International Journal of Engineering Research in Electronic and Communication Engineering (IJERECE) Vol 2, Issue 8, August 2015

Smart Vending Machine

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Abstract: **Today in fast moving world everyone want things with ease and quality. Vending machines are used to dispense different products, when money is inserted. Here in paper we have designed an efficient vendingmachine on FPGA board. FPGA implemented Vending machine give better response and less power consumption than the microcontroller based vending machine. In this paper we are having four products.In simple vending machine automatically cancel if entered money isn't enough and there is no balance provided. This machine accepts moneys as inputs in any sequence and delivers products when required amount is deposited and gives back the change if entered amount is greater than the price of product. The money recognition done using MATLAB by taking the real time photo of money, recognize whether coin or note, and the total value of the money is calculated in terms of Indian National Rupees (INR). The money recognition uses Canny edge detection method .The machine also supports cancel feature means a user can withdraw the request any time and entered money will be returned back without any product. The algorithm is implemented using real time money recognition, product entry and its delivery. The proposed algorithm is implemented using combination of Matlab and Xilinx and simulated in Xilinx StateCAD tool .**

Keywords: ***FSM; Verilog HDL; StateCAD; Xilinx; MATLAB; Vending Machine;***

I. INTRODUCTION

A vending machine is a machine that dispense the product and the change if there is any depending on the customer input in terms of the money and the selected product. These steps would not be time consuming at all. The vendee would get all the details on the screen which he/she should follow. Earlier vending machines are bulky as compared to FPGA based vending machine. Microcontroller and microprocessor were used in earlier days to implement vending machine which were not that efficient. Hence it is necessary to make it more reliable by FPGA based solution.

1.1 Finite State Machine

A finite-state machine (FSM) or finite-state automaton (plural: automata), or simply a state machine, is a mathematical model of computation used to design both computer programs and sequential logic circuits. The machine supports only one state at a time; the state at any particular instant is called the current state. Triggering event or condition changes the state from one state to another when initiated; hence the transition. There are mainly two types of fsm design Moore and Mealy.The proposed algorithm for FPGA based vending machine is a sequential circuit which is based on Mealy Model.

In a Moore machine Model the output depends on the present state, while in a Mealy the output depends on the present state as well as the previous input.

Figure 1 and 2 shows moore and mealy models respectively:

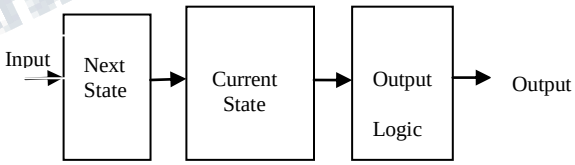

Figure 1 Moore Machine

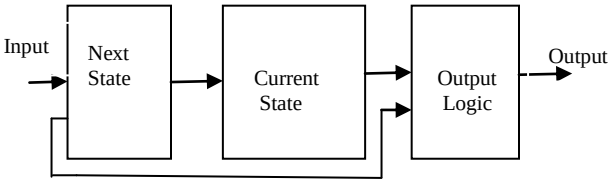

Figure 2 Mealy Machine

1.2 Xilinx StateCAD Tool

In this paper the simulation of vending machine is done by using Xilinx StateCAD tool. StateCAD is a wonderful tool

in Xilinx that is used by engineers to implement their ideas in graphical form such as state diagram. By using StateCAD tool we can get the required results without facing a lot of steps and errors that are faced in writing the HDL code direct. Hence we can say that StateCAD is a time saving tool for engineers.

II. PROCESSING FLOW OF MONEY RECOGNITION

An image taken using the mini camera is sent to for processing using MATLAB and the computed value of the moneys is sent back and displayed on the LCD screen. An example of an unprocessed image taken with the camera is shown in Figure 2. The various processing steps performed by MATLAB are described here.

2.1 Pre-Processing

The Pre-Processing of money has various stages, first is to convert color image to binary .Input money entered the camera takes the Photo. This colour image converted into gray scale for easy processing of image.Figure3 shows the real time image of 2 rupee coin.

Figure 3 Input Images

This image is converted to gray using rgb2gray function in matlab.

