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Finite State Machine Based Vending Machine Controller

Monali Nandkumar Swami, B.E
Dept of Electronics and Telecommunications, Avanti's Scientific Technological and Research Academy, (Approved By Aicte Reg. By Govt. By AP and Affiliated to JNTU Hyderabad).

Mr.N. Ashok Kumar, M.Tech
Associate Professor,
Dept of Electronics and Communication Engineering, Avanti's Scientific Technological and Research Academy, (Approved By Aicte Reg. By Govt. By AP and Affiliated to JNTU Hyderabad).

Abstract:
These days, Vending Machines are notable among Japan, Malaysia and Singapore. The amount of machines in these nations is on the top around the world. This is because of the cutting edge ways of life which require fast food preparing with high caliber. This paper depicts the planning of multi select machine utilizing Finite State Machine Model with Auto-Billing Features. Limited State Machine (FSM) demonstrating is the most vital part in creating proposed model as this decreases the equipment. In this paper the procedure of four state (client Selection, Waiting for cash insertion, item conveyance and overhauling) has been demonstrated utilizing MEALY Machine Model. The proposed model is tried utilizing Spartan 3 advancement board and its execution is contrasted and CMOS based machine.

Keywords:FSM; VHDL; Vending Machine; FPGA Spartan, 3 development board;

1. INTRODUCTION:

Vending Machines are used to dispense various items like Coffee, Snacks, and Cold Drink and so on when cash is embedded into it. Candy machines have been in presence since 1880s. The main business coin worked machine was presented in London and England utilized for offering post cards. The candy machines are more available and pragmatic than the tradition obtaining technique. These days, these can be discovered wherever like at railroad stations offering train tickets, in schools and workplaces distributing beverages and snacks , in banks as ATM machine and gives even precious stones and platinum gem dealers to clients. Past CMOS and SED based machines are additional tedious than the FPGA based machines [7].

The FPGA based machine is likewise more adaptable, programmable and can be re-customized. In any case, in microcontroller based machine, on the off chance that one needs to upgrade the outline, he needs to change the entire design again however in FPGA client can without much of a stretch increment the quantity of items. In this paper another methodology is proposed to outline a FSM based Vending Machine [3] with auto-charging highlights. The machine likewise underpins a cross out component implies that the individual can pull back the solicitation and the cash will be returned back to the client. The client will get a bill of aggregate number of items conveyed with aggregate cost. This machine can be utilized at different spots like Hotels, Restaurants and nourishment avenues. This decreases the time and cost.

1.1 Operation of Vending Machine:

I. At the point when the client puts in cash, cash counter tells the control unit, the measure of cash embedded in the Vending Machine. II. At the point when the client presses the catch to buy the thing that he needs, the control unit turns on the engine and administers the item if right sum is embedded. III. In the event that there is any change, machine will return it to the client. IV. The machine will interest for adjusting when the items are not accessible inside the machine.

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

In a Finite State Machine the circuit's yield is characterized in an alternate arrangement of states i.e. every yield is a state. A State Register to hold the condition of the machine and a next state rationale to disentangle the following state.

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A yield register characterizes the yield of the machine. In FSM based machines the equipment gets decreased as in this the entire calculation can be clarified in one procedure.

Two sorts of State machines are:

Coarse Machine: In this machine demonstrate, the yield relies on upon the present state and on the information. The MEALY machine model is appeared in figure 1.

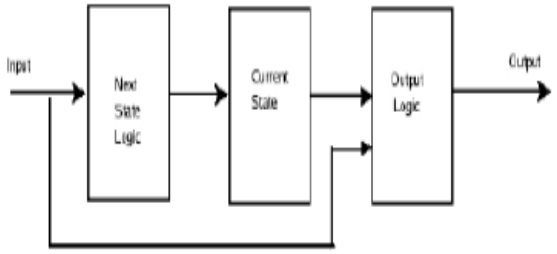

Figure 1: MEALY Machine Model

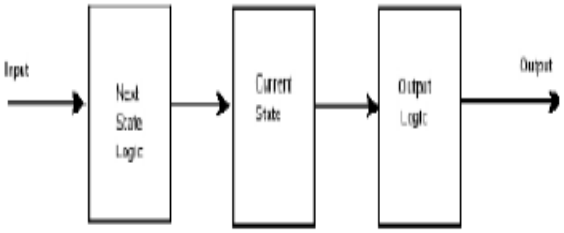

Figure 2: MOORE Machine Model

MOORE Machine: In Moore machine show the utput just relies on upon the present state. The MOORE machine model is appeared in figure 2.

