money_count>=30
  nx_st1<=snacks;
- When state_1=>
  Rs_10=1&rs_20=0;
  Change =0; Product=0;
  money_count=money_count+10;

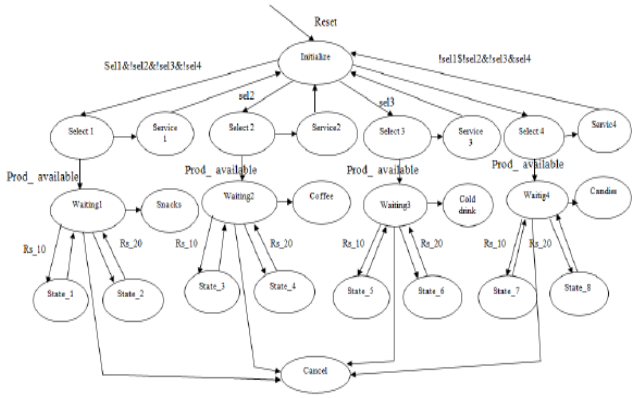

Figure 4: Finite State Machine Diagram of Vending Machine

- When state_2=>

  Rs_10=0 & rs_20=1;

  Change=0; Product=1;

  Money_count=money_count+20;

- When snacks=>
  Money_count>=30;
  Product=1;
  Change=money_count-30;
  Snack_count=snack_count-1;
- When service=>
  snack_count=
  4 product<=0;
  next_state<=resett;
- When cancel1=>
  cancel=1;
  return<=money_count;

Similarly we can select other products (coffee, Cold drink and candies).

V. SIMULATION RESULTS

The state diagram shown in figure 4 is simulated using Xilinx ISE Simulator. Simulation Waveforms for the selection of four products like snacks is shown in figure 5 and 6 respectively with servicing feature when products are not available in the machine and change return features when the money inserted is more than the money of the product.

Let us take an example that the user wants to take Snacks. When one selects sel1 button, the machine will check that whether the products are available or not, if available then it will go to the waiting state and wait for total money insertion. If rs_10 note is inserted it will go to state_1 and if rs_20 note is inserted it will so to state_2 and check whether money_count>=30 or not. If the money_count >- 30 then machine will go to state snacks and vend the product.

1. Price of the Product is Rs. 3

Return of Rs. 2 after the Cancel (pu) button is pressed.

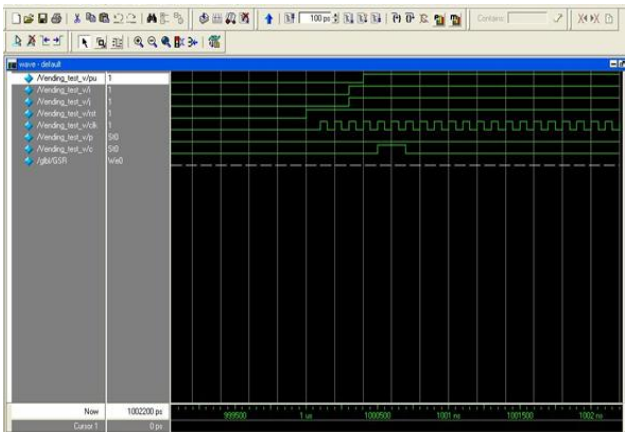

Fig 5.1 Return Money

2. Product Delivery and Return of Change after Rs. 4 insertion.

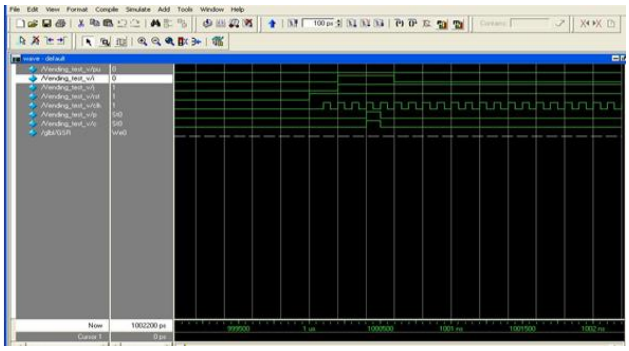

Fig 5.2 Product delivery and Return of change

3. Product Delivery after Rs. 3 insertion

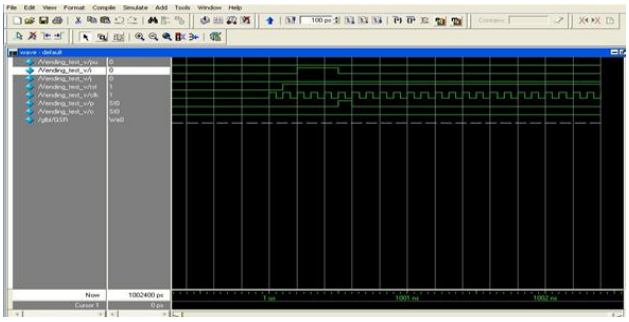

Fig 5.3 Product deliver

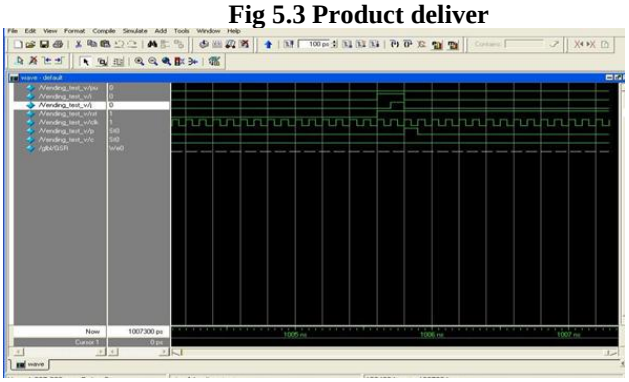

Fig 5.4 Product delivery

RTL Schematic:

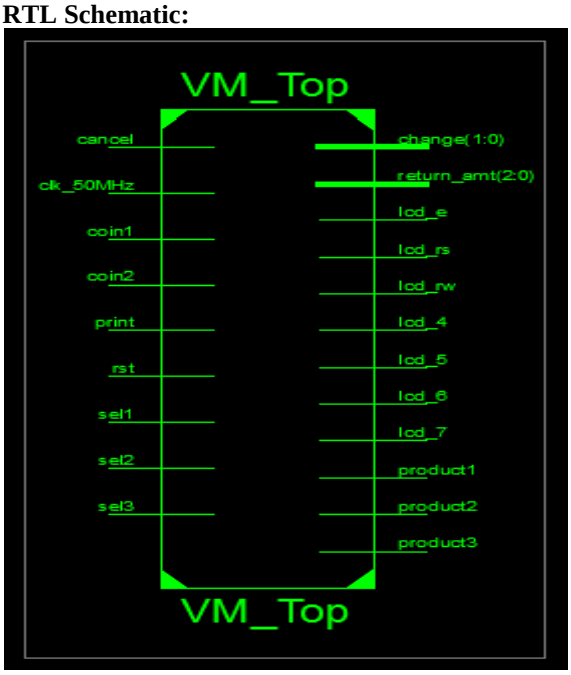

Fig 5.5 RTL schematic of Vending Machine

Logic utilization	Used	Available	Utilization
Number of Slices	228	3584	6%
Number of Slice flip flops	98	7168	1%
Number of 4 input LUT's	432	7168	6%
Number of bonded IOB's	31	173	17%
Number of GCLK's	1	8	12%

Table 3: Device Utilization Summary

The comparison of VHDL based machine with the CMOS technology based machine on the basis of switching speed is shown in table 4.

Table 4: Comparison of Switching Speed

Parameter using	FPGA	Single Electron Device (SED)	Using CMOS technology
Switching Speed	9.3 ns	12.53 ns	300ns

VI. CONCLUSION

When we realized that we have at last made a code that could actually work as a user friendly vending machine. This code can actually provide a variety of options to the user and also return him/her the balance money. This verilog code has been successfully verified using the Xilinx ISE 9.2i tool

and the desired outputs have been achieved. Vending Systems enhances productivity, reduces system development cost, and accelerates time to market. Vending machine gives fast response and is easy to use by an ordinary person. The designed machine can be used for many applications and we can easily enhance the number of selections. The next stage of this study is to convert this model into hardware and to calculate the total power consumption of the machine. Thus we would conclude saying that we tried our bit to modify the present day complex vending machine into a user friendly and user specific vending machine.

Future Work:

Vending Machines designed in this way can be used to dispense single products, cancel request and auto billing features are added by FPGA implementation which are not provided by embedded systems design in future we can use other methods for dispensing multiple products at the same time, which will be more comfortable to the user.

REFERENCES

[1] Fauziah Zainuddin, Norlin Mohd Ali, Roslina Mohd Sidek, Awanis Romli, Nooryati Talib & Mohd. Izham Ibrahim (2009) "Conceptual Modeling for Simulation: Steaming frozen Food Processing in Vending Machine" International Conference on Computer Science and Information Technology, University Malaysia Pahang, pp.145-149.

[2] Zhang Wen & Zhang Xin Long (2010) "Design and Implementation of automatic vending machine Based on the short massage payment" International Conference on Information and Communication technology in Electrical Sciences, Neijiang, Sichuan, China.pp.978-981.

[3] B. Caulfield & M.O Mahony (2005) "Passenger Requirements of a Public Transport Ticketing System" Proceedings of the 8th International IEEE Conference on Intelligent Transportation Systems Vienna, Austria, pp-32-37.

[4] M. Zhou, Q. Zhang & Z. Chen (2006), "What Can Be Done to Automate Conceptual Simulation Modelling?" Proceedings of the 2006 Winter Simulation Conference, pp. 809 – 814.

[5] Biplab Roy & Biswarup Mukherjee (2010) "Design of Coffee Vending Machine using Single Electron Devices" Proceedings of 2010 International Symposium on Electronic System Design. Pp 38-43.

[6] C. J Clement Singh, K Senthil Kumar, Jayanto Gope, Suman Basu & Subir Kumar Sarkar (2007) " Single Electron Device based Automatic Tea Vending Machine" proceedings of International Conference on Information and Communication Technology in Electrical Sciences (ICTES 2007) , pp 891-896.

[7] P. Smith (1997) "Automatic Hot-food Vending Machine," Trends in Food Science & Technology October 1997, Vol. 81, and pp. 349.

[8] M. Zhou, Y. J. Son, & Z. Chen, (2004), "Knowledge Representation for Conceptual Simulation Modeling" Proceedings of the 2004 Winter Simulation Conference, pp. 450 – 458.

[9] Muhammad Ali Qureshi, Abdul Aziz & Hafiz Faiz Rasool "Design and Implementation of Automatic Ticket System using Verilog HDL" proceedings of tnternational conference on Information Technology, pp- 707-712.

[10] Steve Kilts," Advanced FPGA Design: Architecture, Implementation, and optimization", Wiley-IEEE press, 2007.

[11] Seyed Bahram Zahir Azami & Mohammad Tanabian "Automatic Mobile Payment on a non- Connected Vending Machine" proceedings of Canadian Conference on Electrical and Computer Engineering, 2004, pp- 731-734.