Figure 4 Output Image

2.2 Edge Detection

The edge detection of an image is implemented using localization properties. It also searches for the edge pixels. There are many edge finding methods, among which the Roberts, Laplacian and Canny edge finding methods are important. The Roberts method finds edges using the Roberts approximation derivative. It returns edges at those points, where the gradient of image is maximum as shown in Figure 5. The Laplacian of Gaussian (LOG) method finds edges by looking for zero crossings after filtering image, with a LOG filter. The Canny method differs other edge-detection methods in that it uses two different thresholds to detect strong and weak edges. The Canny edge detector is a more sophisticated approach of an edge map for an image, which can perform well in finding the edges.

Figure 5 Edge detected Image

2.3 Recognition Algorithm

The procedure for money recognizing is as follows:
Step 0: Create morphological structuring element from edge detected image (by strel)
Step 1: Determining the surface area and detecting whether coin or note
Step 2: If coin, find the Euclidian Distance of output and comparing the radius and dimensional feature of coin
Step 3: If note, comparing edge marks and surface area
Step 4: Finally displaying and storing coin value.

III. IMPLEMENTATION IN STATECAD

In this paper vending machine is constructed in terms of state diagrams with the help of StateCAD tool.
The customer can get four different kinds of products of different prices, namely Snacks, Coffee ,Coke and Tea. The prices of these products are given in the Table 1. The machine can accept the coins of one rupee, two rupees, five rupee and ten rupee in any possible sequence and notes of ten rupee,20 twenty rupee. There are three product selection buttons, namely SELECT1, SELECT2, and SELECT3 and SELECT4.

For instance, to vend out Coffee, the vendee has to push the button SELECT2. Similarly SELECT1, SELECT3, and SELECT4 represent Snacks, Tea and Coke respectively. This is shown by the schematic diagram Figure 6. Here IN1 and IN2 are mapped to coin selection as shown in Figure 7.CANCEL button is used when the user wants to withdraw his money at any stage provided that the inserted money is not equal to the price of the selected product. The outputs are CHANGE and VEND. Note that COINCOUNT and CHANGE is internal vector. The seven bit bus or vector variable COINCOUNT counts the amount of money inserted at every transition. The CHANGE displays the balance amount and the amount of money that has been returned to the user if he/she cancels. The system changes its states on every transition of positive edge of clock cycle represented by input CLK. The system returns to its initial state when RESET is asserted. . The code synthesized in Verilog HDL in StateCad and testbench is verified for different inputs of the users.

S.No	ITEM	PRICE
1.	SNACKS	Rs10/-
2.	COFFEE	Rs18/-
3.	TEA	Rs17/-
4.	COKE	Rs15/-

Table 1

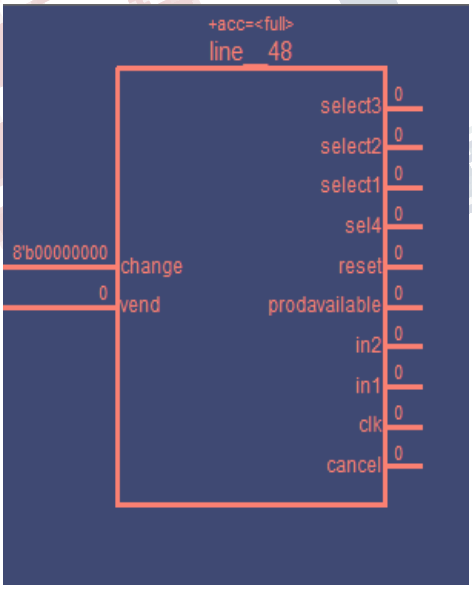

Figure 6

4. Algorithm Description

When the machine is reset, it becomes ready for the user to select the desired product and this state is represented by initial state (INIT) in the State CAD tool. Note that at every transition there is a condition so that machine can decide which next state is to be executed. When the user will insert money, the machine will check the condition at every transition. After executing the correct condition, the machine will come back to the WAITING state. At the end, the user will get his/her desired product if the inserted amount of money is equal to the price of the selected product. For four products, there are twenty two states. Let's take an example that the user wants to purchase Snacks then he/she has to push the SELECT1 button, as a result the machine will enter into the WAITING_1 state from INIT state. Now the machine will wait for the moneys. Suppose the customer inserts 50rupee then the machine will enter into the RUPEE50 which represents that 50rupee has been deposited and the value of COINCOUNT will be 50. At RUPEE50, the value of VEND and CHANGE is 1 and 40 respectively As the condition (COINCOUNT>=10) is correct therefore the machine will enter to the product state at which product will be released. If he/she presses the CANCEL button then he/she will get his money back. Similarly the customers can get all the other products by following the same procedure.