2. RELATED WORK:

Different investigates have been completed with a specific end goal to plan the Vending Machines. A couple of them are talked about here as: Fauziah Zainuddin [1] proposes a candy machine for steaming solidified sustenance utilizing theoretical displaying. In which the procedure of three primary states (client choice state, cooler state and steaming state) has been displayed utilizing process approach, which accentuated on the procedure stream or control rationale to build the model for steamed buns candy machine application.

Applied displaying is portrayed in [6]. In [4] the idea of programmed versatile installment is talked about. This idea depends on the short message installment with the principle control module M68HC11 and GPRS module MC35. Thee different techniques for outlining VHDL based machines are talked about in [2], [3] and [9]. Additionally in [5] the traveler's prerequisites for ticketing framework are given. In [7] an espresso candy machine is composed utilizing single electron encoded rationale (SEEL). The outlined circuit is tried and its energy and exchanging time is contrasted and the CMOS innovation.

3. IMPLEMENTATION OF VENDING MACHINE:

In this paper a state graph is developed for the proposed machine which can distribute four items that is espresso, cool drink, confections and snacks. Four select (select1, select2, select3, select4) inputs are taken for choice of items. Select1 is utilized for the choice of snacks. Likewise select2, select3, select4 are utilized for espresso, cool drink and confections separately. Rs_10 and rs_20 inputs speaks to rupees 10/ - and 20/ - notes separately. A cross out information is additionally utilized when the client needs to pull back his solicitation furthermore the cash will be returned through the arrival yield. Return, item and change are the yields. Return and change vectors are seven bits wide.

Cash is an in/out sign which can be overhauled with the aggregate cash of all items conveyed at once. Cash sign is seven bits wide. Money count is an inward flag which can be redesigned at each move. This sign is likewise seven bits wide. On the off chance that the embedded cash is more than the aggregate cash of items then the change will be returned through the change yield signal. The items with their costs are appeared by table 1. There are likewise two info signal clk and reset. The machine will take a shot at the positive edge of clock and will come back to its underlying state when reset catch is squeezed. The proposed candy machine is planned utilizing FSM demonstrating and is coded in VHDL dialect.

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The point of interest of the whole flag with their course and portrayal is appeared 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/-

4. DESIGN METHODOLOGY:

The state diagram mainly consists of four states (User Choice, Waiting for the cash insertion, item conveyance and adjusting (when item not available='1')). At first when the reset catch is squeezed, the machine will be prepared for the clients to choose the item. This state is the underlying condition of the outline. After this the client will choose the item to be apportioned. This state can be one of the select1, select2, select3 and select 4.

The machine can acknowledge just two sorts of notes i.e. rupees 10/ - and 20/ - . Give us a chance to assume that the client chooses sel1 information. The machine will firstly watch that whether the items are accessible in the machine or not. After this the control unit will move to the holding up state, where it will sit tight for the cash to be embedded. At that point if rupees 10/ - note is embedded then the machine will go to state_1 and hold up until the craved cash is embedded.

What's more, if rupees 20/ - note is embedded the machine will move to state_2 and afterward hold up until 30/ - rupees are embedded to the machine. At the point when the fancied sum is embedded the machine will go to the snacks state and snacks will be conveyed at the item yield. In the event that items are not accessible in the machine then the control unit will interest for overhauling and after administration the machine will get reset. This methodology is clarified utilizing a stream chart appeared as a part of figure 3.

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

There is likewise an extra element of pulling back the solicitation if the client wouldn't like to take the item. At the point when wipe out catch is squeezed then the cash embedded will be come back to the client through the arrival yield. A cash tally sign is utilized for ascertaining the aggregate cash embedded in the machine. What's more, if the cash embedded is more than the cash of the item then the additional change will be come back to the client. The aggregate sum of the item taken at once is appeared by the cash signal. Thus the client can choose and get alternate items taking after the above strategy.

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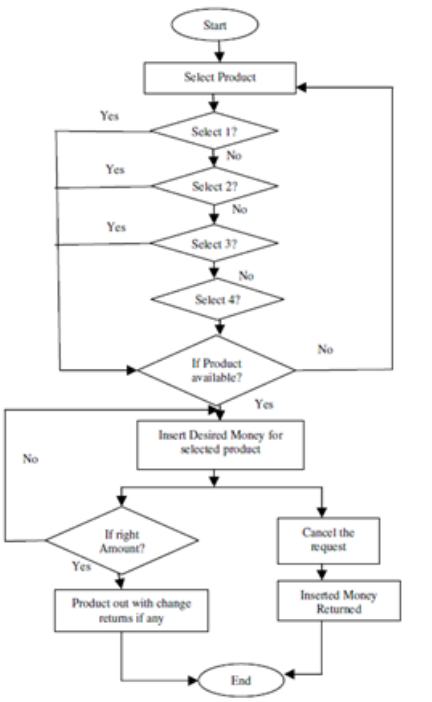

Figure 3: Flow Chart for Proposed Vending Machine

Description of States:

The choice of items and every one of the states are appeared underneath 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;
- 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;

Thus we can choose different items (espresso, Cold drink and confections).

5. SIMULATION RESULTS:

The state outline appeared in figure 4 is reproduced utilizing Xilinx ISE Simulator. Recreation Waveforms for the choice of four items like snacks is appeared in figure 5 and 6 separately with overhauling highlight when items are not accessible in the machine and change return highlights when the cash embedded is more than the cash of the item. Give us a chance to take an illustration that the client needs to take Snacks. When one chooses sel1 catch, the machine will watch that whether the items are accessible or not, if accessible then it will go to the sitting tight state and sit tight for aggregate cash insertion. On the off chance that rs_10 note is embedded it will go to state_1 and if rs_20 note is embedded it will so to state_2 and check whether cash count>=30 or not. On the off chance that the money_count>-30 then machine will go to state snacks and distribute the item.

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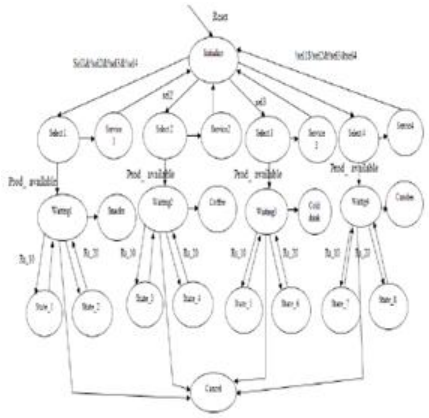

Figure 4: Finite State Machine Diagram of Vending Machine

Figure 5: Simulation waveform showing selection of Snacks

On the off chance that the client needs to wipe out the solicitation, can do as such by squeezing the scratch off catch and the entire cash entered will be come back to the client. This is appeared in figure 7.

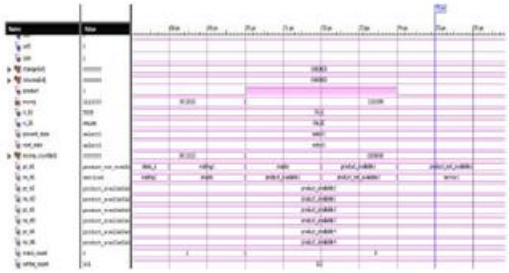

Figure 6: Simulation waveform when snack_count=0

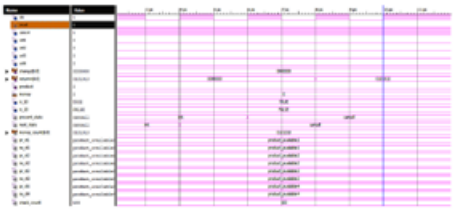

Figure 7: Simulation waveform showing Cancel Operation

The RTL view of the machine is shown in figure 8.

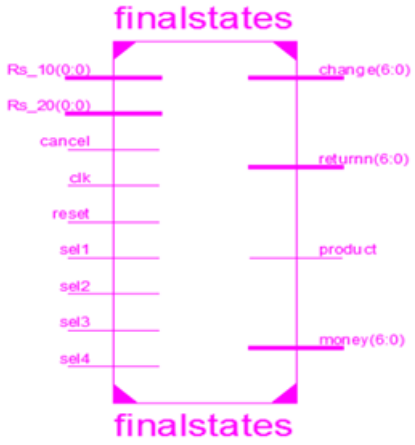

Figure 8: RTL view of Vending Machine.

The configuration synopsis of the proposed machine is appeared beneath in table 3.

Table 3: Device Utilization Summary

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%

The correlation of VHDL based machine with the CMOS innovation construct machine in light of the premise of exchanging rate is appeared in table 4.

Table 4: Comparison of Switching Speed

Parameter	using FPGA	Using Single Electron Encoded Logic (SEEL)	Using CMOS technology
Switching Speed	9.3 ns	12.53 ns	300ns

6. CONCLUSION:

The present FPGA based candy machine controller is actualized utilizing FSMs with the assistance of Xilinx ISE Design Suite 12.4. The configuration is checked on the FPGA Spartan 3 advancement Board. State machines based distributing Systems improves profitability, diminishes framework advancement cost, and quickens time to showcase.

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Additionally FPGA based candy machine give quick reaction and simple to use by a normal individual. The outlined machine can be utilized for some applications and we can without much of a stretch improve the quantity of determinations. The following phase of this study is to change over this model into equipment and to compute the aggregate force utilization of the machine.

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