IV. Simulation Results

The algorithm is simulated using Xilinx StateCAD tool. For different choices of products and various money combinations, the simulation waveforms are generated. In Figure 7, As the snack cost is ten Rupees, the vendee inserts a note of 50 Rupees, The value of COINCOUNT is as indicated in the figure which exceeds the price of product. At the end the machine vends out the product as well as it gives fory Rupee as a change. There are different combinations of moneys by which vendee can get this product.. Let's take an example that the vendee selects the product and cancel this is shown by Figure8. After selecting the product the machine will wait for the user to insert the money. Suppose he/she inserts a coin of one Rupee and suddenly he/she changes his mind to get some other product then he/she has to get his/her money back simply by pressing a Cancel button. The same procedure is adopted in Figure 9.

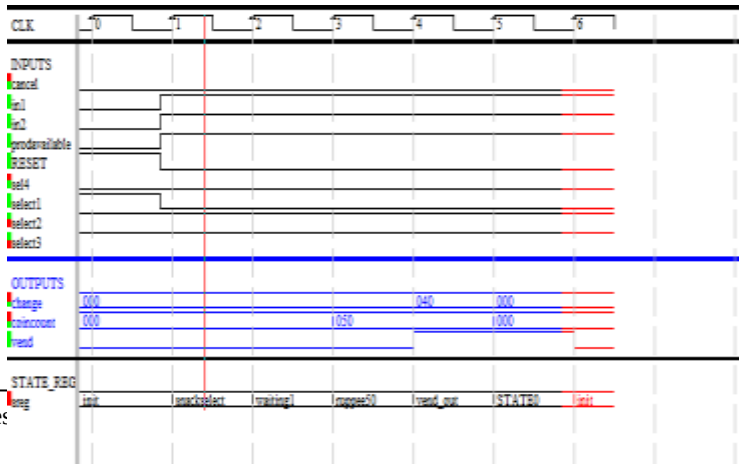

Figure 7

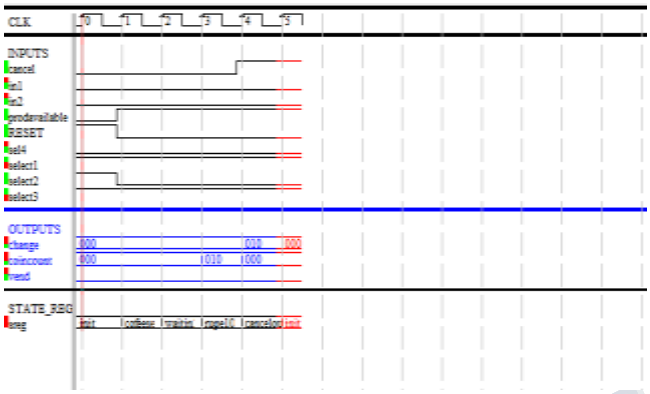

Figure 8

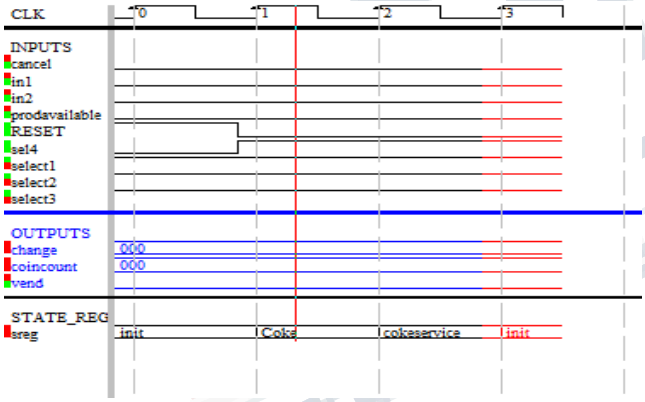

Figure 9

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 StateCAD tool and the desired outputs have been achieved. Vending Systems enhances productivity, reduces system development cost, and accelerates time to market. Vending machine give fast response and 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. The main advantage of algorithm is that the machine can be modified for any number of customers as needed and cost effective technique.

ACKNOWLEDGMENT

We are very grateful to our guide Mr. Agi Joseph George Asst. Professor, Department of ECE, for his valuable guidance and suggestions. We also wish to thank all our respected teachers and friends for their excellent contributions and support for the completion of this paper.

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